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NORTH DAKOTA STATE AGENCY

PUBLIC DOCUMENT

NO. 18

SECOND BIENNIAL REPORT

OF THE

STATE ENGINEER

TO THE

GOVERNOR OF NORTH DAKOTA

FOR THE

Years 1905 and 1906



ER COMMISSION

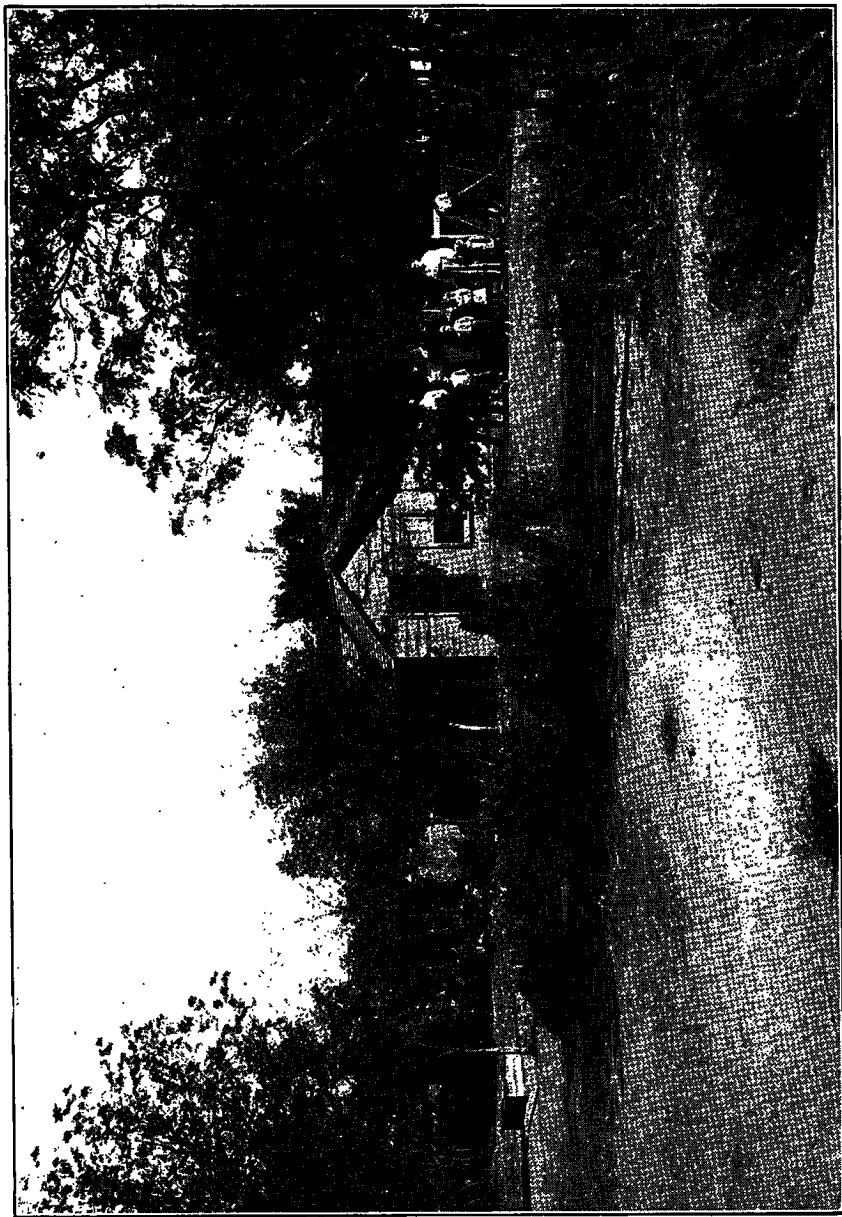
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BISMARCK, N. D.

GRIMME, STATE PRINTERS AND BINDERS
1906

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A Farm on Knife river where irrigation is practiced.

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BISMARCK, N. D.:
TRIBUNE, STATE PRINTERS AND BINDERS
1906.

LETTER OF TRANSMITTAL

BISMARCK, NORTH DAKOTA,

September 30, 1906.

Hon E. Y. Sarles, Governor of North Dakota:

SIR: I have the honor to transmit herewith the transactions of the department of the state engineer for the period of time commencing March 1, 1905, and ending September 30, 1906, with such recommendations as my experience has led me to believe will increase the efficiency of the provisions of our irrigation and drainage laws.

Yours very respectfully,
A. L. FELLOWS,
State Engineer.

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LIST OF OFFICERS
IN CHARGE OF
IRRIGATION IN NORTH DAKOTA.

A. L. FELLOWS State Engineer.

Appointed March 1, 1905.

Qualified March 20, 1905.

T. R. ATKINSONAssistant State Engineer.

Appointed June 7, 1905.

Qualified June 19, 1905.

E. F. CHANDLERU. S. Assistant Hydrographer.

Civil Service United States officer throughout.

LIST OF WATER DIVISIONS

Water Division No. 1

Consisting of all that portion of the state west and south of the Missouri river.

Water Division No. 2—

Consisting of all lands within the state drained by the Mouse river and its tributaries, and all lands within the state north and east of the Missouri river drained by the Missouri river and its tributaries from the boundary of the state of Montana as far down as Fort Berthold.

Water Division No. 3—

Consisting of all lands within the state east of the Missouri river drained by the Missouri river and its tributaries below Fort Berthold, and all lands within the state drained by the James or Dakota river and its tributaries.

Water Division No. 4—

Consisting of all the lands within the state drained by the Red river and its tributaries, excepting the Mouse river, as hereinafore specified, and all the lands within the state drained into Devils Lake.

Appropriation for state engineer's office from March 1, 1905 to March, 1907, \$12,000.

FINANCIAL STATEMENT

WARRANT ACCOUNT FOR PROMOTION OF IRRIGATION AND
DRAINAGE FROM MARCH 1, 1905, TO OCTOBER 14, 1906.
SESSION LAWS 1905.

| No. | Date | To Whom Issued | Amount |
|-------|------------|--------------------------------|---------|
| 61013 | 3-31-1905 | A. G. Patterson, P. M. | \$ 5.06 |
| 61054 | 4- 1-1905 | A. L. Fellows | 80.64 |
| 61310 | 4-29-1905 | A. L. Fellows | 304.78 |
| 61333 | 5- 1-1905 | A. G. Patterson, P. M. | 55.00 |
| 61358 | 5- 1-1905 | T. D. Hughes, Agt. | 8.74 |
| 61454 | 5- 5-1905 | Brown, Treacy & Sperry Co..... | 74.34 |
| 61533 | 5- 5-1905 | Bismarck Tribune Co. | 33.75 |
| 61686 | 6- 1-1905 | A. L. Fellows | 243.23 |
| 61687 | 6- 1-1905 | Laura Connor | 58.06 |
| 61727 | 6- 2-1905 | T. D. Hughes, Agt. | 1.25 |
| 62142 | 6-30-1905 | A. G. Patterson, P. M. | 15.30 |
| 62148 | 7- 1-1905 | Laura Connor | 75.00 |
| 62149 | 7- 1-1905 | A. L. Fellows | 238.33 |
| 62177 | 7- 3-1905 | T. D. Hughes, Agt. | 3.60 |
| 62471 | 7-28-1905 | A. L. Fellows | 208.33 |
| 62472 | 7-28-1905 | Laura Connor | 75.00 |
| 62517 | 8- 1-1905 | T. D. Hughes, Agt. | 9.05 |
| 62580 | 8-14-1905 | Bismarck Tribune Co. | 71.50 |
| 62581 | 8-14-1905 | A. L. Fellows | 41.50 |
| 62582 | 8-14-1905 | T. R. Atkinson | 200.00 |
| 62858 | 9- 4-1905 | A. L. Fellows | 208.33 |
| 62859 | 9- 4-1905 | T. R. Atkinson | 150.00 |
| 62860 | 9- 4-1905 | Laura Connor | 75.00 |
| 62966 | 9- 7-1905 | W. U. Tel. Co. | 1.65 |
| 63063 | 10- 2-1905 | A. L. Fellows | 208.33 |
| 63064 | 10- 4-1905 | T. R. Atkinson | 150.00 |
| 63065 | 10- 4-1905 | Laura Connor | 75.00 |
| 63218 | 10-13-1905 | A. L. Fellows | 136.25 |
| 63273 | 10-31-1905 | A. L. Fellows | 208.33 |
| 63274 | 10-31-1905 | Laura Connor | 75.00 |
| 63439 | 11- 7-1905 | A. L. Fellows | 133.40 |
| 63595 | 11-29-1905 | A. L. Fellows | 208.33 |
| 63596 | 11-29-1905 | T. R. Atkinson | 150.00 |
| 63597 | 11-29-1905 | Laura Connor | 75.00 |
| 63643 | 12- 1-1905 | A. G. Patterson, P. M. | 40.00 |
| 63839 | 12-23-1905 | A. L. Fellows | 208.33 |
| 63840 | 12-23-1905 | T. R. Atkinson | 150.00 |
| 63841 | 12-23-1905 | Laura Connor | 75.00 |
| 64011 | 1-29-1906 | A. L. Fellows | 23.15 |
| 64159 | 1-31-1906 | A. L. Fellows | 208.33 |

FINANCIAL STATEMENT—Continued.

| No. | Date | To Whom Issued | Amount |
|-------|------------|-----------------------------------|--------|
| 64161 | 1-31-1906 | Laura Connor | 75.00 |
| 64256 | 2-26-1906 | A. L. Fellows | 21.00 |
| 64331 | 3- 1-1906 | A.-L. Fellows | 208.33 |
| 64332 | 3- 1-1906 | Laura Connor | 75.00 |
| 64343 | 3- 1-1906 | T. R. Atkinson | 150.00 |
| 64529 | 3-31-1906 | A. L. Fellows | 208.33 |
| 64530 | 3-31-1906 | T. R. Atkinson | 150.00 |
| 64531 | 3-31-1906 | Laura Connor | 75.00 |
| 64693 | 4- 4-1906 | Nor. Pac. Exp. Co. | 1.05 |
| 64796 | 4- 6-1906 | Eugene Dietzgen Co. | 50.95 |
| 64797 | 4- 6-1906 | Pink Paper | 8.00 |
| 64798 | 4- 6-1906 | E. H. Pierce | 7.50 |
| 64799 | 4- 6-1906 | K. Svalstuen | 5.35 |
| 64813 | 4- 8-1906 | T. R. Atkinson | 17.35 |
| 64858 | 4- 9-1905 | W. U. Tel. Co. | .77 |
| 64963 | 4-30-1906 | A. L. Fellows | 208.33 |
| 64964 | 4-30-1906 | T. R. Atkinson | 150.00 |
| 64965 | 4-30-1906 | Laura Connor | 75.00 |
| 65122 | 5- 4-1906 | Nor. Pac. Exp. Co. | 13.25 |
| 65126 | 5- 4-1906 | W. U. Tel. Co. | 2.60 |
| 65236 | 5-10-1906 | A. L. Fellows | 89.58 |
| 65307 | 5-11-1906 | Bismarck Tribune | 15.50 |
| 65442 | 5-31-1906 | A. L. Fellows | 208.33 |
| 65443 | 5-31-1906 | T. R. Atkinson | 150.00 |
| 65444 | 5-31-1906 | Laura Connor | 75.00 |
| 65445 | 5-31-1906 | H. V. Ausburn | 48.00 |
| 65515 | 6- 2-1906 | A. L. Fellows | 14.65 |
| 65516 | 6- 2-1906 | Buff & Buff Mfg. Co. | 470.79 |
| 65684 | 7- 2-1906 | A. L. Fellows | 208.33 |
| 65685 | 7- 2-1906 | T. R. Atkinson | 150.00 |
| 65686 | 7- 2-1906 | Laura Connor | 75.00 |
| 65796 | 7- 3-1906 | A. L. Fellows | 88.27 |
| 65797 | 7- 3-1906 | T. R. Atkinson | 25.60 |
| 65961 | 7- 7-1906 | W. U. Tel. Co. | .68 |
| 66003 | 7-31-1906 | A. L. Fellows | 208.33 |
| 66004 | 7-31-1906 | T. R. Atkinson | 150.00 |
| 66005 | 7-31-1906 | Laura Connor | 75.00 |
| 66053 | 8- 1-1906 | A. G. Patterson P. M. | 15.00 |
| 66123 | 8-18-1906 | A. L. Fellows | 55.34 |
| 66257 | 8-29-1906 | A. L. Fellows | 208.33 |
| 66307 | 8-31-1906 | T. R. Atkinson | 150.00 |
| 66308 | 8-31-1906 | H. V. Ausburn | 122.50 |
| 66309 | 8-31-1906 | Laura Connor | 75.00 |
| 66310 | 8-31-1906 | Thorn Dickinson | 30.00 |
| 66366 | 9- 5-1906 | O. F. Jones | 40.00 |
| 66367 | 9- 5-1906 | Grambs & Wolbert | 21.20 |
| 66368 | 9- '5-1906 | H. L. Reade | 19.20 |
| 66369 | 9- 5-1906 | A. L. Fellows | 6.40 |
| 66402 | 9- 5-1906 | Northern Pacific Express Co. | 2.30 |
| 66505 | 9-29-1906 | A. L. Fellows | 208.33 |
| 66506 | 9-29-1906 | T. R. Atkinson | 150.00 |
| 66507 | 9-29-1906 | Laura Connor | 75.00 |
| 66508 | 9-29-1906 | H. V. Ausburn | 75.00 |

FINANCIAL STATEMENT—Continued.

| No. | Date | To Whom Issued | Amount |
|-------|------------|-----------------------|-------------|
| 66725 | 10- 5-1906 | Asa Gardner | 18.81 |
| 66726 | 10- 5-1906 | T. R. Atkinson | 26.68 |
| 66727 | 10- 5-1906 | A. L. Fellows | 74.15 |
| 66728 | 10- 5-1906 | O. F. Jones | 77.50 |
| 66777 | 10-14-1906 | Thorn Dickinson | 84.00 |
| | | Total | \$ 9,602.50 |
| | | Balance | 2,397.50 |

Note.—At the date to which this statement is complete there were outstanding vouchers for which no warrants had as yet been issued amounting to \$259.89. This amount is not included in the summary given herewith. This would leave a balance available to March 1, 1907, of \$2,137.61.

SUMMARY OF EXPENDITURES.

| | |
|--|-------------------|
| State engineer's salary | \$3,830.53 |
| State engineer's traveling, supplies and survey expenditures | 845.04 |
| Assistant engineer's salary | 2,150.00 |
| Assistants traveling and survey | 69.63 |
| Stenographer's salary | 1,258.06 |
| Office supplies and expenses' | 442.19 |
| Instruments | 470.79 |
| Survey assistants and expenditures | 536.21 |
| Total | \$9,602.50 |

DISTRIBUTION.

Any distribution of these accounts between irrigation and drainage must be somewhat arbitrary but the following division seems fair.

| | |
|--------------------|-------------------|
| Irrigation | \$6,402.50 |
| Drainage | 3,200.00 |
| Total | \$9,602.50 |

RECEIPTS OF STATE ENGINEER'S OFFICE

FROM MARCH 1, 1905, TO SEPTEMBER 30, 1906.

| | |
|---|---------|
| May 1, 1905—U. S. filing fees | \$ 5.00 |
| June 29, 1905—Filing fee application No. 1 | 5.00 |
| Oct. 27, 1905—Proof of publication No. 1 | 1.00 |
| Dec. 6, 1905—Recording fees No. 1 | 1.75 |
| Jan. 26, 1906—Filing fees application No. 2 | 5.00 |
| Feb. 3, 1906—Filing fees application No. 3 | 5.00 |

| | |
|--|-----------------|
| April 13, 1906—Proof of publication No. 2 | 1.00 |
| May 7, 1906—Recording fees No. 2 | 1.75 |
| May 11, 1906—Filing fee application No. 4 | 5.00 |
| May 11, 1906—Filing fee application No. 5 | 5.00 |
| May 11, 1906—Filing fee application No. 6 | 5.00 |
| May 11, 1906—Filing fee application No. 7 | 5.00 |
| May 30, 1906—Survey of reservoir | 36.90 |
| June 25, 1906—Proof of publication No. 4 | 1.00 |
| June 25, 1906—Proof of publication No. 5 | 1.00 |
| June 25, 1906—Proof of publication No. 6 | 1.00 |
| May 25, 1906—Proof of publication No. 7 | 1.00 |
| July 9, 1906—Filing fee application No. 8 | 5.00 |
| July 9, 1906—Filing fee application No. 9 | 5.00 |
| July 23, 1906—Recording fees application No. 4 | 1.75 |
| July 23, 1906—Recording fees application No. 5 | 1.75 |
| July 23, 1906—Recording fees application No. 6 | 1.75 |
| July 23, 1906—Recording fees application No. 7 | 1.75 |
| Sept. 10, 1906—Proof of publication No. 8 | 1.00 |
| Sept. 10, 1906—Proof of publication No. 9 | 1.00 |
| Total | \$105.40 |

DEPOSITED WITH STATE TREASURER.

| | |
|----------------------|-----------------|
| July 3, 1905 | \$ 10.00 |
| Dec. 28, 1905 | 2.75 |
| April 8, 1906 | 10.00 |
| July 2, 1906 | 63.65 |
| Sept. 29, 1906 | 19.00 |
| Total | \$105.40 |

The North Dakota irrigation code, Senate Bill No. 1, approved March 1, 1905, in so far as it relates more particularly to applications for water is as follows:

INTRODUCTION

The Irrigation Code of North Dakota creating the office of state engineer was approved March 1, 1905. Prior to that time there had been no comprehensive law regarding irrigation in this state, but after the passage of the United States reclamation act of June 17, 1902, new interest was felt in the subject and in the year 1904 a fund was raised through the guarantee of leading citizens of the state and Prof. E. F. Chandler of the state university was appointed state engineer to assist in compiling an irrigation code and lay the foundations for systematic control of irrigation matters. That the work was well done is evidenced by the first biennial report of the state engineer. The code, as passed, has already been published in pamphlet form.

On March 1, the same day that the act was approved, the governor appointed the present incumbent who qualified on March 20. As was expected, the first two seasons have been largely consumed in organizing the office, becoming acquainted with the needs of the state, and laying the ground plans for future work. It is believed, however, that an examination of this report will show that much of a permanent value has been accomplished also.

In exercising the functions of the office it soon became apparent the work must necessarily, at the outset, be divided into two main classes, irrigation and drainage. Other fields of usefulness developed, especially those of state roads and forestry and these will also be referred to under their proper divisions, but practically all of the resources of the office have been expended upon two main classes, the others being considered thus far, merely incidentally.

The irrigation code was clearly intended, primarily, as a basis for the state's co-operation with the U. S. Reclamation Service, the Division of Irrigation and Drainage Investigations, Bureau of Experiment Stations, U. S. Department of Agriculture, and other agencies in furthering the practice of irrigation within its borders. The greater part of the work done has therefore been along this line. The act, however, also makes the state engineer a consulting engineer for those interested along drainage lines and this has proved to be a very important

part of his work, and it seems probable that it will, in time, overshadow the irrigation work in importance, although this too must by no means be underestimated. Approximately one-third of the time of the state engineer and the employees of the office has been given over to drainage matters, the other two-thirds being devoted to irrigation. It is upon this approximate estimate that the summary of expenditures is based.

The effort will be made in this report to treat in a clear and comprehensive manner all the subjects to which especial consideration has been given in the state engineer's office. The recommendations made regarding each subject will be found at the close of each respective chapter. An appendix has also been added in which are given certain addresses and essays contributed by the state engineer upon various occasions. It is believed these will be found of sufficient interest to warrant their publication.

As will be shown under the proper headings certain bills for acts and modification of acts have been prepared by the state engineer, which are not printed herewith as they will, doubtless, be considerably modified before passage. These bear upon the subject of irrigation, drainage, state roads, and forestry, and it is believed that their passage by the legislature would, eventually, be of material advantage to the state. Synopsis of these bills are however given herewith.

The thanks of the office are due to many members of the U. S. Geological Survey, the U. S. Reclamation Service, Division of Irrigation and Drainage Investigations, Forest Service, Bureau of Plant Industry, and other branches of the government service, and especially to Prof. E. F. Chandler former state engineer for suggestions and cooperation, and also to the Northern Pacific, Great Northern, Burlington, Minneapolis, St. Paul & Sault Ste. Marie railway companies and to the Fort Benton Packet company, for free transportation furnished, without which it would have been impracticable for nearly so much to be accomplished.

The state engineer desires also to express his high appreciation of the unfailing courtesy and hearty support of the chief executive of the state and the cordial co-operation of the other state officers.

CHAPTER I.

OFFICE ADMINISTRATION.

OFFICES.

No rooms having as yet been provided, the first duty of the state engineer upon assuming the office was to secure the necessary rooms and provide them with suitable furniture. The newer part of the capitol having been recently furnished and a number of the old rooms having thus been vacated, several were available, and those formerly occupied by the commissioner of agriculture were first selected, these being exchanged later for the old office of the commissioner of state lands. The necessary furniture was purchased, the cost being paid from the state engineer's fund. Only such furniture was obtained however as appeared to be indispensable, it being deemed best to purchase only as the needs of the office developed. The rooms equipped as stated answered the purpose very satisfactorily, being provided with a vault and other requirements. It is still deficient, however, in certain much needed furniture.

ASSISTANTS.

Until the state engineer had become familiar with the needs of the office no assistants were employed. It was soon found, however, that there should be some clerk who could be left in the office during the necessarily frequent and long continued absences of the chief, and on May 8, 1905, Miss Laura Conner was employed as stenographer, a position which she has continued to hold up to the present time.

On June 19, 1905, Mr. T. R. Atkinson, having been duly appointed, qualified as assistant state engineer, a position which he also still continues to fill. The greater part of Mr. Atkinson's time has been devoted to drainage, that class of work, especially the field surveying being turned over to him. He has also been able to devote a part of his time, however, to preliminary irrigation surveys in the western part of the state. His work will be described in detail in the proper chapters.

Such other assistance has been employed as was required, this being limited to engineering aids and other assistants for irrigation and drainage surveys. For the investigations of the fall of 1905 a man hand team with a complete camping outfit were

furnished by the U. S. Reclamation Service. For the surveys of 1906 the necessary men and teams were employed and a small equipment for field work was purchased. This outfit is stored and is available for another season's work.

IRRIGATION FORMS.

The Irrigation Code provides that the state engineer shall make suitable regulations and prepare official blank forms regarding the acquirement of water rights. It became necessary at a very early stage, therefore, for him to issue a circular containing instructions and to devise forms with this end in view. Such a circular, together with a series of blank forms were accordingly prepared and printed. These forms, so far as they have been printed up to the present time are shown herewith. Others which have not been issued as yet are in process of preparation.

Two books, one to contain a description of the filings and the progress of the applicants in making due compliance with the law, and the other a book for recording the applications for water rights have also been prepared for office use.

The form in the record books is identical with Form 2 shown herewith. A sample page from the book containing descriptions of filings is presented after form 16 to show the use of this book, the names used being fictitious. An account book showing records and receipts and disbursements is also kept. A property list is also kept in this book showing the property purchased for the office and field and its present condition. The forms mentioned follow in regular order.

APPLICATIONS FOR WATER RIGHTS.

The North Dakota Irrigation Code, Senate Bill No. 1, approved March 1, 1905, in so far as it relates more particularly to applications for water is as follows:

FEEES.

Section 10. Fees of State Engineer. The state engineer shall receive the following fees, to be collected in advance and to be paid by him into the general fund of the state treasury on the last day of March, June, September and December of each year.

(a) For filing and examining an application for permit to appropriate water, map and field notes of the same, five dollars.

(b) For recording any permit, certificate of construction or license issued or any other water right instrument, one dollar for the first hundred words and fifteen cents for each additional hundred words or fraction thereof.

(c) For filing any other paper, one dollar.

(d) For issuing certificates of construction, or license to appropriate water, one dollar each.

(e) For making copy of any document recorded or filed in his office, fifteen cents for each hundred words or fraction thereof.

(f) For blue print copy of any map or drawing, ten cents per square foot or fraction thereof. For other copies of drawings, actual cost of the work.

- (g) For certifying to such copies, one dollar for each certificate.
- (h) For examining and approving in connection with water right applications, plans and specifications for any dam, not exceeding ten feet in extreme height from the foundation, ten dollars; for a dam higher than ten feet and not exceeding thirty feet, twenty dollars; for a dam higher than thirty feet and not exceeding fifty feet, thirty dollars; for a dam higher than fifty feet, fifty dollars; or for a canal or other water conduit of an estimated capacity exceeding fifty and not more than one hundred cubic feet per second, twenty dollars; for an estimated capacity exceeding one hundred cubic feet per second, thirty dollars.
- (i) For inspecting dam sites and construction work when required by law, or when necessary in the judgment of the state engineer, ten dollars per day and actual and necessary traveling expenses. The fees for any inspection deemed necessary by the state engineer and not paid on demand shall be a lien on any land or other property of the owner of the works, and may be recovered by the state engineer in any court of competent jurisdiction.
- (j) Rating ditches or inspecting plans and specifications of works for the diversion, storage and carriage of water, at the request of private parties, not in connection with an application for right to appropriate water, actual cost and expenses; and the state engineer shall attach his approval to such plans and specifications if found satisfactory.
- (k) For such other work as may be required of his office, the fees provided by law.
- (l) In ascertaining actual cost of any work, as the term is used in this section, the salary of any salaried officer for the time employed shall be included.

APPROPRIATION OF WATER.

Sec. 19. Application for Water Right. Any person, association or corporation hereafter intending to acquire the right to the beneficial use of any waters, shall, before commencing any construction for such purpose, or before taking the same from any constructed works, make an application to the state engineer for a permit to appropriate, in the form required by the rules and regulations established by him. Such rules and regulations shall, in addition to providing the form and manner of preparing and presenting the application, require the applicant to state all the data necessary for the proper description and limitation of the right applied for, as to the amount of water and periods of annual use, together with such information, maps, field notes, plans and specifications as may be necessary to show the method and practicability of the construction and the ability of the applicant to complete the same. All such maps, field notes, plans and specifications shall be made from actual surveys and measurements, and shall be retained in the office of the state engineer after the approval of the application. The state engineer may require additional information not provided for in the general rules and regulations, in any case involving the diversion of five hundred cubic feet of water per second, or more, or the construction of a dam more than thirty feet high from the foundation. The owners of works proposing to store or carry water in excess of their needs for beneficial use, may make application for such excess, and shall be held as trustees of such right for the parties applying the water to a beneficial use; and shall be required to furnish the water for such parties at reasonable rates for storage, or carriage, or both, as the case may be.

Sec. 20. Filing and Correction of Application. The date of receipt of such application in the state engineer's office shall be endorsed thereon and noted in his records. If the application is defective as to form, or unsatisfactory as to feasibility or safety of plan, or as to the showing of the ability of the applicant to carry the construction to completion, it shall be returned with a statement of the corrections, amendments or

changes required, within thirty days after its receipt, and sixty days shall be allowed for the refileing thereof. If refiled, corrected as required within such time, the application shall, upon being accepted, take priority as of date of its original filing, subject to compliance with the further provisions of the law and the regulations thereunder. Any corrected application filed after the time allowed shall be treated in all respects as an original application received on the date of its refileing; provided, that the plans of the construction may be amended, with the approval of the state engineer, at any time; but no such change shall authorize any extension of time for construction beyond five years from the date of the permit, except as provided in section 30; provided, further, that a change in the proposed point of diversion of water from a stream shall be subject to the approval of the state engineer, and shall not be allowed to the detriment of the rights of others having valid claims to the use of water from said stream.

Sec. 21. Publication of Notice. Upon the filing of an application which complies with the provisions of this act and the rules and regulations established thereunder, the state engineer shall instruct the applicant to publish notice thereof, in a form prescribed by him, in some newspaper of general circulation in the stream system, once a week for four consecutive weeks. Such notice shall give all essential facts as to the proposed appropriation, among them, the places of appropriation and of use, amount of water, the purpose for which it is to be used, name and address of the applicant and the time when the application will be taken up by the state engineer for consideration. Proof of publication, as required, shall be filed with the state engineer within sixty days from the date of his instructions to make publication. In case of failure to file satisfactory proof of publication in accordance with the rules and regulations applicable thereto, within the time required, the application shall thereafter be treated as an original application filed on the date of receipt of proofs of publication in proper form.

Sec. 22. Approval of Application. Upon the receipt of the proofs of publication, the state engineer shall determine from the evidence presented by the parties interested, from such surveys of the water supply as may be available, and from the records, whether there is unappropriated water available for the benefit of the applicant. If so, he shall endorse his approval on the application, which shall thereupon become a permit to appropriate water, and shall state in such approval the time within which the construction shall be completed, not exceeding five years from the date of approval, and the time within which the water shall be applied to a beneficial use, not exceeding four years in addition thereto.

Sec. 23. Rejection and Appeal. If, in the opinion of the state engineer, there is no unappropriated water available, he shall reject such application. He shall decline to order the publication of notice of any application which does not comply with the requirements of the law and the rules and regulations thereunder. He may also refuse to consider or approve an application or to order the publication of notice thereof if, in his opinion, the approval thereof would be contrary to the public interest. Any applicant may appeal from such decision of the state engineer, or from any other decision by him which denies a substantial right, within sixty days from the date thereof, to the district court of the county in which the proposed place of diversion or storage is situated. In the absence of such appeal, the decision of the state engineer shall be final.

Sec. 24. Prosecution of Work. The construction of the works shall be diligently prosecuted to completion, and if one-fifth of the work shall not be completed within one-half the time allowed, the state engineer may accept and approve, as herein provided, an application for the use of all or any of the waters included in the permit issued to the prior

applicant and the right to use such waters under the former permit shall thereupon be forfeited; provided, that the state engineer shall allow an extension of time on request of the prior applicant, equal to the time during which work was prevented by the operation of law, beyond the power of the said applicant to avoid.

Sec. 25. Completion of Work. On the date set for the completion of the work, or prior thereto, upon notice from the owner that the work has been completed, the state engineer shall cause the work to be inspected, after due notice to the owner of the permit. Such inspection shall be thorough and complete, in order to determine the actual capacity of the work, their safety and efficiency. If not properly and safely constructed the state engineer may require the necessary changes to be made within a reasonable time, not to exceed six months, and shall not issue his certificate of completion until such changes are made. Failure to make such changes shall cause the postponement of the priority under the permit for such time as may elapse from the date for completing such changes until made to the satisfaction of the state engineer, and applications subsequent in time shall have the benefit of such postponement of priority; provided, that for works involving the diversion of not exceeding twenty cubic feet of water per second or a dam not exceeding ten feet in the extreme height from the foundation, the state engineer may, in his discretion, accept the report of an inspection by a reputable hydraulic engineer.

Sec. 26. Certificate of Completion. When the works are found in satisfactory condition, after inspection the state engineer shall issue his certificate of construction, setting forth the actual capacity of the works and such limitations upon the water right as shall be warranted by the condition of the works, but in no manner extending the rights described in the permit.

Sec. 29. Application to Beneficial Use. On or before the date set for the application of the water to a beneficial use, the state engineer shall cause the works to be inspected, after due notice to the owner of the permit. Upon the completion of such inspection, the state engineer shall issue a license to appropriate water to the extent and under the conditions of the actual application thereof to a beneficial use, but in no manner extending rights described in the permit; provided, that the inspection to determine the amount of water applied to a beneficial use shall be made at the same time as that of the constructed work, if requested by the owner, and if such action is deemed proper by the state engineer.

Sec. 30. Extension of Time. The state engineer shall have power to extend the time for the completion of construction, or for application to beneficial use, for three years and two years, respectively, but only on account of delays due to physical or engineering difficulties which could not have been reasonably anticipated, or by operation of law beyond the power of applicant to avoid.

Sec. 31. Assignment of Permit or License. Any permit or license to appropriate water may be assigned, but no such assignment shall be binding, except upon the parties thereto, unless filed for record in the office of the state engineer. The evidence of the right to use water from any works constructed by the United States, or its duly authorized agencies, shall in like manner be filed in the office of the state engineer, upon assignment; provided, that no right to appropriate water for irrigation purposes shall be assigned, or the ownership thereof in any wise transferred, apart from the land to which it is appurtenant, except in the manner specially provided by law; provided, further, that the transfer of title to land in any manner whatsoever shall carry with it all rights to the use of water appurtenant thereto for irrigation purposes.

EXPLANATION.

From a study of the provisions of the law cited above it will be seen that the various steps to be followed in making an appropriation of water for a beneficial use are as follows:

1. Application. Instructions and forms are first to be obtained from the state engineer. After the form has been filled out in detail, it is to be sent to the state engineer accompanied by five dollars (\$5.00) for each separate application, the fee being for the purpose of covering the charge authorized in paragraph (a) of section 10, quoted above. When required, fees to cover the charges authorized in paragraphs (h) and (i) of section 10 must also be sent to the state engineer before any decisive action will be taken by him. The state engineer will then examine the application, and if, in his opinion, the provisions of the law are not duly complied with, he will return the application for correction, informing the applicant concerning any additions or corrections that are to be made. The applicant should carefully study section 20, quoted above, since all its provisions must be complied with before the application can possibly be accepted.

2. Publication of Notice. Section 21 provides that when the application is in proper form the state engineer shall instruct the applicant to publish a notice of his intention in a newspaper of general circulation. The state engineer will furnish the proper forms for notices when he issues the instructions, specifying the paper in which the notice is to be published, the applicant, however stating his preference. A form for proof of publication will also be furnished to the applicant, which must be filled out and filed in the office of the state engineer within sixty days of the date of his instructions, as provided by law. The fee for filing this paper is one dollar (\$1.00). (See paragraph (c) section 10.)

3. Consideration of Application. (Section 22 and 23.) Upon the receipt of the proofs of publication with fee for same, the state engineer will give his consideration to the application, and will decide, in view of all available evidence, whether the application should be accepted or rejected. If he concludes that it should be accepted, he will give it his provisional approval. He will then notify the applicant of such acceptance, informing him as to the fees necessary for recording, as provided in paragraph (b) section 10. The amount necessary to pay this charge must be forwarded so as to reach the office of the state engineer within thirty days of such notification, and in this event the state engineer will record the application with his approval thereof in a book provided for the purpose, granting through this act, a permit to construct the proposed works as above approved, this permit being given a permanent number, all permits in a single water division being numbered consecutively. He will then notify the applicant of his action, sending him the permit, thus, authorizing him to proceed with the work of construction. If the fees required for making the record are not received within thirty days, as provided for herein, the permit will not be recorded until such time as they are received, the right, in that case not relating back to the time of application, but only to the time of the receipt of the fees.

The state engineer may reject an application, as provided in section 23, in case he decides that the proposed appropriation would be detrimental to the public welfare. In such case he will file the papers in the case, notifying the applicant of his action. (Section 23.)

4. Due Diligence. The work shall be diligently prosecuted, as provided in section 24, and, prior to or upon the expiration of one-half of the entire time allowed in the permit, the appropriator shall demonstrate to the satisfaction of the state engineer that one-fifth of the total amount of work has been done as required. Here, as in all other cases of failure to comply with the requirements of the law, if this

amount of work is not completed the applicant may lose his priority. On or before the date set for the completion of the work the applicant shall likewise demonstrate that the work has been completed in accordance with the terms of the permit. When, for good and sufficient reasons, it has been impracticable to complete the work within the time limit fixed in the permit, such reasons should be stated in an affidavit to be filed with the state engineer. The proper forms will be furnished and all charges in accordance with section 10 must be paid upon demand. The fact should be borne in mind that the claim does not become an actual right until the water is actually and beneficially used, and a "license" therefor is issued, as provided in section 29, or the matter has been adjudicated by the district court.

5. Beneficial Use. Section 29 explains fully the method of acquiring the right to appropriate water. Section 2 states specifically that "beneficial use shall be the basis, the measure and the limit of the right to use water, and all waters appropriated for irrigation purposes shall be appurtenant to specified lands owned by the person claiming the right to use the water so long as the water can be beneficially used thereon. Priority in time shall give the better right."

INSTRUCTIONS.

The following additional information and instructions should also be carefully studied and followed:

1. A complete copy of the irrigation laws will be furnished free of charge to anyone making a request for the same to the state engineer. All forms needed will also be similarly furnished upon request.

2. The state engineer cannot engage in private practice, but suggestions and advice, so far as proper, will be gladly furnished. When the official services of the state engineer or of a deputy are required, such services and expenses in connection therewith must be paid for by the applicant in accordance with the provisions of paragraphs (i), (j), (k) and (l), of section 10.

3. Fees must accompany applications as provided by law. All fees must be in form of cash, postal money order or bank draft, and not of check upon any local bank, other than Bismarck banks, since other checks are subject to a discount for collection.

4. Applications, statements, maps and all other papers must be in proper form, as prescribed by law and these regulations, before records will be made or certificates issued.

5. The forms to be used for the enlargement or extension of a canal differ from those used in making an entirely new application. In making a request for forms, the source of supply, purpose and character of the appropriation should be clearly stated.

6. Maps. All maps submitted shall be in duplicate. One copy must be on tracing linen, and the other may be either a blue print or upon thin drawing paper or tracing linen. The size of each sheet shall be 18 x 18 inches, and lands in a single township only shall be shown upon one sheet, excepting by special consent of the state engineer. They may be sent to the state engineer rolled, but not folded. The scale of the map should be sufficient to show clearly the actual location of the structure or works, but should not be needlessly large. In case one sheet is not large enough, two or more may be used. In such cases the title of the map should be placed upon each sheet, and under it the statement, "this map comprises sheets," giving the total number, the statement being followed by the number of the sheet, as "Sheet 1," "Sheet 2," etc., and the numbers of the township and range.

Permanent black ink must be used, as the maps are for permanent record. Higgins' water proof or Windsor Newton's India Ink are preferred.

I. The map of a ditch shall show:

- (a) Title, giving name of ditch or canal.
- (b) Location of headgate, by course and distance to a government corner, or if on unsurveyed lands to some natural object so that the site can be easily found. True courses are to be used, the magnetic variations being also stated.
- (c) Stream, and name thereof, from which water is diverted.
- (d) Route and total length of ditch or canal.
- (e) Lands crossed with names of owners thereof.
- (f) Lands to be irrigated, with names of owners thereof.
- (g) Locations, with elevations thereof, of bench marks at the headgate or other suitable points.

II. The map of the reservoir shall show:

- (a) Title, giving name of reservoir.
- (b) Location of initial point of survey, as in case of canal.
- (c) The location of the dam, of the highwater line and contour lines at appropriate intervals and both the area within the high water line and the capacity of the reservoir when filled to the high water line.
- (d) Stream, with name thereof, from which reservoir derives its supply of water.
- (e) Location of ditches to and from reservoir.
- (f) Legal subdivisions and ownership thereof.
- (g) Lands to be irrigated and ownership thereof.
- (h) A bench mark outside of reservoir, this bench mark being referred to the high water line and other important elevations.
- (i) The location of the outlet with reference to a government corner, or; if upon unsurveyed ground, to some natural object, or to the initial points of survey.

III. (a) Both ditch and reservoir maps shall have thereon a certificate of the engineer who made the survey, substantially as follows:

State of North Dakota, }
 } ss.
 County of

I,, being duly sworn, upon my oath say, that I am the engineer of the; that the survey and map thereof were made by me (or under my direction), and that such survey is accurately represented upon this map; and that I have read the accompanying statement and know of my own knowledge that the statements therein made are true.

.....
Engineer (or surveyor.)

Subscribed and sworn to before me this day of 190....

.....
Notary Public (or other qualified officer.)

(b) Plans of dams, cribs or embankments must be drawn on longitudinal scale of not less than one inch to two hundred feet and for cross section of not less than one inch to twenty feet. Timber, brush and stone where used, shall be shown in detailed plans, the scale of which shall be one inch to four feet. The plans for outlet and waste ways for reservoirs shall be drawn on a scale of one inch to four feet, and are required for all dams over five feet high in a running stream or for any other dam over ten feet high.

(c) The maps of reservoirs shall show the total area to be submerged and enough levels to permit of computing its capacity.

(d) For earth dams the slope must not be less than 3 to 1 for the front or water side, and 2 to 1 for the back.

IV. Maps showing enlargements or extensions should show the original as well as the additional lines.

NOTES.

Lands may be shown by tinting with a colored pencil on the dull side of the tracing linen and this rubbed to an even tint by means of a medium hard rubber eraser. Where an enlargement application is made, the lands under existing rights through the same ditch should be shown in different colors. Colors which will not blue-print well should not be used. The preferred colors are green, orange, red and yellow. Lettering on the map should be sparing, and superfluous matter should not be placed thereon. Indelible pencil or typewriter should not be used on tracing linen since the oil in the cloth will cause these colors to spread and in time it becomes almost obliterated. The affidavit of survey should be neatly lettered on the map. In preparing applications, the 40-acre subdivision, in which the headgate is situated, should be stated, and the bearing and distance to the nearest government corner should be given. In case of an enlargement, if the applicant is the owner of the ditch to be enlarged, he should so state, if not, the written consent of the owners must accompany the application. The following form of consent may be used:

I (or we) the sole owner.. of the ditch taking water from under permit No. do hereby give my (or our) free and voluntary consent to the enlargement (or extension) of and to the use of water through the said ditch by according to the terms of this permit to enlarge.

Subscribed and sworn to before me thisday of 190....

Notary public (or other properly qualified officer.)

7. Each certificate signed by an applicant, surveyor or engineer or other person must be sworn to before a notary public or other officer duly qualified to administer oaths.

8. Application and permits are to be recorded in the state engineer's office in books provided for that purpose. One copy of the map will be filed and the other will be returned to the applicant after approval or rejection.

9. The state engineer may, at his discretion, limit the time for the completion of work and the application of the water to the land to a reasonable period shorter than the maximum limit granted by law. Applicants should, therefore, request no more time than is required for the performance of the work when prosecuted with due diligence.

10. It is within the discretion of the state engineer to fix a higher duty of water than eighty acres to the cubic foot per second in cases where it is known that this rate is too low. He cannot, however, fix a lower duty.

11. A cubic foot of water per second for eighty acres is equivalent in North Dakota to five-eighths (5/8) of a miner's inch per acre. The limit of a water right for 160 acres, therefore, is two cubic feet per second, or 100 miner's inches, and is equivalent to a depth of water upon the land of about three feet in four months' time. In issuing the permit the state engineer will make a reasonable allowance in each case for the probable loss between the diversion point and the delivery point at the upper edge of the land to be irrigated.

12. Construction should not be commenced until the permit has been granted. (See first sentence in section 19, also section 54.)

13. Construction must be prosecuted with reasonable diligence as required by law.

14. The state engineer must be notified promptly when the work of construction is one-fifth and completely finished.

Circular No. 1. }
Approved May 15, 1905. }

A. L. FELLOWS,
State Engineer.

Form 1—Letter Transmitting Forms. No.

STATE OF NORTH DAKOTA.

OFFICE OF STATE ENGINEER, BISMARCK.

In accordance with your request of 190... I am sending you under separate cover blank form No. as requested and also

Please study the instructions carefully, as prompt and thorough compliance with them may save a great deal of time and trouble.

Your attention is directed particularly to
(Blank lines)
Very respectfully,

State Engineer.

By
Deputy.

Form 2.—Application for Permit to Appropriate Water—Original.

No.

Water Division No. District No.
(Blank lines to be filled by the State Engineer.)

APPLICATION FOR PERMIT TO APPROPRIATE WATER WITHIN THE STATE OF NORTH DAKOTA.

[NOTE—Draw a line through items not applicable.]

- 1. Name of applicant.....
- Postoffice address....., County....., State.....
- I. If a corporation:
 - (a) Name of same.....
 - (b) Date and place of incorporation.....
 - (c) Amount of capital stock.....
 - (d) Amount paid in.....
 - (e) Names and addresses of directors: (Blank lines)

[NOTE—A certified copy of articles of incorporation must accompany the application.]

- II. Method of accomplishing the work and financial resources of the applicant:
 - (a) Method of accomplishing the work. (Whether by contract, employment of others or by direct labor).....
 - (b) Cash on hand, \$..... (c) Treasury stock, \$.....
 - (d) Bonds to be issued, \$..... (e) Other resources, \$.....
- 2. Name of division works.....
- 3. Quantity of water claimed..... cubic feet per second.
- 4. Source of water supply.....
- 5. Location of point of diversion..... on bank

[Right or left bank looking down stream.]

- 6. Annual periods during which water is to be used.....
- 7. To be used for:
 - I. Irrigation or domestic use:
 - (a) Number of acres to be irrigated..... acres.
 - (b) Legal subdivisions to be irrigated.....

[NOTE—A list of lands to be irrigated, giving each subdivision and fraction with acreage thereof, should be written here, or may be appended as a part of this application. Same must also be shown on accompanying map.]

- (c) Statement as to domestic use (giving location, etc.).....
- II. Mining, power, manufacturing, transportation, or other purposes:
 - (a) Nature of use.....
 - (b) Amount of power to be generated..... horse power.
 - (c) Location of plant.....
 - (d) Method of developing power.....
 - (e) Point where water will be returned to stream.....
- 8. Estimated cost of works:
 - (a) Head gates, \$..... (b) Pumping plant, \$.....
 - (c) Fluming, \$..... (d) Canal—earth, \$..... rock, \$.....
 - (e) Other structures.....\$..... Total, \$.....

- 9. Description of diversion works:
 - I. Nature of works: (Reservoir, dam, ditch, flume, pumping plant, etc.).....

II. Dimensions of works:

- (a) Dam: Height.....feet; length at bottom.....feet; length at top.....feet; thickness at bottom.....feet; thickness at top.....feet; slope of front (water) face.....; slope of back face.....; material used in construction.....
- (b) Reservoir: Capacity when filled.....acre feet. Surface area at high water mark.....acres.

| DEPTH AT OUTLET FEET | SURFACE AREA AT EACH DEPTH AT OUTLET—ACRES | FEET OF | CAPACITY—ACRE-FEET |
|----------------------|--|---------|--------------------|
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| | | | |
| | | | |
| | | | |
| | | | |

- (c) Head gate: Width.....feet; height.....feet
Material
- (d) Canal: Total length.....miles.

| LOCATION BELOW HEADGATE | DEPTH | BOTTOM WIDTH | WIDTH AT WATER LINE | GRADE PER MILE |
|-------------------------|-------|--------------|---------------------|----------------|
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |

[Give dimensions where reductions in size are made.]

- 10. Time required for completion of work.....years.
- 11. Time required for complete application of water to the proposed beneficial use.....years.
- 12. Choice of newspaper for publication of notice of intention to appropriate.....

STATE OF NORTH DAKOTA, }
 County of } ss.
 I, being first duly sworn, on my oath depose and say: That my relation to the above described undertaking is that of that I have read the above and foregoing statement, and examined the map accompanying the same, and that I know of my own personal knowledge that the matters therein stated and shown are true.

Signed.....
 Subscribed and sworn to before me this day of..... 190..
 Notary Public (or other qualified officer.)

Remarks (by State Engineer):
 STATE OF NORTH DAKOTA, (Blank lines)
 County of } ss.
 Bismarck, North Dakota,..... 190..

This is to certify that the foregoing application was received at this office at..... o'clock..... m. upon the day of 190.. and that after examination it was (Blank lines)

By State Engineer.
 Deputy.

Number of Permit.....
 Date of first receipt of application..... 190..
 Date of return to applicant for correction..... 190..
 Date of receipt of corrected application..... 190..
 Date from which application may claim right..... 190..
 Approved..... 190.. Recorded in Book..... Page.....

This is to certify that I have examined the foregoing application for a permit to appropriate water of the state of North Dakota, and I hereby grant the same as stated herein, subject, however, to the following limitations and conditions:

- 1st. The equivalent of at least one-fifth of the work above specified is to be completed on or before....., 19.....
- 2d. The whole of said work is to be completed on or before....., 19.....
- 3d. The limit of time for proof of beneficial use of water appropriated in accordance herewith is....., 19.....
- 4th. The water appropriated shall be used for the purpose of.....
- 5th. The prior right of all persons who, by compliance with the laws of the state of North Dakota, have acquired a right to the use of water must not be injuriously affected by this appropriation.
- 6th. The amount of appropriation herein granted shall not exceed..... cubic feet of water per second of time; neither shall it exceed the capacity of the above described system of diversion works, nor the least amount of water that experience may hereafter indicate as necessary for the production of crops in the exercise of the best husbandry; and further, said appropriation must be limited to not more than one-eightieth (1-80) of one cubic foot of water per second of time for each acre of land to which water is actually and beneficially applied on or before....., 19.....; said water to be used during the following described annual periods:

Witness my hand this..... day of..... 190.....

State Engineer.....

By..... Deputy.

No..... District No.....
 Division No..... PERMIT
 to appropriate water from.....
county, North Dakota.
 Name of applicant.....
 Name of diversion works.....
 Date of first receipt at office of State Engineer....., 190.....
 Returned to applicant for correction.....
 190.....
 Corrected application received.....
 190.....
 Date of water right.....
 190.....
 Recorded in book..... Page.....
 One-fifth of work to be completed.....
 19.....
 Whole work to be completed.....
 19.....
 Final proof of use of water.....
 19.....
 Approved..... 163.....
 By..... State Engineer.
 Deputy.

Form 3—Application for Permit to Appropriate Water—Enlargement.

Water Division No..... District No.....
(Blanks to be filled by the State Engineer.)

APPLICATION FOR PERMIT TO APPROPRIATE WATER WITHIN THE STATE OF NORTH DAKOTA.

[NOTE—Draw lines through items not applicable. Where not otherwise stated all items refer to the proposed enlargement or extension.]

- 1. Name of applicant.....
- Postoffice address....., County....., State.....
- I. If a corporation:
 - (a) Name of same.....
 - (b) Date and place of incorporation.....
 - (c) Amount of capital stock.....
 - (d) Amount paid in.....
 - (e) Names and addresses of directors:
 (Blank lines)

[NOTE—A certified copy of articles of incorporation must accompany the application.]

- II. Method of accomplishing the work and financial resources of the applicant:
 - (a) Method of accomplishing the work. (Whether by contract, employment of others or by personal labor).....
 - (b) Cash on hand, \$..... (c) Treasury stock, \$.....
 - (d) Bonds to be issued, \$..... (e) Other resources, \$.....
- 2. Name of existing diversion works..... Permit No.....

- Name of enlargement or extension.....
3. Quantity of water claimed by enlargement or extension.....cubic feet per second.
4. Source of water supply.....
5. Location of point of commencement of extension.....
6. Annual periods during which water is to be used.....
7. To be used for:
- I. Irrigation or domestic use:
- (a) Number of acres to be irrigated.....acres.
- (b) Legal subdivisions to be irrigated.....
- [NOTE—A list of lands to be irrigated, giving each subdivision and fraction with acreage thereof, should be written here, or may be appended as a part of this application. Same must also be shown on accompanying map.]
- (c) Statement as to domestic use (giving location, etc.).....
- II. Mining, power, manufacturing, transportation, or other purposes:
- (a) Nature of use.....
- (b) Amount of power to be generated.....horse power.
- (c) Location of plant.....
- (d) Method of developing power.....
- (e) Point where water will be returned to stream.....
8. Estimated cost of works:
- (a) Head gates, \$..... (b) Pumping plant, \$.....
- (c) Fluming, \$..... (d) Canal—earth, \$..... rock, \$.....
- (e) Other structures.....\$..... Total, \$.....
9. Description of diversion works:
- I. Nature of works: (Reservoir, dam, ditch, flume, pumping plant, etc.)
- II. Dimensions of works:
- (a) Dam: Height.....feet; length at bottom.....feet; length at top.....feet; thickness at bottom.....feet; thickness at top.....feet; slope of front (water) face.....; slope of back face.....; material used in construction.....
- (b) Reservoir: Capacity when filled.....acre feet. Surface area at high water mark.....acres.

| DEPTH AT OUTLET FEET | SURFACE AREA AT EACH _____ FEET OF DEPTH AT OUTLET—ACRES | CAPACITY—ACRE-FEET |
|----------------------|--|--------------------|
| | | |
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| | | |
| | | |
| | | |

- (c) Head gate: Width.....feet; height.....feet
Material.....
- (d) Canal: Total length.....miles.

| LOCATION BELOW HEADGATE | DEPTH | BOTTOM WIDTH | WIDTH AT WATER LINE | GRADE PER MILE |
|-------------------------|-------|--------------|---------------------|----------------|
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |
| At mile | feet | feet | feet | feet |

[Give dimensions where reductions in size are made.]

10. Time required for completion of work.....years.
11. Time required for complete application of water to the proposed beneficial use.....years.
12. Choice of newspaper for publication of notice of intention to appropriate.....

STATE OF NORTH DAKOTA, }

County of } ss.

I, _____, being first duly sworn, on my oath depose and say: That my relation to the above described undertaking is that of _____, that I have read the above and

[Owner, manager or engineer]

foregoing statement, and examined the map accompanying the same, and that I know of my own personal knowledge that the matters therein stated and shown are true.

Subscribed and sworn to before me this... day of... Signed... Notary Public (or other qualified officer.)

Remarks (by State Engineer): STATE OF NORTH DAKOTA, County of... Bismarck, North Dakota, ss.

This is to certify that the foregoing application was received at this office at... o'clock... m. upon the... day of... and that after examination it was... (Blank lines)

By... State Engineer. Deputy.

Number of Permit... Date of first receipt of application... Date of return to applicant for correction... Date of receipt of corrected application... Date from which application may claim right... Approved... Recorded in Book... Page...

This is to certify that I have examined the foregoing application for a permit to appropriate water of the state of North Dakota, and I hereby grant the same as stated herein, subject, however, to the following limitations and conditions:

- 1st. The equivalent of at least one-fifth of the work above specified is to be completed on or before... 19...
2d. The whole of said work is to be completed on or before... 19...
3d. The limit of time for proof of beneficial use of water appropriated in accordance herewith is... 19...
4th. The water appropriated shall be used for the purpose of...
5th. The prior right of all persons who, by compliance with the laws of the state of North Dakota, have acquired a right to the use of water must not be injuriously affected by this appropriation.

6th. The amount of appropriation herein granted shall not exceed... cubic feet of... and of time; neither shall it exceed the capacity of the above described system of diversion works, nor the least amount of water that experience may hereafter indicate as necessary for the production of crops in the exercise of the best husbandry; and further, said appropriation must be limited to not more than one-eightieth (1-80) of one cubic foot of water per second of time for each acre of land to which water is actually beneficially applied on or before... 19...; said water to be used during the following described annual periods:

Witness my hand this... day of... 1900.

By... State Engineer. Deputy.

No. District PERMIT to appropriate water from... county, North Dakota. Name of applicant... Name of diversion works... Date of first receipt at office of State Engineer... Returned to applicant for correction... Corrected application received... Date of water right... Recorded in book... Page... One-fifth of work to be completed... Whole work to be completed... Final proof of use of water... Approved... State Engineer. Deputy.

Form 6—Acknowledgment of Receipt of Application. No.....

STATE OF NORTH DAKOTA.

OFFICE OF STATE ENGINEER, BISMARCK.

Your application dated.....190.. for a permit to appropriate water from.....through the examination of same, the receipt of which is hereby acknowledged, was received this day and has been duly filed under the temporary number..... The application will be examined in regular order as soon as possible, after which you will be notified as to further action on your part.

Very respectfully,

By State Engineer. Deputy.

Form 7—Notification of Correction To Be Made. No.....

STATE OF NORTH DAKOTA.

OFFICE OF STATE ENGINEER, BISMARCK.

Your application No..... for a permit to appropriatecubic feet of water per second from.....near.....in.....county, North Dakota, has been received and examined and is returned to you herewith for correction in the following particulars:

(Blank lines)

In accordance with Section 20 of the Irrigation Code of North Dakota you will now have sixty days from date of this letter to complete your application and to refile same in this office.

Very respectfully,

By State Engineer. Deputy.

Form 8—Publication of Notice. No.....

STATE OF NORTH DAKOTA.

OFFICE OF STATE ENGINEER, BISMARCK.

You are hereby notified that your.....190.. application No.....for a permit to appropriate water from.....has been examined and found to comply with the irrigation law of North Dakota and the regulations thereunder. You are now instructed to publish a notice of your intentions in relation to this proposed appropriation for four consecutive weeks in some paper of general circulation in the stream system in which the works are to be located, in accordance with Section 21 of the Irrigation Code.

A notice is enclosed herewith which you are directed to publish in the..... printed at.....North Dakota, in compliance with the law, you making the necessary arrangements with the publisher as indicated in the letter to him, also inclosed.

The proof of publication, also sent herewith, accompanied by a filing fee of \$1, must be filed in this office on or before.....190.. this date being sixty days from the date of these instructions. In case of failure to file satisfactory proof within the time stated, your application will thereafter be treated as an original application filed on the date of the receipts of proof of publication in proper form. It is to your interest, therefore, to see that the proof is promptly returned to this office as directed.

Very respectfully,

By State Engineer. Deputy.

Form 9—Notice of Intention to Appropriate Water. No..... (First Publication.....190..)

APPROPRIATION OF WATER

OFFICE OF STATE ENGINEER, BISMARCK.

Notice is hereby given that....., whose postoffice address is....., county North Dakota, has made an application in accordance with the provisions of the irrigation laws of North Dakota for a permit to appropriate for beneficial use.....cubic feet of water per second of time from..... through the....., the point of diversion of which is to be located upon the.....bank of said stream in the.... 1-4 of section.....

township..... range....., said water to be used for the purpose of..... upon the.....

(Blank lines)

This application will be taken up by the state engineer at his office at Bismarck for consideration and appropriate action upon the..... day of..... 190.. at 9 a. m., at which time all persons who believe that the prior rights would be injuriously affected, or that the allowance of the permit would be detrimental to the public welfare, and also parties making the application, and to be benefited, are notified to be present either by sworn affidavit or in person for the purpose of presenting any relevant testimony.

State Engineer.

Form 10—Letter to Publisher—Notice of Intention to Appropriate. No.....

STATE OF NORTH DAKOTA, OFFICE OF STATE ENGINEER, BISMARCK.

Enclosed find form of notice of the application of..... for a permit to divert water from..... in..... county, North Dakota, which please publish for four consecutive weeks in your paper, the..... as provided for in Section 21, Senate Bill No. 1, Laws of the Ninth Legislative session, this state, approved March 1, 1905.

The expense of the publication will be paid by..... with whom you will make the necessary arrangements, and to whom you will kindly furnish proof of publication of this notice on or before..... 190..

Please receipt for this notice on form below as promptly as possible, kindly mailing me also a copy of the first issue containing this publication that I may compare it with my records.

Very respectfully,

State Engineer.

By..... Deputy.

(Perforated line)

STATE ENGINEER, BISMARCK, N. D.,....., 190.....

DEAR SIR: I am in receipt of your letter of....., 190....., enclosing notice of application No..... for the use of water, which will be published as requested, commencing with our issue of..... 190..

Very truly yours,

PROOF OF PUBLICATION

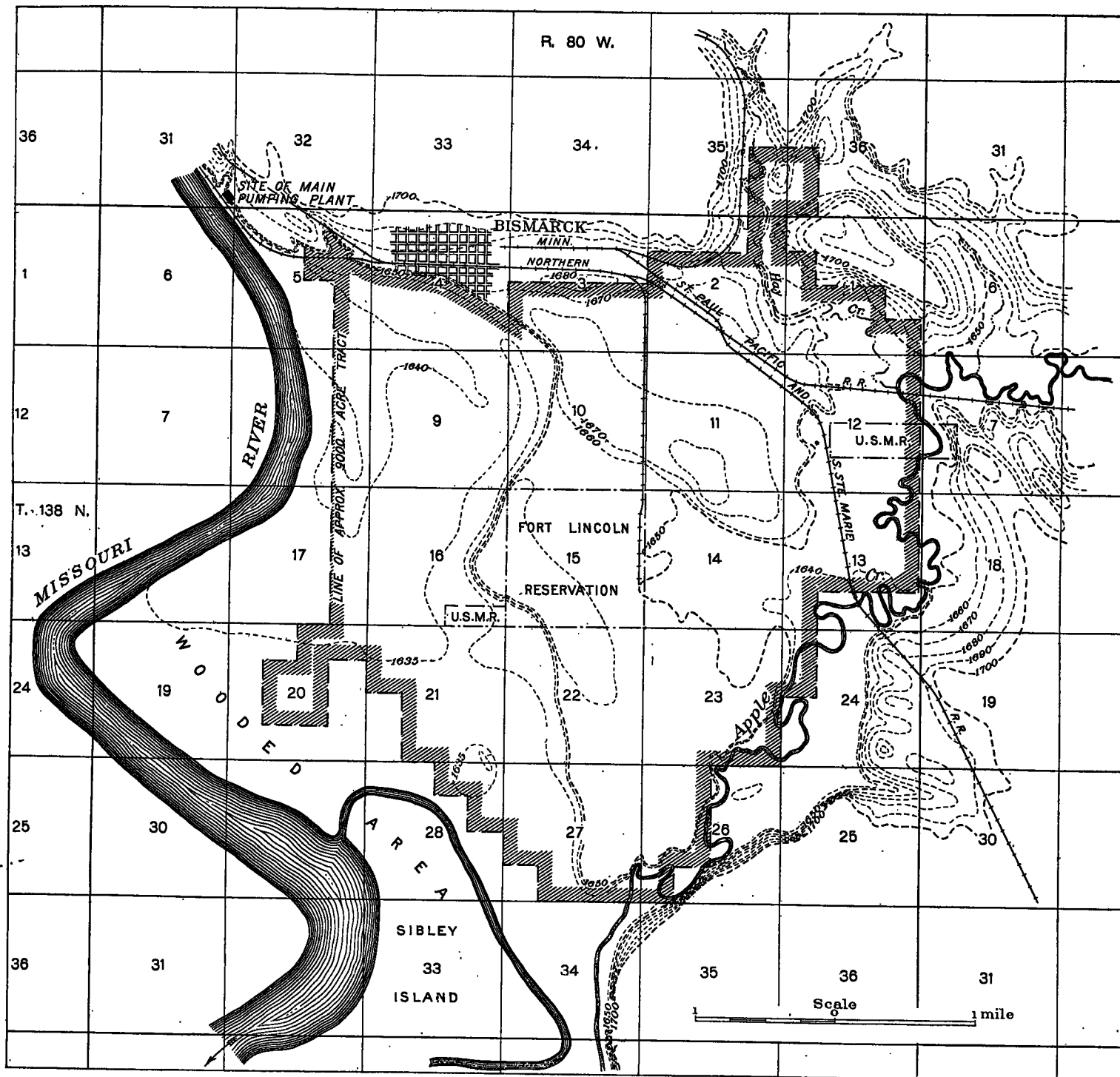
State of North Dakota, } being duly sworn, deposes and says that the annexed printed copy of Notice of Intention to Appropriate Water was taken from the..... a newspaper, which, during the whole time of publication of said notice hereinafter stated, has been and is printed and published in the..... of..... county of..... Dakota. That the said notice was published in said newspaper on the following dates:..... in each and every issue of the full number thereof, commencing on the..... day of..... 190.., and ending on the..... day of..... 190.., upon which days or times of publication aforesaid the newspaper was regularly published, and that during the whole time of said publication he was..... the printer..... and publisher..... of the said newspaper.

Subscribed and sworn to before me this..... day of..... A. D., 190..... Notary Public..... County, N. D.

Form 13—Notification of Recording Fees Upon Approval of Application. No.....

STATE OF NORTH DAKOTA, OFFICE OF STATE ENGINEER, BISMARCK.

You are hereby notified that your application No..... for a permit to appropriate water from..... through the..... has been duly examined, that notice of your intention has been duly published, and that a hearing concerning the same was held in this office upon..... 190.. and that it has now been approved and is being held for record subject to the payment



BISMARCK PROJECT.

of \$..... as fees for recording the same. Upon receipt of this amount, which should be within thirty days from the date hereof, the application with permit will be recorded as soon as possible, in regular order, and the permit forwarded to you. In case the fees are not received within the thirty days prescribed, you will forfeit your priority of application as stated in the instructions previously sent you.

Very respectfully,

.....
By State Engineer.
..... Deputy.

Form 14—Rejection of Application for Permit. No.....

STATE OF NORTH DAKOTA.
OFFICE OF STATE ENGINEER, BISMARCK, N. D.

You are hereby notified that your application No..... 190... for a permit to appropriate water from..... through the..... has been duly examined, that notice of your intention has been duly published and that a hearing concerning same was held in this office upon..... 190... and that it has been found necessary to reject the application for the following reasons:
(Blank lines)

You are further informed, however, that you are entitled to appeal to the district court, should you so desire, within sixty days of the date of this notification. (See Sec. 23, Irrigation Code of 1905.)

Very respectfully,

.....
By State Engineer.
..... Deputy.

Form 15—Transmittal of Fees Recording Application for Permit. No.....

STATE ENGINEER, BISMARCK, N. D.:

DEAR SIR: In accordance with the directions contained in your letter of..... 190..., I am forwarding herewith \$..... as fees for recording my application No..... for a permit to appropriate..... cubic feet of water per second from.....

Very respectfully,
(Perforated line)

STATE OF NORTH DAKOTA.
OFFICE OF STATE ENGINEER, BISMARCK.

Receipt is hereby acknowledged of your letter of..... 190... together with \$..... as fees for recording your application for a permit No.....

Very respectfully,

.....
By State Engineer.
..... Deputy.

Form 16—Issuance of Permit to Appropriate Water. No.....

STATE OF NORTH DAKOTA.
OFFICE OF STATE ENGINEER, BISMARCK.

Enclosed herewith please find your application No..... 190... for a permit to appropriate..... cubic feet of water per second through the..... to which I have given my approval, thus authorizing you to make the appropriation requested under the conditions therein stated.

Very respectfully,

.....
By State Engineer.
..... Deputy.

SAMRLE PAGE FROM DESCRIPTION OF FILINGS, USING FICTITIOUS NAMES.

Application No..... by John Smith, Huston, N. D.
Received Aug. 1, 1905. Returned to be corrected Aug. 2, 1905.
Received corrected as required Aug. 29, 1905.
Directions concerning publication in Huston Herald issued same date.
Hearing set for Oct. 12, 1905.
Proof of publication received Oct. 5, 1905.

Hearing held and application approved Oct. 12, 1905.
 Recording fees received Oct. 24, 1905.
 Record made and original application with approved plat and permit forwarded Oct. 26, 1905.
 Recorded in book 1, page....
 Right to date from Aug. 1, 1905.
 Work to be one-fifth done Oct. 26, 1906.
 Work to be completed Oct. 26, 1907.
 Beneficial application to be completed May 1, 1909.
 Proof of completion of one-fifth of work filed.....
 Proof of completion of all work filed.....
 Proof of beneficial application filed.....
 License to water right issued and filed.....
 (Note: The date will vary greatly in different cases and no printed form is issued for this reason.)

LIBRARY.

Believing that a well selected technical library is of very great value to any scientific office, the state engineer has devoted especial attention to acquiring such publications as were available that could be secured at little or no expense. In this way quite an extensive official library, consisting for the most part, of government, state, and other official reports bearing upon irrigation, drainage, forestry, good roads and similar matters has been collected. It has, moreover, for about twenty years been a practice of the present state engineer to collect for his own personal library all available data bearing upon these subjects, and thus he is at this time in possession of what he believes to be one of the best private irrigation libraries in the entire country. This entire library is kept in the office and is available to any one making a study of irrigation, drainage or kindred subjects.

INSTRUMENTS.

As the office was not, at the outset, in possession of any instruments, it was found necessary to purchase a transit and level, and their essential adjuncts. Accordingly in the spring of 1906 one transit, one level, two wooden range poles, one spring balance, one set of marking pins, one Philadelphia leveling rod with one extra target, one steel tape one hundred feet in length, one metallic tape fifty feet in length, and one precision planimeter were purchased from the firm of Buff and Buff, Jamaica Plains, Mass. These instruments are of the finest quality and have given complete satisfaction.

The office is also in possession of a small Price current meter, purchased by E. F. Chandler, former state engineer. Other instruments comprising the necessary equipment for drawing, an extra level and rod, drawing board, etc., are the personal property of the present state engineer and the assistant. Other instruments are badly needed, however, and will be supplied as soon as conditions will permit.

RECOMMENDATIONS.

It is recommended that, as soon as practicable, a plane table outfit, a good drawing board and stool, a blue print frame and

tank, a first class protractor and set of drawing instruments be purchased, and that the office be supplied with suitable book cases, filing cabinets, and other necessary equipment. In particular it is recommended that a dark room for protographic work be constructed for the operations of the state engineer, since photography has come to be recognized as an essential adjunct to engineering, and the state engineer's office, above all others, should be provided with sets of views illustrating its work. It is also recommended that increased attention be given to the upbuilding of the library through correspondence with government and other agencies furnishing free reports, and that, furthermore, the sum of \$100 per year be set apart for the purchase of suitable engineering works of permanent value to the office and subscriptions for valuable engineering periodicals.

CHAPTER II

IRRIGATION FILINGS.

FILINGS MADE PRIOR TO THE PASSAGE OF THE IRRIGATION CODE.

The irrigation code provides not only for the filing of new applications for water rights, but, in section 32 of the act, it provides that claims filed with county officers prior to the passage of the act shall be reported by them to the state engineer. Accordingly upon May 2, 1905, no transcripts as yet having been sent from any of the counties of the state, letters of which the following is a copy of one form, were sent to the registers of deeds of all the counties in which it seemed probable that filings might have been made, these being the counties of Billings, Burleigh, Emmons, Mercer, McLean, Morton, Oliver, Stark, Ward and Williams:

May 2, 1905.

County Register of Deeds:

Dear Sir: In view of the reported present and probable future use of water for irrigation and other purposes in your county, I desire to call your attention to section 32 of the North Dakota Irrigation Code enacted at the 1905 session of the state legislature which is as follows:

"Section 32. Transfer of Water Records. It shall be the duty of the county register of deeds and the county auditor of each county in the state, within thirty days of the passage of this act, to prepare and forward by express or registered mail, at the expense of the county, to the office of the state engineer, a transcript of all records relating to water rights; provided, that they may forward any original records in their office which may have been duly recorded."

Under separate cover I am sending you a copy of the proceedings of the Third Irrigation Congress which contains the code from which I have quoted. I trust that it will be possible for you to send such a transcript to this office at an early date as it will greatly facilitate the task of organization here.

Very truly yours,

A. L. FELLOWS,

State Engineer.

Replies were promptly received from Billings, Emmons, Oliver, and Ward counties and the list of filings are given below. It is understood that a set of filings was partially prepared in Williams county, also, but it has not, as yet, been sent to this office. It is believed that a much greater number of filings have been made in Williams county than in any other.

LIST OF FILINGS IN BILLINGS COUNTY.

| No. | Name of Applicant | Description of Lauds | Source of Supply | Amount of Water Claimed | Date of Claim |
|-----|--------------------------------|--|---|-------------------------|----------------|
| 1 | Geo. H. Hyde..... | W $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 36, T. 153 N., R. 102 | Herman's Conlee | 1000 inches | Aug. 15, 1901 |
| 2 | A. L. Slater..... | S $\frac{1}{4}$ NW $\frac{1}{4}$ & NE $\frac{1}{4}$ NW $\frac{1}{4}$ & NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 36, T. 153 N., R. 102 W. | Herman's Conlee | 1000 inches | Sept. 2, 1901 |
| 3 | Jos. E. Clifford..... | Secs. 8 & 17, T. 153 N., R. 104 W. | Four Mile Creek | 2000 inches | Dec. 20, 1901 |
| 4 | A. F. Nohle..... | Secs. 5, 8, 9 & 17, T. 151 N. R. 104 W. | Four Mile Creek | 28000 inches | April 14, 1902 |
| 5 | C. Hendrickson & Gunder Olson. | W $\frac{1}{2}$ NE $\frac{1}{4}$ & NE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 5, T. 152 N., R. 102 W. and SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 35, T. 153 N., R. 102 W. | Unnamed Conlee Sec. 5, T. 153 N., R. 102 W. | 800 inches | April 18, 1902 |

LIST OF FILINGS IN EMMONS COUNTY.

| No. | Name of Applicant | Description of Lands | Source of Supply | Amount of Water Claimed | Date of Claim |
|-----|----------------------|---|------------------|-------------------------|---------------|
| 1 | W. C. H. East..... | 380 Acres of Sec. 4 and 5 T. 133 N. R. 73 W..... | Horse Head Creek | 300 inches | June 15, 1895 |
| 2 | C. A. Patterson..... | 20 acres of SW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 7 T. 132 N. R. 76 W..... | Spring Creek | 238 inches | June 2, 1904 |

LIST OF FILINGS IN OLIVER COUNTY.

| | | | | | |
|---|------------------------------------|---|--------------------|------------|-------------------|
| 1 | J. F. V. Kiebert..... | 50 acres of NE $\frac{1}{4}$ Sec. 34 T. 141 N. R. 82 W..... | | | December 21, 1894 |
| 2 | W. V. Kiebert and D. L. Van Voorst | 5 acres of NW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 12 T. 141 N. R. 83 W..... | | | March 5, 1895 |
| 3 | Chas. M. Whitmer..... | SE $\frac{1}{4}$ Sec. 8 and E $\frac{1}{2}$ Sec. 17, T. 141 N. R. 82 W..... | Square Butte Creek | 150 inches | February 9, 1895 |

LIST OF FILINGS IN WARD COUNTY.

| | | | | | |
|---|---------------------|---|---|----------------------------------|-------------------------------|
| 1 | William Black..... | Unsurveyed but described by metes and bonds | Little Knife Creek | 12 inches per acre for 160 acres | May 1893 |
| 2 | William Black..... | Unsurveyed but described by metes and bonds | Little Knife Creek | 24 inches per acre for 160 acres | May 1893 |
| 3 | William Henson..... | SE $\frac{1}{4}$ and W $\frac{1}{2}$ NE $\frac{1}{4}$ Sec. 26 and W $\frac{1}{2}$ Sec. 23 T. 153 N. R. 94 W..... | Whitd Earth River | 3,000 inches | Nov. 15, 1906 |
| 4 | William Gibb..... | W $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 18, W $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 18, S $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 17, NW $\frac{1}{4}$ NW $\frac{1}{4}$ and E $\frac{1}{2}$ NE $\frac{1}{4}$ Sec. 20 T. 153 N. R. 92 W..... | Little Knife River | 24 inches per acre for 320 acres | April 25, 1901 May 7, 1901 |
| 5 | William Black..... | Unsurveyed W $\frac{1}{2}$ SE $\frac{1}{4}$, SE $\frac{1}{4}$ SE $\frac{1}{4}$, E $\frac{1}{2}$ SW $\frac{1}{4}$, W $\frac{1}{2}$ SE $\frac{1}{4}$, SE $\frac{1}{4}$ SE $\frac{1}{4}$, SW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 6 T. 153 N. R. 93 W..... | Little Knife River | 864 inches | May 13, 1901 |
| 6 | William Gibb..... | SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 32, SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 31 T. 153 N. R. 92 W and NE $\frac{1}{4}$ NW $\frac{1}{4}$, S $\frac{1}{2}$ NW $\frac{1}{4}$, M $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 2 T. 152 N. R. 93 W..... | Stream crossing SE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 6-153-93 | 24 inches per acre for 280 acres | May 13, 1901 |
| 7 | Mary E. Black..... | | Little Knife River | 868 inches | May 23, 1901 |

LIST OF FILINGS IN WARD COUNTY—Continued.

| No. | Name of Applicant | Description of Lands | Source of Supply | Amount of Water Claimed | Date of Claim |
|-----|------------------------------------|---|---|--|--------------------------------|
| 8 | Adam Black..... | S $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ and SE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec 2 T 152 N R 93 W 93 | Little Knife River | 884 inches | May 30, 1901 |
| 9 | May Frank..... | S $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 21, SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 20 and N $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 23 and N $\frac{1}{2}$ E $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 29 T. 153 R. 89 | Shell Creek Stream crossing NE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 9-133-96 | 1,723 inches 24 inches per acre for 168 acres | May 31, 1901 |
| 10 | James Gibb..... | Sec. 8 T. 153 N. R. 93 | White Earth River | 24 inches per acre for 300 acres | June 28, 1901 |
| 11 | M. F. Gilmour..... | N $\frac{1}{2}$ NE $\frac{1}{4}$, SW $\frac{1}{4}$ NE $\frac{1}{4}$, S $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 3-154-91 | Little Creek | 1,000 inches | June 23, 1901 |
| 12 | Angus McKay..... | SW $\frac{1}{4}$ Sec. 25 and SE $\frac{1}{4}$ Sec. 26-157-94 | Chilcoot School House Coulee | 1,000 inches | July 2, 1901 |
| 13 | William Gibb..... | E $\frac{1}{2}$ SW $\frac{1}{4}$ W $\frac{1}{2}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ 28-157-94 | | | July 20, 1901 |
| 14 | William Gibb..... | W $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 8, W $\frac{1}{2}$ NW $\frac{1}{4}$ and S $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 17, NW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 29 NE $\frac{1}{4}$ NE $\frac{1}{4}$ 19-153-92 | Little Knife River | 1,000 inches | July 20, 1901 |
| 15 | John B. Carter..... | Desert and homestead entries of John B. Carter. | Flatmouth Coulee | 1,000 inches | July 31, 1901 |
| 16 | William Gibb..... | W $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 8, W $\frac{1}{2}$ NW $\frac{1}{4}$ and S $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 17, NW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 20, NE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 19-153-92 | | | July 31, 1901 |
| 17 | Daniel Hawkins..... | Homestead and desert entry. | Little Knife River | 500 inches | July 31, 1901 |
| 18 | W. J. Carroll..... | Lands in Secs. 18 and 30 T. 154 R. 91 and Secs. 25 and 26 T. 154 R. 92 | Little Knife River | 1,000 inches | July 31, 1901 |
| 19 | W. J. Carroll..... | Lands in secs. 32 and 33 T. 155 R. 91 | Little Knife River | 432 inches | Feb. 24, 1902 |
| 20 | W. J. Carroll..... | Lands in Secs. 4, 9, 17 and others T. 154 R. 91 | Little Knife River | 432 inches | Feb. 24, 1902 |
| 21 | Mary A. M. Jennett..... | Lands in Secs. 4 and 9 T. 154 R. 91. | Little Knife River | 288 square inches | Feb. 24, 1902 |
| 22 | E. H. Sikes..... | Lands in Sec. 9 T. 154 R. 91. | Little Knife River | 288 square inches | May 10, 1902 |
| 23 | Elizabeth Sikes..... | Lands in Secs. 11, 18 and 19 T. 154 R. 91. | Little Knife River | 288 square inches | May 10, 1902 |
| 24 | William Gibb..... | Lands in Sec. 6 and 7 T. 153, R. 93. | Little Knife River | 288 square inches | May 10, 1902 |
| 25 | Wm. J. Falcon..... | Lands in Sec. 2 and 11 T. 152 R. 92. | Little Knife River | 800 inches | May 26, 1902 |
| 26 | Mary E. Black..... | N $\frac{1}{2}$ SW $\frac{1}{4}$ Sec. 2 T. 152 R. 93. | Slouch Coulee | 884 cubic inches | April 8, 1903 |
| 27 | Guy O. Frank..... | Lands in Sec. 29 T. 153 R. 89 | Hay Coulee | 1,152 inches | May 16, 1903 |
| 28 | Wm. Black..... | Lots 3 and 4 and S $\frac{1}{2}$ NW $\frac{1}{4}$ Sec. 1 T. 152 R. 93 | | 600 inches | June 16, 1903 |
| 29 | Nicolaus Zirbes and Mary E. Zirbes | Lands in Sec. 23, 26 and 27 T. 156 R. 94 | Cold Coulee | 864 inches | Nov. 13, 1903 |
| 30 | Catherine Carter Gibb..... | NE $\frac{1}{4}$ Sec. 6 T. 152 R. 92 | White Earth River Stream along W. line of NE $\frac{1}{4}$ 6-153-92 | 1,600 inches 1,000 inches | Nov. 14, 1903 Nov. 27, 1903 |

LIST OF FILINGS IN WARD COUNTY—Continued.

| No. | Name of Applicant | Description of Lands | Source of Supply | Amount of Water Claimed. | Date of Claim |
|-----|--|--|--|--|--------------------------------|
| 31 | Ervin Williams. | NE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 21 and NW $\frac{1}{4}$ NW $\frac{1}{4}$ | Half Breed Coulee | 720 inches | Feb. 15, 1904 |
| 32 | William Gibb (assigned to Martha D. Prusk, March 29, 1905) | Sec. 22 T. 156 R. 94 | Benson Coulee | 1000 inches | March 5, 1904 |
| 33 | Fredrick W. Hannah. | Lands in Secs. 6 and 7 T. 153 R. 93. | Chilcott Creek | 1000 inches | April 23, 1904 |
| 34 | Fred D. Alger. | Lands in Secs. 8 and 17 T. 153 R. 93 Lands in Sec. 18 T. 155 R. 91 | Canyon or Ravine in 13-155-92 | 2160 inches | June 10, 1904 |
| 35 | Fred D. Alger. | Lands in Sec. 18, T. 155, R. 91 | Little Knife River | 864 inches | June 10, 1904 |
| 36 | Nina C. Alger. | Lands in Sec. 19-155-91 | Little Knife River | 1296 inches | June 10, 1904 |
| 37 | Nina C. Alger. | Lands in Sec. 19-155-91 | Canyon or Ravine crossing SE $\frac{1}{4}$ 19- 155-91 | | June 10, 1904 |
| 38 | Fred Kelley. | Lands in Sec. 29 and 30 T. 153 R. 92 | Little Knife River | 2592 inches | June 30, 1904 |
| 39 | Walter M. Thayer. | Lands in Sec. 5, 6 and 8 T. 153 R. 92. | Little Knife River | 200 acres | Oct. 26, 1904 |
| 40 | Elias R. Powers. | Lands in Secs. 19 and 20 T. 153 R. 92 | Little Knife River | 14 inches per acre for | Dec. 13, 1904 |
| 41 | Charles L. Hagen. | Lots 1 and 2 Sec. 19 T. 155 R. 86 and N $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 24 T. 155 R. 87 | Little Knife River | 200 acres | Dec. 13, 1904 |
| 42 | William Gibb. | Lands in Secs. 17, 19 and 20, T. 153 R. 92 | Coulee in NW $\frac{1}{4}$ Sec. 19-155-86 Little Knife River | 200 acres 256 inches 2000 inches | Jan. 28, 1905 March 1, 1905 |

Efforts will be made to secure copies of filings in other counties also, if there are any such, and the lists will be published as obtained. It is also thought that it may be possible that other filings may have been made in the county offices within the past two years. Such filings would of course be worthless and it is hoped that any county auditor or register of deeds to whom such filings may be offered will refer the applicant to this office.

FILINGS MADE IN ACCORDANCE WITH THE IRRIGATION CODE.

Owing largely, no doubt, to the fact that there has been an unusual precipitation during the last two years, and to some extent, probably, to the fact that the present method of making filings appears to be somewhat cumbersome and expensive to the average farmer, but few filings have been made in the state engineer's office in the years 1905 and 1906. Many enquiries concerning the subject have been made, however, and it is believed that a considerable number of filings will be made in the next two years. A list of those already made follows:

| No. | Name of Applicant | Lands to be Irrigated | Source of Supply | Amount of Water Claimed | Date of Application |
|-----|--------------------------------|---|--------------------|-------------------------|---------------------|
| 1 | C. J. Hartwell..... | 320 acres in section 24, township 143 range 94..... | Knife River | 4 sec. feet | June 29, 1905 |
| 2 | Thos. E. McGregor..... | 291 acres in section 26, township, 149 range 100..... | Box Spg. Creek | 3.64 sec. feet | Jan. 26, 1906 |
| 3 | *Chas. and Eva Shafer..... | 240 acres in sections, 23, 25 and 26, township 150, range 98..... | Benson Draw | 3 sec. feet | Feb. 3, 1906 |
| 4 | Geo. E. Burgess..... | 50 acres in the W 1/2 section 12, township 140, range 102..... | Little Missouri | 1/2 sec. feet | May 17, 1906 |
| 5 | Erland Paulson..... | 200 acres in S 1/4 section 1, township 142, range 93..... | Knife River | 2 1/2 sec. feet- | May 11, 1906 |
| 6 | Erland Paulson..... | 142, range 93..... | Knife River | 3 1/2 sec. feet | May 11, 1906 |
| 7 | Robt. and Henry Piaggemeier... | 250 acres in section 2, township 142, range 93..... | Knife River | 3 1/2 sec. feet | May 11, 1906 |
| 8 | Harry W. Landon..... | 93 acres in sections 21 and 28, township 149, range 99..... | Dry Creek | 1.17 sec. feet | July 9, 1906 |
| 9 | Lottie J. Landon..... | 261 acres in sections 8 and 17, township 149, range 99..... | Burning Miné Creek | 3.26 sec. feet | July 9, 1906 |

*Prosecution of claim abandoned before publication of notice.

RECOMMENDATIONS.

It is recommended that special effort be made to complete the list of filings in the county offices by visits to such offices in person if necessary, and at the same time the fact should be impressed upon the county auditors and register of deeds that irrigation filings made with them are illegal and without effect.

CHAPTER III

THE IRRIGATION CODE.

The Irrigation Code has served the purpose for which it was passed in a very satisfactory manner. It was clearly devised however with a view to a much more extended practice of irrigation than has obtained up to the present time or will obtain in the near future in this state. From this point of view arose the provision that water commissioners and water masters should be appointed to have charge of the distribution of the waters of the state under the direction of the state engineer. It has not as yet been necessary to ask for such appointments and it is not likely that such assistance will be necessary within the next two years. The law is not, therefore, directly applicable to this state in this respect, but the provisions may stand without harm, being inoperative until the necessity arises. It is thought, however, that a number of changes should be made in the code and it is the intention of the state engineer to draw up a bill to be presented to the next session of the legislature asking that such changes as he deems essential be made. The proposed changes are indicated below. The code as now in operation was compiled principally by Hr. Morris Bien, supervising engineer of the U. S. Reclamation Service, in consultation with other engineers and lawyers. The following is a quotation from a recent article written by him.

“Immediately after the passage of the reclamation act, surveys and investigations were commenced by the United States, with a view to the construction of irrigation works in the various states and territories mentioned in the law. Prior to the legislative sessions of 1903, the reclamation service was asked to suggest legislation in order to meet the obstacles found in some of the states on account of the existing laws concerning water rights and irrigation.

“It was felt, however, by the officers of the service, that there had not been sufficient practical experience to warrant any suggestion upon the question. Two years ago, however, preceding the legislative session of 1905 in the various states, in response to urgent requests from representative bodies in the several states, particularly in Oregon and Washington, a draft of a state irri-

gation code was prepared by the reclamation service as a suggestion to the commissions engaged in preparing recommendations for the legislatures.

"This draft was carefully considered in a number of the states and territories and was adopted without substantial change in the states of North and South Dakota and in the territory of Oklahoma. In Oregon, Washington, Montana, New Mexico, and others, some features of this draft were adopted.

"There is now a renewal of interest in this matter and commissions in Montana, Oregon and Washington are again considering the proper form of recommendations to be laid before their legislatures at the next session."

The changes in the code which will be recommended have for the most part been approved by Mr. Bien and are incorporated in the draft which is to be considered in Montana, Oregon, and Washington. A number of these changes were originally recommended by the writer. They are as follows:

In section 2 at the end of the first sentence, after the words "so long as the water can be beneficially used thereon," add, "or until the severance from the land in the manner hereinafter provided," thus making it possible to transfer water rights under proper safeguards, from a place where its use is of comparatively little value to one where it may be demanded.

In section 9 change the word "September" to "November," and change the last clause so that it shall read "including a detailed statement of expenditures thereof to and including October 31, with such recommendations for legislation and appropriation as he may deem advisable."

The intent of this change is to permit of the extension of time covered by the report so as to cover the whole normal irrigation or surveying season, September 30th being too early, to permit this.

Add to the first paragraph of section 10 the words "or in case the last day of any such month falls upon a Sunday or a legal holiday, thereupon the first day not a legal holiday thereafter." Change paragraph 10 (a) so that it will read "(a) for filing and examining an application for permit to appropriate water, map and field notes of the same, which shall include the filing of proofs of publication and all other papers relating to the application up to the recording of the permit to appropriate water, five dollars."

Change paragraph (c) so that it will read:

"(c) For filing any other paper necessarily forming a part of the permanent record of the water right, application, permit or license, one dollar."

These proposed changes make more clear the meaning of the act without detracting in any way from the powers of the state engineer.

In section 14 change the words "federal government" and in the middle and "government" at the end of the section to "United States" in each case. This makes no difference in the meaning, but substantiates a better wording.

In the middle of section 15, after the words "use of such water" in sert "in order that the amount of unappropriated water subject to disposition under the terms of this act may become known" and leave out the words "and shall diligently prosecute the rights to the use of such water."

Change section 16 so that it shall read as follows :

"Section 16. Parties and Cost of Suits.) In any suit for the determination of a right to the use of the waters of any stream system all those whose claims to the use of such waters are of record and all other claimants, so far as they can be ascertained with reasonable diligence, shall be made parties. When any such suit has been filed the court shall, by its order duly entered, direct the state engineer to make or furnish a complete hydrographic survey of such stream system as hereinbefore provided, in order to obtain all data necessary to the determination of the rights involved. The costs of such suit shall include the fees of witnesses, the taking of depositions and the fees of officers for serving process and together with costs on behalf of the state, and such surveys shall be charged against each of the private parties thereto in proportion to the amount of water right allotted. The court in which any suit involving the adjudication of water rights may be properly brought shall have exclusive jurisdiction to hear and determine all questions necessary for the adjudication of all water rights within the stream system involved; and the attorney general may bring suit as provided in section 15 in any court having jurisdiction over any part of the stream system, which shall likewise have exclusive jurisdiction for such purposes."

This simply makes the section somewhat explicit.

Change the clause at the end of section 19 so that it will read "and shall be required to sell water rights for a reasonable price and to furnish the water for such parties at reasonable rates for storage, or carriage, or both, as the case may be."

At the end of section 20 instead of the words "and shall not be allowed to the detriment of the rights of others having valid claims to the use of water from said streams" substitute "under the provisions of section 50 hereof, and shall not be allowed to the detriment of the rights of others having valid claims to the use of water from said stream."

Near the beginning of section 36, after the words "intends to utilize certain waters," insert "and shall give public notice to the effect as herein provided" and at the end of the section add the words "whenever the waters of any stream of the state are reserved as herein provided, a notice to that effect, in a form

prescribed by the state engineer, shall be published within sixty days after the filing of such notice for four consecutive weeks in some legal weekly newspaper of general circulation in the district to be affected, the cost of such publication to be borne by the United States."

At the beginning of section 38 insert the words "whenever there shall be a necessity for the establishment of such office," change the word "during" at the middle of the last paragraph to "prior to" and at the end of the sentence add the words "until the office has been regularly filled."

At the end of the first sentence of section 43 add the words "and shall be removed upon the petition of a majority of the water users of said district."

In section 45 for the sentence reading as follows:

"The accounts of the water masters shall in all cases specify the distribution of the amounts charged, based upon the amount of work performed as to each ditch and water right, showing the charges to be allotted to each owner," substitute "The accounts of the water master shall in all cases specify the distribution of the amounts charged, based upon the quantity of water received by each water user and by each ditch owner, in proportion to the total quantities delivered to all, and shall show the charges to be allotted to each water user and to each ditch owner."

In the last sentence of section 52, after the word "misdemeanor" insert "for any unauthorized person."

At the end of section 55 add this sentence "The owner or owners of any ditch, canal, or other structure for carrying or storing water shall keep the same in good repair at the crossing of any highway or publicly traveled road or at other places where the water therefrom may flow over or in any wise injure any road or highway; and the county commissioners shall require necessary repairs for the protection of the road to be made or shall make them at the expense of the owners of such works and collect the expense thereof and costs as herein provided.

These changes would serve to make more clear the meaning of the sections affected without invalidating any work that may have been done in the past and it is recommended that they be made.

CHAPTER IV

BY E. F. CHANDLER

HYDROGRAPHY.

Section 14 of the irrigation code is as follows:

"Section 14. Hydrographic Surveys and Co-Operation.) The state engineer shall make hydrographic surveys and investigations of each stream and source of water supply in the state, beginning with those most used for irrigation, obtaining and recording all available data for the determination, development and adjudication of the water supply of the state. He shall be authorized to co-operate with the agencies of the federal government engaged in similar surveys and investigations, and in the construction of works for the development and use of water supply of the state, expending for such purposes any money available for the work of his office and may accept and use, in connection with the operation of his department, the results of the work of the agencies of the government."

The hydrographic surveys made during 1905 and 1906 are described in chapter 5 of this report. Measurements of streams have been taken as in preceding years by the officers of the hydrographic division of the United States geological survey, Prof. E. F. Chandler of the state university having direct charge of this work.

Soon after the establishment of the state engineer's office the state engineer wrote to the chief hydrographer of the hydrographic division referred to above and offered the co-operation of this office. As Professor Chandler had this work well in hand, however, but little has been done in this line directly by the state engineer's office excepting where streams were measured in the course of the study of specific projects. Thus measurements have been made of the north fork of Grand river three times at Haley when the discharges were respectively 3, 2 and 9 second feet; of Heart river when the discharges were 2, 16 and 50 second feet; of Knife river near Rock Springs when the discharges were 2 and 8 second feet, and of the Little Missouri at the Diamond C crossing when the discharge was 64 second feet. These

discharges are not included in the tables given below, which are furnished through the courtesy of Prof. E. F. Chandler, by whom they were made. A basis of co-operation for the year 1907 has been decided upon and it is hoped that the plan can be carried out.

RIVER RECORDS.

The hydrographic work of the United States geological survey includes the collection of facts and the study of conditions affecting the behavior of water from the time it reaches the earth as rain or snow until it joins the oceans or great navigable rivers. This work includes the study of the hydrography of every important river basin in the United States, and is of direct value in the commercial and agricultural development of the country.

In order to collect the data from which estimates of flow are made, gauging stations are established. The selection of a site for a gauging station and the length of time it is maintained depend largely upon the physical features and needs of each locality. The flow of a river varies much in quantity from week to week, and the total flow of one year may be many times greater or smaller than that of another year. Hence a fairly approximate river record for a long period of years is far more valuable for most purposes than the most precise possible record which continues for a shorter time. Furthermore it cannot always be foreseen which stream records will ultimately be found most useful, and it is therefore sometimes desirable to begin records upon the possibility of future needs. In order to carry on work at a large number of river stations for the longest possible period it is therefore the policy of the geological survey to maintain each station at the smallest expense consistent with obtaining sufficient data upon which to base fairly reliable summaries and estimates of the daily and seasonal flow, but not to attempt to attain the absolute accuracy which would result from the disproportionately large expenditure necessary for removing entirely every trifling source of error.

The following are the methods of procedure at the stations in this portion of the United States.

At a suitable point on the river a gauge (marked with feet and tenths of feet) is established, upon which the height of the river is observed and recorded once or twice daily by some competent person residing near, who is appointed as observer.

At occasional visits to the station an engineer (or "hydrographer") makes discharge measurements of the stream. A discharge measurement consists of measurements with proper instruments of the width, the depth, and the velocity of the river. The depth is taken at many points across the width so as to show the average depth, and the velocity of the current is taken at many points from one side of the stream to the other and from

the water surface to the bottom of the channel so as to show the average velocity at the guage; width, depth, and velocity being found, the actual flow that passes by the guage is computed, usually in cubic feet of water each second.

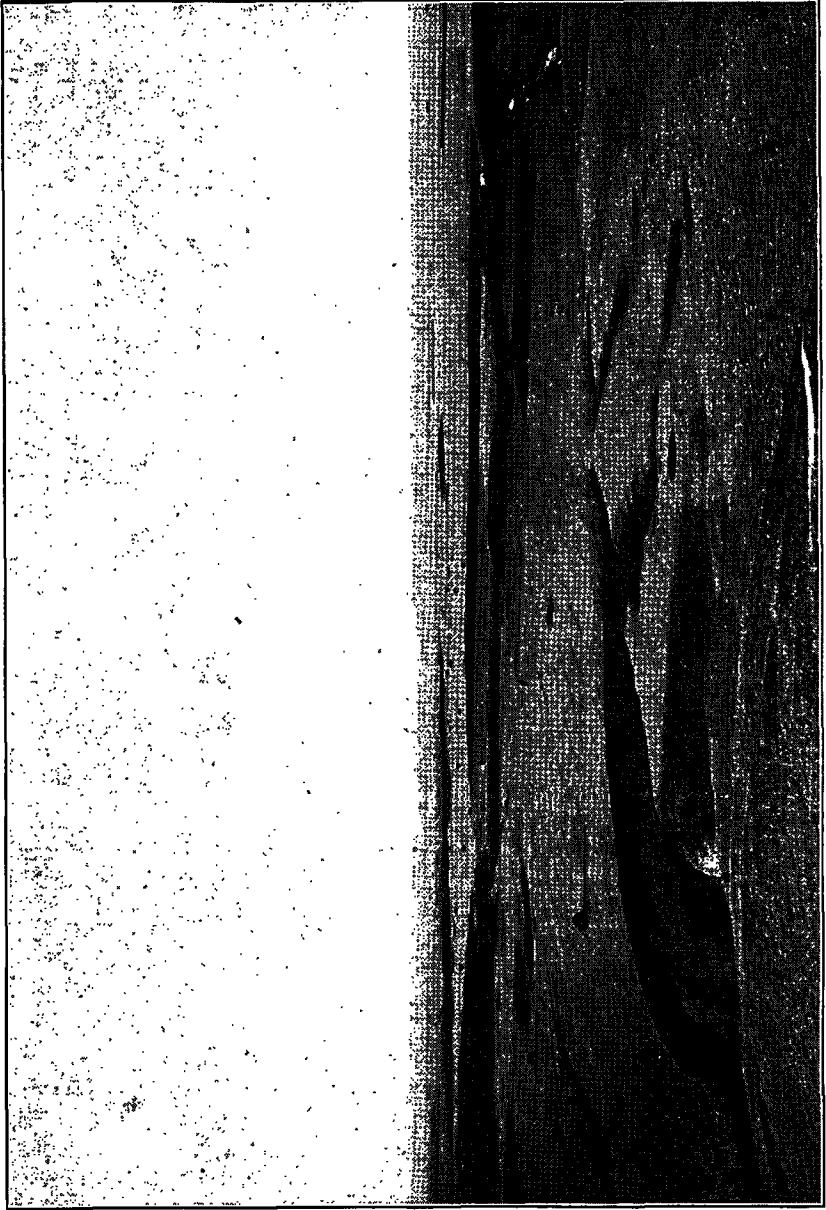
At the close of the season, if a sufficient number of satisfactory discharge measurements at high, low, and intermediate stages have been secured a "rating table" can be prepared showing how great a quantity of water (under normal conditions) will flow by the guage at each foot and tenth of river height. This table is then applied to the record of daily heights and a record of daily run-off obtained, the actual quantity flowing by the station each day.

As the most convenient form for publication and general use, the records are then summarized by months, so as to show the maximum flow in the month (i. e., the average flow in second feet for that day in the month when the flow was greatest), the minimum flow of any day in the month, and the mean or average flow for the whole month. A glance at the summaries will then show not only the approximate quantities of water that flowed by the station in any month, but also whether great fluctuations or a steady and uniform run-off are characteristic of the stream.

By a "second foot" is meant one cubic foot of water per second, which would be the quantity of water in a stream one foot wide and one foot deep flowing at a rate of one foot per second. A "miner's inch" is variously defined in different states, 38.4 to 50 miner's inches being equal to one second foot. One second foot of water if turned into a reservoir or upon a field will cover about two acres one foot deep in a day of twenty-four hours. The discharge or run-off in all the tables on the following pages is computed and recorded in second feet.

In winter it is more difficult to obtain accurate records of the flow, since the velocity depends upon the thickness and character of the ice and other conditions that cannot be ice and other conditions that cannot be put in figures, as well as on the guage height; so that accurate complete records in winter would require many discharge measurements and a great increase of expenditure, but rough estimates may be based upon a few measurements. During the season of the spring thaws, when ice jams may form for a few hours or days, the guage height is again not a certain indication of the amount of flow, as likewise sometimes under other unusual conditions for short periods.

In fact, a river channel is always undergoing gradual change, so that conditions are never found to be identically alike at different times. But if the location of the gauging station is a suitable one the discrepancies and inaccuracies arising on this account are in general comparatively small, so that the allowances or corrections to be made are inappreciable as compared



Lands in Bismarck project susceptible of irrigation.

with the great variations in weather and rainfall conditions from one year to another.

The summaries which follow are as accurate as the data permit, and it may be safely assumed that they are as a rule not in error more than two to five per cent, except; first, at the times starred or otherwise indicated as estimates, and second, on some of the smaller streams, to extreme low water stage; for at extreme low stage of such streams the total flow is so small that an error of only one or two second feet may be twenty per cent of the total flow, or even more, and such slight errors will, of course, arise if the observer reads the height of the river no more correctly than the nearest tenth of a foot.

For the past four seasons the river station work of the geological survey in North Dakota and in a part or the whole of Minnesota has been in charge of Prof. E. F. Chandler (of the state university), assistant engineer in the geological survey, by whom the following summaries of the more reliable station records in North Dakota and the Red River valley have been prepared. Any inquiries concerning details of the records from these stations and the stations not included in this list, or other questions arising on this topic, will receive immediate attention if addressed to him at the postoffice university, North Dakota, where complete records of all the work of this nature in the district are kept on file and brought up to date:

RED RIVER AT GRAND FORKS, N. D.

Gagings of the Red River at Grand Forks were begun by the U. S. Geological Survey in 1901, but a gage-height record had been maintained by the U. S. Engineers (War Department) for a long succession of years previous. The gaging station is located below the confluence of the Red Lake River, and the records therefore include the flow of this most important tributary, which during a considerable part of each season brings to the Red River more water than the total amount entering the Red River from all sources above. The total drainage area is 25,000 square miles, of which 13,400 is in Minnesota.

The gage zero is 781.4 feet above sea-level, this being 45.6 feet above the official Grand Forks city datum, or about 52 feet below the average height of the pavement on Third street. The zero of the gage read by the U. S. engineers is 5.0 feet above that of the Geological Survey gage. The lowest gage reading recorded since June, 1895, was on October 22, 1895, 3.8 feet; the highest, on April 10, 1897, 50.2 feet; the highwater mark of 1904 (April 27) was at 40.6 feet.

The tables of discharge are based on the measurements in the list below and on twenty-two measurements made during the four preceding years, and are well-checked and accurate for all stages during the open season. During the frozen season but few measurements have been made, so that the summaries given for that time can be considered only as estimates, but may be assumed to be reasonably close.

DISCHARGE MEASUREMENTS.

| Date and name of hydrographer | Gage height. | Discharge. |
|---|--------------|------------|
| April 8, 1905—L. L. Wilcox | 14.55 | 6097 |
| April 25, 1905—R. Richards | 7.93 | 2183 |
| May 16, 1905—R. Richards | 26.11 | 16850 |
| August 21, 1905—R. Richards | 20.04 | 10967 |
| December 22, 1905—Chandler and Richards | * 9.05 | 1842 |
| January 29, 1906—Chandler and Richards | * 9.45 | 1771 |
| March 5, 1906—Chandler and Richards | * 9.51 | 1554 |
| March 23, 1906—Chandler and Clark | *10.24 | 1881 |
| April 9, 1906—R. Richards | 32.40 | 22990 |
| August 11, 1906—E. F. Chandler | 10.27 | 3709 |
| November 5, 1906—Chandler and Clark | 8.21 | 2410 |

*Frozen; thickness of ice, 1.0 to 2.5 ft.

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

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|--------|
| 1905— | | | |
| January ..... | ..... | ..... | *1,200 |
| February ..... | ..... | ..... | *1,140 |
| March | *4,600 | *1,400 | *2,550 |
| April | *7,500 | 2,030 | 3,886 |
| May | 16,640 | 1,990 | 8,195 |
| June | 5,480 | 4,330 | 4,940 |
| July | 6,860 | 4,890 | 5,758 |
| August | 10,850 | 4,860 | 6,637 |
| September | 5,240 | 3,820 | 4,608 |
| October | 4,200 | 2,980 | 3,437 |
| November | 3,330 | 2,510 | 2,806 |
| December ..... | ..... | ..... | *2,530 |

*Estimated.

River opened April 7; closed Nov. 28.

Maximum gage heights, 17.5 feet, April 6; 26.0 feet May 16; 19.9 feet, August 21.

Minimum gage heights, 7.0 feet, February 28; 7.4 feet, May 1; 11.5 feet, June 21; 8.4 feet, November 5.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|--------|
| 1906— | | | |
| January ..... | ..... | ..... | *1,750 |
| February ..... | ..... | ..... | *1,590 |
| March ..... | ..... | ..... | *1,890 |
| April | 27,550 | *7,000 | 19,768 |
| May | 9,615 | 6,980 | 8,220 |
| June | 7,880 | 5,200 | 6,062 |
| July | 6,530 | 3,210 | 4,564 |
| August | 3,910 | 2,700 | 3,180 |
| September | 2,920 | 2,180 | 2,466 |
| October | 2,535 | 1,915 | 2,201 |

*Estimated.

River opened April 9.

Maximum gage heights, 33.5 feet April 7; 36.0 feet April 18.

Minimum gage heights, 9.1 feet February 24; 28.9 feet April 13; 7.2 feet October 26.

RED RIVER AT FARGO, N. D.

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. During the melting of the snows or after unusually heavy rains the western and southern portions of this area contribute their appropriate share to the flow of the river at Fargo, but in ordinary years during most of the season the greater fraction of the water (from one-half to three-fourths) comes from the lake region at the eastern side, above Fergus Falls, which includes only about 22 per cent of the entire area drained.

The zero of the gage is 863 feet above sea-level. The lowest stage recorded since the establishment of the station was on November 13, 1902, 6.7 feet, and the highest on April 20, 1904, 21.3 feet.

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

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|---|--------------|------------|
| March 30, 1905—R. Richards | 9.86 | * 855 |
| June 22, 1905—Chandler and Richards | 9.84 | 1,044 |
| July 29, 1905—Hanna and Chandler | 10.19 | 1,115 |
| August 22, 1905—R. Richards | 10.90 | 1,317 |
| November 18, 1905—R. Richards | 8.84 | 760 |
| April 14, 1906—E. F. Chandler | 13.69 | **2,394 |
| June 27, 1906—Chandler and Clark | 12.03 | 1,626 |
| September 10, 1906—E. F. Chandler | 10.04 | 971 |
| October 27, 1906—E. F. Chandler | 10.20 | 984 |

*Ice running; poor measurement.

**Conditions unfavorable; rather poor.

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

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|-------|
| 1905— | | | |
| March | * 680 | * 150 | * 400 |
| April | 707 | 519 | 598 |
| May | 4,268 | 519 | 1,686 |
| June | 1,082 | 890 | 1,024 |
| July | 1,195 | 972 | 1,106 |
| August | 1,520 | 998 | 1,188 |
| September | 1,082 | 890 | 997 |
| October | 972 | 783 | 855 |
| November | 809 | 708 | 754 |

*Estimated.

River opened April 1; closed November 29.

Maximum gage heights, 9.5 feet March 31; 18.4 feet May 17; 11.4 feet August 19.

Minimum gage heights, 7.6 feet February 28; 7.8 feet May 1; 8.6 feet November 29.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|-------|
| 1906— | | | |
| April | 3,040 | 1,217 | 1,979 |
| May | 2,420 | 1,250 | 1,617 |
| June | 1,898 | 1,561 | 1,670 |
| July | 1,898 | 1,250 | 1,537 |
| August | 1,454 | 1,090 | 1,278 |
| September | 1,316 | 939 | 1,062 |
| October | 1,153 | 771 | 927 |

*Estimated.

River opened April 6.

Maximum gage heights, 15.5 feet April 9; 14.0 feet May 17; 12.7 feet July 6.

Minimum gage heights, 8.6 feet February 12; 10.8 feet April 29; 11.8 feet June 24; 9.3 feet October 21.

OTTERTAIL RIVER NEAR FERGUS FALLS, MINN.

The gaging station on the Ottertail (or Red) river near Fergus Falls, Minn., 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.

On account of the many lakes from which the river draws its supply, there are no sudden fluctuations in the flow, and no extreme flood or low stages. The total variation in height since the station was established has been only 1.6 feet.

The tables of discharge are based upon the measurements in the list below, and six measurements made during 1904, and are accurate for all stages.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| March 31, 1905—R. Richards | 2.84 | 248 |
| July 15, 1905—R. Richards | 3.75 | 714 |
| July 27, 1905—Hanna and Chandler | 3.78 | 718 |
| September 4, 1905—R. Richards | 3.84 | 759 |
| November 4, 1905—E. F. Chandler | 3.49 | 539 |
| May 14, 1906—E. F. Chandler | 3.89 | 786 |
| June 25, 1906—Chandler and Clark | 4.30 | 1,008 |

MONTHLY DISCHARGE OF OTTERTAIL RIVER NEAR FERGUS FALLS, MINN.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|-------|
| 1905— | | | |
| March | * 402 | * 200 | * 305 |
| April | 315 | 240 | 293 |
| May | 611 | 315 | 517 |
| June | 670 | 526 | 617 |
| July | 790 | 670 | 722 |
| August | 850 | 730 | 779 |
| September | 820 | 670 | 752 |
| October | 670 | 582 | 617 |
| November | 553 | * 470 | 548 |

*Estimated.

River opened March 28; closed November 29.
 Maximum gage height, 4.0 feet August 7.
 Minimum gage height, 2.8 feet April 11.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1906— | | | |
| April | 670 | 400 | 500 |
| May | 820 | 670 | 774 |
| June | 1,000 | 820 | 950 |
| July | 1,000 | 820 | 920 |
| August | 820 | 670 | 745 |
| September | 760 | 670 | 730 |
| October | 730 | 670 | 673 |

*Estimated.

River opened April 6.
 Maximum gage height, 4.25 feet July 1.
 Minimum gage height, 3.2 feet April 7; 3.7 feet September 30.

PEMBINA RIVER AT NECHE, N. D.

The gaging station on the Pembina river was established April 29, 1903, and is located 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. In this portion of its course the river has cut in the level prairies a channel of 20 to 25 feet depth and 100 to 200 feet top width.

The highest water recorded since the establishment of the station was on May 2, 1904, being 20.9 feet above the gage zero; extreme low water is about 3 feet above the gage zero. The gage zero is 815 feet above sea-level.

The tables of discharge are based upon the measurements in the list below. Twelve measurements made during the preceding two years were also taken into account after due allowance was made for some changes in the channel during the elapsed time which affect the height at low stages. The tables are reliable for all stages.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| April 10, 1905—R. Richards | 5.71 | 507 |
| April 24, 1905—R. Richards | 4.30 | 214 |
| July 14, 1905—R. Richards | 3.95 | 174 |
| July 28, 1905—Hanna and Chandler | 3.51 | 124 |
| August 20, 1905—R. Richards | 3.20 | 92 |
| April 23, 1906—R. Richards | 4.47 | 288 |
| June 11, 1906—E. F. Chandler | 4.88 | 372 |
| August 15, 1906—E. F. Chandler | 3.67 | 140 |
| October 22, 1906—E. F. Chandler | 3.67 | 132 |

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

| | Maximum | Minimum | Mean |
|-------------------|---------|---------|------|
| 1905— | | | |
| March 23-31 | 718 | 400 | 580 |
| April | 1,400 | 307 | 567 |
| May | 1,224 | 208 | 452 |
| June | 1,224 | 271 | 499 |
| July | 410 | 114 | 199 |
| August | 130 | 74 | 98 |
| September | 114 | 76 | 95 |
| October | 142 | 75 | 113 |
| November | 119 | 80 | 99 |

River opened March 23; closed October 27.

Maximum gage heights, 9.8 feet April 5; 9.0 feet May 13; 9.0 feet June 11.

Minimum gage heights, 4.2 feet May 6; 2.9 feet August 30.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1906— | | | |
| April | 1,220 | 193 | 479 |
| May | 231 | 175 | 192 |
| June | 340 | 193 | 271 |
| July | 270 | 119 | 179 |
| August | 143 | 119 | 131 |
| September | 166 | 136 | 147 |
| October | 150 | 136 | 144 |

River opened April 7.

Maximum gage heights, 9 feet April 4; 4.75 feet June 21, 30.

Minimum gage heights, 3.9 feet May 18; 3.5 feet August 1.

RED LAKE RIVER AT CROOKSTON, MINN.

The gaging station on the Red Lake river was established May 19, 1901, and its summaries include almost the entire discharge of the river, as no considerable tributaries enter between the station and the mouth of the river at Grand Forks. The drainage area above Crookston is 5,525 square miles.

The gage is located below the Crookston dam, and its zero is 825 feet above sea-level. The highwater mark at this point, said to have been about the year 1897, is 25.2 feet above the gage zero, and the highest stage since the establishment of the station was on April 15, 1906; 21 feet; the 1904 flood stage, on April 24, was 20.4 feet. The lowest recorded stage is 3.6 feet.

The tables of discharge are based on the measurements in the list below and twenty-three measurements made in the four preceding years, and are unusually accurate, the conditions at the station being very favorable at all stages.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| April 10, 1905—L. L. Wilcox | 7.06 | 2,505 |
| July 24, 1905—Hanna and Chandler | 7.66 | 2,957 |
| August 19, 1905—R. Richards | 9.93 | 4,846 |
| November 20, 1905—E. F. Chandler | 5.90 | 1,682 |
| February 12, 1906—Chandler and Richards | * 6.75 | 984 |
| April 16, 1906—E. F. Chandler | 20.13 | 14,060 |
| June 30, 1906—Chandler and Clark | 6.72 | 1,990 |
| September 11, 1906—Grover and Chandler | 4.80 | 968 |

*Frozen; thickness of ice, 1.5 feet.

MONTHLY DISCHARGE OF RED LAKE RIVER AT CROOKSTON, MINN.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|--------|
| 1905— | | | |
| March | | * 400 | * 800 |
| April | 4,560 | 1,050 | 2,002 |
| May | 8,090 | 1,260 | 3,160 |
| June | 3,050 | 1,555 | 2,070 |
| July | 4,240 | 2,060 | 2,866 |
| August | 4,800 | 2,310 | 2,995 |
| September | 3,760 | 2,200 | 2,972 |
| October | 3,050 | 1,650 | 2,257 |
| November | 2,340 | 505 | 1,676 |
| December | *2,450 | * 570 | *1,500 |

Maximum gage heights, 9.7 feet April 3; 14.05 feet May 13; 10 feet August 18.

Minimum gage heights, 4.9 feet April 30; 5.7 feet June 20; 4.1 feet December 2.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|--------|
| 1906— | | | |
| January | | | *1,500 |
| February | | | *1,020 |
| March | | | *1,560 |
| April | 14,700 | 4,960 | 8,012 |
| May | 5,120 | 2,825 | 3,714 |
| June | 3,320 | 2,030 | 2,527 |
| July | 2,240 | 1,520 | 1,812 |
| August | 1,855 | 1,295 | 1,538 |
| September | 1,650 | 815 | 1,270 |

*Estimated.

Maximum gage height, 16.1 feet April 4; 21 feet April 15.

Minimum gage height, 4.5 feet September 18.

SHEYENNE RIVER AT HAGGART, N. D.

The gaging station on the Sheyenne river at Haggart was established March 22, 1902, and 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 ten miles above its mouth.

At this point the average depth of the channel below the level prairies is about twenty feet, and the width at the top of the banks one hundred to one hundred and fifty feet. The fall of the valley in this portion is so small that the flow is sluggish, and the water does not rise rapidly in flood nor fall quickly again. The greatest recorded height since the establishment of the station, on April 22, 1904, was practically the top of the banks, being 18.6 feet above the gage zero. The gage zero is 881 feet above sea-level.

The tables of discharge are based upon the measurements in the list below and fifteen measurements made in the three preceding years, and are fairly reliable for all stages.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| March 30, 1905—R. Richards | 6.60 | * 198 |
| June 22, 1905—Chandler and Richards | 4.70 | 173 |
| July 11, 1905—R. Richards | 4.60 | 156 |
| July 29, 1905—Hanna and Chandler | 4.42 | 146 |
| August 22, 1905—R. Richards | 6.01 | 238 |
| November 18, 1905—E. F. Chandler | 3.64 | 69 |
| April 14, 1906—E. F. Chandler | 10.89 | 948 |
| June 27, 1906—Chandler and Clark | 5.92 | 317 |
| September 10, 1906—Grover and Chandler | 3.45 | 68 |

*River raised by ice-jam.

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

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1905— | | | |
| April | 351 | 109 | 200 |
| May | 758 | 91 | 305 |
| June | 307 | 146 | 200 |
| July | 362 | 82 | 171 |
| August | 628 | 100 | 282 |
| September | 156 | 74 | 116 |
| October | 100 | 59 | 74 |
| November ..... | .... | .... | 70 |

River opened about April 1; closed November 29.

Maximum gage heights, 6.5 feet April 3; 9.8 feet May 13; 8.8 feet August 18.

Minimum gage heights, 3.9 feet May 3; 3.8 feet July 9; 3.5 feet October 31.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1906— | | | |
| April | 1,061 | 346 | 678 |
| May | 476 | 169 | 311 |
| June | 411 | 245 | 295 |
| July | 257 | 113 | 162 |
| August | 169 | 51 | 104 |
| September | 65 | 32 | 48 |
| October | 58 | 44 | 46 |

River opened April 3.

Maximum gage heights, 11.7 feet April 16; 7.2 feet May 28.

Minimum gage heights, 4.7 feet May 15; 3 feet September 12.

MOUSE RIVER AT MINOT, N. D.

The gaging station on the Mouse River at Minot was established May 5, 1903, and is near the roundhouse of the Great Northern railway. 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 fall of the Mouse River along this portion of its course is very slight, averaging only about sixteen inches to the mile, and its current is very sluggish, the swiftest speed in mid channel during the highest floods being less than two miles per hour, and at ordinary stages between one fourth-mile and one mile per hour. The valley bottom is a very level plain, through which the river winds in a channel whose top width is usually about a hundred feet, and depth to low-water, ten or fifteen feet below the level plain; as soon as the river rises so as to fill its whole channel and flow out of its banks, its width is so great that the most extreme floods cause only a few feet further rise. At the gaging station the average elevation of the valley bottom is between nineteen and twenty feet above the gage-zero (low-water mark being about four feet above the gage zero) and the highest recorded flood, of April 20, 1904, which is said to have been the highest in twenty years, reached an elevation of 21.9 feet above the gage-zero. The gage zero is 1,540 feet above sea-level.

The tables of discharge are based upon the measurements in the list below and fifteen measurements made in the two preceding years, and are approximately correct.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|---|--------------|------------|
| March 27, 1905—R. Richards | 4.40 | 114 |
| April 27, 1905—E. F. Chandler | 4.03 | 44 |
| May 24, 1905—E. F. Chandler | 4.45 | 122 |
| May 24, 1905—E. F. Chandler | 4.56 | 139 |
| July 26, 1905—Hanna and Chandler | 4.60 (?) | 48 |
| August 18, 1905—R. Richards | 4.10 | 36 |
| September 17, 1905—E. F. Chandler | 3.86 | 13.6 |
| April 23, 1906—E. F. Chandler | 5.19 | 300 |
| May 29, 1906—E. F. Chandler | 4.41 | 112 |
| June 29, 1906—Chandler and Clark | 5.33 | 343 |
| September 6, 1906—E. F. Chandler | 4.00 | 30 |
| September 6, 1906—E. F. Chandler | 4.00 | 31 |

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

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1905— | | | |
| March | 110 | *55 | *92 |
| April | 180 | 35 | 63 |
| May | 130 | 35 | 67 |
| June | 120 | 35 | 85 |
| July | 110 | 61 | 83 |
| August | 110 | 35 | 71 |
| September | 90 | 10 | 31 |
| October | 21 | 10 | 16 |
| November | 35 | 21 | 27 |

*Estimated.

River opened about March 10; closed November 28.

Maximum gage height, 4.5 feet May 31.

Minimum gage height, 3.8 feet September 30.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1906— | | | |
| April | 1,208 | 220 | 425 |
| May | 218 | 108 | 159 |
| June | 462 | 264 | 372 |
| July | 264 | 130 | 204 |
| August | 130 | 31 | 62 |
| September | 31 | 18 | 26 |

River opened about April 5.

Maximum gage heights, 9.4 feet April 10; 6.1 feet June 15.

Minimum gage heights, 4.4 feet May 27; 3.9 feet September 30.

DES LACS RIVER AT FOXHOLM, N. D.

The gaging station on the Des Lacs River was established June 23, 1904, and is located eleven miles above the mouth of the river. The drainage area above this point is about 615 square miles. More than half of this area is above at least the lower one of the Des Lacs Lakes; hence it appears that the evaporation from these is in part responsible for the small amount of water that is found at the gaging station in ordinary weather. The gage-zero is 1,634 feet above sea-level. The highest recorded gage reading was 9 feet, on August 2, 1905.

The station was discontinued, on account of lack of funds, July 31, 1906. The complete period during which it was operated, with the list of all discharge measurements made, is given here. The flood figures above 200 second-feet are mere rough estimates, and the conditions at the station were such that the tables are likely to be slightly in error at some other points. But they are at least fair approximations of the monthly discharge.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| June 23, 1904—E. F. Chandler | 3.80 | 41 |
| July 13, 1904—R. Richards | 3.12 | 24 |
| August 12, 1904—R. Richards | 2.45 | 9.6 |
| September 17, 1904—Chandler and Richards | 2.22 | 6.2 |
| September 17, 1904—Chandler and Richards | 2.22 | 5 |
| March 28, 1905—R. Richards | 2.64 | 9.5 |
| April 26, 1905—E. F. Chandler | 1.98 | 2.9 |
| May 24, 1905—R. Richards | 2.04 | 4.5 |
| July 26, 1905—Hanna and Chandler | 2.45 (?) | 1.6 |
| August 18, 1905—R. Richards | 2.02 | 2.5 |
| September 16, 1905—E. F. Chandler | 1.96 | 1.6 |
| April 24, 1906—E. F. Chandler | 2.36 | 6.6 |
| June 28, 1906—Chandler and Clark | 2.31 | 5.9 |

MONTHLY DISCHARGE OF DES LACS RIVER AT FOXHOLM, N. D.

| | Maximum | Minimum | Mean |
|-------------------|---------|---------|-------|
| 1904— | | | |
| June 23-30 | 41 | 33 | 38 |
| July | 32 | 16 | 23 |
| August | 15 | 3 | 9 |
| September | 7 | 3 | 5 |
| October | 9 | 4 | 8 |
| November | 7 | 2 | 3 |
| 1905— | | | |
| March | 38 | 6 | 17 |
| April | 5.9 | 1.8 | 2.9 |
| May | 4 | 1.8 | 2.3 |
| June | 8 | 1.2 | 2.5 |
| July | 41 | 1.1 | 4.6 |
| August | * 425 | 1.5 | * 14 |
| September | 1.4 | 1.2 | 1.2 |
| October | 1.2 | 1.2 | 1.2 |
| November | 2 | 1.1 | 1.6 |
| 1906— | | | |
| March 25-31 | * 265 | 18 | * 118 |
| April | * 355 | 5.8 | * 59 |
| May | 38 | 2 | 13 |
| June | 41 | 2 | 19 |
| July | 2 | 1.2 | 1.4 |

*Estimated.

LITTLE MUDDY RIVER NEAR WILLISTON, N. D.

The gaging station on the Little Muddy River near Williston was established February 4, 1904, and is located in section 19, township 155 N., range 100 W., about 7 miles north of Williston and the mouth of the river. The drainage area above this point is about 800 square miles; but the topography of the region is such that the drainage area has no definite boundaries, the valley being surrounded by prairies pitted with small lakes and sloughs which receive the flow from the vicinity and evaporate it, not being filled deep enough to overflow except in very unusual years. The real drainage area can therefore be considered as more or less than 800 square miles, to the extent even of twenty per cent. For this reason, under exceptional conditions of heavy rainfall the flow

in the stream may become very large, but it is usually small with few fluctuations. The highest flood recorded at the gaging station was on April 11, 1904, (10.3 feet on the gage, or 8 feet above extreme low-water), which is said to have been higher than any other flood within ten years. The gage-zero is 1,856 feet above sea level.

The tables of discharge are based upon the measurements in the list below and six measurements made the preceding year, and is fairly accurate for figures below 1,200; above that figure the estimates are subject to later revision.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|---|--------------|------------|
| April 5, 1905—F. C. Davis | 2.60 | 16 |
| April 25, 1905—E. F. Chandler | 2.45 | 9.1 |
| April 25, 1905—E. F. Chandler | 2.45 | 9.2 |
| May 23, 1905—R. Richards | 2.54 | 17.5 |
| June 22, 1905—F. C. Davis | 2.50 | 15.3 |
| July 25, 1905—Hanna and Chandler | 2.57 | 11.6 |
| September 20, 1905—E. F. Chandler | 2.39 | 5.9 |
| April 22, 1906—E. F. Chandler | 2.66 | 16.4 |
| May 28, 1906—E. F. Chandler | 2.92 | 30.2 |
| September 4, 1906—E. F. Chandler | 2.45 | 8.8 |

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

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1905— | | | |
| June | 146 | 10 | 27 |
| July | 20 | 10 | 15 |
| March | * 200 | 16 | 57 |
| April | 16 | 6 | 9 |
| May | 10 | 10 | 10 |
| August | 10 | 6 | 7 |
| September | 10 | 6 | 6 |
| October | 16 | 10 | 11 |
| November | 16 | 10 | 11 |

*Estimated.

River opened about March 7; closed November 29.

Maximum gage heights, 3.9 feet March 1; 3.45 feet June 6.

Minimum gage heights, 2.4 feet April 15; 2.4 feet August 11 to September 30.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1906— | | | |
| April | 545 | 20 | 84 |
| May | 60 | 20 | 26 |
| June | 1,570 | 35 | 199 |
| July | 35 | 9 | 9 |
| August | 14 | 9 | 10 |
| September | 9 | 6 | 8 |
| October | 9 | 9 | 9 |

River opened about April 1.

Maximum gage heights, 4.6 feet April 3; 7 feet June 7.

Minimum gage heights, 2.7 feet May 15; 2.4 feet September 10.

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 40 miles south of Mandan, and about 30 miles from the mouth of the river. The drainage area above this point is about 3,650 square miles. The valley has a fair inclination and the sides are in most portions steep, so that the flow of the river subject to large fluctuations, floods occurring suddenly after storms. In the vicinity of the gage the river channel has a width of about a hundred feet, with one bank usually sloping gently up, so that the river widens at flood stage; hence the highest recorded flood rose at the gaging station only 8 feet above ordinary low water.

The tables of discharge are based upon the measurements in the list below and eleven measurements in the two preceding years, and are fairly accurate except the flood figures above 600 second feet, which are based on only one high-stage measurement and are therefore subject to possible revision later.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|---|--------------|------------|
| March 28, 1905—E. F. Chandler | 3.56 | 99 |
| June 29, 1905—Chandler and Richards | 3.45 | 123 |
| June 30, 1905—Chandler and Richards | 3.49 | 114 |
| August 3, 1905—R. Richards | 3.52 | 102 |
| August 28, 1905—R. Richards | 2.88 | 20 |
| August 29, 1905—R. Richards | 2.85 | 19.2 |
| October 17, 1905—E. F. Chandler | 2.61 | 4.8 |
| April 9, 1906—E. F. Chandler | 4.48 | 393 |
| August 23, 1906—E. F. Chandler | 3.14 | 50 |
| August 24, 1906—E. F. Chandler | 3.09 | 42 |
| September 14, 1906—E. F. Chandler | 2.92 | 27 |

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

| | Maximum | Minimum | Mean |
|----------------------|---------|---------|---------|
| 1905— | | | |
| February 23-28 | * 3,580 | .... | * 2,210 |
| March | 2,530 | 98 | 633 |
| April | 201 | 5 | 53 |
| May | 1,340 | 4 | 292 |
| June | 2,320 | 3 | 355 |
| July | 1,060 | 14 | 402 |
| August | 332 | 3 | 86 |
| September | 22 | .... | 6 |
| October | 22 | .... | 6 |
| November 1-25 | 63 | 8 | 28 |

*Estimated.

River opened February 26.

Maximum gage heights 8.9 feet, February 27.

Minimum gage, height 9 feet, October 15.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|-------|
| 1906— | | | |
| April | * 1,900 | 44 | 399 |
| May | 2,620 | 24 | 649 |
| June | 5,350 | 57 | 2,183 |
| July | 187 | 2 | 54 |
| August | 136 | 5 | 48 |
| September | 73 | 9 | 35 |

*Estimated.

River opened April 5.

Maximum gage height, 10.5 feet June 7.

Minimum gage height, 2.3 feet July 6.

HEART RIVER AT MANDAN, N. D.

No regular record has been maintained of the flow of the Heart River at its mouth, near Mandan; but some occasional measurements have been made, as detailed in the list below. The drainage area above this point is 3,360 square miles.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Discharge. |
|--|------------|
| August 3, 1904—R. Richards | 23 |
| September 28, 1904—E. F. Chandler | 11 |
| October 26, 1904—L. L. Wilcox | 13 |
| March 26, 1905—E. F. Chandler | 69 |
| July 1, 1905—Chandler and Richards | 110 |
| August 3, 1905—R. Richards | 96 |
| October 15, 1905—E. F. Chandler | 12 |
| April 8, 1906—E. F. Chandler | 416 |
| August 26, 1906—E. F. Chandler | 59 |
| September 13, 1906—E. F. Chandler | 34 |

HEART RIVER NEAR RICHARDTON, N. D.

The gaging station on the Heart River was established May 18, 1903, and is located at the iron highway bridge 10 miles south of Richardton. The drainage area above this point is 1,250 square miles. In the vicinity of the gaging station the river has a deep channel, with steep banks rising about 20 feet above the river bed and only 100 to 150 feet apart at the top. The difference in height between flood stage and low water is therefore large; a rise of $21\frac{1}{2}$ feet above ordinary low water is recorded.

The tables of discharge are based upon the measurements in the list below and twelve measurements made in the two preceding years. Only one measurement above medium stage has been obtained, hence the figures above 800 second-feet are subject to possible slight revisions later, but for medium and low stages the tables are fairly accurate.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| March 25, 1905—E. F. Chandler | 4.64 | 17 |
| July 7, 1905—Chandler and Richards | 6.88 | 325 |
| August 8, 1905—R. Richards | 4.24 | 5 |
| August 24, 1905—R. Richards | 4.00 | .9 |
| October 16, 1905—R. Richards | 4.14 | 2.9 |
| April 11, 1906—E. F. Chandler | 5.05 | 30 |
| August 29, 1906—E. F. Chandler | 4.50 | 18.2 |

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

| | Maximum | Minimum | Mean |
|---------------------|---------|---------|------|
| 1905— | | | |
| March | 378 | 16 | 92 |
| April | 16 | 2 | 7 |
| May | 11 | 2 | 6 |
| June | 290 | 4 | 44 |
| July | 761 | 11 | 128 |
| August | 7 | .... | 3 |
| September | 16 | .... | 3 |
| October | 7 | .... | 2 |
| November 1-23 | 11 | 4 | 7 |

River opened March 1; closed November 24.
 Maximum gage height, 9.1 feet July 5.
 Minimum gage height, 3.8 feet September 10.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|-------|
| 1906— | | | |
| March | 888 | .... | .... |
| April | 689 | 11 | 106 |
| May | 1,840 | 11 | 281 |
| June | 8,800 | 29 | 1,156 |
| July | 37 | 11 | 26 |
| August | 37 | 11 | 20 |
| September | 16 | 4 | 8 |
| October | 7 | 4 | 4 |

River opened about March 26.
 Maximum gage heights 12.4 feet, May 27; 14.4 feet, June 1; 25.9 feet, June 10.
 Minimum gage heights 4.2 feet, September 30.

KNIFE RIVER AT BRONCHO, N. D.

The gaging station on the Knife River was first established May 29, 1903, at the Haven ranch, which was about 23 miles north of Hebron. After the close of the season of 1904 the station was moved about three miles up the valley to the present location of the postoffice of Broncho, in section 4, township 142 N., range 90 W. The drainage area above this point is about 1,260 square miles. The valley has a fair inclination and the sides are steep, so that the flow of the river increases suddenly after storms. In this portion of the valley the river channel is as a rule about twenty-five feet deep, with a width of only 100 to 150 feet at the top of the banks, and large rises therefore occur. The highest recorded stage in the past four seasons is 18 feet above extreme low water.

The tables of discharge are based upon the measurements in the list below, in conjunction with the results of eleven measurements made during the two preceding years at the former location. But as only one high-stage measurement has yet been obtained, and this was at the former location, all figures above 800 second feet in the table below are

liable to considerable later revision. For medium and ordinary low stages the tables are fairly accurate.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| March 23, 1905—E. F. Chandler | 3.89 | 18 |
| July 3, 1905—Chandler and Richards | 3.60 | 9.8 |
| July 5, 1905—Chandler and Richards | 6.92 | 486 |
| July 5, 1905—Chandler and Richards | 7.51 | 632 |
| August 5, 1905—R. Richards | 4.05 | 44 |
| August 26, 1905—R. Richards | 3.35 | 2 |
| October 17, 1905—R. Richards | 3.37 | 3.1 |
| April 12, 1906—E. F. Chandler | 4.08 | 36 |
| April 12, 1906—E. F. Chandler | 4.08 | 39 |
| August 27, 1906—E. F. Chandler | 3.87 | 13.5 |

MONTHLY DISCHARGE OF KNIFE RIVER AT BRONCHO, N. D.

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|------|
| 1905— | | | |
| March | 440 | 14 | .... |
| April | 14 | 4 | 7 |
| May | 24 | 4 | 10 |
| June | 595 | 4 | 85 |
| July | 634 | 4 | 61 |
| August | 302 | 1 | 17 |
| September | 4 | .... | 1.4 |
| October | 5 | 2 | 2.5 |
| November | 7 | 2 | 4 |

River closed November 26.

Maximum gage heights, 7.4 feet June 7; 7.6 feet July 5.

Minimum gage height, 3.1 feet September 7.

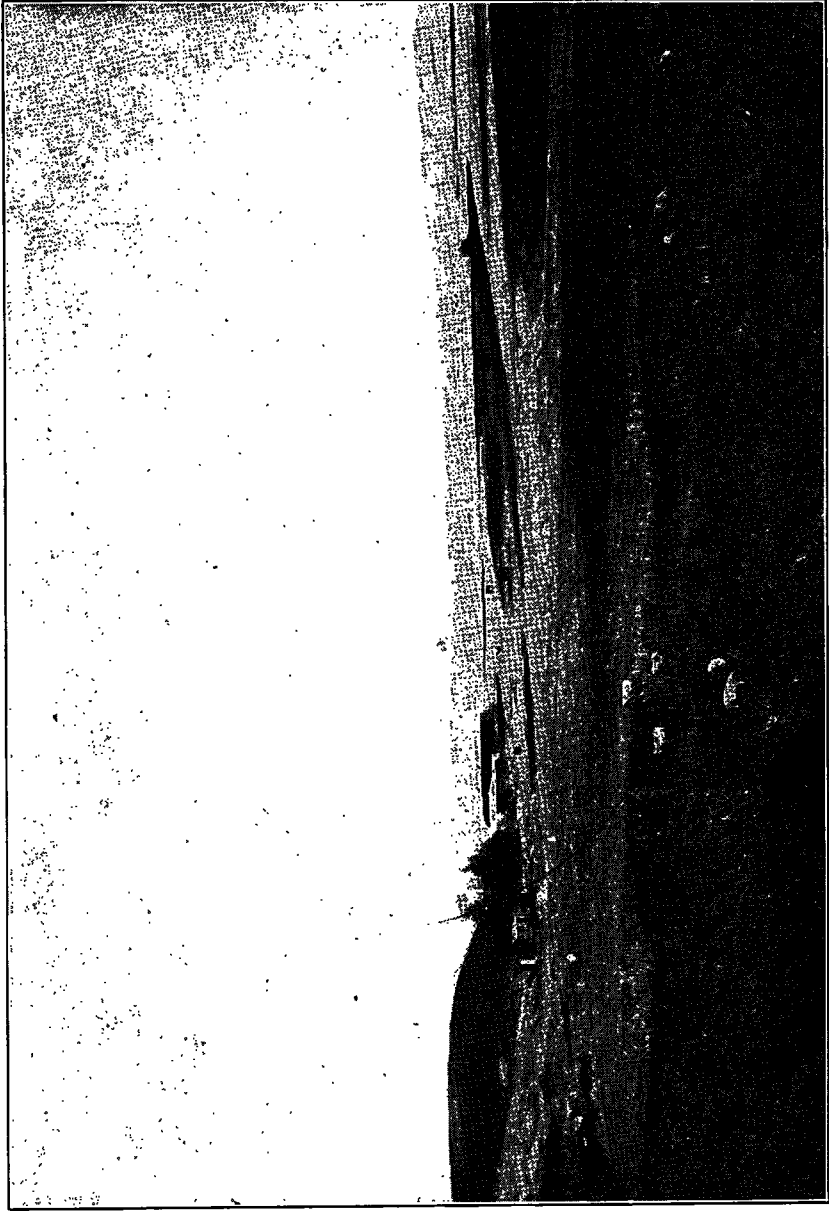
| | Maximum | Minimum | Mean |
|-------------------|---------|---------|-------|
| 1906— | | | |
| March 27-31 | * 1,167 | .... | 946 |
| April | 1,062 | 8 | 117 |
| May | * 2,430 | 6 | * 369 |
| June | * 2,205 | 50 | * 702 |
| July | 2,030 | 16 | 103 |
| August | 38 | 16 | 24 |
| September | 21 | 10 | 14 |
| October | 10 | 7 | 10 |

*Estimated.

River opened March 27.

Maximum gage heights, 10.2 feet March 30; 15.6 feet May 27; 14 feet May 31; 14.7 feet June 10; 14 feet July 1.

Minimum gage height, 3.5 feet October 5.



Lands on Green river susceptible of irrigation.

LITTLE MISSOURI RIVER AT MEDORA, N. D.

The gaging station on the Little Missouri River at Medora was established May 12, 1903. As nearly as can be determined from the surveys thus far published, the drainage area above this point is 5,785 square miles. The "bad lands" topography of the valley causes sudden increase of the flow after heavy rains, the discharge sometimes increasing a hundredfold in a few hours. In this portion of the valley the channel usually has one gently sloping bank, so that at flood stages the width of the river becomes 300 feet or more. The highest flood since the establishment of the gaging station therefore rose only ten feet above extreme low-water. But during floods the swift current scours the bottom of the channel several feet, so that at the time mentioned the depth of the river was probably nearly 15 feet. The gage-zero is 2,230 feet above sea level.

The tables of discharge are based upon the measurements in the list below and fifteen measurements made in the two preceding years. The conditions at the station are not favorable for accuracy in flood measurements, and all figures above 5,000 are therefore subject to possible revision later. On account of the changes in the depth of the channel due to scouring and silting, accurate tables for the lowest stages could be prepared only by making very frequent measurements, and the figures below 100 are therefore merely estimates. For ordinary stages the tables are fairly well checked.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|--|--------------|------------|
| March 26, 1905—E. F. Chandler | 3.60 | 123 |
| July 7, 1905—Chandler and Richards | 8.45 | 4,302 |
| July 8, 1905—R. Richards | 8.18 | 4,195 |
| July 8, 1905—E. F. Chandler | 8.13 | 4,124 |
| July 8, 1905—Chandler and Richards | 8.08 | 4,539 |
| August 6, 1905—R. Richards | 5.96 | 1,256 |
| August 7, 1905—R. Richards | 5.61 | 1,038 |
| August 24, 1905—R. Richards | 4.01 | 269 |
| October 16, 1905—R. Richards | 3.72 | 161 |
| April 11, 1906—E. F. Chandler | 4.77 | 584 |
| August 29, 1906—E. F. Chandler | 7.54 | 3,295 |
| August 30, 1906—E. F. Chandler | 6.59 | 2,027 |
| August 31, 1906—E. F. Chandler | 6.01 | 1,230 |
| September 13, 1906—E. F. Chandler | 3.59 | 104 |
| October 12, 1906—R. Richards | 3.33 | 33.7 |

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

| | Maximum | Minimum | Mean |
|-----------------|---------|---------|-------|
| 1905— | | | |
| March | 2,730 | 41 | 513 |
| April | 41 | 4 | 13 |
| May | 177 | 4 | 64 |
| June | 6,180 | 16 | 2,503 |
| July | 7,540 | 437 | 3,440 |
| August | 5,230 | 92 | 936 |
| September | 1,470 | 2 | 237 |
| October | 681 | 41 | 260 |
| November | 736 | 66 | 219 |

River opened March 1; closed November 28.

Maximum gage heights, 9 feet March 7; 10 feet March 31; 8.5 feet May 23; 10.2 feet July 2; 9 feet July 24; 8.9 feet August 16.

Minimum gage heights, 2.6 feet May 1; 3.1 feet July 3; 2.4 feet September 28.

| | Maximum | Minimum | Mean |
|------------------|---------|---------|-------|
| 1906— | | | |
| March 8-31 | 7,200 | 243 | 1,416 |
| April | 3,890 | 147 | 887 |
| May | 4,690 | 243 | 1,007 |
| June | 10,600 | 355 | 2,002 |
| July | 355 | 92 | 174 |
| August | 4,530 | 92 | 860 |
| September | 1,565 | 79 | 443 |
| October | 79 | 24 | 35 |

River opened March 7.

Maximum gage heights, 9 feet March 7; 10 feet March 31; 8.5 feet May 31; 12 feet June 8; 8.5 feet August 27.

Minimum gage heights, 4 feet March 15; 3.7 feet April 29; 3.5 feet July 31; 3.2 feet October 17.

MISSOURI RIVER.

Some work has been done by the Geological Survey at gaging stations on the Missouri River in North Dakota, but on account of the unfavorable conditions for such work on that river the data do not yet furnish a sufficient basis for the publication of complete summaries.

At Bismarck, N. D., records were continued from September 28, 1904 to April 30, 1906. The following discharge measurements were made.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|---|--------------|--------------|
| October 28, 1904—E. F. Chandler | .16 | 10,352 |
| July 23, 1905—Chandler and Richards | 6.80 | about 49,200 |
| July 10, 1905—Chandler and Richards | 6.70 | about 49,220 |
| August 9, 1905—R. Richards | 4.20 | 28,940 |
| August 30, 1905—R. Richards | 1.30 | 13,248 |
| October 18, 1905—E. F. Chandler | .60 | 8,042 |

The gage zero is 1,617.9 feet above sea level. Low water of November, 1904, was precisely at the gage zero, which corresponded to an estimated discharge of 9,200 second feet. Low water of 1905, on October 5, was at —0.9 (below the gage-zero), and may be estimated at 7,700 second feet. During a brief ice gorge, March 23, 1905, the water rose to the height of 9.1 feet above the gage zero, but the highest mark of the year during the open season was on June 10, when the elevation of 7.9 feet was reached; this may be roughly estimated as corresponding to a flow of between 60,000 and 75,000 second feet.

At or near Williston, N. D., records have been continued from early in April, 1905, to the present time. The following discharge measurements have been made, at Baker's Ferry, about eleven miles below Williston.

DISCHARGE MEASUREMENTS.

| Date and Name of Hydrographer— | Gage Height. | Discharge. |
|---|--------------|------------|
| April 24, 1905—E. F. Chandler | 5.26 | 10,390 |
| May 22, 1905—E. F. Chandler..... | 6.58 | 12,643 |
| June 21, 1905—P. M. Churchill | 12.20 | 69,512 |
| July 10, 1905—P. M. Churchill | 11.10 | 58,028 |
| August 14, 1905—P. M. Churchill | 6.78 | 14,885 |
| September 19, 1905—E. F. Chandler | 4.41 | 6,781 |

The highest stage of 1905, on June 8, was 13.6 feet above the gage zero, and the lowest, on September 29, was 4 feet above the gage zero.

The June flood of 1906 was unusually high, reaching an elevation of 20.2 feet above the gage zero on June 10, and remaining above the 15-foot point from June 8 to June 20, inclusive. The maximum flow was probably between 125,000 and 175,000 second feet.

BIBLIOGRAPHY.

Portions of the river-station records are to be found in the publications in the list below.

Detailed descriptions of stations, lists of discharge measurements, daily gage-height records, and (where computed) station rating tables and summaries of monthly run-off are published each year by the U. S. Geological Survey in the Water-Supply and Irrigation Papers series, as follows:

- For the year 1901, Water-Supply Paper No. 66.
- For the year 1902, Water-Supply Paper No. 85.
- For the year 1903, Water-Supply Paper No. 99, No. 100.
- For the year 1904, Water-Supply Paper No. 130.
- For the year 1905, Water-Supply Paper No. 171, No. 172.

Monthly summaries of discharge at the more important stations for the years 1903 and 1904 were published in the Third Biennial Report of the State Geologist of North Dakota, pages 200 to 208.

Estimates of the seasonal and total flow for the years 1903 and 1904 are also given on pages 45 and 46 of the First Biennial Report of the State Engineer of North Dakota.

In some of the above publications there are to be found various trifling misprints, and some of the estimates first published can now be improved somewhat in view of later data. In the report for 1905 in W.-S. Paper No. 171 there are many omissions and other errors, which have been corrected here; and from the nature of the matter small further revisions are possible; but taken as a whole the records are reliable, and all the data that are of general use are included in the above publications, except those of 1906, as given in the preceding pages, which have not yet been published elsewhere.

CHAPTER V

PRELIMINARY SURVEYS.

Investigations have been made at a number of different times with reference to possible irrigation in the western half of North Dakota. These have generally been undertaken by different officers of the United States reclamation service under the direction of Mr. F. H. Newell, chief engineer. Among the surveys worthy of especial mention are those undertaken by Mr. Frank E. Weymouth, reclamation engineer, 1903, his work being more particularly described in the second annual report of the reclamation service for the year 1902 and 1903, pages 396-400 inclusive, those of Prof. F. A. Wilder, described on pages 400-412 inclusive, in the same report, and also in water supply and irrigation paper, United States geological survey No. 117, under the title of "The Lignite Coal of North Dakota and its relation to Irrigation," the investigations of Mr. S. B. Robbins and Mr. J. A. French of the United States Reclamation service, reported in the third annual report of the reclamation service, pages 420-438 inclusive, and investigations by former State Engineer E. F. Chandler, reported in the first biennial report of the state engineer of this state pages 20-48, inclusive. A still earlier survey of great importance which should be referred to in this connection was that by Mr. Morris Bien, engineer of the United States geological survey in 1890. At that time Mr. Bien investigated the possibility of diverting the waters of the Missouri river out to the Coteau by means of a gravity canal and reported it to be not feasible after very thorough surveys. As reports of all these reconnoissance surveys have been published heretofore, and so are valuable, it is not necessary to do more than to mention them at this time.

RECONNOISSANCE OF THE YEAR 1905.

Investigations of this character made during the year 1905 by the state engineer are described in detail below:

On April 22 the state engineer accompanied by Messrs. H. A. Storrs and J. A. French of the United States reclamation service, and J. S. Green of Mandan, visited the bottom lands of the Missouri valley in the vicinity of Mandan and also certain lands lying near Little Heart Butte. These lands were afterwards described by Mr. French, a plane table survey on a scale of 2,000 feet to the inch, with ten foot contours being made, approximately

fifty square miles in this vicinity being covered in May and June. The survey showed that about 25,000 acres of land in the Little Heart district laid well for the distribution of water, but that it would require a lift of about 200 feet from low water in the Missouri river, the only available source of supply. Of the Missouri River valley flats southeast from Mandan, about 5,000 acres, one-half of which is timbered bottoms, the remainder being of the usual prairie type of the best class, could be covered with a lift of eighty feet. The tracts of land of high grade capable of being covered economically by pumping being too limited in area to warrant the construction of expensive works the project was abandoned for the present, at least. Again upon April 25, accompanied by Messrs. Storrs, French and W. E. Skelton of Bismarck he visited the bottom lands of Apple creek, with a view of studying their irrigability and also to determine as to the feasibility of storing the flood waters of Apple creek through the construction of reservoirs. These features were also afterwards surveyed by Mr. French and it was found that not only was there considerable good land that might be irrigated, but also that it was possible to store a considerable amount of water. Since this was done in connection with the survey of the Bismarck project, described later, and this project is now temporarily abandoned, the possibilities have not been followed up.

On May 4 the office was visited by Mr. C. E. Grunsky, consulting engineer of the United States reclamation service, who discussed in detail the various projects and possibilities in the state with the state engineer. Mr. Grunsky stayed two days, visiting the state engineer's office and the Bismarck project.

On May 9 and 10 certain tracts on the Heart and Knife rivers were visited at the request of private parties and the irrigation of small tracts by pumping was recommended. In company with Messrs. Storrs and French the state engineer went on May 19 to visit the old Fort Stevenson reservation. There is here a large and fine body of land that might be irrigated at a reasonable cost, but as it is now being disposed of to private individuals it is doubtful if anything will be done in this direction. On the 20th the party joined Messrs. F. A. Williams and I. P. Baker at Manhaven and boarded one of the steamers belonging to Mr. Baker. The party were then conveyed down the Missouri river to Bismarck, notes being taken of a number of irrigation possibilities en route, it being apparent that there were large tracts of land susceptible of irrigation worthy of further investigation at some later date. From May 21 to 30 and again from June 2 to 6 and July 3 to 15 inclusive were spent in the vicinity of Williston investigating certain conditions affecting the pumping projects of that region, described later, and co-operating with the officers of the United States reclamation service. On July 16 the state engineer met Messrs. F. H. Newell, chief engineer, H. N. Savage,

Supervising engineer, H. A. Storrs, electrical expert, and G. Y. Wisner, consulting engineer, of the United States reclamation service, at Bismarck, and with them went over the Bismarck, Lower Yellowstone, Budford-Trenton, Williston, and Nesson reclamation projects, this survey taking until the 26th. As these projects are described in detail elsewhere, they are merely referred to at this time.

On August 2 the state engineer, accompanied by Prof. Daniel E. Willard, geologist, of the state agricultural college, left Bismarck for the purpose of making a detailed study of the southwestern corner of the state. On August 3 a number of citizens at Dickinson interested in the subject of irrigation, were interviewed, and upon the same day a livery team having been secured, a start was made to the southward, the distance covered that day being as far as New England on the north fork of the Cannonball river, a distance of about twenty-five miles. From data gathered at this point it appears that there are many small tracts along this stream that could be irrigated to advantage by pumping, with lifts of from twelve to twenty feet. It seems probable, moreover, that reservoirs could be constructed economically on some of the branches of the Cannonball by means of which the good waters could be stored for use when most needed.

August 4 and 5 were occupied in studying the region between New England on the north fork of the Cannonball and Haley on the north fork of Grand river. A number of streams were examined, the channels of which were practically dry at this time. Along Chantapeta creek, Cedar creek, Buffalo creek, and Lightning creek, it would seem that a number of small tracts could be irrigated, during the spring at least, and at other times by storing the flood waters. The 6th and 7th were spent in the study of the north fork of Grand river and its tributaries. There, too, the conditions seemed favorable for the irrigation of considerable land, sometimes in large tracts. It was believed that especially in the vicinity of Haley, several thousand acres might be irrigated if the farmers of that locality would combine in the construction of a reservoir and canals. A more limited area might be profitably irrigated without the construction of storage reservoirs. These, however, would involve pumping, whereas the use of reservoirs would permit of the employment of gravity canals. The sentiment of this region seemed to be somewhat favorable to irrigation as the fact was apparently recognized that much more profitable crops could be raised with irrigation than without it. On the 8th a brief study was made of the conditions of the Little Missouri river. Here, as has been stated by other investigators, notably Mr. Weymouth, referred to above, there are many opportunities for pumping to small tracts for the purpose of raising feed for stock, but owing to the nature of the bad lands it does not seem that it would be practicable to take any great quantity of

water out of the streams by gravity canals. Upon the 9th and 10th the regions drained by Deep creek, Sand creek, and the south branch of the Heart river were studied. Here conditions resemble those on the Cannonball and its tributaries as many small tracts could be irrigated to advantage, the existence of numerous cut banks and the narrowness of the valleys making it impracticable here as there to construct long irrigation canals. As a general thing, pumping is necessary. This reconnoissance was discontinued at this point.

It was resumed once more by the state engineer on September 25, at which time a more extensive study of the conditions in the western part of the state south and west of the Missouri river was undertaken. In this study the United States reclamation service co-operated by furnishing a man and team, Mr. J. I. Bingham, engineering aid, being designated as assistant by Mr. H. N. Savage, supervising engineer, United States reclamation service, and a team and the necessary camp outfit being furnished by Mr. P. M. Churchill, engineer in charge of the United States reclamation work in the vicinity of Williston.

This reconnoissance, undertaken as it was, in co-operation with the reclamation service, had a number of different objects in view.

1. The discovery, if possible, of irrigation projects that might possibly be undertaken by the reclamation service.

2. Further investigation of projects heretofore considered and reports concerning them.

3. Encouragement of those interested in irrigation on their own account, and

4. General study of the region traversed.

From the 25th to the 27th inclusive the Cherry creek and South Tobacco Garden creek valleys were studied. The irrigation of this region had been previously considered possible by pumping either from the Little Missouri or the Big Missouri rivers, or both, and with this object in view large tracts in this locality had been withdrawn from entry by the general government until an investigation could be made. Considerable information was furnished by Mr. Charles Shafer and others, and a report concerning the matter was forwarded on October 2 to Mr. Churchill and was transmitted by him to the supervising and chief engineers of the reclamation service. This report is as follows:

Bismarck, N. D., Oct. 2, 1905.

Mr. P. M. Churchill, Engineer, U. S. Reclamation Service, Williston, N. D.,

SIR: Having examined the proposed Cherry creek and South Tobacco Garden reclamation projects with some care since leaving Williston on September 25, I beg to report as follows:

Location—The proposed reclamation project lines along the ancient glacial drainage valley connecting the Little Missouri and

the Missouri rivers, this valley being now drained by Cherry creek, which flows to the south, emptying into the Little Missouri, and South Tobacco Garden creek, which flows north into the Missouri river, the entire tract lying in what is now McKenzie county, North Dakota. It has been thought by some that in early ages the Little Missouri flowed into the Missouri by way of this pass, an assumption that seems reasonable. The more level portions of the tract, covering an area of some 15,000 acres, lies near the head of the valley with a low flat divide between the two. There are other level tracts aggregating perhaps as great an additional acreage at higher elevations along the two creeks, but, excepting indirectly, these are unimportant from the standpoint of the proposed project.

Character of the Land—The level tracts are of great evenness, and as a rule lie well for irrigation with the possible exception that in some sections they are too flat to permit of satisfactory drainage. They extend for the most part in a north-northeasterly and a south-southwesterly direction, and constitute a strip from one to three miles wide and some twelve or fifteen miles long, beyond which limits the valley becomes narrow and uneven. The lands are of great fertility, about the only drawback being occasional gumbo tracts which should, however, yield readily to irrigation.

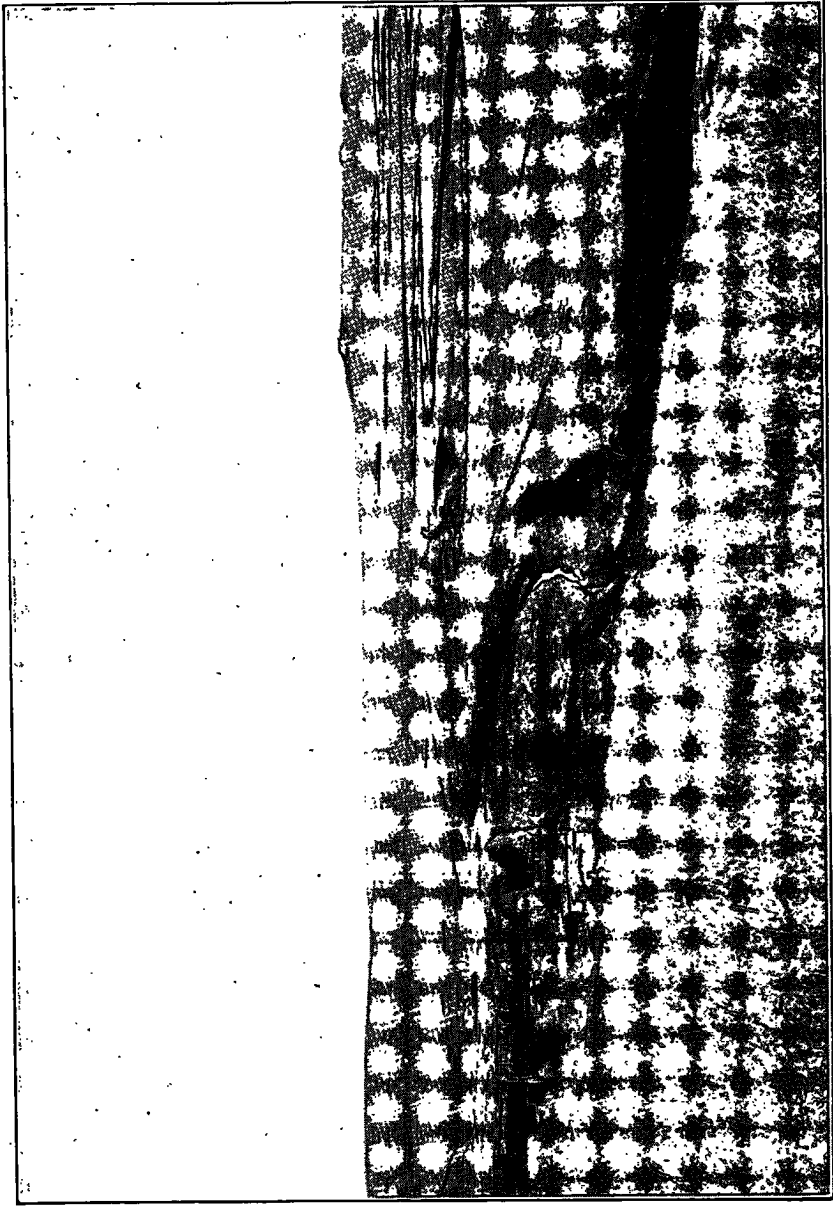
The same varieties of crops could be raised that can be raised about Williston, namely, wheat, oats, speltz, flax, etc., the various kinds of hay, and the hardier varieties of plums and apples.

At the present time this section is given over for the most part to cattle raising, but a small amount of grain is raised, and nearly every ranch has a kitchen garden which produces fairly well in ordinary years without irrigation, but with irrigation produces abundantly in all years, as is demonstrated at the Schafer postoffice. The entire tract is traversed by a preliminary line, just surveyed, of the Northern Pacific railway, but construction has not yet been commenced, nor has a final location been made.

A considerable part of the tract is now under private ownership, and there can be no doubt but that many filings would be made were not the lands withdrawn from entry, since many are now being made in the adjacent territory.

Water Supply—For the irrigation of these flats five sources of water may be considered. These are (1) springs and wells; (2) normal run-off; (3) storage of run-off; (4) the Little Missouri, and (5) the Missouri.

(1) Springs and wells and (2) normal run-off. The supply furnished from these sources is clearly inadequate to irrigate any large tract of land. A careful examination of the two Schafer springs, said to be the most important springs in the region, showed that, combined, they furnished but one-tenth of one cubic



Irrigable lands near Schafer, North Dakota.

foot per second. The wells of that region are like most of the wells of the prairie region, furnishing merely a supply for domestic use and for stock. The normal discharge from both South Tobacco Garden creek and Cherry creeks, added together, is hardly more than two cubic feet per second. The sources of supply are, then, totally inadequate to irrigate any considerable acreage.

(3) Storage of Flood Waters—So far as could be ascertained the flood flow is not to be depended upon. During the summer of 1905 there was practically no flood flow in this region and from a study of the character of the streams, the highwater marks, the drainage basins, and the reports of old residents, I doubt the possibility of storing more than 8,000 or 10,000 acre feet of water in ordinary years. From this amount would have to be deducted losses by evaporation and seepage, and, taking everything into consideration, it is doubtful if more than 4,000 acres could be irrigated by this means alone in ordinary years. The combined drainage area of the two creeks above the proposed projects is approximately 200 square miles, which would, for 10,000 acre feet, require a surface run-off of about one inch, which is probably approximately the actual run-off. Thus far, moreover, no satisfactory reservoir sites have been discovered, although with so flat a valley and with the rolling character of the surrounding country, it is probable that all the run-off could be stored without very great cost. I am of the opinion, moreover, that practically all of it will eventually be stored by private and corporate means, and that it can be utilized to the best advantage, all things considered, in that way. There are many opportunities for storing water on a small scale and utilizing it on tracts of 160 acres and upwards, and it appears to me wise to let this development take place gradually rather than all at once by government assistance.

(4) and (5) The Two Missouris—I was extremely fortunate in being able to secure, through the courtesy of Mr. Hoffman, locating engineer of the Northern Pacific Railway company, the levels along their line that are most important in connection with the project, so that it was unnecessary for me to either run lines or to use aneroid readings although the aneroid readings that I made correspond satisfactorily with those given me by Mr. Hoffman. The most important elevations are as follows:

| Station of Survey | Description of Locality | Sec., Twp., R. | Elevation |
|-------------------|--|----------------|-----------|
| 6026 | Low water level of Little Missouri at mouth of Cherry Creek | 31-149-96 | 1874 |
| 6040 | Low water in Cherry Creek | 31-149-96 | 1874 |
| 6656 | Low water in Cherry Creek at Schafer | 28-154-98 | 1980 |
| 6658 | General prairie level at Schafer | 28-154-98 | 2000 |
| 7466 | Summit of divide between head of Cherry Creek and head of Timber Creek | 23-154-98 | 2243 |
| 8400 | Missouri river bottom | 18-150-100 | 1843 |
| 8680 | Low water level at Baker's ferry, Missouri river | 31-153-100 | 1810 |
| 8680 | High water level at Baker's ferry, Missouri river | 31-153-100 | 1822 |
| 8680 | High water from ice gorge | 31-153-100 | 1833 |

To cover the proposed projects satisfactorily from the Little Missouri would require a lift from an elevation of about 1874 to one of about 2050, approximately, the elevation of the highest lands that should be reached. Allowing also for the grade of the necessary canals a lift of at least 200 feet would be required. A canal some thirty miles long through a rather rough country would be necessary and it is probable that a thorough study would show that it was necessary to flume or syphon a number of low places. Moreover, the low water of the Little Missouri is quite small and probably would have to be augmented by storage which would be impracticable, owing to the nature of the stream and valley, excepting near its head, some 200 miles away in a straight line, not taking into consideration the windings of the river.

From the Missouri river, it would be necessary to lift the water over 250 feet under similar conditions excepting that no storage would be required.

I have not thought it necessary for me to make a detailed estimate as to cost. Comparing the conditions with those prevailing upon the Missouri river projects it would seem that the primary cost would amount to at least \$50 per acre and the maintenance charge would be correspondingly high.

Recommendations—Under the conditions cited above I fear it will be a great many years before it will be thought feasible to irrigate the Cherry creek flats, and I recommend that the tracts withdrawn be restored to entry.

Very respectfully,

A. L. FELLOWS,
State Engineer.

In accordance with the recommendations made at the conclusion of the foregoing report the greater part of the lands which had been segregated were restored to homestead entry, it being deemed wiser that parties desiring to make homestead entries should be permitted, under the terms of the reclamation act, to do so, it being often possible for them by means of storage, or possibly pumping, to irrigate small tracts for themselves, rather than prevent all entries and the consequent development of the country, until such time as the government would feel justified in undertaking the very expensive construction that would be necessary.

From this district the line of investigation crossed the Little Missouri at the "Diamond" C crossing, where, again, such conditions were noted as had previously been found at other places along this stream, i. e. that it was quite practicable to pump from the stream for tracts of from 100 to 1,000 acres along the river bottoms, but that no large gravity system could be constructed owing to the cut banks and the slight grade of the river and the character of the bad lands in general.

The lands along the Green and Knife rivers were then carefully studied. Here, too, as appears to be the case on Spring creek, one of the principal tributaries of the Knife river, there are numerous small opportunities for private construction, many opportunities existing upon the tributaries for the application of water on a small scale, and very many tracts of land being found that could be profitably irrigated. Some interest is being shown in the subject throughout this entire region and a number of small projects are being investigated by the land owners. Irrigation was found to be successfully practiced by Mr. E. Paulson on Knife river and by Fisher Bros. on Green river. There are also many opportunities for co-operation on the part of the farmers, it being found possible in a number of cases for several of them to combine in the construction of diversion dams and canals. This is a common and most profitable practice in irrigation countries generally and might well be employed in this region also, as well as on many other streams in the western part of the state. The most important of the possibilities along these streams was a tract of possibly 5,000 acres upon Green river northwest of Dickinson and 15,000 acres in the vicinity of Stanton on the Knife river. This part of the reconnoissance took until October 11. After three days in Bismarck a fresh start was made on October 14, with a view to studying the conditions along the Muddy, a tributary of the Heart river, emptying into it near Sims in Morton county, and upon the Heart river itself, this stream being followed from its mouth practically to its head. No large or particularly important possibilities were discovered, but the same conditions were found to prevail upon these streams that prevail upon the others, viz: That there are many places where irrigation might profitably be undertaken by the farmers themselves. The largest tract investigated was that near the mouth of the Muddy, owned principally by Mr. John Thompson.

While the investigations did not result in any great or especially important projects that could be undertaken directly by the United States reclamation service, a possibility that was hardly hoped to exist, yet it did result in the discovery of many small possibilities that might be undertaken by the farmers themselves and in the encouragement of those who are interested in the beneficial application of water. It was found, too, that there were a number of places where the land owners might, by combining and making a proper application to the reclamation service, giving assurance that the provisions of the reclamation act would be complied with if the projects were found feasible, and thus furnishing projects of sufficient size and importance to warrant the government's taking hold of them. The initiative in such cases, however, must come from the people themselves, as the bulk of the lands are always in private ownership and are generally held in tracts of more than 160 acres. Since the two prin-

cipal objects of the reclamation service are, first, to create homes for the greatest possible number of people, and, second, the irrigation of lands belonging to the government, and since the largest amount of land for which water can be furnished to any one person is 160 acres, it is clear that if land owners desire to be benefited by the application of the reclamation act they must subdivide their lands into tracts of 160 acres or less and dispose of them to actual settlers, and, also, actually to use the water furnished by the government in the production of crops. The state engineer has been assured by the chief engineer of the reclamation service that where the initiative is thus taken by the people and where proper assurance is given by them that they will comply both in letter and spirit with the terms of the reclamation act, every proper effort will be made by the reclamation service to construct the desired works. The relation that exists between the purposes of the reclamation act and the conditions prevailing in the state of North Dakota are described more in detail elsewhere.

This portion of the investigations was completed on October 25, 1905, the outfit furnished by the government being turned over to Mr. F. E. Weymouth, engineer, United States reclamation service, at the government camp at LaMesa, on the lower Yellowstone project of Montana and North Dakota.

PRELIMINARY SURVEYS OF THE YEAR 1906.

Considerable time having been spent in the year 1905 in becoming familiar with the irrigation needs of the western part of the state, it was deemed best to make certain preliminary surveys in the year 1906, and in the latter part of July this year a small party was organized and sent out with this end in view. The undertaking of this work had been considerably delayed owing to the increasing demands of the drainage problems of the state, but on July 24 the state engineer, accompanied by one assistant visited the valley of the Knife river near Fayette and made a preliminary survey of a reservoir site in that locality. A fairly good site was found and the investigations of the preceding year had demonstrated there was plenty of good land farther down the stream, that might be irrigated. Doubtless this will be done at some time in the future. Small irrigable tracts were also surveyed both upon the Green and Knife rivers, but the results of these surveys have not yet been worked up. They will be platted during the coming winter and will, thereafter, be available for examination by anyone interested.

Pressure of office work called the state engineer in early August, and thereafter this work was prosecuted by the assistant state engineer, Mr. Atkinson, who reports as follows:

PRELIMINARY SURVEYS.

Following the recommendations of the state engineer in his report on reconnoissance investigations in the southwestern part of the state in 1905, the assistant state engineer with two assistants, a team and camp outfit, left Dickinson on the 17th of August, 1906, for the purpose of making preliminary surveys of several of the projects noted by the state engineer, all of which are described in detail below.

NORTH FORK OF GRAND RIVER PROJECT.

The north fork of Grand river rises in township 129 range 105, Bowman county, North Dakota, and flows in an easterly direction nearly parallel with the South Dakota line for forty miles, thence leaves the state of North Dakota in township 129, range 98, flows southeasterly and joining the south fork, thus forms the Grand river, which enters the Missouri near the town of Evarts, South Dakota. The north fork drains part of the Cave Hills country in South Dakota and is joined in township 129 range 101, by Crooked creek from the southwest and by Spring creek coming from the northwest.

Character of the Stream—While the general course of this stream through North Dakota is east, yet it has the same sinuous course as all of our western North Dakota streams. The fall of the valley is nine feet per mile. Owing to the rugged character of the land in the drainage basin, a considerable amount being in the bad lands, the run off is considerably greater than in most of our streams. By observation of the high water marks and from information given by the inhabitants it is believed that the spring floods are generally large, furthermore, each shower raises the stream quite materially. At the commencement of our survey on the 20th of August only about one cubic foot of water per second was flowing at the junction of Spring Creek. On the evening of the 25th a heavy shower occurred to the west, near the bad lands, and on the morning of the 28th the stream reached its maximum flow from this shower, which measured 19 cubic feet per second. The flow held to nearly this amount for three days, then gradually subsided.

Reservoir—The location of the dam site was made near the range line between ranges 100 and 101, just below the junction with Spring creek. A preliminary survey was made of the dam site and also of the reservoir above. The extreme length of the dam on top would be 3,800 feet, the maximum height 41 feet, and the available reservoir capacity 18,000 acre feet, or enough water to irrigate about 9,000 acres. This reservoir would flood Spring creek for about $2\frac{1}{2}$ miles from the dam, and up the north fork of Grand river about the same distance, the average width of each branch of the reservoir being about one-half mile.

The dam would be constructed of earth and it is thought that sufficient stone can be conveniently obtained to do the riprapping and necessary masonry work. The drainage basin west of the dam site is about 400 square miles.

Character of the Land—A preliminary survey of the land which could be placed under ditches from the reservoir was made. The lands lie about equally on either side of the stream, and in the survey no lands were included which were more than 30 feet above the low water mark of the stream, and extending along the stream about 17 miles below the dam, from one-half to a mile and a half wide. A few cut banks are encountered, but are not of enough account to increase very materially the construction of ditches or flumes for the conveying of water in the main canals. The bed of the stream lying from 12 to 15 feet below the surface of the valley bottom gives good drainage for the proposed irrigated lands. Alkali land is found in small quantities, but not of such character but that it can be readily reclaimed by irrigation. Some sloughs were found, especially near the west end of the tract, and old channels of the stream as well, but in general the land lies well for irrigation. The total amount of land lying between the two lines run on either side of the valley and not more than 30 feet above the low water mark of the stream, is about 10,000 acres, but it is thought that a more detailed survey would show about 8,000 acres that can be successfully irrigated. Of this amount about 6,600 acres lies in North Dakota and 1,400 in South Dakota. The soil is a deep rich loam and any of the crops grown in North Dakota do well here.

LIGHTNING CREEK.

A careful examination of Lightning creek, which empties into the north fork of the Grand river, was made on September 14, and while there are several small tracts that could be irrigated by pumping, or upon which spring flooding could be done, by the construction of small diversion dams, yet only one point was found where the storage of water is possible and the water so stored used on the lands below. A preliminary survey was made on September 5 for a dam in section 19, township 129, range 98, and the reservoir formed by the dam would flood part of the above named section and a part of section 24, township 129, range 99.

The capacity of this reservoir would be 1,500 acre feet or a sufficient amount to irrigate 750 acres, which land lies on each side of the stream below the dam and near the mouth. This land is of the same character as that on the north fork of the Grand river.

BUFFALO AND FLAT OR HIDDENWOOD CREEKS.

On the 11th and 12th of September, a study was made of Buffalo creek and Flat or Hiddenwood creek with a view of finding if possible a suitable location for the storage of flood waters. No reservoir sites could be found on these streams. The character of the bottom lands along these creeks is very similar to that on the north fork of Grand river, and it seems probable that many small tracts could be profitably irrigated by pumping.

CEDAR CREEK OR SOUTH FORK OF THE CANNONBALL RIVER.

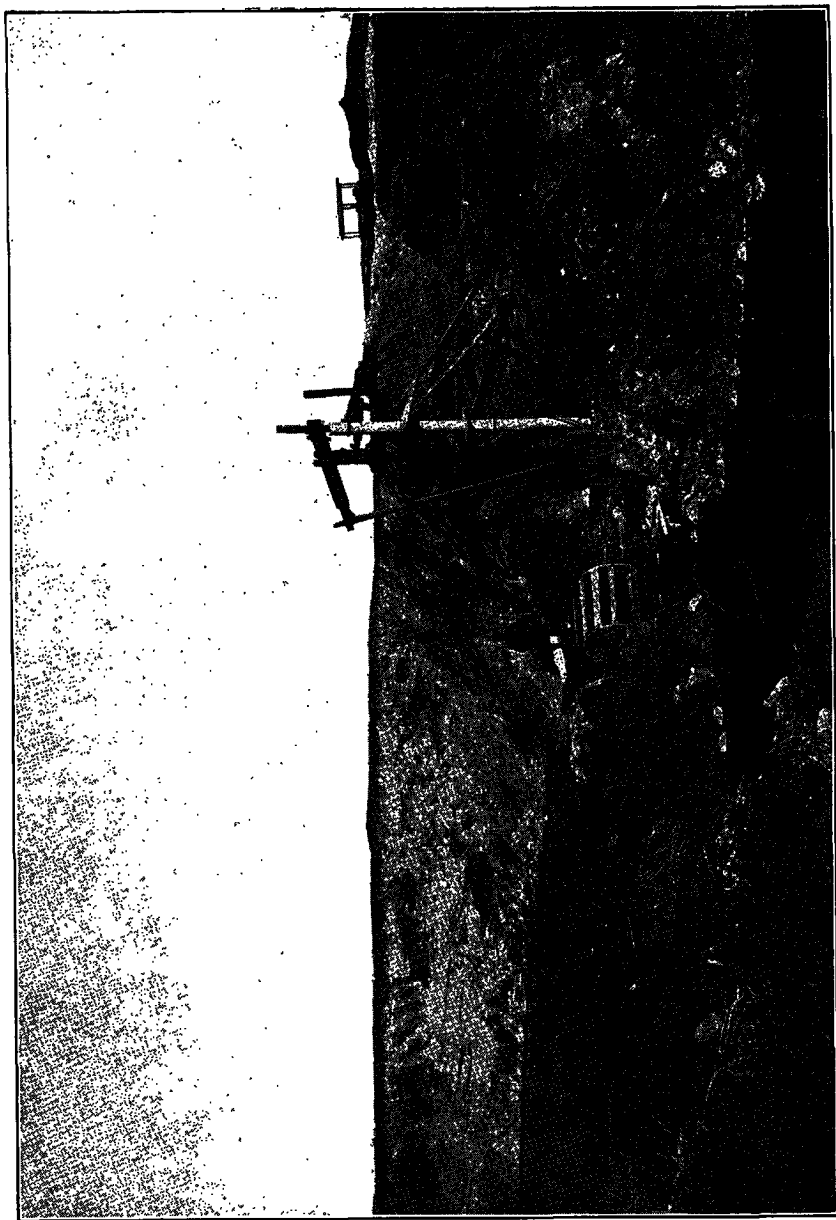
On the evening of September 12 camp was made on Cedar creek, or south fork of the Cannonball, in township 130, range 93, and on the morning of the 13th a study was commenced. The valley of the stream is narrow with high land on either side, with the stream winding through the valley, first touching one side and then the other, forming cut banks so that any extensive irrigation of the bottom lands is impracticable, although many small tracts can be successfully irrigated by pumping, and lignite coal is found in sufficient quantities to make the cost of pumping per acre foot small in comparison with the benefits derived. Also small diversion dams can be constructed diverting the flood waters, and greatly increased yields be the reward for labor and expense involved. On the afternoon of the 13th a suitable reservoir site was discovered in township 134, range 95, and a preliminary survey of this reservoir and the land below was made.

Reservoir—The drainage area of the creek at the dam site is 425 square miles and the capacity of the reservoir at an elevation of 45 feet above the bed of the stream at the dam site is 15,500 acre feet. The length of the dam on top would be 3,000 feet and its height above the bed of the stream 50 feet.

Land Below Dam—The preliminary survey of the land below the dam showed that about 8,000 acres lying not more than 40 feet above the bed of the stream could be successfully irrigated by pumping from the reservoir, the maximum lift of the pump being not over 30 feet. The land in general lies well for irrigation. The soil wherever it has been cultivated shows it to be very fertile, and under irrigation would give abundant harvests annually. After the preliminary surveys above noted were completed a further examination of the stream towards its source was continued, and while several reservoir sites were noted, no survey of them was made for the reason that no land was found on which water from such reservoirs could be profitably utilized.

NORTH FORK OF THE CANNON BALL RIVER.

On September 17 an examination of the north fork of the Cannon Ball river was commenced at the junction of Philbrick creek with this stream, in township 136, range 98, and prosecuted towards its junction with Cedar creek. This branch of



Home-made pumping plant of Erland Paulson on Knife river.

the Cannon Ball is of the same nature as the south fork, and while several reservoirs were noted no survey was made for the reason that land in sufficient quantity to warrant the construction of reservoirs of large capacities could not be found close by. On September 19 a reservoir site was found in township 134, range 95, which apparently had sufficient land below it to warrant its construction, consequently a preliminary survey was made of this reservoir and the land below, which showed that with a dam having a top length of 1,740 feet and 45 feet above the bed of the stream at its highest point would hold back 10,600 acre feet of water, sufficient to irrigate 5,300 acres. The land below the dam which could be irrigated by water stored in a reservoir so constructed was found to be 4,600 acres, 3,600 acres of which would be irrigated by pumping, the maximum lift being 52 feet and the minimum lift 22 feet. One thousand acres could be irrigated by a gravity ditch, this would be land lying along the valley bottom. There is no question about the fertility of the land in this project, and the application of water is sure to result in the increased yields from every variety of crops grown in the state. After the preliminary survey was made, the examination of the stream was made for other projects, the stream being followed to its junction with the Cedar creek or south fork, and no land in tracts larger than 200 acres was found on which water could be placed to advantage.

EXPENSES OF PRELIMINARY SURVEYS.

Regarding the expenses of making the preliminary surveys above described, I have given below an itemized statement of the expense connected with the survey of the project on the north fork of the Grand river.

| | |
|--|--------------|
| Salary, T. R. Atkinson, asst. state engineer, 24 days at \$5 . . . | \$120 |
| Salary, H. V. Ausburn, engineering aid, 24 days at \$2.50 | 60 |
| Salary, Thorn Dickinson, engineering aid, 24 days at \$2 | 48 |
| Team | 72 |
| Board of men | 55 |
| Total | \$355 |

CHAPTER VI.

DRAINAGE.

Section 63 of the Irrigation Code is as follows:

"Sec. 63. Whenever requested so to do by any of the boards of county commissioners of any of the counties of this state, it is hereby made the duty of the state engineer, either by himself or any authorized assistant engineer to co-operate with said county commissioners in the engineering work required to lay out, establish and construct any drain to be used by any county or counties or portions of the same for the purpose of diverting flood waters, lakes, water courses, and in general to aid and assist the counties of this state in making preliminary surveys and establishing systems of drainage."

In accordance with these provisions this office having been requested by some of the boards of county commissioners in the Red River valley to co-operate with them and with the officers of the division of irrigation and drainage investigations, office of experiment stations, United States Department of Agriculture, in the proposed survey of the North Dakota lands needing drainage in the Red River valley, took up the matter with the proper officers at an early stage after the appointment of the state engineer, and a basis of co-operation was soon decided upon. The basis for the surveys of 1905 were that the state engineer furnish the services of an assistant both for field and office work. Mr. T. R. Atkinson of Fargo was appointed as such assistant and the following is from his report:

*DRAINAGE SURVEY OF THE RED RIVER VALLEY.

During the winter of 1904 and 1905 arrangements were made between the division of irrigation and drainage investigations, office of experiment stations, United States Department of Agriculture and the counties of Cass, Traill, Grand Forks and Walsh, whereby the department agreed to make a topographic survey of a strip of land fifteen miles wide along the Red river, the counties above named to pay one-half of the expense. The same proposition was offered the counties of Richland and Pembina. Richland county did not avail itself of the opportunity offered, and Pembina desiring a larger territory surveyed than the fifteen mile strip, no surveys were made of this county during the summer of 1905, but at the annual convention of the North Dakota

Drainage League, held in Grand Forks, January 10 and 11, 1906, James J. Hill, in an address delivered before this meeting, being at the time unaware of the topographical survey made in the four counties of Cass, Traill, Grand Forks and Walsh, stated that the first step toward systematic drainage of the North Dakota side of the Red river valley was to have such a survey thoroughly made, and offered to pay one-third of the cost of such survey, whereupon the state engineer being informed by Mr. Hill that the offer would hold good for Pembina county, met the county commissioners of this county and arrangements were made whereby a strip not less than 24 miles wide from the Red river west through the county should be surveyed, Mr. Hill paying one-third of the expense, or \$900; the United States drainage service \$700, Pembina county \$700, and the state engineer's office the balance in services up to \$400.

The survey of the fifteen mile strip through Cass, Traill, Grand Forks and Walsh counties was commenced on June 19, 1905, at the south line of Cass county, Mr. John T. Stewart, United States drainage engineer, supervising; T. R. Atkinson, assistant state engineer, in charge of the field work, and completed as far as the north line of Walsh county on October 13, 1905.

The field party consisted of four level parties, each consisting of a level man and rod man, and was provided with a camp outfit, one cook and one driver with four horses. Levels were taken every quarter of a mile, and oftener when the topography of the country required, on all section lines running east and west, and on the north and south section lines at the eastern and western limits of the survey. The method of work was as follows: Each level party was daily assigned to one section line, and was given the number of miles of line he must run that day, varying from six to ten, depending upon the weather, conditions of the roads or topography of the country. Camp was also moved ahead and located at a point most easily accessible to all the men at night. Each level party in addition to taking the levels along the line assigned to it also sketched and noted the topography for one-half mile on either side of his line, and in the evening the notes obtained through the day were platted on township plats.

The field work of the four counties of Cass, Traill, Grand Forks and Walsh having been completed on October 13, 1905, Mr. Stewart on the invitation of the state engineer, established his winter quarters at Bismarck, in this office, where with the aid of the assistant state engineer, the drainage map of each county was made, showing the elevations as taken by the survey party in the summer, also the division of the county into drainage districts, and the ditches advised for each district. As Mr. Stewart has written a very exhaustive report of the work covered by the survey, this report showing the approximate cost of each ditch shown on the plat, together with other matter relative

to the work, which report will soon be ready for distribution, and preliminary copies of which are already on file in the respective county offices and in this office, where it may be studied by any one desiring to do so, it is not deemed advisable to go into a more detailed report here, but interested parties are referred thereto.

A summary is however given herewith:

CASS COUNTY.

| Name of District | Acres in District | Estimated Total Cost | Estimated Average Cost per Acre |
|------------------|-------------------|----------------------|---------------------------------|
| Hickson..... | 12,800 | \$ 22,931 | \$1.79 |
| Rose Coulee..... | 39,000 | 64,949 | 1.67 |
| Fargo..... | 35,000 | 54,598 | 1.56 |
| Sheyenne..... | 35,000 | 75,754 | 2.16 |
| Canfield..... | 74,000 | 179,083 | 2.42 |
| Argusville..... | 110,000 | 290,987 | 2.65 |
| Gardner..... | 47,300 | 99,187 | 2.10 |
| Hunter..... | 24,000 | 41,414 | 1.73 |
| Total..... | 377,100 | \$828,903 | \$ 2.20 |

TRAILL COUNTY.

| Name of District | Acres in District | Estimated Total Cost | Estimated Average Cost Per Acre |
|------------------|-------------------|----------------------|---------------------------------|
| Elm River..... | 62,000 | \$ 81,761 | \$ 1.32 |
| Hillsboro..... | 52,500 | 94,187 | 1.79 |
| Belmont..... | 83,000 | 148,514 | 1.79 |
| Buxton..... | 36,400 | 89,970 | 2.47 |
| Total..... | 233,900 | \$ 414,432 | \$ 1.77 |

GRAND FORKS COUNTY.

| Name of District | Acres in District | Estimated Total Cost | Estimated Average Cost per Acre |
|-------------------|-------------------|----------------------|---------------------------------|
| Reynolds..... | 48,000 | \$ 74,900 | \$ 1.56 |
| Thompson..... | 30,000 | 58,054 | 1.93 |
| Merrifield..... | 42,800 | 81,241 | 1.90 |
| Manvel..... | 37,000 | 71,622 | 1.93 |
| Ojata..... | 20,000 | 35,987 | 1.79 |
| Turtle River..... | 104,000 | 228,140 | 2.19 |
| Total..... | \$ 281,800 | \$ 549,944 | \$ 1.95 |

WALSH COUNTY.

| Name of District | Acres in District | Estimated Total Cost | Estimated Average Cost per Acre |
|------------------|-------------------|----------------------|---------------------------------|
| Island..... | 5,760 | \$ 19,507 | \$ 3.39 |
| Marais..... | 22,400 | 52,413 | 2.34 |
| Salt Lake..... | 14,000 | 44,603 | 3.18 |
| Grafton..... | 95,000 | 223,464 | 2.35 |
| Auburn..... | 56,300 | 97,864 | 1.74 |
| Total..... | 193,460 | \$ 437,851 | \$ 2.26 |

SUMMARY.

| Name of County | Acres in County | Estimated Total Cost | Estimated Average Cost per Acre |
|------------------|-----------------|----------------------|---------------------------------|
| Cass..... | 377,100 | \$ 828,903 | \$ 2.20 |
| Trails..... | 233,900 | 414,432 | 1.77 |
| Grand Forks..... | 231,800 | 549,944 | 1.95 |
| Walsh..... | 193,460 | 437,851 | 2.26 |
| Total..... | 1,086,260 | \$ 1,231,130 | \$ 2.05 |

In addition to the estimates given above the following expenditures for river improvement are recommended:

*Elm river, Traill county.....\$72,000

The survey of Pembina county was commenced on the 29th day of June, 1906, camp being made at St. Thomas and the work carried on by the same methods, and practically the same party as used in the counties south the previous season. Levels were run on all the east and west section lines of the county as far west as the foot hills of the Pembina mountains, and plats and reports by Mr. Stewart will soon be issued.

To ascertain the amount of damage caused by land not being properly drained in the Red river valley, circular letters were sent out by this office in the fall of 1905 to the township clerks of 161 townships, representing about 3,000,000 acres of valley land. Replies were received from 130. Taking the number of acres reported, averaging and applying the number of letters sent out, the facts were found to be as follows:

* The estimates are based upon a cost per cubic yard excavated of from eleven to fourteen cents, the amount varying inversely as the size of the ditch.

| | |
|--|---------|
| Number of acres that could not be seeded..... | 89,234 |
| Number of acres that could not be seeded summer fallowed | 70,187 |
| Number of acres not worth cutting..... | 87,035 |
| Number of acres too wet to plow in fall..... | 166,625 |
| Number of acres too wet to be harvested..... | 171,493 |

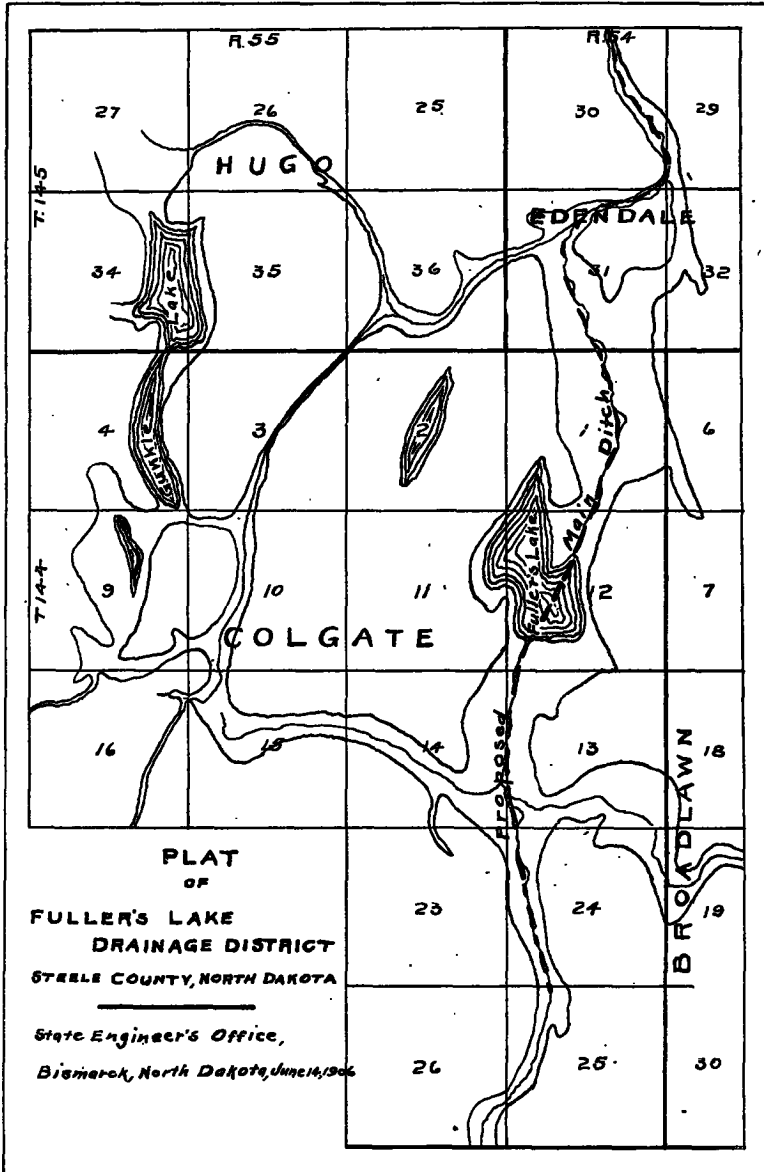
Several letters show that while certain tracts were too wet to be harvested at the proper time, cutting was, nevertheless, done after much of the grain had shelled out. Furthermore, much of the plowing was done when the ground was in poor condition, as was indicated in one of the replies, which stated, "It was too wet to plow, but we plowed." Adding the amount not worth cutting to that which was too wet to be harvested there would be a total loss of crop on 253,660 acres, and estimating the crop on an average acre of properly drained land at 15 bushels of wheat valued at 70 cents per bushel, there would be a loss in this item alone of \$2,663,430. There would be a great additional loss also upon the lands that could not be seeded, summer fallowed, fall plowed and upon which the wheat became over ripe and shelled out. As all the estimates made are conservative, it is probably safe to assume that the total loss to residents of the Red river valley in North Dakota through lack of sufficient drainage in the year of 1905 exceeded \$4,000,000, and the same condition has prevailed for a majority of the last twenty years. Many fields were observed which had been summer fallowed for several years in succession whereon it had been impracticable to do any seeding.

SURVEY OF FULLER'S LAKE DRAINAGE DISTRICT.

A request having been made to the state engineer by Hon. R. A. Pope, secretary of the board of drain commissioners of Steele county, under date of April 14, 1906, asking for assistance in surveying a proposed drainage district in that county, the state engineer on April 24 to 26 inclusive visited the locality to be covered and having decided that the proposition was feasible, on May 3 sent a small party, consisting of the deputy state engineer, Mr. Atkinson, and one assistant, to make the survey. The lands needing drainage proved to be covered with lakes and swamps and difficult to traverse, but the survey was satisfactorily completed upon May 26, and the plats and estimates were at once prepared in this office, being finished upon June 14.

The project was found to be feasible though somewhat more expensive than others located under more favorable conditions. The lands to be drained are of excellent quality and the fall of the valley and the outlet are such as to assure a satisfactory system.

The main features are given in the following summary:



SUMMARY OF ESTIMATED COST, FULLER'S LAKE DRAINAGE DISTRICT,
STEELE COUNTY.

| Township | Acres Benefited | Assessment Against Owners | Assessment for Roads etc. | Total Assessment |
|-------------------|--------------------|------------------------------|------------------------------|---------------------|
| Edendale..... | 388 | \$ 1,598.17 | \$ 200.00 | \$ 1,798.17 |
| Hugo | 439 | 725.95 | 100.00 | 825.95 |
| Broadlawn ... | 276 | 661.57 | 100.00 | 761.57 |
| Colgate | 2,469 | 8,716.73 | 600.00 | 9,316.73 |
| *Steele County | | | 2,500.00 | 2,500.00 |
| Totals.... | 3,572 | \$ 11,702.42 | \$ 3,500.00 | \$ 15,202.42 |

*For roads, etc., may be divided among the townships in the ratio of the assessment for roads

| | |
|--|--------------------|
| Estimated number of cubic yards 123,500; | |
| at 10 cents | \$12,350.00 |
| Estimated incidentals | 1,352.42 |
| Estimated legal expenses, etc..... | 1,500.00 |
| Total | \$15,202.42 |
| Charges for benefits to roads..... | \$ 3,500.00 |
| Net cost to be divided amongst farmers..... | \$11,702.42 |
| Average cost per acre..... | 3.28 |
| Maximum cost per acre..... | 8.75 |
| Minimum cost per acre..... | 1.31 |

The estimate given above is based on a cost of ten cents per cubic yard for excavation. While this allows fair profit for work done by steam excavators, it would be too low if team or hand work was to be depended upon. The scarcity of labor prevailing at the present time has made contract prices much higher than they were two or three years ago, and this fact is to be taken into consideration.

OTHER DRAINAGE INVESTIGATIONS.

The state engineer has been called upon several times to make drainage investigations in other sections, and in accordance with these requests has visited sections in Pembina, Trail, Cass and Richland counties. In all these cases the services were given free of charge and all information requested was furnished. In several cases the great value and importance of the drainage survey of the Red river valley was shown, as the existence of a reliable survey has already saved hundreds of dollars to the people and will, eventually save many thousands.

MEETINGS WITH COUNTY COMMISSIONERS.

In connection with the survey of the Red river valley it has been necessary for the state engineer to visit some of the county seats for the purpose of conferring with the boards of county commissioners. Such visit was made at Fargo June 6, 1905, and at the meeting of the county commissioners held that day the following resolution was passed, to-wit:

“Resolved, That the state engineer of the state of North Dakota be requested to co-operate in the proposed drainage survey of Cass county, as provided for in section 63 of the Irrigation Code, adopted by the ninth legislative assembly, approved March 1, 1905.”

Similar resolutions were passed about the same time by the boards of county commissioners of Traill, Grand Forks and Walsh counties. On March 8, 1906, the state engineer met the board of county commissioners of Pembina county, at Pembina, and arranged a basis of co-operation with them as previously stated. At this meeting the following resolution was passed and placed on record, to-wit:

“Resolved, That in accordance with the provisions of section 63 of the Irrigation Code of the State of North Dakota, the county commissioners of Pembina county hereby invite the assistance and co-operation of the state engineer, through any funds or means at his disposal in the matter of a topographical survey of the Red River valley in Pembina county.”

In accordance with this request the state engineer did co-operate in the proposed survey as has already been described.

On April 3 the county commissioners of Richland county met at Wahpeton, but the board decided not to have any drainage surveys made in that county.

DRAIN CONSTRUCTION.

Considerable study has been devoted to drain construction. The high prices paid on contract work owing to scarcity of labor and other causes, has prevented much construction that would otherwise have been undertaken. Moreover, the construction of drains is inherently difficult for teams and hand labor, as the ground is often wet and boggy. For these reasons it would seem that the work could best be done by excavation machinery, and on July 1, 1906, the state engineer visited a canal near Bowesmont, Pembina county, where a machine constructed by Mr. J. C. Junkin of Drayton, N. D., was at work. Considering the fact that this machine was constructed merely as an experiment, it was doing remarkably good work. Since that time Mr. Junkin has been making a heavier machine to excavate on a large scale.

In this connection should also be mentioned the rotary disc plowing attachments for graders, constructed by the Disc Grader and Plow Company of Hunter, N. D. These can be used in wet

ground where the ordinary plow would not answer at all. The state engineer saw one on July 7, 1906, doing remarkably good work at Hillsboro in sticky wet ground, where the use of any other kind would have been almost impracticable.

The period from July 14 to 19 was spent in Illinois investigating drainage conditions there and some attention was given to the drain excavators of the F. C. Austin Excavator Company. These machines are already in the market and they are doing excellent work. The use of such machines is what is most needed in the construction of the drains of this state. It would be advantageous to contractor and farmer alike for many reasons, among which should be mentioned, construction according to specifications, even slopes, true grades, good berms and excellent appearance. These qualifications are touched upon in the appendix under the title, "Canal Construction."

DRAINAGE CONVENTIONS.

Several drainage conventions have been held at different points in the years 1905 and 1906, which the state engineer has been invited to attend and which he has taken part. The first of these, called through the efforts of Senator J. L. Cashel, was the first annual convention of the North Dakota Drainage League, held at Grand Forks January 10 and 11, 1906. About 300 delegates were present and a number of interesting and valuable addresses were delivered, all of which are published in the proceedings of the convention, the address of the state engineer upon "The Relation of the Office of the State Engineer to Our Drainage Problems" being published herewith in the appendix.

The following resolutions were passed:

To the Honorable Chairman and Delegates of this Convention:

We, your committee on resolutions, respectfully submit the following for your consideration:

First—We recommend that this convention organize a state drainage league with officers as follows: President, and one vice president for each county joining the league, secretary and treasurer, these officers to constitute an executive committee, and have authority to call conventions at such time and place as they deem best.

Second—Resolved, that this convention pledge its support and cooperation with the Minnesota Drainage league in its efforts to secure a congressional appropriation for the straightening, deepening and dredging of the Red River of the North. That the governors of North Dakota, South Dakota and Minnesota and the premier of Manitoba be requested to appoint a conference committee of five members each to discuss matters of interest common to the dominion and the states indicated, and that a committee be appointed to solicit the co-operation of every Red River valley county, and of the state legislature, and of congress, to the end that water overflow of land be prevented.

Third—Resolved, that a memorial to congress be adopted requesting that the irrigation laws be amended so as to allow a part of the national reclamation fund to be expended for the reclamation of our overflowed land as well as for irrigation, and that the irrigation act be amended so as to allow \$1,000,000 of the irrigation fund credited to this state

to be loaned on the lands embraced in our drainage district to be a lien upon the lands as may be equalized, according to the benefits, by the drainage commissioners, to be paid back to the government in twenty annual installments, it to be a lien against the lands the same as state or other taxes, and collected by each county respectively, without charge, and remitted to the United States treasurer.

Fourth—Resolved, that the thanks of this convention be extended to the Commercial club and to the citizens of Grand Forks, for the energy displayed in getting up this convention, and for the courteous treatment of the delegates while in the city. To the officers for the very efficient manner in which they have conducted the business before the convention. To the press for its liberality in advertising this convention and publishing the proceedings thereof, and to the railway companies for reduced rates. To President James J. Hill for his attendance here this afternoon, and his address to the convention; also for the financial aid which he so generously offered us. To Engineers C. G. Elliott and John T. Stewart of Washington, D. C., for their able addresses and their presence with us. To Mr. Scott Rex for his valuable opinion on the drainage law. To A. L. Fellows, state engineer, and to Mr. H. G. Hayes, secretary of the Drainage League of Minnesota; to George A. Ralph, engineer of the Minnesota Drainage Commission, and to J. L. Cashel, chairman of this convention.

James Holes,
John Carmody,
John Miller,
E. C. Myrick,
W. M. House,
James H. Mathews,
A. B. Landt,

Committee.

At the meeting of the Tri-State Grain and Stock Growers' association held at Fargo, January 16-19, 1906, the last day was devoted to the subject of drainage. A number of instructive addresses were delivered, all of which are published in the proceedings of the meetings, that of the state engineer upon "Our Drainage Laws" being published herewith in the appendix.

The following resolution regarding drainage was passed.

Resolved, that we express our gratitude towards the department of agriculture at Washington, D. C., for its liberality in making a topographic survey of the Red River valley, the more so because Dr. Mead, C. G. Elliott, and especially J. T. Stewart, local engineer, have done such thorough work. We likewise express our gratitude to President James J. Hill for his interest in and offer to give financial aid to perfect a drainage system for the Red River valley. We recommend such legislation on drainage as will be consistent with the recommendations made by scientists and drainage experts.

In pursuance with the resolutions passed at the Grand Forks convention an international drainage conference was called by Senator Cashel at Grand Forks, February 27 and 28, 1906, at which delegates from North Dakota, South Dakota, Minnesota and Manitoba, Dominion of Canada, were present, the Red river being an international as well as an interstate stream. The subjects principally discussed were the straightening of the Red river and the control of its flood waters. The following resolutions were passed:

Resolved, that liberal appropriation be made for the prosecution of these surveys by the departments of the governments having the same in charge to the end that the data required for the proper drainage of the Red River valley and the regulation of the flow of the Red river may be secured.

That we earnestly and urgently request the government of Canada and the congress of the United States to secure the appointment of an international commission as early as possible for the purpose of making a thorough investigation of the Red river and its tributaries with a view of regulating the flood flow thereof so as to prevent its overflowing at times of flood and improve navigation in periods of low water.

That the extensive drainage projects now being carried on throughout the valley, and which will materially affect the volume of water in said river in the flood period, make it imperative that the flow of this river be regulated as far as possible with a view to meeting the conditions created by these improvements.

From estimates made by the government engineers and local engineers it is apparent that the waters of the Red River could be controlled by the construction of a canal connecting Lake Traverse with the Big Stone lake and turning its flow from its basin into the Minnesota river; and by the construction of a reservoir dam at Otter Tail lake; a reservoir dam on Sheyenne river at some feasible point to retain the waters of its basin during flood periods, and a dam on the Pembina river suitably located to control floods of this stream, which drains from a large area in Manitoba and North Dakota. By the construction of these dams and reservoirs the damage from overflow of the Red river would be averted and navigation materially improved in low stages of water.

From investigations and estimates made by competent engineers, the proposed improvements can be constructed, we believe, at a cost not to exceed five hundred thousand dollars (\$500,000).

That the senators and representatives from these three states be requested to use all earnest endeavors to have a joint commission appointed, and that an appropriation be made sufficient to defray the expenses thereof, and that the government of Canada be requested to co-operate in the appointment of such joint commission.

That the thanks of this conference be extended to the premier of Manitoba and to the governors of Minnesota, North and South Dakota for their prompt response in sending delegates to this conference as requested by the recent drainage convention held in this city.

That a vote of thanks be extended to the city of Grand Forks, its press and commercial club of the city for the numerous courtesies extended to the delegates to this conference.

That the provincial legislature of Manitoba memorialize the dominion parliament to carry out these recommendations.

That a vote of thanks be extended to the Northwestern Telephone company for the free use of their long distance line by the delegates to this convention.

That copies of these resolutions be sent by the secretary of the Drainage League of North Dakota to the premier of the government of Canada, and to our delegations in congress from the states of Minnesota, North and South Dakota.

The following resolution was also passed by the North Dakota delegation:

We the undersigned North Dakota delegates to the drainage convention held in the city of Grand Forks on February 27 and 28, hereby resolve, that our state engineer be requested to gather copies of the

drainage laws from the province of Manitoba and the different states having the same, and together with some competent attorney draft such a drainage law as, in their judgment, will be constitutional and meet all the requirements of our state, such law to be presented to a drainage convention to be held prior to the convening of the next legislative assembly of this state for the purpose of discussion and revision of the contemplated law, and that the president of the North Dakota Drainage league be requested to bring to bear on the county commissioners of Pembina and Richland counties all argument possible to show them the necessity of a topographical survey of their respective counties in order to co-operate with the balance of the counties in the Red river valley and assist in bringing about such a drainage system as we believe will be greatly beneficial to the entire valley, and also to show the necessity of prompt action in order to assist in receiving government aid and securing the continuance of the service of the government engineer who has been prosecuting the work in the Red River valley for the past season.

Respectfully submitted,

J. L. Cashel.
T. R. Atkinson.
H. A. Mayo.
J. D. Bacon.
John E. Paulson.

The state engineer was also present by invitation and took active part at the meeting of the Minnesota Drainage League held at Wadena, Minn., June 26 and 27, 1906. The subject of drainage was also discussed to some extent at the National Irrigation Congress held at Boise, but only with a view to holding a national drainage congress later. The dates for this congress have now been fixed for December 5-7, inclusive, 1906, at Oklahoma City, Okla.

On July 13, 1906, the state engineer conferred with Maj. Geo. C. C. Derby of the Corps of Engineers, U. S. A., with headquarters at St. Paul, Minn., having charge of the improvement of the Red river and other streams. Major Derby appeared to be in favor of controlling the flood stages of Red river and expressed a willingness to co-operate in all feasible ways. He has published a number of reports bearing upon the subject, copies of all of which are on file in the state engineer's office.

The subject of drainage will be still further agitated at conventions that are to be held as follows:

The Trans-Mississippi Congress, at Kansas City, Mo., November 20-23, 1906.

The First National Drainage Congress, at Oklahoma City, Okla., December 5-7, 1906.

The Second Annual Convention of the North Dakota Drainage League, at Fargo, about December 12, 1906.

At all of these meetings the state engineer expects to take an active part.

PROPOSED NATIONAL DRAINAGE LEGISLATION.

During the year 1906 considerable drainage legislation was proposed in Congress, which should be briefly discussed, as all

of it bears more or less directly upon the drainage situation in North Dakota.

In line with the resolutions adopted at the Grand Forks convention, Senator Hansbrough, upon January 25, 1906, introduced a bill in the United States senate providing for the segregation of one million dollars from the United States reclamation fund, to be transferred by the secretary of the interior to the secretary of agriculture, to be used by him in constructing a drainage system in the Red river valley in North Dakota. This bill passed the senate and has been favorably reported upon by the committee on public lands in the house. Unfortunately other senators and representatives have taken their cue from this bill and are also asking the diversion of large sums from the reclamation fund, and this has naturally resulted in considerable antagonism from irrigation interests. It is expected that the bill will be disposed of in some way at the coming session. Following is the bill as introduced by Senator Hansbrough.

Be it Enacted by the Senate and House of Representatives of the United States of America in Congress Assembled:

That one million dollars of the money arising from the sale of public lands in the state of North Dakota, and which under the act of June 17, 1902, became a part of the reclamation fund, be, and the same is hereby, segregated from the said reclamation fund, and the said sum of one million dollars, or so much thereof as may be necessary, is hereby appropriated for the purpose of constructing a suitable and comprehensive system of drainage of lands in the counties of Pembina, Walsh, Grand Forks, Traill, Cass, and Richland, in the said state of North Dakota, under the supervision of the secretary of agriculture. Provided, that the expense of such construction, including the salaries of engineers, superintendents, and so forth; and the maintenance of the works for a period of not exceeding ten years, shall be assessed against the lands proposed to be drained in proportion to benefits, said assessments to be paid is not to exceed ten annual installments under such regulations and conditions as the secretary of agriculture may prescribe. Provided further, that all money received by the said secretary from the assessments aforesaid shall be returned to the reclamation fund to be used under the provisions of the said act of June seventeenth, nineteen hundred two.

Section 2. That where in carrying out the provisions of the foregoing section it becomes necessary to acquire any rights or property, the secretary of agriculture is hereby authorized to acquire the same for the United States by purchase or by condemnation under judicial process, and to pay from the money appropriated by section one, the sums which may be needed for that purpose, and it shall be the duty of the attorney general of the United States upon every application of the secretary of agriculture, under this act, to cause proceedings to be commenced for condemnation within thirty days from the receipt of the application at the department of justice."

In line with the resolutions of the international drainage conference, held at Grand Forks February 27 and 28, 1906, Senator Hansbrough on March 5, 1906, introduced in the United States senate a joint resolution authorizing the appointment of three commissioners to meet commissioners from the Dominion of

Canada and investigate and report on the conditions of the Red River of the North, and for other purposes. This joint resolution has not been heard from for some time; but will probably be disposed of in some manner during the coming session. It is as follows:

Resolved by the Senate and House of Representatives of the United States of America in Congress Assembled:

That the president of the United States be, and he is hereby authorized to appoint three commissioners, one from the state of Minnesota, one from the state of North Dakota, and one from the state of South Dakota, to meet with any commissioners appointed on the part of the dominion of Canada, for the purpose of investigating the condition of the Red River of the North, an international navigable stream passing through American territory and emptying into Lake Winnipeg, in the province of Manitoba; and the said commissioners appointed on the part of the United States are hereby directed to report to the president not later than the first Monday in December, nineteen hundred and six, on a practical plan under which the flood waters of said river and its principal tributaries in the United States may be diverted and disposed of in such a manner as to prevent overflow and to obviate or lessen the dangers to agriculture along and adjacent to said streams in consequence of such overflow.

The commissioners on the part of the United States are hereby authorized to employ such expert help and other assistants as may be necessary to aid them in their work and to fix the compensation of all persons so employed, and also to sit at such places in Canada or the United States as may be deemed suitable to the purposes of this act.

And the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of any money in the treasury not otherwise appropriated, to defray the expenses of the commissioners on the part of the United States, the said commissioners to receive three thousand dollars each for their services, and their duties to cease upon the filing of their report with the president December third, nineteen hundred and six.

Another bill which has been introduced and which should be mentioned in this connection, for the reasons that it may eventually have an important bearing upon the Red river drainage conditions, and that the Grand Forks drainage convention pledged its assistance and co-operation to the Minnesota Drainage League, is that proposed on January 5, 1906, in the house of representatives by Mr. Steenerson of Minnesota, appropriating the receipts from the sale of public lands in the state of Minnesota to the construction of drainage works for the reclamation of overflowed lands in that state. This bill was favorably reported with certain amendments, and is now before the committee of the whole and will be disposed of in some way at the coming session. It is as follows:

Be it Enacted by the Senate and House of Representatives of the United States of America in Congress Assembled:

That all money received from the sale and disposal of public lands in the state of Minnesota beginning with the fiscal year ending June thirtieth, nineteen hundred and five, including the surplus fees and commissions in excess of allowances to registers and receivers, and excepting the five per centum of the proceeds of the sales of public

lands in said state set aside by law for educational and other purposes, shall be, and the same is hereby, reserved, set aside, and appropriated as a special fund in the treasury, to be known as the "Minnesota drainage fund," to be used in the examination and survey for and construction and maintenance of drainage works and drainage outlets for the reclamation of swamp and overflowed lands on the public domain and ceded Indian lands in said state, and for the payment of all other expenditures provided for in this act.

Section 2. That the secretary of the interior is hereby authorized and directed to make examinations and surveys for and locate and construct, as herein provided, drainage works for the drainage of and affording drainage outlets for said swamp and overflowed lands and to report to congress at the beginning of each regular session as to the result of such examination and survey, giving the estimates of cost of all contemplated works, the quality and location of the land which can be drained thereby, and all facts relative to the practicability of each drainage project; also the cost of works in process of construction, as well as those which have been completed.

Section 3. That the secretary of the interior shall withdraw from public entry or sale the lands required for any drainage works contemplated by this act, or which are likely to be reclaimed thereby, whether such lands shall be public or ceded Indian lands, until the amount of benefit to such lands from such works shall have been ascertained, as hereinafter provided, when the proportion of cost of such drainage works shall be charged against the same and be payable one-fifth cash at the time of entry and the balance in four annual installments in case the land is public land, and be added to the price per acre in case it is ceded Indian land, and be payable in like manner as the original purchase price is now required by law to be paid; such cost of drainage works so added shall, when paid, revert to and be paid into the drainage reclamation fund.

The secretary of the interior shall determine the amount of cost per acre of any contemplated drainage work, to be apportioned to all lands affected in proportion to the benefits thereto, whether directly or indirectly, by affording drainage outlets for such land, and such cost per acre shall be added to the price at which said land may be entered under the homestead law or purchased under the acts governing the disposal of ceded Indian lands, and when so ascertained all such lands shall be restored to entry, subject, however, to all the provisions, limitations, charges, terms, and conditions of this act. Said charge shall be determined with a view of returning to the drainage reclamation fund the estimated cost of construction of the proposed work and shall be apportioned equitably.

That the entryman upon the lands to be drained or reclaimed by such works shall, in addition to other payments required of him, before receiving patent for the lands covered by his entry, pay to the United States the charges apportioned against such tract.

Before constructing any drainage works the repayment of the money to be expended shall be secured by lien upon the lands benefited, either by contract with the owner or assessment under state law; and in a drainage project where the cost will in whole or in part have to be assessed or apportioned against land in private ownership the secretary of the interior may require that the ditches, canals, and improvements necessary shall be authorized and laid out by and under state authority, and the cost thereof assessed against such land in proportion to the estimated benefits thereto, so as to become valid liens thereon for the payment of such assessments, in conformity with such state laws, and that when collected by the proper state or municipal officers having charge thereof the same shall be paid to the United States. Provided, that when said state or municipal officers are authorized to issue their

negotiable bonds, in the name of such municipality, for the amount represented by such assessments and deliver the same to the United States as further security for the repayment of the sums expended under this act the secretary of the interior may require such bond as additional security for such repayment.

Section 4. That upon the determination of the secretary of the interior that any drainage project in said state is practicable and will drain and reclaim public or ceded Indian land, now swamp and overflowed, so as to benefit and increase the value thereof, directly or indirectly to an amount greater than the cost of the improvement, he may cause to be let contracts for the construction of the same in such portions or sections as it may be practicable to construct and complete as parts of the whole project, provided the necessary funds for such portion or section are available in the drainage reclamation fund. And the secretary of the interior is authorized to co-operate with the authorities of the state of Minnesota in all cases where drainage canals or outlets may serve both public, and ceded Indian and state lands, and to make a fair division of the cost of such survey or such works as may be jointly agreed upon by the secretary of the interior and the authorities of said state.

Section 5. That the secretary of the interior is hereby authorized and directed to use the drainage reclamation fund for the operation and maintenance of all ditches, canals, embankments, dikes, structures, or reservoirs constructed under the provisions of this act, and for straightening, deepening, and enlarging natural water courses so as to make them serve as efficient drainage outlets.

Section 6. That where, in carrying out the provisions of this act, it becomes necessary to acquire any right of property, the secretary of the interior is hereby authorized to acquire the same for the United States, by purchase or condemnation under judicial process, and to pay from the drainage reclamation fund the sums which may be needed for that purpose; and it shall be the duty of the attorney general of the United States, upon every application of the secretary of the interior under this act, to cause proceedings to be commenced for condemnation within thirty days of the receipt of the application, at the department of justice.

Section 7. That the secretary of the interior is hereby authorized to perform any and all acts and to make such rules and regulations as may be necessary and proper for the purpose of carrying the provisions of this act into full force and effect."

In all this proposed national legislation this state is vitally interested and it is very important that it should be alive to the fact that it must be zealously active in pushing its own interests.

STATE LAWS.

For over a year the state engineer has been devoting a large share of his time to the study of drainage laws. The statutes bearing upon the subject of a number of different states have been collected and studied as have also the laws of certain foreign countries. In accordance with the request contained in the resolution passed by the North Dakota delegation to the international drainage congress described above, he has compiled a drainage code to be submitted for consideration at the second convention of the state drainage league. In the progress of this study correspondence has been carried on with the officers of the United States division of irrigation and drainage investigations

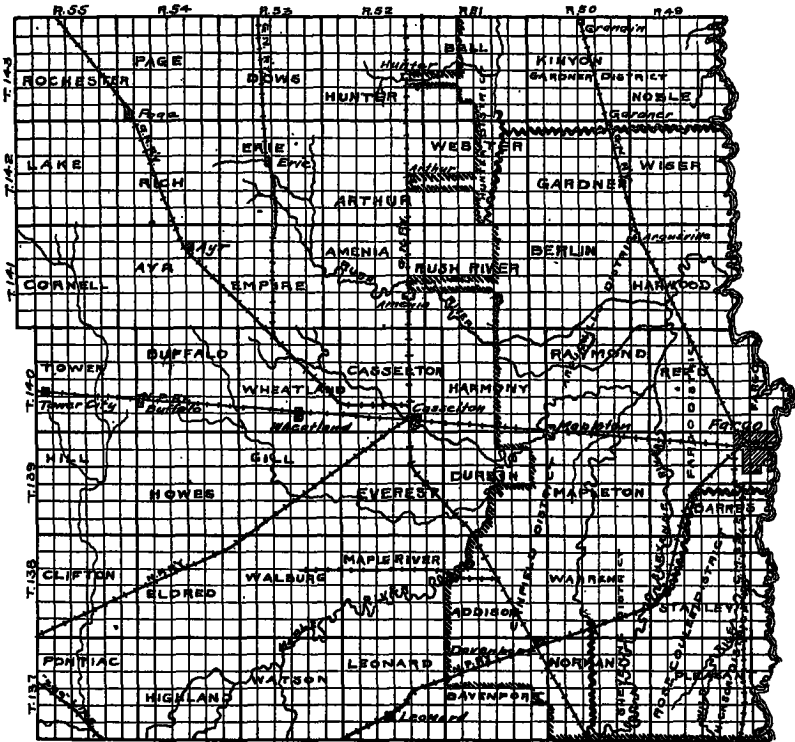
and with many others. One visit was made to Chicago and some of the drainage districts of Illinois for the purpose of studying the conditions there and consulting with the various attorneys concerning their drainage laws. Many valuable suggestions have been made by attorneys and engineers, all of which have been carefully considered in compiling the proposed code. It is expected that this proposed code will soon be ready to be submitted. It is similar to the Iowa code, but contains a number of new features. It is not printed herewith as it is thought that it may be materially changed before passage.

At the request of certain drain commissioners a synopsis of the existing drainage laws of the state was prepared and sent to such of the drain commissioners as asked for them. This synopsis is published herewith in the appendix.

There is no doubt but that new drainage legislation is desirable and the subject will be discussed at length at the next session of the legislature. The present laws are inadequate and are often not explicit. The difficulty, however, will be to get the best code, and in view of the vast amount of drainage work that should be done in the state, it should be satisfied with nothing short of the best.

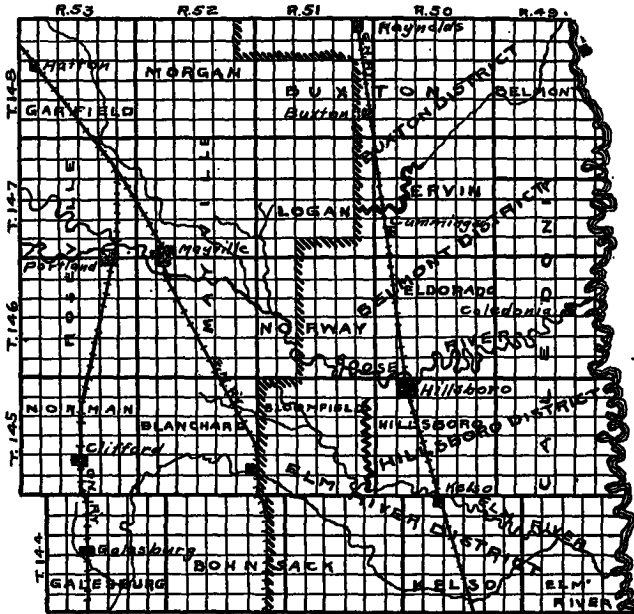
RECOMMENDATIONS.

The state engineer recommends that an adequate drainage code be passed by the state legislature and that all the proper influence possible be brought to bear upon congress to induce it to pass just and effective laws regarding the construction of drains by the United States. He recommends especially that a state drainage board be created, that surveys of districts needing drainage be authorized; that the state engineer be directed to prepare detailed reports concerning matters affecting drainage on the Red river in North Dakota, and that the sum of \$2,500 or as much thereof as may be required, be appropriated to cover the expenses of making such investigations.



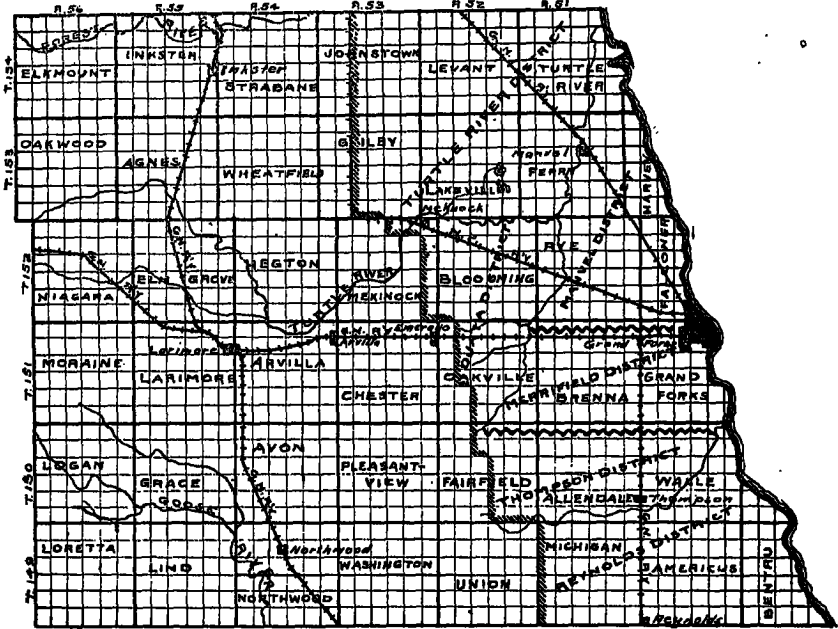
EXPLANATORY
 --- District division
 --- Western & southern boundaries
 of Topographical survey.

MAP OF CASS COUNTY
 showing area covered by Topographical Survey
 and the location of proposed Drainage Districts.
 State Engineer's Office, Bismarck, Sept. 1906.



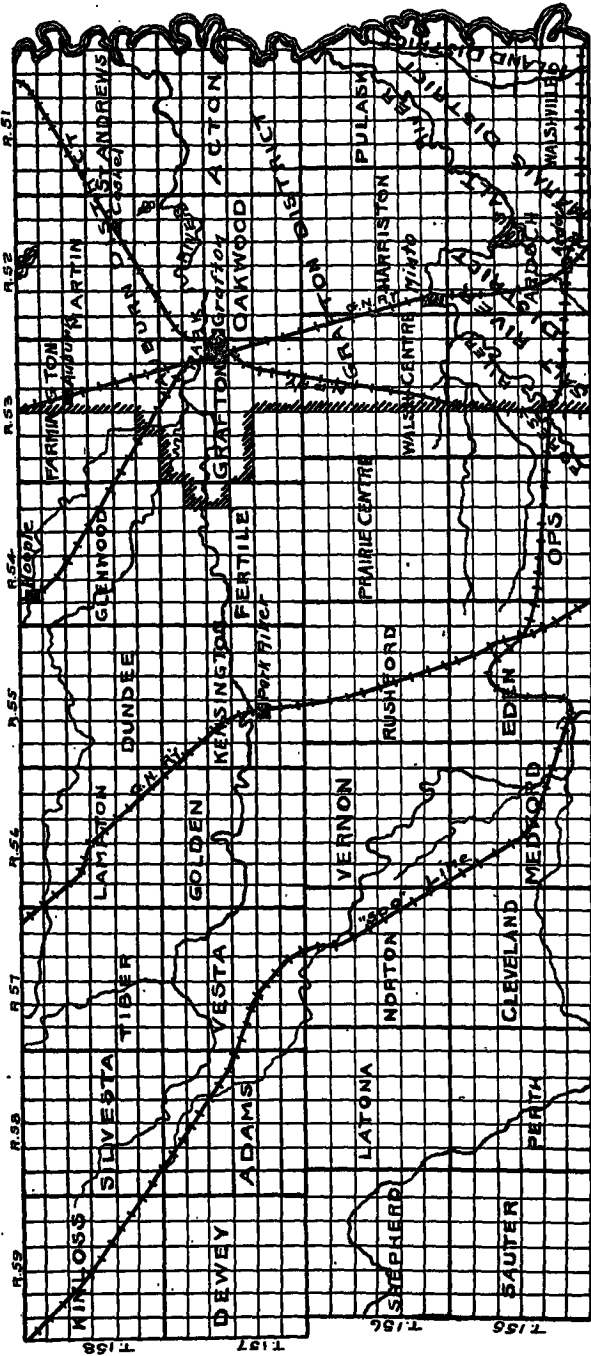
EXPLANATORY.
 ~~~~~ District divisions  
 ——— Western boundary  
 of Topographical Survey

**MAP OF TRAILL COUNTY**  
 showing area covered by Topographical Survey  
 and the location of proposed Drainage Districts.  
 State Engineer's Office, Bismarck, Sept. 1906.



EXPLANATORY  
 ~~~~~ District divisions  
 --- Western boundary
 of Topographical Survey.

MAP OF GRAND FORKS COUNTY
 showing area covered by Topographical Survey
 and the location of proposed Drainage Districts
 State Engineer's Office, Bismarck, Sept. 1906.



Western boundary of Topographical survey

MAP OF WALSH COUNTY
 showing area covered by Topographical Survey
 and the location of proposed Drainage Districts
 State Engineers Office, Bismarck, Sept. 1906

CHAPTER VII.

OPERATIONS UNDER THE UNITED STATES RECLAMATION ACT.

The only irrigation projects of any magnitude carried on in the state during the years 1905 and 1906 are those of the United States reclamation service, operating under the national reclamation act of June 17, 1902. The surveys of the reclamation service have been mentioned elsewhere. The projects that have been provisionally approved are five in number, and are the lower Yellowstone, formerly known as the Ft. Buford, Bismarck, Buford-Trenton, Williston and Nesson projects. So far as it has been possible for him to do so, the state engineer has co-operated in this work, and for this reason this report would not be complete without a brief description of the projects.

The work on all the different projects under the direction of Mr. F. H. Newell, chief engineer, and Mr. H. N. Savage, supervising engineer. Mr. F. E. Weymouth has charge, locally, of the lower Yellowstone project and Mr. H. A. Storrs has charge of all the pumping projects.

LOWER YELLOWSTONE PROJECT.

This project, formerly known as the Buford project, owes its approval to a very great extent to the strong desires of the secretary of the interior and the officers of the reclamation service to find some undertaking that would benefit the state of North Dakota. Up to the present time this is the only project discovered that will permit of the irrigation of any considerable body of land in this state by a gravity canal. The state has been gone over very thoroughly by reconnoissance parties and nothing has been found that seemed practicable until this possibility was investigated.

The project is situated in northeastern Montana and northwestern North Dakota and contemplates the irrigation of between 60,000 and 70,000 acres of land, about two-thirds of which is in Montana and one-third in this state. The strip of land to be covered lies along the northwest side of the Yellowstone river, extending from a point about 20 miles below Glendive, Mont., to the junction of the Yellowstone and Missouri rivers. The plans contemplate the diversion and use of about 830 cubic feet per second through the construction of a diversion dam

across the Yellowstone, and a main canal 67 miles in length with a suitable system of laterals and distributaries. Contracts have been let covering practically the entire system, at an estimated cost of \$1,500,000. The work is progressing nicely and it is expected that water will be ready for delivery for the year 1908. A water users' association has been successfully organized and practically all the residents under the canal system have subscribed for water.

BISMARCK PROJECT.

Surveys were made in the years 1904 and 1905 upon what is known as the Bismarck project. This contemplated the irrigation of about 12,000 acres of land near Bismarck by means of pumping. It was decided by the reclamation service that the project was feasible and the initial steps were taken towards construction, \$250,000 being set aside for the purpose by the secretary of the interior. It was expected that the cost of construction would be about \$20 per acre, the amount to be returned by the parties benefited in ten annual installments. Several meetings were held and opportunities given the land owners to make the necessary applications for water, but they failed to grasp the opportunity, and, although the surveys were completed, the project is now held in abeyance, and it is hardly probable that any work will be done upon it in the near future. The project may be said to be at least temporarily abandoned.

BUFORD-TRENTON PROJECT.

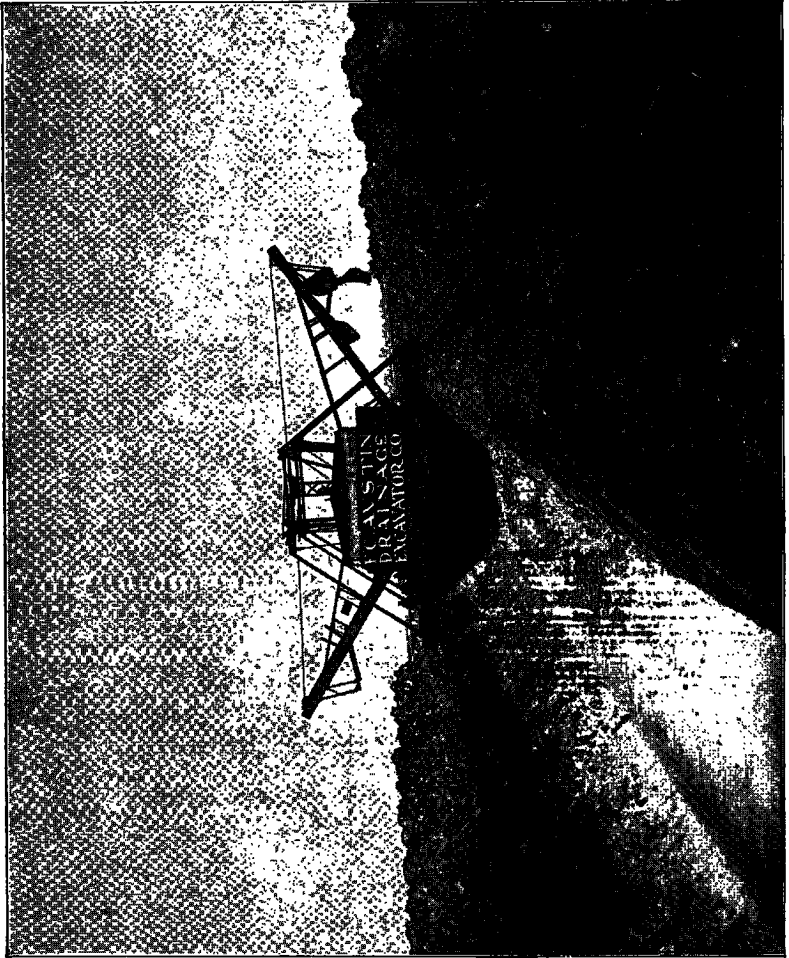
The Buford-Trenton project, near Buford, in Williams county, is now well under way. Contracts have been let for the pumping machinery to the D'Olier Engineering company of Philadelphia, for \$40,906. A water users' association has been formed and the greater part of the land under the project is represented in the association. Bids were asked upon the canal system, but only one was received and that one was rejected. This project is expected to include about 12,000 acres of land at a total cost of about \$250,000, and it is hoped that water will be ready for delivery by the spring of 1906.

WILLISTON PROJECT.

This is a pumping project taking water from the Missouri river at Williston, and is well under way. The surveys were completed in 1906. A water users' association was formed, and the greater part of the land is included in the company. It is expected that about 10,000 acres will be covered by the system at present contemplated, at a cost of about \$250,000, and it is hoped that water can be delivered during the summer of 1907. Contracts have been let covering the pumping plant and the canals



United States Reclamation Service headquarters on Lower Yellowstone project.



Drainage excavator.

and structures, at a cost of about \$215,000, and work is now under way. Coal lands have been withdrawn by the government to insure a permanent supply.

NESSON PROJECT.

This project contemplates the irrigation of about 13,000 acres in the Nesson valley, 35 miles east of Williston. The surveys have been completed and a water users' association has been formed, but no contract has as yet been made with the secretary of the interior. It is believed, however, that enough of the land will eventually be subscribed to insure the success of this undertaking also. The project is a most worthy one and should be carried through to completion.

RECOMMENDATIONS.

All of these projects are described in detail in the third and fourth annual reports of the United States reclamation service, copies of which reports are on file in the office of the state engineer. For this reason it has been thought not wise to publish full accounts in this report. The state engineer has been called upon several times to assist in the formation of water users' associations and in consultation, and has always given his best services. The work when completed will be of incalculable value to the state, and it is earnestly recommended that the reclamation service be encouraged to undertake still further projects and that the heartiest co-operation be given by the state.

CHAPTER VIII

FORESTRY.

The state of North Dakota is almost altogether a prairie state and contains but a very small amount of timber. The state engineer having given considerable attention to this subject for a number of years past and having been during that period in close co-operation with the bureau of forestry, United States Department of Agriculture, has incidentally made some study of the forestry conditions in North Dakota; this has been the case more especially in connection with the various proposed reclamation projects in the vicinity of Williston and Bismarck. There cannot be any question but that the supply of timber is of the utmost importance in any locality and especially is this true in an agricultural state like this. The timber is needed for buildings, fences and for fuel as well as for various other purposes. Less than 1 per cent of the land of North Dakota is covered with timber, a smaller proportion than prevails in any other state. This being the case, the necessity for action in this particular is the more obvious. The importance of forests or at least large tracts of tree covered lands is apparent to every thinking man, and there are undoubtedly great areas within the state that are better adapted to the raising of timber than any other use, and especially is this true along portions of the Missouri and Little Missouri rivers and other similar streams and in the Turtle mountains. In view of this fact the state engineer wrote on July 26, 1905, to Mr. Gifford Pinchot, chief of the United States forest service as follows:

July 26, 1905.

Mr. Gifford Pinchot, Chief of Forest Service, Washington, D. C.:

Sir: I desire to know whether or not it would be practicable for you to have an examination made of the timbered tracts along certain portions of the Missouri river bottoms in this state in order that we might ascertain the value of these timbered areas with reference to the surrounding country, and their relative value with other tracts of land in the vicinity. The question before me is this: The reclamation service is contemplating the irrigation of large tracts of land in the western part of the state, these tracts being situated on the Missouri river. Fringing the river there is generally a belt of cottonwood, elm, ash and boxelder timber interspersed with diamond willows, and other kinds of brush. My opinion, one which I think is held by the officers of the reclamation service generally, is that these tracts are more

valuable for the timber than they would be if cleared, taking the needs of the community into consideration. In addition to this fact there should be considered also the necessity of clearing, leveling, ditching, and probably draining, so that the cost of reclaiming these tracts will be very much greater than reclaiming the up-lands.

At the same time a report might be made to advantage, as it seems to me, concerning arboriculture in connection with the condition of these tracts that are to be irrigated. Rows of trees along the roads that would serve as wind breaks, woodlots in connection with the ranches, and the planting of trees for protection from highwater, might all be made of great advantage.

Trusting that it may be possible for me to secure your co-operation, I am

Very respectfully yours,

A. L. FELLOW,

State Engineer.

In answer to this letter the following reply was duly received:

Washington, D. C., August 1, 1905.

Mr. A. L. Fellows, State Engineer, Bismarck, N. D.:

Dear Sir: Your letter of the 26th instant to Mr. Pinchot has been duly received in his absence. Your plan for the examination of the timbered lands along the Missouri river in North Dakota opens the way to what in my judgment would be an exceedingly valuable piece of work for the forest service. In order that we may get well in line for the actual work Mr. F. G. Miller, forest assistant, now at Helena, Mont., will be instructed to call upon you in the latter part of August and talk the matter over in detail. Mr. Miller will notify you of the exact date of his coming.

Very truly yours,

OVERTON W. PRICE,

Acting Forester.

FOREST CONDITIONS NEAR BISMARCK.

The preliminaries having been arranged, Mr. F. G. Miller of the forest service made an examination of the timbered lands in the vicinity of Bismarck, and the following letter dated September 20, 1905, accompanied by the report of Mr. Miller was received:

Mr. A. L. Fellows, State Engineer, Bismarck, N. D.:

Dear Mr. Fellows: I take pleasure in sending you under separate cover a report on the timber lands of the proposed Bismarck irrigation project, prepared by Mr. F. G. Miller of the forest service. This report has been prepared in compliance with your request of July 26th, and I trust it contains the information desired.

Very sincerely yours,

GIFFORD PINCHOT,

Forester.

REPORT
ON A PRELIMINARY EXAMINATION OF TIMBER LANDS ALONG
THE MISSOURI RIVER NEAR BISMARCK, N. D.

BY F. G. MILLER.

Forest Assistant, Forest Service.

The examination upon which this report is based was made at the request of Mr. A. L. Fellows, state engineer, of North Dakota.

LOCATION AND AREA.

The land examined lies immediately south and southwest of the city of Bismarck, and is a part of the "Bismarck Irrigation Project," as is shown by the accompanying tracing. The project comprises some 18,000 acres, about one-third, or 6,000 acres of which consists of timbered and brush land along the Missouri river.

OWNERSHIP.

The land, except Sibley island, has all been filed upon and is now held by private parties. The title to Sibley island is in the United States government. At one time it was proffered to the city of Bismarck for park purposes by a special act of congress, but the city did not accept the offer. The island contains approximately 2,000 acres. The character of the land and woody growth are the same on the island as on the remainder of the tract, hence the island is not described separately.

CHARACTER OF THE LAND.

The timber and brush land does not extend in a solid body out from the river, but is broken up by small meadow areas here and there toward the east side. The grassy plots contain from a fraction of an acre to several acres and are used as hay lands. The estimated area of 6,000 acres of timber and brush land is exclusive of the meadow areas.

The surface of the whole is uneven, being cut up by many small gullies or ravines. There are areas of from a few to several acres in extent that are quite level. However, to put this land under irrigation would necessitate a heavy outlay for leveling the surface.

The soil varies from an almost pure sand next the river to a sandy loam toward the east border. For the most part it is fertile and with sufficient water it is capable of producing excellent field crops.

WOODY GROWTH.

The entire area has been cut over from time to time, and fires have run through frequently. Consequently the present timber growth is uneven in age, is largely of second growth, and the most of it is small. The timber is reproducing and extending itself, however, and if protected from fires and indiscriminate cutting, it would again become an important source of supply to the community.

The most common tree on the tract is the cotton-wood. It comes in simultaneously with the longleaf willow to cover the newly formed sand bars, and often gains entire possession in a few years. The present stand consists of all ages from seedlings of the past spring up to trees forty to fifty years old. The older trees occur singly, and there are seldom more than a half dozen per acre. Many of them are from 18 to 24 inches in diameter. Most of the cotton-wood timber is small, and should stand some years before being harvested. The wood is used almost entirely for fuel. Next to the cotton-wood the most important tree is the green ash. Owing to the demand of this timber for posts, it is cut as soon as it reaches post size. Saplings down to two inches in diameter are used for this purpose. The stumps sprout up readily, and reproduction from seed is also abundant. This tree becomes more common about the meadow lands, and frequently it occurs in almost pure stands.

Other trees are box elder, white elm, black and diamond willow and burr oak. The latter occurs only rarely. Box elder is very common, and is in demand for both posts and fuel. White elm is not common only over occasional small areas. It is used for fuel. Black Willow, also used for fuel wood, is found quite frequently. Diamond willow occurs more commonly than black willow, and is far more valuable, it being in great demand for posts on account of its durability. It seldom attains to a size of more than 2 to 4 inches in diameter, but posts or stakes cut from trees of this size will last in this climate for many years.

The shrubby growth is very abundant, and occupies a large portion of the land to the exclusion of any tree species at all, due probably to the ability of shrubs to come in more readily after fires

The more common and important shrubs are wolfberry (*Symphoricarpos occidentalis*), dogwood (*Cornus candidissima*), buffalo berry (*Shepherdia argentea*), poison ivy (*Rhus radicans*), and various species of wild rose. Choke cherry (*Prunus virginiana*), and wild plum (*Prunus americana*), are found fre-

quently. Of the vines Virginia creeper (*Ampelopsis quinquefolia*), and wild grape (*Vitus riparia*) were noted. A more thorough examination would doubtless reveal other species of shrubs.

FEASIBILITY OF CLEARING.

The cost of clearing this land is variously estimated by those who are in a position to know at from \$8 to \$25 per acre, according to the density and composition of the woody growth. A very few small clearings have been made, but these consist only of such spots as could be cleared most cheaply. These small areas are being dry farmed, and are proving valuable for this purpose. Doubtless additional small tracts here and there could be cleared and farmed with a profit. But whether it would pay to clear any considerable part of the timber and brush land and put it under irrigation, seems very doubtful, especially when it is remembered that to the cost of clearing must be added the cost of leveling the surface and of water privileges.

On the other hand the land is well adapted to the production of timber, and there is no timber within many miles except along the river. Cottonwood is worth about \$2 per cord on the stump. Green ash, diamond willow, and box elder sell readily at good prices for post purposes, so that there is a good market for all the timber the land will produce.

The trees and shrubs have a high value also in binding the soil in times of floods. The Missouri river is subject to sudden freshets, and at such times it overflows all of the timbered land, subjecting it to severe washing, and at times the river changes its course entirely. The damage from floods would be much worse were the land cleared. Besides if it were under irrigation the ditches would need to be reconstructed nearly every year. Again, owing to danger from high waters, it is not safe to go on to the land and improve it in the way of building homes.

CONCLUSION.

While to determine the real value of this tract for the growing of wood supplies would require a more extended examination, yet in view of the observations recorded in this report, it would seem that at least the greater part of the timber and brush land included in the "Bismarck irrigation project" will yield better returns in the production of timber than if put under irrigation and used for the growing of field crops.

AS TO A FURTHER EXAMINATION.

So far as this particular project is concerned, it does not seem to me that any further examination is practicable at this time. The project, as I understand it, is by no means an assured fact, and unless it is actually to be completed, any further investigation can avail but little.

As to the advisability of examining the other projects which Mr. Fellows mentions in his letter, I am not prepared to speak. Doubtless, however, the questions involved are much the same as this one, and the advisability of examining them depends on whether or not they are to be carried through. If they are, then an investigation to determine more closely the value of the timber lands for the production of timber, and which shall have in view the making of recommendations to farmers and ranchmen, within the reclaimed districts, for establishing shelterbelts and wood lots, would, it seems to me, be very valuable to the people concerned.

FOREST CONDITIONS NEAR WILLISTON.

The subject of forest conditions along the Missouri river was still further discussed by the state engineer and the officers of the forest service at Portland, Ore., during the session of the national irrigation congress held at that place in August, 1905, and a verbal request was made by the state engineer that examinations be made in the vicinity of Williston. Following up this line the following letter dated August 30, 1905, was received by the state engineer:

Mr. A. L. Fellows, State Engineer, Bismarck, N. D.:

Dear Sir: Regarding the examination of timber along streams in your state, I want to say that we shall be glad to give you all possible assistance along this line. I have not been in Washington since the matter was brought up, and know nothing of the details beyond what our Mr. F. G. Miller told me while in Helena. He was instructed to stop in Bismarck on his way east and confer with you and perhaps take up the work in person. It is probable, however, that he reached Bismarck while you were at Portland, and hence failed to make definite arrangements for the work.

I shall be very glad if you will write me as to your desires along this line, the extent of the area to be examined, the probable time it will take, and whether you wish it taken up this fall or later. With this information at hand I can plan to assign a man to the work and I am sure a satisfactory basis of co-operation can be found.

Yours very truly,

E. A. STERLING,
Chief, Forest Extension.

The following reply to this letter was written on September 5, 1905:

Mr. E. A. Sterling, Chief Forest Extension, San Francisco, Cal.:

Dear Sir: Your letter of August 30th is received. It was my plan that an investigation should be made of the forested, and partially forested tracts along the Missouri river under the Buford-Trenton, Williston, and Nesson projects in northwestern North Dakota and the Bismarck project in the vicinity of Bismarck with a view of reporting amongst others upon the following points:

1. Is the land more valuable for timber than for purposes of agriculture, taking into consideration,

- (a) Cost of clearing.
- (b) Cost of leveling.
- (c) Value of the timber as a protection during high water.

2. Would it be desirable to extend the forested areas over certain sloughs and rough places in the same locality, and if so what would be the cost, and what varieties of trees should be planted.

3. What trees and bushes could be used to the best advantage as a protection to the river banks so as to prevent the water from cutting.

4. Are the conclusions arrived at with reference to these tracts applicable to other similar tracts along the Missouri river, and if so to what area, approximately.

In my opinion it would take about two weeks to make these investigations, and if possible I should be glad to see the work done this fall. It would probably be possible for me to co-operate by giving a portion of my time and such suggestions as I am able to make, and I am sure the reclamation service would also co-operate, probably to the extent of furnishing teams and necessary assistants as guides.

Yours very truly,

A. L. FELLOWS,
State Engineer.

The preliminaries thus having been arranged, Mr. C. A. Scott of the forest service was directed to make the desired examination and under date of December 6 and 15 Mr. Scott made the two following reports:

REPORT

ON THE ADVISABLE METHOD OF HANDLING CERTAIN TIMBER LANDS EMBRACED IN BUFORD, TRENTON, WILLISTON, AND NESSON IRRIGATION PROJECTS, NORTH DAKOTA.

BY CHARLES A. SCOTT,

Forest Assistant, Forest Service.

Certain lands lying along the Missouri river within the Buford-Trenton, Williston and Nesson irrigation projects, in North Dakota, were examined to determine the following points:

1. Is the land more valuable for timber than for agricultural purposes, taking into consideration:

(a) Cost of clearing.

(b) Cost of leveling.

(c) Value of timber as a protection during high water.

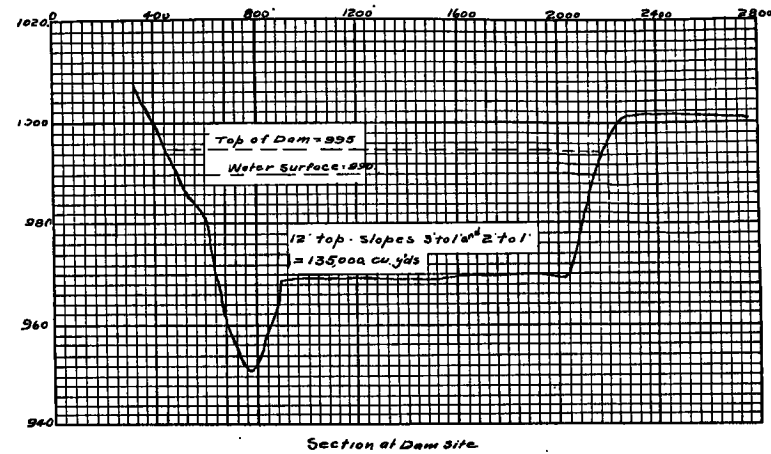
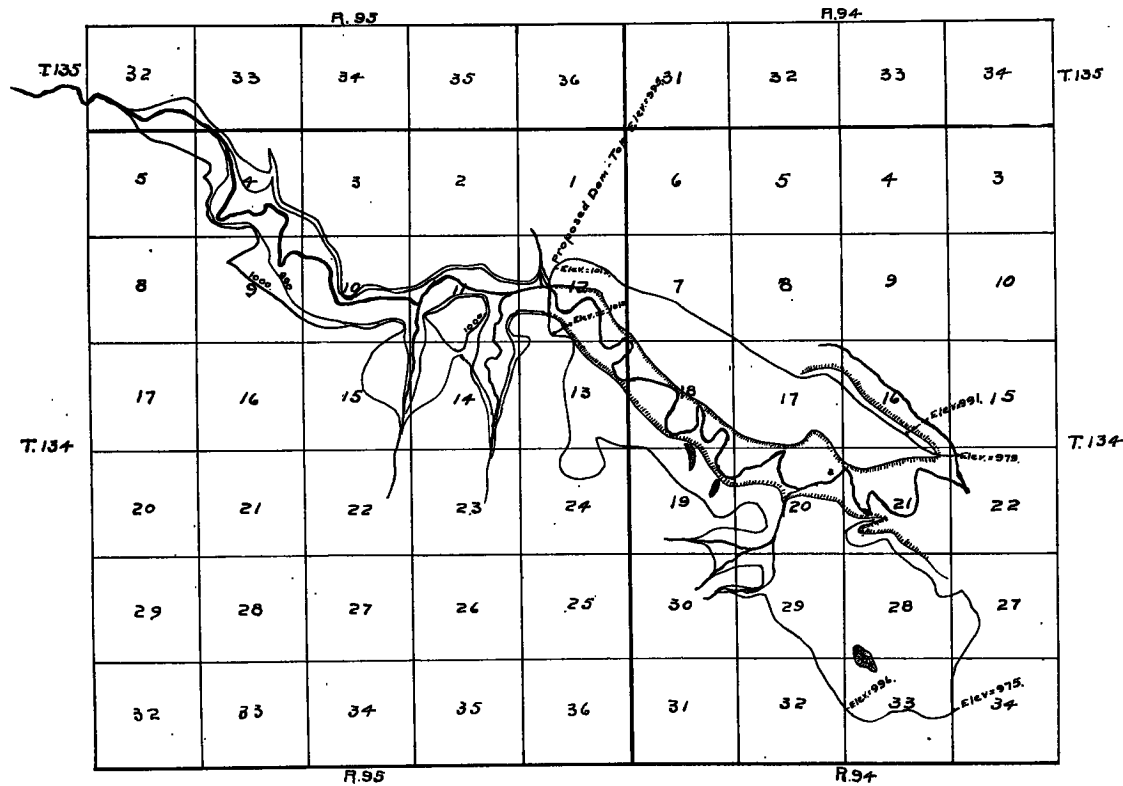
2. Would it be desirable to extend the aforesaid areas over certain sloughs and rough places in the same locality, and if so, what would be the cost, and what species of trees should be planted?

3. What trees and bushes can be used to the best advantage as a protection to the river banks so as to prevent the water from cutting?

4. Will the conclusions arrived at from the examination of these tracts be applicable to other similar tracts along the Missouri river, and if so to what areas, approximately?

The conclusions are:

Data:-
 Estimated available capacity of Reservoir at Elev. 990 = 10,600 acre ft.
 Drainage Area of " " " " 340 Sq miles.
 Land irrigable by gravity, 1,000 acres
 " " " " pumping, 3,600
 Total " " " " land, 4,600 acres
 Maximum lift, 52 ft.
 Minimum " " " " " 22 "



Plan of Proposed Irrigation Project
 North Fork of Cannon Ball River
 Hettinger County, North Dakota.

Scale
 0 1 2 3 miles
 State Engineer's Office, Bismarck, N.D. October, 1906

1. The low land, commonly spoken of as the "first bench," lying along the Missouri river within these projects, is in nearly all instances more valuable as timber land than for agriculture. This land is subject to occasional overflow or submersion by back water resulting from an ice gorge. The submersion by back water usually occurs when the ice breaks up in the river, and would probably do cultivated fields very little harm; while, on the other hand, the resulting deposit of sediment would be wholly beneficial. The result of an overflow of the river that would cause a current across this character of land can have but one result, and that would be a very detrimental washing and scouring of the surface soil. The soil is a light sandy loam that will wash easily even under a sluggish current.

At present the land is mostly grown up to sandbar willow (*Salix fluviatilis*), and diamond willow (*Salix cordata*), and a scattered stand of cotton-wood (*Populus deltoides*). The market value of this growth is just what the diamond willow posts will bring at 10 cents each. The cottonwood logs are worth about what it costs to get them out. Cordwood at the present time has no market value on account of the abundance and cheapness of coal (lignite). Coal sells at the mines at \$1 per ton, and retails in Williston at \$2 and \$2.50 per ton. The total value of the timber growth on the projects in question will not exceed \$3 or \$4 per acre. It would cost between \$10 and \$15 per acre to clear this ground of brush and trees. The cost of leveling will vary with each piece of ground under consideration, but in all instances it will amount to considerable.

It is evident that this low lying land is at present worth more for the production of timber than for agricultural purposes, when all conditions are considered. The advantages derived from having it in timber, as a protection to the land in times of high water is a matter of great importance. By proper management it can be made to yield a good revenue from the sale of timber products. The only timber growing in western North Dakota is confined to the river valleys and coulees, and in quantity is far less than the demand. At the present time the country is being rapidly populated by homesteaders and the demand for timber products, poles and posts in particular, is rapidly increasing, and from this time on the timber supply will be a question of vital importance. A well preserved body of timber will afford protection to game. The deer, which are at present quite abundant, are being rapidly killed off. The woodlands, under a good system of management will go far towards inducing the settlers to give tree planting on their homesteads due consideration and attention.

2. The forested area should by all means be extended over the entire hilly region lying immediately south of the Missouri river valley, from the mouth of the Yellowstone river to the

eastern limit of the Nesson project. These bluffs in the years past have supported a good growth of red cedar, which has been entirely destroyed by fire. Since settlers have come in these hillsides have been cleared, and the dead timber converted into fence posts. These posts are sold on the Williston market at 10 cents each, and some are hauled as far as 40 miles north of Williston to fence homesteads. The destruction of the red cedar in this region has been so complete that scarcely a living tree remains, and no reproduction was noted on the hills. The coulees in this region are well stocked with a young growth of ash and cottonwood, and bordering the streams is a dense growth of excellent diamond willow. As much of this bluff land is as yet in possession of the government it is recommended for permanent withdrawal from sale or settlement.

This entire region should be protected from fire by a series of plowed fire guards extending from the Yellowstone river east to a point on the Missouri river below the Nesson project. From this main line of guards, supplementary guards can be plowed at frequent intervals to the Missouri river.

After this measure of protection is provided, tree planting and improvement cuttings should be begun as soon as possible. A forest nursery should be established at some convenient place within easy access of the regions to be planted. Two acres will be sufficient area for a nursery with an annual capacity of half a million trees. The nursery should be devoted to growing red cedar (*Juniperus scopulorum*) and western yellow pine (*Pinus ponderosa*) to be planted on the denuded bluffs. If the red cedar can be grown successfully in the nursery it should be used much more extensively than the pine, as there is no question of its ultimate success. The pine can be more easily grown in the nursery, but may not succeed so well in the hills.

The hills are of glacial formation and the soil varies from a fine sandy loam to deposits of coarse gravel. The areas to be planted have a light ground cover of grasses and trailing juniper (*Juniper sabina procumbens*). The grasses are very open and thin. In no place will it be necessary to plow the ground before planting, and as the soil is light and loose, planting with spades will not be at all difficult and should be accomplished at a cost not to exceed \$5 or \$6 per acre, including the cost of growing the trees and planting at the rate of 2,000 per acre. The steepness of the hillsides will be the only difficult condition to contend with.

The planting should be confined to the north, east and west slopes, and no instance should an attempt be made to plant on the table land back of the bluffs or where buffalo grass sod has possession of the ground. Trees cannot compete with buffalo grass.

A small area of the land near Williston, on the north side of the river, that is being held for coal supplies by the reclamation service can be planted with the same species and in the same manner.

The low land along the river will not need attention. Where the diamond willow has possession of the ground it should be cut out and the ground planted with cottonwood cuttings. The ground occupied by the sandbar willow should also be planted with cottonwood cuttings. This planting should be done at a cost not exceeding \$3 per acre, including the cost of the cuttings. In thirty years the land thus planted returns yields of 5,000 to 5,500 board feet of lumber, at present worth \$23 per thousand. Cottonwood makes excellent material for dimension stuff and sheathing, but will not endure exposure.

It will be a valuable experiment to try to introduce the burr oak (*Quercus macrocarpa*). This species should do well in the clay soils found along the coulees and the base of the hills.

3. Trees or bushes are of little value in preventing erosion of the steep river banks, where action is under way, as it is immediately south of Williston, or at Jones' Cut near Trenton. If the banks can be reduced to an angle of 30 degrees and the slope then planted with diamond willow cuttings at the rate of 5,000 or more per acre, they would in a few years be a very effective protection.

4. The recommendations of this report are applicable to similar regions only in principle. In other regions probably more valuable species than the cottonwood can be used, and seedling trees substituted for cutting.

RECOMMENDATIONS FOR MANAGEMENT.

If the region examined is to be protected and devoted to timber production, all of the low land, constituting the "first bench," along the Missouri river, and the rough hilly land lying south of the river within the irrigation projects mentioned, which yet remains in government possession, should be permanently withdrawn from sale or settlement. Whether it should be proclaimed as a forest reserve or held as a permanent withdrawal by the reclamation service would depend on the amount of public land available, and whether active reforestation work could be undertaken.

The conditions which make it advisable to reserve the above mentioned areas are:

1. The low land, comprising the "first bench" along the river, is subject to overflow. If cleared for agriculture this ground would be subject to serious damage from overflow.

2. Before the timber land was cut or burned over, a portion of the first bench and all of the second bench, which is similar

in character and composition, produced a fine growth of cottonwood timber. Under proper management this land can be made to produce from 4,000 to 5,000 feet of merchantable timber every thirty or thirty-five years.

3. The bluffs and coulees along the south side of the valley from the Yellowstone river to the eastern limit of the Nesson project is at the present time valued only for grazing purposes. Grazing lands are so plentiful that its value in this respect is very small. The coulees, in which there is running water, are valuable as drinking places, but stock need not be excluded, as they will seldom graze or trample over the areas to be planted.

4. The bluffs, which were originally covered with cedar, are still capable of producing an abundance of valuable cedar timber.

5. There is a sufficient amount of this land to warrant the permanent employment of a forester, and the work is so diversified that it will furnish continual employment.

6. Systematic forest work on the land within these irrigation projects will be a valuable object lesson to the people of the surrounding country. At the present time the timber is looked upon as something to be cut down and gotten out of the way as soon as possible. Forest planting on the waste lands will stimulate the people of the entire region to plant on their farms wherever practicable.

OPPORTUNITY TO ASSIST SETTLERS.

A forest nursery, if established in connection with the management of the withdrawn lands and maintained for the purpose of supplying forest trees to homesteaders and settlers at actual cost of production, would have a desired stimulating effect on forest planting. Such a nursery should have an annual capacity of at least one million trees. The country is new and at present is being rapidly settled up by homesteaders. The demand for forest nursery stock from now on will be large, and the prices asked by nursery men for such stock prohibits even moderate planting.

Few of the settlers understand that the choice of species very largely determines the success or failure of a plantation, and willingly accept such species as the nurseryman offer, which are usually boxelder, cottonwood, willow and ash.

With a nursery under the immediate care of the forester in charge of the withdrawn lands, only the species adapted to the region and existing conditions would be grown and supplied. A planting plan and a few practical suggestions for planting and cultivating the trees could be sent out with each order of planting stock.

The forest service will gladly assist in carrying out the recommendations in this report and co-operate with the state of North Dakota, or with the reclamation service in any possible way.

REPORT
OF TIMBER CONDITIONS IN THE VICINITY OF WILLISTON,
NORTH DAKOTA

BY CHARLES A. SCOTT, FOREST ASSISTANT.

TIMBER CONDITIONS.

The condition of the timber along the Missouri river from Buford, N. D., to Grinnell, N. D., and in the coulees leading into the river valley, presents a very neglected and ravaged appearance. In the past ten or fifteen years repeated fires have swept through nearly every body of timber of any extent in this region. These fires have arisen from one of several sources, and it is safe to say that many of the fires have been set by hunters for the purpose of running deer out of the woods. Accidental fires have occurred, some arising from neglected camp fires, and some from prairie fires that have gotten beyond control. On the north side of the river many of the fires can be charged to sparks from locomotives. As evidence of this I saw on October 12, 1905, a fire burning in the brush land a mile or two above Trenton that had been set by a spark from a locomotive. At the time this fire was seen it had burned over an area of 15 to 20 acres and was still burning. A spark from the locomotive of the train on which I was riding, at the time the above mentioned fire was seen, set another fire not more than a mile from the first. The ranchmen who have been in the country since the earliest settlement by white men, say that destructive fires were practically unknown before settlements were made along the river. They say that the Indians were extremely careful in regard to setting fires.

Many conditions were noted that would indicate that most of the fires have occurred in recent years. For instance, the coppice growth of the ash from burned stumps is all under five inches in diameter, which indicates that the trees are not more than 12 or 15 years old. In the cottonwood belts many of the trunks that have fallen show very little sign of decay. Among them have grown up diamond willow coppice and young cottonwood trees, the latter frequently being six inches in diameter.

The bluffs facing the river on the south side, once well timbered with red cedar, show evidence of the greatest devastation. The timber which was entirely red cedar is completely killed out. Since the settlers have come in, the bluffs have been stripped of the dead trunks, which have been converted into fenceposts.

EXTENT OF THE TIMBER LANDS.

The timber lands along the Missouri river cover thousands of acres of the valley. The distribution of the trees extends over

the first and second benches above the present river level, and in some instances, extend into the third bench.

The species of economic importance are: Cottonwood (*Populus deltoides*), box elder (*Fraxinus lanceolata*), ash (*Fraxinus pennsylvanica*), white elm (*Ulmus americana*), and diamond willow (*Salix cordata*). Maple (*Acer negundo*) and black willow (*Salix amygdaloides*) are also found but are of little importance.

The timber along the river has been of the first quality of the species represented. Many of the cottonwood trees had a diameter of three feet, and were probably 70 or 80 feet in height. The best of all the timber both dead and living, has been cut out so that maximum heights can only be estimated, although the stumps show the diameter.

The cottonwood logs have been used extensively for the construction of farm and ranch improvements. The buildings of all the early settlers, including houses, barns, sheds, are built of cottonwood logs. The farm buildings of the present are, without exception of the same material.

One or two small saw mills have been located along the river. One was located a short distance below Fort Buford. The only saw mill in this region at the present time is on the river a short distance below Grinnell. This is a small mill that runs at irregular intervals. The saw material is mostly dimension stuff used for interior purposes. The dimension stuff and sheathing in the buildings of old Fort Buford is largely native timber.

Ash easily ranks as the species of second importance from the supply standpoint. Stumps still remain that are two feet in diameter. No evidence was seen of ash being used in construction work. Mr. Wm. Laughland and Mr. H. A. Nelson say that ash cordwood was in great demand at the time when steamboats plied the river. The boats paid \$7 per cord for ash and but \$4 per cord for cottonwood. Thousands of cords of ash were cut and sold at these prices. The steamboat days passed with the coming of the railroad.

The white elm ranks third from the stand point of supply. The logs were cut and used in common with cottonwood.

The diamond willow, since the destruction of the red cedar, is the most important species for fence posts. Miles and miles of wire fence are built on diamond willow posts. The diamond willow attains a height of twenty feet or more and a diameter of six or eight inches. The best trees yield two good posts, that are worth eight cents each in the Williston market.

The timber land in the coulees and hill sides bordering on the south side of the river amounts to a sum total of several thousands acres in the region between the mouth of the Yellowstone river and Grinnell. The timber in the coulees is confined to a

narrow belt along the stream or flood plain, spreading out to considerable extent as the coulee emerges into the river valley. The belt of timber extends up the coulees from half a mile to a mile from the river valley. The important species found growing in the coulees are ash and diamond willow. The largest diamond willows seen in the Williston region were growing in the coulees.

The timber on the hill sides along the coulees is confined to lines of seepage. Ash is the only important species found, and it is usually of a scrubby nature and inferior quality. Coppice ash is used extensively on farms and ranches in building corrals, sheds, and various structures where poles can be substituted for boards.

The timber land along the face of the bluffs on the south side of the river, in the sum total, amounts to a considerable area. The only species found in this locality was the red cedar. Few living specimens now exist, but there is abundant evidence to show that there was once a good stand. The maximum diameter of any stump found was eighteen inches; ten inches appears to have been about the average size. The trees have been of a short-trunked, thick-headed type, seldom more than eighteen or twenty feet in height, yielding about two lengths of posts. The butt cut could be split into two or three, or sometimes four posts.

REPRODUCTION.

Reproduction is occurring very satisfactorily in the river valley and the coulees, where the fires have been kept out. In the timber land along the Missouri river the cottonwood is reclaiming its former area and is extending its range to recently formed sand bars. All stages of reproduction are present from yearlings to trees thirty feet in height.

The ash and elm are extending their range of distribution, but the grass sod is a strong competitor, and progress is slow. Ash reproduction is mostly by coppice, elm by seedlings. The diamond willow occupies by far the largest area, and the coppice reproduction is good.

In the coulees the timber growth is extending its range as rapidly as conditions will allow. When fires are rigidly excluded the timber, no doubt, will spread to the hill tops, but the dense sod of the buffalo grass will prevent its wider distribution.

There is no possibility of the cedar ever stocking the denuded bluffs through the natural course of events, as the seed bearing trees have all been destroyed and it is very rarely that a young tree is found. The only cedar reproduction seen was in the cottonwood areas along the Missouri river, where trees from two to five feet in height were occasionally seen.

The following is a list of the woody species noted occurring along the Missouri river and in the coulees leading into the valley :

| | |
|-----------------------------------|------------------------------------|
| <i>Populus deltoides</i> | <i>Salix cordata</i> |
| <i>Populus acuminata</i> | <i>Salix amygdaloides</i> |
| <i>Populus balsamifera</i> | <i>Salix fluviatilis</i> |
| <i>Populus tremuloides</i> | <i>Salix bebbiana</i> |
| <i>Fraxinus lanceolata</i> | <i>Ribes aureum</i> |
| <i>Fraxinus pennsylvanica</i> | <i>Vitis riparia</i> |
| <i>Ulmus americana</i> | <i>Prunus americana</i> |
| <i>Prunus virginiana</i> | <i>Celastris acandens</i> |
| <i>Symphoricarpos occidentali</i> | <i>Juniperus scopulorum</i> |
| <i>Rhus trilobata</i> | <i>Juniperus communis</i> |
| <i>Acer negundo</i> | <i>Juniperus sabina procumbens</i> |
| <i>Betula nigra</i> | <i>Rosa arkansana</i> |
| <i>Betula papyrifera</i> | <i>Amelanchier alnifolia</i> |
| <i>Clematis virginiana</i> | <i>Artemisia longifolia</i> |
| <i>Cormus stolonifera</i> | <i>Artemisia tridentata</i> |
| <i>Ribes gracile</i> | <i>Lepargyrea argentea</i> |
| <i>Crataegus coccinea</i> | |

RECOMMENDATIONS FOR PROTECTION AND IMPROVEMENT OF TIMBER LANDS.

The first necessary step to be taken in the management of the timber lands along the regions examined is their protection from fire. This will not be a difficult problem on the north side of the river, as the greater part of the land is under homestead filings, and the settlers will protect their holdings and at the same time protect the timber. By far the greater area of timber land yet in government possession, lies on the south side of the river and is exposed to prairie fires coming from the south. The land lying south of the river valley is distinctly grazing land and probably will remain unsettled for many years to come. During this time it will be subject to prairie fires which will threaten the destruction of the timber growth in the coulees. The very best means of protection from this danger would be a line of fire guards twenty to thirty feet wide from a point on the Yellowstone river, a short distance above its entrance into the Missouri, extending in a northeast course touching the Missouri near Stroud, then continuing east until the river is again touched at some point near Chilcot. Intersecting fire guards can be plowed from this main line, running north to the bank of the Missouri river. This will divide the area into several divisions and will go far toward preventing extensive destruction by fire.

As long as there is timber on government lands it will be subject to abuse and destructive cutting by settlers from distant homesteads. The presence of a forest ranger to patrol the timbered region will afford ample protection from this danger.

OPPORTUNITY FOR TREE PLANTING.

If the non-agricultural lands along the Missouri river and the broken hilly country, including the coulees for some distance back from the river valley, is reserved for timber growing, a considerable amount of tree planting will be altogether practicable.

The first planting that is advisable, is along the river on the sand bars and first benches. These areas can be planted with cottonwood cuttings at a cost not to exceed \$3.50 or \$4 per acre. Cutting for this work can probably be bought from nurserymen cheaper than they can be collected along the river, as stock of suitable size is not abundant. The necessity of planting this valley land with cuttings in preference to depending upon natural reproduction, arises from the fact that diamond willow brush now occupies the ground and the shade is so dense that seedlings have no opportunity to gain a foothold.

The second planting proposition to be considered is the steep bluffs that face the river valley on the south. These bluffs should be planted with three year old cedar and pine seedlings. Planting at the rate of 2,000 trees per acre it will cost \$5 or \$6 per acre., including the cost of raising the seedlings to three years old. For this work a nursery having an annual capacity of at least half a million three year old trees should be established. This will require at least two acres of seed bed.

OBJECT OF PLANTING.

The object of this planting is to utilize the ground that at present is almost waste land, to provide future timber supplies for local demand, and to demonstrate methods, advisability, and practicability of planting trees in the region in question. The only timber growing in western North Dakota is found along the rivers and coulees, and, as the entire country is being rapidly populated by homesteaders, the demand for timber supplies, poles, and posts particularly, is rapidly increasing. The extension of the timber growing area is of vital importance to the future welfare of the country.

RECOMMENDATIONS OF THE STATE ENGINEER.

It is recommended that the suggestions made in this report be followed not only with reference to the tracts indicated but also similar tracts. It is further recommended that an act be passed directing the state engineer to make investigations regarding forest conditions in the state and co-operate with the U. S. Forest Service and that the sum of \$1,000, or as much thereof as may be needed be appropriated for the necessary expense of the state engineer while engaged in this work. It is further recommended that the state engineer be directed to select the best tracts available for the purpose of establishing forest reserves in the state and that he take the proper steps to secure the establishment of such reserves.

CHAPTER IX

STATE ROADS.

Although it is not made one of the duties of the state engineer to investigate the conditions of the public highways it is impossible for an engineer to travel over the state to any great extent without noting the conditions of the roads and seeing many ways in which the road system of the state might be improved.

The present control of roads is left entirely with township supervisors or county commissioners and there is no state authority provided for the study of highway conditions. The result is that the consideration of the subject devolves upon men not trained or especially educated along that line and the resulting systems have reference rather to local conditions and not the broader needs of the state.

In the early days of settlement of the state there were many important trails, like the Black Hills trail, the Oregon trail, and others, that partook largely of the nature of national highways. They were usually selected as a result of experience and observation by men who naturally picked out the easiest routes for their teams. If a number of these old roads could have been made public highways controlled by the state it would have been in a far better condition with reference to transportation than it is today, as fences have been built, and the roads have been turned to follow section lines or have been cut off altogether, so that a stranger traveling over the country by private vehicles finds himself in a veritable trap at times from which there seems to be no outlet excepting to return by the way which he came.

The problem of the system of highways is one that is almost as important as that of a system of railroads, in fact it comes more closely home to the average settler and homeseeker. More money is wasted in agricultural communities through the breakage of vehicles and the wearing out of horses because of bad roads than in any other way. It is a curious fact that the average farmer will insist upon bad roads which will eventually cost him hundreds of dollars rather than give a right of way worth not more than ten or twenty-five dollars which would result not only in a great saving but in great convenience to himself and family.

Another subject to which no attention is paid in the state, excepting locally, is properly constructed earth roads. Much has

been written upon the subject by those who have studied the matter in other states but the people of this state appear not to be familiar with it. A large number of the states of the union have appointed highway commissioners, or special officers, to study and report upon the needs of the state and to show the residents of certain localities what a properly constructed road is. In the state of Minnesota, for example, a state highway commission has been created with the state engineer acting as secretary, its duty being to study these problems and report upon what has been found and done and at the same time, by the construction of short pieces of properly built roads, to educate the people of the particular region as to their value. In this state nothing of the kind has as yet been done although an immense amount of road building has been carried on by local authorities.

The public roads division of the United States Department of Agriculture has compiled statistics upon this subject and Hon. L. W. Page, director of this division makes the following report upon the roads of North Dakota.

MILEAGE OF ROADS.

The accompanying table shows that in 1904 there were 59,332 miles of public road in the state of North Dakota, of which 205 miles were surfaced with gravel and seven miles with stone. By comparing the total road mileage with the area of the state, it appears that there were eighty-four hundredths of a mile of public road per square mile of area. A comparison of mileage with population shows that there was one mile of road to every five inhabitants. Ten cents on each \$100 worth of taxable property may be levied and collected annually for road purposes. This tax may be worked out at the rate of \$1.50 per day.

A township tax of not to exceed eighty cents and a bridge tax of not to exceed twenty cents may be levied by the electors at the annual township meeting.

In addition to the township proprietors, but only one mile of improved road to every 1,505 inhabitants.

TAXATION FOR ROAD PURPOSES.

In each county having a population of 2,000 or more a tax of not less than one mill on each dollar as a property tax, and every male person between the ages of twenty-one and fifty years is required to pay annually a poll tax of \$1.50 for road purposes. This tax may be paid in money or one day's labor on the public roads.

EXPENDITURES IN MONEY AND LABOR.

The amount derived from the property tax and expended on roads was \$456,130.20 in 1904, and the estimated cash value of the labor tax figured on the basis of \$1.50 per day, was \$94,210.50

making a total expenditure of \$550,340.72. By comparing the total expenditure with the total mileage of public road and with the population of the state, it is found that the funds collected and expended for road purposes, including the estimated cash value of the labor tax amounted to \$9.28 per mile of public road, or \$1.72 per inhabitant."

RECOMMENDATIONS.

I recommend that this subject be given careful consideration and that a commission be appointed to investigate and report upon the needs of the state in this line, making a study of the laws of other states and being prepared to report upon needed legislation at the next session of the legislature. It is further recommended that the sum of \$1,000 be appropriated for this purpose.

CHAPTER X

NATIONAL IRRIGATION CONGRESS.

For many years the state engineer has been a regular attendant at the regular sessions of the National Irrigation Congress almost ever since the first one was held at Salt Lake in 1891. It has been necessary for him to attend two sessions of the congress since his incumbency of this office, the first at Portland, Oregon, August 21-24 inclusive, 1905, and the second at Boise, Idaho, September 3-6 inclusive, 1906. The reports of the proceedings of these sessions are printed in pamphlet form and contain a great many valuable and interesting essays upon irrigation matters accompanied by instructive discussions. The state engineer has taken part in the discussions and delivery of addresses at each session, these addresses being published herewith in the appendix. The state engineer's office is equipped with a copy of the proceedings of each of these congresses and any one interested in the subject may make use of these copies upon request.

The sessions are unquestionably of very great value in permitting persons interested in the subject to meet and exchange ideas. They are generally well attended by the experts in the various branches of irrigation work and the state engineer urges that as many as possible attend the next session which is to be held in Sacramento, Cal., in the autumn of 1907, the exact date not having been set at this writing. Many matters of interest to this state as well as others, will be discussed at this session. At the session at Boise the state engineer was a member of the committee on resolutions and is now a member of the executive committee for the next session.

The importance of the proceedings may be judged to some extent by the resolutions which follow:

RESOLUTIONS ADOPTED AT THE THIRTEENTH ANNUAL SESSION OF THE NATIONAL IRRIGATION CONGRESS, HELD AT PORTLAND, OREGON.

This congress desires to express its high appreciation of the national irrigation law, and hails with pleasure the opportunities afforded under its beneficent provisions for home making, and hope that the several governmental enterprises now under contemplation, as well as under construction will be pushed to a speedy and successful completion.

It is the opinion of the national irrigation congress that the national irrigation law should be extended by congress as to include the state of Texas within its provisions, in so far as to permit the secretary of

the interior to direct the engineers of the United States reclamation service to examine and report upon feasible irrigation projects, and, when approved according to the terms of the said law, to superintend their construction, to the end that Texas may have the benefit of the same service that is now extended to the other arid sections.

We urgently request the congress of the United States to consider, and, if warranted by the constitution, to enact such laws as will enable the government of the United States to exercise the right of eminent domain when necessary to carry out the purposes of the national irrigation law.

This congress favors the early reclamation of small tracts of land whenever the cost per acre of the same does not exceed the cost per acre of the larger enterprises of similar character and whenever in the judgment of the reclamation service it deems such reclamation of sufficient importance to receive attention.

We approve the creation of the national forest service in accordance with the resolutions of previous congresses, and advocate the maintenance of forest reserves and forest extensions and protection of forest reserves where irrigation is necessary on the streams affected. We also endorse the effective and businesslike administration of the forest service under its present head.

We heartily approve the efficient and thorough work of the reclamation service in carrying on the work of national reclamation where works have been commenced and are now being executed, and have the fullest confidence in the honesty, ability and capacity of the officials of that service. We recommend that the reclamation service and its representatives co-operate with state officers in matters affecting the state's landed interests.

We thoroughly commend the excellent work being carried forward by the irrigation and drainage investigations of the office of experiment stations, department of agriculture in establishing a highly efficient climatological service in each state of the arid and semi-arid regions, which has proven itself of great value and utility to the engineers of the United States reclamation service, and to all important irrigation enterprises.

As the continued prosperity of the irrigated region of the United States will depend on the intelligence and skill of the successive generations of farmers and horticulturists dwelling on the irrigated lands, this congress gives its hearty support to the extension and perfecting of the American system of agricultural education, not only by strengthening the agricultural colleges, experiment stations, and farmers' institutes, but also by the better organization of public schools in rural communities through the consolidation of school districts and other means so as to secure the effective introduction of the teaching of agricultural subjects into the schools attended by the masses of our rural youth.

It having been demonstrated that the irrigated lands throughout arid and semi-arid America are pre-eminently adapted to the culture of sugar beets, and sugar factories having already been successfully established in nearly all of the states therein, it is the sense of this congress that we favor such national legislation as will tend to preserve and extend the beet sugar industry, the full development of which will enrich our farmers, laborers, and manufacturers to the extent of over \$150,000,000 annually, which amount the American people yearly expend for sugar now produced in foreign countries.

This congress calls attention to the fact that there is not nor has there been any connection whatever between the national irrigation congress and the incorporated company known as the national irrigation association, and it hereby announces that no person, corporation, or company has been or is authorized to solicit or collect money for or in behalf of the national irrigation congress.

We believe irrigation where necessary of the utmost importance to the prosperity of any people, and realizing that irrigation development and better local conditions may be more effectively secured through state than territorial form of government, we extend the sympathy of this congress to Oklahoma and Indian Territories in their effort to secure joint statehood for their territories, and we recommend that New Mexico should be admitted to the Union as a state without delay.

Believing that too much capital, public and private, cannot and will not be invested in the reclamation of arid lands, it is the sense of this congress that government as well as private enterprises should both be extended to the utmost, and that government enterprises should not unnecessarily interfere with prior private enterprises actually engaged in a particular field nor should subsequent private enterprises unnecessarily interfere with nor prevent government enterprises from building reservoirs and other works for reclaiming lands.

RESOLUTIONS ADOPTED BY THE FOURTEENTH NATIONAL IRRIGATION CONGRESS AT BOISE, IDAHO.

Following are the resolutions recommended by the committee on resolutions of the fourteenth National Irrigation Congress, as adopted by the congress:

"The congress desires to express its high appreciation of the national irrigation law, and hails with pleasure the opportunities afforded under its beneficent provisions for home making, and hopes that the several governmental enterprises now under contemplation as well as under construction will be pushed to a speedy and successful completion.

"We heartily approve of the efficient and thorough work of the reclamation service in carrying on the work of national reclamation where works have been commenced and are now being executed, and have the fullest confidence in the honesty and ability of that service.

"We recommend that the reclamation service and its representatives co-operate with state officers in matters affecting the states' landed interests.

"This congress indorses and commends the earnest and efficient work of the United States weather bureau of the department of agriculture in establishing a highly useful climatological service in each state, which work has proven of great benefit to the irrigation development of the West.

"We heartily commend the excellent work being carried forward by the drainage and irrigation investigations of the office of the experiment stations, United States department of agriculture, and recommend the continuance and extension of this work, and urge upon the United States congress the continuance of the appropriation for this service upon a liberal basis as an essential feature of the thorough development of the arid west.

"Whereas, the building of irrigation works is not a means to an end, since the ultimate success of all irrigation enterprises, whether public or private, depends upon the intelligence, skill and industry of those who settle on the lands, and

"Whereas, the organization of farmers' clubs, the holding of farmers' institutes, the establishment of agricultural and industrial high schools, the carrying on of practical experiments for the benefit of the farmer, and the training given by the agricultural colleges and experiment stations are all valuable agencies in the industrial upbuilding of rural communities in irrigated districts;

"We heartily recommend and endorse the work of these various agencies, and urge upon the legislatures of all the western states and

territories the granting of increased appropriations for the purposes.

"We recommend that the president of this congress appoint a committee consisting of five members of this congress, whose duty it shall be to secure the widest publicity of scientific information concerning irrigation, with the view of educating the new settler on irrigated lands in the proper use of water, stimulating the older users of water to a full appreciation of the value of improved methods, and to secure the publication throughout the United States of such information as will serve to inculcate a full recognition of the advantages of irrigated agriculture.

"This committee shall have power to appoint a secretary at a salary not to exceed \$25 per month and to incur an expense of not to exceed the sum of \$200 for stamps and incidentals, including stationery, which sum shall be paid as other expenses of this congress are paid. and said committee shall make a full report of its work at the session of this congress for 1907.

"We urge upon the United States government the immediate necessity of solving the various problems now pending in connection with the operation of the reclamation act, relating to the use of international streams.

"We pledge our earnest support to the United States forest service in its efforts to maintain and improve our water sheds, where irrigation is necessary, on the streams affected, by renewing and protecting the forests upon them. We also indorse the practical policy of forest protection through reasonable use, adopted by the forest service.

"We regard the conservation of waters for irrigation as a matter of so much importance as to call for protective legislation.

"We favor the passage of senate bill No. 4624 last session fifty-ninth congress, as herein amended, said amended bill being as follows:

"That subject to rules and regulations to be prescribed by the secretary of the interior, the owner in fee simple, or a claimant under any general or special law of the United States, of any land included within the limits of a reservoir site, now or hereafter approved by the secretary of the interior under the provisions of the act of congress entitled, 'An act to amend the timber culture laws, and for other purposes,' approved March 3, 1891, and acts amendatory thereof, may, at the option of such owner or claimant, relinquish or convey such land, included in an approved reservoir site, to the United States and upon the completion of the reservoir site so approved, personally select in lieu of the land so relinquished or conveyed an equal area, as nearly as possible, in compact form, of the unappropriated non-timbered public domain of the United States subject to homestead entry, and not withdrawn under the reclamation act, in the same state or territory; and the secretary of the interior shall by due and appropriate muniments of title, place such water or claimant in the same relation as to the United States to the title, possession and right of possession of the lieu land thus selected as such owner or claimant sustained to the land relinquished at the time the relinquishment was made.

"Section 2. The right of selection as herein provided shall apply to lands relinquished within reservoir sites to be constructed under the reclamation act and in such cases the right of selection may be exercised whenever deemed advisable by the secretary of the interior.

"Believing that too much capital, public and private, cannot and will not be invested in the reclamation of arid lands, it is the sense of this congress that government as well as private enterprises should not unnecessarily interfere with nor prevent government enterprises from constructing reservoirs or other works for reclamation of arid lands.

"Whereas the intelligent conservation of soil moisture will promote an increased duty of water under projects already developed and its extension to additional lands adjacent thereto, and

"Whereas, the same principles will enable successful cultivation by dry farming of immense areas, the tillage of which is now precarious or impracticable.

"Therefore, we heartily endorse the investigations along these lines by the department of agriculture, and recommend the dissemination of information as to better methods of soil agriculture, supplemented by the establishment of experimental stations and model farms in the newly developing districts of the arid and semi arid regions.

We recommend the enactment of a federal law providing penalties for unlawful interference with federal head gates and other federal irrigation works.

"Whereas, the eleventh national irrigation congress in September, 1903, inadvertently adopted a resolution endorsing Zea Mays as the national floral emblem,

"Therefore we rescind said resolution.

"We recommend that the congress of the United States consider the extension of the jurisdiction of the United States courts to provide for the judicial determination of water rights on interstate streams.

"Inasmuch as the sugar beet industry in irrigated America returns to the farmers an annual revenue of over \$20,000,000 and as the production at home of the sugar we now import would afford our farmers an additional market for beets amounting to \$100,000,000, and as it has been urged that the United States congress further stimulate the sugar beet industry of the Philippine islands to produce all or a portion of the sugar we of arid America had hoped to produce,

"Therefore we protest against any further legislation favoring Philippine sugar, and urge that legislative agitation and attacks upon the sugar production of this country cease, that this great industry of arid America be fully developed.

"We thoroughly appreciate the interest shown by president Roosevelt in irrigation, as evidenced by his letter to this congress, and extend to him our thanks for his untiring support of national reclamation of the arid and semi-arid lands; and we express our hearty appreciation of the patriotic address of Vice-President Fairbanks wherein as a broad minded American he so unqualifiedly endorsed the purposes of this congress, and having in view the best interests of our entire nation so forcibly urged the merit of the reservation of arid lands.

"We extend thanks to the local press and the press in general for its generous notice and fair consideration.

"Our thanks are tendered to Hon. L. W. Shurtliff, Senator Thomas H. Carter and Governors Chamberlain and Mead for the able and impartial manner in which they have presided over our deliberations. We also extend our thanks to Hon. Montie B. Gwinn; and to other executive officers for their untiring work and efforts in making this one of the most interesting and instructive sessions in the history of irrigation congresses.

"We extend our hearty and sincere thanks to the people of Idaho, and particularly to the people of Boise, for their splendid welcome, kindly courtesy and marked hospitality, and we shall carry to our respective homes the most pleasant recollections of our visit to this state and its capital city."

RECOMMENDATIONS.

The state engineer desires to call attention to the importance of this subject and recommends that an especial effort be made for a large delegation to attend the next session and especially that it be made a part of the duty of the state engineer to be in attendance.

CHAPTER XI.

ASSOCIATION OF STATE ENGINEERS.

Preliminary steps were taken to form an association of state engineers of all the arid states with a view of giving them opportunities of exchanging ideas and to consult with corporations similarly situated upon subjects relating to their work, in November, 1903, and the organization was perfected in May, 1904, at Salt Lake City and a second meeting was held in Boise, in September, 1904. These meetings were held prior to the incumbency in this office of the present state engineer. Since his appointment three meetings have been held, the first at Cheyenne, Wyo., April 13 to 15 inclusive, 1905, the second at Portland, Oregon, at the time of the National Irrigation Congress, August 21 to 24 inclusive, 1905, and the third at Boise, Idaho, at the time of the session of the National Irrigation Congress held there September 3 to 6 inclusive, 1906. These meetings have been productive of much good by furnishing opportunities for discussion of irrigation laws and irrigation practice. The state engineer has prepared several addresses which are published herewith in the appendix.

The present officers of the association are Jas. Stephenson, state engineer of Idaho, President, and Clarence T. Johnston, state engineer of Wyoming, secretary. It is expected that the proceedings of the various meetings will soon be published in pamphlet form together with all addresses and resolutions to date. This will make a very valuable publication and will contain much of general interest.

The next session is to be held in Reno, Nev., in March, 1907.

It is recommended that it be recognized as a part of the duties of the state engineer to attend the sessions of this association as the broadening of his ideas and the increase to his fund of information resulting from attendance thereon is worth far more than the cost of such attendance.

CHAPTER XII.

CONCLUDING RECOMMENDATIONS.

It is believed that careful study of this report will demonstrate the fact that the office of state engineer can be made of very great value to the state if it is properly administered. Not only in irrigation matters but along many other lines it can be of great service. Some of the duties of state engineers in other states may be mentioned to indicate, to some extent, what is possible in this state also. Among these duties are, administration of irrigation matters, drainage, state roads and highways, construction of bridges and dams, surveying of county lines, membership in state agricultural and land boards, study of statutes of other states relating to his duties, arbitration in disputed surveys and many others.

This office in North Dakota is in its initial stages and its beginnings should be wisely and conservatively made. The first year and a half have been occupied in finding out what things were to be done. It remains to accomplish as many as possible of those things found necessary or expedient. Rightly handled, the office can bring back far more to the state than it will cost.

The state engineer recommends that the following legislation be done.

First. Amendments to the irrigation code as recommended.

Second. The passage of an act providing for an irrigation experimental farm, and appropriating \$15,000 therefor.

Third. The passage of the best drainage code that can be devised and the appropriation of \$2,500 for investigation of drainage conditions.

Fourth. The passage of an act authorizing investigations of forest conditions and the appropriation of \$1,000 for expenditures in connection therewith.

Fifth. The passage of an act authorizing the study of the subject of roads and highways and the preparation of a report concerning the same and appropriating \$1,000 therefor.

Sixth. The appropriation of \$15,000 for the administration of the provisions of the irrigation code.

APPENDIX

IRRIGATION IN NORTH DAKOTA

The day has long since passed when any intelligent and well informed man in almost any part of the United States can say, "We have so much rain in this country that we have no need for irrigation." Scientific irrigation results in increased crops in nearly all countries that are capable of producing any crops at all and so the question becomes, "Is it worth while to irrigate for the increased crops that we can raise?" rather than, "Can we get along as we have been doing?" When irrigation is so extensively practiced and found to pay so well in such countries as France, Spain, Italy, Morocco and others where the annual rain-fall, occurring about as it does in this country, is from thirty to forty inches, when it has been demonstrated in Norway, Denmark, Holland, Great Britain, and Germany in the old world, and in New York, New Jersey, Connecticut, Wisconsin, and many others of the so-called humid states of the East and South that it is profitable to apply water artificially, there can be no question as to the advantages that are to be derived from intelligent irrigation, whenever it is practicable, throughout all the semi-arid, as well as the arid region. It is a question of degree. It was observed in eastern and southern states where there is an annual precipitation of from forty to fifty inches and upward, that agriculture was at its best when the rainfall was most abundant and came most nearly "at the right time." The advantages of the artificial application of water were then seen and now the fact is becoming widely recognized that he is the most fortunate farmer who can control his own water supply. Limiting ourselves to this country only, it is safe to say that there is no state in the Union where a "drought" is not feared by the farmers. It is worth our while to consider the causes for this.

NECESSITY OF WATER FOR PLANT LIFE.

That some soil moisture is vital to land plant life no one will deny. Any kind of plant must have moisture or it will die. Water is needed first to supply food to the plant, and, second, to keep up and aid in the vital processes. Every form of plant transpires through its leaves a considerable amount of water in addition to the amount required in the creation of its structure. The quantity required varies greatly with different plants, nu-

merous experiments showing that it ranges from three to four inches in the case of certain shrubs and trees of but little value, to twenty, thirty, and even forty and more inches for the more valuable products. In fact it is not yet possible to say, in the case of any given plant just what the amount of moisture that it should have to produce the best results in the way of products. In general it may be stated as an axiom that for most of the farm products too much water cannot be given so long as the ground carries the water off well and does not become water logged or sour, and provided the water is of good quality and not too cold. In experiments made at the Montana experiment station, for example, the following results have been attained, where eight plats were seeded to oats at the rate of two bushels per acre. The quantity of water supplied to each plat and the yield per acre were as follows:

| Number of Plat | Depth of Water Inches | Yield Per Acre | |
|----------------|-----------------------|----------------|--------------|
| | | Grain Bushels | Straw Pounds |
| 1 | 0 | 46.12 | 1655 |
| 2 | 2 | 61.73 | 2345 |
| 3 | 3 | 68.16 | 2822 |
| 4 | 4 | 73.54 | 2988 |
| 5 | 5 | 74.83 | 3075 |
| 6 | 6 | 78.15 | 3397 |
| 7 | 7 | 77.64 | 3284 |
| 8 | 8 | 83.53 | 3214 |

Some of the reasons why the artificial application of water of proper quality for the growth of crops, which is one of the definitions of irrigation, is effective in bringing about the results desired are as follows:

1. The water furnishes the ground and the plant with oxygen, which it must have.
2. It carries those mineral elements that the plant needs to its roots in solution which is much better than supplying it in solid form.
3. It dissolves the mineral elements already in the soil.
4. It renews these mineral elements so that the ground does not become impoverished.
5. It warms the soil and renders the conditions favorable for the growth of bacteria that are helpful to plant life.
6. It supplies nitrogen, one of the elements essential to plant life, to its roots.
7. It furnishes the moisture necessary for its lungs, the leaves; it is, almost literally, the breath of life.

So vital is water to plant growth that it has been thought by some, especially by the people of the ancient forms of civilization to be the only plant food needed. That this is not the case is

proved by modern research, but the best judges believe that water furnishes more than half of the elements necessary for plant growth.

Not only is irrigation effective in providing the plant with both the moisture and the food that it requires, but, intelligently practiced, it provides the right amount at the right time, which is almost as important as furnishing it in the first place. The ground may be prevented from becoming either too dry or impoverished at any time thus retarding the plant growth and lessening the amount or causing a deterioration of the quality of the product.

There may easily be such a thing as the application of too much water, but it is hardly likely where the ground drains readily, but is not washed away and does not become water logged, and the water is free from mineral constituents that are injurious to the plant, such as sulphate of iron, common salt, and poisonous compounds of certain kinds found in certain factory districts. In the state of North Dakota but little of the surface runoff could be considered injurious, but the underground water of certain localities undoubtedly contains too much of such minerals to be used.

GENERAL APPLICABILITY OF IRRIGATION.

It would seem hardly necessary to cite specific examples of irrigation in countries even more humid than North Dakota, but the assertion is so frequently made that lands in this state need no irrigation because the rainfall is sufficient to insure crops, that a few examples showing the general applicability of irrigation, even in humid regions, will not be out of place.

The greatest irrigated district of Europe is that of northern Italy where the climate is not very different from that of the northern tier of the United States, and where the precipitation averages about forty inches, about the same as that of Cincinnati. Extensive irrigation in all the northern European countries had already been referred to and irrigation is extensively practiced in all farming countries both of the old and new world. Peru, Chili, and other South American countries are organizing hydrographic services similar to that of this country. In the United States the growth of irrigation practice is rapid in large portions of the humid districts. In a report of the department of agriculture of the state of Georgia, published in 1901, is found this statement: "One of the most pressing needs of Georgia is irrigation, both surface and underground. How many a time have the agricultural interests of our state suffered from a drought that has blasted the brightest prospects of a once prosperous crop! How many a time had the farmer's heart throbbed with anxiety as the sun scorched his fields, while he longed for a favorable season and sighed for the rain that would not come.

Irrigation is not only a preventive of drought, but enables the farmer to control the supply of water and to furnish it to the plant at the right time and in the right quantity." The same is true of all the other southern and eastern states as well as those generally spoken of as those constituting the arid region. The following statement is from Bulletin 16 of the bureau of the census: "Irrigation in the humid states is practiced largely as an insurance against the droughts that occur early in the growing season. As an adjunct of agriculture it occupies a position of growing importance in several of these states, and while it has not reached a high state of development except in Florida the results are usually satisfactory. The statistics of irrigation in the humid states published in the last census report indicate clearly the great benefits resulting from its practice. Irrigation was reported in 1902 in Alabama, Connecticut, Florida, Maine, Massachusetts, Mississippi, New Jersey, New York, Pennsylvania, and Rhode Island. In Florida, where irrigation had made remarkable progress, a great variety of crops was irrigated and the irrigation systems were among the most modern in the country." The rate of increase in irrigation in the humid states in the three years from 1899 to 1902 is estimated at 76.2 per cent.

The same bulletin also gives the rice growing states of Georgia, Louisiana, North Carolina, South Carolina and Texas, showing that the increase in acres irrigated in these states during the same three years amounts to 74.1 per cent, the number of acres irrigated in 1902 being 606,199. Dr. A. C. True, director of the office of experiment stations, U. S. Department of Agriculture, in testimony given before the committee on irrigation of arid lands of the house of representatives on February 11, 1905, made the following statements: "During the past five years irrigated agriculture has made a remarkable advance along the gulf coast. Tobacco and truck farms are being irrigated in Florida; sugar and rice in Louisiana and Texas; Nearly all the water utilized in this region has to be pumped, and more than \$5,000,000 has been expended by the farmers in pumping machinery within this period.

Dr. Elwood Mead, chief of irrigation investigations of the Department of Agriculture testified on February 13, 1905 at some length before the same committee and the following extracts are taken from his testimony. We have been accustomed to consider irrigation as of importance to arid portions only of the country but we are beginning to realize that it is to have a large field of usefulness in the east. Dr. True has referred to the remarkable extension of irrigation along the gulf coast. It will, in time, have a similar development throughout the entire South wherever water can be had at a depth of less than fifty feet. Although irrigation is far more expensive in the East than in the West, the average cost per acre according to the census bulletin

being \$100 as against \$10 for the arid region, nevertheless it has proved profitable. I do not know of a market gardener who has once installed an irrigation plant who has abandoned it, although there are occasional seasons when it is not used, and we have records showing that the number of new irrigation plants established each year is growing rapidly." There are two lines where irrigation will, in time, be of large importance in the east. One is the irrigation of market gardens including cranberries, and the other is the irrigation of both garden and field crops in the south. The conditions in the south are very much like those in Italy, where with forty inches of rainfall they spend as high as \$200 an acre over large areas to provide an additional water supply. They do this, because, without irrigation, the second crop could not be grown. It would be burned out by the intense heat of summer. Irrigation also aids the scientific rotation of crops and enables the farmer to maintain the fertility of his land.

Mr. R. P. Teele, editorial assistant, office of experiment stations, in a report issued in 1904 makes these statements among others: "In the humid regions irrigation is not necessary to profitable agriculture, as it is in the west, and the question is not how to get the largest possible returns from a limited water supply but whether the supplying water to plants during dry seasons or during the short dry periods which occur in almost every season will increase the production enough to repay the expense incurred. This, of course, includes a study of the economical means of securing a water supply and the best method of applying it to crops. Experiments made in Missouri, Wisconsin and New Jersey have demonstrated that irrigation in those sections is highly profitable by methods followed and the experiments are being continued with a view to the determination of the best methods. The work in Missouri is mostly with small fruit and nursery stock. The experiments in Wisconsin include field as well as garden crops, and at present the irrigation of cranberries is being thoroughly tested. In New Jersey small fruits and garden crops have been irrigated.

The greatest field for irrigation in the humid districts is, however, in the southern states. The great extension of irrigation in European countries with a rainfall equal to or greater than our own and more evenly distributed, leads to the belief that it is to prove of equal advantage here."

Dr. F. H. Newell, chief engineer of the United States reclamation service in his popular book "Irrigation" makes, among others, the following statements:

"Experience has shown that irrigation is often advantageous even in localities where the climate is humid. If the rains came at regular intervals, moistening the soil whenever it became dry, there would be no need of artificial application of water; but,

unfortunately, it often happens that the precipitation for a month takes place in one or two large storms, which not only soak, but flood, the ground and washing away the rich surface soil, may do more injury than good. The eastern half of the United States has been aptly termed the region of uncontrollable humidity, in contradistinction to the arid regions, where through systems of irrigation, the application of water to the soil can be exactly controlled. Some of the heavier soils retain moisture for long periods, and the irregularities of rainfall do not noticeably affect vegetation, although somewhat retarding its growth and development. On sandy or pervious soils the alternations of wet and dry produce marked changes, and a drought of a few weeks duration results in decided injury to crops. Thus it happens that in many parts of the humid regions small irrigating systems have been built for occasional use. The investment in these may be regarded in the light of an insurance against accidents of weather which are so injurious to the farmer.

"The most common widespread form of irrigation is the ordinary practice of watering lawns and gardens. In this sense irrigation is habitually employed in every city and town throughout the United States, although it would not, usually, be recognized under that name. There is no marked difference between the irrigation of suburban grass plots and gardens in the east, and that of large farms in the arid region, other than in size and completeness of the mechanical devices for conveying and distributing the water.

"The almost universal practice of watering grass plots and vegetables testifies to the great value of the artificial application of water, even in the eastern and southern states, and the same systematic watering of orchards and fields would produce similar benefits. It is simply a question of cost relative to profits. In the arid region, where crops cannot be raised without water, the cost of bringing it to the fields has by experience, been reduced to the lowest possible amount. In the humid region, where the necessity has been less, invention and enterprise have not been stimulated to the same degree, and while all the facilities for irrigation exist, it has not been generally introduced on a large scale.

"The practice of irrigation in arid regions has to a certain extent, unconsciously prejudiced farmers in the humid regions against it as they viewed it as something consequent upon desert conditions. It is however a method for improving the soil comparable to the application of fertilizers. Large expenses are incurred in purchasing enriching material to be added to the soil, and care is taken to save and apply barnyard manure to increase the yield of crops. The same amount of energy and expense devoted to the construction of irrigation works would doubtless yield even larger returns. Comparing irrigation also

with drainage, it is noted that no hesitation is felt by the farmers of the humid east in digging ditches to remove surplus water from fertile bottom lands, but the reverse process of bringing water to the lands which would be productive if sufficiently moist, is a matter the importance of which has not been fully grasped by the agriculturist."

The authorities quoted above are among the best and are, in fact, possibly the highest authorities upon the subject of irrigation in the United States, and their opinion is shared by all others who have given the subject any considerable degree of thought. The conclusion invariably arrived at is that in any country where agriculture is practiced irrigation or the artificial application of water at times when it is needed will more than pay for the cost. It is true, of course, that where expensive works are constructed more intensive farming must be practiced and products of higher commercial value must be raised than where the cost of irrigation is small. But this is a condition which always takes care of itself. We shall go into this subject more in detail later. It will, however, be worth our while to go somewhat more into detail as to the reasons why it is profitable to irrigate in humid climates.

1. SUPPLY OF WATER NECESSARY FOR PLANT LIFE.

If we assume for clear consideration of the question that twenty inches of precipitation per annum is the mean below which a district may be called semi-humid, or semi-arid and above which a district may be called humid then we shall have for the humid district of the United States a precipitation of from twenty to sixty inches per annum. It has been found in Florida, perhaps to a greater extent than in any other of the humid states, that it is profitable to construct irrigation works, even where the precipitation is fifty or more inches per annum. This is due to a number of causes among which may be cited the length of the growing season which makes it possible to raise crops if there is an abundance of moisture, throughout the entire year, the sandy character of the soil, a great deal of it being what would be considered in this part of the United States of extremely poor quality, the high grade of products that can be raised in that state with a sufficient amount of moisture, and the possibility of producing early vegetables and early fruits for market at a time when the prices paid for them are extremely high. None of these reasons, however, are arguments against the general proposition that it is profitable to irrigate even where it is extremely profitable to farm without irrigation, even though the cost of irrigation works may be very great. The state of Florida is selected for the reason that it is one extreme. The state of Maine may be taken as another extreme of humid states where it is profitable to irrigate. Although but little

irrigation has been practiced in this state, experiments made with truck farming and gardening demonstrate clearly that it is profitable even when the cost of irrigation is considerable. To be sure lands in Maine would not stand as great an amount of irrigation as would lands in Florida, but the same principle is involved, that where farming was already profitable it became more profitable with the scientific application of water. It is to be remembered that when we speak of the annual precipitation amounting to forty or fifty inches we include the precipitation of the entire year, and that perhaps not more than one-third or even one-fifth of that amount comes during the growing season. In the more northern latitudes it has been demonstrated that while this amount of water, varying from ten to thirty inches during the growing season, will generally produce crops that will make it fairly profitable to cultivate, while an increase in the water supplied to the roots of the plants, especially if applied at right time, will often double the products, and sometimes do much better than that. Not only is the quantity increased but the quality is improved also. The reason for this is clear. Plants will grow best when there is a certain percentage of moisture in the soil. This percentage is stated by Prof. F. H. King, physicist of the Wisconsin experiment station, in Farmers' Bulletin No. 46 of the United States Department of Agriculture upon "Irrigation in Humid Climates," to which the reader is referred for a more detailed discussion of this subject, to be from twelve to fourteen per cent in light sandy soils and from eighteen to twenty per cent in more heavy clayey soils.

When the amount of moisture in the soil surrounding the roots of the plant falls below eight per cent in sandy varieties of soil and fourteen per cent in clay varieties, according to this authority, the growth of the plant will be seriously checked and naturally great harm will be done to the fruit or seed of the plant, a deterioration of the quality resulting as well in a diminishing of the quantity. This is due, as has already been intimated, to the necessities of plant nature in two ways, in building up the structure of the plant and its fruitage, and the amounts needed in the processes of life, transpiration or breathing. In a series of very interesting proceedings undertaken by the department of irrigation and investigations office of experiment stations, department of agriculture, not yet published in detail, it is shown that the amount of water transpired by a single plant is very much greater in fact than would be supposed, and that amount varies very greatly with different plants. Incidentally, it may be said that this explains to a very great extent why the presence of weeds in crops is so injurious. Many of the varieties of weeds transpire great amounts of moisture, thus depriving the cultivated plants of the water they need for the attainment of the best results. For example, the attention of the writer has been called

to fields where the farmer wondered why it was that a strip of cultivated land near the edge of his plowed tract should have produced so much less, proportionately, than strips evidently treated in the same way in other places. The reason has been found in some cases to be due to the fact that there was a large percentage of weeds along the edge of the tract, the roots of which drew the moisture away from the sprouting grain or other varieties of valuable plants.

2. CHEMICAL ACTION OF WATER.

Not only is water in itself a vital necessity to growing plants, but it is the medium by which plant foods are made available. The soil may be ever so rich, it may contain all the elements and combination of elements necessary for plant life, but if there is an insufficient supply of moisture these elements are not available for the growth of the plant. They have first to be dissolved. Water is a solvent available and appropriate for the purpose. Acting in combinations with the carbonic acid gas of the air carried into the soil by the water it dissolves comparatively insoluble elements that are found in the soil, making available the phosphoric acid, potash, lime, and magnesia compounds needed by the plants. Since moisture comes primarily through the air it carries with it minute particles of nitrogen essential to plant life and so in a measure renews the nitrates in the soil which would otherwise become exhausted.

3. FERTILIZATION BY IRRIGATION.

What has been said with reference to the amount of water needed and the availability of the water as a solvent for mineral elements in the soil will apply as readily to rain water as to water artificially applied to the land from rivers or lakes or other sources, provided that the amount of water coming in the form of rain is sufficient for the purpose, and that it comes at the right times. Water applied artificially, however, has another important advantage over water falling in the form of rain or snow. The waters of lakes and rivers, resulting originally from precipitation, has passed over and through great tracts of land carrying away from it mineral elements valuable to plant life and acquiring organic matter which has also been found to be of very great benefit in fertilizing the soil to which it has been applied. It is true that this water may sometimes contain mineral elements in too great quantities, and such a water supply should be carefully guarded against in irrigation; but it rarely contains too much of such elements for use, and it is almost never that it contains too much organic matter, a fact that is demonstrated by the application in many cases of sewerage from large cities being of extraordinary value. A suitable supply of water, then, replenishes the soil to which it is applied. Sewerage as a fer-

tilizer of the cheapest possible kind is none the less effective. It is a common statement in irrigation countries that the soil is inexhaustible. It is not so much the fact that the soil is rich, and no soil is inexhaustible; but this condition of inexhaustibility is due rather to the fact that the waters applied in irrigation renew the vitalizing changes as fast as they are taken away by the growth of the plant. So true is this that in districts where irrigation has long been practiced the consumers of water insist on having the first use of the water rather than the second and third, and also often, in Egypt, where irrigation has been practiced for thousands of years, they demand that they have their principal run of water at that season of the year when there is the greatest amount of organic and mineral matter in the river Nile. It will be readily seen, therefore, that water artificially applied has an important advantage, when due precautions are taken, over water falling naturally as rain, in this particular, as well as in the fact that it will be applied by an experienced irrigation, at the right time and in the proper amount.

4. PROTECTIVE ADVANTAGES OF WATER ARTIFICIALLY APPLIED.

In many localities also under certain conditions water artificially applied may be of great benefit as a protective power, though this is by no means its most important function. Water, however, being more dense than air, does not become cold quite so rapidly as air, consequently water may even, when applied at the right time, save crops from a killing frost. This is especially true with reference to vegetables and small fruit. Cranberries particularly may often be saved by the application of water in the proper amount and temperature. However, it is not only a protector from frost but it even stimulates plant growth, warming and improving its condition, thereby rendering it better fitted for rapid growth. Under the most scientific methods of irrigation particular attention is paid to the proper temperature of the water. By applying water from a cool source the growth of plants particularly susceptible to frost may be delayed in the spring to such an extent that crops raised may become certain and on the other hand after the danger of frost is past, water that has been somewhat warmed in the lakes or running long distances over sandy river beds is wonderfully active in stimulating growth, ripening the products much earlier than would be done without its application.

In northern Italy, as stated by Dr. Mead in his bulletin No. 144, of the office of experiment stations, upon "Irrigation in Northern Italy," considerable attention is paid to this point, the water at times being taken from cool streams flowing directly from the mountains, and at other times from the lakes and plain streams where the water has been warmed by the atmosphere. It will be seen, in this particular also, that artificial application of water has a decided advantage over natural precipitation.

CONCLUSIONS.

The above considerations demonstrate beyond the possibility of a doubt that artificial application of water is in a great many cases, and may in a great many more, be of great advantage even in humid districts, giving to the farmer as it does three vital benefits.

First—Increase of Quantity and Improvement of Quality of the Crop: Professor King, already referred to, says that in Wisconsin "the writer has succeed in growing, under field conditions on one eighteenth of an acre, more than 15.5 tons of water free substance in flint corn and 83.5 bushels of kiln dried shelled corn per acre by supplying all the water which the plants could use at the right time. Under similar conditions common red clover yielded over four tons of hay in the first crop. The second crop on the same land exceeded two tons per acre, while the third growth was heavy and six to eight inches high." It should be said, too, that these results were obtained without the aid of manure or fertilizers of any sort, that the water used was pumped from an ordinary lake, and that the land was a clay soil in only fair condition.

"Potatoes have been grown in pots holding 500 to 600 pounds of soil, so aranged that they could be weighed at any time and an exact amount of soil moisture present ascertained; and yields as high as 695 bushels of tubers per acre have been secured, using twenty-four inches of water, which is more than falls during the growing season of this crop in Wisconsin. Flint corn under similar conditions was made to yield at the rate of seventeen and one-third tons of water free substance per acre; but to do this is required thirty-four and one-fourth inches of water, an amount which more than equals the mean rainfall for the whole year; and it is ascertained that had a less quantity of water been used the crop would have been smaller."

Numerous other instances could be given in demonstration of this fact, but those presented by Professor King are sufficient as examples.

Second—Increase of Crop: Insurance is generally accepted throughout the civilized world not as a luxury but as a necessity. We have insurance against fire, hail, storms at sea, and almost every other casualty. It is to some extent in line with this idea that irrigators insure their crops against drought, but this mode of insurance has the decided advantage of being one where the insured is not likely to lose the benefits accruing to him, by reason of the frenzied finance of those who are handling his funds for him, although it is granted that in irrigation also graft and dishonesty have to be guarded against. This form of insurance, however, is one that brings the largest returns and can hardly, in fact, be called a form of insurance in the usual meaning of the term. It is rather an intelligent provision against a common con-

dition occurring in nature. It is stated by Dr. Mead in his book already referred to, that it is related that a clergyman refused in one case to pray for rain on the ground that his people had neglected to provide themselves with the facilities for using the water that was flowing past their doors, and that consequently, since they had refused to avail themselves of their God-given opportunities they alone were responsible for their losses.

Third—Permanency of the Productiveness of the Soil: Common sense tells us that where the vital constituents are being steadily taken from the soil renewals through some fertilizer are needed. Watered only from pure water precipitated from the clouds, in time, the soil must lose its fertility and become unproductive and it must be unprofitable to attempt to raise crops from it. The application of water from running streams or lakes tends to a great extent to migrate this evil and to render the lands more permanently productive. It is the cheapest kind of fertilization, although it is not in itself sufficient as a fertilizer.

It was recently stated by an officer of the department of agriculture of Japan, who was visiting the United States, that in his own country they would never consent to permit such extravagance as was regularly practiced in this. "Why," said he, "we would consider it suicidal to do as is done by nearly all your farmers, namely, to permit the steady exhaustion of the life-giving principles of their soils without renewing them. In our country every part that would otherwise be wasted, as chaff, straw, etc., is taken back as nearly as possible to the soil from which it come, the soil being robbed, therefore, only of the edible portions of the crops raised and this being fully replaced by the use of fertilizers." In this country we have not learned to economize, but the time is soon coming when we must learn it, and one of the easiest methods of practicing it will be found to be through the aid of irrigation.

IRRIGATION IN SEMI-ARID COUNTRIES.

Thus far we have been considering irrigation in humid regions and have found that even here it is profitable to apply water to crops artificially. It is self evident, then, that where the conditions are less favorable to plant life because of a less precipitation, or in other words, in the semi-arid regions, irrigation is much more of a necessity than in those that are classed as humid. It is almost impossible to lay down any hard and fast rule as to what does and what does not constitute humid, semi-arid and arid regions, and it is equally practically impossible to draw any distinct line between these several classes. The answer to the question whether agriculture may be profitably practiced in any given region depends upon a great many different conditions. The latitude, altitude, time of the year when the greatest amount of

precipitation occurs, the manner in which the precipitation occurs and numerous others having important bearings upon the situation. It is generally assumed, however, in the United States, at least, that twenty inches of precipitation per annum is the dividing line between the so-called "humid" and the so-called "semi-arid regions." It is true that twenty inches or fifteen inches per annum means much more in the state of North Dakota than it does in such states as California, New Mexico, Colorado, or even Montana, for the reason that its latitude is higher than the first mentioned states, and that its altitude and soil is more favorable to agriculture than any of the others. In North Dakota, moreover, the rainfall comes at much more favorable times of the year for profitable crop raising than it does in the southwestern and northwestern states, as may be seen by the comparison of the diagrams, the first showing graphically the precipitation of California, the second of Colorado and the third of North Dakota. A study of this diagram will show that a much greater proportion of rainfall comes in the growing season at the time when it is most needed than is the case in the other states, where the rainfall is nearly, if not quite, the same, at least in certain portions. The advantage, however is more apparent than real for the reason that although the precipitation does not come at the more favorable times of the year, still the precipitation in the other states goes into the ground and a considerable portion of it is available in giving the crops a start in the spring.

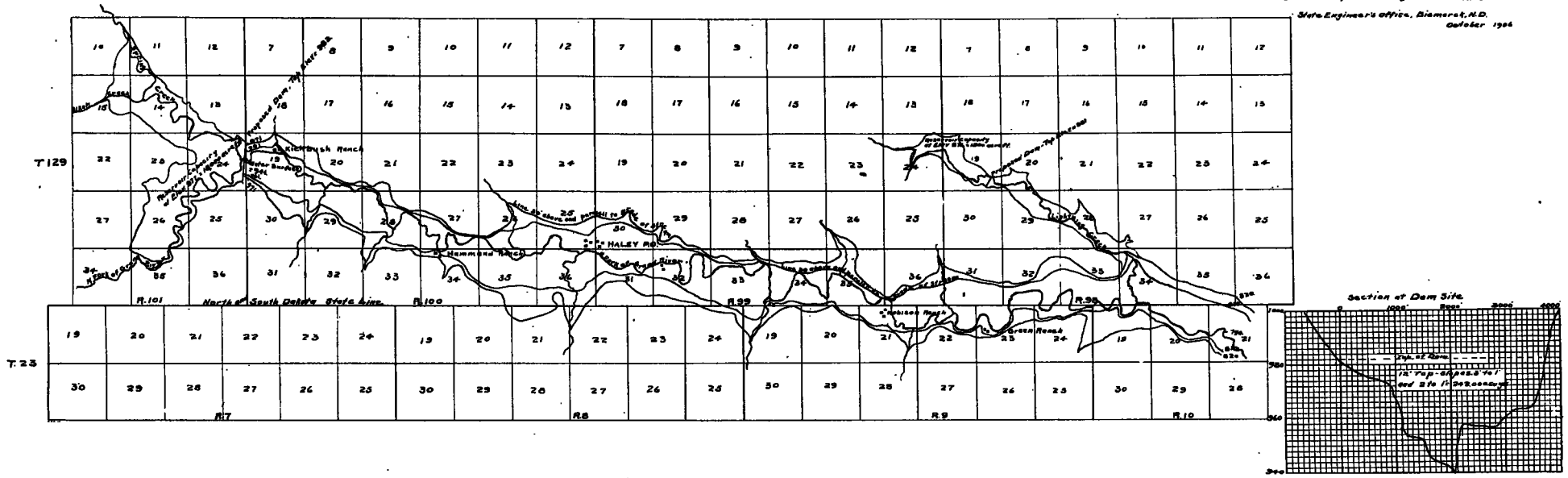
The secretary of the interior in certain decisions of the general land office as to what constitutes desert lands has taken the grounds that twenty inches of precipitation shall constitute the dividing line between regions that may be taken up as dessert lands and those that may not, on the theory that crops cannot regularly be raised profitably upon lands where the precipitation is less than twenty inches. That there are a great many regions where this does not hold true there can be no doubt, but at the same time it is clear that where the rainfall is less than twenty inches per annum, and especially when it becomes less than fifteen inches, crops cannot be nearly as profitably raised as they can where the precipitation is thirty inches or more. As an example of the amount of precipitation in North Dakota the following tables are given, showing the precipitation in North Dakota for each year from 1892 to 1905 inclusive, at Fargo, Bismarck and Williston:

Date: _____
 Estimated available capacity of reservoir at Elev 277: 10000 acre ft
 Drainage Area of Reservoir 40000 acres
 Irrigable Land 20' above present water surface of stream 7700 acres
 30' 10000

Plan of Proposed Irrigation Project
North Fork of Grand River
Burman County, North Dakota.

Scale 1" = 1 mile
 3 miles

State Engineer's Office, Bismarck, N.D.
 October 1904



PRECIPITATION TABLE.

| Year | Fargo | Bismarck | Williston |
|---------|------------|----------|-----------|
| 1892 | 20.92 | 18.17 | 14.26 |
| 1893 | 16.11 | 13.74 | 15.45 |
| 1894 | 18.50 | 14.32 | 17.70 |
| 1895 | 16.05 | 16.92 | 17.06 |
| 1896 | 22.31 | 16.63 | 22.13 |
| 1897 | 19.86 | 14.33 | 12.19 |
| 1898 | 16.36 | 13.67 | 18.44 |
| 1899 | 20.21 | 15.47 | 12.61 |
| 1900 | 25.54 | 17.88 | 15.81 |
| 1901 | 25.40 | 15.59 | 18.36 |
| 1902 | 23.24 | 15.95 | 16.17 |
| 1903 | 20.57 | 17.96 | 17.68 |
| 1904 | 20.26 | 14.17 | 9.44 |
| 1905 | Incomplete | 17.19 | 10.66 |
| Average | 20.41 | 15.86 | 14.85 |

These figures, which are taken from the reports of the United States weather bureau, show that in no one of these years has the precipitation at Bismarck been greater than twenty inches, and although the averages of all these stations are between fourteen and twenty inches, that of Fargo slightly exceeding the latter amount, yet it is seen that there are many years, especially in the western part of the state, when the precipitation is less than fifteen inches and in some years it is clearly too low for a successful raising of crops.

It is for this reason and the attendant consequences that we may find in the reports of one pioneer descriptions of the extremely fertile soil of the prairies of the semi-arid regions, while another traveler, passing along the same country a year or two later, may describe it as a desert unfit for human habitation. It is due to this condition also that in so many portions of the semi-arid regions one group of farmers so rapidly succeeds another. In certain portions of this district the writer has observed that at least four groups of agriculturalists succeeding one another, this state of affairs being due to the fact that in the periods in which the precipitation was the highest the country rapidly settled up and in a great many cases final proof was made on the lands and then when the dry periods came the occupants, many of them having mortgaged their land for a few hundred dollars, being unable to tide over the dry years, were compelled to abandon their homes. When the next wet period came others came in and bought up these farms even at a considerable advance above the amounts for which they were originally mortgaged, and so the procession goes on, one group succeeding another, each hoping that by improved methods of farming a better

selection of seeds, and through the receipt of better prices for their crops, they may be able to find prosperity where others have failed.

The American farmer is generally a very optimistic creature where climate, precipitation, and crops are concerned. This state of affairs was graphically described by Major J. W. Powell, formerly director of the United States geological survey, on August 5, 1889, at a session of the North Dakota constitutional convention. Major Powell, it should perhaps be stated, was better informed upon this subject, perhaps, than any other authority. The portion of his speech referred to on this subject was published in the first biennial report of this office on pages 12 to 14 inclusive, but even at the risk of repetition, a discussion of this subject would not be complete without a quotation of a few paragraphs. Referring to agriculture in this region, he says:

"In the eastern part they will depend on the rainfall, and in the middle portion they will have a series of years when they will have abundant crops; then for two or three years they will have less rainfall, and there will be a failure of crops and disaster will come to thousands of people who will become discouraged and will leave. Up and down the temperature of agriculture will rise and fall with the seasons in this manner, and the only practical way to do is to look the matter squarely in the face and remember that in middle Dakota agriculture will always be liable to meet with failure unless you provide against it. That is the history of all those that live on the border between the humid and arid lands. Years will come of abundance, and years will come of disaster, and between the two the people will be prosperous and unprosperous, and the thing to do is to look the question fairly in the face and provide for this and for all the years. You hug to yourselves the delusion that the climate is changing. The question is 4,000 years old. Nothing that man can do will change the climate. A long succession of years will give you the same amount of rainfall that any other succession of the same length will give you. The settlement of the country, the population of the country, the planting of the country, the cultivation of trees, the building of railroads—all these matters will have no influence upon your climate. You may as well not hope for any improvement in this direction. There is almost rainfall enough for your purpose, but one year and another you need a little more than you get."

It is not the writer's intention to belittle the results that can be and will be obtained through the improved selection of seed and improved methods of cultivation. Wonders have been and can be accomplished in that way, especially by such methods of cultivation as that known as the Campbell system of soil culture, but even such methods as those, which practically provide for the utilization of the precipitation of two years in the crop of

one will sometimes fail, and at its best it cannot compete with a system of agriculture which produces four crops to its one.

The census reports class as semi-arid the following states and territories: Western Kansas, Western Nebraska, North Dakota, South Dakota, Western Oklahoma, Southwestern Texas. There should also probably be added to this list Eastern Montana, Eastern Colorado, and portions of Washington, Oregon and California as the precipitation is about the same in these districts as it is in the vicinity of Bismarck. In face of all these facts a question that is often raised in North Dakota is somewhat amusing in the depth of the ignorance displayed. The question is: "Is irrigation a success? If it can be demonstrated that it is, then we would be glad to have it." Ten million acres are irrigated in the United States and many more millions will be irrigated as rapidly as water can be taken out upon the land. This is being done by men who know what irrigation means and who are paying from \$20 to \$50 per acre for irrigation works and that, too, in regions where a very large portion of the land to be irrigated is as well watered as is the western half, at least, of North Dakota.

The advantages of irrigation in the semi-arid and humid districts may be seen in all the districts named as well as in numerous other cases. Promoters in the state of Colorado are expending \$35 and more per acre for the storage of water for lands well watered and as fertile as any of those of Western North Dakota, in the full knowledge of what is already being done in that state upon 2,000,000 acres of irrigated land.

The writer has had citizens of eastern Colorado come to him imploring for some aid from the government or state or some other source in getting water to their lands, this, too, in spite of the fact that the precipitation for the last two or three years had been so great that waters already stored were not used for irrigation purposes. When this fact was pointed out, they have replied that they know such to be the case, but that they also knew that the dry years would come again when they would be ruined unless they could have an additional water supply; and this is the attitude of the people generally who understand the situation most fully. In western Kansas farmers are paying as high as \$50 per acre for the construction of irrigation works as an insurance. In Kansas, South Dakota, and other states where the conditions are as favorable for agriculture as they are in a great many portions of this state, the government is spending millions of dollars for irrigation in addition to the millions which have already been spent by the people themselves. To the North in Alberta, Canada, where the precipitation has varied from about thirteen inches in 1904 to thirty-two inches in 1902, the average being more than it is in this state, and the statistics as to crops showing that the average yield is also more than it is in this

state, the greatest irrigation project of this continent, at least, is being carried out by the Canadian Pacific Railway company, which plans to irrigate a tract of 1,500,000 acres, practically in one block. In southern Alberta, under similar conditions, irrigation has been found to be most profitable, and its practice has been followed by the construction of sugar beet factories and the production of the more valuable crops. An infinite number of instances might be given showing the increased productivity of the soil under irrigation in all these different regions, but to bring the matter more nearly home a few illustrations are given of instances of irrigation in this immediate locality. Mr. H. A. Nelson of Nesson, N. D., irrigates by spring flooding several hundred acres of land. In 1905 he states that on his irrigated land flax averaged twenty-six bushels per acre, No. 1 northern wheat averaged forty-two bushels per acre, oats averaged 100 bushels per acre; he cuts two crops of alfalfa and leaves a third over a foot high as a protection for the roots, and potatoes averaged over 350 bushels per acre. These results were obtained by spring flooding only, and not by as thorough a system of irrigation as Mr. Nelson himself most ardently desires.

Fisher Bros. of Dickinson, N. D., irrigate by pumping on their land and their wheat averaged in 1905 forty bushels per acre.

Numerous other instances might be given showing similar results. It may be said in general that irrigation in North Dakota, particularly in its western half, would certainly insure the production of at least forty bushels per acre, seventy-five to 100 bushels of oats and other grains in proportion. Compare these figures with those actually attained in practice without irrigation; ten to fifteen bushels of wheat per acre and often less, twenty-five to forty bushels of oats and sometimes none at all, and the difference is so startling that other illustrations are unnecessary.

CANAL CONSTRUCTION.

In the construction of canals for the carriage of water the objects to be attained are, generally speaking, the profitable production of crops either through drainage or irrigation, the improvement of sanitary conditions, the utilization of water for domestic purposes, the development of power, the filling of reservoirs, or some other useful purpose. Too often, however, so long as one or the other of these ends is attained in a more or less satisfactory degree, insufficient attention is given to the attainment of the desired results in the best possible, and hence the most economical way, and the objects of the suggestions presented herein is to call attention to these things that are too often overlooked. They are intended to apply, however, to the larger canals and not so much to canals with a capacity of only a few second feet.

THE GRADE.

In this particular, canals constructed for irrigation differ essentially from those constructed for drainage purposes. The object of a canal built for irrigation is to divert water from a given stream to certain lands, and this is usually to be done with the least possible grade that will effect the desired result and at the same time not permit the deposition of silt upon the bottom. Where there is grade "to throw away" a slightly greater fall may be given so that there will be no danger of the deposition of sediment, but care must be taken on the other hand to see that the fall is not so great as to permit of erosion of the channel, for all dirt thus eroded must necessarily be deposited somewhere, and the poorest possible place for it, generally speaking, is in the reservoir in which the water is to be stored or the field that is to be irrigated—the best possible place for it is just where it was in the first place. Of course, there are exceptions, but this may be stated as the general rule.

Different conditions prevail in the construction of drainage canals. Here the grade must generally conform to some extent to the general fall of the country, but the engineer should still guard against great erosion of the channel. In cases where the fall of the country is such that erosion would otherwise take place, "drops" should be constructed. They may be of masonry, concrete or timber, but in general, concrete will probably answer the purpose most satisfactorily. It is as great a mistake to permit erosion in the drainage canals as it would be to have too slight a grade. Of course, there may be exceptions to this rule also, as, for example, where there is rock near the surface, or where natural "drops" exist or where the erosion would be very slight owing to the short period of time in which any considerable amount of water flows through the canal. Some, however, say that they see no objection to erosion, no matter how great, where drainage is the object to be attained. This is probably due to the fact that they have become so disgusted with seeing the country about them undrained and covered with water and the soil, consequently, sour and sticky, that they are willing to let the pendulum swing to the other extreme. It is self evident, however, that if a ten foot ditch can carry the water with the loss of from two to four acres only to a mile, then a ditch, or I might say a canyon, from 100 to 200 feet wide, and consequently the loss of from twenty to forty acres, is an inexcusable and reprehensible waste. Wherever it is necessary, however, to give more fall than is needed to carry off the water with a velocity greater than four to five feet per second, the greatest safe guard next to drops is to have the bottom of the channel cut carefully and smoothly to grade and have it kept free from stones and obstructions. Every one who had much to do with the flow of water in open channels is familiar

with its tendency to burrow whenever and wherever it has any encouragement:

THE ALIGNMENT.

Wherever it is practicable, the canal should be built upon straight lines so far as possible, with easy curves from one tangent to the next. The amount of curvature and the sharpness of the curves will naturally depend upon the character of the country, the size of the canal, and, to a lesser degree, on the character of the soil. In general, where a canal is being constructed along a hill-side, "cut" should prevail at the points, and the "embankment" should prevail at the "bays" of the contour. In constructing drainage canals there will usually be less trouble in this respect, but here, too, due attention should be given to making transition from one tangent to another an easy curve and even then the outside bank along the curve should be ripped.

THE CROSS SECTION.

This will naturally depend upon the amount of water to be carried and the purpose for which the canal is to be used. In irrigation canals generally the cross section should be wider and consequently shallower, for a given capacity, than in drainage canals, where the purpose to be attained is exactly the opposite. In the latter case the object is primarily to lower the water plane in the soil, while in the former if the water plane is considered at all it is generally to be raised. In each case, however, it is most important that the cross section should be true to the specifications, particularly in earth. Side slopes should hardly ever be less than 1 1-2 to 1 and should generally be more than that, in the majority of cases probably 2 to 1. There are a number of points to be gained in requiring this condition which may be outlined as follows:

1. The object in constructing the canal is to carry the most water possible with the smallest cross section and the given grade. A canal with smooth sides and bottom will carry a great deal more water than a canal of the same size, theoretically, but having a rough surface. In calculating the discharge of water in similar channels by Kutter's formula the extremes of the co-efficient of friction to be employed are .020 for the smoothest and best constructed canals in earth and .035 for canals in bad condition. To take concrete examples: A canal six feet wide on the bottom with side slopes of 1 1-2 to 1 and carrying water four feet deep would, under the best possible conditions, have a capacity for about 200 cubic feet per second, while a canal of the same size under the worst possible conditions of rough sides and bottom would permit of a flow of less than 150 cubic feet per second. In other words, a canal poorly constructed would have to be made forty or fifty per cent larger than the perfectly constructed canal to carry

the same amount of water at first. I say "at first" because it would often happen that after a while the poorly constructed canal would be in so much worse shape that it would not begin to carry the amount that it would at first as we shall see.

2. Earth banks constructed with side slopes of 1 1-2 to 1, or, better still, 2 to 1, are usually practically permanent, while those having steeper side slopes, especially if they approach a vertical condition in any part, are almost certain to slough into the canal and form bars, eddies, and cross currents that retard the flow of the water and at the same time cause under cutting of the banks and increased sloughing, the consequence being that in a badly constructed ditch it will often be more than half filled with sediment and the material sloughed in from the banks, while the better constructed ditch is still in perfect condition.

3. The well constructed ditch, from the fact that the waters have their maximum velocity, keeps itself clean, while the poorly constructed ditch, in which the waters have a slow velocity, are constantly being filled with sediment from the lands draining into it.

4. Banks properly constructed may be made things of beauty, while those left rough are about the ugliest things that can be found, besides being a constant menace. Smooth banks with slopes of 2 to 1 may be readily grassed over with some thrifty and useful grass, but this can hardly be done on slopes steeper than 1 1-2 to 1.

These extreme conditions are sometimes seen in practice when canals are constructed by teams and scrapers, or by dredges or steam shovels. Unless bank are trimmed by hand, they may be left in the worst possible condition, while, on the other hand, banks may readily be trimmed and sloped so as to be permanent and beautiful instead of being temporary and ugly. There is too often a tendency, too, on the part of the engineer in charge to permit the contractor to slight the work and not comply with the specifications. These should be fair to start with, but once made, they should be complied with in both the letter and spirit. I have known ditches that the specifications demanded should be eight feet wide on the bottom, with side slopes of 1 1-2 to 1 to be left with any old side slopes and a bottom width of only three or four feet. There is usually something rotten when this is done.

THE BERM.

This is more especially an advantage on drainage canals. A berm four feet wide and upwards prevents a great deal of waste material from washing back into the canal to its detriment, and it provides, moreover, a means of traversing the canal on solid ground and yet inside the outer embankment. This is especially important on drainage canals in which the water should flow so

low in the canal that it should seldom, if ever, come up to the ground surface excepting at flood stages.

FREE DISCHARGE INTO DRAINAGE CANALS.

A mistake that is sometimes made in the construction of drainage canals is to leave a continuous embankment on both sides, neglecting to provide channels by which surface waters may flow into the channel which is intended to be the means of carrying them off. Drainage ditches have been built in this state, the embankments of which have actually served as dams preventing the surface water flowing into the ditches. Of course, such a state of affairs is ridiculous. In the first place the ditch should be deep enough to carry the water off without permitting its surface, excepting under extraordinary conditions, to rise to the normal level of the lands to be drained. Usually the best use to which the excavated material can be put is to utilize it in filling low places, but if this is not practicable, inlets into the canal should be left at frequent intervals. A good way is to lay tile drains before the embankments are made, so designed that they will carry the surface waters of the fields into the canal. If desired, gates like those of irrigation canals, can be made. In this case, however, they must let water into the canals and not out of them. A little forethought in this particular may mean a very great saving in the end.

THE OUTLET.

In drainage canals the outlet is of very great, if not of the very greatest importance. The water must have a free discharge and at the same time it should not fall off rapidly without being checked by drops or in some other suitable manner. Great harm has been done in having too great a fall from a canal into the river when it was not properly controlled. Cutting back commences immediately and the sides cave in and erosion commences, the stream cutting from side to side until, if left alone, it will form a river valley of its own. On the other hand, even greater harm will result if no outlet is provided so that the water sets back up the canal in a still pool, creating a settling basin in which sediment is deposited, causing the water to spread out over the land more and more each year. All the work is thus undone after a little. A mistake almost equally great is to construct an irrigation canal with too slight a fall so that deposition of silt takes place in a similar way.

The conclusion of the whole matter is that a thing well done is twice done; in fact, the proverb does not go far enough, for a thing well done frequently prevents the necessity of having it done a great many times over.

THE RELATION OF THE OFFICE OF THE STATE
ENGINEER TO OUR DRAINAGE PROBLEMS.*

Ladies and Gentlemen: The general subject of drainage reminds me of the words of a Wyoming orator who was once introducing a friend of mine. He exclaimed with a burst of oratory, "If he is great who can induce two blades of grass to grow where one grew before, how great is he who can make two drops of water flow where one flew before?" The subject of my friend's address was "Irrigation," but irrigation and drainage are twin sisters and both are dependent upon the proper carriage and control of water. In fact, the ideal condition in farming is to have the water under such perfect control that a sufficient amount can be supplied to the land, and then the surplus, after the ground has been sufficiently saturated, be removed by drainage. For these reasons under ideal irrigation conditions a drainage system is always an adjunct.

That the subject under discussion is of vital interest to the state as a whole and especially to this section of it no one will deny for a moment. From a study of the conditions prevailing in the Red River valley in the state of North Dakota by the state engineer's office, by averaging the number of acres reported upon in 130 letters sent in, in reply to 161 letters sent out, we find that the following figures approximately represent the true condition for 1905 as nearly at least as can be arrived at through correspondence:

| | |
|--|-----------|
| Acres represented in correspondence..... | 3,000,000 |
| Acres that could not be seeded..... | 89,234 |
| Acres that could not be summer fallowed..... | 70,187 |
| Acres not worth harvesting..... | 87,035 |
| Acres too wet to be plowed in fall..... | 166,625 |
| Acres too wet to be harvested..... | 171,493 |

Several of the letters show that while certain other tracts were too wet to be harvested at the proper time, cutting was nevertheless done after much of the grain had shelled out. Furthermore, the plowing was done when the ground was in poor condition, as was indicated in one of the replies which stated "It was too wet to plow, but we plowed."

Adding the amount not worth cutting to that which was too wet to be harvested, there would be a total loss of crop upon an average acre at fifteen bushels of wheat valued at 70 cents per bushel, there would be a loss in this item alone of \$2,663,430 for the season of 1905. There would be a great additional loss also upon the lands that could not be seeded, summer fallowed, fall plowed and upon which the wheat became over ripe and shelled out. As all the estimates made are conservative, it is probably

*Address of A. L. Fellows at the National Irrigation Congress at Portland, Oregon, August 23, 1905.

safe to assume that the total cost to residents of the Red River valley in North Dakota, through lack of sufficient drainage in the year 1905, exceeded \$4,000,000. The data here presented sufficiently indicates the importance of the subject and I will not dwell upon it at this time. The subject will be discussed in detail in the next report of the state engineer's office.

The replies to the inquiries that were sent out show that an intense interest is felt in the subject by those locally concerned, many expressing a desire to know how to go about the construction of drainage canals. Realizing the great importance of the subject, the chief of the division of irrigation and drainage investigations in the United States department of agriculture undertook the study of drainage needs in the Red River valley, and four of the counties affected and the state engineer's office cooperating, has caused a drainage survey to be made in those four counties, the plats and estimates of which are now being worked up by Mr. John T. Stewart, who had charge of the survey under the direction of Mr. C. G. Elliott. As both of these gentlemen are with us today, they will inform us as to the results of the surveys so it is not necessary for me to go into detail as to the survey at this time, but I may turn at once to the subject assigned me, which is "The Relation of the Office of the State Engineer to Our Drainage Problems."

The office of state engineer being a new office in the state of North Dakota, the duties and functions of the office are not well understood, and this fact must be my excuse for asking your attention for a few moments to the duties of a state engineer. In general, the state engineer is an officer vested with certain duties and powers appertaining to the public works belonging to, or being constructed by the state or having the administration of the laws relating to certain public works. Naturally his duties will vary widely in different localities. In New York, for example, the office has to do with the large transportation canals, like the Erie canal, to the use of water in the development of power, to the construction of bridges, etc. In Colorado the state engineer has a multiplicity of duties. He has under his direction the distribution and use of water for the development of power, for irrigation, in mining and practically all other uses, the construction of state highways and bridges, the supervision of irrigation and drainage, the administration of laws bearing upon this subject, the making of hydrographic and irrigation surveys and numerous other duties, the statutes specifying some twenty different lines in which he is to operate. In certain other states, as in Utah and Wyoming, he has charge of but little excepting the supervision of irrigation. In North Dakota the office was established for the purpose of having an officer who should have supervision of the water used in irrigation and for other purposes, the administration of irrigation laws, the measurement of streams, the making

of hydrographic surveys, and in general, to have charge of the control and use of water, under which head drainage would properly come. The subject of drainage is especially referred to in section 63 of the act authorizing the appointment of state engineer, as follows:

"Whenever requested so to do by any of the boards of county commissioners of any of the counties of this 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 commissioners in the engineering work required, to lay out, establish and construct any drain to be used by any county or counties or portions of the same for the purpose of diverting flood waters, lakes, water courses, and in general to aid and assist the counties of this state in making preliminary surveys and establishing systems of drainage."

A careful reading of this section shows that there is here opened up a wide range of operations for the state engineer. The board of county commissioners of any county where it is desired that a drainage system be surveyed, established or constructed, whether it be for the drainage of farm or swamp lands, or flood waters, or a lake or series of lakes, or the cleaning out or enlargement of water courses may ask the state engineer for his assistance, and he shall then co-operate with such board to the full extent of his ability, which will probably mean so far as his available funds will let him.: The law, in my opinion, should go farther in this matter than it does and place the subject of drainage on the same basis that it does the subject of irrigation, requiring the state engineer to make surveys of existing and possible systems of drainage, just as it does for irrigation, and furnish the means for making such surveys. The reason for this view may easily be seen. In the first place there should be some central office where all the maps and records pertaining to drainage should be kept just as those that pertain to irrigation are. In the next place the interest of different counties may either coincide or conflict. In either case a proper system of drainage can be worked out best by some state authority who will have no local interest at stake. In studying the drainage needs of the Red River valley, for example, it is found that what may apparently benefit one district or county may seriously injure another, while some other plan, if adopted, will benefit both and injure neither. Again, some of the newer counties will find that they have not the men who could lay out the best plans without injury to other interests or who can even select the plan best adapted to satisfy the needs of the district requiring the investigation. It is evident that such systems should be laid out so as not to injure other localities, but that all the systems should, on the other hand, operate as a harmonious whole, in furnishing one vast, comprehensive method of reclaiming to the greatest possible ad-

vantage of the entire region directly interested. This can only be done through some central authority whose duty it is to harmonize the various conflicting interests and with them all records shall be permanently kept.

It is extremely fortunate for the people of the Red River valley that the officers of the division of irrigation and drainage investigations have become interested in these drainage problems. It is owing to their foresight and perseverance that a comprehensive survey of four of the counties has been accomplished, but, the surveys completed, it will remain for the people themselves, through district organization or otherwise, to construct the system, and while there is no doubt but that the government drainage engineers will always be at the service of the people, it will nevertheless be found to be the greatest possible advantage that there be a depository for the records and a consulting engineer for the people. The state engineer is the consulting engineer of the people, who services may, upon request, be obtained practically free of charge, and all the boards of county commissioners should feel the greatest freedom in calling upon him.

It was with a realization of the great importance of this matter that the state engineer has found the means of co-operating with the four counties and the government drainage division in the survey that has been recently completed. The state engineer's office has furnished all the services of a deputy, Mr. T. R. Atkinson, who compiled the statistics given above, and is continuing the co-operation so pleasantly and profitably inaugurated at the present time with the agricultural department. The expenditures of my office in behalf of drainage up to the present time are about \$1,500, about half of the amount furnished by all the four counties combined. From this it may be seen that the office is doing everything in its power, as are also the agricultural department and the counties. This it will continue to do, taking the initiative wherever it can, and when the way is shown, following the lead of those who have blazed the trail.

The relation of the office of the state engineer to our drainage problems is clear then. The office is at the service of the people in the making of plans and estimates and surveys of all kinds of drainage of a public nature, in the construction of systems, in the formulation of laws, in the formation of drainage district, and in all other ways of a public nature.

All the people have to do to receive this assistance is to ask for it.

OUR DRAINAGE LAWS.

It is generally agreed that drainage is essential to the best development of the Red River valley, and to many other sections of North Dakota, and similar conditions prevail in many other states. It is roughly estimated that there is as much land in

need of drainage in the northern states as there is susceptible of irrigation and twenty times as much land needing drainage in the south.

We have estimated that the loss to the residents of the Red River valley in North Dakota alone during the year 1905 was upwards of \$4,000,000, certainly much more than enough to construct a complete surface system of drainage, and make a good start upon a supplementary system of tile drainage, which could be extended from time to time. These matters were discussed at length at the drainage convention held at Grand Forks in January, 1906, and their importance was then shown. It is not within the scope of this paper to go into details as to the surveys and the estimates at this time, as others will do this; but it is essential that we appreciate fully the magnitude of the subject in order that we may appreciate the extreme necessity of having suitable laws to cope with the situation.

Drainage, like irrigation, implies a higher order of civilization than the earlier and more primitive forms of agriculture. In the earlier stages each man, suspicious of his neighbor, perhaps, at any rate working individually, seeks to obtain from the earth all that it will yield, giving thought neither to the requirements of the future nor to the needs of those about him. In time, however, men find that more is to be gained through co-operation, and, in drainage and irrigation, twin children of agriculture, and themselves the progenitors of more advanced forms of agriculture, a height of social intercourse and interdependence is reached, that would never have been thought of under the ancient regime of "every man for himself." For it is only as men learn to co-operate that they advance to great heights in the agricultural, as in the industrial world.

As soon, however, as men begin to co-operate they find that it is necessary for the different members of the union to be controlled by certain rules formulated for their guidance, and these rules we designate as laws. They mark out the limits beyond which the members of the union may not go, and at the same time they point out the lines along which they may operate. They are always adopted in accordance with the dictation of experience, usually more or less bitter. It has been found that the rights of the many were being jeopardized and perhaps done away with by the stronger few, and justice, becoming dominant at last, asserts itself and says "in these lines you may work, but the strong must not and shall not oppress the weak. Thus far they may go but no farther." Fortunate, indeed, are those people who profit from the experience of others, and in this day and generation there are few subjects upon which light has not been thrown by the study of those who have labored or suffered, perhaps both, in the past.

So in drainage, the earlier settlers selected the more favorable localities and worked, every man for himself. Gradually conditions changed, and where formerly water ran off readily, where coulees, formerly open, have become choked by fences, weeds, and perhaps with evil intention, even those who held the more favorable locations find that they cannot longer farm to advantage. They find that their neighbors on higher ground are even injuring them by turning water down upon them, and those who are less favorably located discover that in the more unfavorable years they cannot raise crops at all, and so co-operation, which they should have voluntarily adopted in the first place, is forced upon them.

Then come laws made in the hope of bettering the conditions and these laws, amended from time to time, as experience dictates, are the rules governing the system of co-operation, or, better still, the system of the Golden Rule. Fortunately, in drainage, as in irrigation, the experience of the past may be drawn upon for present needs. In this state there is already a somewhat extensive set of rules or laws that have been formulated by wise and far-seeing men, who have adapted them from the laws of other states. Thus the laws of Ohio, Indiana, Illinois, Minnesota and other states have been drawn upon in the compilation of the drainage laws of North Dakota, and now it is believed that they may be still further revised and codified to the advantage of all concerned. I am of this opinion and it will be my effort to point out a few of the ways in which I believe that our drainage laws may be bettered by codification and amendments.

Before considering any possible amendments, however, it will be necessary for us to consider briefly what is already provided, and what the results are through existing laws. The first specific drainage law enacted in 1893 was declared unconstitutional by our supreme court a short time after its passage for two reasons. First, because it did not provide for the payment of damages, where parties were injured, and, second, because the counties were to guarantee the payment of drainage district bonds by its own bonds, a course which as it was contended, was forbidden by the constitution, which provides that counties shall not loan their credit. At the next session of the legislature, that of 1895, another law was passed, in substance about the same as the preceding one, but with the objectionable features removed or changed. The supreme court has twice declared this law constitutional with respect to some of its more important provisions, but there is still some possibility of attack upon it from other quarters. It seems fair to say, however, that the act will probably eventually be declared constitutional, in toto, in case it remains upon the statute books in its present form.

With the amendments up to 1903, inclusive, this law provides substantially as follows: Three drainage commissioners may be appointed in any county by the county commissioners, these

drainage commissioners to hold office for two years. Proceedings contemplating the construction of a drainage canal are initiated by the presentation of a petition presented to these commissioners. If the drain is asked for by the residents of any given community for sanitary reasons, there shall be a sufficient number of signers to demonstrate to the drainage board that the drain is generally desired and believed to be a necessity. If it is for the purpose of draining agricultural lands at least six free holders shall sign the petition and they shall be persons whose lands would be affected by the construction of the canal.

The right of way having been secured the board shall cause surveys and estimates to be made and shall then advertise for bids and let the contract. It also assesses the benefits to be paid for making an assessment roll with regard to which all parties to be assessed are to be heard if they so desire, due notice to that effect being given. The assessment roll having been drawn up it is to be delivered to the county auditor, who extends the roll as a special tax against the lands benefited. It is within the discretion of the county commissioners to cause this assessment in its form of special tax to be collected altogether in one year or to be distributed over a term of from three to seven years, bonds being issued for that purpose, the cost of construction being divided up into as many parts as the bonds have years to run, an assessment being levied and collected each year, sufficient in amount to pay that part of the cost apportioned to that particular year, and in addition, the interest upon the bonds.

An act of 1905 provided for the construction of drains lying in two or more adjoining counties, the drainage commissioners of the separate counties meeting as one board and agreeing upon the amounts to be assessed against the separate parts lying in the different counties. Another 1905 act, generally known as the "Irrigation Code," providing for the appointment of a state engineer, provides in paragraph 63 as follows:

"Whenever requested so to do by any of the board of county 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 commissioners in the engineering work required to lay out, establish and construct any drain to be used by any county or counties or portions of the same for the purpose of diverting flood waters, lakes, water courses, and, in general, to aid and assist the counties of this state in making preliminary surveys and establishing systems of drainage."

I have quoted this paragraph in full, since it is my warrant for my especial interest in drainage matters and since I shall wish to refer to it more particularly a little later.

These, in brief, are the principal provisions of the state law referring to drainage at the present time. Experience has demon-

strated that some changes should be made. I cannot hope to do more than indicate a few of them as this should, in my opinion, be the work of an expert legal commission which should devote considerable study to the drainage laws of other states, notably Minnesota, which is doing a considerable amount of work under an admirable drainage law, and to Indiana and some of the others. I believe that such a commission should include the chief of the drainage investigations of the United States department of agriculture, Mr. C. G. Elliott, if he will act, since he, as I know, has devoted a great deal of study to the drainage laws of the different states, and is, above all others, best fitted to say how successful the different laws have been in satisfying the requirements of the different localities. I may, however, venture to make a few suggestions.

The existing laws should first be codified and clarified, certain ambiguous points being cleared up, such as, for example, the payment of the earlier costs, the assessment of damages and benefits and provisions concerning bonding. The employment of expert legal talent by the drainage boards should be specifically provided for and the board itself should, I believe, be done away with as it now stands, its functions being handed over to the regular board of county commissioners. This board has to assume many of the more important duties connected with the maintenance of the canal system, it passing eventually under the control of the said board, and it would seem that all other duties might be performed either by itself or, in the case of inspection of right of way, etc., perhaps by "viewers" appointed for the purpose, as is done in some of the other states.

The state engineer should be especially made the consulting engineer of all the different boards, in order that he may use his influence to the end that drains shall be so constructed as to be, so far as possible, parts of a complete and harmonious system, which shall, so far as practicable, benefit all, injuring none. To this end copies of all plans and estimates should be filed in the office of the state engineer, and, in my opinion, when good and sufficient reason is shown he should have a veto power as to the construction of proposed systems where it is demonstrated that the construction would clearly greatly injure other sections, his decision, if necessary, being subject to appeals to the courts. The state engineer should be directed to make surveys contemplating general systems of drainage as is done in the case of irrigation, and funds should be provided therefor. As is generally known, the importance of this recommendation is well illustrated by the value of the surveys conducted during the past summer by the United States department of agriculture, the state engineer's office co-operating. Provision should further be made so that the county may guarantee the payment of the funds, even though this has to be done through an amendment to the constitution. Those

assessed for benefits should have the right to appeal to the courts, a privilege at present denied them, the drainage board being supreme in this matter as well as in the establishment of a drain. The provision that drains should be constructed, so far as practicable along sectional lines should be done away with, leaving the engineer to determine as to the best line and it should be required that all drains must be constructed in accordance with the recommendations and under the supervision of some competent engineer. It will be far cheaper in the end if this is done. Good engineering and study always pays many times over. The earlier expense should be paid directly from the county funds. At present there is no way of paying for them unless they can be included in the cost of construction, and in case construction does not follow the petition there may be no payment at all.

These and many more changes seem advisable, but this matter can be gone into best through the agency of such a commission as I have indicated. To those who wish to study the subject of desirable changes somewhat more at length I commend the excellent address of Scott Rex, Esq., delivered at the drainage convention held at Grand Forks, to which address I am indebted for much of what I have said. It is necessary, moreover, for me to pass to other important phases of the subject which must claim our attention. I have devoted so much of my time to the state because I am convinced that it is upon these that we must depend for all the construction work that is done. To make this clear we may consider briefly the federal laws that seem to bear more or less intimately upon the subject.

As is well known and as has already been referred to above, a survey has been made during the past season under the direction of the division of irrigation and drainage of the office of experiment stations of the United States department of agriculture, the counties affected and the state engineer's office co-operating. The federal funds furnished for this purpose are from a very small appropriation for the pursuit of irrigation and drainage investigations and they are of far too small an amount to be taken into consideration when it comes to the question of construction. It is clear that funds for this purpose must be derived from some other source, and it is natural to turn first to what is known as the reclamation fund, which from its very name might be thought to be available. This fund is derived from the sale of public lands in the sixteen most western (and arid) states and territories, and is in charge of the secretary of the interior, who is to utilize it in the construction of projects for the irrigation of, primarily, public lands. The money thus expended to be returned to the government in not to exceed ten annual installments by those who are to be benefited. It is argued with a considerable show of reason that since North Dakota has furnished over \$4,000,000 of this fund now approximating a total of \$30,000,000,

and since acceptable irrigation projects have not been found in this state upon which anything like the amount furnished can be expended, therefore a portion of this fund might be loaned for the reclamation of lands that need drainage. Admirable as this plan might be, from certain points of view, it is, in my opinion, impracticable for a number of reasons of which I shall state a few. In the first place no part of the reclamation fund belongs to North Dakota, or to any other individual state until specific amounts have been set apart for the construction of specific projects in such state by the secretary of the interior. The funds derived from the sale of public lands were not, before the reclamation fund was passed, and are not now, the property of the state in which the land sale was made. They belong, as they formerly belonged, to a general fund, which is now devoted to the specific purpose of creating new homes. It is provided in the reclamation act that the lands benefited should be subdivided into tracts of the right size to sustain single families, and that would probably mean in the Red River valley, for example, that the farms must be subdivided into eighty acre tracts. Again, the lands benefited must return the cost of the improvement, and that in the irrigated sections means three or four dollars per year per acre. In the drained sections the repayment of that amount of money for a single year would more than repay the entire cost of the construction necessary for a good system of surface drains and those who are opposed to diverting the reclamation fund from the object for which it was intended naturally argue that where the people can help themselves they should not be assisted by the government, the fact being borne in mind that millions of acres not so favorably situated as the Red River valley lands have already been drained in other states, and more and more are being drained each year, and also, the fact that even in the irrigation of public lands only such projects are to be undertaken as seem properly, owing to their great magnitude, beyond the reach of private capital.

Again, eastern senators and representatives argue that the land all being in private ownership there is no more reason why the government should undertake the drainage of private lands here than it should in Maine or Wisconsin. The situation in that respect is very different here from what it is in Minnesota, for example, where there remain many Indian and swamp lands that require drainage. I have the good fortune to be well acquainted with a number of the leading senators and congressmen at Washington and I have discovered that it is generally agreed that the reclamation fund must remain as it is, a fund for the creation of new homes, and that, further, if any inroads whatsoever were to be made into it there would be no stopping anywhere. There are a number of other states, as many, almost, as there are states in the union, that would at once claim their share if any of this fund

were to be used for drainage alone in the state of North Dakota, or any other one state: Again they argue that there is no more reason why the government should drain a man's private lands here than why it should remove boulders from private lands in Maine or Connecticut. A still more potent reason is the fact that the entire reclamation fund is even now appropriated for specific irrigation projects and it may prove difficult to secure for this state even the small amounts needed by its relatively unimportant plans.

I cite these arguments to show how imprabable it is that any money can be obtained from the reclamation fund or any other government funds for the direct drainage of submerged land in private ownership, and how we must depend upon our own resources for these purposes. There is, however, what may be found to be a proper federal undertaking in the straightening of the Red river and the impounding of flood waters in large reservoirs upon such streams as Red Lake river, Pembina river, the Sheyenne, etc. Work of this kind will eventually have to be done and much of it could be done only by the general government and any effort to secure funds for these purposes should be welcomed as timely and appropriate.

I have already discussed briefly the relations existing between the state engineer's office and our drainage work. The office is primarily an irrigation office and drainage was made rather incidental. I predict that the office will in time be as closely identified with drainage as with irrigation interests in this state. It will be my object at least to make these two lines of work equal in importance, and to devote as much time and money to the one as to the other. I discussed this subject at some length at the Grand Forks meeting and desire to say here merely that, as may be seen from a careful perusal of section 63 of the Irrigation Code, already noted, the state engineer is only the people's consulting engineer in both irrigation and drainage matters, and that his services are at the disposal of the people for the asking as far as his time and the funds of the office will permit. Having had some experience in helping to draft the irrigation and drainage laws of Colorado and of some of the other states I feel that I am in a position to furnish suggestions that may be of value at the proper time. I have indicated very briefly the relation that the state engineer's office does bear to drainage matters and also the relation that, in my opinion, it ought to bear. All residents of the Red River valley now realize as they never before have, that drainage is not a local township, or even county matter. Comprehensive surveys and plans should be made, not only in this but also in other sections, and one locality should not be permitted wantonly to injure another. To avoid such a state of affairs the supervision should be, to some extent at least, in some central office that is responsible for the proper construction and

maintenance. This is the case in irrigation lines where the state engineer is required to pass upon all plans contemplating irrigation before the appropriation of water can secure title to the water supply. Claims for appropriation are filed together with maps and statements and the same course might readily be adopted with reference to drainage. The plan has been found to work well in other states and there is no reason why it should not do so in North Dakota also. The state engineer has the advantage also of being constantly in close touch with the various federal offices and he can, therefore, co-operate with them to the best possible advantage.

Another important point in this connection, although it is along the lines of natural rather than artificial law, is that drainage and irrigation are irrevocably linked. Drainage nearly always follows irrigation and the reverse is very often true also. I have not the slightest hesitation in saying that in order to secure the best possible results the Red River valley should not only have its drainage system, but, especially in years of drought, it should be in a position to irrigate. The construction of such reservoirs as I have suggested might to some extent render this possible and they would soon be found to pay for themselves in this way as well as by holding the flood waters. That, even in the Red River valley, irrigation would greatly increase the output and profits, is a fact that would be easy of demonstration and in time this fact will be clearly seen.

I have briefly and imperfectly sketched for you the present status of our laws and have made certain suggestions regarding the proposed betterment of existing conditions. I desire to close with the pledge that the state engineer's office will give its best service to the working out of these and related problems and the hope that all who are interested will call upon it at any and all times.

SYNOPSIS OF DRAINAGE LAWS.

INTRODUCTION.

The following synopsis of the existing drainage laws of North Dakota has been compiled from the 1905 code adopted July 1, 1906, in accordance with the requests of a number of drain commissioners. The numbers of sections referred to are, therefore, those given in the new code. It is intended as a means of assistance to drain commissioners and others in properly carrying out drainage work by giving a brief outline of the legal methods of procedure. It is essential that the sections referred to be studied in detail, it being understood that this synopsis is intended merely as a guide and index to the law, and does not in general quote the statutes in full.

1. COUNTY COMMISSIONERS' DUTIES.

1. *Appointment of Drain Commissioners.* When petitioned so to do, the board of county commissioners of any organized county of North Dakota shall have the power, by a majority vote of all its members, to appoint three freeholders of its county as a board of drain commissioners of such county. It shall also fix the amount of the bonds to be filed by the drain commissioners.—§§1819-20.

2. *Benefits to Counties.* Since assessments may be made against the county, it is presumed that the county commissioners will pass upon such assessments as guardians of the counties' interests. Such assessments may be made on account of benefits to be derived from improved roads and the public welfare and convenience generally.—§1826.

3. *Roads Along Drains.* When drains are laid along or across public roads, or roads are later built along or across public drains, it is the duty of the board of county commissioners or township supervisors (§§1349, 1272, 1404, etc.), as the case may be, to keep the drains open and free from obstruction. They shall also maintain bridges and passage ways across legal drains officially constructed.—§§1837-38.

4. *Legal Drains.* All drains regularly constructed under the law are to be deemed legal drains and it is the duty of all boards of county commissioners in cases where the records of any drain may not have been preserved to see that such records are properly made in the office of the county auditor.—§1840.

5. *Maintenance of Drains.* Board of county commissioners shall, unless it is otherwise provided, keep open and repair legally constructed drains within their own counties. Cost of maintaining such drains shall be assessed in the same manner as provided for the construction of drains.—§1842.

6. *Rules and Regulations.* Boards of county commissioners may make rules and regulations regarding the maintenance and keeping clear the channels of streams and construction and maintenance of dams thereon.—§1843. They may also, it is presumed, make such proper rules and regulations regarding the maintenance of drainage canals and roads along the same within their own counties as would facilitate the maintenance of such drains and roads and best serve the public interest.

7. *Drainage Bonds.* Boards of county commissioners are authorized to issue bonds to cover the cost of construction of drains and other expenses connected therewith. Such bonds shall bear interest at a rate not to exceed 7 per cent and shall be payable in not less than three years and in not more than seven years from the date of issue. The board shall annually levy, upon the property liable to taxation on account of the location and construction of drains, a tax sufficient to pay the annual interest of any bonds which may have been issued for the purpose of locating or constructing drains and shall provide for the necessary sinking funds.—§§1849-50.

2. DRAIN COMMISSIONERS' DUTIES.

1. *Drainage Board.* Upon the petition of any person interested the board of county commissioners of any county may appoint for terms of two years and until their successors are appointed and qualified a board consisting of three drain commissioners, who shall be freeholders and shall not hold any other state or county office.—§1847. The county commissioners fix the amount of bonds which the drain commissioners are to give, the latter filing oaths of office and the required bonds within ten days after appointment.—§§1819-20. Drain commissioners shall be paid not less than two nor more than three dollars per day.—§1845. They have authority to administer oaths.—§1848.

2. *Petition for Drain.* Upon the petition for a drain (defined in §1818) of the proper number of free holders affected, the board of drain commissioners shall first personally examine the line of the proposed drain.—§1821.

3. *Survey.* If the board of drain commissioners deem the proposed drain desirable it shall cause the project to be surveyed by a competent surveyor who is to prepare profiles, specifications, plans, etc., and an estimate of the cost.—§1821. When it is desired the state engineer may be called upon either for making such survey or for consultation concerning same.—§7666.

4. *Final Location of Drain.* After the completion of the survey, estimates, etc., the drain commissioners, in consultation with the surveyor, shall locate the line, varying from the line described in the petition or extending it until a suitable outlet is found, if it is deemed advisable. So far as practicable drains are to be located upon the dividing lines between sections or their subdivisions, but this rule may be departed from when the drain commissioners deem it necessary. In locating the drain commissioners must furnish opportunities for all persons affected to appear before them and express their opinions concerning the location of the drain and other matters relating thereto.—§1821.

5. *Decision.* After the final location of the drain the commissioners shall decide whether the petition for its construction shall be accepted or rejected, taking into consideration, on the one hand, the costs of rights of way, construction, etc., and, on the other, accruing benefits. If the petition is rejected the petitioners are severally and jointly liable for costs and expenses up to this stage. If the petition is granted the drain commissioners shall make an order establishing the drain giving it a name by which it shall be recorded and indexed.—§§1822-23.

6. *Rights of Way.* The drain commissioners are next to procure the necessary rights of way, which must be conveyed to the county. The titles are to be obtained as is now or may hereafter be required by law, and, upon determination of the amount of damages, the board of drain commissioners may issue warrants to pay same, and, if possible, negotiate them at not less than par value, paying the proceeds into court for the benefit of the persons damaged. If the warrants cannot be negotiated the drain commissioners shall charge up the cost of acquiring the right of way, with the other costs of construction, to be paid for by regular assessments as provided for by other methods.—§§1823-24-25.

7. *Estimated Assessments.* The order of procedure as indicated by the law, is for the assessment of benefits to be made next, but as it may seem not practicable for assessments to be definitely determined until it is known what the cost of construction will actually be, it would seem that the logical thing for the drain commissioners to do would be to decide what the ratio of cost to the different municipalities, corporation, and persons shall be on the basis of a reasonable estimate of cost, taking into consideration the rights of way, bridges, canals, engineering, supervising, etc., and then set a time for a meeting at which complaints and arguments of all parties interested shall be heard, giving due notice of such meetings as required by statute. The assessments thus made are subject to review at a later meeting or at the time of the letting of the contracts. After the assessments have been definitely made the official proceedings of the board are duly recorded with the county auditor.—§§1825-26 27.

8. *Letting Contracts.* The drainage board is next (naturally but not necessarily, in consultation with the surveyor, or in accordance with his advice) to determine upon suitable divisions, specification, etc., and to give notice as provided in §1828, of the letting of the contracts for construction, paying legal rates for publication (§1845). They may take up the subject of assessments and give a hearing to complainants at this time. The board has power to adjourn the letting as may seem wise and to reject any and all bids. Parties who are to be assessed, if bidders, shall be preferred in the awarding of contracts, other things being equal. The letting of the contracts for the building of bridges and culverts for the drains may be deferred until the excavation has reached such a stage that it can be determined just what kind of bridges and culverts will be needed and such contracts are to be proceeded with as prescribed for excavation. The drainage board has power to grant a reasonable extension of time or relet any portion or parts thereof.—§§1828-29-34.

9. *Final Assessment.* The board, when ready to determine definitely the cost of construction, taking everything into consideration, including the interest on the warrants issued or to be issued, fixes the sum which shall be considered the cost of the construction of the drain. It is now to determine the definite amount to be repaid by the parties benefited and it shall make a list showing such amounts, a copy of which is to be served upon the clerk or auditor of each municipality against which taxes are to be assessed. This list is then to be filed with the county auditor who shall extend on the tax list as a special tax such amounts, such special tax to be collected by the county treasurer and credited to the drainage funds to which they belong. Warrants issued by the drain commissioners shall be payable from this fund and shall be received for taxes levied for such fund, such warrants bearing interest at the rate of 7 per cent per annum.—§§1840-31-32.

10. *Additional Work.* Additional assessments may be made if necessary to cover any deficit or additional expense. Drains may be deepened, widened and extended by following the same methods of procedure as in the case of new drains.—§§1833-35.

11. *Joint County Drains.* Where the same drain crosses portions of two or more counties the several boards of drain commissioners interested may meet and agree upon damages and assessments, after which they are to supervise the work in their several counties respectively.—§1836.

3. MISCELLANEOUS PROVISIONS.

1. *Filings With the County Auditor, and His Duties.* There shall be filed with the county auditor all official papers, documents, minutes of proceedings, maps, plans, specifications, assessment lists, etc., connected with regularly constructed drains.

The auditor is to approve the bonds of the drain commissioners and to make such filings and records as is prescribed by statute.—§§1820-21-24-27-31-36-40-41-49.

2. *County Treasurer.* The drain taxes shall be collected by the county treasurer. He shall receive warrants issued by the drain commissioners in return for taxes levied for the benefit of such drains.—§§1832-49-50.

3. *Duties of Railroad Companies.* A drain may be laid along any railroad when necessary, but not to injure such road, and when it shall be necessary to run the drain across the railroad it shall be the duty of such railroad company when notified by the board of drain commissioners to do so, to make the necessary opening through such road and to build and keep repaired suitable bridges and culverts.—§1837.

4. *Bridges and Culverts.* When any drain crosses any highway the cost of constructing the necessary bridges or culverts shall be charged in the first instance, as a part of the cost of constructing such drain, after which the bridge or culvert shall be maintained as a part of such highway. The drain commissioners shall also construct such bridges and culverts as they may deem necessary to permit reasonable passage from one part to another of any farm or tract of land intersected by such drain and the cost of construction thereof shall be charged as a part of the cost of construction of such drain and such bridge or passage way shall be maintained under the authority of the board of county commissioners or township supervisors as the case may be, and the necessary expense thereof shall be deemed a part of the cost of keeping such drain open and in repair.—§1838.

5. *Blind Drains.* Blind drains may be constructed by means of tiles or sewer pipes when the nature of the ground will permit of so doing. When blind drains are constructed their entrance shall be protected from drift wood and debris.—§1839.

6. *Assistance of State Engineer.* "Whenever requested so to do by any of the boards of commissioners of any of the counties of this state it is hereby made the duty of the state engineer, either by himself or any authorized assistant engineer, to cooperate with said county commissioners in the engineering work required to lay out, establish and construct any drain to be used by any county or counties or portions of same for the purpose of diverting flood waters, lakes, watercourses, and in general to aid and assist the counties of this state in making preliminary surveys and establishing systems of drainage."—§7666.

THE RECLAMATION ACT IN NORTH DAKOTA.

The national irrigation act, approved June 17, 1902, generally known as the reclamation act, was published in full in the first biennial report of the state engineer, so it is not necessary for it to be repeated at this time. It provides in general for the recla-

mation of arid lands, primarily public arid lands, in the sixteen most western states and territories. The funds raised from the sale of public lands constitute a fund known as the reclamation fund, under the control of the secretary of the interior. To carry out the provisions of the reclamation act the reclamation service was formed, the engineers of which investigate irrigation possibilities and decide as to their feasibility, and if approved by them and the secretary of the interior, proceed with their construction.

The secretary is instructed to determine the proper size of farm units upon which a family can be reasonably expected to support itself, being limited by the law, however, to a maximum of 160 acres and minimum of, at first, 40 acres. Since it was at first ruled that under existing laws, no further division can be made of the land office subdivisions, farms had to be limited to 40, 80, 120, or 160 acres, the size varying with the locality, character of the crops raised, nature of the soil and other conditions, a new law was passed in 1906 making it possible to subdivide these tracts still further. It is further provided that the cost of construction shall be repaid by the water consumers in not to exceed ten annual installments. As stated, the primary purpose of the law, as enacted, was to make habitable the public arid lands and, in this way, to create as many new homes as possible upon them. Since, however, it would be practically impossible to find large tracts of land in which private holdings were not interspersed, a provision was added to the law by which lands in private ownership might also receive the benefits contemplated by the law, no land owner, however, being permitted to obtain water for more than 160 acres and then only upon the condition that he was an actual resident upon the land or occupant thereof residing in the neighborhood. The secretary might, at his discretion, limit the amount to smaller areas. After construction and delivery of water the control of the works must remain with the government, at least until the payments required by the act are made for the major portions of the land irrigated, after which time the management and operation of said irrigation works may pass into the control of an organization of land owners under such rules and regulations as may be acceptable to the secretary of the interior. The title to and the management and operation of the reservoirs and the works necessary for their protection and operation shall remain in the government until otherwise provided by congress. Such provisions are made that the secretary may carry into effect the provisions of this act, subject to the limitation that nothing shall be construed as interfering in any way with the laws of any state or territory, relating to water used in irrigation and to the condition that the right to the use of water acquired under the provisions of this act shall be appurtenant to the land irrigated and beneficial use shall be the basis, the measure, and the limit of the right.

Section 9 has such an intimate bearing on the conditions in North Dakota that it is quoted verbatim as follows:

"Sec. 9. 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 funds 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 proportions and subject to the conditions as to practicability and feasibility aforesaid." We shall refer to the provisions of the section later.

Section 10 provides that the secretary may make such rules and requirements as may be necessary and proper for the operations of and carrying the provisions of this act into full force and effect.

The act was compiled with the greatest care and is singularly clear and comprehensive in its general provisions, at the same time leaving details to be passed upon by the secretary of the interior under such rules and regulations as he may see fit to adopt. The rules thus far adopted have come into being through necessity rather than as the evidence of any arbitrary use of power on the part of the secretary. It has been found best in localities where there were already many settlers to form water users' associations, as soon as practicable after the project had been found feasible, to look after the necessary details and to bring the settlers into harmonious co-operation with the engineers of the reclamation service, the latter being thus permitted to devote their attention more directly to engineering features, leaving the political side to the people most nearly affected. In all such cases articles of incorporation acceptable to the secretary of the interior have been adopted and beneficiaries have been required to obligate themselves to make the necessary repayments to the government. An important provision, to be credited to Mr. Geo. Y. Wisner, consulting engineer, recently deceased, has also been made by means of which persons owning tracts larger than 160 acres may avail themselves of the opportunities presented by the act, by agreeing to turn over their surplus lands under a trust deed to the water users' association, the conditions being such that the owner may have entire control of his lands until the government is ready to deliver water thereon, but in

case the lands have not been disposed of up to that time to persons eligible to receive water under the terms of the reclamation act, then the association shall have the power of disposing of this land to the highest bidder, the proceeds, less the cost of sale, going, of course, to the land owner. In practice the land owner would ordinarily retain 160 acres, or whatever subdivision was permitted, of the land which he most desired to keep, in his own name, transferring, by sale or otherwise, the remainder to other parties eligible to receive water from the government within the period of construction and before the government on its part, was ready to make further contracts with the individuals. This provision has been found to be of very great value in permitting land owners, who would otherwise have been obliged to see the greater portion of their lands unirrigated, to bring all their lands within the provisions of this act. They may, of course, keep their land out of the project if they so desire, though it is clear that if any considerable portion of land in a given district is left unirrigated it is liable to jeopardize the entire project. For example, if it costs \$25,000 to construct a ditch for 1,000 acres of land the project might be deemed feasible, whereas, if only 500 acres of that land were subscribed, the cost of construction would be nearly as much and the cost per acre would be raised from \$25 per acre to possibly \$45 per acre, in which latter case the project would probably be thought to be not feasible.

Since no construction work could be undertaken excepting where the laws governing the lands were in conformity with the provisions of the reclamation act, the reclamation service found itself handicapped at the outset through the fact that certain of the states had no adequate irrigation codes, and, in some places, by the fact that existing laws or customs were contrary to certain of the provisions of the reclamation act, particularly in its provisions that the water must be appurtenant to the land, and it was found necessary that such states should pass laws in harmony with the reclamation act. A code of laws was compiled with great care by Mr. Morris Bien, supervising engineer of the U. S. reclamation service, and submitted to the legislatures of such states as did not have suitable codes. North Dakota was one of these states and it accepted Mr. Bien's code practically without change, and the code now adopted in this state is, therefore, the one suggested by him as being in conformity with the provisions of the reclamation act. Since this law, together with the reclamation act, has been issued in pamphlet form it is not thought advisable to republish it at this time.

The reclamation service has devoted a great deal of study to irrigation conditions and possibilities in this state. These surveys and investigations will be described more fully elsewhere. As a result of its investigations five projects have been selected

as feasible from the government standpoint, provided that the people under them meet the conditions of the reclamation act. These five projects are the Lower Yellowstone project and those in the vicinity of Bismarck, Fort Buford, Williston and Nesson. All these projects are described in detail elsewhere.

There has been, apparently, a widespread misunderstanding regarding certain phases of the reclamation act. It has been assumed without careful study that because a large portion of the reclamation fund, approximately \$5,400,000, more than has been furnished by any other state with the exception of Oregon, has been derived from the sale of public lands in North Dakota, for this reason the state is entitled to the use of that money. A moment's consideration of the matter will show, however, that there is no basis for such a belief. Before the reclamation act was passed all money derived from the sale of public lands in the United States went into the general treasury, excepting so far as portions of this amount was set aside for specific purposes, and never, at any time, has the bulk of the proceeds from such sales gone to the state in which the lands were situated. The United States, and not the individual states, being the owner of the lands, the money derived from their sale naturally went into its own treasury. This condition was modified, but not materially changed, but the passage of the reclamation act, in which it was made incumbent upon the reclamation service to construct irrigation works in the arid and semi-arid regions of the United States for the purpose of irrigating public lands primarily, and in that way making them habitable and, incidentally, permitting lands that had passed into private ownership to be benefited along with the public lands. The money derived from the sale of the public lands in the sixteen most western states and territories covered by the bill is, it is true, to be used somewhere in those sixteen states and territories, but primarily this entire area is considered as one great domain in which the lands that can be reclaimed are to be benefited regardless of whether the land to be irrigated is in the particular tract or in the particular state where the sale was made or not. It would be as logical to say that each quarter section sold was entitled to have expended upon it the amount derived from its sale, and no more, as to say that because the proceeds arose within a certain state irrigation projects should be constructed with in that state to the extent of the funds furnished, and only to that extent. As a matter of fact the needs of communities in the arid regions are almost in the inverse proportion to the money furnished. For example, the state of Nevada which has furnished almost the smallest amount of money to the fund has the greatest need of that money and the state of Oregon which has furnished the largest amount has almost the least need. More than that, it is logical that the money should be used where it will do the

most good and where it is most needed since it is here that the return to the reclamation fund will be made most quickly; as, for example, in New Mexico where there is such a demand for water for irrigation that any reasonable cost would be repaid to the government without delay, while in other sections, where the rainfall is greater, there is danger that the residents will shirk the responsibility of repayment on the ground that they could get along without the water. The act does, however, give the state from which the funds are derived nominally the first chance by saying that it is the duty of the secretary of the interior, "so far as the same may be practicable," to expend the major portion, (construed as 51 per cent) of the funds arising from the sale of lands in any given state for the benefit of arid and semi-arid lands within its own limits, it being provided, however, that he may "temporarily" use such portion also, i. e., the major portion, for the benefit of arid and semi-arid lands in any of the other states named, the excess to be restored to the funds "as soon as practicable." As a matter of fact if section 9 had read as follows it would have meant exactly what it does now and been a great deal more clear: "Section 9. That the secretary of the interior is authorized to utilize the reclamation fund upon the most feasible projects within the limits of the sixteen states and territories above named as he shall deem best, giving the benefit of the doubt, where one exists, to the states in which the funds arise."

Making direct application to the state of North Dakota, the situation is as follows: Since a greater portion of the reclamation fund has been furnished by the sale of lands in this state than in any other excepting Oregon the reclamation service has investigated conditions in this state more thoroughly than in almost any other. Owing to the peculiar conditions existing here, however, but few feasible projects, and these of quite limited extent, suited to government construction have been found, and in these few, even, it has been found difficult to persuade the people holding the lands that it was to their advantage to pay for the expensive irrigation works required. The reclamation service is now in possession of all material facts regarding the possibilities of irrigation in the state of North Dakota, and stands ready at any time to take hold of any project which the people themselves desire to have undertaken under the terms of the reclamation act.

As would naturally be expected, the lands first filed upon have been along the running streams and in the valleys, and for this reason the government cannot take hold of any large tracts of land entirely public but there must invariably be large portions of the land in private ownership and in such case it is clear that the reclamation service cannot well undertake a project unless its co-operation is desired by the people, and the people should under such conditions take the initiative.

There are very many localities in the state where the occupants of from 5,000 to 15,000 acres might organize water users' associations and invite the assistance of the reclamation service, but in view of the difficulties experienced by the government officers in the localities already investigated there is little likelihood that they will make any strong effort to undertake work in regions where it seems probable that such assistance is merely not desired, but is, on the other hand, regarded with suspicion. Notable examples of such localities are those near the mouth of Knife river, Muddy creek in Williams county, Muddy creek in Morton county, Grand river in Bowman county, the Little Missouri river in a number of different places, and upon various branches of the Heart and Cannonball rivers. There seems to be no physical reason why many of these districts might not organize and construct irrigation systems of their own, and there is not the slightest doubt but that they would be exceedingly profitable undertakings and would add great wealth to the sections in which they would be located. If the residents of these communities desire government co-operation they will, however, have to express their desire in plain statements. The state engineer is ready to co-operate with the residents of any such communities at any time, in the preliminary steps of the organization and investigation, if such wish is expressed by a petition signed by enough residents to show that the improvement is generally desired.

Once for all it will be well for would be irrigators in the state to know that the reclamation service stands ready to help only those who are willing to help themselves and then only on the condition that there are some public lands left in the region to insure a public character to the project.

THE RELATION THAT SHOULD EXIST BETWEEN THE STATE AND FEDERAL AUTHORITIES IN IRRIGATION MATTERS.*

This subject is one of considerable importance and presents a number of different phases and is worthy of the most careful consideration. The duties of state officers with reference to the administration and control of irrigation affairs are so varied that they must touch the operations of the different branches of the federal service in many and diverse ways. There are, for example, the duties of the state engineer or other state officer having charge of irrigation matters with reference to the application for, the adjudication of, and the transfer of water rights, the distribution of water, the supervision of the construction of dams and to a certain extent of canal systems, the supervision of irrigation itself, the measurement of water and various other details con-

*Address of A. L. Fellows at the National Irrigation Congress at Portland, Ore. August 23, 1905.

nected with the administration of irrigation laws, in which it will be necessary for him to parallel in some respects the work carried on by the federal authorities along similar lines. It will be well to define briefly the character of the duties of the state engineer and of some of the federal authorities before attempting to lay down any line of action.

The State Engineer: Under this title are classed all who have direct charge of the administration of irrigation laws in their respective states regardless of their exact titles. We shall not at this time take into consideration other duties devolving upon certain of the state engineers, as, for example, the construction of roads and bridges, membership on certain boards and surveys of state and county lines, but deal only with those that have to do with the use of water for irrigation purposes. The state engineers in most of the states at the present time have control over,

First: The application of water rights and the granting of such rights upon the completion of the necessary work.

Second: The adjudication of rights upon streams where water has been used to a considerable extent before the modern method of granting permits had been established.

Third: The construction of dams and irrigation systems in compliance with the laws and the instructions of the state engineer.

Fourth: The transfer of water rights.

Fifth: The control and distribution of water in accordance with the decrees and permits.

Sixth: Hydrographic surveys and investigations combined with the measurement of streams.

Seventh: The consideration of claims for water under the Carey act, and, in some states, irrigation district laws.

Eighth: As in Colorado, for example, determination of precipitation.

Ninth: Preparation of reports.

Other related duties will occur to each but those enumerated will be sufficient to show the general scope of the work to the state engineer in irrigation matters.

The general land office has important duties related in a number of different ways to the distribution of water and the administration of water laws. Under the terms of the Desert Land act the claimant is obliged to irrigate a portion of his land, and such irrigation must be in accordance with the state laws governing the same, where there are such. The secretary of the interior through the general land office also grants rights to make use of reservoir sites and rights of way for pipe and canal systems, the applicant in such cases showing that he has complied with the state laws and regulations. The same is true of withdrawals of land under the Carey act. In all of these cases the department

theoretically requires that there shall be a strict compliance with the state laws, although it would seem in the case of the desert land entries at any rate, that the requirements of the general Land office do not go far enough to insure a certainty of correct decisions.

The reclamation service was organized for the purpose of carrying out the provisions of the reclamation act, that is to say, to examine and survey for, and construct and maintain irrigation works for the storage and distribution of water for arid and semi-arid regions in certain states and territories: It is especially provided in section 8 of this act that nothing in the act "shall be construed as affecting or intending to affect or in any way to interfere with the laws of any state or territory relating to the control, appropriation, use, or distribution of water used in irrigation or any vested right required thereunder, and the secretary of the interior in carrying out the provisions of this act shall proceed in conformity with such laws, and nothing therein shall in any way affect any right of any state, or of the federal government or of any land owner, appropriator or user of water in, to, or from any interstate stream or the waters thereof, Provided, that the right to the use of water acquired under the provisions of the act shall be the basis, the measure and the limit of the right."

The reclamation service, therefore, has nothing to do with the distribution of water or the administration of water laws in the state in which it is operating, excepting so far as they relate directly to the works constructed by the service itself. In order that there may be no friction with the state officers the chief engineer of the reclamation service desires, as I am informed, that there shall be close harmony between the state engineer and the officers of the reclamation service to the end that the rights of those using water under the government systems shall be as fully protected as it is expected they would be were they under private systems. It is the policy of the reclamation service, as I understand it, to call into consultation regarding matters of importance those who have charge of the administration of the state laws for the mutual benefit of both parties.

Operating as the reclamation service does, under the direction of the secretary of the interior, complete harmony with the other branches of the department, as for example the general land office, is fully assured, and in this way co-operative investigations are made with reference to the desert land entries and other forms of entry within tracts set apart for reclamation.

Both the hydrographic branch of the geological survey and the reclamation service have issued numerous valuable bulletins and papers which are of great interest to the irrigation engineers generally.

In the department of agriculture a number of bureaus and divisions have to do more or less directly with irrigation, and hence with the work of the state irrigation officers. The one more directly connected therewith than any other is the office of experiment station through the branch of irrigation investigations. The province of this branch is to investigate and compare water laws, water rights, methods of irrigation and the advantageous use of water. Neither this nor any other branch of the department of agriculture has anything to do directly with the administration of water laws, but amongst its other duties it is expected to give such information as will be of the greatest advantage in the compilation and administration of irrigation laws, and to issue reports bearing upon the subject. These reports are of very great value, and the suggestion and advice of this branch should be always desired and may be most profitably used.

Less directly, but still intimately, connected with the state engineer is the work of the bureau of soils, the bureau of plant industry, the forest service, the weather bureau, the census bureau in the department of commerce and labor, and other bureaus.

The bureau of soils does most important work in connection with irrigation through its study of soils, the determinations concerning alkali and mineral constituents of soil in general, and is doing a work with which every state engineer should be thoroughly familiar, and the reports of which he should have upon his shelves, so far at any rate, as they relate to his own territory.

The bureau of plant industry investigates conditions of plant growth and is prepared to furnish information concerning plants suited to irrigation conditions. Here also much work, which is of deep interest to all of the engineers is being carefully and conscientiously done.

The work of forestry service is also of great importance in connection with irrigation through the study of the relation of runoff to rain fall in forested and nonforested tracts, and through the regulations of the water supply by means of forest reserves and in certain other ways.

The weather bureau is determining the amount of precipitation throughout the country with far greater consistency and thoroughness than is possible in the individual states. It is also making a study of the heights of water in rivers with reference to a determination as to danger from floods.

The census bureau of the department of commerce and labor goes systematically into the study of the amount of irrigation practiced and, to some extent, into various classes of irrigation carried on in the different states. The work of the other departments is also of more or less interest to the state engineer, as for example, the work of the coast and geodetic survey, the topographic branch of the geological survey and the geologic branch of the same survey, etc.

The relationship which should exist between the state engineer and all the different departments and bureaus can be summed up in two words: Familiarity and co-operation. The state engineer should become familiar with the work of these different departments, and having become familiar with their work he should, for the mutual advantage of all, co-operate with them. He can at times be of very great assistance to the general land office through his reports, affidavits and suggestions; to the various branches of the geological survey, especially the topographic and hydrographic branches, by co-operating with them so far as lies in his power; to the reclamation service by suggesting feasible irrigation projects, by co-operating with it to see that no projects that would not be feasible are undertaken, by judicious suggestions, since in such a large and new service, many of the men must necessarily be lacking in experience irrigation engineering, by assisting it in making its filings in accordance with the state laws, and, in short, by doing all that he can to further the interests of the state through the beneficent application of the reclamation act. He should ever keep in mind that he is the consulting engineer for the people of the state which he represents and it is his duty to see that they go into no unprofitable scheme, while at the same time he should further every proper undertaking so far as he can consistently do so.

He should assist the division of irrigation and drainage investigations of the office of experiment stations by his suggestions and assistance, and also the bureau of soils, the bureau of plant industry, the forest service, the weather bureau, and other branches of the government service. In doing this he can rest assured that he will receive far more than he can ever give. All these different branches of the government service desire the assistance and not the antagonism of the state officers. The state engineer will fill his office to the best advantage to the state while working harmoniously with the government officers. It is not to be assumed, for it would be a great mistake to make such assumption, that the work of all or any of the departments of the government is perfect. There are certain to be in all the different branches, both among the state engineers and in the government service, those who are weak and vacillating, those who are averse to co-operation, those who, while pretending to co-operate, rank so high in their own estimation that the greater the familiarity with them the less is the respect they command, and those who assume to co-operate rather for the purpose of obtaining suggestions which they may appropriate as their own; but these are the exceptions rather than the rule. This condition of affairs in no way affects the general correctness of the position taken that there should be the closest intimacy and co-operation between the officers of the state and the government along all these lines.

The basic idea in all the different branches is that the work undertaken is for the betterment of mankind through the dissemination of knowledge or the actual construction of works that will be of benefit to man, and the little excrescences and imperfections are such, I believe, as will become modified or will disappear altogether as time goes on and relations become better understood.

The following examples can no doubt be duplicated or improved upon by all present, but they are offered as illustrations of the ways in which the state engineer's office of North Dakota is co-operating with and receiving benefit from the different departments of the government service, and may not be out of place. First of all the irrigation law under which the state engineer is operating was compiled from earlier laws by one of the officers of the reclamation service. The state engineer has under consideration at the present time plans for co-operation with the hydrographic branch of the geological survey, and his office is being benefited by the investigations carried on by both that and the topographic branches. He is endeavoring to co-operate with the officers of the reclamation service in the establishment of irrigation projects, but only such projects as are good business propositions for the people in the different parts of the state. He is co-operating to the best of his ability with the drainage surveys and investigations of the department of agriculture, by furnishing an assistant to work in the drainage surveys of the Red River valley. He is working to the end that the state may be benefited still more in the future than it has in the past by the investigations of the bureau of soils. He has invited the bureau of plant industry to make investigations in connection with certain willows said to be adapted to the protection of river banks. He has requested the forest service to make investigations of the timbered tracts along the Missouri river partly with the same end in view, and partly to determine whether these tracts are more valuable for timber and forestration than for agriculture. This state, also, like other states is being benefited by the efficient services of the weather, census, and other bureaus in various ways.

One feature of great interest to all has not been touched upon, and that is the control of the water of interstate streams, where there are conflicting rights in different states. At present state engineers have of course, no jurisdiction over irrigation matters outside their own state lines, and there will always be conflicts between adjoining states. At the present time however, neither is there any federal authority having control over such conditions, and it seems probable that when the time does come for an authority to have control over such conditions the state engineers will be most important factors in such control. It is certain, I am sure, that they will be called upon for information and suggestions, as to the proper distribution of waters, and that

will result, I believe, in their becoming members of any board which will have to determine such conflicting claims.

My recommendation is, then, intelligent, not blind co-operation. Thus will be established those relations that will be most advantageous to all, both to the state and nation.

*APPLICATIONS FOR WATER.

The two subjects assigned me for discussion are:

1. How shall state engineers construe the expression "provided that the appropriation is not detrimental to the public welfare," in passing upon the applications for new appropriations of water?—and

2. The practice of state engineers in dealing with applications for small appropriations in isolated sections.

Since the second of these two subjects may be thought of as akin to, or as a corollary of, the first, I have thought it best to discuss the two in a single paper, though in regular sequence.

In the consideration of a subject of the interest and importance of this one, and one which may be studied from so many different points of view, there are certain to be wide divergencies of opinion, and, in presenting my view, I cannot expect to do more than to open the way for discussion. If what I have to say shall meet with a reception which can be construed as favorable in any degree from those who have had experience along the lines under consideration it will be a source of gratification to me.

In considering the first phase of the subject it is important that we examine the laws of the different states that bear upon it and the causes leading up to them, and determine, if possible, what is intended by the laws and the lawmakers, since it is always to be assumed that laws are made to be followed and not to be evaded, but, if wrong, are to be changed.

In the early stages of irrigation practice in this, as in other countries, it was assumed, so far as any assumption whatsoever was made, that the right to the use of water belonged with the land upon which it was beneficially used and that under the principle of "first come first served" the prior appropriator would always be able to keep his own, and the later appropriators were entitled to and would get only what was left. The situation may also have been and undoubtedly often was complicated by dense ignorance concerning the available water supply. It was generally thought (though the opinion was generally rather characterized by want of thought) that the water supply was inexhaustible, hence there was no necessity for regulation.

Whatever the reason, the earlier laws bearing upon irrigation made little if any reference to regulation by any state officer, disputes being left for settlement by local custom or court decisions, and no limitations whatsoever were made governing the

*Address by O. L. Fellows at State Engineers Association at Cheyenne, Wyo, April 13, 1905.

amounts or methods of appropriations. This was the case in California, in Colorado, and in the early irrigation history of several of the other states. In some of these states, as in Colorado, it has been in the past and still is argued that every application should be granted, thus giving the appropriator the opportunity of making the fullest possible use of any unappropriated water, and letting the courts adjudicate the rights and establish the priorities. Passing, for the present, the question as to whether or not this might not be, upon the whole, the best plan, it is certain that it led to many difficulties and great expense and when Dr. Elwood Mead, who was thoroughly familiar with the situation and its complications, supervised the drafting and passage of the Wyoming irrigation code, he incorporated the following provisions:

Section 871, R. S. Providing for the measurement of water in the adjudication of water rights.

Section 919, R. S. All applications which shall comply with the provisions of this chapter and with the regulations of the engineer's office shall be recorded in a suitable book kept for that purpose; and it shall be the duty of the state engineer to approve all applications made in proper form, which contemplate the application of the water to a beneficial use and where the proposed use does not impair the value of existing rights, or be otherwise detrimental to the public welfare. But where there is no unappropriated water in the proposed source of supply or where the proposed use conflicts with the existing rights, or threatens to prove detrimental to the public interest it shall be the duty of the state engineer to reject such applications and refuse to issue the permit asked for.

This is intended to be in accord with section 31 of the state constitution which is as follows: "Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the state, which, in providing for its use, shall equally guard all the interests involved."

The Nebraska code copies the Wyoming provision very closely but is, in my opinion, somewhat more definite and for this reason I read the essential portions.

Sec. 6771, R. S. It shall be the duty of the secretary of the state board of irrigation, as soon as practicable after the passage of this act to measure or cause to be measured the quantity of water flowing in the several streams of the state and to make a record thereof in the office of the said board, and he shall from time to time make such additional measurements as may be necessary, or cause the same to be made for the information of such board in considering applications for water appropriations and such controversies as may arise regarding the distribution of water.

The end of section 6782 provides: "If there is unappropriated water in the source of supply named in the application and if such appropriation is not otherwise detrimental to the public welfare the state board, through its secretary shall approve the same by endorsement thereon."

"Provided that the application may be approved for a less amount," etc. And again: "If there is no unappropriated water in the source of supply or if a prior appropriation has been made to water the same land to be watered by the applicant the state board through its secretary shall refuse such appropriation and the party making such application shall not prosecute such work so long as such refusal shall continue in force."

No further legislation of importance bearing upon this subject was passed by any of the different states until 1903, in which year, curiously enough, two codes, each carefully and thoroughly digested, were passed in two states where irrigation is of prime importance, Idaho and Utah, and these two codes take diametrically opposite stands upon this point. Idaho reverting to the old theory, it being made "the duty of the state engineer to approve all applications made in proper form which contemplate the application of water to a beneficial use." And Utah adhering to the provisions copied from the Nebraska law, that the state engineer should refuse to grant applications when he considers them detrimental to the public interest, or that there is no unappropriated water supply.

The Utah law referred to was also very carefully devised and considered, as follows:

Sec. 6 provides that the state engineer shall make complete hydrographic surveys, that he shall ascertain the surplus or unappropriated supply of any stream, going, in short, into the duties of the state engineer along these lines in considerable detail.

Sec. 39 is as follows: "All applications which shall comply with the provisions of this act, and with the registration in the state engineer's office, shall be filed and recorded in a suitable book kept for that purpose, and it shall be the duty of said engineer to approve all applications made in proper form where the proposed use will not impair the value of the existing rights or be otherwise detrimental to the public welfare. But where there is no unappropriated water in the proposed source of supply or where the proposed use will conflict with existing rights or threatens to prove detrimental to the public interests it shall be the duty of the state engineer to reject such applications."

Sec. 54 recognizes the possibility of scarcity, however, and makes certain provisions to cope with this condition.

In 1905, owing to the operations of the U. S. reclamation service and to other causes, several of these western states which had not previously passed irrigation laws adopted codes based in general upon a proposed code, framed by Mr. Morris Bien, legal ad-

visor of the reclamation service. This code was compiled with great care, being in the main based upon the Utah code a direct descendant of the Wyoming laws, and the section bearing upon this point is as follows, as taken from the laws of North Dakota:

"Section 23. Rejection and Appeal.) If in the opinion of the state engineer, there is no unappropriated water available he shall reject such application. He shall decline to order the publication of notice of any application which does not comply with the requirements of the law and the rules and regulations thereunder. He may also refuse to consider or approve an application or to order the publication of a notice thereof if, in his opinion, the approval thereof would be contrary to the public interest. An applicant may appeal from the decision of the state engineer, or from any other decision by him which denies a substantial right, within sixty days from the date thereof, to the district court of the county in which the proposed place of diversion of storage is situated. In the absence of such appeal, the decision of the state engineer shall be final."

In 1905 also the Nevada code was considerably revised and a section covering this point added, which, however, since it is almost a copy of the Nebraska provision, is not included.

I have given these citations somewhat fully because it seemed necessary for the complete understanding of the question. It is seen that there are two diametrically opposed points from which the problem may be approached. That of Idaho which follows the lead of the older irrigation states, and that of Wyoming, and those that have followed her, which endeavors to fly from the evils that were seen but also possibly meeting others that they knew not of. The laws covering the subject seem to me to be clear. They provide that when there are no unappropriated waters, or when the allowance of the application would be detrimental to the public interest then it shall not be granted. The difficulty seems to be that the judgment is left with the state engineer, and that he is seldom if ever in a position to state absolutely what would or would not be detrimental to the public welfare, or whether there can be said to be no unappropriated water. These difficulties are so obvious that they will need no explanation. The decision will depend altogether upon the point of view. A stream is said, in general, to be many times over appropriated. The state engineer may or may not have measurements of the flow of that stream. If he has they are probably too few and cover too short a period to give him any adequate idea of the normal flow of the stream. Even if he has a series of observations extending over a considerable number of years, he cannot be certain that the future years will give anything like the same discharge: they may give less and they may give more. The applicant says: "What is it to you, anyway? If I am satisfied that with the decree allowed me through due process of law, even though I might

not get anything but flood waters, I can still make a living, getting one cutting of hay and carrying my stock over winter, why should you, who know no more about it than I, say me nay?" He takes the risk; should you do more than advise him, furnishing him, if he desires it, such information as you have concerning the available water supply? Is the information that you have anything more than the data upon which an investigator may decide whether or not he will become an investor? The one school says "No," and the other "Yes." Every man will naturally look upon the question in the light of his own experience. For my part I have seen so much evil resulting from the allowance of every claim and the subsequent fighting of, but never settling, the matter in the courts, that my vote is yes, and I base my opinion upon these arguments:

Some authority, the government or state, must have control of the distribution of water. The water supply is elusive by nature, as easy of misappropriation as of appropriation, and hence necessarily subject to police regulation. Too often the applicant for an apparently inadequate supply makes his application with the mental reservation that he can steal enough to make his crop, and he nearly always, if allowed to go ahead, does try this method. The sanest plan ever suggested was that broached by Major J. W. Powell thirty or more years ago when he recommended that an irrigation survey should be made which would determine where the available water supply could be used to the best advantage, and that no other lands should be irrigated until it had been definitely determined that there was enough water to make further irrigation a success. That course, if rigidly followed, would have made impossible the endless irrigation litigation, water stealing, and loss of crops in old irrigation districts that is prevalent in many states today, and would have placed irrigation on the firm basis where it belongs. It is perhaps too late to consider that now, but we may still do what we can to approach that ideal condition.

Now, state officers are appointed to control the distribution of water, and at the head of this work is the state engineer. He cannot say where water shall be used, he must recognize the principle of "First come, first served." But he can and in my opinion should say when the appropriation, or, too often, misappropriation, should stop. It will often take some nerve to do this, but the head of the police force should have nerve or he should not be there. It will be said the courts will not back the state engineer, or that he has not the funds to do what is required of him. Both of these statements are too often true, but in such cases put the onus fairly and squarely where it belongs and do the best you can to carry out the law. If you are convinced that it is wrong do the best you can to change it but do not try to evade it so long as it is in force. The great crime of the American

people today is the evasion of the law. The state engineer must be above either the evasion of the law or the shirking of his duty. The man is wrong who says that he understands the conditions as well as the state engineer. He is looking at the matter from his own narrow and selfish standpoint. The state engineer is looking at it from the standpoint of the public welfare, and he is in a better position to know what is right than anyone else, I care not who it is. "It places great power in the hands of the state engineer," yes, but it is a power for good. He dares not, if he would, use it for evil.

But the question, how will the state engineer construe the question "Provided the appropriation is not detrimental to the public welfare"? is not answered, but the answer is quickly made. They must answer it separately for each individual case, and as they think right for the particular case. You cannot lay down any hard and fast rule for a single stream even. It may be necessary to refuse an application for the diversion above prior appropriations when it would be permissible to allow it if it were below them. In some cases it may be best to deny an application for the good of the applicant, man or company; in another it may be necessary to deny it for the good of the earlier appropriations.

A grave responsibility is placed upon the state engineer it is true, but what is he? He is an engineer first who is appointed to guard the public welfare. It is as much an engineer's duty to make an adverse report when he finds that conditions are not favorable under the proper conditions. That is the duty he assumed when he became an engineer, long before he was appointed to represent the common good. Having accepted the latter responsibility also, he is doubly bound to make an adverse report when he finds that conditions demand it. He may be, he is sure to be, the subject of criticism, but he will not deserve it in any part of the degree that he would have deserved it had he rendered a report contrary to his judgment.

But how is he to render an intelligent decision in all of the hundreds of cases that will arise? you ask. And in my answer I mean to try to answer also the question raised, by inference at least, in the second subject assigned me as to the "Practice of state engineers in dealing with applications for small appropriations in isolated sections." They must as soon as possible after, if not before, appointment, familiarize themselves with every part of the territory under their jurisdiction. This may be either through the chief, or if the funds permit of any, through the deputies. After giving thorough study to this state the state engineer will usually not be obliged to visit the isolated localities when applications come in, or if he is, one visit by himself or deputy should answer for applications.

It is not so much of a problem as it might appear to be at first sight. It may seem somewhat egotistical for me to say it, but

I think it is true that during the five or six years I was located in the state engineer's office of the state of Colorado, there were very few out of the thousands of applications that were made that would have required a personal visit at the time the application was made, in order to permit an intelligent decision being made. Of course this requires perfect familiarity with his territory and with the people; at the same time doubtful cases should be investigated, both for present and future reference.

I have, perhaps, taken too much time in discussing these questions, but their importance is my excuse. The rule that I suggest for your guidance, however, is short, and is this: Act as you would if you were still in private practice, mindful of your reputation, and the high responsibility placed upon you, both through your office and your calling, without fear of man. First, last, and all the time, follow the dictates of your conscience and your best judgment and do that which you conceive to be your duty.

DISCUSSION OF PAPER.

Mr. Chandler asked concerning requirements regarding maps.

Mr. Johnson stated that in Wyoming the regulations of the state engineer were working satisfactorily. There it was required that the maps be made and certified to by engineers, each irrigation engineer in the state being furnished with uniform rubber certificate stamps. The consequence was that competent young surveyors and engineers were going into the irrigating districts to the advantage of all concerned.

Mr. Stephenson stated that in Idaho the surveys were made by surveyors regularly licensed by the state, and that the system worked satisfactorily.

Referring particularly to the paper of Mr. Fellows he explained that the reason for the Idaho law requiring the state engineer to accept all filings was that the constitution provided that "The right to appropriate water should never be denied." He stated that he personally preferred the method used by the other states.

Mr. Tanner stated that it was his opinion that a fair construction of the Idaho constitution would permit regulation on the part of the state engineer by which he could refuse to accept filings contrary to the public welfare.

Mr. Fellows explained that in Colorado maps must be in duplicate, on linen backed paper 24x36 inches with two inches margin on the left hand side, making the available space for the map 24x34 inches. All maps must be this size, irrespective of the size of the reservoir, or of the ditch shown, and not folded. The scale of the map must correspondingly vary, but should be sufficient to clearly show each course and distance. The ink must be for permanent record.

Mr. Chandler asked Mr. Tanner if any disapprovals in Utah had been contested. Mr. Tanner stated that none had been carried beyond the district court, although several applications had been disapproved.

The conclusions reached in the paper seemed to meet with general approval.