PUBLIC DOCUMENTS OF MAINE

1912

BEING THE

ANNUAL REPORTS

OF THE VARIOUS

DEPARTMENTS AND INSTITUTIONS

For the Year 1911

VOLUME IV

AUGUSTA
WALLACE S. LADD PRINTING COMPANY
1912

STATE OF MAINE.

SECOND ANNUAL REPORT

State Water Storage Commission

JANUARY, 1912.

WATERVILLE
SENTINEL PUBLISHING COMPANY
1912

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MAINE STATE WATER STORAGE COMMISSION.

AUGUSTA, MAINE, January 1, 1912.

To the Honorable Senate and House of Representatives:

In accordance with the provisions of Chapter 212, of Public Laws of 1909, and Chapter 170, of Public Laws of 1911, we beg to submit the 2nd annual report of the State Water Storage Commission.

For the details of the investigation on the water resources of the State, you are respectfully referred to the attached report of our chief engineer, Mr. Cyrus C. Babb.

Respectfully submitted,

FREDERICK W. PLAISTED, Governor,
Chairman.

F. E. MACE, Land Agent
E. P. RICKER,
J. M. MCNULTY,
E. C. JORDAN,
Commissioners.

AUGUSTA, MAINE, December 30, 1911.

To the State Water Storage Commission, Augusta, Maine.

GENTLEMAN:—In accordance with the agreement effective January 1, 1911, between the Director of the U. S. Geological Survey and the Chairman of the State Water Storage Commission, I herewith submit a report for the year ending December 31, 1911 on the investigation of the water resources of the State of Maine.

This agreement specifies that it is a continuation of the similar agreement dated December 1, 1909 between the same parties, whereby provision is made for a coöperative survey of the natural resources of the State; that said survey shall include the continuation of topographic mapping, the determination of the amount and availability of water resources, their present development, and the best methods of their further utilization, also, the further determination of geologic resources.

The agreement further provides that the hydrographic work shall be under the immediate charge of a duly appointed employee of the Director of the U. S. Geological Survey, designated as District Engineer, who on July 1, 1911, shall be designated Chief Engineer of the State Water Storage Commission. The agreement further provides that said District Engineer shall make reports to the State organization as it may demand, for publication or such other use as it may find necessary or desirable.

The investigations have been made in accordance with the regulations of and under the general supervision of Mr. M. O. Leighton, Chief Hydrographer, U. S. Geological Survey. Continuous assistance has been rendered in the office and field by Mr. F. E. Pressey, assistant engineer, and Miss Elizabeth C. Spooner, clerk, employees, under the U. S. Civil Service rules, of the U. S. Geological Survey and on detail to the State Water Storage Commission.

Very respectfully,

CYRUS C. BABB,
Chief Engineer.

REPORT OF THE CHIEF ENGINEER

CYRUS C. BABB.

LEGISLATION.

EXISTING LEGISLATION:—

The organic law creating the State Water Storage Commission and outlining its duties is published as Chapter 212, Laws of 1909 and is quoted in full on pages 4 to 6 of the 1st Annual Report.

The Seventy-fifth Legislature consolidated the State Water Storage Commission and the State Survey Commission by repealing the laws creating the latter commission and transferring its duties to the former commission by amending the organic law of the Water Storage Commission. The new act is known as Chapter 170, Laws of 1911. The title of the act and the new amended sections are as follows:

An Act to consolidate the State Water Storage Commission and the State Survey Commission and to amend certain sections of Chapter two hundred and twelve, Public Laws, nineteen hundred and nine, creating the State Water Storage Commission, and to repeal Chapter ninety-nine, Public Laws, eighteen hundred and ninety-nine, and Chapter one hundred and forty-four, Public Laws, nineteen hundred and five.

Be it enacted by the People of the State of Maine, as follows:

Section 1. The governor, with the advice and consent of the council, is authorized to appoint three citizens of the state, who, together with the governor and the state land agent, shall constitute a commission to be known as the State Water Storage Commission, of which the governor shall be chairman. As members of said commission, they shall receive no salaries but shall be paid their actual and necessary expenses incurred in the performance of their duties, and may employ a competent engineer, with the title of chief engineer, who shall have charge, under the direction of the commission, of the operations under this act. The office of the commission shall be at the state house in the city of Augusta. The chief engineer is hereby authorized and empowered to employ, subject to the approval of the commission, such engineers, stenographers, clerks, and other subordinates as he may find necessary to carry out the provisions of this act, and to fix and pay the reasonable salaries and expenses of such employees.

Section 3. The commission is hereby authorized to confer with the director or the representative of the United States geological survey and to accept its coöperation with this state in the prosecution of hydrographic and geological surveys and the preparation of a contour topographic survey and map of this state which are hereby authorized to be made.

Section 5. The commission shall present to the legislature on or before the fifteenth day of January in the year of our Lord nineteen hundred and thirteen, a report showing the progress made in its investigations, and, if practical, shall complete its investigations to such an extent before January first in the year of our Lord nineteen hundred and thirteen, as will enable it to present in its report a comprehensive and practical plan for the improvement and creation of such water storage basins and reservoirs as will tend to develop and conserve the water powers of the state. The commission shall also report so far as its investigations will permit on the present development of the water powers in the state with reference to the general plan proposed so that the legislature may have before it a comprehensive summary of the possibilities that lie in the development of the water powers in the state, as a natural resource and the necessary steps that should be taken by the state to further increase and conserve them. The commission shall thereafter present and publish an annual report of its operations and include any data that it may collect bearing on the water powers and water resources of the state.

Section 10. Chapter ninety-nine of the public laws of eighteen hundred and ninety-nine, and chapter one hundred and forty-four of the public laws of nineteen hundred and five are hereby repealed.

Approved March 30, 1911.

PROPOSED LEGISLATION :—

From the confusion of a year or so ago regarding the relationship of the public to quasi-public service companies and corporations, a method of procedure is slowly being evolved in various States. It is largely taking the form of the appointment of public utilities commissions or of commissions with similar standings where through their powers conferred upon them by legislative acts, the public have an intimate control of the affairs of corporations that derive their powers from the people and that serve the people. Such corporations are beginning to realize the advantages of publicity, more so than they did a few years ago.

It is believed that some kind of control of Maine's water powers and storage basins should be exercised by the State. Development of our water powers is progressing and the State should encourage every effort in this direction, but not to the detriment of its present or future interests. Concentration of water power control and mergers of various companies have taken place during the past year in this State and it is believed that public regulation is necessary.

The law of this State and Massachusetts is peculiar in that, under the Colonial Ordinances of 1641-7, all great ponds, that is, ponds containing more than 10 acres, are owned by the State.

The Supreme Judicial Court of the State of Maine, in the case of the City of Auburn vs. the Union Water Power Co., (90, Maine, 577), among other findings, held as follows:

"The waters of the great ponds and lakes are not private property; the State owns the ponds as public property held in trust for public use; it has not only the ownership of the soil, but also the right to control and regulate the public uses to which the ponds shall be applied; the authority of the State to control waters of great ponds and determine the uses to which they may be applied, is a governmental power and the governmental powers of the State are never lost by mere non-use."

The Revised Statutes of Maine, Chapter 47, Section 2, declares that:

"Acts of incorporation, passed since March 17, 1831, may be amended, altered or repealed by the legislature. as if express provision therefor were made in them, unless they contain an express limitation."

Based on the tenets as stated above, it is believed we now can consider a policy for the State to adopt in this very important matter. The entire subject is at present in a formative stage, and methods of procedure, policies, and ideas have not yet thoroughly crystalized. It is a matter for discussion and consideration by many minds.

A bill, introduced late in the session of the last legislature, having the approval of the Chief Engineer, provided for State control and regulation of water power and water storage companies. Provision was made for enlarging the powers of the State Water Storage Commission and placing the operation of the act under its direction. The measure in question was something entirely new in so far as this State was concerned, but it contained nothing that had not been adopted by one or the other of several other States, including New York, Wisconsin, Pennsylvania, and Oregon. At the time given for the hearing of the bill before the legal affairs committee of the Legislature, nearly all of the large water power interests of the State were represented. The proponent of the measure realized that it was late in the session for adequate consideration of the various features of the bill and he therefore suggested to the committee that the bill be referred to the next legislature, which was done.

There is given below the text of the bill proposed by the Chief Engineer, but which has not yet been officially passed upon by the State Water Storage Commission itself. It is somewhat modified from the proposed act that was referred to the next legislature. The new bill is preceded by a brief discussion of the various sections.

Section 1 empowers the State Water Storage Commission to divide the State into drainage districts by water-shed lines for the purpose of creating administrative districts in order to carry out the provisions of the act.

The purpose is stated to be the state control and regulation of all great ponds of the State and all reservoirs created or hereafter created in part or in whole on any state lands or public lots. The section further authorizes the commission to mark by permanent monuments, heights to which water may be raised or lowered on the reservoirs of the State and further authorizes the commission to supervise the time and extent of the drawing of water from such reservoirs. Some such control is deemed necessary on account of the advantages that are given to various reservoir companies by later provisions of the act, especially section 15 given below.

Exceptions have been taken to this latter provision as imparing existing contracts that the State has made with various water storage companies through charters granted in the past. It is believed that these objections cannot stand in the light of the quotations given above, that is, the decision of the Supreme Judicial Court that the State owns great ponds and that the State has not lost the authority to control the waters of such great ponds; and the declaration of the Revised Statutes of

Maine that all charters granted since 1831 may be amended, altered, or repealed, by the legislature.

Section 1 places a restriction on the State commission by requiring it to regulate reservoirs under its control so that all water users shall derive the greatest benefit.

The section further provides that an appeal may be had from the decisions of the commission to a board of arbitration to consist of three hydraulic engineers to be appointed by a judge of the Supreme Judicial Court. The term reservoir as used in the bill, is defined as any storage basin having an available capacity of over 200,000,000 cubic feet. This provision was inserted in order that the State commission would be relieved of the operations of small reservoirs, especially those created by mill dams on the various rivers of the State. The 200,000,000 cubic feet capacity is simply an arbitrary figure and might be changed if deemed advisable. This limiting capacity does not apply to reservoirs created on great ponds as it is believed that the State should control all reservoirs on all the great ponds of the State.

Section 2 of the bill provides that the drainage districts created shall be in charge of district superintendents appointed by the commission through recommendation of the various water users of the district in question. This provides for the appointment of men intimately familiar with the basin, by the water users in that basin. The intent is that in case any of the water users are not satisfied with the acts of the district superintendents, appeal may be had to the State commission.

Section 3 provides that any engineers of, or members of the State commission shall have free access to the buildings and grounds of water power companies, shall have access to books, accounts, and plans of such companies as are necessary for the purposes of this act.

Section 4 is an important section giving authority to the State commission to pass upon and accept or reject any plans for dams constructed in the State. The rejection of the plans is to be only on the grounds of the inadequacy of engineering features and in this connection a board of arbitration is furthermore provided for. The grounds for this section are on account of public safety and of publicity. Up to the present time the State of Maine has not felt the need of suitable engineering supervision of plans for storage or power dams. The time has now arrived, however, when such supervision should be had on account of the construction of larger and higher structures of this nature. It is often the case in many sections of this country that high impounding reservoir dams have been constructed without any engineering supervision of the slightest. The failure of almost all dams can be laid to the inadequacy of the engineering plans.

Section 5 provides that certificates of incorporation of water storage or water power companies shall first be filed with the State Water Storage Commission before they are approved by the attorney general. It further provides that such certificates shall designate the body of water that is proposed to be dammed.

Section 6 has a similar object in view as the preceding section, namely, that of publicity, in that no sale, assignment, etc., of any franchise of any corporation formed for the development of storage or water power shall be valid until it has been filed with the Water Storage Commission.

Section 7 provides that the State of Maine may at any time in the future take over the physical properties of any corporations hereafter organized for the development of water storage in the State. This is the usual provision now inserted in legislative charters for large water storage or power companies.

Section 8 provides that time limit for all franchises granted under terms of this act shall be from 25 to 60 years, the period of termination being determined by the State Water Storage Commission at the time of the approval of the franchise. Provision is also made for possible extension of the charter.

Section 9 declares what a public utility is within the meaning of this act.

Section 10 provides for an annual tax on the gross receipts of all water power companies. The first draft of this section contemplated an annual tax or rental based on the horsepower developed with provision for deduction on account of transmission losses. However, there is an objection to this method in that the man that sells his power at a lower rate is taxed higher than one who sells his power at a higher rate. To overcome this inequality the tax is to be assessed on a percentage of the gross receipts. Provision is made for the tax being assessed on a sliding scale.

Section 11 provides a penalty for non-payment of taxes.

Section 12 requires the keeping of such accounts and records as the commission deems necessary.

Section 13 provides that whenever the owner of any dam desires to take or overflow any land, he shall apply to the commission for the approval of his request, and whenever said approval is given, right of eminent domain may be exercised under the so-called mill act.

Section 14 provides that whenever the owner of any franchise that has received the approval of the State Water Storage Commission desires to overflow any great pond or any public lots or State lands, application shall be made to the Water Storage Commission. The said commission is then to make an engineering investigation of the matter and report to the next legislature results of its investigations together with its recommendations.

Section 15 provides for the reimbursement to persons or companies who make expenditures in the creation or improvement of storage reservoirs. Such owners shall be paid by the State of Maine all reasonable costs of operation and maintenance and a net annual return for 20 years of five per cent of the cash spent in creating, improving or increasing storage. Furthermore, all water users below, who are benefited by such increase shall pay their proportionate share of the cost of operation and maintenance of the reservoirs and their proportional amount of the net annual return for 20 years of five per cent of the money invested. In other words, if a person or company goes to the expense of creating, increasing, or improving storage, they are reimbursed by all the water users on the stream benefited thereby.

Section 16 provides for the installation of suitable and accurate meters and other instruments adequate for the measurement of electrical energy generated by any person, firm, or corporation in the State and also provides for a penalty in case such meters are not installed within a prescribed limit of time. The commission is given power, however, to extend the time in which the installation must be made before the penalty attaches.

The reasons for this requirement are brought out on page 60 of this report. A circular letter was sent to the various light and power companies in the State requesting them to report, among other matters, the total annual output of the generators in kilowatt hours. The answers to this question were meager and in many cases where figures were given they were estimated. This is generally due to the fact that many companies, especially smaller ones, have no measuring devices for recording the total annual output in kilowatt hours of generating stations. It will not be many years before a Public Utilities Commission is created by statute in this State and the questions on Form No. 4, as sent out by this commission, will be among the principal questions asked by a Public Utilities Commission. This proposed Section 16 should therefore be enacted into law as soon as possible.

Section 17 provides for an appeal to the Supreme Judicial Court against any decision of the State Water Storage Commission.

The bill in question is as follows:

An Act for the creation of drainage districts, the supervision of the construction of dams, and the control and regulation of storage reservoirs.

Be it enacted by the People of the State of Maine, as follows:

Section 1. The State Water Storage Commission is hereby authorized and empowered to divide the state into drainage districts by watershed lines for the purpose of controlling and regulating all great ponds of the state and all reservoirs created or hereafter created in part or in whole on any state lands or public lots of the state; and said commission is hereby authorized and empowered to mark by permanent monuments and bench marks the heights to which water may be raised or lowered on the great ponds of the state and on all reservoirs created or hereafter created on any state lands or public lots of the state; and, furthermore, the said commission is hereby authorized and empowered to supervise and control the times and extent of the drawing of water from all great ponds and from the reservoirs created or hereafter created on any state lands or public lots of the state.

All reservoirs under the supervision and control of the State Water Storage Commission shall be regulated by said commission so that all the water users shall derive the greatest benefit.

Provided, however, that if any water user feels himself aggrieved as to the manner of said regulation, he may appeal to a board of arbitration to consist of three hydraulic engineers to be appointed by a judge of the Supreme Judicial Court, the cost of said arbitration to be paid by the party requesting the arbitration.

The term reservoir, as used in this section, shall mean any storage basin having an available capacity of over 200,000,000 cubic feet, provided, however, that this limiting capacity shall not apply to any reservoir created on any great pond of the state.

Section 2. The drainage districts created under the provisions of section one of this act shall be in charge of district superintendents who shall report to and receive their instructions from the chief engineer of the State Water Storage Commission. Said district superintendents shall be appointed by the State Water Storage Commission from lists of persons recommended by the water users, including the log-driving associations, the water power users and the dam and reservoir owners of the respective drainage districts. Provided, that one district superintendent may have charge of more than one drainage district.

Section 3. For the purpose of carrying out the provisions of this act, or for any other lawful purpose, the State Water Storage Commission, the chief engineer, or any other engineer, or other person appointed by said commission for that purpose, shall have free access to all parts of the buildings, structures or grounds utilized by the owner or owners of any franchise granted under the terms of this act, and may take any measurements and observations, and may have access to and copy therefrom, all books, accounts, plans and records of said owner or owners, as are necessary for the purposes of this act.

Section 4. Every person, firm, or corporation, before commencing the erection of a dam, or the enlargement of any existing dam, for the purpose of developing any water power in this state, or the creation or improvement of a water storage basin or reservoir for the purpose of controlling the waters of any of the great ponds or rivers of the state, shall file with the State Water Storage Commission for its information and use, copies of plans for the construction of any such dam or storage basin or reservoir, and a statement giving the location, height and nature of the proposed dam and appurtenant structures and the estimated power to be developed thereby and also the name of the river, stream, lake, pond, or other body of water from which it is proposed to use water power, or on which it is proposed to store water, and as near as may be, the points on said river, stream, lake, pond, or other body of water, between which said water power or storage of water is proposed to be taken or used or developed, and such other information as said commission may require, and until said plans and statements are filed with, and have received the approval of a majority of the members of said commission, and until a certificate to this effect has been issued, it shall be unlawful to start construction on any such said dam or dams or appurtenant structures; and, furthermore, it shall be unlawful to change or modify any such plans or any designs until the changes and modifications have received the approval of a majority of the members of said commission, and until a certificate to this effect has been issued; Provided, however, that the rejection of any plan or plans shall be on the ground of the inadequacy of the engineering features of the plans, unless a great pond or state land or public lot or lots are involved; and provided, further, that in case of the rejection of plan or plans on account of inadequacy of the engineering features, recourse may be had to a board of arbitration as provided for in section one. Every person, firm, or corporation shall, as soon as practicable, after this act takes effect, file similar plans, reports and estimates in relation to any dam or storage basin or reservoir then in process of construction by them.

Section 5. No certificate of incorporation, among the purposes of which are the development of water storage or water power in this state, shall be approved by the Attorney General unless said certificate is first filed with the State Water Storage Commission; nor unless said certificate of incorporation shall contain, in addition to the statements now required to be made, the name of the river, stream, lake, pond, or other body of water from which it is proposed to use water power, or on which it is proposed to store water, and, as near as may be, the points on said river, stream, lake, pond, or other body of water, between which said water power or storage of water is proposed to be taken or used or developed, and such other information as said commission may require.

Section 6. No sale, assignment, disposition, transfer, or conveyance of the franchises, and all the property, real, personal, and mixed, of any person or firm engaged in the development of water storage or water power in this state, or of any corporation heretofore or hereafter formed, for the development of water storage or water power in this state, to any other such corporation, or to any person or firm, shall be valid until a certificate, prepared and duly executed by the president and secretary of the corporation so purchasing, under the seal of said corporation, or by such person or firm designating the river, stream, lake, pond, or other body of water, and as near as may be, the points on the said river, stream, lake, pond, or other body of water, between which said water power or storage of water is proposed to be taken, or used, or developed, and such other information as the State Water Storage Commission may require, has been filed with the said commission.

Section 7. All the property, rights and franchises within the state of Maine acquired, erected, owned, held or controlled by any corporation, hereafter organized for the development of water storage in this state, or its successors or assigns, at any time after this act shall take effect, under and by virtue of the terms thereof, shall be subject to be taken over by, and become the property of the state of Maine, whenever said state shall determine by appropriate legislation that the public interests require the same to be done. Upon the taking effect of such legislation, the ownership of said property, rights and franchises shall immediately be transferred to, and vested in, said state of Maine, and said state shall pay to the owner or owners thereof, the fair value of all the same, excepting, however, such franchises and rights as are conferred upon said corporation under and by virtue of the provisions of this act, which said franchises and rights shall be wholly excluded in the determination of the amount to be paid to said corporation by said state of Maine; Provided, that should the state proceed under this section, it shall assume the contracts of the company or companies whose property it takes.

The fair value of the property, rights, and franchises so taken by the state of Maine, subject to the exceptions hereinbefore mentioned shall be determined by agreement between said corporation and such officers and agents of said state as shall be thereunto authorized to act in its behalf by the act which authorizes the taking of said property, rights and franchises; and such agreement failing within six months after said act takes effect, then by such fair and impartial tribunal and under such provisions as to the manner of procedure and for full hearing of parties and payment of damages awarded as shall be provided in said act.

Section 8. Any franchise granted under the terms of this act, shall terminate within a period of from 25 to 60 years from the date of approval of the franchise, unless earlier taken over by the state under the provisions of section seven of this act, the period of termination being determined by the State Water Storage Commission at the time of their approval of the franchise in question.

At the expiration or earlier termination thereof of any franchise, all rights under the franchise shall revert to and become the property of the state upon the state making just compensation for the physical property to the person, firm, or corporation, in accordance with the provisions of section 7 of this act; Provided, however, that the State Water Storage Commission may extend the franchise under the terms of this act, and if the holder of any such franchise, during the term thereof, has complied with all the laws and regulations, said holder shall have a preference right to renew the franchise on reasonable terms laid down by the commission and in case said holder declines to accept the new franchise, the State Water Storage Commission shall elect whether the state shall take over the physical property in accordance with the provisions of section 7 of this act, or whether it shall grant another franchise in which case the original concessioner shall have the privilege of selling or disposing of his buildings and machinery to his successor in concession.

Section 9. Every person, firm, or corporation, their heirs, executors, administrators, successors, assigns, lessees, trustees, or receivers appointed by any court whatsoever, who accepts, takes and holds a franchise for the erection and operation of a water storage reservoir under the provisions of this act, is hereby declared a public utility.

Section 10. Every person, firm, or corporation, except municipal corporations, engaged in the development of water power, shall, in lieu of all other forms of state taxation, pay to the State of Maine an annual tax on or before the second day of January of each year, of not less than one-half of one per cent or not more than five per cent of the gross annual income of said person, firm, or corporation, or if the power is used by the owner and not sold, the annual tax shall be at the above mentioned rates but based on an appraisal of the value of said power as determined by the State Water Storage Commission; Provided, that, in the case of a disagreement on said appraisal, recourse may be had to a board of arbitration as provided for in section one. The rate of taxation may be on a sliding scale but shall be fixed by the State Water Storage Commission. The said commission may also determine at what future dates the rates may be readjusted within the above limits.

Section 11. If any person, firm, or corporation shall fail to pay the annual franchise tax as provided for in section 10 of this act within 90 days after the same is due and payable, the state shall have a preference lien therefor, prior to all other liens or claims, upon all the property of said person, firm, or corporation, and upon notice from the State Water Storage Commission the attorney general shall proceed to enforce the lien and collect any unpaid fees in the same manner as other liens on property are enforced.

Section 12. It shall be the duty of every person, firm, or corporation granted a franchise under the terms of this act, to keep such accounts and records as may be required by the State Water Storage Commission, and to report the same together with such other information over affidavit, as may be required by said commission on suitable blanks to be furnished by the commission, and at such times and dates as may be specified by said commission. The failure upon the part of any said person, firm, or corporation to comply with the provisions of this section shall be deemed a substantial non-compliance with the provisions of this act, and of the franchise granted to such person, firm or corporation.

Section 13. Whenever the owner or owners of any dam or dams used for the purpose of developing water power in this state, or the creation or improvement of any water storage basin or reservoir, find that, for the purpose of creating, acquiring, maintaining and operating their dam or dams and other works, it is necessary to overflow certain lands, said owner or owners shall apply to the State Water Storage Commission for the right to take and use any lands, riparian or other rights, that may be required for the creation, construction and maintenance of any and all reservoirs, dams, and other structures and improvements that may be necessary to accomplish the purposes of their charter, and after the approval of the majority of the members of the State Water Storage Commission has been given and a certificate has been issued stating that said commission does approve the taking or overflow for the particular purpose stated, then and not until then, the said owner or owners of the said franchise may proceed to exercise the right of eminent domain for the particular purposes stated in accordance with the provisions of Chapter 94 of the Revised Statutes and laws amendatory and supplementary thereto; Provided, however, that the rejection of the application for the said taking or overflow shall be on the ground of the inadequacy of the engineering features of the plans, unless a great pond or state land or public lot or lots are involved; and provided, further, that in the case of the rejection of the said application for the said taking or overflow on the ground of the inadequacy of the engineering features, recourse may be had to a board of arbitration as provided for in section one.

Section 14. Whenever any person, firm or corporation contemplating the erection or the enlargement of any dam or dams for the purpose of developing water power in this state, or the creation or improvement of any water storage basin or reservoir, find that, for the purpose of creating, acquiring, maintaining and operating their dam or dams and other works, it is necessary to overflow any great pond or take or overflow any public lot, lots, or state lands, said owner or owners shall apply to the State Water Storage Commission for such rights of taking or overflow.

The said commission may make an engineering investigation of the desirability or necessity of such taking or overflow, and report to the next legislature the results of its investigations together with its recommendations for or against the said taking or overflow and include in said report its estimates of damages if any state land or public lot or lots are involved.

Section 15. In case the owner or owners of any dam or dams used for the purpose of developing water power in this state, or the creation or improvement of any water storage basin or reservoir, shall create, improve, or increase storage on any great pond or any reservoir created for the storage of water, said owner or owners shall be entitled to be reimbursed by the treasurer of the State of Maine on warrants drawn and approved by the Governor with the advice and consent of the Council for all reasonable costs of operation and maintenance and a net annual return for 20 years of five per cent on the cash actually spent in creating, improving or increasing said storage. All owners or lessees of each and every improved water power operated for over 8 months in the year, located below said reservoir or reservoirs or storage basin or basins and benefited thereby, shall pay into the treasury of the state of Maine his or their proportionate share of all the reasonable costs of operation and maintenance and a net annual return for 20 years of five per cent on the cash actually spent in creating, improving or increasing said storage, including the cost to the state of the supervision and regulation of said reservoir or reservoirs or storage basin or basins. The apportionment of the said reasonable costs and the said annual return of five per cent shall be made by the State Water Storage Commission in proportion to the resulting benefits.

If any said owner or lessee of any improved and operated water power fail to pay his or their proportionate share of all the reasonable costs of operation and maintenance and a net annual return of five per cent on the cash actually spent in creating, improving, or increasing storage from which they are benefited, within 90 days after the same is due and payable, the state shall have a preference lien therefor, prior to other liens or claims, except for taxes, upon all the property of said owner or lessee, and upon notice from the State Water Storage Commission, the attorney general shall proceed to enforce the lien and collect any unpaid fees in the same manner as other liens on property are enforced.

Section 16. Every person, firm, or corporation engaged in the generation of electric current in this state shall install, within three months of the date of approval of this act, suitable and accurate meters and other instruments approved by the State Water Storage Commission, adequate for the measurement of the electric energy generated, and such person, firm, or corporation shall keep accurate and sufficient records showing the quantity of electric energy generated each day in the year and the number of hours run per day, and report same to the State Water Storage Commission on blanks prescribed by, and at such times as shall be determined by said commission: Provided, that in case any person, firm, or corporation engaged in the generation of electric current in this state fails to install suitable and accurate meters and other instruments within the time above specified, such person, firm, or corporation shall be subject to a penalty of $10 per day for each and every day over the above limit of three months, during which they have not made the necessary installation, said penalty or penalties to be paid into the treasury of the State of Maine; and provided further, that the State Water Storage Commission may extend the time before the penalty attaches in which to install the suitable and accurate meters and other instruments.

Section 17. Any party, feeling himself aggrieved by any act done, or failure to act, or by any findings or rulings made by the State Water Storage Commission, subsequent to the granting and acceptance of the franchise as provided in this act, shall have the right to appeal to the supreme judicial court in the county in which its dam is located, or at its option in Kennebec County.

FINANCES.

The 75th legislature made an appropriation of $12,500 for the year 1911 and of $12,500 for the year 1912 for the work of the Commission. This was a reduction of the amounts available during the previous year for the same work. The allotment for this State by the U. S. Geological Survey was also curtailed, making the total reduction $7,500.

By the terms of the coöperation agreement of January 1, 1911, the following amounts were made available:

By the U. S. Geological Survey

From the appropriation for:

Topographic surveys	$4,500
Water resources investigation	1,350
Geologic surveys	1,350
Total	$7,200

By the State Water Storage Commission

Topographic surveys	$4,700
Water resources investigation	1,350
Geologic surveys	1,350
Total	$7,400

FIELD OPERATIONS.

TOPOGRAPHIC SURVEYS.

The U. S. Geological Survey, in coöperation in the past with the State Survey Commission and during the present year with the State Water Storage Commission, have been prosecuting surveys throughout the State. The unit of publication is an atlas sheet showing a tract (quadrangle) 15′ in extent each way or about 215 square miles, varying with the latitude. The scale is 1 : 62,500 or about one mile to an inch. Contours, or lines of equal elevation, are shown with a 20-foot interval. These sheets are sold by the U. S. Geological Survey at the rate of five cents a sheet. When one hundred or more are ordered, the rate is $3.00 per hundred.

Fifty sheets have been issued for the State of Maine, named as follows: Eastport, Petit Manan, Cherryfield, Bar Harbor, Swan Island, Mt. Desert, Ellsworth, Deer Isle, Bluehill, Orland, Orono, Matinicus, Vinalhaven, Castine, Penobscot Bay (scale 1 : 125,000), Bucksport, Bangor, Tenants Harbor, Rockland, Monhegan, Boothbay, Wiscasset, Vassalboro, Waterville, Small Point, Bath, Gardiner, Augusta, Norridgewock, Anson, Bingham, The Forks, Casco Bay, Freeport, Lewiston, Biddeford, Portland, Gray, Poland, York, Kennebunk, Buxton, Sebago, Norway, Dover, Berwick, Newfield, Fryeburg, Kezar Falls, North Conway, N. H., and Gorham, N. H.

The Buckfield and Livermore quadrangles have been completed and preliminary lithographic copies have been issued. The engraved edition for general distribution will be available shortly. During 1911 field work was prosecuted on the tier of three quadrangles due west of the Livermore sheet, known as the Buckfield, Bryant Pond and Bethel quadrangles. The field work was completed on the two former sheets and preliminary lithographic copies have been issued. About one-third of the Bethel sheet was finished and it is planned to complete it during 1912. The last sheet will carry this tier of quadrangles to the western boundary of the State and join the Gorham, N. H. quadrangle.

River and Lake Surveys.

Special river and lake surveys of many of the more important rivers and lakes in the State have been made. The resulting river maps, generally on a scale of 1 inch to 2000 feet, show, not only the plan of the rivers with 5-foot contours along the banks, but also the profiles of the rivers. These maps are of great value in studying both developed water powers and undeveloped water power possibilities. From these maps can be obtained a close estimate of the total horsepower that can be developed at the various unutilized falls and rips, when studied in connection with the stream gaging work.

The special lake maps are on varying scales of one inch to 1,200 feet, 2,000 feet, 3,000 feet and 4,000 feet. Some large scale maps, one inch to 200 feet, of the outlets of a number of the lakes are also shown. These maps in general show the high water line, the low water line, and the 5-foot contour lines from 10 to 25 feet above the lake. Soundings are often shown, and occasionally several 5-foot sub-contours. These sub-contour lines are interesting, in that they represent the shore lines that would result if the lakes should be drawn down 5 or 10 feet as the case may be. These lake maps are of special value in computing the capacity of the various lakes in cubic feet when their use as storage reservoirs is contemplated.

Owing to the reductions in the appropriation and the allotments, the special river and lake surveys had to be discontinued for the current year. However, it is possible to publish and issue the maps resulting from the field work of the previous year, numbers 49 to 78 in the following list, 30 sheets in all, whereas during the previous years or since 1903 when the special surveys were started, only 48 sheets had been issued.

The following is a complete list of these maps as issued and as surveyed to date:

River and Lake Surveys.

Kennebec Basin.

1. Kennebec River, Skowhegan to The Forks, Sheet No. 1.
2. Kennebec River, Skowhegan to The Forks, Sheet No. 2.
3. Kennebec River, Skowhegan to The Forks, Sheet No. 3.
4. Kennebec River, Skowhegan to The Forks, Sheet No. 4.
5. Kennebec River, The Forks to Moosehead Lake.
6. Kennebec River, Profile, Augusta to Moosehead Lake.

7. Brassua Lake and plan of outlet.
*8. Wood Pond and plan of outlet.
*9. Attean Pond.
*10. Long Pond; Holeb Pond; Moose River, Moosehead Lake to Brassua Lake.
*11. Flagstaff Lake; West Carry Pond; Spring Lake; Spencer Ponds; Middle Roach Pond; Lower Roach Pond.

PENOBSCOT BASIN.

12. Penobscot River, Bangor to North Twin Lake, Sheet No. 1.
13. Penobscot River, Bangor to North Twin Lake, Sheet No. 2.
14. Penobscot River, Bangor to North Twin Lake, Sheet No. 3.
15. Penobscot River, Bangor to North Twin Lake, Sheet No. 4.
16. Penobscot River, Bangor to North Twin Lake, Sheet No. 5.
17. West Branch Penobscot River, Chesuncook Lake to Ambejejus Lake, Sheet 1.
18. West Branch Penobscot River, Chesuncook Lake to Ambejejus Lake, Sheet 2.
19. West Branch Penobscot River, Chesuncook Lake to Ambejejus Lake, Sheet 3.
20. East Branch Penobscot River, First Grand Lake to Medway, Sheet No. 1.
21. East Branch Penobscot River, First Grand Lake to Medway, Sheet No. 2.
22. East Branch Penobscot River, First Grand Lake to Medway, Sheet No. 3.
23. Chamberlain, Telos, and Webster Lakes and Round Pond.
24. Baskahegan, First and Second Grand and Allagash Lakes.
25. Mattawamkeag River, mouth to No. Bancroft, Sheet No. 1.
26. Mattawamkeag River, mouth to No. Bancroft, Sheet No. 2.
27. Mattawamkeag River, mouth to No. Bancroft, Sheet No. 3.
28 Schoodic, Seboois, Endless and Mattawamkeag Lakes and Pleasant Pond.
29. West Branch Penobscot River, Chesuncook Lake to Seeboomook, Sheet No. 1.
30. West Branch Penobscot River, Chesuncook Lake to Seeboomook, Sheet No. 2.

ANDROSCOGGIN BASIN.

31. Androscoggin River, Brunswick to Umbagog Lake—profile only, Sheet 1.
32. Androscoggin River, Brunswick to Umbagog Lake—profile only, Sheet 2.
33. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 3.
34. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 4.
35. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 5.

* Edition exhausted.

36. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 6.
37. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 7.
38. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 8.
39. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 9.
40. Androscoggin River, Brunswick to Umbagog Lake—plan and profile, Sheet 10.
41. Umbagog, Lower and Upper Richardson Lakes, Sheet No. 1.
42. Mooselucmaguntic Lake.
43. Mooselucmaguntic and Richardson Lakes, Outlet plans, Sheet No. 3.

Union River Basin.

44. Abraham, Scammons and Molasses Ponds and Webbs Pond Outlet, Sheet 1.
45. Alligator, Rocky and Spectacle Ponds, Sheet 2.
46. Great Pond, Green Lake Outlet and Branch Lake Outlet, Sheet 3.
47. Union River, Ellsworth to Great Pond, Sheet 1.
48. Union River, Ellsworth to Great Pond, Sheet 2.

Kennebec Basin.

49. Dead River, mouth to Chain of Ponds, Sheet No. 1.
50. Dead River, mouth to Chain of Ponds, Sheet No. 2.
51. Dead River, mouth to Chain of Ponds, Sheet No. 3.
52. Dead River, mouth to Chain of Ponds, Sheet No. 4.
53. Dead River, mouth to Chain of Ponds, Sheet No. 5.
54. Dead River, Chain of Ponds and outlet; Jim Pond and outlet, Sheet 6.
55. Dead River, South Branch; Tim Pond and outlet, Sheet 7.
56. Spencer Stream; Little Spencer Stream; King and Bartlett Lake and outlet; Little Bartlett Lake and outlet; Baker Pond and outlet, Sheet 8.
57. Dead River, Long Falls, special map, Sheet 9.
58. Sandy River, mouth to Madrid, Sheet No. 1.
59. Sandy River, mouth to Madrid, Clearwater Pond and outlet, Sheet No. 2.
60. Sandy River, mouth to Madrid, Sheet No. 3.
61. Sandy River, moutr to Madrid, Sheet No. 4.
62. Sandy River, mouth to Madrid, Sheet No. 5.

Piscataquis Basin.

63. Piscataquis River, mouth to Blanchard, Sheet No. 1.
64. Piscataquis River, mouth to Blanchard and Schoodic Stream, Sheet No. 2.

65. Piscataquis River, mouth to Blanchard, Sheet No. 3.
66. Piscataquis River, mouth to Blanchard, Sheet No. 4.
67. Piscataquis River, mouth to Blanchard, Sheet No. 5.
68. Sebec River, mouth to Sebec Lake, Sheet No. 6.
69. Sebec Lake and outlet, Sheet No. 7.
70. Pleasant River, mouth to Katahdin Iron Works, Sheet No. 8.
71. Pleasant River, mouth to Katahdin Iron Works, Sheet No. 9.
72. Houston Stream, mouth to Big Houston Pond, Sheet No. 10.
73. Big Houston Pond and outlet; Silver Lake and outlet, Sheet No. 11.

ANDROSCOGGIN BASIN.

**74. Rangeley Lake, Sheet No. 1.
**75. Rangeley Lake outlet, Sheet No. 2.
**76. Rangeley River; Kennebago River, Sheet No. 3.
**77. Kennebago Lake; Little Kennebago Lake, Sheet No. 4.
**78. Rapid River; Pond-in-River, Sheet No. 5.

** Surveyed but not yet published.

HYDROGRAPHIC SURVEYS.

Stream gagings, a special branch of such surveys, are only considered in this section. This is one of the most important branches of work in connection with the investigations of water storage and the development of water powers. The run-off of a stream, like the rainfall in its basin, varies from day to day, month to month, and year to year. For the correct determination of the value of any stream for a storage development, a continuous record of its discharge should be available in order to determine the maximum, the minimum, and the dependable run-off from season to season.

During the current year this important branch of the work has been continued, but with a decreased allotment from what it was during 1910. A number of private companies of the State, realizing the importance of this information at the location of their respective plants, maintain at their expense, such gaging stations where the daily discharge is determined, and furnish this department, without charge, their computations.

The results of the work for 1910 and 1911 are given in the following pages, in their appropriate places under the respective river basins. Some changes are noted for the 1910 run-off data as published in the 1st annual report.

The following is a list of the various gaging stations in the State that have been maintained from time to time, with the length of record of each:

List of Gaging Stations in Maine.

St. John River at Fort Kent (1905-1911).
Fish River at Wallagrass (1903-1908).
Aroostook River at Fort Fairfield (1903-1910).
St. Croix River at Woodland (1902-1911).
St. Croix River near Baileyville (1910-1911).
Machias River at Whitneyville (1903-1911).
Union River at Amherst (1909-1911).
Green Lake Stream at Lakewood (1909-1911).
Branch Lake Stream near Ellsworth (1909-1911).
West Branch Penobscot River at Millinocket (1901-1911).
Penobscot River at West Enfield (1902-1911).
East Branch Penobscot River at Grindstone (1902-1911).
Mattawamkeag River at Mattawamkeag (1902-1911).
Piscataquis River at Foxcroft (1902-1911).
Cold Stream at Enfield (1904-1906).
Kenduskeag River near Bangor (1908-1911).
Phillips Lake and outlets (1904-1908).
Moose River at Rockwood (1902, 1908, 1910-1911).
Moosehead Lake at Greenville (1903-1906, stage only).
Moosehead Lake at East Outlet (1895-1911, stage only).
Kennebec River at The Forks (1901-1911).
Kennebec River at Bingham (1907-1911).
Kennebec River at North Anson (1901-1907).
Kennebec River at Waterville (1893-1911).
Roach River at Roach River (1901-1908).
Dead River at The Forks (1901-1907, 1910-1911).
Carrabassett River at North Anson (1901-1907).
Sandy River at Farmington (1910-1911).
Sandy River at Madison (1904-1908).
Messalonskee Stream at Waterville (1903-1905).
Sebasticook River at Pittsfield (1908-1911).
Cobbosseecontee Stream at Gardiner (1890-1911).
Androscoggin River at Errol, N. H. (1905-1911).
Androscoggin River at Gorham, N. H. (1903) fragmentary.
Androscoggin River at Shelburne, N. H. (1903-1907, 1910).
Androscoggin River at Rumford Falls (1892-1910).
Androscoggin River at Dixfield (1902-1908).
Presumpscot River at Outlet of Sebago Lake (1887-1911).
Saco River near Center Conway, N. H. (1903-1911).
Saco River at West Buxton (1907-1911).

Geologic Surveys.

Results of the geological investigations appear in the various reports of the U. S. Geological Survey, as the annual reports, monographs, and bulletins, and in the geologic folios. In the former class is bulletin No. 313, Granites of Maine; bulletin No. 376, Peat deposits of Maine; bulletin No. 445, Pegmatites and associated rocks of Maine. For a list of these publications reference should be made to the 1st annual report, State Water Storage Commission, page 36.

Geologic maps of the State appear in what are known as geologic folios. The base of each folio is a topographic map and various other maps of the same area are shown, representing the geology. These latter maps show by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land, and the structure sections showing their underground relations, as far as known, and in such detail as the scale permits. Following the topographic sheet is a sheet showing superficial geology, as swamps, muck, peat, marine clay, lacustrine deposits, and glacial drifts. The next sheet, areal geology, shows by color patterns the areas occupied by various formations. The economic geology map is the next, representing the distribution of useful minerals and rocks, and showing their relations to the topographic features and to the geologic formations. The last map, a structure-section sheet, exhibits the formations beneath the surface.

Two geologic folios have been issued for the State, the Rockland folio and the Penobscot Bay district folio. The field work for the Eastport folio is completed and the maps and descriptions are practically done. It will be submitted for publication early in 1912.

On the opening of the field season of 1911, it became necessary to start a new area for geological surveys. Several sections of the State were given consideration, including a geological reconnaissance of the Mt. Katahdin region, and similar reconnaissances along the lines of the Maine Central Railroad from Vanceboro to Old Town, the Bangor & Aroostook Railroad from Old Town to Greenville, and the Canadian Pacific from Greenville to the western border of the State. A survey made along such lines of communication could use the railroad surveys as a basis of exact locations and elevations and of course economic products situated close to these railroad lines would naturally be the first to be developed. Such investigations in the central portion of the State away from the lines of the railroad would be slow and expensive as a good deal of time and money would have to be spent on topographic locations and elevations, that in sections which had already been mapped could be spent for purely geological work. It is also difficult to get a sufficiently trained and experienced geologist for such reconnaissance work.

On the special recommendation of the geologists of the Federal Bureau, work was started on the Portland-Casco Bay folio. It was stated that detailed work in this vicinity would fit in excellently with the general scheme of the mapping of eastern New England and would do much to tie in the existing detailed work in Maine with the detailed work in Massachusetts.

The field work was about two-thirds completed for the Portland folio during 1911 and should be finished next year. It is expected that the resulting folio can be issued sooner after the field work is completed than has been the case of the other work.

PUBLICATIONS.

The results of the coöperative work of the State of Maine and the U. S. Geological Survey have appeared in various publications of the Federal Bureau, including the annual reports, monographs, professional papers, bulletins, water supply papers, mineral resources, geologic folios, and the editions of maps previously described.

In the first annual report of this commission, pages 35 to 37, is given a list of the various publications to date of issue. During the past year the following, with special information relating to Maine, have been issued:

Underground-water papers; Composition of Mineral Springs in Maine, by F. A. Clapp. Water Supply Paper No. 258.

Feldspar deposits of the United States (Maine, pages 23 to 33). Bulletin No. 420.

PRECIPITATION.

In an engineering study of any drainage basin whether for storage problems or water power investigations, a knowledge is valuable of the amount of rainfall, the maximum, the minimum, and the average, and the variations in its distribution during the year and from year to year and decade to decade. In such engineering studies, the stream flow is the most important, for instance in a study of a water power possibility, but often this information is not available for certain streams. Precipitation records are then used. Run-off records may be available for some adjoining basin. Then from a comparison of the rainfall in the two basins and the run-off of one, the run-off of the other may be computed. A study of a long rainfall record is valuable at times as showing either an excess or deficient series of years that may not be covered by a run-off record.

Relation of Stream Run-off to Precipitation.

During the past year or so there has been extended discussion on the value of forests for increasing or equalizing stream flow. Valuable facts are being discovered from such discussions and writings. The primary fact that run-off is the direct result of precipitation is always accepted. The factors that modify and control run-off are complex and many. Even in adjoining basins, where topographic, geologic, and forest conditions are similar, the run-off may and often does vary considerably. A notable contribution on this subject has lately been presented by Prof. D. W. Mead of the University of Wisconsin. [a]

[a] Bulletin No. 425, University of Wisconsin. The flow of streams and the factors that modify it, by Prof. D. W. Mead.

It seems advisable to publish his summary conclusions.

Factors that modify or control run-off.

1. Precipitation—
   (a) Whether it occurs as rain or as snow.
   (b) The amount of each, and the total annual precipitation.
   (c) Its distribution throughout the year.
   (d) Its intensity or manner of occurrence.
   (e) The character of storms, including their direction, extent and duration.

2. Temperature—
   (a) The variations of temperature on the area.
   (b) The relation of extreme temperatures to the occurrence of precipitation.
   (c) The accumulation of snow and ice, caused by low temperatures.
   (d) The occurrence of low temperatures causing the freezing of the ground surface at times of heavy spring rains, resulting in excessive run-off.

3. Topography of the Drainage Area—
   (a) As to whether the surface is level or inclined, and the degree of inclination.
   (b) As to character of area, whether smooth or rugged.

4. Geology of Drainage Area—
   (a) Whether pervious or impervious.
   (b) If pervious, whether such pervious deposits are (a) shallow or deep; (b) level or inclined; whether the outlet or point of discharge of the pervious deposits are (c) in the lower valley of the same river, or (d) in the valleys of other rivers, or in the sea.
   (c) As to the condition of the channel of the stream, whether (a) pervious or impervious; (b) whether or not the bed contains more or less extensive deposits of sand and gravel, permitting of the development of a more or less extensive underflow.

5. The Condition of the Surface—
   (a) Whether bare or covered with vegetation.
   (b) Whether in natural condition or cultivated.
   (c) Nature of vegetation, whether grassland, cultivated crops, or forests.

6. The Character of the Natural Storage on the Drainage Area—
   (a) Nature and extent of surface storage, consisting of lakes, ponds, marshes, swamps.
   (b) Nature and extent of ground storage, consisting of gravel, sand, and other similar pervious deposits.

7. The Nature of the Drainage Area Considered—
   (a) As to size, whether large or small.
   (b) As to shape, whether long and narrow, or short and broad.
   (c) The location of the area relative to prevailing winds.
   (d) The direction relative to the path of storms.

8. Character of the Stream and Its Tributaries—
   (a) As to slope or gradient, whether flat or inclined.
   (b) As to falls and rapids on the stream.
   (c) As to the section of the stream, whether deep or shallow.
   (d) As to the arrangement of tributaries, whether joining the main stream at various points along its course or concentrated in a fan-like arrangement at a more or less common point of discharge.

9. The Artificial Control of the Stream—
   (a) As to dams and storage reservoirs on the drainage area.
   (b) As to the restrictions of the river sections by dikes and levees.
   (c) As to the obstruction of the stream by piers, abutments, and other encroachments in or adjacent to the waterway.

10. The Artificial Use of the Stream—
    (a) For irrigation.
    (b) For water supply.
    (c) For the supply of navigation canals.
    (d) For artificial storage and regulation of the same.

11. Character and Extent of the Winds on the Drainage Area—
    (a) As to their intensity and direction.
    (b) As to the modification of the same by mountains and forests.

12. Ice Formation—
    (a) As modifying the winter flows of the stream.
    (b) As to the formation of ice gorges and their accompanying floods.

MONTHLY PRECIPITATION.

The following table gives the monthly precipitation record for 1911 at the various stations throughout the State. It is a continuation of the tables published in the 1st Annual Report, pages 45 to 59.

Precipitation at Stations in Maine for 1911.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Soldier Pond	1.04	0.72	2.06	0.18	1.26	2.44	4.11	1.39	2.49	0.36	0.62	0.40	17.07
Presque Isle	2.68	1.02	1.81	1.03	0.34	....	....	2.87	3.29	0.78	2.75	2.78	.....
Houlton	1.25	0.85	1.65	0.95	0.03	1.95	2.11	2.80	3.85	1.80	2.65	1.85	21.74
Eastport	2.98	2.47	3.68	2.55	0.13	5.07	3.50	2.53	2.67	1.57	3.83	2.80	33.78
Ellsworth	3.19	1.83	4.16	0.84	0.66	3.21	3.48	1.82	5.24	2.15	5.53	3.24	35.35
Patten	3.13	1.47	3.65	1.02	2.58	4.46	3.73	4.55	6.75	1.54	4.02	3.10	40.00
Danforth	2.78	1.70	2.75	0.75	0.20	3.61	1.97	1.05	2.32	1.02	4.27	3.80	26.22
Chesuncook Dam	2.56	1.13	2.63	0.93	0.68	3.75	3.46	4.12	4.00	2.01	2.56	2.53	30.36
Millinocket	2.87	1.96	4.26	1.08	0.51	5.06	4.56	3.90	2.73	1.77	4.36	4.29	37.35
Orono	3.21	2.78	3.97	1.18	0.75	4.60	4.45	2.94	3.05	1.94	3.28	3.91	36.06
Bar Harbor	4.55	4.14	4.35	1.70	T	3.51	4.41	1.90	5.15	2.10	6.65	4.30	42.76
Greenville	2.91	2.68	4.95	1.24	0.40	3.85	4.04	4.06	3.89	2.63	3.86	4.27	38.78
Eustis	1.51	1.49	4.41	0.61	0.63	3.36	3.45	4.39	3.35	1.89	2.60	3.09	30.78
The Forks	2.15	2.15	3.79	....	....	....	1.69	2.28	1.75	1.65	5.10	2.18	.....
Madison	2.28	1.77	5.71	0.93	0.59	5.33	4.91	7.01	3.86	3.44	3.67	3.24	42.74
Farmington	1.96	2.06	5.54	1.03	1.20	4.72	2.68	3.90	3.22	3.08	3.40	3.07	35.86
Fairfield	1.98	2.19	4.03	0.58	1.34	2.21	2.75	2.38	2.28	1.68	2.81	3.12	27.35
Winslow	2.24	1.40	3.83	0.59	0.61	4.17	4.43	2.63	3.60	2.13	3.04	3.00	31.67
Maine Insane Hospital, Augusta	1.30	....	1.30	0.30	3.40	2.75	1.30	2.86	6.90	1.70	3.60	0.70	.....
Gardiner	2.73	2.51	4.60	0.78	1.10	3.57	5.43	2.59	4.85	2.35	3.76	2.19	36.46
Oquossoc	1.45	1.88	4.45	1.10	0.90	5.50	4.68	7.79	4.15	3.20	3.55	2.52	41.17
Upper Dam	1.30	1.45	3.80	0.78	0.77	3.61	3.34	5.33	3.28	2.02	2.33	2.79	30.80
Middle Dam	1.23	1.08	2.97	0.53	0.79	2.80	3.23	7.02	3.64	2.36	2.39	1.94	29.98
Errol Dam	1.87	1.81	4.46	1.19	0.74	2.93	4.08	6.18	4.41	2.85	2.99	3.48	36.99
Rumford Falls	1.97	2.58	4.16	0.76	0.88	2.75	2.46	4.85	3.20	3.23	2.88	2.74	32.46
Livermore Falls	2.29	2.00	3.78	0.75	1.50	3.46	3.29	3.84	4.33	2.69	3.34	2.77	34.04
Lewiston	2.75	2.69	5.04	1.00	0.56	3.88	5.64	2.34	3.88	2.38	3.42	3.14	36.72
North Bridgton	2.75	2.56	4.31	0.91	1.35	2.88	3.89	2.82	3.63	2.82	3.21	2.97	34.10
Songo	1.92	2.36	4.27	1.98	0.97	2.54	4.81	2.83	4.35	1.68	3.96	3.22	34.89
Portland	2.58	5.02	5.60	2.25	1.37	2.74	4.71	2.56	2.84	1.85	3.51	4.49	39.52
Cornish	2.94	3.46	4.29	1.16	1.00	3.04	3.84	3.13	5.34	2.99	3.78	3.34	38.31
Biddeford	3.90	3.35	5.40	1.00	1.05	3.90	5.40	2.40	3.90	2.20	4.40	4.20	41.10
Aziscohos Dam	2.39	0.70	3.30	0.78	0.99	3.97	3.62	4.85	3.59	2.72	2.95	3.05	32.91
Ponticook Dam, N. H	2.37	1.97	4.41	1.29	0.63	2.64	3.25	5.45	3.70	3.12	3.35	3.68	35.86

RAINFALL MAP.

Studies of the general distribution of rainfall in the State have been made during the past year, and many interesting facts have been perceived. The work is so far advanced that a preliminary rainfall map of the State has been constructed, showing by isohyetal lines, or lines of equal rainfall, a long time average distribution of rainfall for the State. The preparation of such a map is a considerable piece of work. There are a few long term, say 20 year records and over, and many short period records. These latter may cover periods of abnormal rainfall, either maximum or minimum cycles, and it is necessary to reduce them to the basis of the long term records.* The method was adopted of correcting the average of each short term series of records to make it conform to the normal or long term average, by first finding at the neighboring long term stations what percentage the rainfall in each of the years covered by the said short record had borne to the long term average and then compensating the average of the short term series in the same ratios.

The following table gives the stations that have been adopted for the long term records. The period adopted is 1887 to 1910 known as the fundamental period. The table shows the length of each record; the average annual precipitation for the entire period, the average for the fundamental period, 1887 to 1910, and the percent of the latter average to the average for the entire record, or in other words, the error of using the 1887-1910 average instead of the longer one. The maximum error is 8.5% in the case of Eastport. It was considered best to base the computations on the various means for the same period and hence the period from 1887 to 1910 was adopted, except in the case of Eastport where the average of 42.6 inches for 1875 to 1910 was taken.

* See Progress Report, 1908, New York State Water Supply Commission, page 143.

Rainfall Long Term Records.

Station.	Length of record.	Average annual total record.	Average annual 1887 to 1910.	Per cent. 1887 record to total record.
Eastport	1874–1910	42.11	38.57	91.5
Orono	1870–1910	42.87	41.99	98.1
Bar Harbor	1886–1910	46.43	47.97	103.3
Fairfield	1886–1910	35.06	34.92	99.7
Gardiner	1837–1910	42.92	42.69	99.4
Upper Dam	1886–1910	33.15	33.26	100.3
Errol	1885–1910	36.07	36.61	101.5
Lewiston	1875–1910	45.00	43.80	97.4
Portland	1872–1910	42.30	42.44	100.3
Cornish	1857–1910	46.45	47.44	102.2
Biddeford	1881–1910	46.28	48.13	104.1

The short term stations were grouped around the nearby long term ones and their records compensated as described above. The following tables show the result of these computations as arranged by the long term record which is given at the head of each table. The first column is the station; 2nd, the length of record; 3rd, the annual mean for that station and the length of record; 4th the compensated mean by the long term record at the head of the table. As an example, consider the Orono table, and the short term Millinocket record. The Orono average 1887-1910 is 41.99 inches. The Millinocket average 1900-1910 is 42.36 inches. The average at Orono for 1900-1910 is 40.92 inches (not given in the table) or 97.5 percent of 41.99 inches. Applying this percent to the Millinocket average will give 43.5 inches as the compensated Millinocket figures which are used on the map.

The precipitation records on which computations are based are given in the 1st annual report, pages 45 to 59.

Compensation of Rainfall Records.

Orono Record.

Station.	Length of record.	Mean annual inches.	Compensated annual.
Orono	1887–1910	41.99	42.0
Patten	1903–1910	38.86	43.1
Chesuncook P. O	1904–1905	25.49	30.6
Chesuncook Dam	1906–1910	35.67	38.2
Debsconeag	1907	46.01	46.0
Millinocket	1900–1910	42.36	43.5
Mayfield	1893–1907	44.69	47.1
South Lagrange	1904	39.57	43.6
Carmel	1900–1902	46.42	40.0
Danforth	1903–1910	36.99	41.0

Houlton Record (a.)

Station.	Length of record.	Mean annual inches.	Compensated annual.
Houlton	1892–1895 1903–1910	30.53	31.6b
Soldier Pond	1908–1910	28.67	33.7
Van Buren	1903–1908	33.83	37.2

a Houlton, auxiliary long term station.
b Houlton compensated by Orono through Danforth and Patten.

Bar Harbor Record.

STATION.	Length of record.	Mean annual inches.	Compensated annual.
Bar Harbor	1887–1910	47.97	48.0
Ellsworth	1909–1910	40.72	45.3
Belfast	1902–1904	45.22	45.0

Fairfield Record.

STATION.	Length of record.	Mean annual inches.	Compensated annual.
Fairfield	1887–1910	34.92	34.9
Greenville	1895–1897, 1901–1902, 1906–1910	39.66	40.0
Flagstaff	1896–1901	38.51	36.9
The Forks	1902–1910	38.87	38.9
Madison	1902–1910	45.81	45.8
Farmington	1891–1910, except 1906	42.24	43.4
Winslow	1896–1910	37.98	37.5
Augusta	1889–1890, 1894–1899, 1904–1910	39.87	41.3

Gardiner Record.

STATION.	Length of record.	Mean annual inches.	Compensated annual.
Gardiner	1887–1910	42.69	42.7
Kents Hill	1891–1892	39.82	38.0
Augusta	1861–1886	42.54	40.9
Augusta	1889–1890, 1894–1899, 1904–1910	39.87	42.8
Augusta	....	....	*a*41.7

a Mean Fairfield and Gardiner adjustments.

Upper Dam Record.

STATION.	Length of record.	Mean annual inches.	Compensated annual.
Upper Dam	1887–1910	33.26	33.3
Oquossoc	1900–1901, 1904–1906, 1908–1910	36.06	38.5
Middle Dam	1905–1910	30.83	34.2

Lewiston Record.

Station.	Length of record.	Mean annual inches.	Compensated annual.
Lewiston	1887–1910	43.80	43.8
Rumford Falls	1894–1910	40.04	42.0
Livermore Falls	1910	34.91	43.4

Biddeford Record.

Station.	Length of record.	Mean annual inches.	Compensated annual.
Biddeford	1887–1910	48.13	48.1
Union Falls	1904–1909	45.51	48.0
Durham	1897–1909	42.25	40.6*a*

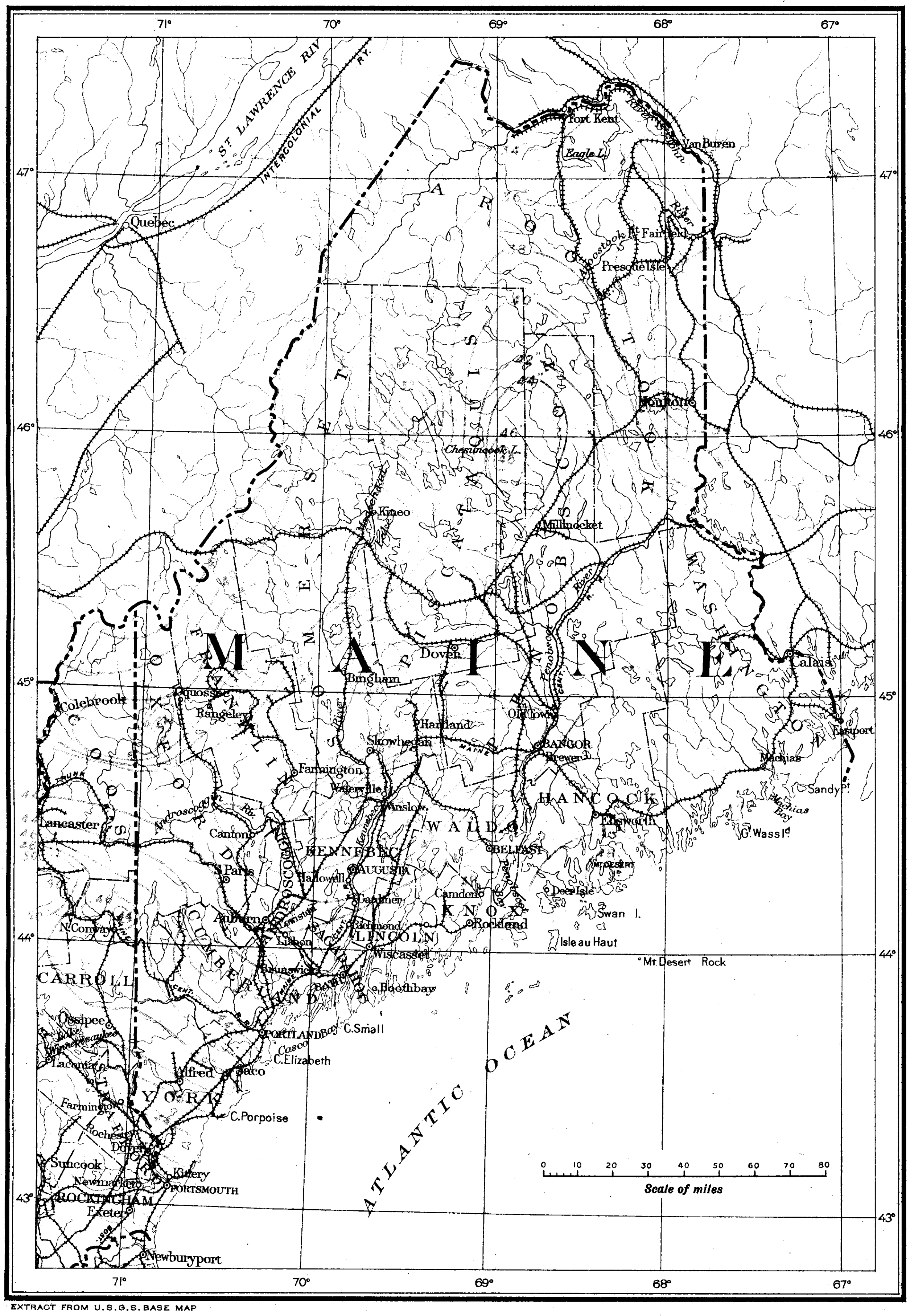
Cornish Record.

Station.	Length of record.	Mean annual inches.	Compensated annual.
Cornish	1887–1910 1872–1910	47.44 45.98	47.4
North Bridgton	1895–1910	44.63	44.6
Songo	1901–1910	39.47	40.3
Mt. Washington	1872–1886	83.53	89.5
Durham	1897–1909	42.25	42.0*a*
Chatham	1902–1904	46.33	43.6

a Mean 41.3.

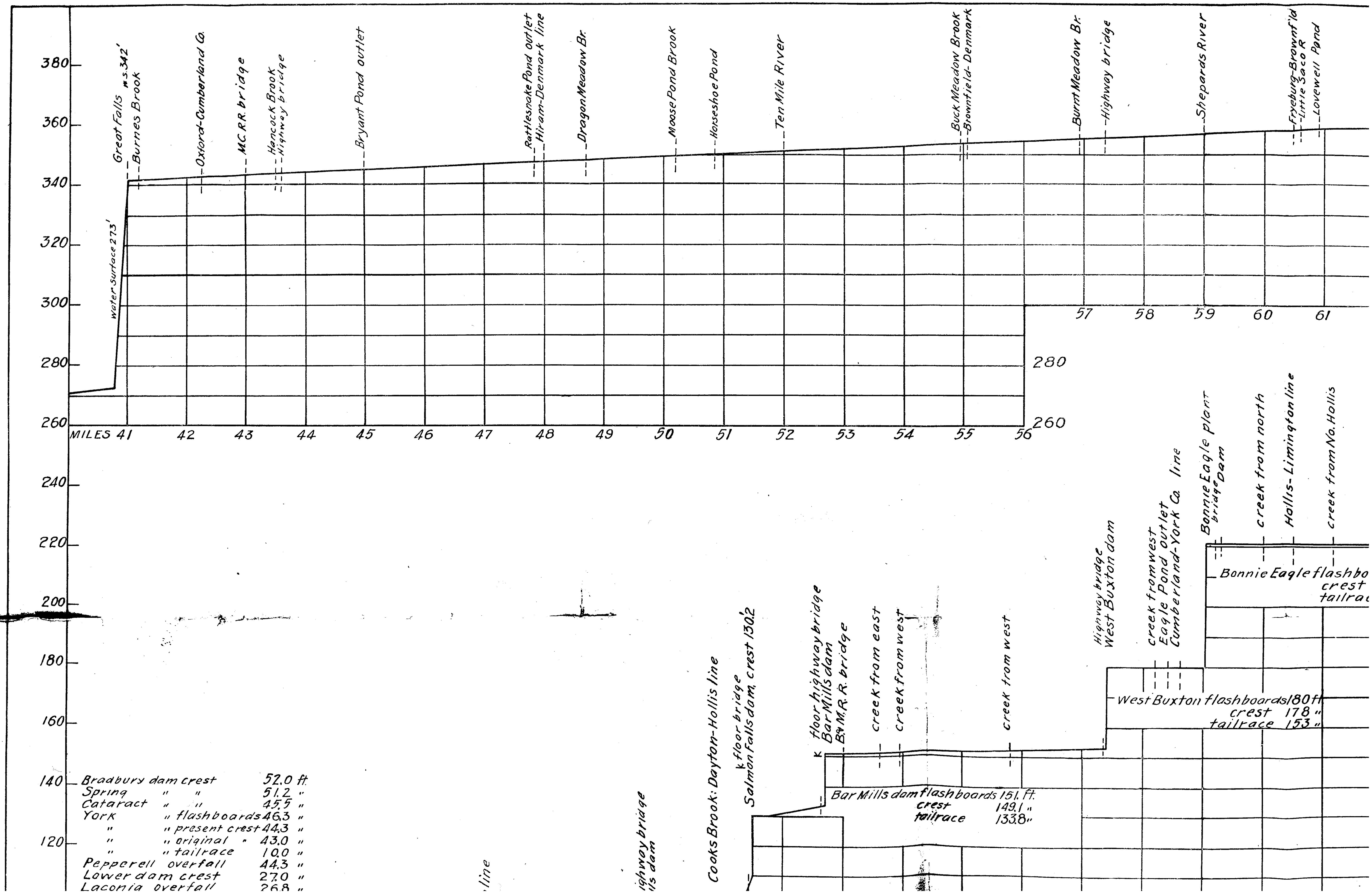
The compensated averages in the above tables were plotted on a contour map of the State, the contour interval being 1000 ft, as sketched from the best sources available to this office. The lines of equal rainfall or isohyetal lines were then sketched in 2-inch intervals, giving consideration to the trend of the river valleys and mountain ridges. The resulting map is shown as plate I.

The map brings out the following interesting facts: There are 5 areas of high average precipitations; Mt. Washington with an average precipitation of nearly 90 inches; Biddeford and northwestward with over 48 inches; Mt. Desert Island with perhaps 50 inches; the southern slope of the high land extend-



EXTRACT FROM U.S.G.S. BASE MAP

AVERAGE ANNUAL PRECIPITATION


380
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MILES 41
42
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47
48
49
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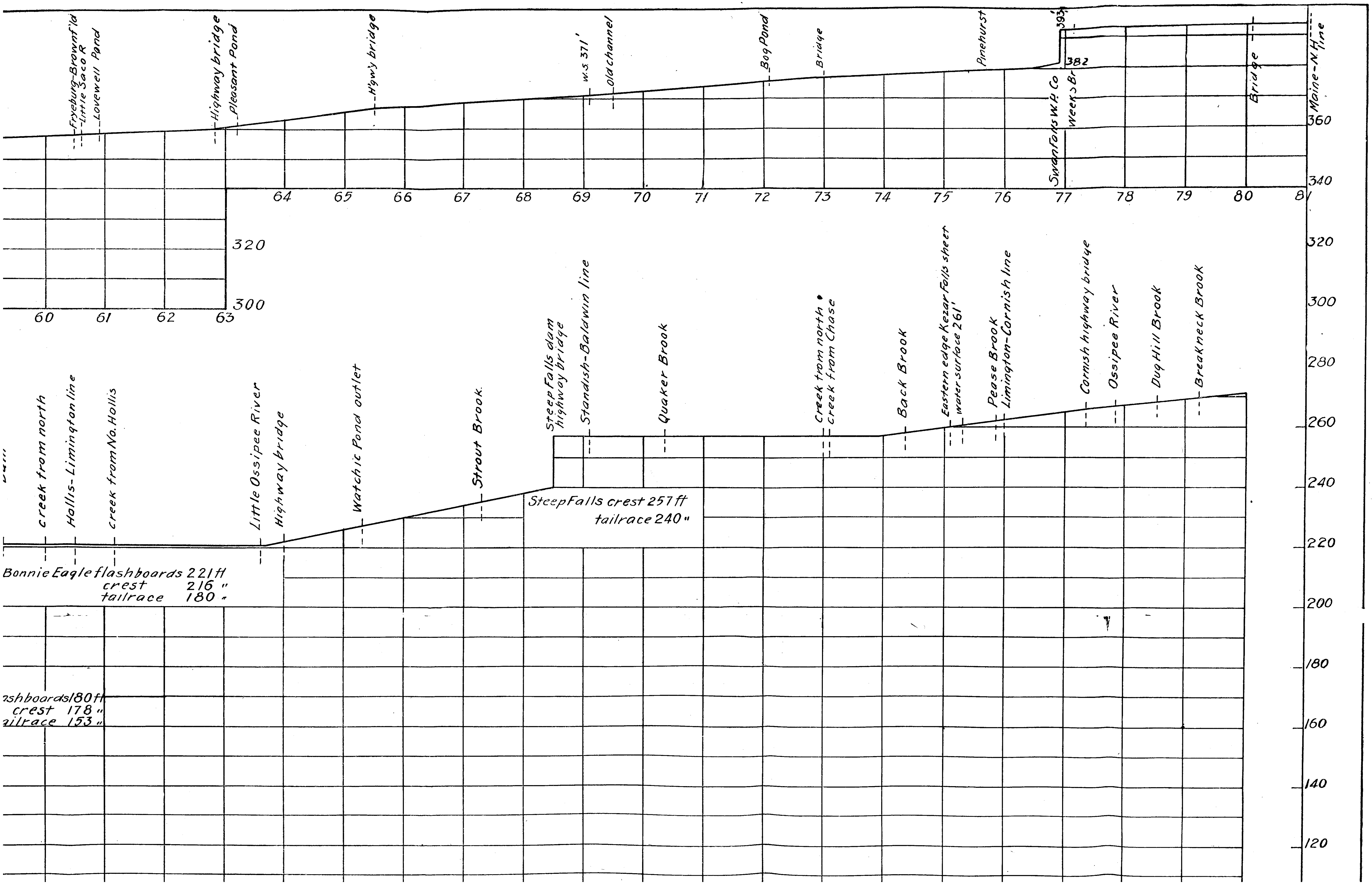
55
56
57
58
59
60
61
280
260
Great Falls ws 342'
Burnes Brook
water surface 273'
Oxford-Cumberland Co.
M.C.R.R. bridge
Hancock Brook
Highway bridge
Bryant Pond outlet
Rattlesnake Pond outlet
Hiram-Denmark line
Dragon Meadow Br.
Moose Pond Brook
Horseshoe Pond
Ten Mile River
Buck Meadow Brook
Brownfield-Denmark
Burnt Meadow Br.
Highway bridge
Shepards River
Fryeburg-Brownf'ld
Little Saco R.
Lovewell Pond
Bonnie Eagle plant
bridge Dam
creek from north
Hollis-Limington line
creek from No. Hollis
Bonnie Eagle flashbo
crest
tailrac
Highway bridge
West Buxton dam
creek from west
Eagle Pond outlet
Cumberland-York Co. line
West Buxton flashboards 180 ft
crest 178 "
tailrace 153 "
floor highway bridge
Bar Mills dam
B.&M.R.R. bridge
creek from east
creek from west
creek from west
Bar Mills dam flashboards 151. ft.
crest 149.1 "
tailrace 133.8"
k floor bridge
Salmon Falls dam, crest 130.2
Cooks Brook: Dayton-Hollis line
ighway bridge
lls dam
line
Bradbury dam crest 52.0 ft.
Spring " " 51.2 "
Cataract " " 45.5 "
York " flashboards 46.3 "
" " present crest 44.3 "
" " original " 43.0 "
" " tailrace 10.0 "
Pepperell overfall 44.3 "
Lower dam crest 27.0 "
Laconia overfall 26.8 "



Fryeburg-Brownf'ld
Little Saco R
Lovewell Pond
Highway bridge
Pleasant Pond
H'g'wy bridge
w.s. 371'
Old channel
Bog Pond
Bridge
Pinehurst
393
382
Swan Falls W.P. Co
Week's Br
Bridge
Maine-N.H. line
360
340
320
300
64
65
66
67
68
69
70
71
72
73
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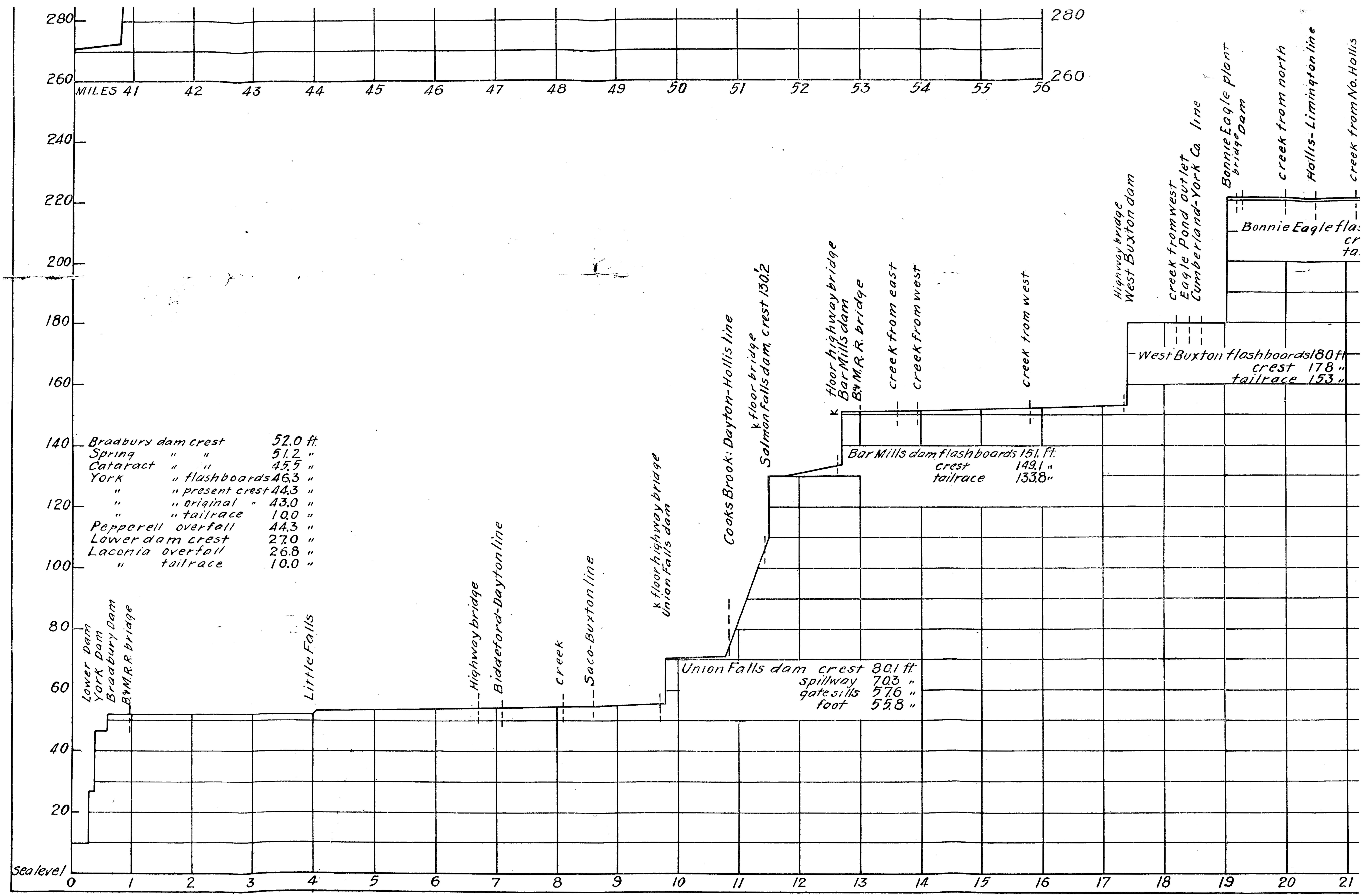
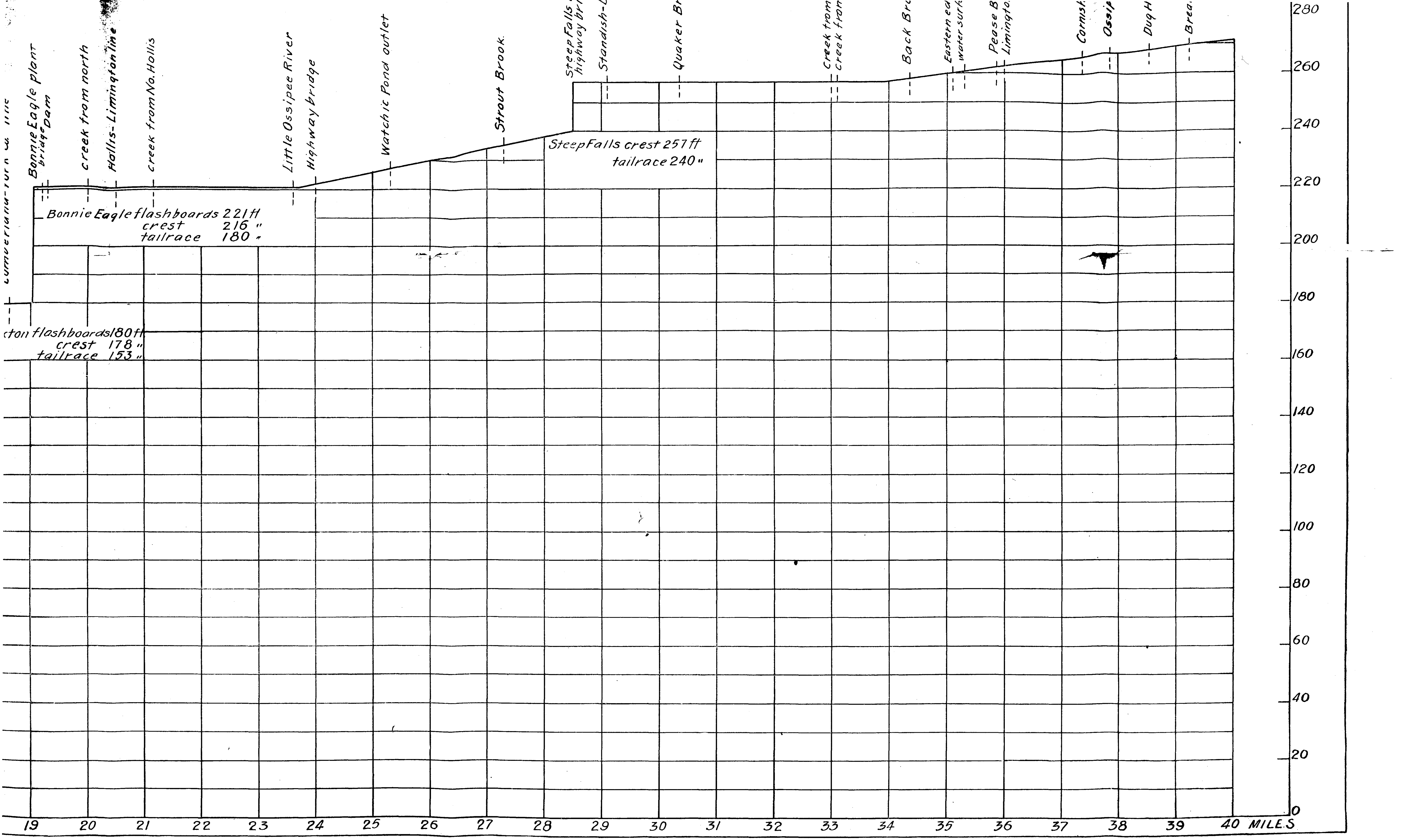
77
78
79
80
81
60
61
62
63
creek from north
Hollis-Limington line
creek from No. Hollis
Little Ossipee River
Highway bridge
Watchic Pond outlet
Strout Brook
Steep Falls dam
highway bridge
Standish-Baldwin line
Quaker Brook
Creek from north
creek from Chase
Back Brook
Eastern edge Kezar Falls sheet
water surface 261'
Pease Brook
Limington-Cornish line
Cornish highway bridge
Ossipee River
Dug Hill Brook
Breakneck Brook
Steep Falls crest 257 ft
tailrace 240 "
Bonnie Eagle flashboards 221 ft
crest 216 "
tailrace 180 "
ashboards 180 ft
crest 178 "
ailrace 153 "
280
260
240
220
200
180
160
140
120



PROFILE SACO RI



ROFILE SACO RIVER, MAINE

ing from Mayfield with over 47 inches, northeastward to the Mt. Katahdin district with probably 48 inches and possibly higher; and the divide constituting the western boundary of the State at the headwaters of the Dead and Moose rivers and the West Branch of Penobscot, with probably over 42 inches.

The areas of depression curves are seven in number, as follows: Rangeley Lake district with a minimum record of nearly 33 inches; Chatham, N. H. and vicinity on the Maine-New Hampshire line with a record of about 44 inches; district north of Portland with perhaps slightly under 42 inches; Fairfield and vicinity with 35 inches; northern end of Chesuncook Lake with 30.6 inches; Houlton and vicinity with 31.6 inches and the extreme northern section of the State in the vicinity of Fort Kent, 33.7 inches.

This is a preliminary map and subject to change as further data become available.

Mass Curves of Precipitation.

One of the best methods for studying the variations of rainfall at any place or the relation of rainfall at different places is by the graphical method of mass curves. For an explanation of the general properties and uses of mass curves, reference should be made to the Water Supply Papers of the U. S. Geological Survey. (*a*)

Briefly described, the mass curve is computed as follows: For each year, the excess (+) or the deficit (—) of the annual precipitation from the mean of the period is computed. The arithmetical sum of these values is then taken by adding the excess or subtracting the deficit as the case may be. These figures, as computed for each year, are used in plotting the mass curve.

Plate II shows mass curves for Cornish, Portland, Lewiston, Gardiner, Orono, and Eastport. With the exception of Cornish and Gardiner, each curve is for the period 1875-1910, although some of the records begun a few years earlier as can be seen by reference to the table on page 31. It is believed that better comparisons in the variations of rainfall can be made by a consideration of the same period. On account of

a Water Supply Paper No. 198, page 153 and Water Supply Paper No. 279, U. S. Geological Survey.

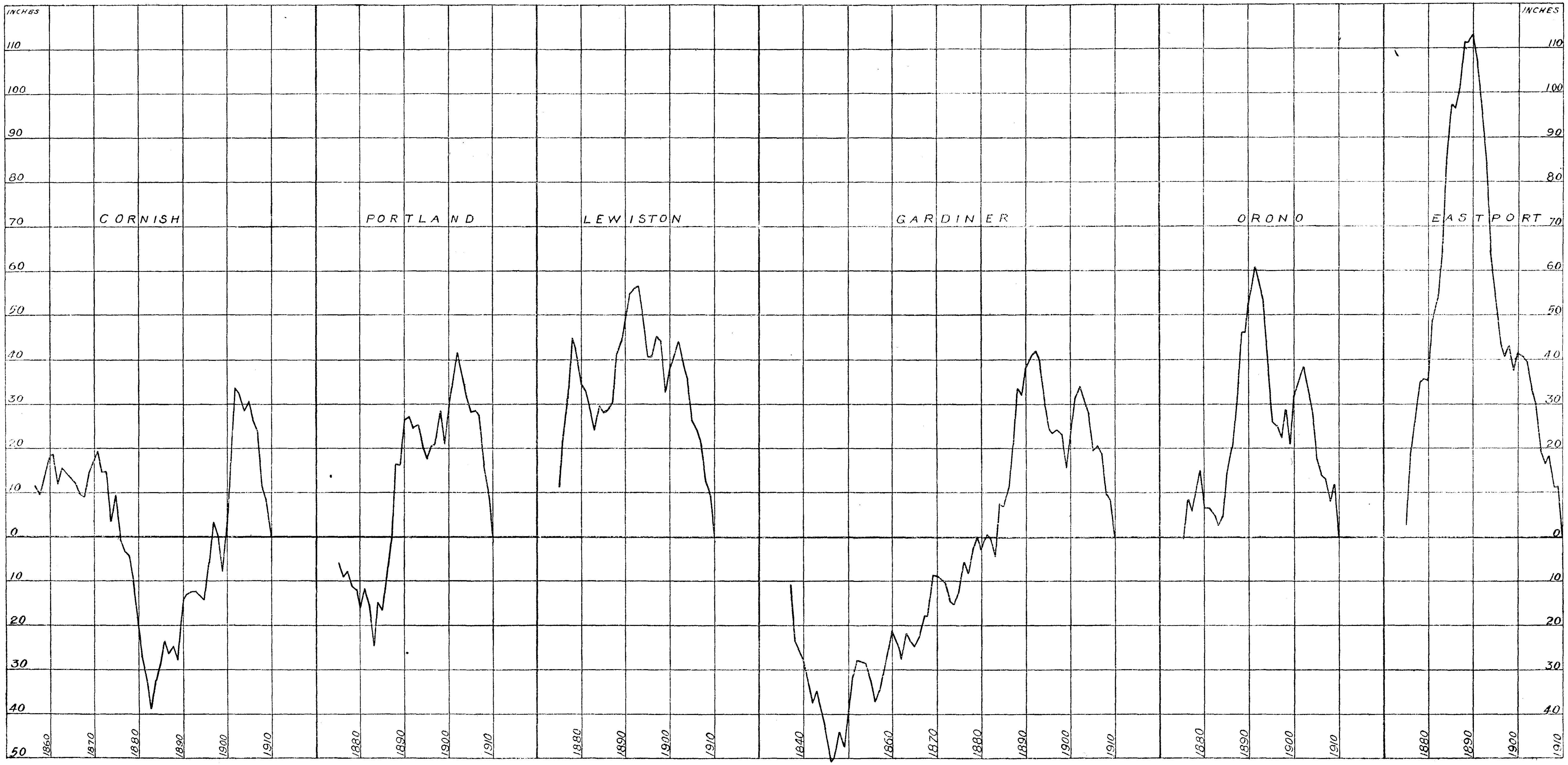
the extreme lengths of the Cornish and Gardiner records, it was considered wise to compute them for their entire lengths.

The mass curve shows the tendency toward a cyclical surplus or deficit. It gives for any year, in the case of Portland, Lewiston, Orono, and Eastport, the total yearly excess precipitation since 1875 over the mean for the period 1875-1909. An ascending part of the curve shows a time when the mean annual precipitation is in excess of the mean for the period, and conversely, a descending portion of the curve indicates a time of deficit in annual precipitation as compared with the mean for the period.

These mass curves should not be confused with the diagrams of annual rainfall as ordinarily plotted.

Generally speaking, 1883 was the end of a period of considerable depression. Gardiner and Eastport are somewhat exceptions to this but in those cases slight deficits can be noticed. Then followed a term of years when the mean annual rainfall was in excess of the mean for the period. A peak of excess was reached from 1890 to 1893 and for the western part of the State the maximum peak of excess was reached about 1903. For Lewiston and eastward, however, the maximum peak of excess was the earlier date, namely about 1892, and thereafter followed a period of deficient precipitation, but with minor excess peaks about 1903 for the eastern section.

Certain authorities are recently stating that excess and deficiency periods of rainfall occur in cycles of about 20 years. Their opinions are based on similar studies of long term rainfall records for the entire United States. An examination of plate II will show a tendency for such 20-year periods for stations in this State. The records for 1911 still indicate a descending curve or a continuation of the present deficient rainfall that the eastern United States has been experiencing for the past number of years.



MASS CURVES OF PRECIPITATION

ALTITUDES.

There is always a popular interest in the elevations of mountains and hills of any section of country and many requests have been received by this department for the elevations of certain special peaks, or lists of the highest mountains of the State. Unfortunately authoritative surveys have not been made of the sections of the State where the highest peaks are located.

In the following table the elevations are generally taken from the topographic sheets of the U. S. Geological Survey. Where the authority is different it is so indicated in the foot notes. Many of the highest mountains of the State are not given as the elevations have not yet been determined.

Elevations of Mountains of Maine.

NAME.	LOCATION.	Elevation feet.
Abraham, Mount	T 4, R. 1, B. K. P. W. K. R.	*a*3,388
Abram, Mount	Greenwood	1,960
Adams Mountain	Stoneham	1,600
Allen Hill	Peru	1,300
Allen Mountain	Peru	1,560
Allen Mountain	Stoneham	1,220
Allen Mountain	Denmark	1,100
Babbitt Ridge	Moscow	1,468
Baker Mountain	Gore A 2, R. 13, W. E. L. S	*f*3,589
Bald Mountain (*e*)	Bald Mountain Township	2,630
Bald Mountain	Camden	1,272
Bald Mountain	Dedham	1,261
Bald Mountain	Woodstock	1,660
Bald Head	Cornish	1,017
Bald Hill	Canton	1,060
Bald Ledge	Porter	1,180
Barkers Mountain	Newry	*b*2,550
Barkers High Ledge	Rumford	1,110
Barton Hill	Anson	1,260
Beach Ridge	Sebago	1,052
Bean Mountain	Milton Plantation	1,880
Bear Mountain	Hartford	1,207
Bear Mountain	Waterford	1,065
Beech Hill	Waterford	1,520
Ben Barrows Hill	Hebron	1,200
Benson Hill	Sumner	1,100
Besse, Mount	Bethel	1,880
Big Hill	Dedham	1,090
Bigelow, Mount (*e*)	Bigelow	*a*3,600
Bill Merrill Mountain	Hiram	1,580

Elevations of Mountains of Maine—Continued.

NAME.	LOCATION.	Elevation feet.
Birch Hill	Albany	1,140
Bird Hill	Bethel	1,440
Black Hill	Embden	1,320
Black Mountain (Bald)	Newry	2,587
Black Mountain	Sumner and Peru	2,200
Black Nubble	Squaretown and East Moxie	1,620
Black Nubble	Carratunk	2,100
Blue Mount	Avon	*b*3,200
Boil Mountain	T. 3, R. 5, W. B. K. P	*g*3,620
Browns Mountain	Hartford	1,380
Bryant Mountain	Milton Plantation	1,750
Bucks Ledge	Woodstock	1,220
Burnell Hill	Waterford	1,380
Burnt Meadow Mountain	Brownfield	1,560
Burnt Nubble	Squaretown	1,780
Campbell Hill	Hartford and Livermore	1,100
Caribou Mountain	Mason and Fryeburg Academy Grant	2,828
Cates Hill	Caratunk	1,600
Cedar Mountain	Parsonsfield	1,220
Chairback Mountain	T. 7, R. 9, N. W. P	*f*2,371
Chamberlain Mountain	Milton Plantation	2,040
Christopher, Mount	Greenwood	1,180
Clark Mountain	Cornish	1,320
Cobble Hill	Paris	1,140
Coburn Ridge	Mayfield	1,460
Cold Stream Mountain	Ten Thousand Acre Tract	2,160
Cow Hill	Jay	1,040
Cow Hill	Caratunk, Spaulding and Moscow	2,020
Croker Hill	Paris	1,400
Cummins Mountain	Albany	1,500
Curtis Hill	Woodstock	1,475
Cushman Hill	Sumner	1,160
Cutler, Mount	Hiram	1,180
Damon Hill	Sumner	1,160
Davis Mountain	Milton Plantation	1,800
Days Ledge	Bethel	1,380
Deer Hill	Stow	1,220
Devils Den	Porter	1,183
Dimmick Mountain	Spaulding	1,876
Divide, The	The Forks	1,480
Douglas Hill	Sebago	1,407
Dry Mountain	Eden	1,268
Durell Hill	Paris	1,000
East Royce Mountain	Batchelders	3,125
Fessenden Hill	Denmark	1,020
Fields Hill	Sumner	1,140
Fitch Hill	Bridgton	1,143
Fletcher Mountain	Concord	1,700
Fort Ridge	Alfred and Shapleigh	1,124
Foster Hill	Stoneham	1,160
Front Mountain	Brownfield	1,220
Fuller Hill	Woodstock	1,180
Glines, Mount	Milton Plantation	1,620
Goose-eye Mountain	Riley	3,800
Gould Mountain	Hiram	1,280
Great Mountain	Orland	1,037
Green Mountain	Eden	1,532
Hammonds Ledge	Buckfield	1,020
Hampshire Hill	Mercer and New Sharon	1,020
Harding Hill	Stoneham	1,100
Hark Hill	Gilead and Shelburne, N. H	1,130
Harndon Hill	Stoneham and Stow	1,300
Harris, Mount	Dixmont	*d*1,251
Hayford Hill	Hartford	1,140
Hawk Mountain	Waterford	1,065
Hedgehog Hill	Buckfield and Paris	1,160
Hedgehog Hill	The Forks	1,620
Heimingway Mountain	Milton Plantation	1,880
Holt Hill	Norway	1,005
Hosac Mountain	Cornish	1,300
Howard Mountain	Bethel	1,460
Humpback Mountain (Lead) (*e*)	T. 28, M. D	*d*1,480

Elevations of Mountains of Maine—Continued.

NAME.	LOCATION.	Elevation feet.
Hutchinson Hill	Hartford	1,120
Irish Hill	Hartford	1,040
Joe McKeen Hill	Lovell	1,060
Johns Hill	East Moxie	1,340
Johnson Mountain	Bingham	1,600
Jordan Mountain	Mt. Desert	1,180
Katahdin, Mount	T. 3, R. 9, W. E. L. S	*c*5,273
Kennebago, East, Mountain	Ts., 2 and 3, R. 3, W. B. K. P	*g*2,750
Kennebago, West, Mountain (*e*)	T. 4, R. 4, W. B. K. P	*g*3,625
Kineo, Mount (*e*)	Days Academy Grant	*b*1,958
Knights Hill	Peru	1,080
Knights Pond Hill	Moxie Gore and Squaretown	1,300
Libby Hill	Porter	1,040
Little Mountain	Bridgton	1,000
Little Bear Mountain	Hartford	1,100
Little Deer Hill	Stow	1,000
Little Indian Hill	Squaretown	1,320
Little Zircon Mountain	Rumford	1,900
Little Singepole Mountain	Hebron and Paris	1,360
Little Spruce Mountain	T. B. R. 11, W. E. L. S	*f*3,274
Long Mountain	Greenwood	1,820
Lord Hill	Lovell & Stoneham	1,240
Lovejoy Mountain	Albany	1,760
McDaniels Hill	Stoneham	1,300
McGaffey Mountain	Mt. Vernon and Vienna	1,240
Mann Mountain	Shapleigh	1,075
Megunticook, Mount	Camden	1,380
Mica, Mount	Paris	1,000
Middle Mountain	Spaulding and The Forks	2,180
Misery, Mount	Hiram	1,500
Moll Ockett Mountain	Woodstock	1,940
Moody Mountain	Woodstock	1,360
Moose Hill	Fayette and Livermore	1,120
Mosquito Mountain	The Forks	2,230
Moulton Ridge	Porter	1,060
Moxie Mountain	Caratunk and Spaulding	2,925
Newport Mountain	Eden	1,060
No. 4 Hill	Hebron	1,120
Noyes Mountain	Greenwood	1,440
Oak Hill	Buckfield and Paris	1,360
Oak Hill	Lovell	1,160
Oak Hill	Woodstock	1,040
Old Bluff Mountain	Concord	1,180
Ossipee Hill	Waterboro	1,050
Overset Mountain	Greenwood	1,350
Owls Head	Buckfield	1,400
Panther Mountain	T. 3, R. 5, W. B. K. P	*g*3,586
Parsonage Hill	Sumner	1,120
Patch Mountain	Greenwood	1,560
Payne Ledge	Greenwood	1,140
Peabody Mountain	Albany	1,550
Peaked Hills	Sebago	1,107
Peaked Mountain	Hiram	1,080
Peaked Mountain	Dedham	1,104
Peaked Mountain	Greenwood	1,240
Pease Mountain	Cornish	1,140
Pebley Mountain	Bethel	1,500
Peter Grover Hill	Bethel	1,210
Pickett Hill	Sweden	1,060
Pickett Hill	Gilead	1,340
Pickett Henry Mountain	Gilead	2,180
Pierce Hill	Moscow	1,220
Pine Hill	Lovell and Stow	1,240
Pine Hill	Porter	1,300
Pine Mountain	Gilead	2,000
Pinnacle, The	Paris	1,520
Pisgah, Mount	T. 2, R. 6, W. B. K. P	*g*3,428
Pleasant Mountain	Bridgton and Denmark	2,007
Pleasant Mountain	Rockport and Warren	1,064
Pleasant Pond Mountain (*e*)	The Forks	2,480
Pleasant Ridge	Pleasant Ridge	1,540
Plummer Mountain	Sweden	1,100

Elevations of Mountains of Maine—Continued.

Name.	Location.	Elevation feet.
Popple Hill	Sweden	1,080
Province Mountain	Newfield and Parsonsfield	1,152
Ragged Mountain	Camden and Rockport	1,301
Ragged Jack Mountain	Peru	1,020
Randall Mountain	Parsonsfield	1,105
Rattlesnake Mountain	Porter	1,160
Rattlesnake Mountain	Casco	1,046
Rice Hill	Waterford	1,320
Robbins Hill	Hiram	1,340
Round Mountain	Albany	1,820
Ryerson Hill	Paris	1,420
Ryerson Hill	Sumner	1,360
Sabattus Mountain	Lovell	1,280
Saddleback Hills	Baldwin (Douglas Hill)	1,407
Saddleback Mountain	Madrid	*g*4,456
Saddlerock Mountain	T. B., R. 11, W. E. L. S	*f*3,054
Sargent Mountain	Mt. Desert	1,344
Savage Hill	Concord	1,060
Sawyer Mountain	Limerick	1,210
Shack Hill	Sumner	1,040
Shackley Hill	Livermore	1,130
Shaws Ledge	Greenwood	1,220
Singepole Mountain	Paris	1,420
Skillings Hill	Lovell	1,120
Snow Mountain (*e*)	T. 2, R. 5, W. B. K. P	*g*3,986
South Mountain	Spaulding	2,080
Sparrow Hawk Mountain	Bethel	1,425
Speckled Mountain	Mason	2,877
Speckled Mountain	Peru	2,207
Spencer Mountain (*e*)	Middlesex Canal Grant	*b*3,035
Spruce Mountain (Sigotch)	Woodstock	2,420
Squaw Mountain (*e*)	T. 2, R. 6, B. K. P. E. K. R	*f*3,262
Stacy Hill	Porter	1,060
Starks Mountain	Fryeburg	1,020
Stearns Hill	Paris	1,100
Stearns Hill	Waterford	1,340
Stone Hill	Hebron	1,280
Stone Mountain	Brownfield	1,580
Streaked Mountain	Hebron	1,770
Styles Mountain	Stoneham	1,280
Sugar Loaf Mountain	Brownfield & Porter	1,080
Sumner Hill	Sumner	1,180
Tear Cap Mountain	Hiram	1,000
Thompson Hill	Hartford	1,000
Thompson Mountain	Hartford	
North Peak		1,460
Pinnacle		1,680
West Peak		1,540
Thorn Mountain	Hartford	1,300
Thurston Mountain	Rumford	1,480
Tire'm Mount	Waterford	1,047
Tom, Mount	Fryeburg	1,040
Tom, Mount	Sumner	1,700
Trask Mountain	Peru	1,710
Tumble Down Dick Mountain	Peru	
South Peak		1,520
The Pinnacle		1,720
North Peak		1,300
Tunk Mountain	T. 7, S. D	*c*1,150
Turner Hill	Buckfield and Paris	1,180
Tyler Mountain	Gilead	2,180
Vienna Mountain	Vienna	1,180
Waldo, Mount	Frankfort	1,062
Walkers Mountain	Bethel	1,560
Wassataquoik Mountain	T. 4, Rs. 10 and 11, W. E. L. S	*b*3,245
Waterspout	Bethel	1,880
Webb Rowe Hill	Baldwin	1,372
Western Mountain	Tremont	1,073
Whales Back	Porter	1,580
Whitecap Mountain (*e*)	T. 7, R. 10, N. W. P	*f*3,707
Whitecap Mountain	T. 4, R. 5, W. B. K. P	*g*2,635

Elevations of Mountains of Maine—Concluded.

NAME.	LOCATION.	Elevation feet.
Whitehouse Hill	Stoneham	1,040
Wiggin Mountain	Parsonsfield	1,275
Wilbur Mountain	Bethel	1,860
Will, Mount	Newry	1,740
Wilson Hill	West Forks	1,560
Winns Hill	Sweden	1,180
Woodbury Hill	Sweden	1,080
York Hill	New Sharon	1,190
Zircon, Mount	Peru	2,240

a Gannett, Dictionary of Altitudes.
b County Atlas.
c Water Supply Paper 279.
d U. S. Coast and Geodetic Survey.
e Lookout Stations, Maine Forestry District.
f Hubbard's Map.
g Railroad Guide Map.

Mountains of Maine. Elevations Undetermined.

NAME.	LOCATION.
Adams Mountain	Stoneham.
Albany Mountain	Albany and Stoneham.
Alder Stream Mountain	T. 3, R. 4, W. B. K. P.
Allagash Mountains	T. 12 and 13, R. 10, W. E. L. S.
Aroostook Mountain	T. 10, R. 7, W. E. L. S.
Attean Mountain (*a*)	Attean.
Aunt Hepsy Brown Mountain	Dixfield.
Avery Hill	Temple and Wilton.
Aziscohos Mountain (*a*)	Lincoln Pl.
Badin Mountain	T. 3, R. 4, B. K. P. W. K. R.
Bald Mountain	T. 4, R. 3, N. B. K. P.
Bald Mountain	Perkins Pl.
Bald Mountain	T. 10, S. D.
Bald Mountains	T. D, R. 2, W. E. L. S.
Bald Mountain	T. 3, R. 6, B. K. P. W. K. R.
Bald Mountain	Clifton.
Bald Mountain	Rangeley.
Bald Mountain	Roxbury.
Bannock Mountain	Industry.
Barren Mountain	Ts. 7 and 8, R. 9, N. W. P.
Bear Mountain	Roxbury.
Bear Mountain	Weld.
Bear Ridge	T. 3, R. 5, W. B. K. P.
Beech Hill	T. 2, R. 4, W. B. K. P.
Benson Mountain	T. 7, R. 9, N. W. P.
Birch Mountain	Bowerbank.
Black Hills	T. 10, S. D.
Black Mountain	Rumford.
Black Mountain	Kingfield.
Black Mountain	T. 2, R. 4, W. B. K. P.
Black Nubble	T. 3, R. 4, W. B. K. P.
Blackwood Mountain	T. 7, S. D.
Blakes Mountain	Guilford.
Blanchard Mountain	T. 3, R. 4, B. K. P. W. K. R.
Blue Mountain	Byron.
Blue Ridge	Rockwood.
Boar Mountain	Elliottsville.
Boardman Mountain	Industry.
Boardman Mountain	T. A., R. 11, W. E. L. S.
Boarstone Mountain	T. 8, R. 9, N. W. P.
Boundary (Bald Mountain) (*a*)	T. 4, R. 3, N. B. K. P.
Breakneck Hill	Blanchard.
Brothers, The	T. 4, R. 10, W. E. L. S.
Buckfield Hill	Byron.
Bull Hill	Eastbrook.
Bunker Mountain	Roxbury.
Burnt Hill	Highland Pl.
Burnt Jacket	T. A. 2, R. 13 and 14, W. E. L. S.
Burnt Mountain	Holeb.
Camels Hump	T. 5, R. 5, W. B. K. P.
Carmel, Mount	T. 5, R. 5, W. B. K. P.

Mountains of Maine, Elevations Undetermined—Continued.

NAME.	LOCATION.
Carrying Place Mountain	Carrying Place Pl.
Caucogomoc Mountain	T. 7, R. 15, W. E. L. S.
Centre Mountain	Flagstaff.
Chase, Mount (*a*)	Mt. Chase.
Chase Mountain	T. 6, R. 6, W. E. L. S.
City Camps (*a*)	T. 4, R. 9, W. E. L. S.
Coburn, Mount (*a*)	T. 3, R. 6, W. K. R.
Coe, Mount	T. 3, R. 10, W. E. L. S.
Cooper Mountain	T. A., R. 10, W. E. L. S.
Cow Ridge	T. 3, R. 5, W. B. K. P.
Culcusso Mountain	T. 5, R. 16, W. E. L. S.
Days Mountain	Avon.
Deer Mountain	T. 5, R 3, W. B. K. P.
Depot Mountain (*a*)	T. 3, R.16, W. E. L. S.
Double Top Mountain	T. 3, R 10, W. E. L. S.
Doughtys Hill	Shirley.
Dunham Hill	Byron.
Durgin Mountain	Mason and Stoneham.
Ebeemee Mountain	T. 5, R. 9, N. W. P.
Elephant Mountain	T. 8, R. 10, N. W. P.
Elliott Mountain	Wellington.
Ellis Mountain	Stoneham.
Ephraim, Mount	Gilead.
Ephraim Ridge	T. 3, R. 3, W. B. K. P.
Farmers Hill	Andover.
Five Round Mountain	T. 5, R. 5, W. B. K. P.
Flagstaff Mountain	Flagstaff Pl.
Fletchers Mountain	Concord.
Gamage Hill	Anson.
Gleason Hill	Temple.
Grannys Cap	T. 2, R. 5, B. K. P. W. K. R
Great Ledge	Newry.
Green Mountain	T. 4, R. 18, W. E. L. S.
Gregg Mountain	Andover.
Guilford Mountain	Guilford.
Heald Mountain	T. 3, R. 5, B. K. P. W. K. R.
Hedgehog Hill	Byron.
Houston Mountain	T. 7, R. 9, N. W. P.
Humpback Mountain	T. 28, M. D.
Hunt Mountain	T. 3, R. 7, W. E. L. S.
Jo Mary Mountain	T. A., R. 10, W. E. L. S.
Johnson Mountain	T. 2, R. 6, B. K. P. W. K. R.
Kibbie Mountain (*a*)	T. 1, R. 6, W. B. K. P.
Lane Mountain	Andover.
Lane Hill	Andover.
Ledge Ridge	T. 5, R. 6, W. B. K. P.
Lily Bay Mountain	T. A., R. 13, W. E. L. S.
Limestone Mountain	Flagstaff.
Little Bigelow Mountain	Dead River Pl.
Little Kineo Mountain	Days Academy Grant.
Little River Mountain	T. 43, M. D.
Little Squaw Mountain	T. 3, R. 5, B. K. P. E. K. R.
Long Mountain	Andover.
Lookout Mountain	T. 2, R. 4, W. B. K. P.
Lunksoos Mountain	T. 4, R. 8, W. E. L. S.
Lyford Mountain	T. 8, R. 10, N. W. P.
Mars Hill	Mars Hill.
Mattamiscontis Mountain	T. 2 and 3, R. 8, and T. 3, R. 9, N. W. P.
Milton Mountain	Centerville.
Miseree Mountain	T. 2, R. 7, B. K. P. W. K. R.
Moody Mountain	Andover North Surplus.
Moose Head	T. 2, R. 8, W. B. K. P.
Moose Hill	T. 5, R. 6, W. B. K. P.
Moose Mountain	Magalloway Pl.
Mooseleuk Mountain	T. 10, R. 9, W. E. L. S.
Mucalsea Mountain	T. 5, R. 16, W. E. L. S.
Nicolas, Mount	T. 5, R. 6, W. B. K. P.
Niles Hill	Flagstaff.
Nulhedus Mountain	T. 5, R. 17, W. E. L. S.
No. 5 Mountain	T. 6, R. 7, B. K. P. W. K. R.
North Mountain	T. 3, R. 4, W. B. K. P.
Oak Mountain	T. 19, M. D.
Observatory, Mount	Lincoln Pl.
Olasaces Mountain	T. 8, R. 15, W. E. L. S.
Old Speck Mountain	Grafton.
Onawa Peak	Elliottsville.
Onion Hill	T. 3, R. 5, W. B. K. P.

Mountains of Maine, Elevations Undetermined—Concluded.

NAME.	LOCATION.
Ore Mountain	Katahdin Iron Works.
Otter Lake Mountain (*a*)	T. 3, R. 4, W. E. L. S.
Owls Head	Jackman.
Owls Head	Jerusalem.
Owls Head	Madrid.
Parkers Hill	Lincoln Pl.
Parkers Mountain	Berlin.
Passadumkeag Mountain	T. 2, N. D.
Peaked Hill	Lexington.
Peaked Mountain	T. 10, Rs. 10 and 11, W. E. L. S.
Peaked Mountain	T. 19, M. D.
Peaked Mountain	Clifton.
Peaked Mountain	T. 10, R. 10, W. E. L. S.
Pleasant Mountain	Byron.
Pleasant Mountain	T. 10, R. 12, W. E. L. S.
Potatoe Hill	Madrid.
Potaywadjo Mountain	T. 1, R. 10, W. E. L. S.
Priestly Mountain (*a*)	T. 10, R. 13, W. E. L. S.
Prospect Mountain	T. 5, R. 4, W. B. K. P.
Puzzle Mountain	Newry.
Ragged Mountain (*a*)	T. A., R. 9, W. E. L. S.
Red Rock Mountain	Mason.
Rocky Mountain (*a*)	T. 8, R. 12, W. E. L. S.
Round Mountain (*a*)	T. 11, R. 8, W. E. L. S.
Round Mountain	T. 10, R. 11, W. E. L. S.
Round Top	Wellington.
Russell Mountain	Blanchard.
Saddleback Mountain	Grafton.
Saddleback Mountain	Washington Pl.
Sally Mountain	Attean.
Sawyer Mountain	Andover North Surplus.
Schoodic Mountain	T. 5, R. 9, N. W. P.
Sentinel Mountain	T. 3, R. 10, W. E. L. S.
Shell Mountain	Stoneham.
Smiths Hill	Avon and Strong.
Soper Mountain (*a*)	T. 8, R. 12, W. E. L. S.
Sowbung Mountain	T. 4, R. 11, W. E. L. S.
Spencer Mountain	Hobbstown.
Spencer Bale Mountain	T. 1, R. 6, W. B. K. P.
Spotted Mountain	T. 3, R. 3, W. B. K. P.
Spruce Mountain	T. 2, R. 4, W. B. K. P.
Spruce Mountain	Avon and Temple.
Spruce Scrabble	Madrid.
Spruce, Big, Mountain	T. 7, R. 10, N. W. P.
Square Mountain	Albany.
Stubs Mountain	Avon.
Sugar Loaf Mountain	T. 5, R. 7, W. E. L. S.
Tanquoomoc Mountain	T. 7, R. 15, W. E. L. S.
Tim Pond Mountains	T. 2, R. 4, W. B. K. P.
Tomah Mountain	Codyville Pl.
Toolbah Mountain	T. 7, R. 14, W. E. L. S.
Travellers Mountain	T. 5, R. 9, W. E. L. S.
Trout Brook Mountain (*a*)	T. 5, R. 9, W. E. L. S.
Tug Mountain	T. 3, D. and 31, M. D.
Tumble Down Mountain (*a*)	T. 5, R. 6, W. K. R.
Tumble Down Mountain	Berlin.
Turk, Mount	Byron.
Turner Mountain	T. 4, R. 9, W. E. L. S.
Twin Mountain	T. 4, R. 4, W. B. K. P.
Veto Mountain	T. 4, R. 11, W. E. L. S.
Walker Mountain	Roxbury.
Wassataquoick Mountain	T. 3, R. 7, W. E. L. S.
Wesley Mountain (*a*)	Wesley.
West Mountain	Berlin.
West Ridge Mountains	Lexington.
Whalesback	Byron.
Wheelers Mountain	Riley.
Whetstone Mountain	T. 2, R. 7, W. E. L. S.
Whitecap Mountain	T. B, R. 9, W. E. L. S.
Whitecap	Grafton.
Whitecap	Rumford.
Whitecap	Newry.
Whitecap	T. 4, R. 5, W. B. K. P.
Wilder Hill	Temple.
Williams Mountain (*a*)	T. 2, R. 7, W. K. R.
Witham Hill	West Forks.
Wild Cat Mountain	T. 3, R. 3, W. B. K. P.

(*a*) Lookout stations, Maine Forestry District.

The explanation of the abbreviations used in the foregoing table are given below. They refer to the different original surveys made of the State and are generally given on maps of the State.

Systems of Surveys.

Abbreviation.	Definition.
T	Township.
R	Range.
W. E. L. S	West from east line of State.
N. B. K. P	North of Binghams Kennebec Purchase.
W. B. K. P	West of Binghams Kennebec Purchase.
B. K. P. W. K. R	Binghams Kennebec Purchase, west Kennebec River.
B. K. P. E. K. R	Binghams Kennebec Purchase, east Kennebec River.
N. B. P. P	North Binghams Penobscot Purchase.
E. D	East Division Binghams Penobscot Purchase.
N. D	North Division Binghams Penobscot Purchase.
M. D	Middle Division Binghams Penobscot Purchase.
S. D	South Division Binghams Penobscot Purchase.
E. P. R	East of Penobscot River.
W. P. R	West of Penobscot River.
I. P	Indian Purchase.
O. I. P	Old Indian Purchase.
R. T	River Township.
N. W. P	North of Waldo Patent.
A. P	Abbot Purchase.
T. S	Titcomb Survey.

MAGNETIC DECLINATION

Since the establishment in 1899 of the division in the U. S. Coast and Geodetic Survey devoted exclusively to magnetic work, it has been found that the phenomena of the secular changes of the magnetic elements are far more complicated than hitherto supposed. The results of the investigations appear from time to time in the various reports of this Federal Bureau (*a*) and for detailed information on the subject, reference should be made to those reports.

Since the publication of the 1905 special report, further information has become available and was furnished this office by the Superintendent, U. S. Coast and Geodetic Survey, in October, 1911 and March, 1912. The following table has this information incorporated in it and gives the magnetic declination for Portland, Bangor, and Eastport from 1750 to 1910. The figures are for January 1 of each year as noted.

Magnetic Declinations.

Year.	Portland.	Bangor.	Eastport.
1750	8° 44′ West	10° 48′ West	12° 22′ West
1760	8 25	10 32	12 10
1770	8 20	10 30	12 10
1780	8 20	10 36	12 22
1790	8 25	10 49	12 43
1800	8 44	11 15	13 15
1810	9 12	11 49	13 55
1820	9 48	12 29	14 40
1830	10 28	13 13	15 29
1840	11 07	13 58	16 19
1850	11 48	14 46	17 15
1860	12 28	15 29	18 00
1870	12 58	15 59	18 30
1880	13 32	16 26	18 50
1890	14 00	16 45	19 00
1900	14 26	17 06	19 16
1905	14 43	17 22	19 31
1910	15 13	17 52	20 01

(*a*) Annual Report for 1906, appendix 4, U. S. Coast & Geodetic Survey.
U. S. Magnetic tables and Magnetic charts for 1905.

Plate III is a map of the State showing lines of magnetic declination as of date January 1, 1910, and is based on the tables and charts of the 1910 (*a*) report, corrected by the above mentioned special correspondence. This map may indicate a greater degree of accuracy than is actually warranted. The lines represent average conditions. In fact, the secular change tables of the U. S. Coast and Geodetic Survey as published, are based on results at a number of group stations and values derived from them will in general differ somewhat from observed values. In the southwestern portion of the State, the local disturbances are extensive and it is impossible to represent the declination by continuous lines. In such cases recourse was had to small closed curves inclosing a locality where the observations show a large departure from a uniform distribution.

The table below was furnished by the Superintendent of the U. S. Coast and Geodetic Survey while this report was in press and includes the results of determinations of the magnetic declination in this State together with the corresponding values as reduced for January 1, 1910, which were used in the construction of the isogonic chart, plate III. They include the results given on pages 34 and 35 of "Magnetic Tables and Charts for 1905" as well as those determined from 1907 to 1910 and which have not heretofore appeared in print. It will be noticed that the observed values are given in degrees, minutes, and decimals of a minute, while the reduced values to January 1, 1910 are only expressed to degrees and decimals of a degree.

(*a*) Terrestrial Magnetism for January 1, 1910, Special Publication No. 9.

Distribution of the Magnetic Declination in Maine, January 1, 1910.

Station.	Latitude.	Longitude.	Date of observation.	Declination West. Observed.	Declination West. 1910.0
	° ′	° ′		° ′	°
Appledore Island	42 59	70 37	1847.6	10 03.5	13.9
Kittery Point	43 04	70 41	1909.8	14 24.1	14.4
do	43 05	70 43	1898.9	13 12.3	14.0
Cape Neddick	43 12	70 36	1851.7	11 09.0	14.7
Agamenticus	43 13	70 42	1847.7	10 09.8	14.0
Kennebunkport	43 20	70 28	1903.8	14 12.4	14.8
Fletcher Neck	43 27	70 20	1850.7	11 17.5	14.8
Richmond Island	43 33	70 14	1850.7	12 18.1	15.8
Portland	43 39	70 17	1906.8	14 57.0	15.4
do	43 39	70 17	1910.6	15 17.6	15.2
Bailey Island	43 43	70 00	1905.7	15 05.5	15.6
Harpswell Neck	43 44	70 02	1905.7	16 33.9	17.0
Mt. Independence	43 46	70 19	1849.8	11 46.4	15.4
Cape Small	43 47	69 51	1851.8	12 05.5	15.3
Freeport	43 51	70 06	1863.5	14 11.7	16.8
Brunswick	43 54	69 58	1873.7	14 18.0	16.4
Bath	43 55	69 49	1863.5	12 51.8	15.3
Fryeburg	44 01	70 58	1910.6	15 19.2	15.3
Damariscotta	44 02	69 32	1887.6	15 12.8	16.5
Mount Pleasant	44 02	70 49	1851.6	14 32.1	17.7
Auburn	44 05	70 15	1910.5	16 23.4	16.3
Kimball Island	44 05	68 38	1905.6	15 49.7	16.3
Rockland	44 06	69 06	1863.5	15 02.1	17.4
do	44 07	69 05	1905.7	16 30.5	17.0
Mt. Sabattus	44 09	70 05	1853.6	12 53.5	15.9
Camden Village	44 12	69 05	1854.8	13 57.1	16.8
Mount Ragged	44 13	69 09	1854.7	14 16.8	17.1
Southwest Harbor	44 15	68 18	1905.8	16 20.6	16.8
Mount Desert	44 21	68 14	1856.8	15 14.2	17.8
Augusta	44 20	69 46	1910.6	15 44.6	15.7
Bethel	44 24	70 47	1910.5	15 53.2	15.8
Bar Island	44 24	68 12	1904.8	16 48.9	17.3
Jordans Island	44 25	68 08	1904.8	14 49.1	15.3
Belfast	44 26	69 01	1863.5	15 30.3	17.8
Beans Island	44 28	68 13	1905.7	16 53.2	17.4
Mill Bridge	44 32	67 54	1887.6	17 04.9	18.2
Oakland	44 33	69 44	1910.5	16 41.2	16.6
Howard	44 38	67 24	1859.6	18 31.6	20.8
Mount Saunders	44 39	68 36	1856.5	14 59.4	17.6
Epping Base, east end	44 40	67 50	1857.5	16 20	18.7
Mount Harris	44 40	69 09	1855.7	14 34.6	17.4
Farmington	44 40	70 11	1905.8	15 55.8	16.4
do	44 40	70 09	1907.6	15 51.6	16.1
Machiasport	44 41	67 24	1887.6	17 42.9	18.8
Pittsfield	44 46	69 22	1887.7	15 59.3	17.2
Bangor	44 48	68 48	1910.6	17 55.4	17.9
Humpback	44 52	68 07	1858.6	15 47.8	18.1
Eastport I	44 55	66 59	1906.7	19 21.5	19.8
Eastport II	44 55	67 00	1910.6	20 04.6	20.0
Rangeley	44 58	70 38	1905.8	16 17.8	16.8
Cooper	44 59	67 28	1859.7	16 31.9	18.8
Calais	45 11	67 17	1895.6	17 25.3	18.3
do	45 11	67 17	1906.7	17 58.4	18.4
Greenville	45 28	69 36	1887.7	16 48.1	17.9
Greenville Junction	45 28	69 37	1910.5	18 05.3	18.0
Mattawamkeag	45 31	68 24	1887.7	17 56.6	19.0
Vanceboro	45 34	67 27	1887.7	18 21.6	19.5
Capens	45 36	69 39	1910.5	18 14.6	18.2
Danforth	45 40	67 58	1887.7	18 22.7	19.5
Kineo	45 42	69 44	1910.5	18 20.6	18.3
Northeast Carry	45 52	69 33	1910.5	18 40.2	18.6
Pole Hill	45 57	67 47	1907.5	19 27.5	19.7
Chesuncook	46 04	69 24	1910.5	19 13.8	19.2
Houlton	46 07	67 53	1887.7	19 00.3	20.0
Smyrna Mills	46 08	68 08	1910.6	20 01.8	20.0
Chamberlain Lake	46 14	69 18	1910.5	19 00.5	19.0
Eagle Lake	46 24	69 20	1910.5	19 06.0	19.0
Chases Carry	46 28	69 16	1910.5	18 55.6	18.9
Presque Isle	46 39	68 00	1887.7	20 03.8	21.1
Ashland	46 40	68 23	1910.6	20 21.2	20.3
Depot Farm	46 42	69 22	1910.6	19 46.6	19.7
Allagash Falls	46 57	69 07	1910.6	20 17.3	20.2
Rankin Rapids	47 10	68 55	1910.6	20 38.5	20.6
Fort Kent	47 15	68 35	1910.6	21 07.8	21.1

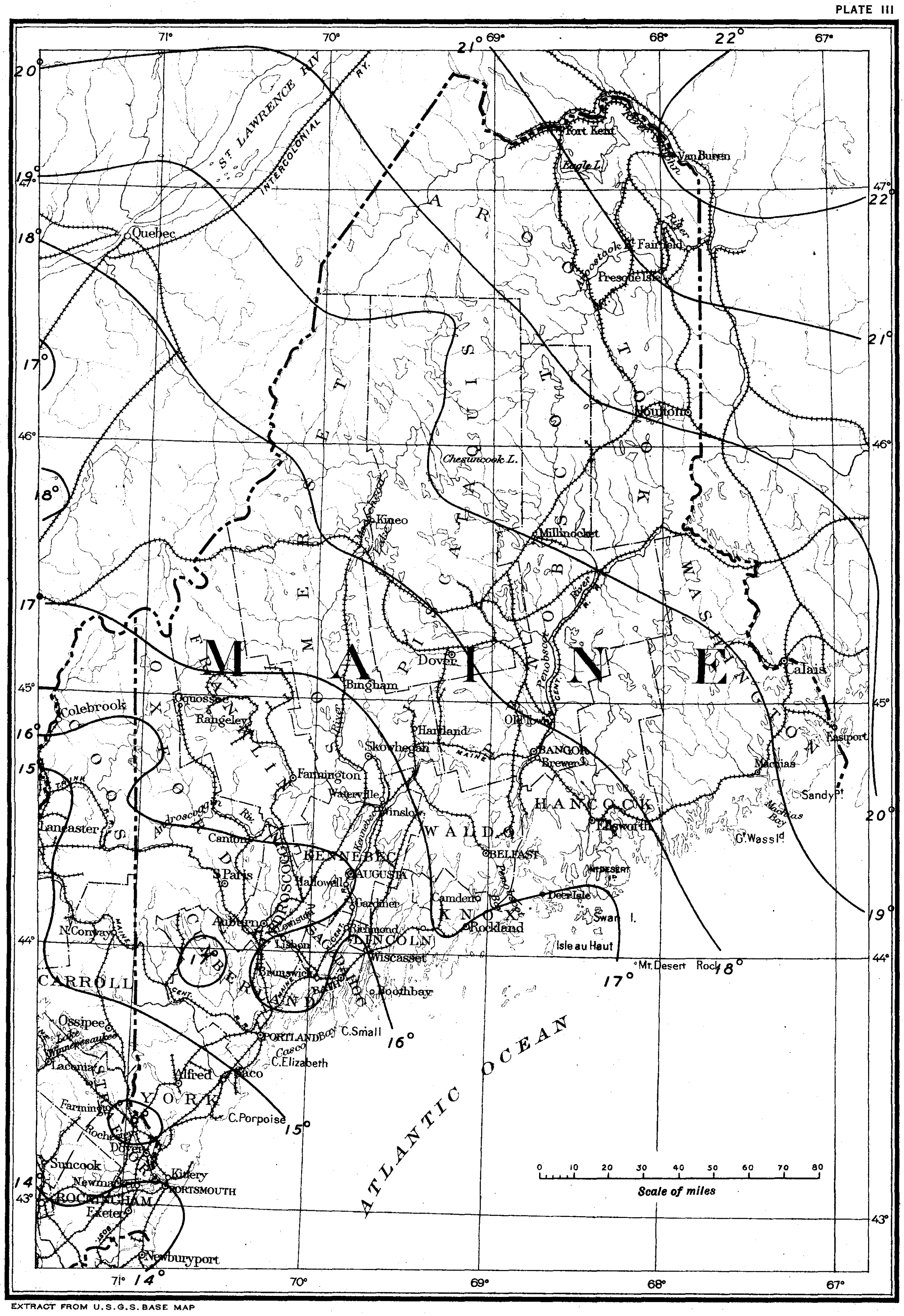
Whenever the surveyor is called upon to redetermine the boundary line of a tract of land run out at some previous period with a compass, and can find in the vicinity a well-defined line known to have been established with the same compass and at about the same time as the survey of the tract under consideration, he can not do better than determine the amount of the change in the compass bearing of this well defined line and use it to obtain the present bearings of the boundary lines to be reestablished. In this way he will also take into account the error of the compasses used. Only in the absence of such definite information is the use of the table above and the magnetic chart recommended for the practical purposes of land surveying.

In using these tables the surveyor must bear in mind the uncertainties incident to the use of the compass and should not be surprised if, for example, the change in declination for the past 100 years, as given by the tables, differs by half a degree or even more from the value indicated by his own retracing of old lines. Even at the present time many compasses are in error by as much as a quarter of a degree, owing to imperfect construction or lack of proper care, and 100 years ago the state of affairs was still worse. The tables give approximately the actual change in the magnetic declination, eliminating as far as possible the errors of individual instruments. (b)

The table on page 45 may be found of special value in determining the annual change during any period. For instance, the annual change at Portland from 1905 to 1910 was 6′; at Bangor 1830 to 1840, it was 4′.5. To illustrate another use of the table: What was the declination at Millinocket January 1, 1850? If the actual declination for 1910 is not known, note from the chart that the approximate declination on January 1, 1910 was 19° 0′ W; at Bangor in 1910 it was 17° 52′ and in 1850 14° 46′ or a change of 3° 6′. Applying these figures to Millinocket would give a declination on January 1, 1850 of 15° 54′. To repeat a caution: for practical uses, exhaust all sources of information regarding located lines and old determinations of the magnetic declination for the immediate vicinity before using the table and chart, and then recognize that the table is more accurate than the chart.

A few extra copies of plate III are available for distribution on request.

(b) Terrestrial Magnetism for January 1, 1910, Special Publication No. 9.



MAGNETIC DECLINATION, MAINE

DEVELOPED WATER POWERS.

In the 1st Annuarl Report details were given of the methods pursued in making a census of the developed water powers of the State and the form as sent out, was printed in detail. 965 letters were sent out, but answers were not received from about 370 power users or nearly 40 percent. It is believed, however, that data for all the larger users of power are on file in the office of the commission. Undoubtedly there are many small power users in the State of which the office has no record, and including those who did not answer the letter blanks, it is probable that returns have not yet been received from 50 percent of the water power users. The only way of getting information from them is by personal visits to their plants and in many cases, estimating the horsepower they use. Funds were not sufficient during the past year to make such a personal visitation census. As stated above, developments for which no data are available are small, perhaps averaging from 50 to 70 horsepower each, or totaling perhaps from 35,000 to 45,000 horsepower.

The special United States water power census of 1908 gave as the total development of the State 343,096 horsepower. The returns on file in this office total 304,000 horsepower to which should be added the developments for which no returns have been made. It is probable that the Federal figures are within 3 percent of the true amount.

According to the special U. S. census above quoted, the total water power development in the United States in 1908 was about 5,400,000 horsepower.

According to a committee of the American Institute of Electrical Engineers presented at the meeting of the U. S. National Waterways Commission, November 21, 1911, the steam development of the country is placed at 27,000,000 horsepower. A large part of this is not only possible but easy for water power to replace if it were made freely available through development. Within range of development at a cost of investment that would make the cost of such power about equal to that of steam power, there is still undeveloped in the streams of the United States about 35,000,000 horsepower.

Hydro-Electric Power.

The organic law of the commission directs that a full investigation of the water resources of the State be made and the necessary steps to be taken to further increase and conserve them, and also directs that an estimate be made of the increased power that would be developed. To arrive at a practicable plan for such a report, the question of the costs of such developments must be considered, both the capital costs of development and the revenues that can be derived from the sale of power.

This commission has not yet had the opportunity to make such detailed estimates of cost for any project proposed in this State, nor has the appropriation been sufficient to investigate the building costs of the various developed hydro-electric plants in the State. Some information is at hand, however, on existing rates for electric current of present developments in this State and is given on page 62.

The cost of developing a water power and transmitting electrically the power so developed should be thoroughly investigated for any project to be developed, as every such project has its own peculiarities. For purposes of general discussion, it is valuable to know the cost of construction or estimates of cost of construction of existing or proposed plants. The Hydro-Electric Power Commission of Ontario, Canada, has made thorough investigations and reports on a large number of developments, and the information below is taken from its reports. Its estimates on the cost of steam power are valuable and have often been quoted and used by engineers and technical journals all over the country.

The body is a government commission and is invested with all the powers necessary to control rates by various companies utilizing water power in the Province of Ontario, to build and construct all necessary works, and to take such steps as would place electrical energy for power and light within reach of the greatest possible number of people.

In the table below the annual charges for plants Nos. 4 to 14 were based on a price of $12 per year per 24 hour horsepower. Subsequently this commission instead of building a new generating plant at Niagara Falls, contracted for its power from existing plants. The contract price, which is delivered from the generators at 12,000 volts, is $9.40 per horsepower per annum, but when the amount reserved by the commission amounts to 25,000 horsepower or more, the price is $9.00 per horsepower per year.

Cost of Hydro-Electric Power in Canada.

No.	PLANT.	Total horse-power.	Capital cost per horse-power.	Annual cost per 24-hour horse-power.
1.	Niagara Falls	48,750	$119 00	$11 16
2.	Niagara Falls	73,100	96 00	9 05
3.	Niagara Falls	97,500	89 00	8 32
4.	Hamilton	16,000	....	15 36
5.	Toronto	50,250	....	16 53
6.	Orangeville	1,250	....	23 66
7.	Brampton	419	....	21 23
8.	Georgetown	900	....	20 40
9.	Milton	537	....	19 89
10.	St. Thomas	2,000	....	21 89
11.	London	5,860	....	19 51
12.	Telsonburg	624	....	24 30
13.	Woodstock	1,673	....	18 26
14.	Paris	625	....	18 12
15.	Maitland River	1,600	203 12	15 10
16.	Saugeen River	1,333	187 53	16 00
17.	Eugenia Falls	2,267	128 28	
18.	Big Chute	4,000	87 50	12 14
19.	South River	750	153 33	18 50
20.	Goderich	625	....	16 44
21.	Clinton	250	....	22 08
22.	Seaforth	437	....	21 03
23.	Mitchell	250	....	26 47
24.	Dog Lake	13,675	61 00	9 10
25.	Cameron Rapids	16,350	50 00	9 75
26.	Slate Falls	3,690	97 00	14 72
27.	Graveyard Chute	1,000	63 00	9 52
28.	Graveyard Chute	500	95 00	14 25
29.	Spanish Chute	860	68 00	9 82
30.	Spanish Chute	430	103 00	14 40
31.	Bancroft	500	85 00	14 12
32.	Bancroft	150	197 00	34 33
33.	Blind River	550	144 00	21 80
34.	Blind River	280	219 00	29 90
35.	Peterboro	1,850	145 00	18 30
36.	Bruce Mines	1,750	158 00	18 80
37.	Bruce Mines	880	215 00	25 60
38.	North Bay	2,500	106 00	14 95
39.	North Bay	1,200	142 00	20 23

1. Estimates made on a new generating plant at Niagara Falls and includes the best class of construction in keeping with the surroundings. The yearly charges are given at the high-tension bus-bars of the transformer station and include 2 1-2% of transformer losses. The following expenses are included: operating, maintenance and repair, sinking fund, interest at 4% and rental of water.

1st Report, Hydro-Electric Power Commission of Ontario, p 15.

2. See remarks under 1.

3. See remarks under 1.

4. Annual charges are based on a price of $12 per annum, per 24 hour horsepower at high-tension bus-bars of transformer station at Niagara Falls, the price sales of large blocks of power at Niagara about 1905. The annual charges in the table are on 24 hour basis at sub-station low-tension bus-bars, step-down transformer stations and include transmission, transformation, interswitching, and administration. Calculations based on the current being generated three-phase, 25-cycle, at 11,000 volts, transformed at a nearby station and raised to a voltage that would maintain a potential of about 60,000 volts. The various sub-stations have been estimated on a basis of transformation down to 2,200 volts.

5 to 14. 1st Report, Hydro-Electric Power Commission of Ontario, p. 17. See remarks under 4.

15 to 19. 3rd Report, Hydro-Electric Power Commission of Ontario p. 15.

20. Annual cost on 24-hour basis at sub-station low-tension bus-bars and includes transmission, transformation, and administration.

21 to 23. 3rd Report, Hydro-Electric Power Commission of Ontario See remarks under No. 20.

24. 5th Report, Hydro-Electric Power Commission of Ontario, p. 18. Capital cost includes all cost of development, including step-up transformer stations. Annual costs on 24-hour basis at sub-stations low-tension bus-bars and includes charges for transmission, transformation, and administration.

25 and 26. See remarks under No. 24.

27. Capital cost includes dam, power house, hydraulic and electrical equipment, engineering and interest during construction, and its cost at power house switchboard ready for local distribution.

Annual charge includes: operation and maintenance, depreciation and interest on capital investment. The head developed is 55 feet. See 1st and 2nd Annual Report, Hydro-Electric Power Commission of Ontario, p. 144.

28. Same as 27 except estimate is for one-half capacity.

29. Plant near and similar to No. 27 except head is 43 feet.

30. Same as 29 except estimate is for one-half capacity.

31-34. See remarks under No. 27.

35. 1st and 2nd Annual Reports, Hydro-Electric Power Commission of Ontario, p. 164. Includes dam, permanent works, hydraulic and electrical equipment, transmission, step-up, and step-down transformers.

Annual cost is at low-tension bus-bars of sub-station.

36 and 37. See remarks under No. 35.

38 and 39. See remarks under No. 35.

Costs of various American and foreign water power plants.
(From Mead's Water Power Engineering)

Name or Location.	Head in feet.	Horse-power capacity at turbine shaft.	Cost per horse-power.	See notes below.
1. Chicago Drainage Canal, Lockport, Ill.	28	15,500	$225 80	d
2. Columbus, Ga	40	9,000	50 00	c and e
3. Catawba, S. C	25	10,000	110 00	[illegible] and f
4. Tariffuille, Conn	31	2,300	125 00	d
5. Delta, Penn	42	550	54 00	and g
6. Lachine, Montreal	16	6 600	145 80	d and h
7. Winnepeg, Manitoba	40	25,600	156 25	and i
8. Manchester, N. H	30	6,000	66 00	a and j
9. Lowell, Mass	13	....	110 00	a and j
10. Lowell, Mass	18	....	57 00	a and j
11. Big Cottonwood, Utah	370	3,000	108 25	[illegible] and k
12. Lawrence, Mass	....	1,000	67 50	a and j
13. Spier Falls, N. Y	90	50,000	42 00	c
14. Zurich, Switzerland	very low	25,300	183 90	d and l
15. Rhinefelden, Germany	10 to 16	15,000	81 70	c
16. Paderno, Italy	90	13,000	120 00	b
17. Champ, France	104	6,750	148 00	d
18. Dep't de l'Isere, France	330	4,000	34 00	b
19. Dep't de Jura, France	6.5	300	150 00	d
20. Upper Savoy, France	450	11,000	165 50	c and m
21. Chedde, France	455	10,000	30 00 42 50	a c and n
22. Chevres, Switzerland	14 to 27	9,600	109 00	b
23. Kubel, Switzerland	296	5,000	215 00	d and o
24. Schaffhausen, Germany	13.8 to 15.8 11.5 to 14.8	2,700	135 00	d and p
25. Gersthofen, Germany	32.8 to 34.4	6,000	135 00	b
26. Augsburg, Germany	....	9,100	206 00	d
27. Heimbach, Germany	230 to 360	16,500	130 00	d and q
28. Lyon, France	33 to 40	22,750	287 50	d and r
29. Muhlhausen, Germany	24 to 30	23,000	132 50	b

a The cost of water power development, not including dam.
b The cost of water power development, including dam.
c The cost of complete water power development, including electric station equipment.
d The cost of complete water power development, including electric station equipment and transmission lines.
e Mostly 12-hour H. P. distributed to adjacent mills at the generated voltage.
f Severe climatic and river conditions during construction.
g Very favorable location; cheap timber dam; transmission line only 5 miles long.
h Includes extra real estate investment.
i Expensive canals in rock, and very extensive concrete construction.
j Factory installation.
k Pelton wheels and 1,500 feet wood-stave pipe line.
l Four interconnected plants; including also steam auxiliary.
m Not including 5,000 H. P., necessary steam auxiliary.
n Not including dam.
o With 1,000 H. P. steam auxiliary.
p Two interconnected plants.
q 15-mile transmission line.
r 12-mile feeder canal.

Cost of a Number of Hydro-Electric Power Plants. (a)

Name or Location.	Head in feet.	Net H. P. at turbine.	Cost per H. P.	Operation cost per net H. P. at high tension bus-bars, 24-hour use.
Newton Falls, O. (Porter)	18	1,000	$47 00	$9 05
Newton Falls, O. (Lowry)	16	1,000	52 00	9 68
Leavittsburg, O.	9	500	88 00	17 30
Charles City, Ia. (1)	13	300	100 00	23 20
Parkman, O., 2 plants (2)	50 & 60	600	53 00	9 00
Greenfield, O. (3)	106	20,000	85 00	
Hickory, N. C.	45	16,000	40 50	
New York, No. 1 (4)	30	1,600	109 80	
New York, No. 2 (5)	39	1,600	85 70	
New York, No. 3 (6)	185	12,000	66 00	

1. 1,100 ft. penstock cost $26.60 per H. P.
2. Two dams, one, 2000-foot, 39-inch steam pipe canal and reservoir.
3. Two 68-foot dams, tunnel 5,000 feet.
4. Earth dam.
5. Earth dam and 4,000 by 8-foot penstock.
6. Earth dam and two 12,000 by 9-foot penstock.

a Financial Aspect of Water Powers by R. C. Beardsley, Electrical Review, Vol. 57, page 1236.

The first four plants were actually built and the others closely estimated. Reinforced concrete construction. No lands or water rights. Plants complete to high-tension transmission. Attendance charge taken at $2000 per year which is high for small plants. 40 year replacement fund allowed on total development. Interest at 6 percent. Maintenance at 3 percent on total physical cost. Administration about $3 per H. P. delivered to line. Taxes at 105. Oil, waste and small tools 40 cents per H. P.

Individual Installations.

The cost of distribution from the municipal sub-stations to the consumers' premises varies widely with different conditions and depends upon the distances involved, the magnitude of the demands of individual consumers and the grouping of these consumers. A special study is necessary in each case.

Many instances arise, however, in which it is desired to supply a single large consumer or a small municipality at some distance from a sub-station. When this is the case the following table may be used. The total cost of power to such a consumer is ascertained by adding the rate per horsepower from this table to the cost of power at the nearest sub-station The charges for such a branch transmission do not include any allowance of right of way or telephone, it being assumed that the highway would be available for such low voltage lines.

Cost of distribution of electric power from sub-station to an individual consumer, not covered by local distribution. (*a*)

Distance in miles from Municipal sub-station.	Cost per Horse-power per Annum for the Delivery of Various Amounts of Power.							
	50 H. P.	75 H. P.	100 H. P.	150 H. P.	200 H. P.	250 H. P.	300 H. P.	
2	$5 58	$4 20	$3 53	$2 92	$2 74	$2 60	$2 51	2,200 Volts.
3	6 89	5 20	4 41	3 60	3 25	3 10	3 03	
4	7 92	6 18	5 20	4 27	3 93	3 72	3 86	
5	8 87	7 18	5 98	4 96	4 55	4 32	4 17	
6	10 20	8 24	6 77	5 38	5 13	4 60	4 43	
8	14 10	10 14	8 40	6 97	6 24	5 79	5 58	11,000 Volts.
10	16 12	12 13	9 54	8 31	7 68	6 96	6 17	
12	18 76	14 03	11 12	10 12	8 42	7 96	7 22	16,500 Volts.
15	22 74	17 08	13 48	10 89	9 35	8 84	8 32	

a Fifth Report Hydro-Electric Power Commission of Ontario, p. 24.

The following table shows the cost of induction motor service per horsepower per year. By combining the costs given in this table with the cost of distributed power, the final or total charge per horsepower per year will be obtained. It is for polyphase, 60-cycle induction motors.

Cost and Annual Charges on Motor Installations. (*a*)

Capacity horse-power.	Capital cost per horse-power installed.	Annual charges per brake, horse-power.
5	$39 00	$8 29
10	36 00	6 96
15	30 00	5 80
25	25 00	4 75
35	22 00	4 17
50	20 00	3 70
75	19 00	3 34
100	17 00	2 87
150	15 00	2 45
200	14 00	2 24

a Fifth Report, Hydro-Electric Power Commission of Ontario, p. 26.

Hydro-Electric Companies of Maine.

The following table is a list of the electric light and power companies in the State according to the records of this office. Full data are not available at present to distinguish between the pure hydro-electric, the steam, and the mixed plants. The localities or communities served by the different companies are more or less incomplete.

Electric Light and Power Companies of Maine.

Ashland Electric Co.
- Ashland
- Sheridan

Atlantic Shore Ry.
- Biddeford
- Dover
- Kennebunk
- Kittery
- Ogunquit
- Portsmouth
- Sanford
- So. Berwick
- York

Bangor & Aroostook Railway Co.
- Milo Junction

Bangor Power Co.
- Bangor
- Milford
- Old Town
- Brewer

Bangor Railway & Electric Co.
- Bangor
- Brewer
- Charleston
- Corinth
- Hampden
- Kenduskeag
- Old Town
- Orono
- Veazie

Bar Harbor & Union River Power Co.
- Bangor
- Bar Harbor
- Ellsworth

Bath & Brunswick Light & Power Co.
- Bath
- Brunswick
- Topsham

Berwick & Salmon Falls Electric Co.
- Berwick
- Jewett
- South Berwick

Boothbay Harbor Electric Light Co.
- Boothbay Harbor

Bridgewater Electric Co.
- Bridgewater Center.

Bridgton Water & Electric Co.
- Bridgton

Brownville Electric Light & Power Co.
- Brownville

Buckfield Water Power & Electric Light Co.
- Buckfield

Cabot Manufacturing Co.
- Brunswick.

Caribou Water, Light & Power Co.
- Caribou

Carrabassett Co.
- North Anson

Castine Light, Power & Heating Co.
- Castine

Central Maine Power Co.
- Augusta
- Benton
- Bingham
- Burnham
- Chelsea
- Clinton
- Corinna
- Dexter
- East Winthrop
- Fairfield
- Farmingdale
- Gardiner
- Hallowell
- Oakland
- Pittsfield
- Pittston
- Randolph
- Richmond
- Skowhegan
- Solon
- Vassalboro
- Waterville
- Winslow

Cherryfield Electric Light Co.
- Cherryfield

Consolidated Electric Light Co. of Maine.
- Portland and vicinity

Cornish & Kezar Falls Light & Power Co.
- Cornish
- Kezar Falls
- Hiram
- Parsonsfield
- Porter

Cumberland County Power & Light Co.
- Bonnie Eagle
- Portland

Dixfield Light & Improvement Co.
- Dixfield

Dover & Foxcroft Light & Heat Co.
- Dover
- Foxcroft

Easton Electric Co.
- Easton

Eastport Electric Light Co.
- Eastport
- Pembroke

Emerson Lumber Co.
- Island Falls

Ft. Fairfield Light & Power Co.
- Ft. Fairfield.

Franklin Power Co.
- Farmington
- Wilton

Freeport Electric Light, Heat & Power Co.
- Freeport

Fryeburg Electric Light Co.
- Fryeburg

Greenville Light & Power Co.
- Greenville
- Guilford
- Monson
- Sangerville

Haynes, E. & A.
- Lincoln Center

Houlton Water Co.
- Houlton

Huse Spool & Bobbin Co.
- Kingfield

International Paper Co.
- Livermore Falls

Lewiston & Auburn Electric Light Co.
- Auburn
- Lewiston

Limerick Water & Electric Co.
- Limerick

Linn Woolen Co.
- Hartland

Lisbon Falls Gas & Electric Co.
- Lisbon Falls
- Durham

Livermore Falls Light and Power Co.
- East Livermore
- Jay
- Livermore Falls

Lubec Sardine Co.
- Lubec

Machias Electric Light Co.
- Machias

Madison Village Corporation
Madison
Maine Power Co.
Norway
Maine & New Brunswick Electrical Power Co. Ltd.
Blaine
Bridgewater
Easton
Ft. Fairfield
Houlton
Limestone
Maple Grove
Mars Hill
Monticello
Presque Isle
Van Buren
Washburn
Aroostook Jct., N. B.
Andover, N. B.
Perth, N. B.
St. Leonards, N. B.
Mallison Power Co.
Westbrook
Mars Hill & Blaine Electric Light & Water Co.
Mars Hill
Blaine
Mechanic Falls Electric Light Co.
Mechanic Falls
Oxford
Hebron
Merrill Mill Co.
Patten
Merrill Springer Co.
Bethel
Millinocket Light Co.
Millinocket
Milo Electric Light & Power Co.
Milo
Milo Junction
Newport Light & Power Co.
Detroit
Newport
Norridgewock Electric Light Co.
Norridgewock
North Aroostook Electric Co.
Limestone
Norway & Paris Street Railway Co.
Norway
Paris
Ossipee Valley Power Co.
Sanford
Springvale
Oxford Light & Power Co.
Norway
South Paris
Pembroke Electric Light & Power Co.
Pembroke
Penobscot Bay Electric Co.
Belfast
Bucksport
Orland
Stockton Springs
Phillips Electric Light Co.
Phillips
Piscataquis Woolen Co.
Guilford
Portland Electric Co.
Buxton
Portland
Sanford
Portland Light & Power Co.
Portland
Gorham
Portland Power & Development Co.
Damariscotta
Damariscotta Mills
New Castle
Nobleboro
Boothbay Harbor
Wiscasset
Presumpscot Electric Co.
Falmouth
Westbrook
Woodfords
Princeton Electric Light Co.
Princeton
Putnam, H. H.
Danforth
Rangeley Light & Power Co.
Rangeley

Readfield Light & Power Co.
Readfield
Kents Hill

Rockland, Thomaston & Camden Street Ry. Co.
Camden
Rockland
Rockport
Thomaston

Rumford Falls Light & Water Co.
Rumford

Rumford Falls Power Co.
Rumford

St. Croix Gas Light Co.
Calais

St. Stephen Electric Light Co.
Calais
Mill Town, N. B.
St. Stephen, N. B.

Sanford Light & Power Co.
Sanford
Springvale

Searsport Electric Co.
Searsport

Union Electric Light & Gas Co.
Belgrade Lakes

Union Electric Light & Power Co.
Union

Van Buren Light & Power Co.
Van Buren
St. Leonard, N. B.

Waldoboro Water, Electric & Power Co.
Waldoboro

Washburn Electric Co.
Washburn

Waterville & Fairfield Railway & Light Co.
Waterville
Fairfield

Winthrop & Wayne Electric Light & Power Co.
Wayne
Winthrop

Yarmouth Manufacturing Co.
Freeport
Yarmouth

York Light & Heat Co.
Biddeford
Biddeford Pool
Kennebunk
Kennebunkport
Old Orchard
Saco
Wells
York

The following circular letter and Form No. 4 were sent to the various electric light and power companies in the preceding table, when the manuscript for this report was nearly completed. The replies to date are incomplete but such data as were received regarding output and rates are included in the table on page 62 and the foot notes following same.

The replies to the questions regarding annual output of generators are especially meager and in many cases where figures are given, they are estimated. This is generally due to the fact that many companies, especially the smaller ones, have no measuring devices for recording the total annual output in kilowatt hours of the generating stations. It will not be many years, before a Public Utilities Commission is created by statute in this State, and the annual output in kilowatt hours will be one of the principal questions asked of all companies generating electric current.

It is therefore recommended that a law be passed compelling such companies to install suitable recording devices for electric current to be under the supervision temporarily of the State Water Storage Commission.

STATE OF MAINE.

WATER STORAGE COMMISSION

AUGUSTA, MAINE.

GENTLEMEN:

This office is directed by law to investigate the present development of water power in this State and to present a plan to develop and increase it. In order to do this intelligently, the special inquiry covered by the questions on the attached sheet is being made. It is for the purpose of investigating the extent of the electric light and power industry of the State where current is sold commercially in order that comparison can be made of the amount of power developed by water and by steam respectively, and the cost of each.

Will you kindly send me, also, a copy of your published schedule of rates and discounts for electric current, both for lighting and small power purposes, and also such rates for large blocks of power as you may wish this office to have at the present time.

Your answers to the questions are respectfully requested and are necessary for the purposes of the investigation. By using the enclosed envelope for your reply, extra postage will not be required.

Very respectfully,

CYRUS C. BABB,

Chief Engineer.

MAINE STATE WATER STORAGE COMMISSION.

ELECTRIC LIGHT AND POWER DEVELOPMENT.

Name of company ....
Post Office ....
Name of Stream ....
Location ....
Maximum capacity of generators by Water Power:
In Kilowatts ....
....
Maximum capacity of generators by Steam Power (steam plant only):
In Kilowatts ....
....
Maximum capacity of generators by Water & Steam Power (auxiliary steam)
In Kilowatts ....
....
Total annual output of generators by Water Power in 1911:
In Kilowatt hours ....
....
Total annual output of generators by Steam Power plant only in 1911:
In Kilowatt hours ....
....
Total annual output by Water and Steam Power in 1911 (auxiliary steam):
In Kilowatt hours ....
....
Towns or communities served ....
....
Our published schedule of rates for electric lighting and power is attached herewith or given on the back of this sheet.
Information furnished by ....
Date .... Address ....

EXISTING RATES.

In the subjoined table will be found a schedule of lighting and power rates of some of the companies operating in the State of Maine, followed by explanatory notes.

The total generator capacity of the plants shown is 79,211 kilowatts or 106,143 horsepower.

Output and Rates for Electric Current.

Number.	Name.	Locality.	Maximum capacity generator Kilowatts.	Total annual output generators in 1911. Kilowatt hours.	Rate per Kilowatt Hour in Cents.	
					Lighting.	Power.
1.	Ashland Electric Co.	Ashland	50	38,000	12 to 20	
2.	Atlantic Shore Ry.	Kennebunk	2,960	2,832,708		
3.	Bangor & Aroostook Ry. Co.	Milo Junct.	66	100,000	5	
4.	Bangor Ry. & Electric Co.	Bangor	2,500	3,740,561	6 to 15	2 to 10
5.	Bangor Power Co.	Milford	8,000	9,518,350		
6.	Bar Harbor & Union River Power Co.	Ellsworth	2,350	7,329,430	10 to 25	
7.	Bath & Brunswick Light & Power Co.	Brunswick	1,875	2,127,992	8 to 10	2.3 to 10
8.	Berwick, Salmon Falls Electric Co.	So. Berwick	550	1,168,000 (*a*)	12 to 15	
9.	Bridgton Water & Electric Co.	Bridgton	135	....	13½	
10.	Cabot Manufacturing Co.	Brunswick	700			
11.	Caribou Water, Light & Power Co.	Caribou	200	....	12½	
12.	Carrabassett Co.	No. Anson	2,300	....	8 to 15	
13.	Central Maine Power Co.	Augusta	9,000	20,000,000	9	8
13*a*	Central Maine Power Co.	Skowhegan	......	....	5 to 10	1½ to 5
14.	Consolidated Electric Light Co. of Maine.	Portland	3,000	2,313,507	3 to 10	1½ to 7
15.	Cornish & Kezar Falls Light & Power Co.	Kezar Falls	250	....	5 to 7	
16.	Cumberland Co. Power & Light Co.	Bonnie Eagle	9,000			
17.	Dixfield Light & Improvement Co.	Dixfield	50	100,000	12	6
18.	Dover & Foxcroft Light & Heat Co.	Dover	300	....	8 to 15	3 to 8
19.	Easton Electric Co.	Easton	......	....	10	
20.	Emerson Lumber Co.	Island Falls	60	....	10	
21.	Fort Fairfield Light & Power Co.	Fort Fairfield	300	145,800	10	2½ to 9
22.	Franklin Power Co.	Farmington	135			
23.	Fryeburg Electric Light Co.	Fryeburg	75	22,000 (*a*)		
24.	Greenville Light & Power Co.	Greenville	500	1,200,000 (*a*)	12	6
25.	Houlton Water Co.	Houlton	150	....	5 to 10	2½ to 10
26.	Huse Spool & Bobbin Co.	Kingfield	120	16,552	11	
27.	Lewiston & Auburn Electric Light Co.	Lewiston	3,900	10,154,000	8	1.4 to 7
28.	Limerick Water & Electric Co.	Limerick	300	515,000	10	1.3
29.	Lisbon Falls Gas & Electric Co.	Lisbon Falls	100	80,137	15	10
30.	Livermore Falls Light & Power Co.	Livermore Falls	......	....	10	7
31.	Machias Electric Light Co.	Machias	100	....	10	
32.	Maine & New Brunswick Electrical Power Co., Ltd.	Presque Isle	2,500	1,694,900		
33.	Mallison Power Co.	Westbrook	792	3,091,000		
34.	Mechanic Falls Electric Light Co.	Mechanic Falls	150	357,332	5 to 9	7
35.	Merrill Springer Co.	Bethel	150	55,000		
36.	Milo Electric Light & Power Co.	Milo	95	....	11	
37.	Newport Light & Power Co.	Newport	150	4,340,000	7½ to 10	3 to 7½
38.	Norway & Paris St. Ry.	Norway	460	595,000	15	3 to 10
39.	Ossipee Valley Power Co.	Sanford	240	....	11	2.2 to 5

Output and Rates for Electric Current—Concluded.

Number.	Name.	Locality.	Maximum capacity generator Kilowatts.	Total annual output generators in 1911. Kilowatt hours.	Rate per Kilowatt Hour in Cents. Lighting.	Power.
40.	Penobscot Bay Electric Co	Belfast	925	....	10 to 12	2.3 to 7
41.	Phillips Electric Light & Power Co	Phillips	35	80,950	10 to 15	
42.	Portland Electric Co	West Buxton	3,000	11,620,500	3 to 10	1½ to 7
43.	Portland Lighting & Power Co	North Gorham	2,000	4,057,350	3 to 10	1½ to 7
44.	Portland Power & Development Co	Damariscotta	275	....	15	5
45.	Presumpscot Electric Co.	Westbrook	4,150	....	5 to 10	
46.	Putnam, H. H	Danforth	300			
47.	Readfield Light & Power Co	Readfield	125	....	10	
48.	Rockland, Thomaston & Camden St. Ry. Co	Rockland	1,610	2,095,509	9 to 15	4 to 7
49.	Rumford Falls Light & Power Co	Rumford	......	....	10	1 to 7
50.	Rumford Falls Power Co.	Rumford	10,000	23,218,000	10	1 to 7
51.	St. Croix Gas Light Co	Calais	435	....	10 to 20	
52.	Sanford Light & Power Co	Sanford	480	....	10	10
53.	Searsport Electric Co	Searsport	150	15,000	12	
54.	Van Buren Light & Power Co	Van Buren	......	....	.. 10	3
55.	Waldoboro Water, Electric & Power Co	Waldoboro	128			
56.	Washburn Electric Co	Washburn	......	....	12	6
57.	Winthrop & Wayne Electric Light & Power Co.	Wayne	135	....	10	
58.	Yarmouth Manufacturing Co	Yarmouth	150	160,742	10	2 to 3
59.	York Light & Heat Co	Biddeford	1,750	3,302,500	15 to 25	6 to 20

(*a*) Estimated.

1. Ashland Electric Co., Ashland:—12 cents for carbon lamps, 20 cents for tungsten lamps. Discount for over 100 K. W. hr. per month. No power rate.

2. Atlantic Shore Ry., Kennebunk:—Generator capacity by water power 2100 K. W.; by steam power 860 K. W. Current not sold for lighting or power purposes.

3. Bangor & Aroostook Ry. Co., Milo Junction:—To railroad employees only. Minimum charge 50 cents per month.

4. Bangor Railway & Electric Co.:—Discount on all bills of 10% if paid before 10th of each month. Minimum charge of 80c per month per meter.

Residence Lighting Rates:—Where the total installation of lamps does not exceed 30 sixteen candle power lamps or the equivalent thereof, the first 40 hours use per month of 60% of the connected installation for which capacity is provided will be charged for at 15 cents per K. W. hr. Current used in excess 6 cents per K. W. hr.

Where the total installation of lamps is between 31 and 60 sixteen candle power lamps or the equivalent thereof, the first 40 hours use per month of 50% of the connected installation for which capacity is provided will be charged for at 15 cents per K. W. hr. Current used in excess 6 cents per K. W. hr.

Where the total installation of lamps is in excess of 60 sixteen candle power lamps or the equivalent thereof, the first 40 hours use per month of 40% of the connected installation for which capacity is provided will be charged for at 15 cents per K. W. hr. Current used in excess 6 cents per K. W. hr.

The company furnishes free G. E. M. filament incandescent lamps.

Commercial Lighting Rates:—Where the total installation of lamps does not exceed 30 sixteen candle power lamps or the equivalent thereof, the first 30 hours use per month of the connected installation for which capacity is provided will be charged for at 15 cents per K. W. hr. Current used in excess 6 cents per K. W. hr.

Where the total installation of lamps is between 31 and 60 sixteen candle power lamps or the equivalent thereof, the first 20 hours use per month of the connected installation for which capacity is provided will be charged for at 15 cents per K. W. hr. Current used in excess 6 cents per K. W. hr.

Where the total installation of lamps is in excess of 60 sixteen candle power lamps or the equivalent thereof, the first 10 hours use per month of the connected installation for which capacity is provided will be charged for at 15 cents per K. W. hr. Current used in excess 6 cents per K. W. hr.

All current used in excess of 1,000 K. W. hours per month subject to a discount of 20%.

Heating & Cooking:—For heating and cooking purposes a separate meter will be installed and current will be charged for at the rate of 3 cents per kilowatt hour net.

The minimum monthly charge on this service will be $2.00.

Tailors' Press Irons:—Current will be supplied for Tailors' press irons of not less than 7 ampere capacity at the rate of 10 cents per K. W. hr. for first 20 K. W. hrs. per iron per month. Current used in excess 2 cents per K. W. hr.

Power:—For motor installations of less than 25 H. P. the charge will be 10 cents per K. W. hr. for the first 20 K. W. hrs. per H. P. of motors installed per month. Current used in excess two cents per K. W. hr.

For motor installation of 25 H. P. or over where the consumer enters into a written contract for a term of not less than five years and pays a minimum charge of $1.00 per H. P. of motors installed per month, a rate of two cents per K. W. hr. will be charged.

For motor installations for use in the operation of refrigerating machines *only,* where the consumer agrees not to use power from 4 P. M. to 8 P. M. daily during the six months commencing October 1 and ending March 31, the charge will be 10 cents per K. W. hr. for the first 10 K. W. hrs. per H. P. of motors installed per month. Current in excess two cents per K. W. hr.

In a specific large power contract of 2800 H. P. for 24 hours service at an 80% load factor, the rate averages 4½ mills per H. P. hr.

5. Bangor Power Co., Milford:—This company furnishes power in large quantities either as water or by electricity, $22 per H. P. per year.

6. Bar Harbor & Union River Power Co., Ellsworth:—

Lighting: Ellsworth 10 cents per K. W. H. Bar Harbor 15 cents per K. W. H. for all year customers; 25 cents per K. W. H. for summer customers.

7. Bath & Brunswick Light & Power Co., Brunswick:—

Lighting: 20 K. W. H. or less per month, 10 cents per K. W. H. All in excess of 20 K. W. H. 8 cents.

Net Prices for Power Meter Readings.

Meter readings K. W. hours per month.	Rate per K.W.hour.	Meter readings K. W. hours per month.	Rate per K.W.hour.
0 to 50	$ .10	2,200 to 2,400	$ .04
50 to 100	.095	2,400 to 2,800	.038
100 to 175	.09	2,800 to 3,200	.036
175 to 250	.085	3,200 to 3,500	.034
250 to 350	.08	3,500 to 4,000	.033
350 to 475	.075	4,000 to 5,000	.032
475 to 650	.07	5,000 to 6,500	.031
650 to 850	.065	6,500 to 8,000	.03
850 to 1,050	.06	8,000 to 10,000	.029
1,050 to 1,200	.056	10,000 to 12,000	.028
1,200 to 1,400	.053	12,000 to 14,000	.027
1,400 to 1,600	.05	14,000 to 16,000	.026
1,600 to 1,800	.047	16,000 to 18,000	.025
1,800 to 2,000	.044	18,000 to 20,000	.024
2,000 to 2,200	.042	20,000 and above	.023

Regular running time, 25 days of 10 hours each per month or 3,000 hours per year.

Minimum charge: for 10 H. P. in motors and less, $1.50 per H. P. per month; for 11 H. P. in motors up to 24 H. P., $1.25 per H. P. per month; for 25 H. P. in motors, and more, $1.00 per H. P. per month.

8. Berwick, Salmon Falls Electric Co., South Berwick:—Lighting: Meter, 12 cents to 15 cents per K. W. H. Flat rates, houses $1.00 to $4.00 per month; stores $1.50 to $5.00 per month; Hotels, $4.00 to $16.75 per month; pumping, water station $500 per annum.

Street Lighting: arcs, $75.00 per year per lamp 2000 c. p.; incandescent $17.00 per year per light, 40 watts; moonshine schedule, all night service.

9. Bridgton Water & Electric Co., Bridgton:—Lighting: commercial, 13½ cents per K. W. H. Power, small $60.00 to $75.00 per horsepower; power, large, $35.00 per horsepower. Average output of generator 75 K. W.

10. Cabot Manufacturing Co., Brunswick:—1000 H. P. of water wheels leased to Lewiston, Brunswick & Bath Street Ry. Co. The railroad company owns and operates the plant. $20 per H. P. per year for 17 hours daily 365 days.

11. Caribou Water, Light & Power Co., Caribou:—Discount of 10% if paid in 10 days.

12. Carrabassett Co., North Anson:—Lighting: First 15 K. W. hrs. 15 cents; second 15 K. W. hrs. 12 cents; all above 30 K. W. hrs. 8 cents. Load of 1500 lamps and 3 street arcs and 20 incandescents.

13. Central Maine Power Co., Augusta:—Lighting, discounts if paid before the 15th of each month, 5% to all customers, 10% where monthly bills are between $10 and $20, 15% where monthly bills are $20 and over. Minimum monthly rate $ .75.

Power only to purchasers of not less than 3 H. P. or to users of at least 125 K. W. hours in each month, to be used on week days between 7 A. M. and 5 P. M. Discounts if paid before the 15th of each month, 5% to all customers, 25% where monthly bills are between $7.50 and $10, 50% where monthly bills are $10 and over.

13a. Central Maine Power Co., Skowhegan:—Lighting, 10 cents per K. W. hr. for the first 15 K. W. hrs.; 8 cents per K. W. hr. for the second 15 K. W. hrs.; 5 cents for all over 30 K. W. hrs. Large consumers, hotels, shops and mills, 5 cents per K. W. hour.

Power: small motors on lighting circuit; rate, lighting schedule. Motors on separate service 1 to 10 H. P. rate 3 cents to 5 cents per K. W. hr. according to amount used. Motors 15 H. P. and larger 1½ cents to 3 cents per K. W. hr. according to amount used.

14. Consolidated Electric Light Company of Maine, Portland:—Lighting: 10 cents per K. W. hr. for first three kilowatt hours per 50 watt lamp installed, per month. 6 cents per K. W. hour for the next 3 kilowatt hours per 50 watt lamp installed, per month. 3 cents per K. W. hour per 50 watt lamp, installed, per month for all over and above. Less 10% discount. Minimum charge $12 per year.

In residence lighting, company takes one-third of lights installed as connected load, after the first ten.

The company charges for the first installation of incandescent lamps, but renews, free of charge, all standard dim and burned-out lamps of 8, 16 and 32 candle power.

Municipal:

Lighting Contract

Arc lamps	$60.00	per annum
65 c. p.	30.00	"
30 c. p.	18.00	"
25 c. p.	16.00	"
16 c. p.	9.00	"

All current for municipal buildings, 4½ cents per K. W. hour net.

Power:

Six cents per K. W. hour for first 40 K. W. hours per H. P. installed per month; all over and above, 3 cents a K. W. hour less a cash discount of 10%. Minimum rate 50 cents per H. P. per month.

For motors of 50 or more total horsepower maximum demand; a fixed rate of $1.00 per H. P. per month for maximum demand as determined by test when in operation plus a meter rate of 2 cents per

K. W. hour or 1½ cents per K. W. hour when in any month the consumption exceeds 10,000 K. W. hours; 5% cash discount.

A special rate for limited service is made to off-peak customers agreeing not to use power between the hours of 4 P. M. and 10 P. M. daily. For this class, the base rate is 7 cents a K. W. hour with sliding scale discounts ranging from 44% to 75% depending on customers' daily demand as given in the table below, less 5 percent cash discount. A minimum charge of 50 cents per H. P. per month is made.

Electric Current for Operating Motors between 11 P. M. and 4 P. M., Except for Elevators, Emergency and Breakdown Service, at the Following Rates per K. W. hours.

7 cents per Kilowatt, with the following discounts.

Horse power 10 hours per day.	Discount per cent.	Net rate per K. W.
5.38 to 6.36	44	$.0392
6.36 " 7.42	47	.0371
7.42 " 8.48	50	.0350
8.48 " 9.54	53	.0329
9.54 " 10.60	56	.0308
10.60 " 11.66	58	.0294
11.66 " 12.72	60	.0280
12.72 " 14.84	62	.0266
14.84 " 16.96	64	.0252
16.96 " 18.65	66	.0238
18.65 " 21.20	67	.0231
21.20 " 26.50	68	.0224
26.50 " 34.60	69	.0217
34.60 " 42.40	70	.0210
42.40 " 53.00	71	.0203
53.00 " 63.60	72	.0196
63.60 " 74.20	73	.0189
74.20 " 84.80	74	.0182
84.80 or above	75	.0175

The above subject to 5% discount on bills paid in ten days.

15. Cornish & Kezar Falls Light & Power Co., Kezar Falls:—Rates: for all amounts up to 15,000 watts per month, 7 cents per K. W.; for all amounts of the second 15,000 watts per month, 6 cents per K. W.; for all amounts over 30,000 watts per month, 5 cents per K. W. Minimum charge $12 per year.

16. Cumberland County Power and Light Co., Bonnie Eagle:—This plant was placed in operation in 1911. It is one of the associated companies of the Consolidated Electric Light Company of Maine.

17. The Dixfield Light & Improvement Company, Dixfield:—Lighting: residences, 12 cents per K. W. hr. less 10%; municipal flat rate of $10 per year per lamp of 32 c. p. Power: 6 cents per K. W. hr. with 10% discount. Steam power only and night service only.

18. Dover and Foxcroft Light & Heat Co., Dover:—Lighting: residences, 15 cents per K. W. hr. with 10% discount if paid by the 10th of month; stores, 15 cents for first K. W. hr., 10 cents for second K. W. hr., 8 cents for third K. W. hr. and others. No discount. Street, $15 per 60 c. p. lamp per year. Power: 8 cents to 3 cents per K. W. hr. according to quantity.

19. Easton Electric Company, Easton:—10 cents per K. W. hr. is net rate. Current purchased from Maine & New Brunswick Electrical Power Co.

21. Fort Fairfield Light & Power Co., Fort Fairfield:—Lighting: 10 cents per K. W. hr. with 10% discount.

Power: motors ½ to 2 H. P., rate 9 cents per K. W. hr.; motors 5 to 10 H. P., rate 9 cents for first 50 K. W. hrs. and 5 cents per K. W. hr. for the next 100 K. W. hrs. and 3 cents for all above; motors 20 to 50 H. P., rate 2½ cents per K. W. hr. when using over 2000 K. W. hours per month.

23. Fryeburg Electric Light Co., Fryeburg:—Not developed to full capacity but can reasonably develop to 500 H. P. and would expect to furnish power in large quantities at $20 per H. P. per year, 12 hour service.

24. Greenville Light & Power Co., Greenville:—For current in large quantities the rate is $35 per H. P. per year.

25. Houlton Water Co., Houlton:—Power purchased from Maine & New Brunswick Electrical Power Co.

Lighting:

For first 50 K. W. hours per month.............	$0.10 per K. W. hr.
For next 50 K. W. hours per month.............	.09 per K. W. hr.
For next 100 K. W. hours per month.............	.08 per K. W. hr.
For next 100 K. W. hours per month.............	.07 per K. W. hr.
For next 200 K. W. hours per month.............	.06 per K. W. hr.
All above 500 K. W. hours	.05 per K. W. hr.

Subject to discount of 12½% for cash in 10 days.

Power:

Minimum monthly charge for first 5 H. P......	$1.00 per H. P. demand
Minimum monthly charge for next 5 up to 10..	.50 per H. P. demand
Minimum monthly charge for all over 10 H. P.	.25 per H. P. demand

It is understood that the demand shall be the capacity indicated on the motor.

For the first 50 K. W. hrs. consumption per mo.	$0.10	per K. W. H.
For the next 50 K. W. hrs. consumption per mo.	.06	per K. W. H.
For the next 100 K. W. hrs. consumption per mo.	.05	per K. W. H.
For the next 300 K. W. hrs. consumption per mo.	.04	per K. W. H.
For the next 500 K. W. hrs. consumption per mo.	.03½	per K. W. H.
For the next 1000 K. W. hrs. consumption per mo.	.03	per K. W. H.

For each additional 1,000 K. W. hours $ .025 per K. W. hour, subject to regular discount of 12½% for cash in 10 days.

26. Huse Spool and Bobbin Co., Kingfield:—Discount of 1 cent per K. W. hour if paid before 10th of month. Steam plant only.

28. Limerick Water & Electric Co., Limerick:—Average day load 160 H. P. Average night lighting load for one community 26 H. P. and for night lighting and power load for another district 60 H. P. Street lighting, flat rate on contract for one year $225.00 for 16 lights; residence, 10 cts. per K. W. hr.; power 1.3 cts. per K. W. hr.

30. Livermore Falls Light & Power Co., Livermore Falls:—Minimum charge of $1.00 per month. Power purchased from International Paper Co.

33. Mallison Power Co., Westbrook:—Power sold in large quantities at $15 per H. P. per year.

34. Mechanic Falls Electric Light Co., Mechanic Falls:—Lighting: residences, 9 cents per K. W. hr.; special large quantities, 5 cents per K. W. hr. Power: 7 cents adjusted to sliding discount scale on quantities used.

35. Merrill Springer Co., Bethel:—Steam power only.

37. Newport Light & Power Co., Newport:—Lighting: residences, 7½ cents per K. W. hr.; halls 10 cents; stores that open 6 nights per week, 7½ cents; stores that open only two nights per week, 10 cents per K. W. hr. Power: small motors 7½ cents per K. W. hr.; 10 to 25 H. P. motors 3 cents per K. W. hr.

38. Norway & Paris Street Ry., Norway:—Lighting: incandescent, 15 cents per K. W. hr.; minimum monthly charge 50 cents with no discount. Discounts monthly from 5 to 50%. Renewals of old lamps unbroken are made. Arc, 10 cents net per 1000 watts. Power: electric fans, 15 cents per K. W. hour.

Motor, bills	$ 0.50 to	$3.00	rate 10	cents per K. W. hr.
	3.00 to	5.00	rate 7	cents per K. W. hr.
	5.00 to	10.00	rate 6	cents per K. W. hr.
	10.00 to	30.00	rate 5	cents per K. W. hr.
	30.00 to	50.00	rate 4	cents per K. W. hr.
	50.00 to	100.00	rate 3½	cents per K. W. hr.
	100.00 to	200.00	rate 3	cents per K. W. hr.

39. Ossipee Valley Power Co., Sanford, 5 percent discount for prompt payment.

40. Penobscot Bay Electric Co., Belfast:—Lighting: Bucksport, 10 cents per K. W. hr.; Belfast and Stockton Springs, 12 cents per K. W. hr. with discount of 2 cents per K. W. hr. if paid before 10th of month.

Power:

Net prices for power meter readings.

Meter readings K. W. hours per month.	Rate per K. W. hour.	Meter readings K. W. hours per month.	Rate per K.W.hour.
0 to 650	$0.07	3,200 to 3,500	$0.034
650 to 850	.065	3,500 to 4,000	.033
850 to 1,050	.06	4,000 to 5,000	.032
1,050 to 1,200	.056	5,000 to 6,500	.031
1,200 to 1,400	.053	6,500 to 8,000	.03
1,400 to 1,600	.05	8,000 to 10,000	.029
1,600 to 1,800	.047	10,000 to 12,000	.028
1,800 to 2,000	.044	12,000 to 14,000	.027
2,000 to 2,200	.042	14,000 to 16,000	.026
2,200 to 2,400	.04	16,000 to 18,000	.025
2,400 to 2,800	.038	18,000 to 20,000	.024
2,800 to 3,200	.036	20,000 and above	.023

Minimum charge: for 10 H. P. in motors, and less, $1.50 per H. P. per month; for 11 H. P. in motors up to 24 H. P., $1.25 per H. P. per month; for 25 H. P. in motors, and more, $1.00 per H. P. per month.

41. Phillips Electric Light & Power Co., Phillips:—Lighting: meter, residences 10 cents per K. W. hr.; stores 12½ cents per K. W. hr.; halls and special, 15 cents per K. W. hr. Also flat rate 1½ cents per 16 c. p. lamp per night. No power load.

42. Portland Electric Co., Portland:—For details of rates see foot notes above under Consolidated Electric Light Co. of Maine.

43. Portland Lighting & Power Co., Portland:—For details of rates see foot notes above under Consolidated Electric Light Co. of Maine.

44. Portland Power & Development Co., Damariscotta:—Lighting in Damariscotta Mills, Newcastle and Damariscotta, 15 cents per K. W. hr. with 5% discount if paid in 10 days, and a minimum monthly charge of $1.00. Power in same towns, 5 cents per K. W. hr., no discount and minimum monthly charge based on size of motor. Boothbay Harbor is supplied from an 11,000 volt transmission line and current sold to lighting company on a maximum demand of 150 K. W.

Wiscasset is also supplied from the transmission line and power sold to lighting company at 5 cents per K. W. hour with minimum monthly charge of $50.00.

45. Presumpscot Electric Co., Westbrook:—Lighting: houses by meter, 10 cents per 1000 watts, minimum rate per month $1; by contract $6 per year for one 16 c. p. lamp; stores, 5 cents per 1000 watts. Minimum rate per month $1.

MOTOR RATES:

H. P.	Rate per annum per E. H. P. as indicated by meter.	Minimum monthly charge for service.
3	$60 00	$5 00
5	55 00	7 00
7½	50 00	10 00
10	45 00	12 50
15	40 00	15 00
25	35 00	25 00
50	30 00	50 00
100	25 00	100 00

Special rates for 24 hour service. For very large power users there is a special rate of $0.00725 per 1000 Watts. A discount is allowed of 20% on bills paid before the 10th of the month.

46. Putnam, H. H., Danforth:—Flat rate; lighting residences, $2.50 per month; lighting stores 1 cent a light. $2.00 per year for power from the Danforth Water Co.

47. Readfield Light & Power Co., Readfield:—Lighting: residences, 10 cents per K. W. hr., 5% discount; special for Kents Hill College, 400 lights, 7 cents per K. W. hr.; detached lamps for barns, etc., flat rate 25 cents per lamp per month; street lamps 32 c. p. $15 per year per lamp.

48. Rockland, Thomaston & Camden Street Ry., Rockland:—

LIGHTING.

K. W. per month.	Rate per K. W.	K. W. per month.	Rate per K. W.
1 to 5	$0.15	601 to 700	$0.12
6 to 32	.15	701 to 800	.115
33 to 100	.145	801 to 900	.11
101 to 300	.14	901 to 1,000	.105
301 to 400	.135	1,001 to 1,200	.10
401 to 500	.13	1,201 to 1,600	.09
501 to 600	.125		

Minimum charge $ .75 per month. One-half cent per K. W. discount on 6 to 32 K. W. One cent per K. W., discount on 33 or more K. W. for prompt payment, if paid within 10 days of date of bill. Summer residences 20 cents per K. W. with 5% discount if paid within 10 days of date of bill. Commercial arc lighting 10 cents per K. W. Minimum charge $2.00 per month.

POWER.

K. W. per month.	Rate per K. W.	K. W. per month.	Rate per K. W.
1 to 20	$0.07	876 to 1,050	$0.05
21 to 50	.07	1,051 to 1,225	.048
51 to 100	.065	1,226 to 1,400	.046
101 to 175	.06	1,401 to 1,575	.044
176 to 350	.058	1,576 to 1,750	.042
351 to 525	.056	1,751 to 2,625	.0414
526 to 700	.054	2,626 to 3,500	.04
701 to 875	.052		

Minimum charge $1.25 per month. One cent per K. W. discount on 21 or more K. W. for prompt payment, if paid within 10 days of date of bill.

49. Rumford Falls Light & Power Co., Rumford:—Electric current purchased from Rumford Falls Power Co. Lights: 10 cents per 1000 Watts. On bills of $20.00 or less, per month, a discount of 10% will be allowed if paid within 15 days from date of bill. On bills over $20.00 and not exceeding $40.00 per month, 20% discount on the excess above $20.00 if paid within 15 days from date of bill. On bills over $40.00 per month 30% discount on the excess above $40.00 if paid within 15 days from date of bill. Minimum rate $1.00 per month. Lights for period less than one year, 15 cents per 1000 Watts. Minimum rate $1.50 per month. Plain incandescent lamp renewals, carbon class free, but remain the property of this company.

Power: Rates 7 cents to 1 cent according to hours use and load factor.

50. Rumford Falls Power Co., Rumford:—Lighting: 10 cents per K. W. hr. with 10% discount; cooking and off peak batteries charging 3 cents. Power: motors 1 to 100 H. P. rate 1 cent to 7 cents per K. W. hr. according to demand and load factor. Special rates for large consumers of power.

51. St. Croix Gas Light Co., Calais:—Lighting: residences, 20 cents for first 5 Kilowatts, 15 cents for second 5 Kilowatts; all over, 10 cents per Kilowatt per month. Flat rate, 1 cent per night per 16 c. p. lamp. Commercial, 20 cents per Kilowatt and flat rate 2 cents per night per 16 c. p. lamp.

Includes St. Stephen Electric Light Co.

54. Van Buren Light & Power Co., Van Buren:—Current bought at sub-station switchboard from Maine and New Brunswick Electric Power Co. Ltd.

56. Washburn Electric Co., Washburn:—Power purchased from Maine and New Brunswick Electrical Power Co. Lighting: 12 cents per K. W. hr. with 5% discount. Power: 6 cents per K. W. hour flat.

58. Yarmouth Manufacturing Co., Yarmouth:—Lighting: Metered service for residence and commercial, 10 cents per K. W. hr.; street lights, town contract, $12 per year for 25 c. p. lamps, moonlight schedule, all night service. Power: rate 3 cents per K. W. hr. up to 50 H. P. motors and 2 cents for all above.

59. York Light & Heat Co., Kennebunkport:—Yearly contracts. Lighting: 15 cents per K. W. hr. with discount of 2 cents per K. W. hr. if paid before 15th of month. Minimum monthly charge $1.00. Power: rates to purchasers of not less than 3 horsepower or to users of at least 50 K. W. hrs. per month.

POWER.

Kilowatt hours per month.	Rate per K. W. hr.	Kilowatt hours per month.	Rate per K. W. hr.
50	$0.10	400 to 600	$0.075
50 to 100	.095	600 to 800	.07
100 to 200	.09	800 to 1,000	.065
200 to 300	.085	1,000 to 1,250	.06
300 to 400	.08		

Discounts on power rates, 1 cent per K. W. hr. to all customers. Current used for power less than 50 K. W. per month will be charged for at lighting rate of 15 cents per K. W. hr. with regular lighting discount for prompt payment. Minimum monthly charge $1.50.

Summer season rates: for 6 lights or more, 25 cents per Kilowatt hour. Discount: provided bill is paid at our office on or before the 15th day of the month, 3 cents per K. W. hr. to all customers; 5 cents per K. W. to all customers whose monthly bills are $25; 7 cents per K. W. to all customers whose monthly bills are $50; 10 cents per K. W. hour to all customers whose monthly bills are $75 and over. Minimum monthly service charge $3.00. Flat rates for 1 to 5 16 c. p. lights for summer season, 2½ months; for stores, shops, offices, $4.50 per light, 16 c. p.; for dwelling houses, $3.00 per light, 16 c. p.; additional time over 2½ months, pro rata price. Discount of 10% provided bill is paid at our office on or before the 15th of the month.

Summer season rates: power, only to purchasers of not less than 3 H. P., or to users of at least 50 K. W. hrs. in each month, usable in one or more motors or heating devices.

POWER.

Kilowatt hours per month.	Rate per K. W. hr.	Kilowatt hours per month.	Rate per K. W. hr.
50	$ .20	300 to 400	$ .16
50 to 100	.19	400 to 600	.15
100 to 200	.18	600 to 800	.14
200 to 300	.17	800 to 1,000	.13

Discount: provided bill is paid at our office on or before the 15th day of the month, 2 cents per Kilowatt to all customers. Electric current used for power, less than 50 Kilowatts per month, will be charged for at the lighting rate of 25 cents per Kilowatt with regular lighting discount for prompt payment. No discount allowed after the 15th day of the month. Minimum monthly service charge $5.00.

The foregoing table shows a marked diversity in rates for different localities. This may be due in part to management and might be somewhat equalized through regulation by a public utilities commission by means of the introduction of a uniform system of accounting. However, rates may and should vary between some localities and some of the reasons for such variations may be noted as follows:

One company may be a pure hydro-electric development serving one community, while in an adjoining town, the prime mover may be a steam engine. Even in two towns the price of coal may vary greatly owing to more favorable transportation facilities for one, or to differences in freight rates. Some centers may receive their current over long transmission lines while others have the water power close by. One plant may be subject to high tax rates on account of being located in the center of the business district of a populous city. Some plants have old-fashioned machinery, poorly arranged for economical management and requiring a large operating force. The load factor may be different, that is, the ratio of the average load in kilowatts for which the company receives payment to the maximum or peak load which the company supplies at times, and for which the plant is designed. Some plants have only night service while others have day power demands causing the load factor to more nearly approach 100 percent for 24 hour use. The distribution system of one community may be much more simple and a great deal less expensive to install and maintain for practically the same amount of power used and sold.

Through the operation of a public utilities commission or of a commission with similar powers, such facts as above outlined would be made public and if the rates charged are shown to be equitable, dissatisfaction that may now exist, should be allayed. As a matter of fact, the cost of rendering service is seldom the same in communities which, on a casual consideration, seem to be comparable.

Steam Power. (*a*)

In order to institute a comparison between the cost of electric power as has just been set forth and the cost of power generated by steam, the following tables have been compiled by the Canadian Hyro-Electric Power Commission after a careful study of data available in technical journals and also from data collected by the Ontario Commission's engineers in various towns within the district under consideration. The capital costs have been compiled from information supplied by various makers of engines and other machinery. The tables represent average working conditions and assume a high-class installation.

Steam Power Plants.

Showing Capital Costs of Plants Installed and Annual Costs of Power per Brake Horse-power.

Size of plant, horse-power.	*Capital cost of plant per horse-power installed.	Annual cost of 10-hour power per brake, horse-power.	Annual cost of 24-hour power per brake, horse-power.
Class 1—Engines: Simple, slide-valve, non-condensing. Boilers: return tubular.			
10	$106 00	$91 16	$180 76
20	93 00	76 31	151 48
30	83 70	66 46	131 68
40	78 25	59 49	117 74
50	74 00	53 95	106 46
Class II.—Engines: Simple, Corliss, non-condensing. Boilers: Return tubular.			
30	$105 70	$61 14	$117 70
40	96 35	55 50	107 10
50	90 00	50 70	97 73
60	86 70	47 42	91 34
80	77 50	43 86	85 41
100	69 60	40 55	79 19
Class III.—Engines: Compound, Corliss, condensing. Boilers: Return tubular with reserve capacity.			
100	$91 40	$33 18	$60 05
150	77 70	29 83	54 63
200	70 10	28 14	51 72
300	63 90	26 27	48 83
400	59 55	24 84	46 12
500	55 25	23 73	44 21
750	53 50	23 56	44 02
1,000	51 00	23 26	43 71
Class IV.—Engines: Compound, Corliss, condensing. Boilers: Water tube with reserve capacity.			
300	$73 20	$25 77	$46 32
400	67 50	24 18	43 61
500	63 40	23 19	42 03
750	59 70	22 88	41 56
1,000	56 80	22 47	41 11

Note.—Annual costs include interest at 5 per cent., depreciation and repairs on plant, oil and waste, labor and fuel (coal at $4.00 per ton). Brake horse-power is the mechanical power at engine shaft.

* Includes engines, boilers, etc., installed and buildings.

a Fifth Report Hydro-Electric Power Commission of Ontario, p. 28.

It will be noted that for a consumer requiring a large installation operating for ten hours only, there appears to be little advantage to be derived from the use of transmitted electric power, provided the power is not to be distributed throughout a consumer's buildings by a complicated system of shafting, belts, etc. But in the majority of cases this condition obtains, and herein lies one of the specific advantages of electric power. Motors can be installed on each floor of the factory, or even on each machine, but with little loss in efficiency, and only such motors as are required to drive the machinery in use from time to time need be operated. In many cases due to this fact, the total electric power consumption of a large factory would be reduced from 25 per cent to 50 per cent below that which is required under steam operation, working from a central station. Again, where electric power is available throughout the 24 hours many industries will work night and day, thereby effecting a great economy.

Effect of the Cost of Steam Power of a Variation in the Price of Coal of One-half Dollar per Ton (a).

Size of plant. H. P.		10-hour.	24-hour.
10		\$6 14	\$13 47
20	Simple slide-valve engine...	5 25	11 56
30		4 71	10 35
40		3 56	7 84
50	Simple automatic non-condensing................	3 37	7 41
60		3 26	7 16
80		3 15	6 97
100		3 12	6 87
150		1 75	3 85
200	Compound condensing.....	1 69	3 71
300		1 62	3 60
400		1 56	3 44
500	Compound condensing; water-tube boilers.......	1 39	3 05
750		1 39	3 05
1,000		1 39	3 05

a Fifth Report, Hydro-Electric Power Commission of Ontario, p. 31.

It would seem that the cost of developing a horse-power by steam should be known quite closely but there is a wide divergence as indicated in the table below.

Annual Cost of a 300 H. P. Steam Plant (b).

AUTHORITY.	Annual cost of 10-hour power per H. P.
William O. Webber	$37 50
Ontario Commission	26 27
A. F. Nagle	43 57
Wm. E. Snow	25 00
Average	$34 08

Coal at $3.00 per ton.

(*b*) R. C. Beardsley, Electrical Review, Vol. 57, Page 1238.

Water power developments have recently been criticised on account of their excessive cost. The McCall Ferry development has often been cited in this connection, but competent engineers have stated that the dam as built, cost $250,000 more than a modern structure should and that a construction bridge of reinforced concrete costing some $100,000 was built when a steel structure would have answered, and the salvage would have been of some value. The average cost of development of the plants given in the table on page 54 is about $73 per net horsepower at the turbine shaft.

Generally a water power plant is developed to a point that the cost will not exceed a development from a fuel plant. Speaking in a general way, the average economic limit of development is about $150 per horsepower. With a high cost of fuel, one authority states that even $300 per horsepower would not be an excessive price to pay for a water right. Only a year or so ago 80% efficiency in a water turbine was considered good but 90% efficiency can now be reached. Formerly water wheels had little overload capacity as compared to 50 percent overload for the usual steam engine and a greater percentage for the steam turbine. Very recently manufacturers have turned their attention to part load efficiency of water wheels and now the average operation of the modern water turbine is three-fourths gate opening allowing a 33 percent overload capacity. With the average water power development to get a 50 percent peak overload capacity, the additional turbines, flumes and penstocks necessary, add but about $3.25 per horsepower to the annual operating charges. The average cost of operating a 300 horsepower steam plant is $34 per horsepower as above, with coal costing $3.00 per ton. For each dollar that coal costs more than $3.00 the operation of the steam plant will be increased $3.20 per horsepower per year for ten-hour service.

One of the greatest advantages in a water power plant is in cost of operation. The subjoined table indicates the fixed charges and shows that in percentages, the cost of operation of the average steam plant is about double that of the water plant.

Operation Fixed Charges in Percent (a).

ITEM.	Steam plant.	Water power.
Interest	6	6
Insurance	0.5	0
Taxes	2	1
Maintenance	5	1
Obsolescence	5	1.5
Total	18.5	9.5

a R. C. Beardsley, Electrical Review, Vol. 57, page 1240.

SURFACE WATER SUPPLY.

In the words of John R. Freeman, consulting engineer of the New York Water Supply Commission:

Accurate measurements of the stream flow or run-off and of the precipitation to determine the water yield of a given territory are the indispensable preliminaries to all study of regulation by water storage and constitute the foundation of the entire structure of computations and estimates which determine in every case to what extent the construction of reservoirs can be justified on engineering and economic grounds.

Stream flow data for Maine, considered for the State as a whole, are as lengthy and as widely distributed as for any other section of the country. There are one or two longer records, as for instance at certain stations in Massachusetts and New York, but for a large area, our records are fairly complete. There is given on page 23 a list of gaging stations maintained in this State and the lengths of records in each case.

METHODS OF MEASUREMENT AND COMPUTATION.

There are three distinct methods of determining the flow of open-channel streams: (1) By measurements of slope and cross-section and the use of Kutter's and other formulas; (2) by means of a weir or dam; (3) by measurements of the velocity of the current and the area of the cross-section.

First: This method has its use especially in flood estimates. It is seldom or never used, however, for continuous records.

Second: Some of the stations in the State are of this type, especially those maintained by a number of water power companies. The records for the flow over the dam proper have generally to be supplemented by the discharge through water wheels and turbines. A gaging station at a dam has the general advantage of continuity of record through the periods of ice and floods, and the disadvantage of uncertainty of coefficients to be used in the weir formula and of complications in the diversion and use of the water. The determination of discharge over the different types of weirs and dams is treated fully in "Weir experiments, coefficients and formulas" (Water Supply Paper 200) and in the various text books on hydraulics. "Turbine water-wheel tests and power tables" (Water Supply Paper 180) treats of the discharge through turbines when used as meters.

Third: Most of the measurements of the U. S. Geological Survey are done by this method. Such stations consist essentially of a gage for determining in feet and tenths the daily fluctuations of stage of the river and some structure or apparatus from which discharge measurements are made, usually a bridge or cable. The discharge of a stream, usually expressed as cubic feet per second or second-feet, is the product of the area of cross-section at any point in cubic feet, times the mean velocity of the water in feet per second, at the same section.

In making the measurements, an arbitrary number of points are laid off on a line perpendicular to the thread of the stream. The points at which the velocity and depth are observed are known as measuring points, and are usually fixed at regular intervals, varying from 2 to 20 feet, depending on the size and condition of the stream. For each strip of the river between measuring points, the area and velocity is determined, the latter generally by current meter. The corresponding discharge for each strip is then computed. By this method conditions existing in one part of the stream are not extended to parts where they do not apply.

Discharge measurements should be well distributed over the fluctuations of the river where possible, from the lowest to the highest gage heights.

Rating tables are computed for each station, giving for each tenth of a foot on the gage record, the corresponding discharge in cubic feet per second or second-feet. The rating tables are then applied to the daily gage heights, as sent in by the river observers, to obtain the daily discharge and from these applications the tables of monthly discharge and run-off are computed.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the run-off or discharge—is expressed in various terms, each of which has become associated with a certain class of work.

"Second-foot" is an abbreviation for cubic foot per second and is the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at the rate of 1 foot per second. It is generally used as a fundamental unit from which all others are computed.

"Gallons per minute" is generally used in connection with pumping and city water supply.

"Second feet per square mile," is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area. It is the unit most convenient to use when comparing run-off from different basins, and when using the measured run-off from one basin for computations of the discharge from another basin where stream measurements are not available.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

"Cubic feet" is the unit generally used in the east to express the capacity of reservoirs.

EXPLANATION OF RECORDS.

In the yearly reports of the Water Resources Branch of the U. S. Geological Survey on surface water supply, the following data are given, as far as available, for each regular gaging station:

1. Description of station.
2. List of discharge measurements.
3. Gage-height table.
4. Rating table.
5. Table of monthly and yearly discharges and run-off.

The descriptions of stations give such general information about the locality and equipment as would enable the reader to find and use the station, and they also give, as far as possible, a complete history of all the changes that have occurred since the establishment of the station that would be factors in using the data collected.

The discharge-measurement table gives the results of the discharge measurements made during the year, including the date, name of the hydrographer, width and area of cross section, gage height, and discharge in second-feet.

The table of daily gage heights gives the daily fluctuations of the surface of the river as found from the mean of the gage readings taken each day. The gage height given in the table represents the elevation of the surface of the water above the zero of the gage. At most stations the gage is read in the morning and in the evening.

The discharge measurements and gage heights are the base data from which the other tables are computed. In cases of extensive development it is expected that engineers will use these original data in making their calculations, as the computations made by the Survey are based on the data available at the time they are made and should be reviewed and, if necessary, revised when additional data are available.

The rating table gives the discharge in second-feet corresponding to various stages of the river as given by the gage heights. It is published to enable engineers to determine the daily discharge in case this information is desired.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gage height was highest, and it is the flow as given in the rating table for that mean gage height. As the gage height is the mean for the day, there might have been short periods when the water was higher and the corresponding discharge larger than given in this column. Likewise in the column of "Minimum" the quantity given is the mean flow for the day when the mean gage height was lowest. The column headed "Mean" is the average flow for each second during the month. Upon this mean, the computations for the remaining columns, the second-feet per square mile, and run-off in inches, defined above, are based.

There was printed in the 1st Annual Report in condensed form as run-off in second-feet and depth in inches on the drainage area, all the earlier data available for the several gaging stations in the State. There are given in the following pages, under the separate river basins, the tables of monthly discharge as described above for 1910 and 1911. The data for 1910 as given in the 1st Annual Report were preliminary estimates and in some cases have been revised on basis of later gagings. The final computations as accepted by the U. S. Geological Survey for both 1910 and 1911 are given in this report.

ENGINEERING MASS CURVE STUDIES.

In order to report on a comprehensive plan of reservoir storage for any river basin, it is necessary to make detailed studies of the run-off of the streams in that basin and for this purpose, continuous series of stream gagings and determination of the daily discharge of the rivers are necessary. When such river discharge data are available the best method for such study is by means of mass curves. The Rippl method is described in a number of the Water Supply Papers of the U. S. Geological Survey (*a*), and is especially applicable in certain special cases.

Another method of mass curve computation is somewhat simpler and is described as follows:—Add the totals of the monthly yields for the entire length of gaging record for the river station under consideration. See storage computations for Kennebec River at The Forks. It is convenient to use as the unit, depth in inches on the drainage area. Then plot the successive sums on cross section paper using months as abscissae and summation of monthly depth in inches as ordinates. The result will be an irregular line or the mass curve. (See Plate IV). Any desired rate of draft may then be assumed and its successive sums plotted to the same scale, and if a uniform rate, this draft curve forms a straight inclined line. If a different rate is assumed for certain months, say an excess draft during the log driving season, the draft line will be somewhat irregular. If the draft line is made to start from some summit on the mass curve, the divergence of the two curves represents the amount of water in inches on the watershed required to keep up the assumed draft. Knowing the drainage area at the point of study, the storage required in billion cubic feet can be readily found to maintain the assumed draft. Furthermore, whenever the draft line again intercepts the mass

a U. S. Geological Survey Water Supply Paper No. 198, Water Resources of Kennebec River Basin, page 150. Water Supply Paper No. 279, Water Resources of the Penobscot River Basin.

curve, the period of time through which storage is necessary can be found by the difference of time between the date of the summit of the mass curve from which the draft line starts and the date when it again intercepts the mass curve.

A number of gaging stations in the State are located below large reservoir systems and the observed records of discharge do not represent the natural flow. In a number of cases however, continuous records are kept of the levels of the various reservoirs and it is then possible to compute approximately what the natural flow would have been wtihout artificial storage, provided the areas of the reservoirs are known for different heights. Such computations have been made for the Millinocket and West Enfield stations on the Penobscot River based on the levels of the reservoir system on the West Branch; for The Forks and Waterville stations on the Kennebec, based on the gage height records of Moosehead Lake; for the Errol and Rumford Falls stations on the Androscoggin River, based on the gage height records of Umbagog, Upper and Lower Richardson, and Mooselucmaguntic lakes.

The mass curve tables are based on the computed natural flow whenever the gaging records can be so reduced. When computing draft curves for the regulation of existing reservoirs, it is not necessary to consider the question of evaporation as that has already been taken care of in the tables of actual discharge.

After the mass curves and draft lines have been plotted, the next step is the construction of the "condition of reservoir" or depletion diagrams. For each month the difference between the draft line and mass curve gives the depletion in inches depth on the watershed which is reduced to billion cubic feet when the drainage area is known. These monthly depletions in cubic feet are plotted, using time intervals as abscissae and billion cubic feet as ordinates. See fig. 1.

Mass curves and "condition of reservoir" diagrams are being constructed for all gaging stations in the State, but are not sufficiently completed for publication in this report. The assumed draft lines depend or should depend to a certain extent on the present and the possible storage capacities of the reservoirs in the several river basins. What is being done in the investigations of reservoir storage is described in the next section.

LAKE STORAGE.

The final plan for the development and regulation of a reservoir system should be based on accurate and detailed topographic maps of the several reservoir sites similar to the maps described on page 19, which this department is issuing from time to time as the surveys are completed. Such maps should show the high and low water lines, a number of contours above high water up to the limits of practical storage and a number of sub-contour lines or down to the limits to which the lakes may be drawn. From such maps, accurate determinations of the storage capacities for varying heights can be determined. It will be many years, however, before such detailed maps of all the lakes and ponds of the State can be prepared.

Meanwhile, this department has undertaken the planimeter measurements of all the lakes and ponds in the State as can be found on the best maps available. For this purpose the following maps are used: the special lake maps as issued by this department; the regular topographic sheets of the U. S. Geological Survey; the township plans in the office of the State Assessors; many private recent reservoir and township maps on file in this office; and in a few cases county atlases where more accurate maps were not available.

The lake and pond areas as thus determined are given in the following pages under appropriate river basins. There is also given in the same tables an estimate for each lake of the amount of present storage both in feet and in cubic feet and also of the possible storage in feet and cubic feet. For many of the sites more or less accurate information on this subject is available, that is, the amounts in cubic feet of both present and possible storage. Most of these reliable data are given in the 1st Annual Report under the subject headings of lake storage. For other lakes and ponds, reports were at hand on the storage in feet, such as heights of dams, etc. In a large number of cases, however, no such information was available and an estimate of height was made and the corresponding capacity in cubic feet computed. In the capacity tables in the following pages, wherever the heights appear as 5 feet or 10 feet it is in almost all cases the assumed or estimated height of storage. For instance, under present storage, when it was known that there was a dam at the outlet of a pond and no other information was available, the height was put as 5 feet. The height of possible storage depends on a number of factors; as to whether the drainage area above is sufficient to contribute the amount of water to fill the reservoir to that height; whether the topography at the dam site is such that it will be feasible financially to build the dam; or whether settlements around the shores of the lake will permit raising to the height as contemplated. In the various capacity tables, these detailed studies have not been made on the 5 and 10-foot assumed heights. After scanning the base map of the State, compiled in this office, if it was thought the drainage area was small or if any local conditions were known to exist, as settlements around the lake in question, the smaller height, that is, 5 feet, was adopted. In other cases the 10-foot height was used. It is believed that this 10-foot height of possible storage is a fairly conservative figure to adopt for all the lakes and ponds in the State where exact information as to storage capacities was not available. It was found necessary to make some such kind of an estimate of total storage for various river basins in connection with the mass curve studies of run-off, both leading up to an approximate estimate of the total capabilities for reservoir storage in the entire State.

ST. JOHN DRAINAGE BASIN.

Description.

St. John River drains the largest basin between the St. Lawrence and Susquehanna rivers. Its extreme headwaters lie in the mountainous region between Maine and Canada, adjacent to those of the Penobscot. From the junction of the northwest and the southwest branches, where the river first takes its name, to its junction with St. Francis River, a distance of 90 miles, its course is in general northeastward and lies wholly in Maine, although a portion of the tributary drainage area lies wholly in Canada. In this distance it receives Allagash River, its second largest tributary. From its junction with the St. Francis the St. John flows eastward, forming the northern boundary of Maine for 70 miles and receiving in this stretch two important tributaries—Fish River, from the south, at Fort Kent, and Madawaska River, from the north, at Madawaska. At the point where the St. John leaves the state line its drainage area measures 8200 square miles. Beyond this point it flows southward and receives the waters of Aroostook, Presque Isle, and Meduxnekeag rivers, the basins of which are almost entirely in Maine. From source to mouth its length is about 450 miles, and its total drainage area measures about 26,000 square miles.

In the eastern or lower portion of the basin the country is almost level near the river, but at a distance from the stream it becomes undulating and moderately hilly, finally subsiding and merging into the flat country bordering Aroostook River. Above the mouths of St. Francis and Allagash rivers the aspect of the basin is diversified by highlands.

The basin of the St. John is higher than that of any other river in the State, but as its elevation is quite uniform, the fall of the stream and the possibilities for the development of water power are less than on the other great rivers. Allagash River, which drains 1240 square miles of entirely wild and forest country, has considerable fall and affords excellent storage facilities, all unutilized.

The area as a whole is well forested. Large tracts have never been touched by the ax, and other portions have been lumbered for pine only. Probably 90 per cent of the whole basin tributary to the St. John at the eastern boundary of Maine is in forest.

The prevailing rocks in the eastern part of the area are limestone and slate, with patches of sandstone, coarse rock, and granite. Clays and slates are found over about 75 per cent of the total area.

The ponds and lakes in the St. John basin have an aggregate area of 227 square miles, the largest of these lakes being tributary to Allagash and Fish rivers. On some of the lakes rough timber crib dams are used to store water for log driving, but no attempt is made to store water after the driving season is over. Previous to 1845 a canal was cut from Telos Lake, in the Allagash basin, to Webster Lake, in the Penobscot basin, and a dam was constructed between Chamberlain and Eagle lakes. In this way Chamberlain Lake, with its drainage area of 270 square miles, was rendered in part tributary to the Penobscot. This diversion continues at the present time. Its general use is to supply water to the Penobscot during the log-driving season. After the gates at the dams are opened more water flows toward the St. John, as the gate sills are 0.06 foot lower than those at Telos Lake.

DRAINAGE.

The drainage areas of St. John River at a number of points, and various of the more important tributaries have been measured on the base map of the State as compiled in the office of the Commission. The areas in Canada were measured on certain official Canadian maps on file in the office. The following table is the most complete table of drainage areas ever published for this basin. The figures do not include Chamberlain Lake drainage as the area of that basin is included in the Penobscot drainage figures.

Drainage Areas, St. John River Basin.

(Not include Chamberlain Lake drainage)

	square miles.
St. John River, South Branch—outlet Baker Pond	155
St. John River, South Branch above junction South West Branch	335
St. John River, South East Branch—mouth	82
St. John River, Boundary Branch—mouth	106
St. John River, South West Branch—mouth	290
St. John River, South Branch below junction of South West Branch	625
St. John River, South Branch—mouth	700
Mataguam River—mouth	266
St. John River, North Branch above mouth Mataguam River	232
St. John River, North Branch below mouth Mataguam River	498
St. John River, North Branch—mouth	526
St. John River, below junction North and South branches	1226
St. John River, at Seven Islands	1412
St. John River, above mouth Big Black River	1503
Depot Stream, outlet Depot Lake	41
Depot Stream, mouth	109
Rateau River above mouth Depot Stream	214
Big Black River below mouth Depot Stream	323
Big Black River above mouth Shields Brook	356
Shields Brook—mouth	141
Big Black River below mouth Shields Brook	497
Four Mile Branch—mouth	56
Big Black River—mouth	627
St. John River below mouth Big Black River	2130
St. John River above mouth Chimenticook Stream	2185
Chimenticook Stream—mouth	145
St. John River below mouth Chimenticook Stream	2330
Tulandic Stream—mouth	74
St. John River below mouth Tulandic Stream	2410
St. John River above mouth Little Black River	2495
Little Black River—mouth	312
St. John River below mouth Little Black River	2810
St. John River above mouth Allagash River	2820
Allagash River—outlet Heron or Eagle Lake (not include Chamberlain Lake)	161
Allagash River—outlet Churchill Lake	281
Chemquassabamticook Stream, outlet Chemquassabamticook Lake	55
Chemquassabamticook Stream, mouth	223
Allagash River—outlet Long Pond	659
Allagash River—outlet Round Pond	740
Allagash River above mouth Musquacook Stream	774
Musquacook Stream—outlet 1st Musquacook Lake	82
Musquacook Stream—mouth	164
Allagash River below mouth Musquacook Stream	938

Allagash River above mouth Big Brook	1094
Big Brook, mouth	78
Allagash River below mouth Big Brook	1172
Allagash River, mouth	1240
St. John River below mouth Allagash River	4060
St. John River above mouth St. Francis River	4170
St. Francis River—outlet Pohemegamook Lake	120
Blue River, mouth	197
St. Francis River, mouth	560
St. John River below mouth St. Francis River	4730
St. John River at Ft. Kent above Fish River	4880
Fish River at outlet Fish Lake	141
Fish River at outlet Portage Lake	241
Fish River at outlet St. Froid Lake	426
Fish River at outlet Eagle Lake	763
Fish River above mouth Wallagrass Stream	791
Wallagrass Stream at mouth	69
Fish River below mouth Wallagrass Stream	860
Fish River at mouth	890
St. John River below mouth Fish River	5770
St. John River above mouth Madawaska River	6080
Madawaska River, outlet Lake Temiscouata	920
Madawaska River at Ste. Rose du Degele, Quebec	958
Madawaska River at mouth	1080
St. John River below mouth Madawaska River	7160
St. John River at Van Buren	7960
St. John River at eastern boundary of State	8200
St. John River at Grand Falls, N. B.	8220
St. John River above mouth of Aroostook River	8800
Aroostook River above mouth Mooseluck Stream	229
Mooseluck Stream at mouth	179
Aroostook River below mouth Mooseluck Stream	408
Aroostook River above mouth Umculcus Stream	498
Umculcus Stream, mouth	69
Aroostook River below mouth Umculcus Stream	567
Aroostook River above mouth St. Croix Stream	656
St. Croix Stream, mouth	221
Aroostook River below St. Croix stream	877
Aroostook River above mouth Big Machias River	1006
Big Machias River, outlet Big Machias Lake	146
Big Machias River, mouth	313
Aroostook River, below mouth Big Machias River	1319
Little Machias Stream, mouth	70
Aroostook River above mouth Beaver Brook	1434
Beaver Brook, mouth	83
Aroostook River below mouth Beaver Brook	1517
Aroostook River above mouth Salmon Brook	1563

ERRATA

Subsequent to the printing of pages 90 and 91 a more accurate map of the drainage basin in Canada of lower St. John River was made available, and the following changes in drainage areas are noted:

Page 90	Square miles.
St. John River at Van Buren	8270
St. John River at eastern boundery of State	8510
St. John River at Grand Falls, N. B.	8530
St. John River above mouth Aroostook River	9110
Page 91	
St. John River below mouth Aroostook River	11,400

Salmon Brook, mouth	53
Aroostook River below mouth Salmon Brook	1616
Aroostook River above mouth Presque Isle Stream	1668
Presque Isle Stream, mouth	165
Aroostook River below mouth Presque Isle Stream	1833
Aroostook River at Caribou	1931
Aroostook River above mouth Little Madawaska River	1957
Little Madawaska River, outlet Madawaska Lake	92
Little Madawaska River, mouth	256
Aroostook River below mouth Little Madawaska River	2213
Aroostook River at Ft. Fairfield	2250
Aroostook River at mouth	2290
St. John River below mouth Aroostook River	11,100
Tobique River, mouth	1700
Presque Isle River, mouth	217
Meduxnekeag River, above mouth South Branch	106
Meduxnekeag River, South Branch, mouth	59
Meduxnekeag River, below mouth South Branch	165
Meduxnekeag River, above mouth North Branch	265
Meduxnekeag River, North Branch, mouth	185
Meduxnekeag River, below mouth North Branch	450
Meduxnekeag River, mouth	497

Lake Storage.

Systematic measurements of the water surface areas of the lakes and ponds in the State have been made in the office of the Commission from the best maps available, as described in detail on page 85. For the St. John basin, the series of maps in the office of the State Assessors (scale 2 inches = 1 mile) were used almost exclusively and they covered nearly all the townships in the basin. In a few of the older incorporated towns the county atlas was used.

An estimate of the possible amount of storage in each basin was made. No information was at hand on the present storage in any of the lakes and this feature, as found for the other basins, was omitted for the St. John basin. Furthermore, little information was at hand as to the height in feet to which the lakes or ponds could be raised and a uniform height of 10 feet was used. Where the height is different from 10 feet, it signifies that information was available of the amount of possible storage.

Storage in St. John River Basin.

CONNECTED WITH UPPER ST. JOHN RIVER.

NAME.	Location.	Surface area sq. miles.	Possible Storage	
			Feet.	Cubic Feet.
	W. E. L. S.			
Baker Lake	T 7, R 17	1.45	10	404,237,000
Beau Lake	Ts 11, R 17	0.05	10	13,939,000
Burnt Land Pond	T 11 & 12, R 17	0.08	10	22,303,000
Charlie Lake	T 14, R 15	0.37	10	103,150,000
Chemquasabamticook Lake	Ts 9 & 10, R 15	8.52	10	2,375,240,000
Clayton Pond	T 6, R 17	0.09	10	25,091,000
Dead Water	T 15, R 14	0.27	10	75,272,000
Depot Lake	T 13, R 16	1.27	10	354,055,000
Desolation Pond	T 8, R 16	0.30	10	83,635,000
Francis Lake	T 8, R 16	0.35	10	97,574,000
Lac de C'est	T 17, R 14 & Canada	2.18	10	607,749,000
Mosquito Pond	T 12, R 17	0.20	10	55,757,000
Nine Mile Pond	T 13, R 16	0.14	10	39,030,000
Pond	T 17, R 12	0.22	10	61,333,000
"	Ts 16, R 13 & 14	0.04	10	11,151,000
"	T 8, R 15	0.18	10	50,181,000
"	T 12, R 15	0.03	10	8,364,000
"	T 12, R 13	0.15	10	41,817,000
"	T 13, R 15	0.09	10	25,091,000
"	T 14, R 15	0.09	10	25,091,000
"	Ts 13, R 15 & 16	0.08	10	22,303,000
"	T 5, R 16	0.06	10	16,727,000
"	T 13, R 16	0.10	10	27,878,000
"	T 14, R 16	0.02	10	5,576,000
"	T 4, R 17	0.02	10	5,576,000
"	T 5, R 17	0.04	10	11,151,000
"	T 4, R 17	0.01	10	2,788,000
"	T 9, R 17	0.06	10	16,727,000
"	T 12, R 17	0.25	10	69,696,000
"	T 12, R 17	0.21	10	58,545,000
"	T 8, R 19	0.04	10	11,151,000
"	T 8, R 19	0.08	10	22,303,000
"	T 8, R 19	0.07	10	19,515,000
"	T 5, R 20	0.14	10	39,030,000
St. John Pond	Ts 5 & 6, R 17	0.96	10	267,633,000
Summit Pond	T 4, R 17	0.17	10	47,393,000
Sweeney Brook Bog	T 6, R 17	0.15	10	41,817,000
Turner Pond	T 7, R 16	0.31	10	86,423,000
Upper St. John, 1st Pond	T 4, R 17	0.10	10	27,878,000
Upper St. John, 2nd Pond	T 4, R 17	0.19	10	52,969,000
Upper St. John, 3rd Pond	Ts 4 & 5, R 17	0.33	10	91,999,000
Upper St. John, 4th Pond	T 5, R 17	0.32	10	89,211,000
Whites Pond	T 13, R 15	0.51	10	142,180,000
Total		20.29		5,656,529,000

Storage in St. John River Basin—Continued.

CONNECTED WITH ALLAGASH RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Burnt Pond	Ts 14, R 9 & 10	0.16	10	44,605,000
Churchill Lake	T 9, R 12	3.67	10	1,023,137,000
Clayton Lake	T 11, R 14	0.31	10	86,423,000
Clear Lake	T 10, R 11	0.78	10	217,452,000
Cliff Lake	Ts 8 & 9, R 12	0.49	10	136,605,000
Eagle Lake	Ts 7 & 8, R 12, Ts 8 & 9, R 13	12.37	5	1,724,279,000
Fifth Musquacook Lake	T 10, R 11	0.94	10	262,057,000
First Musquacook Lake	T 11 & 12, R 11	1.24	10	345,691,000
Fourth Musquacook Lake	Ts 10 & 11, R 11	1.92	10	535,266,000
Grass Pond	T 9, R 12	0.05	10	13,939,000
Harrow Lake	Ts 10, R 10 & 11	1.15	10	320,601,000
Indian Pond	T 7, R 12	1.68	10	468,357,000
Long Lake	Ts 11 & 12, R 13	2.66	10	741,565,000
Long Pond	Ts 11, R 10 & 11	0.32	10	89,211,000
McKeen Lake	T 14, R 10	0.21	10	58,545,000
Mink Lake	T 14, R 10	0.41	10	114,302,000
Pleasant Lake	Ts 9 & 10, R 11	1.48	10	412,601,000
Pond	T 9, R. 7	0.09	10	25,091,000
"	T 15, R 9	0.01	10	2,788,000
"	T 15, R 9	0.03	10	8,364,000
"	T 15, R 9	0.02	10	5,576,000
"	T 15, R 9	0.07	10	19,515,000
"	T 15, R 9	0.17	10	47,393,000
"	T 15, R 9	0.04	10	11,151,000
"	Ts 10, R 10 & 11	0.02	10	5,576,000
"	T 11, R 10	0.21	10	58,545,000
"	T 13, R 10	0.32	10	89,211,000
"	T 14, R 10	0.33	10	91,999,000
"	T 15, R 10	0.12	10	33,454,000
"	T 16, R 10	0.14	10	39,030,000
"	Ts 10, R 10 & 11	0.10	10	27,878,000
"	T 8, R 11	0.05	10	13,939,000
"	T 8, R 11	0.04	10	11,151,000
"	T 9, R 11	0.02	10	5,576,000
"	T 10, R 11	0.23	10	64,120,000
"	T 10, R 11	0.18	10	50,181,000
"	T 10, R 11	0.14	10	39,030,000
"	T 10, R 11	0.10	10	27,878,000
"	Ts 7, R 11 & 12	0.08	10	22,303,000
"	Ts 7, R 11 & 12	0.04	10	11,151,000
"	T 12, R 11	0.12	10	33,454,000
"	T 12, R 11	0.12	10	33,454,000
"	T 14, R 11	0.12	10	33,454,000
"	T 14, R 11	0.02	10	5,576,000
"	T 14, R 11	0.04	10	11,151,000
"	T 7, R 12	0.05	10	13,939,000
"	T 7, R 12	0.22	10	61,332,000
"	Ts 8 & 9, R 12	0.02	10	5,576,000
"	T 8, R 12	0.10	10	27,878,000
"	T 11. R 12	0.16	10	44,605,000
"	Ts 11 & 12, R 12	0.01	10	2,788,000
"	T 12, R 12	0.05	10	13,939,000
"	T 12, R 12	0.09	10	25,091,000
"	T 12, R 12	0.02	10	5,576,000
"	T 12, R 12	0.02	10	5,576,000
"	T 12, R 12	0.01	10	2,788,000
"	T 12, R 12	0.03	10	8,364,000
"	T 13, R 12	0.14	10	39,030,000
"	T 15, R 12	0.14	10	39,030,000
"	T 15, R 12	0.12	10	33,454,000
"	T 15, R 12	0.14	10	39,030,000

Storage in St. John River Basin—Continued.

CONNECTED WITH ALLAGASH RIVER—Concluded.

Name.	Location.	Surface area sq. miles.	Possible Storage. Feet.	Possible Storage. Cubic Feet.
	W. E. L. S.			
Pond	T 8, R 13	0.12	10	33,454,000
"	T 10, R 13	0.12	10	33,454,000
"	T 12, R 13	0.24	10	66,908,000
"	T 8, R 14	0.09	10	25,091,000
"	T 9, R 14	0.05	10	13,939,000
"	T 9, R 14	0.05	10	13,939,000
"	T 9, R 14	0.13	10	36,242,000
"	Ts 8, R 15 & 8 & 9, R 16	0.17	10	47,393,000
"	Ts 9, R 13 & 14	0.03	10	8,364,000
Portage Ponds	T 9, R 11	0.11	10	30,666,000
Priestly Lake	T 10, R 13	2.62	10	730,414,000
Round Pond	T 13, R 12	1.68	10	468,357,000
Round Pond	T 9, R 13	0.25	10	69,696,000
Russell Pond	T 9, R 14	0.22	10	61,332,000
Second Musquacook Lake	T 11, R 11	1.28	10	356,843,000
Soper Pond	T 8, R 12	0.27	10	75,272,000
South Branch Pond	T 8, R 14	0.26	10	72,484,000
Spider Lake	Ts 9, R 11 & 12	1.44	10	401,449,000
Third Musquacook Lake	T 11, R 11	1.00	10	278,784,000
Togue Pond	T 15, R 9	0.17	10	47,393,000
Twin Lake	T 9, R 12	0.05	10	13,939,000
Umsaskis Lake	Ts 10 & 11, R 13	3.15	10	878,169,000
Total		47.63		11,554,203,000

CONNECTED WITH ST. FRANCIS RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage. Feet.	Possible Storage. Cubic Feet.
	W. E. L. S.			
Beau Lake	T 19, R 11 & Canada	2.98	10	830,777,000
Cross Lake	T 18, R 10	0.10	10	27,878,000
Fall Brook Lake	T 18, R 10	1.08	10	301,087,000
Glaziers Lake	T 18, R 10	1.62	10	451,630,000
Jones Lake	Ts 20, R 11 & 12	0.08	10	22,303,000
Pond	T 13, R 11	0.25	10	69,696,000
"	T 17, R 11	0.04	10	11,151,000
"	T 18, R 11	0.12	10	33,454,000
"	T 19, R 11	0.14	10	39,030,000
"	T 19, R 11	0.20	10	55,757,000
"	T 19, R 11	0.21	10	58,545,000
"	T 19, R 12	0.05	10	13,939,000
Pohemegamook Lake	Ts 20, R 11 & 12, & Canada	3.58	10	998,047,000
Total		10.45		2,913,294,000

Storage in St. John River Basin—Continued.

CONNECTED WITH FISH RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage. Feet.	Possible Storage. Cubic Feet.
	W. E. L. S.			
Black Pond	T 15, R 9	0.17	10	47,393,000
Blake Pond	T 16, R 6	0.16	10	44,605,000
Carr Pond	T 13, R 8	0.44	10	122,665,000
Chase Pond (east)	T 14, R 9	0.13	10	36,242,000
Chase Pond (west)	T 14, R 9	0.11	10	30,666,000
Clayton Pond	T 12, R 8	0.24	10	66,908,000
Cross Lake	Ts 16 & 17, R 5	4.50	14	1,756,339,000
Debulle Pond	T 15, R 9	0.20	10	55,757,000
Eagle Lake	Ts 16, R 5 & 6, & Eagle Lake	7.38	16	3,291,882,000
Fish Lake	T 13, R 8	5.87	18	2,945,632,000
Fish Pond	T 15, R 9	0.08	10	22,303,000
Furgerson Pond	T 14, R 8	0.31	10	86,423,000
Gardner Pond	T 15, R 9	0.08	10	22,303,000
Goddards Pond	T 14, R 5	0.07	10	19,515,000
Hot Pond	T 14, R 8	0.26	10	72,484,000
Hourglass Pond	T 14, R 9	0.10	10	27,878,000
Island Pond	T 15, R 9	0.06	10	16,727,000
Long Lake	Ts 17, R 3 & 4, & Madawaska	16.64	9	4,175,070,000
Martin Lake	Ts 17, R 5	0.13	10	36,242,000
Moccasin Pond	T 14, R 8	0.22	10	61,332,000
Mud Lake	Ts 17, R 4 & 5	1.20	9	301,087,000
Mud Pond	T 13, R 8	0.34	10	94,787,000
Mud Pond	T 15, R 9	0.05	10	13,939,000
North Pond	T 14, R 9	0.14	10	39,030,000
Pond	T 16, R 3	0.15	10	41,818,000
"	T 15, R 5	0.06	10	16,727,000
"	T 15, R 6	0.11	10	30,666,000
"	T 16, R 6	0.01	10	2,788,000
"	T 16, R 6	0.03	10	8,364,000
"	T 14, R 7	0.12	10	33,454,000
"	T 12, R 8	0.07	10	19,515,000
"	T 14, R 8	0.06	10	16,727,000
"	T 15, R 9	0.02	10	5,576,000
"	T 15, R 9	0.01	10	2,788,000
"	T 15, R 9	0.04	10	11,151,000
"	T 15, R 9	0.01	10	2,788,000
"	T 15, R 9	0.03	10	8,364,000
"	T 15, R 9	0.01	10	2,788,000
"	T 15, R 9	0.04	10	11,151,000
"	T 16, R 9	0.08	10	22,303,000
"	Madawaska	0.11	10	30,666,000
"	Wallagrass Pl	0.04	10	11,151,000
Portage Lake	T 13, R 6	4.32	10	1,204,347,000
St. Froid Lake	Ts 14, & 15, R	4.06	20	2,263,726,000
Square Lake	Ts 15 & 16, R 5	14.62	14	5,706,151,000
Wallagrass Lake	Eagle Lake Pl	0.17	10	47,393,000
Total		63.05		22,887,611,000

Storage in St. John River Basin—Continued.

CONNECTED WITH MADAWASKA RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage.	
			Feet.	Cubic Feet.
Aigles Lake	Quebec	1.12	10	312,238,000
Grand Squateck Lake	Quebec	4.96	10	1,382,769,000
Lac du pain de sucre	Quebec	4.80	10	1,338,163,000
Long Lake	Quebec	5.92	10	1,650,402,000
St. John Lake	Quebec	0.80	10	223,027,000
Squateck Lake	Quebec	0.80	10	223,027,000
Temiscouata Lake	Quebec	24.16	10	6,735,421,000
Touladi Lake	Quebec	3.36	10	936,714,000
Total		45.92		12,801,761,000

CONNECTED WITH UPPER AROOSTOOK RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Atkins Pond	T 8, R 9	0.10	10	27,878,000
Beaver Pond	T 7, R 9	0.19	10	52,969,000
Beaver Pond	Ts 7, R 9	0.10	10	27,878,000
Beaver Pond	T 8, R 5	0.15	10	41,818,000
Boody Pond	T 8, R 8	0.12	10	33,454,000
Brown Pond	T 8, R 9	0.11	10	30,666,000
Chandler Lake	T 9, R 8	0.46	10	128,241,000
Cut Lake	Ts 7 & 8, R 6	0.39	10	108,726,000
Dead Water	T 9, R 8	0.25	10	69,696,000
Echo Lake	T 9, R 11	0.20	10	55,757,000
Elbow Lake	T 10, R 10	0.16	10	44,605,000
Haymock Lake	Ts 7 & 8, R 11	1.38	10	384,722,000
Isthmus Pond	T 8, R 8	0.15	10	41,818,000
Little Millinocket Lake	T 7, R 9	0.26	10	72,484,000
Little Munsungan Lake	Ts 8, R 9 & 10	0.32	10	89,211,000
Long Pond	Ts 7 & 8, R 10	0.62	10	172,846,000
Marsh Pond	T 10, R 10	0.04	10	11,151,000
Millimagassett Lake	T 7, R 8	1.48	10	412,601,000
Millinocket Lake	Ts 7 & 8, R 9	3.34	10	931,138,000
Mooseleuk Lake	T 10, R 9	0.35	10	97,574,000
Mud Pond	T 8, R 10	0.14	10	39,030,000
Munsungan Lake	Ts 8 & 9, R 10	2.71	10	755,505,000
Otter Pond	T 8, R 5	0.10	10	27,878,000
Pillsbury Lake	T 8, R 11	0.32	10	89,211,000
Pond	T 8, R 5	0.07	10	19,515,000
"	T 8, R 5	0.02	10	5,576,000
"	T 9, R 6	0.13	10	36,242,000
"	T 9, R 7	0.01	10	2,788,000
"	T 7, R 9	0.10	10	27,878,000
"	T 7, R 9	0.02	10	5,576,000
"	T 8, R 9	0.02	10	5,576,000
"	T 8, R 9	0.02	10	5,576,000
"	T 9, R 9	0.01	10	2,788,000
"	T 10, R 9	0.25	10	69,696,000
"	T 10, R 9	0.25	10	69,696,000

Storage in St. John River Basin—Continued.

CONNECTED WITH UPPER AROOSTOOK RIVER—Concluded.

NAME.	Location.	Surface area sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
	W. E. L. S.			
"	Ts 7, R 9 & 10	0.08	10	22,303,000
"	T 7, R 10	0.04	10	11,151,000
"	T 7, R 10	0.05	10	13,939,000
"	T 7, R 10	0.03	10	8,364,000
"	T 7, R 10	0.06	10	16,727,000
"	T 7, R 10	0.02	10	5,576,000
"	Ts 7, R 10 & 11	0.04	10	11,151,000
"	T 8, R 10	0.04	10	11,151,000
"	T 8, R 10	0.10	10	27,878,000
"	Ts 8 & 9, R 10	0.04	10	11,151,000
"	T 9, R 10	0.19	10	52,969,000
"	T 10, R 10	0.04	10	11,151,000
"	T 10, R 10	0.12	10	33,454,000
"	T 10, R 10	0.02	10	5,576,000
"	T 10, R 10	0.02	10	5,576,000
"	T 10, R 10	0.01	10	2,788,000
"	T 10, R 10	0.11	10	30,666,000
"	T 10, R 10	0.11	10	30,666,000
"	T 10, R 10	0.09	10	25,091,000
"	T 8, R 11	0.10	10	27,878,000
"	Ts 7 & 8, R 11	0.04	10	11,151,000
"	T 8, R 11	0.11	10	30,666,000
"	T 8, R 11	0.03	10	8,364,000
"	T 8, R II	0.02	10	5,576,000
"	T 8, R 11	0.14	10	39,030,000
"	T 8, R 11	0.04	10	11,151,000
"	T 9, R 11	0.03	10	8,364,000
Reed Pond	T 8, R 10	0.16	10	44,605,000
Umcolcus Lake	Ts 7 & 8, Rs 5 & 6	1.65	10	459,993,000
Upper Lake	Ts 10, R 10 & 11	0.21	10	58,545,000
Total		18.08		5,040,415,000

CONNECTED WITH ST. CROIX STREAM (AROOSTOOK).

NAME.	Location.	Surface area sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Cranberry Pond	T 9, R 5	0.19	10	52,969,000
Pond	Ts 7 & 8, R 3	0.03	10	8,364,000
"	T 8, R 3	0.06	10	16,727,000
"	Ts 8 & 9, R 5	0.04	10	11,151,000
St. Croix Lake	Ts 7 & 8, R 4	1.00	10	278,784,000
Total		1.32		367,995,000

Storage in St. John River Basin—Continued.

CONNECTED WITH BIG MACHIAS RIVER (AROOSTOOK).

NAME.	Location.	Surface araa sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Big Machias Lake	T 12, R 8	0.80	10	223,027,000
Caribou Pond	Ts 11, R 9 & 10	0.06	10	16,727,000
Center Lake	T 10, R 8	0.21	10	58,545,000
Chase Pond	T 10, R 10	0.41	10	114,301,000
Dead Water	T 9 R 10	0.17	10	47,393,000
Greenlaw Pond	Ts 12, R 7 & 8	0.26	10	72,484,000
Horseshoe Pond	T 11, R 10	0.06	10	16,727,000
McGowen Pond	T 11, R 8	0.53	10	147,756,000
McNally Pond	T 11, R 10	0.34	10	94,787,000
Pond	T 11, R 7	0.02	10	5,576,000
"	T 10, R 8	0.07	10	19,515,000
"	T 11, R 8	0.02	10	5,576,000
"	T 11, R 8	0.02	10	5,576,000
"	T 11, R 8	0.01	10	2,788,000
"	T 11, R 9	0.02	10	5,576,000
"	T 11, R 10	0.06	10	16,727,000
"	T 11, R 10	0.09	10	25,091,000
"	T 11, R 10	0.04	10	11,151,000
Pratt Pond	T 11, R 9	0.14	10	39,030,000
Round Mountain Lake	T 11, R 8	0.46	10	128,241,000
Spectacle Pond	T 10, R 8	0.50	10	139,392,000
Total		4.29		1,195,986,000

CONNECTED WITH PRESQUE ISLE STREAM (AROOSTOOK).

NAME.	Location.	Surface area sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Alder Brook Pond	T 11, R 4 & Chapman	0.30	10	94,787,000
Pond	T 9, R 3	0.10	10	27,878,000
"	Presque Isle	0.02	10	5,576,000
"	Presque Isle	0.02	10	5,576,000
Quaggy Joe Lake	Presque Isle	0.19	10	52,969,000
Westfield Lake	Westfield	0.02	10	5,576,000
Total		0.65		192,362,000

Storage in St. John River Basin—Continued.

CONNECTED WITH LITTLE MADAWASKA RIVER (AROOSTOOK).

NAME.	Location.	Surface area sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Bog Lake	T 14, R 5	0.13	10	36,242,000
Little Madawaska Lake	T 15, R 4	0.08	10	22,303,000
Madawaska Lake	Ts 15 & 16, R 4	2.76	10	769,444,000
Pond	New Sweden	0.01	10	2,788,000
Total		2.98		830,777,000

CONNECTED WITH MAIN AROOSTOOK RIVER.

NAME.	Location.	Surface area sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Caribou Lake	Washburn	0.22	10	61,332,000
Little Madawaska Lake	T 12, R 6	0.37	10	103,150,000
Pond	T 14, R 5	0.03	10	8,364,000
"	Ashland	0.05	10	13,939,000
"	Washburn	0.02	10	5,576,000
"	"	0.04	10	11,151,000
"	Ft. Fairfield	0.02	10	5,576,000
"	" "	0.01	10	2,788,000
"	" "	0.02	10	5,576,000
"	" "	0.02	10	5,576,000
Salmon Brook Lake	Perham	0.13	10	36,242,000
Squawpan Lake	Ts 10 & 11, R 4	5.00	10	1,393,920,000
Total		5.93		1,653,190,000

CONNECTED WITH PRESQUE ISLE RIVER.

NAME.	Location.	Surface area sq. miles.	POSSIBLE STORAGE.	
			Feet.	Cubic Feet.
Pond	Blaine	0.03	10	8,364,000
"	Bridgewater	0.02	10	5,576,000
"	"	0.01	10	2,788,000
"	Easton	0.04	10	11,151,000
"	Mars Hill	0.01	10	2,788,000
Youngs Pond	Westfield	0.06	10	16,727,000
Total		0.17		47,394,000

Storage in St. John River Basin—Continued.

CONNECTED WITH MEDUXNEKEAG RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage.	
			Feet.	Cubic Feet.
	W. E. L. S.			
Bradbury Lake	New Limerick	0.07	10	19,515,000
Cochrans Lake	" "	0.18	10	50,181,000
Dead Water Lake	T 8, R 3	0.08	10	22,303,000
Goulds Lake	New Limerick	0.04	10	11,151,000
Meduxnekeag Lake (Drew)	Oakfield, Linneus, New Limerick	1.78	10	496,236,000
Mud Lake	Linneus	0.06	10	16,727,000
New Limerick Lake	New Limerick	0.42	10	117,089,000
No. 9 Lake	T 9, R 3	0.21	10	58,545,000
Pond	T A, R 2	0.01	10	2,788,000
"	T A, R 2	0.02	10	5,576,000
"	T B, R 2	0.04	10	11,151,000
"	T B, R 2	0.002	10	558,000
"	T B, R 2	0.03	10	8,364,000
"	T B, R 2	0.02	10	5,576,000
"	T D, R 2	0.005	10	1,394,000
"	T D, R 2	0.01	10	2,788,000
"	T D, R 2	0.01	10	2,788,000
"	T 3, R 2	0.12	10	33,454,000
"	T 7, R 3	0.01	10	2,788,000
"	T 8, R 3	0.03	10	8,364,000
"	T 8, R 3	0.02	10	5,576,000
"	T 8, R 3	0.02	10	5,576,000
"	Houlton & Littleton	0.03	10	8,364,000
"	Linneus	0.06	10	16,727,000
"	Linneus	0.02	10	5,576,000
"	New Limerick	0.04	10	11,151,000
"	" "	0.06	10	16,727,000
"	Smyrna, New Limerick	0.16	10	44,605,000
"	Oakfield	0.06	10	16,727,000
Ten Mile Lake	T 3, R 2	0.15	10	41,818,000
Timoney Lake	Oakfield	0.12	10	33,454,000
Total		3.887		1,083,637,000

Storage in St. John River Basin—Concluded.

CONNECTED WITH MAIN ST. JOHN RIVER.

Name.	Location.	Surface area sq. miles.	Possible Storage Feet.	Possible Storage Cubic Feet.
	W. E. L. S.			
Pond	T 16, R 9	0.12	10	33,454,000
"	T 16, R 9	0.19	10	52,969,000
"	T 16, R 9	0.02	10	5,576,000
"	Easton	0.02	10	5,576,000
"	"	0.02	10	5,576,000
"	"	0.01	10	2,788,000
"	Ft. Fairfield	0.03	10	8,364,000
"	Grand Isle	0.31	10	86,423,000
"	Littleton	0.02	10	5,576,000
"	"	0.02	10	5,576,000
"	"	0.06	10	16,727,000
"	Monticello	0.06	10	16,727,000
"	St. Francis & St. John Pl	0.22	10	61,332,000
"	St. John Pl.	0.25	10	69,696,000
"	" " "	0.08	10	22,303,000
"	" " "	0.10	10	27,878,000
"	St. John Pl. & Wallagrass Pl	0.24	10	66,908,000
"	Wallagrass Pl	0.10	10	27,878,000
Violet Pond	T 17, R 3	0.08	10	22,303,000
Total		1.95		543,630,000

Summary of Storage St. John Basin.

Basin.	Drainage area, sq. miles.	Lake surface area, sq. miles.	Ratio water surface to drainage area.	Possible storage capacity, cubic feet.
Upper St. John River	2,670	20.29	132	5,656,529,000
Allagash River	1,240	47.63	26	11,554,203,000
St. Francis River	560	10.45	54	2,913,294,000
Fish River	890	63.05	14	22,887,611,000
Madawaska River	800	45.92	17	12,801,761,000
Upper Aroostook River	656	18.08	36	5,040,415,000
St. Croix Stream	221	1.32	167	367,995,000
Big Machias River	313	4.29	73	1,195,986,000
Presque Isle Stream	165	0.65	254	192,362,000
Little Madawaska Stream	256	2.98	86	830,777,000
Main Aroostook River	679	5.93	115	1,653,190,000
Presque Isle River	77	0.17	453	47,394,000
Meduxnekeag River	497	3.89	128	1,083,637,000
Main St. John River	2,420	1.95	–	543,630,000
Total	11,444	226.60	50.5	66,768,784,000

STREAM FLOW.

The following gaging stations have been maintained in the St. John River Basin:

St. John at Ft. Kent (1905-1911).

Fish at Wallagrass (1903-1908, 1911).

Aroostook at Ft. Fairfield (1903-1910).

The following stations were established in 1910 by the International Commission, River St. John. The records will be available later.

St. John River near Dickey, Maine (1910-1911).

Allagash River near Allagash, Maine (1910-1911).

St. Francis River near St. Francis, Maine (1910-1911).

Madawaska River near Ste. Rose du Degele, P. Q. (1910-1911).

St. John River at Van Buren, Maine (1908-1911).

ST. JOHN RIVER AT FORT KENT.

This station, which is located at the footbridge that crosses the St. John near Fort Kent post-office, a short distance above the confluence of Fish River with the St. John, was established October 13, 1905. It is about 15 miles below the mouth of St. Francis River and about 50 miles above Grand Falls, Canada, an important undeveloped power.

The run-off record for 1905 to 1910, published in the 1st Annual Report, page 81, was computed for a drainage area of 5280 square miles. The new drainage area of 4880 square miles shown on page 90 is the result of recent measurements from more reliable maps and does not include Chamberlain Lake drainage, as the latter is included in the Penobscot basin areas.

The monthly estimates of run-off for this station for 1910 and 1911 are given in the table below.

Monthly Discharge of St. John River at Ft. Kent, Maine.
[DRAINAGE AREA, 4880 SQUARE MILES.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
January	....	....	1,450	0.297	0.34
February	....	....	1,200	.246	.26
March	....	....	3,200	.656	.76
April	63,300	13,000	32,900	6.74	7.52
May	35,000	5,040	16,400	3.36	3.87
June	18,600	2,420	8,630	1.77	1.98
July	3,860	1,060	1,850	.379	.44
August	4,900	1,270	2,640	.541	.62
September	6,380	1,060	2,410	.494	.55
October	3,610	1,060	2,080	.426	.49
November	15,400	1,460	4,880	1.00	1.12
December	....	....	1,400	.287	.33
The year	63,300	....	6,570	1.35	18.28
1911					
January	....	....	800	0.164	0.19
February	....	....	600	.123	.13
March	....	....	650	.133	.15
April	18,600	....	6,050	1.24	1.38
May	70,000	7,660	25,900	5.31	6.12
June	13,500	2,320	5,640	1.16	1.29
July	9,960	1,060	2,370	.486	.56
August	13,300	1,270	3,300	.676	.78
September	5,320	1,270	2,500	.512	.57
October	3,610	1,520	2,300	.471	.54
November	....	....	2,330	.477	.53
December	....	....	1,650	.338	.39
The year	70,000	....	4,540	.930	12.63

GAGING STATIONS, INTERNATIONAL COMMISSION, RIVER ST. JOHN.

A number of gaging stations have been maintained by the International Commission, River St. John under the general direction of Mr. M. H. Ranney, Chief Engineer. The daily gage heights and discharge measurements were furnished this office and the rating curves and computations of daily discharge were made by the U. S. Geological Survey.

The following are the stations maintained by the International Commission:

St. John River near Dickey, Maine: This station is located 2 miles above the confluence of the Allagash and St. John rivers and 3-4 mile below the mouth of Little Black River.

Allagash River near Allagash, Maine. This station is located 105 feet below the ferry crossing the Allagash River, 2 miles below Dickey Post Office, and 1500 feet above the mouth of the river.

St. Francis River near St. Francis, Maine: This station is located 1 1-2 miles from St. Francis Post Office, 1 mile above the mouth of the river and 3 miles below Glazier Lake.

Fish River at Wallagrass, Maine: This station is located at the old gaging station of the U. S. Geological Survey near Soldier Pond Post Office just below the outlet of Wallagrass Stream, about 7 miles south of Ft. Kent and 4 miles below Eagle Lake. All readings were referred to the U. S. gage datum.

Madawaska River near St. Rose du Degele, P. Q. This station is located at the highway bridge crossing the river 1-5 mile from Temiscouata Railroad station, 2 miles below the foot of Lake Temiscouata and 21 miles above Edmunston, Canada, and the mouth of the river.

St. John River at Van Buren, Me., is located at the international bridge across St. John River, 14 miles above Grand Falls, N. B. Estimates of discharge for 1908 to 1911 will appear in later reports.

The estimates for the several stations as given below, cover the entire record from the establishment of the stations to their discontinuance by the International Commission.

Monthly discharge of St. John River near Dickey, Me.

[DRAINAGE AREA, 2820 SQUARE MILES.]

Month.	Discharge in Second-Feet				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
July 5–31	3,380	350	1,050	.372	0.37
August	3,380	410	1,550	.550	.63
September	4,220	350	1,040	.369	.41
October	4,000	470	1,410	.500	.58
November 1–24	6,900	710	2,510	.890	.79

Monthly discharge of St. John River near Dickey, Maine—Continued.

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1911					
May 6-31	30,000	2,980	12,600	4.47	4.32
June	9,430	921	3,170	1.12	1.25
July	3,000	477	1,280	.454	.52
August	8,620	665	2,200	.780	.90
September	3,680	860	1,880	.667	.74
October	2,730	965	1,690	.599	.69
November 1-21	4,340	1,200	2,960	1.05	.82

Monthly discharge of Allagash River near Allagash, Me.

[Drainage area, 1240 square miles.]

Month.	Discharge in Second-Feet				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
July	1,160	165	439	0.354	0.41
August	740	295	426	.344	.40
September	3,230	355	919	.741	.83
October	650	200	356	.287	.33
November 1-21	935	295	479	.386	.30
1911					
May 4-31	7,780	1,910	4,310	3.48	3.62
June	4,580	448	1,700	1.37	1.53
July	2,320	179	422	.340	.39
August	1,090	147	336	.271	.31
September	778	218	453	.365	.41
October	599	381	426	.344	.40
November	686	319	564	.455	.51

Monthly discharge of St. Francis River near St. Francis, Maine.

[DRAINAGE AREA, 560 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
May 11–31	3,300	1,500	2,190	3.91	3.05
June	2,070	460	1,230	2.20	2.46
July	460	240	343	.612	.71
August	516	145	313	.559	.64
September	240	120	161	.288	.32
October	320	120	189	.338	.39
November	830	279	477	.852	.95
1911					
May 4–31	12,000	796	5,280	9.43	9.82
June	1,030	280	656	1.17	1.30
July	504	142	348	.621	.72
August	796	199	422	.754	.87
September	266	169	216	.386	.43
October	214	142	155	.277	.32
November	230	142	172	.307	.34

Monthly discharge of Fish River at Wallagrass, Me., for 1911.

[DRAINAGE AREA, 860 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1911					
May 7–31	6,600	1,290	3,470	4.03	3.74
June	1,920	545	1,140	1.33	1.48
July	608	348	429	.499	.58
August	737	319	445	.517	.60
September	348	237	300	.349	.39
October	319	128	187	.217	.25
November	237	109	168	.195	.22

Monthly discharge of Madawaska River at Ste Rose du Degele, P. Q.

[DRAINAGE AREA, 958 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
May 12–31	8,220	3,820	5,540	5.78	4.30
June	3,820	1,550	2,770	2.89	3.22
July	1,460	780	1,050	1.10	1.27
August	1,020	455	721	.753	.87
September	455	350	413	.431	.48
October	575	305	414	.432	.50
November	1,020	575	891	.930	1.04
December 1–14	935	855	872	.910	.47
1911					
May 3–31	8,180	3,680	6,380	6.66	7.18
June	3,800	1,430	2,410	2.52	2.81
July	1,340	898	1,080	1.13	1.30
August	898	286	598	.624	1.72
September	462	341	426	.445	.50
October	462	286	375	.391	.45
November	401	286	326	.340	.38

ST. CROIX DRAINAGE BASIN.

Description.

St. Croix River is formed by two principal branches: the East Branch, also known as the Upper St. Croix, is the outlet of the Schoodic Lake system, including Grand and Spednic lakes; the West Branch is formed by the Grand Lake system, including Sysladobsis, Grand and Big lakes. The St. Croix, including the East Branch forms nearly half of the eastern boundary of Maine, and its total length is about 100 miles. Tributaries are small and unimportant. The total drainage area is 1473 miles, the East or principal branch having 644 square miles and the West Branch 674 square miles at their junction. The river discharges into Passamaquoddy Bay.

The basin is in general lower than that of any other of the larger streams of the State flowing into the Atlantic, its headwaters having an elevation of about 540 feet.

A large part of the drainage basin is still covered with timber, and above Vanceboro and Princeton, at the foot of the two systems of lakes, the region is for the most part wild and inaccessible.

Lake Storage.

The lake system of the St. Croix is the largest in the State in proportion to the drainage basin, except that of the Presumpscot, which is, however, a much smaller stream. The former basin averages 1 square mile of lake surface to 9.1 square miles of drainage area and the latter basin 1 square mile of lake surface to 8.3 square miles of drainage area.

The following table gives the areas of the various lakes and ponds in the basin as recently measured from existing maps. There is also included the present and possible storage both in feet and cubic feet. For an explanation of these tables, reference should be made to page 85.

Storage in St. Croix River Basin.

CONNECTED WITH EAST BRANCH.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Brackett Lake....	Weston.........	1.05	....	....	10	292,723,000
Grand Lake......	Forest City, Danforth, Weston..	23.68	6	3,960,964,000	10	6,601,603,000
Hound Brook Pond..........	T 1, R 2, T. S....	0.22	....	....	10	61,332,000
Lambert Lake....	T 1, R 3, Ts 11, R 3, N B P P....	0.54	....	....	10	150,543,000
Longfellow Lake..	Weston.........	0.38	....	....	10	105,938,000
Pond............	Weston.........	0.09	....	....	10	25,091,000
"	Easton.........	0.13	....	....	10	36,242,000
Simsquash Lake..	T 1, R 3, T S.....	0.18	....	....	10	50,181,000
Spednic Lake.....	Forest, Forest City, T 11, R 3, N B P P, and Vanceboro.....	22.84	13.5	8,596,023,000	15	9,551,138,000
Sucker Brook Lake	Weston.........	0.04	....	....	10	11,151,000
Total........	....	49.17		12,556,987,000		16,885,942,000

CONNECTED WITH WEST BRANCH.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Big Lake........	T 27, E D, T 21, E D, T S, R 1, T S.	16.28	5	2,269,300,000	10	4,538,600,000
Bottle Lake......	T 4, R 1, N. B P P	0.40	....	....	10	111,514,000
Bug Lake........	T 5, R 1, N B P P	0.06	....	....	10	16,727,000
Clifford Lake.....	T 26, E D, T 27, E D..........	2.24	5	312,238,000	5	312,238,000
Duck Pond.......	T 4, R 1, N B P P	0.34	4	37,915,000	10	94,787,000
Farrows Lake....	Topsfield.......	0.50	4	55,757,000	5	69,696,000
First Chain Lake..	T 5, N D........	0.28	4	31,224,000	10	78,060,000
Flipper Cr. Pond..	Talmadge & Waite	0.15	....	....	5	20,909,000
Grand Lake......	T 5 & 6, N D, 5 & 6, R 1, N B P P, T 3, R 1, T S..	23.49	7	4,584,043,000	10	6,548,634,000
Horseshoe Lake...	T 4, R 1, N B P P, T 5, N D, T 5, R 1, N B P P....	0.36	6	60,217,000	10	100,362,000
Junior Lake......	T 5, N D, T 4, R 1, N B P P, T 5, R 1, N B P P....	5.68	6	950,096,000	10	1,583,493,000
Keg Lake........	T 4, R 1, N B P P	0.34	....	....	5	47,393,000
Lambert Lake....	T 4, R 1, N B P P	0.16	....	....	10	44,605,000
Leweys Lake.....	Indian Township & Princeton....	0.66	5	91,999,000	10	183,997,000
Little Tomah Lake	Topsfield & T 9, R 2............	0.30	....	....	5	41,818,000

Storage in St. Croix River Basin—Continued.

CONNECTED WITH WEST BRANCH.

NAME.	Location.	Surface area, sq. miles.	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Long Lake	Indian Township & Princeton	0.93	5	129,635,000	10	259,269,000
Mathson Lake	Topsfield	0.10	....	....	5	13,939,000
Musquash Lake	"	1.32	7	257,596,000	10	367,995,000
Norway Lake	T 5, R 1, N B P P	0.04	....	....	5	5,576,000
Oxbrook Lake	T 6, N D, T 6, R 1, N B P P, Talmadge	1.09	3	91,162,000	5	151,937,000
Pleasant Lake	T 6, R 1, T 7, R 2, N B P P	2.20	4	245,330,000	10	613,325,000
Pocumpus Lake	T 5 & 6, N D	3.44	7	671,312,000	10	959,017,000
Pond	T 3, R 1, T S	0.22	....	....	10	61,332,000
"	T 3, R 1, T S	0.05	....	....	10	13,939,000
"	T 3, R 1, T S	0.04	....	....	10	11,151,000
"	T 3, R 1, T S	0.02	....	....	10	5,576,000
"	T 4, R 1, N B P P	0.10	....	....	10	27,878,000
"	T 5, R 1, N B P P	0.05	....	....	10	13,939,000
"	T 1, R 3, N B P P	0.02	....	....	10	5,576,000
"	T 43, M D	0.04	....	....	10	11,151,000
"	T 37, M D	0.01	....	....	10	2,788,000
"	T 26, E D	0.05	....	....	10	13,939,000
"	Talmadge	0.05	....	....	10	13,939,000
"	"	0.08	....	....	10	22,303,000
"	T 6, R 1, N B P P	0.08	....	....	10	22,303,000
"	T 6, R 1, N B P P	0.005	....	....	10	1,394,000
Scraggly Lake	Ts 5 & 6, R 1, N B P P	2.08	6	347,923,000	10	579,871,000
Second Chain Lake	T 4, N D	0.35	4	39,030,000	5	48,787,000
Shaw Lake	Ts 5 & 6, R 1, N B P P	0.33	....	....	10	91,999,000
Sysledobsis Lake	T 5, N D, T 4, R 1, N B P P	9.86	8	2,199,049,000	10	2,748,810,000
Sysledobsissis Lake	T 4, R 1, N B P P	1.90	3	158,907,000	10	529,690,000
Tomah Lake, Upper	T 10, R 3	0.04	....	....	5	5,576,000
Tomah Lake, Lower	T 10, R 3	0.03	....	....	5	4,182,000
Third Chain Lake	T 4, N D	1.06	4	118,205,000	5	147,756,000
Wabasses Lake	T 43, M D, Ts 5 & 6, N D	1.94	....	....	5	270,421,000
West Musquash Lake	Talmadge, T 6, R 1, N B P P	3.35	4	373,571,000	5	466,964,000
Total	....	82.115		13,024,509,000		21,285,155,000

Storage in St. Croix River Basin—Concluded.

CONNECTED WITH MAIN RIVER.

NAME.	Location.	Surface area, sq. miles.	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Beaver Lake	Calais	0.21	....	....	5	29,272,000
Conic Lake	Baring	0.08	....	....	5	11,151,000
East Mugurrewock Lake	Calais	1.35	....	....	5	188,180,000
Eastern Lake	Robbinston	0.07	....	....	5	9,757,000
Flowed Land Pond	Calais	0.23	....	....	5	32,060,000
Goulding Lake	Robbinston	0.06	....	....	5	8,364,000
Moneymakers Lake	Robbinston	0.07	....	....	5	9,757,000
Pond	Calais	0.05	....	....	5	6,970,000
Rand Lake	Robbinston	0.06	....	....	5	8,364,000
Round Pond	Calais & Robbinston	0.05	....	....	5	6,970,000
Shattuck Lake	Calais	0.18	....	....	5	25,091,000
Vose Lake	Calais	0.14	....	....	5	19,515,000
Western Lake	Robbinston	0.13	....	....	5	18,121,000
West Mugurrewock Lake	Calais & Robbinston	1.13	....	....	5	157,513,000
Total	....	3.81				531,085,000

Summary of Storage St. Croix Basin.

BASIN.	Drainage area, sq. miles.	Lake surface area, sq. miles.	Ratio water surface to drainage area.	Present storage, cubic feet.	Possible storage capacity, cubic feet.
East Branch	644	49.17	13.1	12,556,987,000	16,885,942,000
West Branch	674	82.115	8.2	13,024,509,000	21,285,155,000
Main River	155	3.81	48.5	....	531,085,000
Total	1,473	135.095	10.9	25,581,496,000	38,702,182,000

Stream Flow.

ST. CROIX RIVER NEAR WOODLAND.

This station was originally established December 4, 1902, at a point a short distance above Spragues Falls, now called Woodland, near Baring, Maine. On June 8, 1905, it was moved about 1 1-2 miles down stream to avoid backwater effect from a paper mill and dam constructed at Spragues Falls. It is about 10 miles below the junction of the West with the East Branch, and about 14 miles above the mouth of the St. Croix River. It is about 1 mile below the dam of the St. Croix Paper Co.

The run-off record from 1903 to 1909 is published in the 1st Annual Report on page 92. The monthly estimates of discharge for 1910 and 1911 are given in the table below.

Monthly discharge of St. Croix River near Woodland, Maine.
[Drainage area, 1420 square miles.]

Month.	Discharge in Second-Feet				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
January	4,070	500	2,310	1.63	1.88
February	3,170	500	2,260	1.59	1.66
March	3,890	2,280	2,680	1.89	2.18
April	3,360	2,140	2,670	1.88	2.10
May	3,190	1,760	2,430	1.71	1.97
June	3,360	2,140	2,640	1.86	2.08
July	2,440	2,070	2,280	1.61	1.86
August	2,230	1,660	1,960	1.38	1.59
September	2,370	1,000	1,990	1.40	1.56
October	2,370	1,000	1,900	1.34	1.54
November	1,470	950	1,270	.894	1.00
December	1,900	950	1,350	.951	1.10
The year	4,070	500	2,140	1.51	20.52
1911					
January	1,760	1,200	1,400	.986	1.14
February	1,760	1,000	1,510	1.06	1.10
March	1,680	1,100	1,370	.965	1.11
April	4,070	1,830	3,030	2.13	2.38
May	2,870	1,200	1,850	1.30	1.50
June	2,280	1,000	1,420	1.00	1.12
July	2,280	590	1,470	1.04	1.20
August	1,510	1,280	1,410	.993	1.14
September	1,630	790	1,120	.789	.88
October	1,400	400	977	.688	.79
November	2,720	590	1,220	.859	.96
December	4,070	1,200	2,020	1.42	1.64
The year	4,070	400	1,570	1.11	14.96

Note.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

COASTAL DISTRICT, NUMBER 1.

This district includes the drainage basins of Dennys, Pemaquam and associated streams located between the St. Croix and Machias rivers and draining into Passamaquoddy Bay and the Atlantic Ocean. The area comprises about 375 square miles, of which Dennys River drains about 150 square miles; Pemaquam 40 square miles; the remainder being drained by various small streams. Dennys River has its source in Meddybemps Lake, which has an area of water surface of 12.40 square miles. The river in its course to the sea, falls about 250 feet in a distance of 25 miles. The flow of the river is small although comparatively uniform on account of control of the lake at its head.

The following table gives the areas of the lakes and ponds in the district as recently measured, as well as estimates of the possible storage capacities. For an explanation of the table see page 85 of this report.

Storage in Coastal Basin No. 1.

CONNECTED WITH CATHANCE RIVER BASIN.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Cathance Lake....	Cooper & T 14, E D..........	5.37	6	898,242,000	10	1,497,070,000
Little Cathance Lake..........	T 14, E D.......	0.29	....	....	5	40,424,000
Pond............	Marion..........	0.03	....	....	5	4,182,000
Pond............	Edmunds........	0.10	....	....	5	13,939,000
Total........	....	5.79		898,242,000		1,555,615,000

CONNECTED WITH DENNYS RIVER BASIN.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Little Lake.......	Meddybemps & Baring........	0.61	5	85,029,000	5	85,029,000
Meddybemps Lake	Meddybemps, Baring, Baileyville, Alexander.....	12.40	7	2,419,850,000	10	3,456,914,000
Pleasant Lake....	Alexander.......	0.50	....	....	5	69,696,000
Pond	T 14, E D.......	0.04	....	....	5	5,576,000
Total........	....	13.55		2,504,879,000		3,617,215,000

Storage in Coastal Basin, No. 1—Continued.

CONNECTED WITH LITTLE RIVER BASIN.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Boydens Lake....	Perry..........	3.15	4	351,268,000	5	439,085,000
				351,268,000		439,085,000

CONNECTED WITH LITTLE FALLS RIVER BASIN.

Edmunds Pond...	Edmunds........	0.18	....	....	5	25,091,000
						25,091,000

CONNECTED WITH ORANGE RIVER BASIN.

Little Lake.......	Whiting	0.06	....	....	5	8,364,000
Orange Lake.....	"	0.47	....	....	10	131,028,000
Pond	Marion	0.07	....	....	5	9,757,000
"	"	0.20	....	....	5	27,878,000
Roaring Lake....	Whiting........	0.09	....	....	5	12,545,000
Rocky Lake......	Whiting & Marion	1.31	....	....	10	365,207,000
Sunken Lake.....	Whiting.........	0.04	....	....	5	5,576,000
Total........	....	2.24				560,355,000

Storage in Coastal Basin, No. 1—Continued.

CONNECTED WITH PEMAQUAM RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Coalback Lake....	Charlotte........	0.03			5	4,182,000
Pemaquam Lake..	Charlotte........	1.76	4	196,264,000	10	490,660,000
Pond	Pembroke.......	0.19	....	....	5	26,484,000
"	Charlotte	0.02	....	....	5	2,788,000
"	"	0.04	....	....	5	5,576,000
"	Baring.........	0.04	....	....	5	13,939,000
"	Pembroke.......	0.10	....	....	5	8,364,000
"	Baring	0.02	....	....	5	2,788,000
"	Pembroke.......	0.06	....	....	5	5,576,000
Round Lake......	Charlotte........	0.56	3	46,836,000	10	156,119,000
Total........	....	2.82		243,100,000		716,476,000

Storage in Coastal Basin, No. 1—Concluded.

CONNECTED WITH TIDEWATER.

NAME.	Location.	Surface area, sq. miles.	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Holmes Pond	Whiting	0.03	....	....	5	4,182,000
Indian Lake	"	0.24	....	....	5	33,454,000
Pond	Pembroke	0.05	....	....	5	6,970,000
"	Dennysville	0.01	....	....	5	1,394,000
"	"	0.03	....	....	5	4,182,000
"	"	0.05	....	....	5	6,970,000
"	"	0.03	....	....	5	4,182,000
Total		0.44				61,334,000

Summary of Storage Coastal Basin, No. 1.

BASIN.	Lake surface area, sq. miles.	Present storage, cubic feet.	Possible storage capacity, cubic feet.
Cathance River	5.79	898,242,000	1,555,615,000
Dennys River	13.55	2,504,879,000	3,617,215,000
Little River	3.15	351,268,000	439,085,000
Little Falls River	0.18	....	25,091,000
Orange River	2.24	....	560,355,000
Pemaquam River	2.82	243,100,000	716,476,000
Tidewater	.44	....	61,334,000
Total	28.17	3,997,489,000	6,975,171,000

MACHIAS DRAINAGE BASIN.

Description.

Machias River is fairly representative of several of the smaller streams in Maine that discharge their waters into the ocean and are commonly referred to as "coastal rivers." It rises in the Machias Lakes, in the near vicinity of the Grand Lake system of the St. Croix, flows in a generally southeasterly direction to tide water at Machias, a distance of 50 miles, and its drainage area measures 495 square miles. At East Machias, near the mouth, it is joined by East Machias River, a stream of similar characteristics rising in Pocamoonshine Lake, near Princeton, and draining about 345 square miles.

The Machias drainage basin is considerably broken with hills and low mountains, and attains an altitude in its northwestern portion of about 400 feet above sea level. Near the coast the prevailing rock is quartzite, while farther inland granite is found, and near the headwaters mica schists prevail. The basin is generally forested.

The mean annual rainfall is probably about 42 inches, or a little greater than that of the St. Croix basin, and winter conditions are similar to those of the St. Croix.

In the whole Machias basin there are 54 square miles of lake surface, which are, however, largely near the headwaters. They are utilized to a small extent for log-driving.

There are good water-power sites on the Machias and its principal branch, and developments have been made at Machias, East Machias, and Whitneyville. The river is one of promise as regards storage possibilities when conditions warrant development.

Lake Storage.

The following table gives the areas of the various lakes and ponds in the basin as recently measured from available maps, together with estimates of the present, as well as the possible storage capacities. See page 85 for an explanation of the tables.

Storage in Machias River Basin.

CONNECTED WITH EAST BRANCH.

NAME.	Location.	Surface area, sq. miles.	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Barrows Lake....	Alexander.......	1.13	3	94,508,000	5	157,513,000
Beaver Dam Lake	T 26, E D.......	0.99	....	....	5	137,998,000
Crawford Lake....	Crawford & T 21, E D.........	2.68	9	672,427,000	15	1,120,711,000
Gardners Lake....	Marion..........	8.71	5	1,214,104,000	10	2,428,209,000
Hadley Lake.....	East Machias....	2.80	5	390,298,000	10	780,595,000
Josh Lake........	Whiting.........	0.06	....	....	5	8,364,000
Little Seavy Lake	Wesley..........	0.13	....	....	5	18,121,000
Long Lake.......	Wesley, Northfield, Ts 18 & 19, E D.........	0.90	6	150,543,000	10	250,906,000
Love Lake.......	Crawford & 19 E D...........	1.78	6	297,742,000	10	496,236,000
Mud Lake........	Alexander.......	0.24	....	....	5	33,454,000
Munson Lake.....	T 19, E D, & 18, E D...........	0.14	....	....	5	19,515,000
Patrick Lake.....	Marion & T 14, E D...........	0.61	....	....	5	85,029,000
Pocamoonshine Lake..........	Princeton........	4.17	....	....	5	581,264,000
Pond	T 19, E D.......	0.09	....	....	5	12,545,000
"	Marion..........	0.09	....	....	5	12,545,000
Rocky Lake......	T 18, E D.......	2.69	5	374,964,000	10	749,929,000
Round Lake......	Ts 18 & 19, E D..	0.51	5	71,090,000	10	142,180,000
Second Lake.....	T 18, E D.......	0.56	....	....	10	156,119,000
Spectacle Lakes...	T 19, E D.......	0.53	....	....	5	73,878,000
Total........	....	28.81		3,265,676,000		7,265,111,000

CONNECTED WITH WEST BRANCH.

NAME.	Location.	Surface area, sq. miles.	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Bog Lake........	Northfield.......	1.45	6	242,543,000	10	404,237,000
Bowles Brook Lake..........	T 31, M D.......	0.16	....	....	5	22,303,000
Cranberry Lake...	Ts 30 & 36, M D..	0.63	....	....	10	175,634,000
First Lake.......	T 37, M D.......	0.34	....	....	10	94,787,000
First Chain Lake..	T 26, E D.......	0.53	5	73,878,000	10	147,756,000
Fletcher Brook Flowage.......	T 42, M D.......	0.10	....	....	10	27,878,000
Fourth Lake.....	T 37, M D.......	0.02	....	....	5	2,788,000
Goose Pond......	T 24, M D.......	0.04	....	....	5	5,576,000
Grass Pond......	T 24, M D.......	0.03	....	....	5	4,182,000
Great Brook Lake	Marshfield.......	0.11	....	....	5	15,333,000
Green Lake......	T 35, M D.......	0.11	....	....	5	15,333,000
Horse Lake......	T 37, M D.......	0.04	....	....	5	5,576,000
Knox Lake.......	T 36, M D.......	0.11	....	....	5	15,333,000

Storage in Machias River Basin—Continued.
CONNECTED WITH WEST BRANCH—Continued.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Lake of the Green Isle	T 35, M D	0.14	....	....	5	19,515,000
Lily Lake	Marshfield	0.04	....	....	5	5,576,000
Lily Lakes	T 30, M D	0.12	....	....	5	16,727,000
Little Machias Lake	T 41, M D	0.04	....	....	5	5,576,000
Machias First Lake	T 37, M D	0.55	5	76,666,000	10	153,331,000
Machias Second Lake	T 37, M D	0.46	5	64,120,000	10	128,241,000
Machias Third Lake	Ts 42 & 43, M D, & T 5, N D	3.59	10	1,000,835,000	15	1,501,252,000
Machias Fourth Lake	Ts 41 & 42, M D, & T 5, N D	3.42	7	667,409,000	10	953,442,000
Machias Fifth Lake	Ts 35, 36, 41, 42, M D	2.66	7	519,096,000	10	741,565,000
Machias Lake	T 42, M D	0.89	....	....	10	248,118,000
Mark Longfellow Lake	Marshfield	0.33	....	....	5	45,999,000
Mopang Lake	T 30, M D	0.44	7	85,866,000	10	122,665,000
North Sabao Lake	T 35, M D	0.18	....	....	10	50,181,000
Peaked Mt. Pond	Northfield & Centerville	0.50	....	....	10	139,392,000
Peep Lake	T 30, M D	0.02	....	....	10	5,576,000
Pond	T 26, E D	0.12	....	....	10	33,454,000
"	T 19, M D	0.07	....	....	5	9,757,000
"	T 24, M D	0.04	....	....	10	11,151,000
"	T 24, M D	0.03	....	....	10	8,364,000
"	T 24, M D	0.04	....	....	10	11,151,000
"	T 30, M D	0.02	....	....	10	5,576,000
"	T 30, M D	0.04	....	....	10	11,151,000
"	T 35, M D	0.04	....	....	10	11,151,000
"	T 35, M D	0.03	....	....	10	8,364,000
"	T 35, M D	0.01	....	....	10	2,788,000
"	T 43, M D	0.02	....	....	10	5,576,000
"	T 43, M D	0.02	....	....	10	5,576,000
"	T 43, M D	0.02	....	....	10	5,576,000
Pretty Pond	T 24, M D	0.08	....	....	10	22,303,000
Sam Hill Lake	T 31, M D	0.13	....	....	5	18,121,000
Seavy Lake	Wesley	0.27	....	....	10	75,272,000
" "	Marshfield	0.04	....	....	5	5,576,000
Sabao Lake	T 35, M D	0.74	7	144,410,000	10	206,300,000
Second Lake	T 37, M D	0.40	....	....	10	111,514,000
" "	Marshfield	0.14	....	....	5	19,515,000
Second Chain Lake	T 26, E D, & Ts 31 & 37, M D	3.16	5	440,479,000	10	880,957,000
Second Great Brook Lake	Marshfield	0.17	....	....	5	23,697,000
Second Mopang Lake	Ts 29 & 30, M D	0.38	....	....	10	105,938,000
Six Mile Lake	Marshfield	0.19	....	....	5	26,484,000
Third Lake	T 37, M D	0.20	....	....	5	27,878,000
Third Chain Lake	T 26, E D	0.26	5	36,242,000	10	72,484,000
Third Mopang Lake	T 29, M D	0.81	....	....	10	225,815,000
Trout Brook Lake	T 31, M D	0.05	....	....	5	6,970,000
Unknown Lake	T 4, N D	0.49	....	....	5	68,302,000
Total	....	25.06		3,351,544,000		7,100,633,000

Summary of Storage in Machias Basin.

Basin.	Drainage area, sq. miles.	Lake surface area, sq. miles.	Ratio water surface to drainage area.	Present storage, cubic feet.	Possible storage capacity, cubic feet.
East Branch	345	28.85	12.0	3,265,676,000	7,265,111,000
West Branch	495	25.06	19.8	3,351,544,000	7,100,633,000
Total	840	53.91	15.6	6,617,220,000	14,365,744,000

Stream Flow.

MACHIAS RIVER AT WHITNEYVILLE.

This station was established October 17, 1903, and was originally located at the bridge of the Washington County Railroad, near Whitneyville, about 8 miles above the mouth of the river. On October 3, 1905, the gage was transferred to the wooden highway bridge, about one-half a mile up stream from the railroad bridge.

The record of run-off from 1903 to 1909 was published in the 1st Annual Report, page 97. The corrected monthly estimates of discharge for 1910 and 1911 are given in the table below.

Monthly Discharge of Machias River at Whitneyville for 1910 and 1911.

[DRAINAGE AREA 465 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
January	3,380	642	1,210	2.60	3.00
February	2,650	642	1,110	2.39	2.49
March	4,300	937	1,520	3.27	3.77
April	3,680	937	1,770	3.81	4.25
May	3,480	1,070	2,150	4.62	5.33
June	1,280	937	1,050	2.26	2.52
July	1,800	343	718	1.54	1.78
August	482	191	283	.609	.70
September	642	105	242	.520	.58
October	587	105	172	.370	.43
November	224	132	145	.312	.35
December	1,070	81	293	.630	.73
The year	4,300	81	888	1.91	25.93
1911					
January	1,350	161	510	1.10	1.27
February	482	161	355	.763	.79
March	4,580	161	648	1.39	1.60
April	3,010	1,140	1,700	3.66	4.08
May	1,720	698	1,260	2.71	3.12
June	2,560	482	1,500	3.23	3.60
July	1,070	105	302	.649	.75
August	300	81	174	.374	.43
September	343	161	247	.531	.59
October	534	132	229	.492	.57
November	1,280	161	461	.991	1.11
December	3,380	343	899	1.93	2.22
The year	4,580	81	690	1.48	20.13

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

COASTAL DISTRICT, NUMBER 2.

This district lies to the west of the Machias River basin and includes the basins of the Pleasant, Narraguagus, Tunk, Chandlers, Patten, Bagaduce, and many small tidal streams. The district does not include the Union River, as that is made a separate basin, but it includes two small basins west of the Union as well as the larger islands at the mouth of Penobscot Bay.

The following table gives the areas of the various lakes and ponds in the district as measured on the U. S. Geological Survey topographic sheets, the series of maps in the office of the State Assessors and in the case of some of the older incorporated towns, county atlases where more recent maps were not available. See page 85 of this report for an explanation of these tables.

Storage in Coastal Basin, No. 2.

CONNECTED WITH PLEASANT RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Pleasant Pond....	Beddington & T 29, M D.......	1.85	5	257,876,000	5	257,876,000
Pond	Beddington......	0.04	....	....	5	5,576,000
"	T 29, M D.......	0.12	....	....	5	16,727,000
"	T 19, M D.......	0.15	....	....	5	20,909,000
Southwest Pond..	Beddington......	0.26	....	....	5	36,242,000
Total........	....	2.42		257,876,000		337,330,000

Storage in Coastal Basin, No. 2—Continued.

CONNECTED WITH NARRAGUAGUS RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Baker Brook Flowage.......	T 29, M D.......	0.81	....	....	5	112,908,000
Chalk Pond......	T 22, M D & Beddington.......	0.17	....	....	5	23,697,000
Deer Pond.......	T 34, M D.......	0.06	....	....	5	8,364,000
Eagle Pond......	T 34, M D.......	0.42	....	....	5	58,545,000
Lake of the Woods	T 35, M D.......	0.13	....	....	5	18,121,000
Narraguagus Pond	Ts 9 & 10, S D & 16, M D.......	0.86	....	....	10	239,754,000
Narraguagus Lake	Beddington......	0.70	....	....	10	195,149,000
Pond	Deblois	0.09	....	....	5	12,545,000
"	"	0.06	....	....	5	8,364,000
"	T 34, M D.......	0.03	....	....	5	4,182,000
"	T 34, M D.......	0.02	....	....	5	2,788,000
"	T 34, M D.......	0.01	....	....	5	1,394,000
"	T 34, M D.......	0.03	....	....	5	4,182,000
"	T 35, M D.......	0.01	....	....	10	2,788,000
Schoodic Pond....	Cherryfield, Columbia, T 18, M D...........	0.54	....	....	5	75,272,000
Spruce Mt. Pond..	Beddington......	1.09	....	....	5	151,937,000
Third Pond......	T 28, M D.......	0.32	....	....	10	89,211,000
Total........	....	5.34				1,009,201,000

Storage in Coastal Basin, No. 2—Continued.

CONNECTED WITH TUNK STREAM.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Anderson Pond...	T 10, S D.......	0.06	....	....	5	8,364,000
Bluff Pond.......	T 10, S D.......	0.02	....	....	5	2,788,000
Downing Pond....	T 10, S D.......	0.16	9	40,145,000	10	44,605,000
Great Tunk Pond.	Ts 7 & 10, S D & Sullivan.......	2.49	11	763,590,000	11	763,590,000
Little Long Pond.	T 10, S D.......	0.06	....	....	5	8,364,000
Little Round Pond	T 10, S D.......	0.01	....	....	5	1,394,000
Little Tunk Pond.	Sullivan.........	0.29	....	....	5	40,424,000
Long Pond.......	T 10, S D.......	0.42	12	140,507,000	12	140,507,000
Roan Pond.......	T 10, S D.......	0.28	....	....	5	39,030,000
Round Pond.....	T 7, S D........	0.04	....	....	5	5,576,000
Silver Pond......	T 10, S D.......	0.01	....	....	5	1,394,000
Total........	....	3.84		944,242,000		1,056,036,000

CONNECTED WITH TIDEWATER.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Aunt Betty Pond.	Mt. Desert.......	0.04	....	....	5	5,576,000
Ball Pond........	Bluehill.........	0.02	....	....	5	2,788,000
Blunts Pond.....	Lamoine........	0.05	....	....	5	6,970,000
Burnt Land Pond.	Stonington......	0.04	....	....	5	5,576,000
Cain Pond.......	Searsport........	0.06	....	....	5	8,364,000
Donnels Pond....	T 9, S D, Franklin	2.03	11	622,525,000	11	622,525,000
Eagle Lake.......	Mt. Desert......	0.71	....	....	5	98,968,000
Echo Lake.......	"	0.38	....	....	5	52,969,000
First Pond.......	Bluehill.........	0.14	....	....	5	19,515,000
Flanders Pond....	Sullivan.........	0.95	....	....	5	132,422,000
Forbes Pond.....	Gouldsboro......	0.34	....	....	5	47,393,000
Fourth Pond.....	Bluehill.........	0.07	....	....	5	9,757,000
Fox Pond........	T 10, S D.......	0.16	....	....	5	22,303,000
Fresh Pond......	North Haven....	0.16	....	....	5	22,303,000
Great Pond......	Franklin........	0.51	....	....	10	142,180,000
Hadlock Ponds...	Mt. Desert.......	0.09	....	....	5	12,545,000
Jones Pond......	Gouldsboro......	0.68	....	....	5	94,787,000
Jordan Pond.....	Mt. Desert.......	0.30	....	....	5	41,818,000
Lake Wood......	Eden...........	0.03	....	....	5	4,182,000
Lily Pond........	Gouldsboro......	0.02	....	....	5	2,788,000
Lily Pond........	Deer Isle........	0.06	....	....	5	8,364,000
Little Muckleberry Pond.....	T 7, S D........	0.02	....	....	5	2,788,000
Little Round Pond	Mt. Desert.......	0.02	....	....	5	2,788,000

Storage in Coastal Basin, No. 2—Continued.

CONNECTED WITH TIDEWATER—Concluded.

NAME	Location.	Surface area, sq. miles.	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Long Pond	Mt. Desert	1.34			5	186,786,000
Long Pond	Isle au Haut	0.10			5	13,939,000
McClures Pond	Searsport	0.08			5	11,151,000
Meadow Pond	North Islesboro	0.02			5	2,788,000
Morency Pond	Sullivan & T 7,S D	0.16			5	22,303,000
Norris Pond	Bluehill	0.06			5	8,364,000
Otter Bog Pond	T 9, S D	0.01			5	1,394,000
Pond of Witch Hollow	Eden	0.03			5	4,182,000
Pond	Sullivan	0.06			5	8,364,000
"	"	0.24			5	33,454,000
Salt Pond	Bluehill	0.93			5	129,635,000
Seal Cove Pond	Tremont	0.46			5	64,120,000
Second Pond	Bluehill	0.10			5	13,939,000
Somes Pond	Mt. Desert	0.16			5	22,303,000
Third Pond	Bluehill	0.36			5	50,181,000
Torry Pond	Deer Isle	0.06			5	8,364,000
Turtle Lake	Mt. Desert	0.04			5	5,576,000
Total		11.09		622,525,000		1,956,512,000

CONNECTED WITH BAGADUCE RIVER.

NAME	Location.	Surface area, sq. miles.	Present Feet.	Present Cubic feet.	Possible Feet.	Possible Cubic feet.
Black Pond	Sedgwick	0.06			5	8,364,000
Frost Pond	"	0.25			5	34,848,000
Parker Pond	Brooksville	0.09			5	12,545,000
Pierce Pond	Penobscot	0.17			5	23,697,000
Snake Pond	Brooksville	0.04			5	5,576,000
Walker Pond	Sedgwick & Brooksville	1.07			5	149,149,000
Wight Pond	Penobscot	0.19			5	26,484,000
Total		1.87				260,663,000

Storage in Coastal Basin, No. 2—Concluded.

CONNECTED WITH PATTEN STREAM.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Lower Patten Pond	Surry	1.15	....	....	5	160,301,000
Upper Patten Pond	Orland & Surry	0.56	....	....	5	78,060,000
Total		1.71				238,361,000

Summary of Storage in Coastal Basin, No. 2.

Basin.	Lake surface area, sq. miles.	Present storage, cubic feet.	Possible storage capacity, cubic feet.
Pleasant River	2.42	257,876,000	337,330,000
Narraguagus River	5.34	....	1,009,201,000
Tunk Stream	3.84	944,242,000	1,056,036,000
Tidewater	11.09	622,525,000	1,956,512,000
Bagaduce River	1.87	....	260,663,000
Patten Stream	1.71	....	238,361,000
	26.27	1,824,643,000	4,858,103,000

UNION RIVER DRAINAGE BASIN.

Description.

The Union River is located mainly in Hancock County in the southeastern part of the State. The main river is formed by the junction of the East and West branches in the towns of Waltham and Mariaville. From the junction the river flows in a general southerly direction for 15 miles, meeting tidewater at Ellsworth.

The East Branch has its source in the Lead Mountain ponds of Township 28, M. D. It thence flows southerly for 8 or 9 miles to Rocky Pond; thence in a southwesterly direction 7 miles or so to Spectacle Pond; thence northerly and westerly some 10 miles by river to its junction with the West Branch.

The West Branch rises in the extreme northern end of Hancock County in Townships 39 M. D. and 40 M. D. It flows in a general direction a little west of south for about 35 miles joining the East Branch about 0.9 mile above Jordans Bridge. During its course it passes through Brandy and Great ponds and in addition receives the drainage from a number of other ponds, the largest of which are Alligator Pond and Long Pond. Above Great Pond the basin is largely covered with young growth of timber. There is little cultivated land in the whole course of the river except in the town of Amherst.

The tributaries of the main river are on the west, Branch Lake Outlet which enters between Ellsworth and Ellsworth Falls, Green Lake Stream which enters just above Brimmers Bridge, Beech Hill Stream and Floods Pond Outlet. On the east the main tributary is Webbs Brook.

River and Lake Surveys.

During 1909, the U. S. Geological Survey in coöperation with the State of Maine surveyed certain sections of the river as well as a number of the more important lakes.

The following maps, the results of these surveys may be obtained from the State Water Storage Commission, Augusta, Maine; Union River, Ellsworth to Great Pond, 2 sheets; Abraham, Scammons and Molasses ponds and Webbs Pond Outlet; Alligator, Rocky and Spectacle ponds; Great Pond, Green Lake Outlet and Branch Lake Outlet.

The following lakes are shown on the Ellsworth Quadrangle of the U. S. Geological Survey: Green Lake, Beech Hill Pond, and Webbs Pond. Branch Lake is shown on the Orland Quadrangle.

Lake Storage.

From the surveys and maps just described and from other maps, the areas of the various lakes and ponds in the basin have been measured. The special lake maps described above show not only the water line but also several contour lines above the shore lines and in these cases accurate computations of the capacities as storage reservoirs of a number of the lakes were made. On other ponds a storage height was assumed, and the capacity in cubic feet computed directly. For further explanations of the table, see page 85 of this report. Complete reports on the storage capacities of a number of these lakes are given in the 1st Annual Report, pages 106 to 126.

Storage in Union River Basin.

CONNECTED WITH EAST BRANCH.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Giles Pond.......	Aurora..........	0.19	....	....	10	52,969,000
Lead Mt. Pond, east..........	T 22 & 28, M D..	1.38	....	....	5	192,361,000
Lead Mt. Pond, center.........	T 28, M D.......	0.16	....	....	5	22,303,000
Lead Mt. Pond, west..........	T 28, M D.......	0.35	....	....	5	48,787,000
Middle Branch Ponds (lower)..	Aurora..........	0.51	....	....	5	71,090,000
Middle Branch Ponds (upper)..	Aurora..........	0.90	....	....	5	125,453,000
Pond...........	Aurora..........	0.04	....	....	5	5,576,000
Rocky Pond......	T 22, M D.......	0.96	3	80,290,000	8	140,000,000
Spectacle Pond...	T 21, M D.......	2.74	5	414,000,000	10	888,000,000
Total........	....	7.23		494,290,000		1,546,539,000

CONNECTED WITH WEST BRANCH.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Alligator Pond....	Ts 28 & 34, M D..	1.73	....	....	5	258,000,000
Brandy Pond.....	T 39, M D.......	0.94	....	....	10	262,057,000
Great Pond......	T 33, M D.......	1.01	....	....	23	1,591,000,000
Hopkins Pond....	Clifton & Mariaville..........	1.85	....	....	5	257,876,000
L.ttle Pond......	T 33, M D.......	0.17	....	....	5	23,697,000
Long Pond.......	Aurora & T 33, M D..........	0.90	....	....	5	125,453,000
Morrisons Pond...	T 33, M D.......	0.40	....	....	5	55,757,000
Pond	T 40, M D.......	0.02	....	....	5	2,788,000
"	T 40, M D.......	0.02	....	....	5	2,788,000
"	T 40, M D.......	0.01	....	....	5	1,394,000
"	T 40, M D.......	0.01	....	....	5	1,394,000
"	T 40, M D.......	0.01	....	....	5	1,394,000
"	T 40, M D.......	0.03	....	....	5	4,182,000
"	Amherst	0.03	....	....	5	4,182,000
"	"	0.01	....	....	5	1,394,000
"	"	0.03	....	....	5	4,182,000
Rift Pond.......	T 33, M D.......	0.21	....	....	10	58,545,000
Total........	....	7.38				2,656,083,000

Storage in Union River Basin—Continued.

CONNECTED WITH MAIN RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Abraham Pond	Eastbrook, Franklin	0.69	....	....	5	190,000,000
Beech Hill Pond	Otis	2.09	5	322,000,000	21	1,592,700,000
Bog Pond	Ellsworth	0.02	....	....	5	2,788,000
Branch Lake	"	4.33	4	482,300,000	14	2,242,800,000
Burnt Pond	Otis	0.11	....	....	5	15,333,000
Burnt Pond	Dedham, Otis, Clifton	0.52	....	....	5	72,484,000
Floods Pond	Otis	1.01	....	....	20	920,000,000
Georges Pond	Franklin	0.93	....	....	5	129,635,000
Goose Pond	Dedham	0.31	....	....	5	43,212,000
Green Lake	Dedham, Ellsworth	4.43	4	534,800,000	24	3,796,500,000
Harriman Pond	Dedham	0.10	....	....	5	13,939,000
Hat Case Pond	"	0.26	....	....	5	36,242,000
King Pond	T 33, M D	0.20	....	....	5	27,878,000
Little Duck Pond	Dedham, Ellsworth	0.09	....	....	5	12,545,000
Little Hat Case Pond	Dedham	0.01	....	....	5	1,394,000
Little Rocky Pond	Dedham, Ellsworth	0.09	....	....	5	12,545,000
Little Webb Pond	Waltham	0.12	....	....	5	16,727,000
Molasses Pond	Eastbrook	1.90	5	286,000,000	5	286,000,000
Mountain Pond	Dedham	1.09	....	....	5	151,937,000
Muddy Pond	Otis	0.02	....	....	5	2,788,000
Rocky Pond	Otis	0.19	....	....	5	26,484,000
Rocky Pond	Orland	0.24	....	....	5	33,454,000
Scammon Pond	Eastbrook	1.11	5	100,000,000	5	100,000,000
Webbs Pond	Waltham, Eastbrook	1.43	3	147,800,000	7	431,000,000
Wormwood Pond	Ellsworth	0.01	....	....	5	1,394,000
Youngs Pond	Otis	0.03	....	....	5	4,182,000
Brimmer's Bridge Reservoir Site	Ellsworth, No. 8, Waltham, Mariaville	18.19	....	....	17	6,126,300,000
Total	....	39.52		1,872,900,000		16,290,261,000

Summary of Storage in Union River Basin.

Basin.	Drainage area, sq. miles.	Lake surface area, sq. miles.	Ratio water surface to drainage area.	Present storage, cubic feet.	Possible storage capacity, cubic feet.
East Branch	123	7.23	17.0	494,290,000	1,546,539,000
West Branch	172	7.38	23.3	....	2,656,083,000
Main River	242	39.52	......	1,872,900,000	16,290,261,000
Total	537	54.13	......	2,367,190,000	20,492,883,000

STREAM FLOW.

GREEN LAKE STREAM AT LAKEWOOD.

A gaging station was established July 2, 1909, at the highway bridge across Green Lake Stream about 1-4 mile downstream from the dam at the outlet of Green Lake.

The monthly estimates of discharge since the establishment of the station are given in the table below.

Monthly Discharge of Green Lake Stream at Lakewood.

[DRAINAGE AREA 47 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1909					
July	47	38	43.0	.915	1.05
August	331	44	98.5	2.10	2.42
September	177	74	118	2.51	2.80
October	26	16	22.2	.472	.54
November	19	7	12.5	.266	.30
December	119	16	77.0	1.64	1.89
1910					
January	211	70	104	2.21	2.55
February	194	108	152	3.23	3.36
March	376	96	202	4.30	4.96
April	268	96	166	3.53	3.94
May	256	96	150	3.19	3.68
June	92	56	67.4	1.43	1.60
July	62	49	54.3	1.16	1.34
August	96	49	56.6	1.20	1.38
September	211	77	122	2.60	2.90
October	146	44	68.2	1.45	1.67
November	49	38	46.9	.998	1.11
December	146	19	87.7	1.87	2.16
The year	376	19	106	2.26	30.65
1911					
January	19	12	14.3	.304	.35
February	211	12	128	2.72	2.83
March	108	12	54.5	1.16	1.34
April	74	18	43.7	.930	1.04
May	70	28	38.7	.823	.95
June	49	28	39.5	.840	.94
July	146	49	58.4	1.24	1.43
August	288	49	107	2.28	2.63
September	177	49	124	2.64	2.94
October	146	19	78.2	1.66	1.91
November	49	19	24.5	.521	.58
December	96	13	19.9	.423	.49
The year	288	12	60.3	1.28	17.43

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

BRANCH LAKE STREAM NEAR ELLSWORTH.

A record of stage of Branch Lake and also that of Branch Lake Stream just below the outlet dam have been furnished since July 2, 1909, by H. B. Moor.

The monthly estimates of discharge since the establishment of the station is given in the table below.

Monthly Discharge of Branch Lake Stream near Ellsworth.

[DRAINAGE AREA 31 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1909					
July	118	10	66.6	2.15	2.48
August	120	2	53.0	1.71	1.97
September	80	2	47.4	1.53	1.71
October	94	10	51.4	1.66	1.91
November	109	10	54.6	1.76	1.96
December	125	34	69.8	2.25	2.59
The year	....	....	....	1.84	12.62
1910					
January	88	27	45.3	1.46	1.68
February	81	30	55.7	1.80	1.87
March	293	38	119	3.84	4.43
April	220	34	102	3.29	3.67
May	223	46	112	3.61	4.16
June	139	34	81.5	2.63	2.93
July	116	18	57.8	1.86	2.14
August	118	35	75.0	2.42	2.79
September	118	1	58.3	1.88	2.10
October	100	1	54.0	1.74	2.01
November	93	45	62.4	2.01	2.24
December	93	26	42.1	1.36	1.57
The year	293	1	72.2	2.33	31.59
1911					
January	40	8	22.0	0.710	0.82
February	10	5	8.7	.281	.29
March	64	5	45.4	1.46	1.68
April	80	5	64.9	2.09	2.33
May	95	12	63.8	2.06	2.38
June	99	12	68.0	2.19	2.44
July	91	5	48.8	1.57	1.81
August	94	5	55.9	1.80	2.08
September	90	5	50.3	1.62	1.81
October	60	18	33.0	1.06	1.22
November	47	10	23.9	.771	.86
December	56	22	31.0	1.00	1.15
The year	99	5	43.2	1.39	18.87

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301

PENOBSCOT DRAINAGE BASIN.

DESCRIPTION.

The West, or principal branch of Penobscot River rises in the mountainous region of Maine near the Canadian boundary at an elevation of about 2000 feet and flows in a general southeasterly direction to its junction with the East Branch of the river at Medway, a distance of over 100 miles.

The East Branch of the Penobscot formerly had its rise in small lakes and ponds lying about midway between the western and eastern boundaries of the State, but about 1840 the drainage area tributary to Chamberlain and Telos lakes, whose natural flow is into the St. John basin, was added to that of the East Branch by means of an artificial cut or canal from Telos Lake to Webster Lake. This additional drainage area amounts to about 270 square miles, and affords excellent opportunities for storage. The elevation of Chamberlain and Telos lakes is about 938 feet above mean sea level, while that of Allagash Lake, the principal tributary of these lakes, is about 1042 feet.

From the mouth of the East Branch to tidewater at Bangor is about 75 miles, this latter point being 27 miles above what is commonly known as the mouth of the river opposite Sandy Point or the head of Penobscot Bay. The total length of the river is, therefore, about 200 miles. The drainage basin has an extreme breadth of about 115 miles and comprises 8500 square miles or more than one-fourth of the entire State.

The basin lies in general at a somewhat lower elevation than that of Kennebec River, for the latter is nearer to the summit mountain range on the western boundary of the State. As a whole, it is rather uniform in its topographic features, hills and low mountains stretching from the region near the sea to a point above Bangor. Farther north its surface is an undulating plain, westward it becomes more broken and is generally diversified by hills, detached peaks, lakes, ponds, and swamps. The headwaters of the Kennebec, Penobscot, and St. John are all in the same vicinity, a highland region intermingled with swamps and lagoons. Mount Katahdin, the highest peak of which is 5,273 feet above mean tide and the highest mountain in the State, lies in a detached range of mountains between the West and East branches of the Penobscot.

The predominant rocks of the Penobscot basin are shales, slates, and schists. In the Mount Katahdin region and near the mouth of the river granite also occurs in considerable areas. The character of the river valley is determined largely by the prevailing rocks. Thus, for many miles above Bangor the river flows through an area where the rocks are relatively soft shales, slates, schists, and its valley here is broad. Between Hampden and Bucksport, however, where harder granites and schists are found, the valley is narrow with steep walls, and a short distance below Ripogenus Lake some of the finest river scenery in the country is found.

Chesuncook Lake lies near the center of the basin at an elevation of 930 feet above sea level. From this point to tide water the distance along the river is 126 miles, or an average fall of 7.4 feet per mile.

Nearly two-thirds of the Penobscot River basin consists of timber land. Spruce prevails, although white pine, cedar and white birch are also produced in considerable quantities.

The mean annual precipitation varies from about 43 inches near the coast to less than 35 inches in the northern portions, the mean for the whole basin being about 39 inches, slightly less than that of the Kennebec.

The river freezes over during the winter and large accumulations of snow occur.

The natural storage facilities of the Penobscot, with its total lake and pond surface of approximately 407 square miles, are surpassed only by those of the Kennebec and Androscoggin basins. On the West Branch some 33 billion cubic feet of storage in the Twin and Chesuncook Lake systems is utilized in connection with the developments of the Great Northern Paper Co., at and near Millinocket, with marked effect upon the regimen of flow. On the East Branch Chamberlain and Allagash lakes and a number of others are capable of storing much of the flow. Mattawamkeag and Piscataquis rivers all have good storage possibilities and it is safe to say that eighty or ninety billion cubic feet of water could economically be stored in the various portions of the Penobscot basin. The total possible storage in the entire basin is approximately 160,700,000,000 cubic feet as shown in tables below. Storage on the West Branch of the river is very efficiently controlled by the Great Northern Paper Co., but in all other localities the stored water is used only for log driving, and a systematic regulation of stored flow would be of great benefit to present and future users of power.

Log driving is an important industry on the Penobscot, and the annual drive amounts to over 200,000,000 feet b. m. The river is navigable to Bangor except during the winter months.

The longest run-off record in the Penobscot basin is that at Millinocket, beginning in 1901. The driest year at that point since 1900 was 1911, and the wettest was 1902, the total flow during these two years being in the ratio of 1 to 2.36. Storage on the West Branch has very materially changed the regimen of flow since 1901.

River and Lake Surveys.

Surveys have been made in the Penobscot River drainage basin by the United States Geological Survey in coöperation with the State of Maine as follows:

Penobscot River, from tide water to Seboomook Falls, near Northwest Carry; East Branch Penobscot River, from Grand Lake to mouth; Mattawamkeag River, from North Bancroft to mouth.

Piscataquis River, mouth to Blanchard; Sebec River; Pleasant River; Big Houston Stream.

Allagash, Chamberlain, Telos, Webster, Second, and Grand lakes in East Branch Penobscot drainage basin.

Mattawamkeag and Baskahegan lakes and Pleasant Pond in Mattawamkeag drainage basin.

Schoodic, Seboois, Endless, Sebec and Silver lakes and Big Houston Pond in Piscataquis drainage basin.

From the data collected by the river surveys, sheets have been prepared showing as far as available the profile of water surface, plan of the river, contours along the banks, and prominent natural or artificial features.

From the lake surveys, sheets have been prepared showing as far as possible the shore lines and bank contours covering any probable increase in storage capacity.

The results of these surveys have been published on sheets which may be had on application to State Water Storage Commission, Augusta, Maine.

LAKE STORAGE.

From the lake maps, described above, accurate computations of the storage capacities for varying heights can be determined. It will be many years, however, before such detailed maps of all the lakes and ponds of the basin can be prepared.

Meanwhile, this department has undertaken the planimeter measurements of all the lakes and ponds in the State as can be found on the best maps available. For this purpose, the following maps are used: the special lake maps as issued by this department; the regular topographic sheets of the U. S. Geological Survey; the township plans in the office of the State Assessors; many private recent reservoir and township maps on file in this office; and in a few cases, county atlases where more accurate maps were not available.

The lake and pond areas as thus determined for the Penobscot are given in the tables below. There are also given in the same tables, estimates for each lake of the amount of present storage both in feet and in cubic feet and also of the possible storage in feet and cubic feet. For many of the sites more or less accurate information on this subject is available, that is, the amounts in cubic feet of both present and possible storage. Most of these reliable data are given in the 1st Annual Report under the subject headings of Lake Storage. For other lakes and ponds reports were at hand on the storage in feet, such as heights of dams, etc. In a large number of cases, however, no such information was available and an estimate of height was made and the corresponding capacity in cubic feet computed. In the capacity tables in the following pages, wherever the heights appear as 5 feet or 10 feet it is in almost all cases the assumed or estimated height of storage. For instance, under present storage, when it was known that there was a dam at the outlet of a pond and no other information was available, the height was put as 5 feet. The height of possible storage depends on a number of factors; as to whether the drainage area above is sufficient to contribute the amount of water to fill the reservoir to that height; whether the topography at the dam site is such that it will be feasible financially to build the dam; or whether settlements around the shores of the lake will permit raising to the height as contemplated. In the various capacity tables, these detailed studies have not been made on the 5 and 10-foot assumed heights. After scanning the base map of the State compiled in this office, if it was thought the drainage area was small or if any local conditions were known to exist, as settlements around the lake in question, the smaller height, that is, 5 feet was adopted. In other cases the 10-foot height was used. It is believed that this 10-foot height of possible storage is quite a conservative figure to adopt for all the lakes and ponds in the basin where exact information as to storage capacities was not available.

For more detailed information regarding certain of the storage basins reference should be made to the 1st Annual Report pages 165 to 195. There has just been issued by the U. S. Geological Survey, Water Supply Paper No. 279, entitled "Water Resources of the Penobscot River Basin," which gives a very detailed account of the potential water powers and reservoir capabilities of this basin.

Storage in Penobscot River Basin.

CONNECTED WITH WEST BRANCH.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Abacotnetic Bog	T 6, R 17	0.08	....	....	5	11,151,000
Abol Pond	T 2, R 9	0.19	....	....	10	52,969,000
Ambejejus Lake	T 1, R 9	......	....	A	....	....
Avery Pond	T 7, R 15	0.06	....	....	10	16,727,000
Beaver Pond	T 3, R 11	0.02	....	....	5	2,788,000
Beaver Pond	T 3, R 13	0.06	....	....	5	8,364,000
Beaver Bog	T 5, R 20	0.03	....	....	5	4,182,000
Big Lyford Pond	T A, R 12	0.17	....	....	5	23,697,000
Big Smith Brook Pond	Millinocket	0.24	....	....	5	33,454,000
Black Pond	Ts 6, R 13 & 14	0.60	....	....	10	167,270,000
Black Pond	T 1, R 12	0.46	....	....	5	64,120,000
Blackberry Pond	T 2, R 13	0.22	....	....	5	30,666,000
Bottle Pond	T 2, R 9	0.04	....	....	5	5,576,000
Caribou Lake	Ts 2 & 3, R 12 & T 3, R 13	5.86	....	B	....	....
Caucogomoc Lake	Ts 6 & 7, R 14 & T 6, R 15	7.00	8	1,357,950,000	15	2,872,850,000
Chain Pond	Ts 3 & 4, R 4, N B K P	0.35	....	....	5	48,787,000
Chesuncook Lake	Ts 3, 4, 5, R 12, 4 & 5, R 13	35.90	22	15,600,000,000	24	17,600,000,000
Chesuncook Pond	T 2, R 11	0.22	....	....	5	30,666,000
Compass Pond	T 2, R 9	0.14	....	....	5	19,515,000
Cooper Pond	T A, R 10	0.49	....	....	10	136,604,000
Cranberry Pond	T 3, R 14	0.12	....	....	5	16,727,000
Crawford Pond	T A, R 11	0.82	....	....	10	228,603,000
Cunningham Pond	T 2, R 4, N B K P	0.03	....	....	5	4,182,000
Cuxabexis Lake	T 5, R 12	1.54	....	....	6	257,597,000
Daggett Pond	T 7, R 14	0.76	....	....	10	211,876,000
Daisy Pond	T 3, R 10	0.01	....	....	5	1,394,000
Debsconeag, First Lake	T 2, R 10	0.51	....	....	5	71,090,000
Debsconeag, Second Lake	T 2, R 10	0.34	....	....	5	47,393,000
Debsconeag, Third Lake	Ts 1 & 2, R 10	1.54	....	....	5	214,664,000
Debsconeag, Fourth Lake	Ts 1, R 10 & 11	0.52	....	....	5	72,484,000
Deer Pond	T 2, R 13	0.25	....	....	5	34,848,000
Deer Pond	T 3, R 13	0.45	....	....	5	62,726,000
Dole Pond	T 3, R 5, N B K P	0.56	....	....	10	156,119,000
Draper Pond	T 3, R 10	0.01	....	....	10	2,788,000
Duck Pond	T 2, R 13	0.10	....	....	10	27,878,000
Duck Pond	Ts 4 & 5, R 12	0.99	....	....	5	137,998,000
Duncan Pond	T 4, R 4, N B K P	0.38	....	....	10	105,938,000
Elbow Lake	T 3, R 10	0.04	....	....	10	11,151,000
Elm Pond	T 4, R 16	0.90	....	....	10	250,906,000
Female Pond	T 1, R 12	0.22	....	....	10	61,332,000
Ferguson Lake	Millinocket	0.42	....	....	5	58,545,000
Fish Pond	T 5, R 20	0.04	....	....	5	5,576,000
Fish Pond	T 3, R 3, N B K P	0.09	....	....	10	25,091,000
Fish Pond	T 4, R 3, N B K P	0.48	....	....	5	66,908,000
Fisher Pond	T 2, R 12	0.05	....	....	5	6,970,000
Foley Pond	T 4, R 18	0.38	....	....	10	105,938,000
Frost Pond	T 3, R 11	0.34	....	....	5	47,393,000
Green Pond	T 2, R 12	0.03	....	....	5	4,182,000
Hale Pond	T 2, R 10	0.19	....	....	5	26,484,000
Hale Pond	T 3, R 3, N B K P	0.07	....	....	5	9,757,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH WEST BRANCH—Continued.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Harrington Lake..	Ts 3 & 4, R 11...	1.84	....	....	10	512,962,000
Henderson Pond..	Ts A & 1, R 11...	0.37	....	....	5	51,575,000
Holbrooks Pond..	T 2, R 11	0.25	....	....	5	34,848,000
Hurd Pond.......	T 2, R 10........	1.05	5	146,362,000	5	146,362,000
Hurd Pond.......	T 6, R 15........	0.76	....	....	5	105,938,000
Hurricane Pond...	T 5, R 20........	0.05	....	....	5	6,970,000
Jackson Pond....	Ts 3, R 10 & 11...	0.04	....	....	5	5,576,000
Jerry Pond.......	T A, R 7, T 1, R 7 & Millinocket..	0.12	....	....	5	16,727,000
Jo-Mary, Upper Lake..........	T A, R 8 & 9, T A, R 10.........	2.98	....	....	5	415,388,000
Jo-Mary, Middle Lake..........	T 4, Indian Purchase, T A, R 8 & 9, T A, R 10.	1.65	....	....	5	229,997,000
Jo-Mary, Lower Lake..........	T 4, Indian Purchase, T 1, R 9, Ts A & 1, R 10.	3.56	....	....	5	496,236,000
Jones Pond......	T 4, R 3, N B K P	0.62	....	....	5	86,423,000
Katahdin Pond...	T 2, R 9.........	0.64	....	....	5	89,211,000
Katahdin Pond...	T 3, R 10........	0.03	....	....	10	8,364,000
Kelly Pond......	T 2, R 12........	0.08	....	....	5	11,151,000
Kidney Pond.....	T 3, R 10........	0.03	....	....	10	8,364,000
Knowlton Pond...	T 3, R 10........	0.06	....	....	5	8,364,000
Leavitt Pond.....	T 1, R 11........	0.08	....	....	5	11,151,000
Lily Pad Pond....	T 3, R 10........	0.01	....	....	5	1,394,000
Little Lobster Lake..........	Ts 3, R 14 & 15..	0.38	....	....	10	105,938,000
Little Pine Pond..	Ts 3, R 14 & 15..	0.13	....	....	5	18,121,000
Lobster Lake.....	T X & Ts 3, R 14 & 15..........	4.80	....	....	10	1,338,163,000
Long Pond.......	T 3, R 5, N B K P	0.46	....	....	5	64,120,000
Long Pond.......	T A, R 11.......	0.50	....	....	5	69,696,000
Longley Pond....	T 6, R 13........	0.80	7	156,119,000	10	223,027,000
Loon Lake.......	T 6, R 15........	1.59	....	....	10	443,267,000
Lost Pond.......	T 3, R 10........	0.03	....	....	5	4,182,000
Millinocket Lake..	Ts 1 & 2, R 8, Ts 1 & 2, R 9......	13.95	10	2,440,000,000	22	6,719,000,000
Mink Pond.......	T 2, R 9........	0.04	....	....	5	5,576,000
Moose Pond......	Ts 5, R 12 & 13..	0.54	....	....	5	75,272,000
Mud Pond.......	Ts A & 1, R 10...	0.46	....	....	5	64,120,000
Mud Pond.......	T 4, R 12........	0.90	....	....	5	125,453,000
Mud Pond.......	Ts 1 & 2, R 13...	0.08	....	....	5	11,151,000
Muskrat Ponds...	T 1, R 11........	0.14	....	....	5	19,515,000
Nahmakanta Lake	Ts 1 & 2, R 11...	2.32	8	517,423,000	10	646,779,000
Nollesemic Pond..	T 3, R 9, N W P, T A, R 8 & 9, W E L S...........	1.10	....	....	5	153,331,000
Nulhedus Pond...	T 4, R 16........	0.72	....	....	5	100,362,000
Passamagormac Lake..........	Ts 1, R 9 & 10...	0.44	....	....	5	61,332,000
Pemadumcook Lake..........	Ts 1, R 9 & 10...	......	....	A		
Penobscot Lake..	Ts 3 & 4, R 4, T 3, R 5, N B K P..	1.96	....	....	10	546,417,000
Penobscot Pond..	Ts 1, R 11 & 12..	0.62	....	....	5	86,423,000
Pine Pond.......	T 3, R 13........	0.22	....	....	5	30,666,000
Poland Pond.....	Ts 7, R 14 & 15..	0.46	....	....	10	128,241,000
Pollywog Pond...	Ts 1 & 2, R 11, T 1, R 12........	0.70	....	....	5	97,574,000
Pond	Bradford........	0.03	....	....	5	4,182,000
"	Middlesex Canal..	0.06	....	....	5	8,364,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH WEST BRANCH—Continued.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Pond	Hopkins Academy Grant........	0.03	....	....	5	4,182,000
"	T 4, Indian Purchase........	0.04	....	....	5	5,576,000
"	T 4, Indian Purchase........	0.08	....	....	5	11,151,000
"	T 2, R 9........	0.01	....	....	5	1,394,000
"	T 2, R 9........	0.01	....	....	5	1,394,000
"	T 2, R 9........	0.02	....	....	5	2,788,000
"	T 3, R 9........	0.13	....	....	5	18,121,000
"	T 3, R 9........	0.16	....	....	5	22,303,000
"	T 3, R 9........	0.44	....	....	5	61,332,000
"	T 3, R 9........	0.17	....	....	5	23,697,000
"	T A, R 10........	0.15	....	....	5	20,909,000
"	T A, R 10........	0.08	....	....	5	11,151,000
"	T A, R 10........	0.05	....	....	5	6,970,000
"	T 2, R 10........	0.01	....	....	5	1,394,000
"	T 2, R 10........	0.02	....	....	5	2,788,000
"	T 2, R 10........	0.01	....	....	5	1,394,000
"	T 2, R 10........	0.02	....	....	5	2,788,000
"	T 2, R 10........	0.14	....	....	5	19,515,000
"	T 2, R 10........	0.04	....	....	5	5,576,000
"	T 2, R 10........	0.02	....	....	5	2,788,000
"	T 3, R 10........	0.01	....	....	5	1,394,000
"	T 3, R 10........	0.01	....	....	5	1,394,000
"	T 5, R 10........	0.13	....	....	5	18,121,000
"	T A, R 11........	0.02	....	....	5	2,788,000
"	T A, R 11........	0.02	....	....	5	2,788,000
"	T A, R 11........	0.02	....	....	5	2,788,000
"	T A, R 11........	0.005	....	....	5	697,000
"	T A, R 11........	0.02	....	....	5	2,788,000
"	T 1, R 11........	0.05	....	....	5	6,970,000
"	T 1, R 11........	0.05	....	....	5	6,970,000
"	T 1, R 11........	0.02	....	....	5	2,788,000
"	T 1, R 11........	0.04	....	....	5	5,576,000
"	T 1, R 11........	0.03	....	....	5	4,182,000
"	T 1, R 11........	0.01	....	....	5	1,394,000
"	T 1, R 11........	0.04	....	....	5	5,576,000
"	T 2, R 11........	0.06	....	....	5	8,364,000
"	T 2, R 11........	0.02	....	....	5	2,788,000
"	T 2, R 11........	0.01	....	....	5	1,394,000
"	T 2, R 11........	0.01	....	....	5	1,394,000
"	T 2, R 11........	0.01	....	....	5	1,394,000
"	T 2, R 11........	0.02	....	....	5	2,788,000
"	T 2, R 11........	0.03	....	....	5	4,182,000
"	T 3, R 11........	0.18	....	....	5	25,091,000
"	T 3, R 11........	0.05	....	....	5	6,970,000
"	T 3, R 11........	0.07	....	....	5	9,757,000
"	T 3, R 11........	0.03	....	....	5	4,182,000
"	T 4, R 11........	0.05	....	....	5	6,970,000
"	T 5, R 11........	0.20	....	....	5	27,878,000
"	T 1, R 12........	0.05	....	....	5	6,970,000
"	T 1, R 12........	0.06	....	....	5	8,364,000
"	T A, & T 1, R 12.	0.02	....	....	5	2,788,000
"	T 2, R 12........	0.02	....	....	5	2,788,000
"	T 2, R 12........	0.06	....	....	5	8,364,000
"	T 2, R 12........	0.08	....	....	5	11,151,000
"	T 2, R 12........	0.04	....	....	5	5,576,000
"	T 2, R 12........	0.04	....	....	5	5,576,000
"	T 2, R 12........	0.02	....	....	5	2,788,000
"	T 2, R 12........	0.03	....	....	5	4,182,000
"	T 1, R 12 & 13...	0.03	....	....	5	4,182,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH WEST BRANCH—Continued.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Pond	T 4, R 12	0.07			5	9,757,000
"	T 4, R 12	0.12			5	16,727,000
"	T 2, R 13	0.03			5	4,182,000
"	T 4, R 13	0.02			5	2,788,000
"	T 4, R 13	0.09			5	12,545,000
"	T 4, R 13	0.02			5	2,788,000
"	T 4, R 14	0.02			5	2,788,000
"	T 5, R 14	0.02			5	2,788,000
"	T 5, R 14	0.06			5	8,364,000
"	T 5, R 14	0.02			5	2,788,000
"	T 6, R 14	0.06			5	8,364,000
"	T 4, R 15	0.13			5	18,121,000
"	T 5, R 15	0.03			5	4,182,000
"	T 5, R 15	0.02			5	2,788,000
"	T 5, R 15	0.14			5	19,515,000
"	T 5, R 15	0.04			5	5,576,000
"	T 5, R 16	0.02			5	2,788,000
"	T 5, R 16	0.06			5	8,364,000
"	T 4, R 17	0.03			5	4,182,000
"	T 4, R 17	0.04			5	5,576,000
"	T 4, R 17	0.02			5	2,788,000
"	T 4, R 17	0.01			5	1,394,000
"	T 4, R 18	0.04			5	5,576,000
"	T 5, R 20	0.02			5	2,788,000
"	T 5, R 20	0.04			5	5,576,000
"	T 5, R 20	0.02			5	2,788,000
"	T 3, R 3, N B K P	0.03			5	4,182,000
"	T 3, R 3, N B K P	0.02			5	2,788,000
"	T 3, R 3, N B K P	0.05			5	6,970,000
"	T 3, R 3, N B K P	0.14			5	19,515,000
"	T 3, R 3, N B K P	0.05			5	6,970,000
"	T 2, R 4, N B K P	0.10			5	13,939,000
"	T 3. R 4,N B K P	0.03			5	4,182,000
"	Millinocket	0.10			5	13,939,000
"	T 4, R 4, N B K P	0.08			5	11,151,000
"	T 4, R 4, N B K P	0.03			5	4,182,000
"	T 4, R 4, N B K P	0.04			5	5,576,000
"	T 4, R 4, N B K P	0.15			5	20,909,000
"	T 4, R 4, N B K P	0.02			5	2,788,000
"	T 3, R 5, N B K P	0.43			5	59,939,000
Quakish Lake	Millinocket	1.70	2	94,787,000	...	1,000,000,000
Ragged Lake	Ts 2 & 3, R 13	3.24			5	451,630,000
Rainbow Lake	T 2, R 11	2.30	6	384,722,000	10	641,203,000
Rat Pond	T 2, R 9	0.09			5	12,545,000
Ripogenous Lake	Ts 3, R 11 & 12	1.27	10	301,100,000	56	9,301,100,000
River Pond	T 2, R 9	0.22			5	30,666,000
Roberts Pond	T 5, R 20	0.07			10	19,515,000
Rocky Pond	T 3, R 10	0.03			5	4,182,000
Rocky Pond	T A, R 11	0.28			5	39,030,000
Rocky Pond	T 2, R 11	0.10			5	13,939,000
Ross Pond	T 7, R 15	0.52			5	72,484,000
Round Pond	T 7, R 14	0.71			10	197,937,000
Round Pond	T 3, R 13 & 14	0.18			5	25,091,000
Russell Pond	T 4, R 15	0.89	6	148,871,000	10	248,118,000
Russell Pond	T 5, R 16	0.26			10	72,484,000
Seboomook Lake	Seboomook & T 1, R 4, N B K P	8.52	9	2,137,716,000	10	2,375,240,000
Shad Pond	Millinocket	0.36			5	50,181,000
Shallow Pond	T 7, R 13, Ts 6 & 7, R 14	1.72	6	287,705,000	10	479,509,000
Shirley Pond	T 7, R 14	0.52			5	72,484,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH WEST BRANCH—Concluded.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Slaughter Pond	T 3, R 11	0.10	....	....	5	13,939,000
Sourdnahunk Lake	T 4, R 10, T 5, R 10 & 11	3.84	....	....	4	428,213,000
Spencer Pond	T 4, R 18	0.04	....	....	5	5,576,000
Spruce Pond	T 2, R 4, N B K P	0.03	....	....	5	4,182,000
Tea Pond	T 2, R 9	0.05	....	....	5	6,970,000
Tracy Pond	T 3, R 10	0.01	....	....	5	1,394,000
Truesdell Pond	T 4, R 18	0.06	....	....	5	8,364,000
Twin Lake System	Millinocket, T 4, Indian Purchase, Ts 1, R 9 & 10	24.90	23	14,880,000,000	23	14,880,000,000
Twin Pond	T 2, R 9	0.09	....	....	5	12,545,000
Umbazooksus Lake	T 6, R 13	1.45	6	242,542,000	10	404,237,000
Wadleigh Pond	T 4, Indian Purchase	0.08	....	....	5	11,151,000
Wadleigh Pond	T 1, R 11	0.42	....	....	5	58,545,000
Wadleigh Pond	T 8, R 15	0.16	....	....	5	22,303,000
Williams Pond	T 4, R 11	0.04	....	....	5	5,576,000
Windy Pitch Pond	T 3, R 10	0.01	....	....	5	1,394,000
Yoke Pond	T A, R 11	0.38	....	....	5	52,969,000
Total	....	172.375		38,695,297,000		68,688,110,000

A Included in Twin Lake system.
B Included in Chesuncook Lake.

Storage in Penobscot River Basin—Continued.

CONNECTED WITH EAST BRANCH.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Allagash Lake	Ts 7 & 8, R 14	7.05	8	1,320,000,000	35	7,325,400,000
Beaver Pond	T 7, R 6 & 7	0.22	...	...	5	30,666,000
Big Pond	T 4, R 9	0.19	...	...	5	26,484,000
Billfish Pond	Ts 6, R 8 & 9	0.09	...	...	5	12,545,000
Blunder Pond	T 6, R 10	0.09	...	...	5	12,545,000
Bowlin Pond	T 5, R 8	0.52	4	57,987,000	10	144,968,000
Burnt Land Pond	T 2, R 7	0.14	...	...	10	39,030,000
Chamberlain Lake	Ts 6, R 11 & 12, T 7, R 13	17.48	10	4,728,000,000	28	14,742,000,000
Coffeelos Lake	T 6, R 11	0.22	...	...	5	30,666,000
Crescent Pond	T 9, R 15	0.34	...	...	5	47,393,000
Davis Pond	T 5, R 7	0.08	...	...	5	11,151,000
East Messer Pond	T 5, R 8	0.04	...	...	5	5,576,000
First Pond	T 7, R 14	0.27	...	...	10	75,272,000
Fourth Lake	T 7, R 11	0.32	12	107,053,000	12	107,053,000
Fowler Pond	T 6, R 9	0.10	...	...	5	13,939,000
Frost Pond	T 6, R 9	0.05	...	...	5	6,970,000
Grand & Second Lakes	Ts 6, R 8 & 9	6.63	14	1,959,000,000	29	5,277,800,000
Grand Lake	T 7, R 7	2.44	...	...	10	680,233,000
Hathorn Pond	T 4, R 8	0.06	...	...	5	8,364,000
Hay Lake	T 6, R 8	0.91	...	...	5	126,847,000
Hay Pond	T 6, R 8	0.22	...	...	5	30,666,000
Hot Pond	Ts 6, R 6 & 7	0.30	...	...	5	41,818,000
Hudson Pond	T 6, R 10	0.16	...	...	5	22,303,000
Jones Pond	Ts 7 & 8, R 8	0.04	...	...	5	5,576,000
Katahdin Pond	T 3, R 8	1.02	...	...	10	284,360,000
Leadbetter Pond	T 7, R 12	0.07	...	...	5	9,757,000
Leadbetter Pond	T 7, R 11	0.28	8	62,448,000	10	78,060,000
Little Pond	T 7, R 12	0.49	10	136,604,000	10	136,604,000
Littlefield Pond	T 6, R 9	0.02	...	...	5	2,788,000
Long Pond	T 6, R 9	0.06	...	...	5	8,364,000
Lost Pond	Ts 7, R 12 & 13	0.07	...	...	5	9,757,000
Lunksoos Pond	T 4, R 7	0.72	...	...	10	200,724,000
Marble Pond	T 5, R 8	0.06	...	...	5	8,364,000
Messer Pond	T 5, R 8	0.07	...	...	5	9,757,000
Mile Pond	T 8, R 14	0.20	...	...	5	27,878,000
Mud Pond	Ts 6 & 7, R 8	0.06	...	...	5	8,364,000
Mud Pond	T 6, R 8	0.58	...	...	10	161,695,000
Mud Pond	T 6, R 12	0.97	...	C	...	...
Mud Pond	Ts 9, R 14 & 15	0.26	...	...	10	72,484,000
Narrow Pond	T 8, R 14	0.32	...	...	5	44,605,000
Otter Pond	T 8, R 14	0.02	...	...	5	2,788,000
Peaked Mt. Pond	T 4, R 7	0.05	...	...	5	6,970,000
Perry Pond	T 5, R 7	0.59	...	...	10	164,483,000
Pond	T 7, R 7	0.07	...	...	5	9,757,000
"	T 2, R 7	0.01	...	...	5	1,394,000
"	T 2, R 7	0.02	...	...	5	2,788,000
"	T 2, R 7	0.02	...	...	5	2,788,000
"	T 3, R 7	0.005	...	...	5	697,000
"	T 3, R 7	0.002	...	...	5	279,000
"	T 3, R 7	0.005	...	...	5	697,000
"	T 3, R 7	0.01	...	...	5	1,394,000
"	T 3, R 7	0.01	...	...	5	1,394,000
"	T 3, R 7	0.01	...	...	5	1,394,000
"	T 3, R 7	0.005	...	...	5	697,000
"	T 5, R 7	0.08	...	...	5	11,151,000
"	T 6, R 7	0.01	...	...	5	1,394,000
"	T 6, R 7	0.03	...	...	5	4,182,000
"	T 6, R 7	0.04	...	...	5	5,576,000
"	T 7, R 7	0.12	...	...	5	16,727,000
"	T 4, R 8	0.02	...	...	5	2,788,000
"	T 4, R 8	0.02	...	...	5	2,788,000
"	T 4, R 8	0.02	...	...	5	2,788,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH EAST BRANCH—Concluded.

Name.	Location.	Surface area, sq. miles.	Present Storage.		Possible Storage.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Pond	T 4, R 8	0.02	....	....	5	2,788,000
"	T 4, R 8	0.02	....	....	5	2,788,000
"	T 5, R 8	0.03	....	....	5	4,182,000
"	T 5, R 8	0.01	....	....	5	1,394,000
"	T 6, R 8	0.04	....	....	5	5,576,000
"	T 7, R 8	0.38	....	....	5	52,969,000
"	T 7, R 8	0.04	....	....	5	5,576,000
"	T 3, R 9	0.28	....	....	5	39,030,000
"	T 4, R 9	0.02	....	....	5	2,788,000
"	T 4, R 9	0.005	....	....	5	6,697,000
"	T 4, R 9	0.02	....	....	5	2,788,000
"	T 4, R 9	0.01	....	....	5	1,394,000
"	T 4, R 9	0.02	....	....	5	2,788,000
"	T 5, R 9	0.14	....	....	5	19,515,000
"	T 5, R 9	0.24	....	....	5	33,454,000
"	T 7, R 9	0.14	....	....	5	19,515,000
"	T 7, R 11	0.15	....	....	5	20,909,000
"	T 7, R 11	0.03	....	....	5	4,182,000
"	T 7, R 11	0.04	....	....	5	5,576,000
"	T 7, R 11	0.24	....	....	5	33,454,000
"	T 7, R 11	0.10	....	....	5	13,939,000
"	T 6, R 12	0.12	....	....	5	16,727,000
"	T 8, R 14	0.01	....	....	5	1,394,000
"	T 8, R 14	0.04	....	....	5	5,576,000
"	T 8, R 15	0.02	....	....	5	2,788,000
"	T 9, R 15	0.11	....	....	5	15,333,000
Round Pond & Telos Lake	T 6, R 11	3.85	10	1,000,700,000	28	3,062,400,000
Scraggly Lake	T 7, R 8	1.96	....	....	5	273,209,000
Seboois Lake	T 8, R 7	2.30	6	384,722,000	10	641,203,000
Second Lake	T 6, R 9	......	....	*D*		
Second Pond	T 7, R 14	0.32	....	....	5	44,605,000
Shin Pond	T 5, R 7, T 6, R 6, Mt. Chase	1.56	....	....	20	869,806,000
Snake Pond	T 7, R 11	0.38	7	74,156,000	10	10,594,000
Snowshoe Lake	T 7, R 7	1.14	....	....	5	158,907,000
Stink Pond	T 7, R 11	0.05	....	....	5	6,970,000
Telos Lake	T 6, R 11	......	....	*E*		
Third Lake	T 7, R 10	0.77	9.7	208,224,000	10	214,664,000
Thissell Pond	T 5, R 11	0.09	....	....	5	12,545,000
Trout Brook Ponds (north)	T 5, R 9	0.48	....	....	10	133,817,000
Trout Brook Ponds (central)	T 5, R 9	0.11	....	....	5	15,333,000
Trout Brook Ponds (south)	T 5, R 9	0.08	....	....	5	11,151,000
Webster Lake	T 6, R 10 & 11	1.00	10	253,700,000	25	722,100,000
Whitehorse Lake	T 7, R 7	0.84	....	....	5	117,089,000
Total	....	61.582		10,292,594,000		36,745,253,000

C Included in Chamberlain Lake.
D See Grand Lake.
E See Round Pond.

Storage in Penobscot River Basin—Continued.

CONNECTED WITH MATTAWAMKEAG RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Baskahegan Lake	Brookton, Topsfield	16.40	7	2,468,000,000	27	15,070,000,000
Beaver Brook Lake	Linneus	0.08	....	....	5	11,151,000
Brayley Lake	T 3, R 4	0.38	....	....	10	105,938,000
Caribou Lake	T 3, R 4 & Island Falls	0.60	....	....	10	167,270,000
Duck Pond	Smyrna	0.10	....	....	5	13,939,000
Flinn Pond	Benedicta & T 1, R 5	0.27	....	....	5	37,636,000
Grass Pond	Moro Pl	0.10	....	....	5	13,939,000
Green Pond	Moro Pl	0.04	....	....	5	5,576,000
Hale Lake	Moro Pl	0.11	....	....	5	15,333,000
Hotbrook Lakes	T 8, R 4, N B P P, Danforth & Bancroft	2.53	....	....	10	705,324,000
Jackson Brook Lakes	Brookton, T 10, R 3, N B P P	1.08	....	....	5	150,543,000
Lilly Pond	Moro Pl	0.02	....	....	5	2,788,000
Long Lake	Oakfield	0.24	....	....	10	66,908,000
Macwahoc Lake	Sherman & T 3, R 4	0.59	....	....	10	164,483,000
Mattakeunk Pond	Lee	0.81	5	112,908,000	10	225,815,000
Mattawamkeag Lake	Island Falls & T 4, R 3	6.02	9	1,331,500,000	10	1,501,600,000
Molunkus Lake	T 1, R 6, Molunkus, Macwahoc	1.59	....	....	10	443,267,000
Mud Lake	T 4, R 3, Oakfield	0.24	....	....	5	33,454,000
Mud Pond	T 6, R 6	0.16	....	....	5	22,303,000
Mud Pond	T 7, R 4, N B P P	0.21	....	....	5	29,272,000
Otter Pond	T 3, R 4	0.16	....	....	5	22,303,000
Picked Mt. Pond	T 6, R 6, & Moro Pl	0.21	....	....	10	58,545,000
Pleasant Pond	T 4, R 3	2.20	....	....	12	802,280,000
Pleasant Pond	T 6, R 6	0.28	....	....	5	39,030,000
Plunket Pond	Benedicta	0.62	....	....	10	172,846,000
Pond	Danforth	0.09	....	....	10	25,091,000
"	Linneus	0.05	....	....	5	6,970,000
"	Moro Pl	0.06	....	....	5	8,364,000
"	Oakfield	0.01	....	....	5	1,394,000
"	Patten	0.18	....	....	5	25,091,000
"	Springfield	0.06	....	....	10	16,727,000
"	"	0.04	....	....	5	5,576,000
"	"	0.04	....	....	5	5,576,000
"	T 8, R 3, N B P P	0.02	....	....	5	2,788,000
"	T 8, R 3, N B P P	0.04	....	....	5	5,576,000
"	T 8, R 3, N B P P	0.28	....	....	5	39,030,000
"	T 2, R 3	0.03	....	....	5	4,182,000
"	T 3, R 3	0.47	....	....	5	65,514,000
"	T 3, R 3	0.05	....	....	5	6,970,000
"	T 2, R 4	0.04	....	....	10	11,151,000
"	T 2, R 4	0.06	....	....	10	16,727,000
"	T 2, R 4	0.26	....	....	10	72,484,000
"	T 3, R 4	0.04	....	....	5	5,576,000
"	T 3, R 4	0.05	....	....	5	6,970,000
"	T 3, R 4	0.08	....	....	5	11,151,000
Rockabema Lake	Moro Pl	0.64	....	....	10	178,422,000
Skitacook Lake	T 4, R 3 & Oakfield	1.04	....	....	10	289,935,000
Spaulding Lake	Oakfield	0.24	....	....	10	66,908,000
Tenmile Lake	Leavitt	0.16	....	....	10	44,605,000
Trout Pond	Moro Pl	0.06	....	....	10	16,727,000
Wytopitlock Lake	Ts 2, R 3 & 4	1.63	....	....	10	454,418,000
Total	....	40.76		3,912,408,000		21,275,466,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH PISCATAQUIS RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Adams Farm Pond	Howland	0.85	....	....	5	118,483,000
B Pond	T B, R 11	0.97	....	....	10	270,420,000
Bald Mt. Pond	Bald Mt.	1.81	5	283,662,000	11	722,747,000
Bear Pond	T 7, R 8, N W P	0.04	....	....	10	11,151,000
Bennett Pond	Parkman	0.04	5	5,576,000	5	5,576,000
Benson Pond	Willimantic	0.24	....	....	5	33,454,000
Benson Pond	Ts 7, R 8 & 9, N W P	0.65	....	....	10	181,210,000
Big Lyford Pond	T 7 & 8, R 10, N W P	0.04	....	....	5	5,576,000
Brown Pond	T 8, R 10, N W P	0.06	....	....	5	8,364,000
Burden Pond	T 7, R 8, N W P	0.32	....	....	10	89,211,000
Burnham Pond	Sebec	0.04	....	....	5	5,576,000
Cedar Pond	T 3, R 9, N W P, T A, R 8 & 9, W E L S	1.10	....	....	5	153,331,000
Crooked Pond	T 7, R 8, N W P	0.21	5	29,272,000	10	58,545,000
Davis Pond	Guilford, Willimantic	0.34	5	47,393,000	5	47,393,000
Dow Pond	Sebec	0.06	....	....	5	8,364,000
Duck Pond	T 7, R 8, N W P	0.10	....	....	5	1,394,000
East Branch Lake	T 3, R 9	1.08	....	....	5	150,543,000
East Chair Pond	T 7, R 9, N W P	0.12	....	....	5	16,727,000
Ebeemee Lake	T 5, R 9, N W P & Brownville	2.04	8	454,975,000	10	568,719,000
Endless Lake	T 3, R 9, N W P	2.57	8	499,100,000	13	881,000,000
Foss Pond	Kingsbury	0.14	4	15,612,000	5	19,515,000
Fourth Pond	T 7, R 8, N W P	0.33	....	....	5	45,999,000
Garland Pond	Sebec	0.04	....	....	10	11,151,000
Gauntlet Pond	T B, R 10	0.11	....	....	5	15,333,000
Grapevine Pond	T 7, R 8, N W P	0.14	....	....	5	19,515,000
Green Pond	T 7, R 10, N W P	0.06	....	....	5	8,364,000
Greenleaf Pond	Abbot	0.12	....	....	5	16,727,000
Greenwood Ponds	Elliotsville & Willimantic	0.64	....	....	5	89,211,000
Grindstone Pond	Willimantic	0.04	....	....	5	5,576,000
Hardy Pond	T 4, R 8, N W P	0.28	....	....	5	39,030,000
Harlow Pond	Parkman	0.16	6	26,763,000	10	44,605,000
Harriman Pond	Sebec	0.11	....	....	5	15,333,000
Hebron Pond	Monson	1.13	5	157,513,000	5	157,513,000
Hedgehog Pond	T 8, R 10, N W P	0.08	....	....	10	22,303,000
Hilton Ponds	Kingsbury	0.08	....	....	5	11,151,000
Horseshoe Pond	Willimantic	0.03	....	....	5	4,182,000
Horseshoe Pond	T 8, R 10, N W P	0.31	....	....	10	86,423,000
Houston Pond	T 6 & 7, R 9, N W P	1.19	11	396,208,000	18	635,405,000
Hussey Pond	Blanchard	0.06	....	....	5	8,364,000
Kingsbury Pond	Brighton Pl. & Mayfield	0.91	10	253,693,000	15	380,540,000
Little Hastings Pond	T 6, R 9, N W P	0.04	....	....	5	5,576,000
Little Lyford Pond	T 7, R 10, N W P	0.02	....	....	5	2,788,000
Little Wilson Pond	Greenville	0.08	....	....	5	11,151,000
Long Pond	Ts 7 & 8, R 9, Ts 7 & 8, R 10	1.21	....	....	10	337,328,000
Long Pond	T 7, R 8, N W P	0.62	....	....	4	69,138,000
Marr Pond	Sangerville	0.14	4	15,612,000	5	19,515,000
Mill Brook Pond	T 7, R 8, N W P	0.11	....	....	5	15,333,000
Monson Pond	Monson	0.51	....	....	6	71,090,000
Mountain Pond	T 8, R 10, N W P	0.05	....	....	5	6,970,000
Mountain Pond	T 8, R 10, N W P & T A, R 13, W E L S	0.15	....	....	5	20,909,000
Mud Pond	T 7, R 8, N W P	0.10	....	....	5	13,939,000
Northwest Pond	Parkman, Sangerville	0.67	6	112,071,000	10	186,785,000
Number 4 Pond	Willimantic	0.04	....	....	5	5,576,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH PISCATAQUIS RIVER—Continued.

NAME.	Location.	Surface area, sq. miles	PRESENT STORAGE.		POSSIBLE STORAGE.	
			Feet.	Cubic feet.	Feet.	Cubic feet.
Oakes Bog.......	Shirley..........	0.08	5	11,151,000	10	22,303,000
Onawa Lake.....	Elliotsville & Willimantic.......	2.22	5	309,450,000	15	928,351,000
Piper Pond.......	Abbot...........	0.79	5	110,120,000	10	220,240,000
Pond	Blanchard.......	0.08	....	....	5	11,151,000
"	Brownville	0.02	....	....	5	2,788,000
"	"	0.03	....	....	5	4,182,000
"	Foxcroft........	0.02	....	....	5	2,788,000
"	Monson	0.02	....	....	5	2,788,000
"	"	0.02	....	....	5	2,788,000
"	"	0.02	....	....	5	2,788,000
"	Willimantic......	0.04	....	....	5	5,576,000
"	T 4, R 8, N W P..	0.01	....	....	5	1,394,000
"	T 6, R 8, N W P..	0.05	....	....	5	6,970,000
"	T 6, R 8, N W P..	0.01	....	....	5	1,394,000
"	T 3, R 9, N W P..	0.13	....	....	5	18,121,000
"	T 4, R 9, N W P..	0.04	....	....	5	5,576,000
"	T 5, R 9, N W P..	0.12	....	....	5	16,727,000
"	T 6, R 9, N W P..	0.005	....	....	5	697,000
"	T 6, R 9, N W P..	0.01	....	....	5	1,394,000
"	T 7, R 9, N W P..	0.01	....	....	5	1,394,000
"	T 7, R 9, N W P..	0.01	....	....	5	1,394,000
"	T 7, R 9, N W P..	0.02	....	....	5	2,788,000
"	T 7, R 9, N W P..	0.08	....	....	5	11,151,000
"	T 7, R 9, N W P..	0.04	....	....	5	5,576,000
"	T 8, R 9, N W P..	0.04	....	....	5	5,576,000
"	T 8, R 9, N W P & Shirley........	0.02	....	....	5	2,788,000
"	T 8, R 9, N W P..	0.04	....	....	5	5,576,000
"	T 8, R 9, N W P..	0.02	....	....	5	2,788,000
"	T 8, R 9, N W P..	0.01	....	....	5	1,394,000
"	T 8, R 9, N W P..	0.01	....	....	5	1,394,000
"	T 8, R 10, N W P.	0.04	....	....	5	5,576,000
"	T 8, R 10, N W P.	0.04	....	....	5	5,576,000
"	T A, R 11.......	0.002	....	....	5	279,000
"	T A, R 11.......	0.01	....	....	5	1,394,000
"	T A, R 11.......	0.01	....	....	5	1,394,000
"	T A, R 11.......	0.005	....	....	5	697,000
"	T A, R 11.......	0.005	..	....	5	697,000
"	T B, R 11.......	0.05	....	....	5	6,970,000
"	T A 2, R 13 & 14, west..........	0.08	....	....	5	11,151,000
"	T B, R 10.......	0.06	....	....	5	8,364,000
Poverty Pond....	Willimantic......	0.05	....	....	5	6,970,000
Pudding Pond....	T 7, R 8, N W P..	0.05	....	....	5	6,970,000
Roaring Brook Pond..........	T 7, R 9, N W P..	0.19	....	....	5	26,484,000
Rum Pond.......	T 8, R 10, N W P & Greenville	0.20	....	....	5	27,878,000
Salmon Stream Pond..........	Guilford.........	0.18	....	....	5	25,091,000
Schoodic Lake....	T 4, R 8, N W P..	10.92	4	1,202,300,000	7	1,969,000,000
Sebec Lake.......	Willimantic, Bowerbank, Foxcroft......	10.93	12	3,366,540,000	16	4,752,654,000
Seboois Lake & Northwest Pond	T 4, R 9, N W P..	6.40	8	1,345,300,000	13	2,268,100,000
Second Houston Pond..........	T 7, R 9, N W P..	0.28	....	....	10	78,060,000
Shirley Bog......	Shirley..........	2.00	7	390,298,000	12	669,082,000
Silver Lake......	T 6, R 9, N W P..	0.70	5	74,436,000	24	767,716,000
Spectacle Pond...	Blanchard.......	0.22	5	30,666,000	10	61,332,000
Spectacle Pond...	Monson.........	0.24	....	....	10	66,908,000
Sucker Pond.....	T 6, R 9, N W P.	0.16	....	....	10	44,605,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH PISCATAQUIS RIVER—Concluded.

Name.	Location.	Surface area, sq. miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Trout Pond......	T 8, R 10, N W P.	0.04	....	....	5	5,576,000
Trout Pond......	T A 2, R 13 & 14, east.........	0.12	....	....	5	16,727,000
Turtle Pond......	T 4, R 8, N W P..	0.20	....	....	5	27,878,000
Upper Ebeeme Pond..........	T 4, R 9, N W P, T 13, R 10, W E L S.............	0.36	....	....	10	100,362,000
Upper Grapevine Pond..........	T 7, R 8, N W P..	0.13	....	....	5	18,121,000
Upper Greenwood Pond..........	T 8, R 9, N W P..	0.14	....	....	5	19,515,000
Upper Wilson Pond..........	T 8, R 10, N W P & Greenville...	0.60	....	....	10	167,270,000
West Branch Ponds.........	T A, R 12.......	0.78	....	....	10	217,452,000
West Chair Pond.	T 7, R 9, N W P..	0.10	....	....	10	27,878,000
Whetstone Pond..	Kingsbury & Blanchard.....	0.14	4	15,612,000	5	19,515,000
Wilder Pond.....	T 7, R 9, N W P..	0.02	....	....	5	2,788,000
Wilson Pond.....	Greenville.......	1.52	7	296,626,000	11	466,128,000
Total........	....	63.367		9,449,949,000		18,942,115,000

CONNECTED WITH PASSADUMKEAG RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Cold Stream Pond	Enfield..........	7.38	8	1,645,941,000	10	2,057,426,000
Cranberry Pond...	Lowell..........	0.04	....	....	5	5,576,000
Duck Lake.......	T 4, N D........	2.13	9	534,429,000	10	593,810,000
Eskatassis Pond..	Lowell & Burlington........	1.36	8	303,317,000	10	379,146,000
First Pistol Lake..	T 3, N D........	1.34	....	....	10	373,570,000
Gassabias Lake...	T 41, M D.......	1.34	6	224,143,000	10	373,570,000
Horseshoe Lake...	T 35, M D.......	0.39	....	....	5	54,363,000
Little Eskatassis Pond..........	Burlington.......	0.13	....	....	10	36,242,000
Little Madagascal Pond..........	T 3, R 1, N B P P & Lee.........	0.20	....	....	10	55,757,000
Little Round Pond	Lincoln	0.14	....	....	5	19,515,000
Madagascal Pond..	Burlington.......	0.99	7	193,197,000	10	275,996,000
Nicatous Lake....	T 3, N D, Ts 40 & 41, M D.......	8.82	8	1,967,100,00	10	2,458,875,0
Nicatous Brook Lake..........	T 35, M D.......	0.04	....	....	5	5,576,000
Number 3 Pond...	T 3, R 1, N B P P & Lee.........	0.76	....	....	5	105,938,000
Pickerel Lake....	Lowell..........	0.04	....	....	5	5,576,000
Pond	Lee.............	0.07	....	....	5	9,757,000
"	T 3, N D........	0.04	....	....	5	5,576,000
"	T 3, R 1, N B P P.	0.07	....	....	5	9,757,000
Porter Pond......	T 3, N D........	0.15	....	....	5	20,909,000
Saponic Lake.....	Burlington & Grand Falls..	1.05	....	....	10	292,723,000
Second Cold Stream Pond...	Enfield & Lincoln	1.14	8	254,251,000	10	317,813,000
Second Pistol Pond	Ts 3 & 4, N D....	0.42	....	....	10	117,089,000
Spencer Pond.....	Ts 3 & 4, N D....	0.06	....	....	5	8,364,000
Spring Pond......	T 3, N D........	0.62	....	....	5	86,423,000
Third Pistol Pond	T 4, N D........	0.20	....	....	5	27,878,000
Trueworthy Ponds	T 3, N D........	0.07	....	....	5	9,757,000
Trout Pond......	T 2, N D........	0.04	....	....	5	5,576,000
Ware Pond.......	Lee.............	0.34	....	....	10	94,787,000
Total........	....	29.37		5,122,378,000		7,807,345,000

Storage in Penobscot River Basin—Continued.

CONNECTED WITH MAIN RIVER.

Name.	Location.	Surface area, sq. miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Alamoosook Pond	Orland	1.51	....	....	5	210,482,000
Ben Annis Pond	Hermon	0.08	....	....	5	11,151,000
Boyd Lake	Orneville	0.14	....	....	5	19,515,000
Brewer Pond	Orrington, Bucksport, Holden	1.38	5	192,361,000	5	192,361,000
Brown Pond	Bucksport	0.20	....	....	5	27,878,000
Burnt Pond	T 2, R 6	0.36	....	....	5	50,181,000
Cambolasse Pond	Lincoln	0.39	5	54,363,000	10	108,726,000
Caribou Pond	Lincoln	0.39	....	....	5	54,363,000
Chemo Pond	Eddington, Clifton, Bradley	1.80	....	....	5	250,906,000
Craig Pond	Orland	0.33	....	....	5	45,999,00e
Crooked Pond	Lincoln	0.26	....	....	5	36,242,000
Davidson Pond	T 2, R 6, W E L S	0.15	....	....	5	20,909,000
Davis Pond	Holden & Eddington	0.68	....	....	5	94,787,000
Egg Pond	Lincoln	0.13	....	....	5	18,121,000
Etna Pond	Stetson, Etna & Carmel	0.91	....	....	5	126,847,000
Fields Pond	Orrington	0.29	....	....	5	40,424,000
Fitts Pond	Clifton	0.17	....	....	5	23,697,000
Folsom Pond	Lincoln	0.26	5	36,242,000	5	36,242,000
George Pond	Holden	0.03	....	....	5	4,182,000
George Pond	Hermon	0.08	....	....	5	11,151,000
Half Moon Pond	Searsport	0.26	....	....	5	36,242,000
Hammond Pond	Hampden	0.16	....	....	5	22,303,000
Hancock Pond	Bucksport	0.09	....	....	5	12,545,000
Heart Pond	Orland	0.12	....	....	5	16,727,000
Hermon Pond	Hermon	0.72	....	....	5	100,362,000
Holbrook Pond	Holden	0.46	....	....	5	64,120,000
Holland Pond	Alton	0.12	....	....	5	16,727,000
Hothole Pond	Orland	0.09	....	....	5	12,545,000
Hurd Pond	Dedham	0.06	....	....	5	8,364,000
Jacob Buck Pond	Bucksport	0.29	....	....	5	40,424,000
Little Pushaw Pond	Corinth & Hudson	0.68	....	....	5	94,787,000
Lower Mattamiscontis Lake	T 3, R 9. N W P	1.18	....	....	10	328,965,000
Long Pond	Lincoln	0.69	5	96,180,000	5	96,180,000
Long Pond	Bucksport	0.41	....	....	5	57,151,000
McGann Bog	Bucksport	0.02	....	....	5	2,788,000
Mansell Pond	Alton	0.08	....	....	5	11,151,000
Mattaceunk Lake	T A, R 5, W E L S	1.51	....	....	10	420,964,000
Mattanawcook Pond	Lincoln	0.54	5	75,272,000	10	150,543,000
Medunkeunk Pond	T 2, R 9, N W P	0.46	....	....	5	64,120,000
Mill Pond	Garland	0.15	....	....	10	41,818,000
Mitchell Pond	Dedham	0.02	....	....	5	2,788,000
Moulton Pond	Dedham & Bucksport	0.07	....	....	5	9,757,000
Mud Pond	Old Town	0.54	....	....	0	
Mud Pond	Dedham	0.02	....	....	5	2,788,000
Mud Pond	Bucksport	0.05	....	....	5	6,970,000
Parks Pond	Clifton	0.10	....	....	5	13,939,000
Patten Pond	Hampden, Newburg	0.06	....	....	5	8,364,000
Phillips Lake	Dedham	1.41	....	....	5	196,543,000
Pickerel Pond	Alton	0.10	5	13,939,000	5	13,939,000
Pleasant Pond	Orneville	0.14	....	....	5	19,515,000
Pleasant Pond	Dexter & Garland	0.11	....	....	5	15,333,000
Pond	T 32, M D	0.04	....	....	5	5,576,000
"	T 2, R 6	0.01	....	....	5	1,394,000
"	Charleston	0.04	....	....	5	5,576,000
"	Charleston	0.02	....	....	5	2,788,000
"	Charleston	0.06	....	....	5	8,364,000

Storage in Penobscot River Basin—Concluded.

CONNECTED WITH MAIN RIVER—Concluded.

Name.	Location.	Surface area, sq miles.	Present Storage. Feet.	Present Storage. Cubic feet.	Possible Storage. Feet.	Possible Storage. Cubic feet.
Pond	Chester	0.04	....	....	5	5,576,000
"	Lincoln	0.04	....	....	5	5,576,000
"	Lincoln	0.11	....	....	5	15,333,000
"	Monroe	0.07	....	....	5	9,757,000
"	Monroe	0.07	....	....	5	9,757,000
Pug Pond	Alton	0.10	....	....	5	13,939,000
Pushaw Lake	Hudson, Glenburn, Orono	7.25	....	....	3	1,233,600,000
Salmon Stream Pond, upper	T 1, R 6	0.12	....	....	5	16,727,000
Salmon Stream Pond, middle	T 1, R 6	0.86	....	....	10	239,754,000
Salmon Stream Pond, lower	T 1, R 6	0.17	....	....	5	23,697,000
Saulter Pond	Dedham	0.02	....	....	5	2,788,000
Second Pond	Dedham	0.08	....	....	5	11,151,000
Silver Lake	Bucksport	0.08	....	....	5	11,151,000
Snowshoe Pond	Clifton	0.01	....	....	5	1,394,000
South Branch Lake	Ts 2 & 3, R 8, N W P	3.06	....	....	10	853,079,000
Sweets Pond	Orrington	0.20	....	....	5	27,878,000
Thistle Pond	Monroe	0.04	....	....	5	5,576,000
Toddy Pond	Swanville	0.35	....	....	5	48,787,000
Toddy Pond	Orland, Penobscot, Surry, Bluehill	3.13	....	....	5	436,297,000
Tracy Pond	Hermon	0.06	....	....	5	8,364,000
Trout Pond	Orrington	0.03	....	....	5	4,182,000
Upper Pond	Lincoln	0.79	5	110,120,000	5	110,120,000
Upper Mattamiscontis Pond	Ts 2 & 3, R 9, N W P	2.95	....	....	10	822,413,000
Williams Pond	Bucksport	0.19	....	....	5	26,484,000
Total	....	40.24		578,477,000		7,240,004,000

Summary of Storage in Penobscot Basin.

Basin.	Drainage area, sq. miles.	Lake surface area, sq. miles.	Ratio water surface to drainage area.	Present storage, cubic feet.	Possible storage capacity, cubic feet.
West Branch	2,100	172.38	12.2	38,695,297,000	68,688,110,000
East Branch	1,130	61.58	18.4	10,292,594,000	36,745,253,000
Mattawamkeag River	1,500	40.76	36.8	3,912,408,000	21,275,466,000
Piscataquis River	1,500	63.37	23.7	9,449,949,000	18,942,115,000
Passadumkeag River	383	29.37	13.0	5,122,378,000	7,807,345,000
Main River	1,957	40.24	48.7	578,477,000	7,240,004,000
Total	8,570	407.70	21.0	68,051,103,000	160,698,293,000

Stream Flow.

The following gaging stations have been maintained in the Penobscot River basin. The run-off computations from the establishment of the various stations to 1910 were published in the 1st Annual Report, pages 201 to 214.

West Branch Penobscot River at Millinocket (1901-1911).
Penobscot River at West Enfield (1902-1911).
East Branch Penobscot River at Grindstone (1902-1911).
Mattawamkeag River at Mattawamkeag (1902-1911).
Piscataquis River at Foxcroft (1902-1911).
Cold Stream at Enfield (1904-1906).
Kenduskeag River near Bangor (1908-1911).
Phillips Lake and outlets (1904-1908).

WEST BRANCH PENOBSCOT RIVER AT MILLINOCKET.

The discharge of the Penobscot River at Millinocket, has been furnished since 1901 by H. S. Ferguson, engineer of the Great Northern Paper Company.

Monthly discharge of Penobscot River at Millinocket.

[Drainage area, 1880 square miles.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	2,238	1,810	2,134	1.14	1.31
February	5,385	2,120	4,067	2.16	2.25
March	4,476	2,870	4,052	2.16	2.49
April	3,180	2,035	2,512	1.34	1.50
May	10,465	1,492	5,706	3.03	3.49
June	8,165	3,530	5,381	2.86	3.19
July	4,280	2,184	2,854	1.52	1.75
August	3,315	1,535	2,305	1.23	1.42
September	2,795	2,035	2,348	1.25	1.40
October	2,280	1,770	2,209	1.18	1.36
November	2,270	1,030	2,152	1.14	1.27
December	2,265	1,740	2,144	1.14	1.31
The year	10,465	1,030	3,148	1.68	22.74
1911.					
January	2,260	1,920	2,190	1.16	1.34
February	2,360	430	1,430	.761	.79
March	740	450	687	.365	.42
April	2,100	320	1,100	.585	.65
May	2,750	260	2,390	1.27	1.46
June	2,670	1,220	2,340	1.24	1.38
July	2,370	1,760	2,220	1.18	1.36
August	2,670	1,820	2,320	1.23	1.42
September	2,670	1,760	2,210	1.18	1.32
October	2,260	1,830	2,220	1.18	1.36
November	2,260	1,790	2,160	1.15	1.28
December	2,190	1,470	2,010	1.07	1.23
The year	2,750	260	1,940	1.03	14.01

Note.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

PENOBSCOT RIVER AT WEST ENFIELD.

This station, which has been maintained to obtain data regarding the total flow of the Penobscot, was established November 5, 1901, and prior to 1904 was designated as being at Montague, Maine. In 1904 the name of this village was changed to West Enfield. It is located at the steel highway bridge about 1,000 feet below the mouth of Piscataquis River. There is a dam on Piscataquis River near its entrance into the Penobscot, and about a mile above the station is the dam of the International Paper Company, on the main river. During low water considerable daily fluctuations in gage height occur, due to the variations in wheel gate openings at the mills above.

Monthly discharge of Penobscot River at West Enfield.

[DRAINAGE AREA, 6600 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	....	....	7,400	1.12	1.29
February	....	....	8,600	1.30	1.35
March	....	....	11,800	1.79	2.06
April	38,600	15,000	27,800	4.21	4.70
May	29,800	12,300	19,800	3.00	3.46
June	22,500	14,100	16,800	2.55	2.84
July	16,400	4,060	8,380	1.27	1.46
August	7,580	4,620	6,140	.930	1.07
September	6,140	3,230	4,260	.645	.72
October	4,840	2,470	3,370	.511	.59
November	5,420	3,230	4,070	.617	.69
December	8,120	....	4,000	.606	.70
The year	38,600	....	10,200	1.55	20.93
1911.					
January	....	....	5,000	.758	.87
February	....	....	3,500	.530	.55
March	....	....	3,900	.591	.68
April	37,800	....	20,100	3.05	3.40
May	39,200	7,300	16,100	2.44	2.81
June	10,700	5,650	8,390	1.27	1.42
July	7,040	4,500	5,390	.817	.94
August	6,390	3,140	4,790	.726	.84
September	8,120	4,390	5,930	.898	1.00
October	7,040	3,430	5,070	.768	.89
November	10,000	3,740	5,910	.895	1.00
December	21,300	8,400	12,600	1.91	2.20
The year	39,200	....	8,110	1.23	16.60

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

EAST BRANCH PENOBSCOT RIVER AT GRINDSTONE.

The gaging station was established October 23, 1902, at the Bangor & Aroostook Railroad bridge, one-half mile south of the railroad station at Grindstone. It is about 8 miles above the junction of the East Branch of the Penobscot with the Penobscot at Medway. No water power is used on the river above the station, but dams are maintained at the outlet of several of the lakes and ponds near the source of the river, and the impounded water is used for log driving.

Monthly discharge of East Branch Penobscot River at Grindstone.

[DRAINAGE AREA, 1100 SQUARE MILES.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	....	....	1,070	.973	1.12
February	....	....	591	.537	.56
March	....	....	663	.603	.70
April	8,170	....	5,510	5.01	5.59
May	6,890	2,120	3,980	3.62	4.17
June	8,290	2,450	4,870	4.43	4.94
July	3,320	750	1,610	1.46	1.68
August	1,080	210	509	.463	.53
September	608	180	264	.240	.27
October	455	150	210	.191	.22
November	590	240	396	.360	.40
December	....	....	278	.253	.29
The year	....	....	1,660	1.51	20.47
1911.					
January	....	....	450	0.409	0.47
February	....	....	350	.318	.33
March	....	....	500	.455	.52
April	7,810	....	2,850	2.59	2.89
May	9,550	1,250	3,470	3.15	3.63
June	3,470	680	2,050	1.86	2.08
July	2,480	465	1,060	.964	1.11
August	1,230	198	527	.479	.55
September	1,660	338	649	.590	.66
October	1,520	324	651	.592	.68
November	1,630	360	832	.756	.84
December	....	....	1,230	1.12	1.29
The year	9,550	....	1,220	1.11	15.05

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

MATTAWAMKEAG RIVER AT MATTAWAMKEAG.

The gaging station, which was established August 26, 1902, is located at the Maine Central Railroad bridge in the village of Mattawamkeag, about half a mile from the mouth of the river.

Monthly discharge of Mattawamkeag River at Mattawamkeag.
[DRAINAGE AREA, 1500 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	....	....	1,800	1.20	1.38
February	....	....	1,650	1.10	1.14
March	3,800	....	2,250	1.50	1.73
April	10,700	4,380	8,070	5.38	6.00
May	8,360	2,500	4,680	3.12	3.60
June	4,280	1,440	3,070	2.05	2.29
July	2,430	470	1,090	.727	.84
August	906	295	538	.359	.41
September	375	114	267	.178	.20
October	420	86	142	.095	.11
November	1,380	420	704	.469	.52
December	1,550	....	648	.432	.50
The year	10,700	86	2,070	1.38	18.72
1911.					
January	....	....	1,100	.733	.85
February	....	....	800	.533	.56
March	....	....	1,200	.800	.92
April	10,100	....	6,530	4.35	4.85
May	11,200	1,560	4,550	3.03	3.49
June	3,070	818	1,900	1.27	1.42
July	736	190	327	.218	.25
August	906	190	458	.305	.35
September	1,380	590	813	.542	.60
October	1,440	470	885	.590	.68
November	3,250	660	1,490	.993	1.11
December	6,580	2,220	4,220	2.81	3.24
The year	11,200	190	2,030	1.35	18.32

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

PISCATAQUIS RIVER NEAR FOXCROFT.

The gaging station, which was established August 17, 1902, is located at Lows Bridge, about half way between the villages of Guilford and Foxcroft, and is just above the mouths of Black and Salmon Streams.

Monthly discharge of Piscataquis River at Foxcroft.
[DRAINAGE AREA, 286 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	....	....	300	1.05	1.21
February	....	....	300	1.05	1.09
March	2,780	....	806	2.82	3.25
April	4,430	1,110	2,280	7.97	8.89
May	1,400	220	596	2.08	2.40
June	1,560	220	688	2.41	2.69
July	267	72	131	.458	.53
August	318	40	146	.510	.59
September	123	40	78.9	.276	.31
October	64	24	41.5	.145	.17
November	51	19	39.0	.136	.15
December	638	17	122	.427	.49
The year	4,430	17	459	1.60	21.77
1911.					
January	....	....	150	.524	.60
February	....	....	120	.420	.44
March	....	....	250	.874	1.01
April	7,010	....	2,300	8.04	8.97
May	4,340	51	976	3.41	3.93
June	470	46	192	.671	.75
July	318	19	50.6	.177	.20
August	199	19	60.1	.210	.24
September	81	36	57.9	.202	.23
October	536	51	125	.437	.50
November	1,210	58	535	1.87	2.09
December	3,020	374	1.040	3.64	4.20
The year	7,010	19	488	1.71	23.16

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

KENDUSKEAG STREAM NEAR BANGOR.

This station, which was established September 15, 1908, to obtain general statistical data regarding the total flow of the Kenduskeag Stream, is located at the wooden highway bridge about six miles northwest of the Bangor post office and is just below the Six Mile Falls, which is the best unutilized power development of the lower stretch of the river. The discharge at this point does not represent the actual discharge from the original or natural drainage basin of Kenduskeag Stream. A number of years ago an artificial cut was made for log driving purposes through a low divide between Souadabscook Stream and Black Stream, the latter a tributary of the Kenduskeag entering it about seven miles above the gaging station. During high stages in the Souadabscook a portion of its waters finds its way through the artificial cut into Kenduskeag. At low stages in the Souadabscook all of the flow continues down its own channel. It is believed that all of the flow of Black Stream is into the Kenduskeag and none into the Souadabscook.

Monthly discharge of Kenduskeag Stream near Bangor.

[DRAINAGE AREA, 191 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	2,590	56	538	2.82	3.25
February	745	199	407	2.13	2.22
March	2,290	431	994	5.20	6.00
April	1,040	249	592	3.10	3.46
May	770	71	273	1.43	1.65
June	177	86	132	.691	.77
July	86	30	45.9	.240	.28
August	119	18	47.7	.250	.29
September	25	12	17.6	.092	.10
October	34	12	15.4	.081	.09
November	45	18	28.0	.147	.16
December	501	25	113	.592	.68
The year	2,590	12	266	1.39	18.95
1911.					
January	....	....	457	2.39	2.76
February	....	....	173	.906	.94
March	1,170	....	485	2.54	2.93
April	3,120	722	1,780	9.32	10.40
May	745	51	304	1.59	1.83
June	350	51	119	.623	.70
July	128	18	63.1	.330	.38
August	156	34	85.6	.448	.52
September	137	45	80.4	.421	.47
October	236	86	116	.607	.70
November	538	57	237	1.24	1.38
December	2,050	276	826	4.32	4.98
The year	3,120	18	394	2.06	27.99

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

KENNEBEC DRAINAGE BASIN.

Description.

Kennebec River rises in Moosehead Lake in the west central part of Maine, the headwaters being collected by Moose River, Roach River, and a number of smaller streams rising in the hilly forested areas east and west of the lake. The drainage basin extends from the Canada line to the ocean. It measures about 150 miles in length, varies in width from 50 to 80 miles in the main portion, and embraces a total area of 5,970 square miles (about one-fifth the total area of the State), of which 1,240 square miles are tributary to Moosehead Lake. The length of the river from the lake to its entrance into Merrymeeting Bay, near Brunswick, including the more considerable windings, is about 140 miles.

The northern part of the drainage basin is broken by offsets from the White Mountains. Near Moosehead Lake the hills and highlands lie well back from the lake, leaving a great open plain. Below the lake nearly to The Forks, the river is a torrent, flowing in a narrow, rocky chasm with precipitous sides. Below the junction of Dead River at The Forks the Kennebec flows through a broader valley with gentler slopes. The general elevation of the basin is less than that of the Androscoggin, which adjoins it on the west, although near the center of the area Saddleback, Abraham, and Bigelow mountains rise as isolated peaks to an elevation higher than any mountains in the State except Katahdin. The extreme headwaters of the Kennebec at the Canadian line reach an elevation of approximately 2,000 feet. Moosehead Lake is about 1,026 feet above tidewater and distant from it 120 miles, corresponding to an average descent of 8.55 feet per mile.

The Kennebec basin presents considerable variety in its rock formations. In the northern part of the basin the rocks are mostly sedimentary, including sandstones, conglomerates, shales, slates, and impure limestones. A few masses of igneous rocks are found, notably the rhyolite of Mount Kineo. In the central and southern portions of the basin extensive areas of granite appear, and in general the tendency is toward metamorphic rocks. The quarries at Hallowell are located on one of the larger masses of pure granite. A notable characteristic of the rocks in the Kennebec basin is their compactness and hardness, which gives a permanence to the present channels of the river. The surface materials are usually finely pulverized, and water-retaining sands and gravels are more abundant in the northern part, succeeded by a greater proportion of loam and clay to the southward.

The greater part of the Kennebec River drainage basin is forest covered, and the upper portion is heavily timbered, although extensive cutting has been going on for many years. Spruce is most abundant, and large quantities of poplar, valuable in the production of the best grades of paper, are found. About one-third of all the lumber used in the State for pulp and paper comes from the Kennebec basin.

The mean annual precipitation in the Kennebec River basin above Waterville is about 40 inches. It ranges from a little over 44 inches at Gardiner to probably not over 35 inches in the extreme northwestern part of the basin.

The river is generally frozen over during the winter, and the accumulation of snow in the northern portions of the basin frequently reach a depth of 3 feet, with a water equivalent of 5 or 6 inches.

The natural storage facilities on the Kennebec basin are excellent, there being about 420 square miles of lake and pond surface. Moosehead Lake, with an area of about 115 square miles, is the largest lake in New England. It is about 35 miles in extreme length, 12 miles in maximum width, and of such depth that it is crossed by steamboats from end to end. It has been in use many years as a reservoir to store the spring flow for use in log driving and for power and is commanded by substantial log-crib dams at its two outlets. The east outlet stream is the most important and is joined by the west outlet stream at the upper end of Indian Pond, about 4 miles below the lake. The present head of water at Moosehead Lake is about 7.5 feet, corresponding to about 23.5 billion cubic feet storage.

Other important storage basins in Kennebec headwaters, little used at present, are Brassua Lake, Long, Wood, Attean, and the Roach ponds. Economical storage in the headwaters up to 40,000,000,000 cubic feet capacity is possible, which with that on Dead River and other tributaries should make the Kennebec River, with its large amount of fall, one of the best power streams in the country.

While the regimen of flow of the Kennebec has been much improved by storage in Moosehead Lake, a systematic regulation of the use of stored water is greatly needed, for much of the stored water impounded by the lake at the present time is needlessly wasted during log driving and at other times for lack of an adequate system of measuring and recording the flow from the outlets.

The Kennebec has always been an important river for log driving, the annual drive at present amounting to about 150,000,000 feet b. m.

River and Lake Surveys.

In order to point out the power and storage possibilities in the Kennebec basin, surveys have been made as follows:

Kennebec River, Skowhegan to The Forks, 4 sheets.
Kennebec River, The Forks to Moosehead Lake.
Kennebec River, Profile, Augusta to Moosehead Lake.
Brassua Lake and plan of outlet.
Wood Pond and plan of outlet.
Attean Pond.
Long Pond; Holeb Pond; Moose River, Moosehead Lake to Brassua Lake.
Flagstaff Lake; West Carry Pond; Spring Lake; Spencer Ponds; Middle Roach Pond; Lower Roach Pond.
Dead River, mouth to Chain of Ponds, 5 sheets.
Dead River, Chain of Ponds and outlet; Jim Pond and outlet.
Dead River, South Branch; Tim Pond and outlet.
Spencer Stream, Little Spencer Stream, King and Bartlett Lake, Little Bartlett Lake.
Dead River, Long Falls, special map.
Sandy River, mouth to Madrid, 5 sheets.
Clearwater Pond and outlet.

From the data collected by the river surveys, sheets have been prepared, showing as far as available the profile of water surface, plan of the river, contours along the banks, and prominent natural or artificial features.

From the lake surveys sheets have been prepared showing as far as possible the shore lines and bank contours, covering from 10 to 20 feet depth of storage.

The results of these surveys have been published on sheets, and may be had on application to the State Water Storage Commission, Augusta, Maine.

Lake Storage.

The systematic work of the measurements of the water surface areas of the lakes and ponds of the State from the best maps available, as described on page 85, have not yet been completed for the Kennebec basin. The information given in the 1st Annual Report, pages 263 to 267 was compiled from various sources. The more accurate determinations for this basin will appear in the next report.

Reservoir Storage.

Detailed surveys of the reservoir capacities of the various lakes in the basin of the Kennebec River above The Forks have been made and are described in detail in the 1st Annual Report, pages 243 to 249. The following table is a summary of both the present and available storage capacities in the basin under consideration:

Upper Kennebec Reservoir Storage.

Lake.	Present storage, cubic feet.	Available storage, cubic feet.
Moosehead Lake	23,735,000,000	30,247,000,000
Brassua Lake	0	3,512,000,000
Long Pond	625,000,000	625,000,000
Wood & Attean Ponds	0	2,341,700,000
Holeb Pond	0	627,000,000
Lower Roach Pond	1,093,000,000	1,093,000,000
Middle Roach Pond	167,000,000	234,000,000
Total	25,620,000,000	38,679,700,000
Total not raise Moosehead Lake		32,167,700,000
Total only raise Brassua Lake		29,132,000,000

In the detailed studies of the best method of regulating this reservoir system, computations have been made based on present storage in Moosehead Lake alone, 23.7 billion cubic feet;

total present storage, 25.6 billion cubic feet; available storage including present storage and increasing it by the construction of the proposed Brassua Lake reservoir, 29.1 billion cubic feet; available storage by increase of proposed basins with the exception of the increase of Moosehead Lake, giving a total capacity of 32.2 billion cubic feet. The total available storage for the lakes under consideration is about 38.7 billion cubic feet.

There is described on page 83 the method of determining the capabilities of reservoir storage in any particular river basin. This method is by means of the construction of mass curves. Such a special study has been made for the regulation of Moosehead Lake and the reservoirs in the same drainage area based on the record of the discharge of the Kennebec River at The Forks. The gaging station was established here in 1902 and the record has been more or less continuous since that date. This record of discharge, however, is the observed flow or the amount actually passing the station and is largely dependent on the artificial regulation of Moosehead Lake, and the figures, therefore, do not indicate on the face of them what the natural flow would be if there was no dam at the outlet of Moosehead. However, a continuous record of the rise and fall of the water surface of Moosehead Lake has been kept and it is thus possible to compute what the natural run-off would be.

The regulation of Moosehead Lake storage is complicated by the fact that a certain amount of water in excess of general power uses has to be released annually for log driving purposes. From careful studies made during 1911 the average discharge at The Forks during the log driving season was found to be 2600 cubic feet per second. The usual length of driving season is three months and in the computations below, it has been assumed that the excess water for this purpose will be required in May, June and July. During 1911 the time was somewhat longer than this but it is believed that the shorter period will approximate closer the average length for the log driving season.

During 1912 an automatic gage will be installed at The Forks for giving a continuous record of the variations in height of the river. As a reliable rating curve has been developed for this station, the final 1912 estimates of discharge at the end of the year should be accurate within allowable working percent.

The following table shows the detailed computations of the construction of the mass curve for the Kennebec River and the stage of Moosehead Lake at the end of each month based on the use of 2600 second feet for log driving purposes during May, June, and July and with the present storage in Moosehead Lake only of 23,725,000,000 cubic feet. Computations show that during the balance of the year a constant flow of 1120 second feet could be obtained or 0.90 second feet per square mile. It is not necessary to consider the question of evaporation in these computations as this factor has already been taken care of in the actual run-off figures. The small increase of evaporation due to the enlarged area of water surface for the additional storage is so slight that it can be disregarded.

Kennebec River at The Forks.

OBSERVED RUN-OFF AND AS CORRECTED FOR STORAGE WITH MASS CURVE COMPUTATIONS.

[DRAINAGE AREAS: AT THE FORKS, 1570 SQ. MILES; AT OUTLET MOOSEHEAD LAKE, 1240 SQ. MILES.]

1.	2.	3.	4.	5.	6.	7.	8.	9.
		Run-off—Corrected for Storage.			Draft, 0.90 Sec. Ft. per Sq. Mile, or 1,120 Sec. Ft., and 2,600 Sec. Ft. May, June, July.			
			Depth in inches.		Draft.		Deficiency.	
Month.	Observed flow, sec. ft. per sq. mile.	Sec. ft. per sq. mile.	Monthly.	Sum.	Monthly.	Sum.	Inches.	Billion cu. feet.
1902.								
January	....	*a*1.42	1.64	1.64	1.04			
February	....	*a* .99	1.03	2.67	.94			
March	2.09	2.83	3.26	5.93	1.04			
April	6.37	8.82	9.84	15.77	1.00			
May	6.05	6.13	7.07	22.84	2.42			
June	6.11	5.83	6.50	29.34	2.34			
July	3.86	2.52	2.90	32.24	2.42			
August	1.87	1.18	1.36	33.60	1.04			
September	1.04	.96	1.07	34.67	1.00			
October	.91	.91	1.05	35.72	1.04			
November	.66	*a*1.74	1.94	37.66	1.00			
December	1.57	*a*1.25	1.44	39.10	1.04			
1903.								
January	....	*a*1.25	1.44	40.54	1.04	40.54		
February	1.85	*a* .85	.89	41.43	.94	41.48	.05	0.1
March	2.08	4.08	4.70	46.13	1.04	42.52		
April	5.32	5.52	6.16	52.29	1.00	52.29		
May	2.26	2.06	2.38	54.67	2.42	54.71	.04	0.1
June	2.72	2.05	2.29	56.96	2.34	57.05	.09	.3
July	2.93	1.85	2.13	59.09	2.42	59.47	.38	1.1
August	1.78	1.18	1.36	60.45	1.04	60.51	.06	.2
September	1.21	.05	.06	60.51	1.00	61.51	1.00	2.9
October	.71	.00	.00	60.51	1.04	62.55	2.04	5.9
November	.44	.09	.10	60.61	1.00	63.55	2.94	8.5
December	.38	*a* .43	.50	61.11	1.04	64.59	3.48	10.0
1904.								
January	....	*a* .31	.36	61.47	1.04	65.63	4.16	12.0
February	....	*a* .29	.31	61.78	.97	66.60	4.82	13.9
March	....	*a*1.18	1.36	63.14	1.04	67.64	4.50	13 0
April	1.46	*a*4.66	5.20	68.34	1.00	68.64	.30	0.9
May	3.22	7.34	8.46	76.80	2.42			
June	4.15	3.28	3.66	80.46	2.34			
July	3.60	2.92	3.37	83.83	2.42	83.83		
August	1.89	.83	.96	84.79	1.04	84.87	.08	0.2
September	1.35	1.66	1.85	86.64	1.00	86.64		
October	1.00	.72	.83	87.47	1.04	87.68	.21	.6
November	.85	.73	.81	88.28	1.00	88.68	.40	1.2
December	....	*a* .56	.65	88.93	1.04	89.72	.79	2.3

a Waterville discharge multiplied by 1.33.

Kennebec River at The Forks—Continued.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Month.	Observed flow, sec. ft. per sq. mile.	Run-off—Corrected for Storage.			Draft, 0.90 Sec. Ft. per Sq. Mile, or 1,120 Sec. Ft., and 2,600 Sec. Ft. May, June, July.			
		Sec. ft. per sq. mile.	Depth in inches.		Draft.		Deficiency.	
			Monthly.	Sum.	Monthly.	Sum.	Inches.	Billion cu. feet.
1905.								
January	....	*a* .19	.22	89.15	1.04	90.76	1.61	4.6
February	....	*a* .45	.47	89.62	.94	91.70	2.08	6.0
March	1.01	*a*1.82	2.10	91.72	1.04	92.74	1.02	2.9
April	1.06	3.32	3.70	95.42	1.00	93.74		
May	2.76	4.43	5.11	100.53	2.42			
June	3.44	2.85	3.18	103.71	2.34	103.71		
July	2.59	1.57	1.81	105.52	2.42	106.13	.61	1.8
August	1.32	.16	.18	105.70	1.04	107.17	1.47	4.2
September	.80	.18	.20	105.90	1.00	108.17	2.27	6.5
October	.55	−.01	−.01	105.89	1.04	109.21	3.32	9.6
November	.53	.15	.17	106.06	1.00	110.21	4.15	12.0
December	.46	*a* .47	.54	106.60	1.04	111.25	4.65	13.4
1906.								
January	....	*a*1.00	1.15	107.75	1.04	112.29	4.54	13.1
February	....	*a* .82	.85	108.60	.94	113.23	4.63	13.3
March	....	*a* .72	.83	109.43	1.04	114.27	4.84	13.9
April	1.68	3.30	3.68	113.11	1.00	115.27	2.16	6.2
May	4.74	8.23	9.49	122.60	2.42	117.69		
June	3.64	3.24	3.62	126.22	2.34	126.22		
July	2.74	1.21	1.40	127.62	2.42	128.64	1.02	2.9
August	1.75	.39	.45	128.07	1.04	129.68	1.61	4.6
September	1.03	.18	.20	128.27	1.00	130.68	2.41	6.9
October	.81	1.33	1.53	129.80	1.04	131.72	1.92	5.5
November	.40	.79	.88	130.68	1.00	132.72	2.04	5.9
December	....	*a* .84	.97	131.65	1.04	133.76	2.11	6.1
1907.								
January	.59	.44	.51	132.16	1.04	134.80	2.64	7.6
February	.80	.30	.31	132.47	.94	135.74	3.27	9.4
March	1.03	.36	.42	132.89	1.04	136.78	3.89	11.2
April	1.00	3.01	3.36	136.25	1.00	137.78	1.53	4.4
May	5.38	7.81	9.00	145.25	2.42	140.20		
June	3.23	3.15	3.51	148.76	2.34			
July	2.50	2.35	2.71	151.47	2.42			
August	2.34	1.65	1.90	153.37	1.04	153.37		
September	1.24	.77	.86	154.23	1.00	154.37	.14	.4
October	.76	1.52	1.75	155.98	1.04	155.41		
November	3.79	4.19	4.68	160.66	1.00			
December	1.73	1.88	2.17	162.83	1.04			

a Waterville discharge multiplied by 1.33.

Kennebec River at The Forks—Concluded.

1. Month.	2. Observed flow, sec. ft. per sq. mile.	3. Run-off—Corrected for Storage. Sec. ft. per sq. mile.	4. Run-off—Corrected for Storage. Depth in inches. Monthly.	5. Run-off—Corrected for Storage. Depth in inches. Sum.	6. Draft, 0.90 Sec. Ft. per Sq. Mile, or 1,120 Sec. Ft., and 2,600 Sec. Ft. May, June, July. Draft. Monthly.	7. Draft. Sum.	8. Deficiency. Inches.	9. Deficiency. Billion cu. feet.
1908.								
January	1.56	1.25	1.44	164.27	1.04	164.27		
February	1.29	.72	.78	165.05	.97	165.24	.19	.5
March	1.97	.75	.86	165.91	1.04	166.28	.37	1.1
April	1.93	3.11	3.47	169.38	1.00	167.28		
May	6.69	7.76	8.95	178.33	2.42			
June	4.37	3.66	4.08	182.41	2.34	182.41		
July	1.89	.37	.43	182.84	2.42	184.83	1.99	5.7
August	1.80	.74	.85	183.69	1.04	185.87	2.18	6.3
September	.99	−.09	−.10	183.59	1.00	186.87	3.28	9.4
October	.58	−.05	−.06	183.53	1.04	187.91	4.38	12.6
November	.37	.10	.11	183.64	1.00	188.91	5.27	15.2
December	.29	.10	.12	183.76	1.04	189.95	6.19	17.8
1909.								
January	.30	.34	.39	184.15	1.04	190.99	6.84	19.7
February	.57	.52	.54	184.69	.94	191.93	7.24	20.9
March	.57	1.14	1.31	186.00	1.04	192.97	6.97	20.1
April	1.73	4.99	5.57	191.57	1.00	193.97	2.40	6.9
May	5.11	7.02	8.09	199.66	2.42	199.66		
June	2.52	1.77	1.98	201.64	2.34	202.00	.36	1.0
July	2.06	1.07	1.23	202.87	2.42	204.42	1.55	4.5
August	1.63	.28	.32	203.19	1.04	205.46	2.27	6.5
September	1.15	1.03	1.15	204.34	1.00	206.46	2.12	6.1
October	.80	1.40	1.61	205.95	1.04	207.50	1.55	4.5
November	.88	.96	1.07	207.02	1.00	208.50	1.48	4.3
December	.56	.40	.46	207.48	1.04	209.54	2.06	5.9
1910.								
Sanuary	1.27	.85	.98	208.46	1.04	210.58	2.12	6.1
February	1.11	.99	1.03	209.49	.94	211.52	2.03	5.8
March	.96	1.15	1.33	210.82	1.04	212.56	1.74	5.0
April	2.59	5.34	5.96	216.78	1.00	213.56		
May	3.81	3.96	4.56	221.34	2.42			
June	3.03	2.99	3.34	224.68	2.34	224.68		
July	2.04	.85	.98	225.66	2.42	227.10	1.44	4.2
August	1.55	.56	.65	226.31	1.04	228.14	1.83	5.3
September	.89	.19	.21	226.52	1.00	229.14	2.62	7.5
October	1.01	.07	.08	226.60	1.04	230.18	3.58	10.3
November	.76	.30	.33	226.93	1.00	231.18	4.25	12.2
December	.80	.32	.37	227.30	1.04	232.22	4.92	14.2
1911.								
January	.81	.34	.39	227.69	1.04	233.26	5.57	16.0
February	.57	.26	.27	227.96	.94	234.20	6.24	18.0
March	.48	.37	.43	228.39	1.04	235.24	6.85	19.7
April	.58	1.61	1.80	230.19	1.00	236.24	6.05	17.4
May	1.66	3.48	4.01	234.20	2.42	238.66	4.46	12.8
June	1.93	1.46	1.63	235.83	2.34	241.00	5.17	14.9
July	1.48	.61	.70	236.53	2.42	243.42	6.89	19.8
August	1.46	.60	.69	237.22	1.04	244.46	7.24	20.9
September	1.09	.59	.66	237.88	1.00	245.46	7.58	22.1
October	.62	.73	.84	238.72	1.04	246.50	7.78	22.4
November	.31	.62	.69	239.41	1.00	247.50	8.09	23.3
December	.59	1.79	2.06	241.47	1.04	248.54	7.07	20.4

Column 1 is the month and the year.

Column 2 is the actual or observed run-off in second feet per square mile as measured at The Forks gaging station on Kennebec River.

Column 3 is a similar run-off in second feet per square mile but as corrected for storage in Moosehead Lake. It therefore represents the approximate natural flow of the river as corrected for storage. The records are missing for certain winter months during the earlier years. In those cases the Waterville run-off was taken and multiplied by 1.33 as the percentage of discharge at the outlet of Moosehead Lake to the Waterville discharge was about in this proportion as shown in Water Supply Paper 198, page 149.

Column 4 is run-off corrected for storage expressed in depth in inches on the drainage area as this is the more convenient unit to use in mass curve computations.

Column 5 is the progressive sums of the figures in the immediately preceding column and are the figures that are used to plot the mass curve shown as the continuous irregular line on plate IV, the lower lines in the case of the occasional loops of the diagram.

Column 6 is the assumed draft on the reservoir or the continuous amount of water that is released through the gates of the dam. The quantities are 2600 second feet during May, June and July and 1120 second feet during the balance of the year. The monthly figures are expressed in depth in inches on the drainage area of 1240 square miles above the outlet of Moosehead Lake.

Column 7 shows the monthly summations of the assumed draft. The rèspective summations start at some peak of the mass curve where the monthly natural run-off is less than the assumed draft. This summation is continued until the result in each case is less than the corresponding sum of the run-off corrected for storage in depth in inches as given in column 5. The figures in this column, No. 7, are plotted on the mass curve diagram, plate IV, and are shown as the upper lines in the detached occasional loops of the diagram. Other portions of the curve indicate that the natural outflow was greater than the assumed draft.

Column 8 shows the difference between the corresponding monthly figures in columns 7 and 5 and is the deficiency expressed in inches depth on the drainage area that would result from the assumed draft.

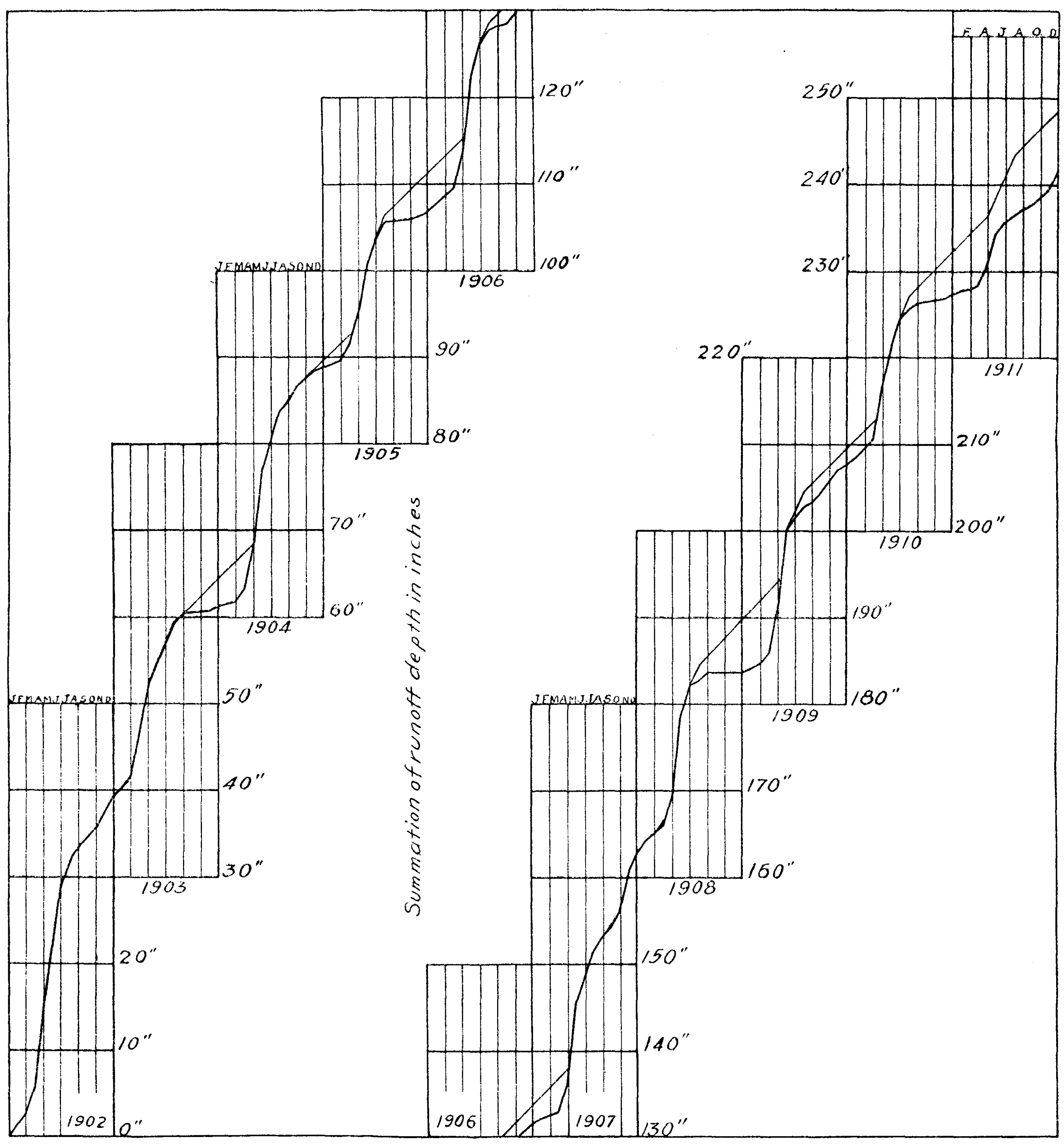
Column 9 is the deficiency expressed in billion cubic feet and is found by multiplying the figures in column 8 by the drainage area, in this case 1240 square miles and using appropriate factors to reduce to the unit used. These figures are the deficiencies in billion cubic feet at the end of each month resulting from the assumed draft, or in other words, they represent the storage required to maintain the assumed draft. Column 8 or the deficiency in inches, can be measured directly from the diagram and is the distance or ordinate between the draft curve and the natural discharge mass curve.

Plate IV is a graphical representation therefore of columns 5, 7, and 8. The draft lines starting from the various peaks of the mass curve can be considered as starting from a full reservoir. The lower line of the loops would indicate the inflow, and the upper or draft lines, the outflow. The ordinate at any point, especially the maximum ordinate, would indicate the amount of storage required to maintain the assumed draft.

Furthermore, whenever the draft line intercepts the mass curve the period of time through which storage is necessary can be found by the difference of time between the date of the summit of the mass curve from which the draft line starts and the date when it again intercepts the mass curve.

For example, there is a slight draft on the reservoir in February and March, 1908, but in April the reservoir is full again and continues so until the end of June. During this period there is the constant draft from the reservoir but there is also water wasted from the reservoir. In July, as the draft begins to exceed the inflow, stored water in the reservoir is drawn upon and continues until into April, 1909. The greatest deficiency was in February, 1909 and equalled 20.9 billion cubic feet, or in other words, if we had started in June, 1908 with the reservoir full of 23.7 billion cubic feet capacity, the period of this drought could have been successfully passed with a constant draft assumed, and there would have been 2.8 billion cubic feet remaining in the reservoir.

However, the greatest period of deficiency since the establishment of the station in 1902 and as shown by the Waterville record since 1893 and for many years prior to that, judging



MASS CURVE OF RUN-OFF OF KENNEBEC RIVER AT THE FORKS.

from the mass curve of rainfall, occurred in November, 1911. The above table and plate IV show that with a proper handling of Moosehead Lake with its present capacity of 23.7 billion cubic feet, the constant flow of 1120 second feet could have been maintained from August to April inclusive with 2600 second feet during May, June and July.

November, 1911, was probably the most critical period on the Kennebec River for the past 50 years. At the present writing in February, 1912, Moosehead Lake is 4 feet on the gage and it probably will be necessary to let out an extra quantity of water very shortly in order to take care of the spring flood run-off.

A number of other similar computations to the one described above have been made under different conditions of requirements for log driving and for the different reservoir capacities as shown in the table on page 159. Speaking generally, computations have been made for log driving requirements of 2600, 3000, and 3500 second feet. The following table shows the results of these computations.

Kennebec Storage Deductions.

No.	Draft.		Draft for log driving—May, June, July.	Maximum Deficiency or Storage Required.	
	Second feet.	Second feet per sq. mile.		Time.	Billion cubic ft.
1.	1,120	0.90	2,600	Nov. 1911.....	23.3
2.	1,000	.81	3,000	" "	23.6
3.	840	.68	3,500	" "	23.4
4.	1,180	.95	2,600	" "	25.5
5.	1,050	.85	3,000	" "	25.5
6.	910	.73	3,500	" "	25.5
7.	1,280	1.03	2,600	" "	28.9
8.	1,170	0.94	3,000	" "	29.2
9.	1,000	.81	3,500	" "	28.9
10.	1,260	1.02	2,600	" "	28.5
11.	1,450	1.17	2,000	" "	28.3
12.	1,390	1.12	2,500	" "	31.6
13.	1,330	1.07	3,000	" "	34.6
14.	1,040	0.84	4,000	" "	36.6
15.	1,130	0.91	4,000	" "	39.3

Numbers 1 to 3 in the preceding table are based on storage in Moosehead Lake only of 23.7 billion cubic feet and show what constant drafts from the lake can be maintained under the three different assumptions for log driving requirements during May, June and July.

Numbers 4 to 6 are based on total present storage of 25.6 billion cubic feet above the outlet of Moosehead Lake.

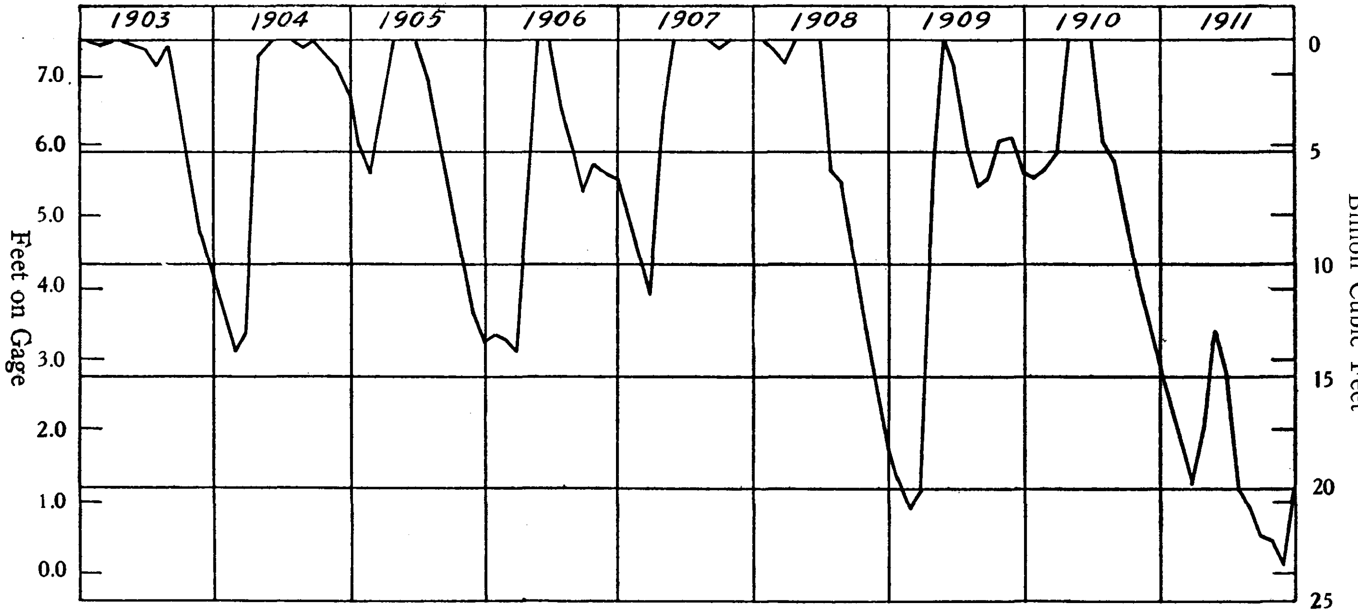


FIG. 1. "CONDITION OF RESERVOIR" MOOSEHEAD LAKE.

Numbers 7 to 9 are especially interesting as they are based on present storage with the addition of increased storage that would be available by the construction of the proposed dam at the outlet of Brassua Lake and on the assumptions of the varying quantities for log driving purposes of 2600, 3000, and 3500 second feet.

The remaining computations are for miscellaneous reservoir capacities and log driving requirements.

After the mass curves and draft lines have been plotted as shown on plate IV, the next step is the construction of the "condition of reservoir" or depletion diagram. For each month the difference between the draft line and the mass curve gives the depletion in inches depth on the water shed which is reduced to billion cubic feet when the drainage area is known. These monthly depletions in cubic feet are plotted using time intervals as abscissae and billion cubic feet as ordinates. This condition of reservoir curve for Moosehead Lake is shown in figure 1. The horizontal lines and figures on the right hand side of the diagram represent billion cubic feet. The short lines and the figures on the left hand side of the diagram represent feet on the Moosehead Lake gage near the outlet. The horizontal line immediately below the years or on which the irregular line stops, represents the full reservoir and corresponds to the blank lines in columns 8 and 9 of the tables on pages 162, 163 and 164.

This diagram brings out the periods of greatest draft on Moosehead Lake if the gates had been regulated in accordance with the plan here outlined. In February 1904 the lake would have been drawn down to nearly 3.0 feet on the gage and 13.9 billion cubic feet would have been drawn out. In March, 1906 the lake would have been drawn to the same point. In February, 1909, it would have been drawn down to about 1 foot on the gage with a quantity of water used of 20.9 billion cubic feet. Starting with a full reservoir in June 1910 the lake would have been drawn down in March 1911 to about 1.3 on the gage. At the end of May 1911 it would have gone up to about 3.4 on the gage and thereafter rapidly drawn down until the end of November when the lake would have been practically emptied.

The computations of storage control described in detail above were based on present capacity of Moosehead Lake alone as a number of people in considering storage in this basin disregard the additional lakes. In the opinion of the writer, however, the storage in Long Pond and both Roach ponds should be considered. This, in addition to Moosehead gives a storage capacity of 25.5 billion cubic feet. Using 2600 second feet in May, June, and July, it is found that 1180 second feet can be drawn from the reservoir for the balance of the year as shown in the table on page 167.

If the dam at Brassua Lake is constructed, 1280 cubic feet per second can be drawn constantly from the reservoir from August 1 of each year to April 30 of the following year while during the log driving season May, June and July 2600 second feet could be drawn or the amount that was used for log driving purposes in 1911.

Stream Flow.

The following gaging stations have been maintained in the Kennebec basin. The run-off computations from the establishment of the various stations to 1909 were published in the 1st Annual Report, pages 269 to 286. The 1910 discharge has in some cases been recomputed, based on better rating curves and the monthly estimates of discharge for 1910 and 1911 are given in the following pages.

Moose River at Rockwood (1902-1908 and 1910-1911).
Moosehead Lake at Greenville (1903-1911, stage only).
Moosehead Lake at East Outlet (1905-1911, stage only).
Kennebec River at The Forks (1901-1911).
Kennebec River at Bingham (1907-1910).
Kennebec River at North Anson (1901-1907).
Kennebec River at Waterville (1893-1911).
Roach River at Roach River (1901-1908).
Dead River at The Forks (1901-1907 and 1910-1911).
Carrabassett River at North Anson (1901-1907).
Sandy River at Farmington (1910-1911).
Sandy River at Madison (1904-1908).
Messalonskee Stream at Waterville (1903-1905).
Sebasticook River at Pittsfield (1908-1911).
Cobbosseecontee Stream at Gardiner (1890-1911).

All reliable data pertaining to the Kennebec River drainage collected prior to 1907 have been assembled and published in Water Supply Paper, 198, Water Resources of Kennebec River Basin.

MOOSE RIVER NEAR ROCKWOOD.

The gaging station was established Sepember 7, 1902 and discontinued December 31, 1908, but was re-established May 16, 1910. It is located 4 miles west of Kineo, near the village of Rockwood, and 2 miles from the mouth of the river.

Monthly discharge of Moose River at Rockwood.

[DRAINAGE AREA, 680 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
May	2,420	1,730	1,960	2.88	1.71
June	3,560	1,770	2,290	3.37	3.76
July	2,200	303	867	1.28	1.48
August	338	177	277	.407	.47
September	303	134	237	.349	.39
October	338	177	236	.347	.40
November	584	303	434	.638	.71
December	....	....	200	.294	34
1911.					
January	....	....	180	.265	.31
February	....	....	130	.191	.20
March	....	....	140	.206	.24
April	3,670	177	787	1.16	1.29
May	5,460	1,170	3,170	4.66	5.37
June	1,200	707	894	1.31	1.46
July	876	270	643	.946	1.09
August	631	303	447	.657	.76
September	681	434	573	.843	.94
October	906	631	765	1.12	1.29
November	846	584	684	1.01	1.13
December	1,540	631	1,070	1.57	1.81
The year	5,460	....	796	1.17	15.89

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

KENNEBEC RIVER AT THE FORKS.

This station is located at the wooden highway bridge across Kennebec River at The Forks, about 2,000 feet above the mouth of Dead River. It was established September 28, 1901. The nearest dam used for storage is about 12 miles above the station, at the outlet of Indian Pond. From about May 1 to July 31 considerable fluctuation in gage height, ranging from 2 to over 5 feet, occurs daily, owing to regulation of flow for log driving.

Monthly discharge of Kennebec River at The Forks.
[DRAINAGE AREA, 1570 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	....	....	2,000	1.27	1.46
February	....	....	1,750	1.11	1.16
March	2,350	1,040	1,510	.962	1.11
April	9,070	1,330	4,070	2.59	2.89
May	9,810	2,290	5,980	3.81	4.39
June	7,320	3,050	4,760	3.03	3.38
July	4,390	2,840	3,210	2.04	2.35
August	5,560	1,530	2,440	1.55	1.79
September	1,630	1,160	1,400	.892	1.00
October	1,960	1,430	1,590	1.01	1.16
November	1,530	920	1,200	.764	.85
December	....	....	1,250	.796	.92
The year	9,810	....	2,610	1.66	22.46
1911.					
January	....	....	1,280	.815	.94
February	....	....	900	.573	.60
March	....	....	760	.484	.56
April	4,690	....	905	.576	.64
May	5,870	668	2,600	1.66	1.91
June	6,830	2,370	3,030	1.93	2.15
July	2,680	700	2,330	1.48	1.71
August	2,620	1,830	2,290	1.46	1.68
September	2,100	1,330	1,720	1.09	1.22
October	1,330	235	980	.624	.72
November	1,030	300	487	.310	.35
December	1,240	700	923	.588	.68
The year	6,830	235	1,520	.968	13.16

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

KENNEBEC RIVER AT WATERVILLE.

Records of flow of Kennebec River at the dam of Hollingsworth & Whitney Company of Waterville, Maine, have been furnished since 1893.

Monthly discharge of Kennebec River at Waterville, Maine.

[DRAINAGE AREA, 4270 SQUARE MILES.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	23,300	1,300	5,530	1.30	1.50
February	8,620	3,280	4,760	1.11	1.16
March	30,600	4,490	10,400	2.44	2.81
April	36,000	6,550	22,300	5.22	5.82
May	23,000	6,340	14,400	3.37	3.88
June	18,200	6,840	11,700	2.74	3.06
July	9,240	1,920	5,360	1.26	1.45
August	10,900	172	4,210	.986	1.14
September	3,380	100	2,510	.588	.66
October	3,650	237	2,550	.597	.69
November	4,010	242	2,520	.590	.66
December	2,820	194	1,930	.452	.52
The year	36,000	100	7,350	1.72	23.35
1911.					
January	3,000	207	2,020	0.473	0.55
February	1,810	206	1,380	.323	.34
March	3,270	285	1,410	.330	.38
April	27,900	2,740	12,000	2.81	3.14
May	24,400	3,240	7,790	1.82	2.10
June	6,590	1,360	4,270	1.00	1.12
July	5,230	744	2,910	.681	.79
August	4,360	667	3,250	.761	.88
September	4,290	392	2,800	.656	.73
October	3,990	408	2,630	.616	.71
November	4,540	248	2,930	.686	.77
December	9,820	445	4,530	1.06	1.22
The year	27,900	206	4,000	.937	12.73

NOTE.—The complete hydrographic data for this station, including descriptions, list fo discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

DEAD RIVER NEAR THE FORKS.

A station on Dead River, about 1 1-2 miles west of The Forks was established September 29, 1901, discontinued August 15, 1907, and re-established March 16, 1910.

Monthly discharge of Dead River at The Forks.
[DRAINAGE AREA, 878 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	....	....	1,000	1.14	1.31
February	....	....	900	1.03	1.07
March	4,480	580	1,470	1.67	1.92
April	12,800	2,340	6,300	7.18	8.01
May	8,250	1,650	4,120	4.69	5.41
June	4,240	700	1,830	2.08	2.32
July	955	270	501	.571	.66
August	825	185	436	.497	.57
September	580	110	371	.423	.47
October	470	110	173	.197	.23
November	580	270	436	.497	.55
December	....	....	200	.228	.26
The year	12,800	....	1,470	1.67	22.78
1911.					
January	....	....	220	0.251	0.29
February	....	....	170	.194	.20
March	....	....	180	.205	.24
April	9,510	....	1,690	1.93	2.15
May	11,300	1,120	4,050	4.62	5.33
June	1,560	560	1,140	1.30	1.45
July	715	160	402	.458	.53
August	1,000	240	478	.545	.63
September	610	415	489	.558	.62
October	1,190	510	762	.869	1.00
November	940	462	677	.772	.86
December	3,600	610	1,340	1.53	1.76
The year	11,300	....	972	1.11	15.06

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

SANDY RIVER NEAR FARMINGTON.

The gaging station was established June 22, 1910. It is located at the Fairbanks bridge about 3 miles above Farmington and 8 miles above the dam at Farmington Falls.

Monthly discharge of Sandy River at Farmington.

[DRAINAGE AREA, 270 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
July	100	53	69.5	.257	.20
August	488	46	107	.396	.46
September	119	40	65.1	.241	.27
October	119	40	62.7	.232	.27
November	298	46	87.8	.325	.36
December	100	....	62.8	.233	.27

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

SEBASTICOOK RIVER AT PITTSFIELD.

The gaging station on the Sebasticook River, which was established July 3, 1908, is located at the steel highway bridge just above the Maine Central Railroad bridge across the river in the town of Pittsfield, Maine.

About 800 feet upstream from the gaging station is a dam which furnishes power to the Robert Dobson Company and the Smith Woolen Company. About 5 miles below the station is the Sebasticook Power Company's dam.

Monthly discharge of Sebasticook River at Pittsfield.

[DRAINAGE AREA, 320 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	989	193	473	1.48	1.71
February	745	374	522	1.63	1.70
March	2,200	395	792	2.48	2.86
April	2,590	125	1,150	3.59	4.00
May	1,040	290	598	1.87	2.16
June	838	142	344	1.08	1.20
July	395	125	266	.831	.96
August	331	97	273	.853	.98
September	250	71	206	.644	.72
October	230	60	132	.412	.48
November	212	22	122	.381	.42
December	212	14	98.6	.308	.36
The year	2,590	14	415	1.30	17.54
1911.					
January	230	30	132	0.412	0.48
February	212	40	120	.375	.39
March	230	22	132	.412	.48
April	2,990	270	1,390	4.34	4.84
May	1,470	97	465	1.45	1.67
June	270	97	218	.681	.76
July	230	71	169	.528	.61
August	212	84	162	.506	.58
September	212	71	136	.425	.47
October	250	14	152	.475	.55
November	374	125	255	.797	.89
December	1,040	193	544	1.70	1.96
The year	2,990	14	322	1.01	13.68

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

COBBOSSEECONTEE STREAM AT GARDINER.

The discharge of Cobbosseecontee Stream at the dam of the Gardiner Water Power Company at Gardiner has been furnished by the S. D. Warren Company Since 1890.

Monthly discharge of Cobbosseecontee Stream at Gardiner.

[DRAINAGE AREA, 240 SQUARE MILES.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	260	0	184	.767	.88
February	270	0	207	.862	.90
March	400	0	276	1.15	1.33
April	708	0	293	1.22	1.36
May	875	0	380	1.58	1.82
June	280	0	243	1.01	1.13
July	280	0	206	.858	.99
August	260	0	226	.942	1.09
September	260	0	225	.938	1.05
October	260	0	194	.808	.93
November	220	0	167	.696	.78
December	150	0	111	.462	.53
The year	875	0	226	.942	12.79
1911.					
January	180	0	125	0.521	0.60
February	200	0	148	.617	.64
March	520	0	154	.642	.74
April	758	0	398	1.66	1.85
May	280	0	232	.967	1.11
June	260	0	225	.938	1.05
July	255	0	166	.692	.80
August	200	0	174	.725	.84
September	200	0	173	.721	.80
October	200	0	139	.579	.67
November	120	0	100	.417	.47
December	185	0	105	.438	.50
The year	758	0	178	.742	10.07

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

ANDROSCOGGIN DRAINAGE BASIN.

Description.

Androscoggin River is formed by the junction of Magalloway River and the outlet of the Umbagog-Rangeley lakes near the Maine-New Hampshire boundary. For about 35 miles it flows southward in New Hampshire, then turns abruptly and flows eastward in Maine, finally turning toward the south and joining the Kennebec in Merrymeeting Bay, near Brunswick. The river is about 200 miles long and the greatest width of its basin is about 70 miles. The total drainage area is 3500 square miles, about 80 percent of which is in Maine. Its only important tributary is Little Androscoggin River, which enters at Lewiston.

The lower part of the basin is hilly and partly wooded, and much of it is farm land; the upper part is very broken and mountainous and is largely in forest. The general elevation of the basin is greater than that of any other on the Atlantic coast. Umbagog Lake is about 1,240 feet above sea level, and Rangeley Lake about 1,500 feet. The sources of Magalloway River reach elevations of from 2,600 to 2,900 feet.

Granite, gneiss, and mica schists are found along the main course of the river, with clay slate in the upper part of the basin. The bed of the river, like that of the Kennebec and Penobscot, is rocky where falls occur, and its high banks little subject to overflow—conditions that are advantageous in the development of water power.

The mean annual precipitation is probably about 40 inches, ranging from 43 inches near the coast to less than 35 inches in the extreme northern part of the basin. Winters in the northern portions of the basin are extremely rigorous and low water frequently occurs during the winter months on this account.

The Androscoggin is naturally provided with storage facilities as fine as those of any river in the East. Including the Umbagog-Rangeley series, which afford a combined water surface of about 69 square miles, there is a storage of about 19,000,000,000 cubic feet. The drainage area at the outlet of Umbagog Lake and above the mouth of Magalloway River is 635 square miles; of Magalloway River at its mouth, 460 square miles. Under the efficient management of the controlling interests on the river, the storage afforded by these lakes has had a marked effect upon the regimen of flow during low water for the past few years. By the completion of the Aziscohos dam on Magalloway River, in 1911, approximately 8,000,000,000 cubic feet of additional storage has been provided, very materially increasing the low-water flow of the Androscoggin.

Androscoggin River is probably as well developed as any other river in the country. Of the 1,240 feet fall between Umbagog Lake and tide water about 515 feet has been developed aud furnishes power to many mills, including the cotton mills of Brunswick and Lewiston, and the great pulp and paper mills of Livermore Falls, Rumford Falls, and Berlin; but there still remain some excellent unutilized sites of especial value on account of the uniform flow of the stream.

Androscoggin River is an important stream for log driving and care is exercised in the amount of water used for this purpose. The regulation of the flow is under one management, and is controlled in the interests of both log driving and the water-power developments.

Little Androscoggin River, about 30 miles long and draining an area of about 380 square miles, is well endowed with storage facilities and is an important water-power stream for its size.

The longest record of flow on the Androscoggin River is that at Rumford Falls, extending back to 1892. The driest year since the beginning of the records was 1911 and the wettest 1902, the total flow during these two years being about in the ratio of 1 to 2.01.

River and Lake Surveys.

Surveys have been made in this basin by the United States Geological Survey in coöperation with the State of Maine as follows:

Androscoggin River, Brunswick to Umbagog Lake, 10 sheets.
Umbagog, Lower and Upper Richardson lakes.
Mooselucmaguntic Lake.
Mooselucmaguntic Lake and Richardson lakes, outlet plans.
* Rangeley Lake.
* Rangeley Lake outlet.
* Rangeley River and Kennebago River.
* Kennebago Lake.
* Rapid River and Pond-in-River.

The results of these surveys may be had on application to the State Water Storage Commission, Augusta, Maine.

Lake Storage.

The systematic work of the measurement of the water surface areas of the lakes and ponds of the State as described on page 85 of this report is being extended to cover the Androscoggin River basin. Results will appear in the next report.

Stream Flow.

The following stations have been maintained in this river basin:

Androscoggin River at Errol, N. H. (1905-1911).
Androscoggin River at Gorham, N. H. (1903) fragmentary.
Androscoggin River at Shelburne, N. H. (1903-1907 and 1910).
Androscoggin River at Rumford Falls, Maine (1892-1911).
Androscoggin River at Dixfield, Maine (1902-1908).

The longest record of flow on the Androscoggin is that at Rumford Falls, extending back to 1892. The driest year since the beginning of the records was 1911 and the wettest 1902, the total flow during these two years being in the ratio of 1 to 2.01.

Run-off computations from the establishment of the various stations to 1909 were published in the 1st Annual Report, pages 321 to 326. The monthly estimates of discharge for 1910 and 1911 are given in the table below. Detailed data for these stations for 1910 will be found in Water Supply Paper No. 281 and for 1911 in Water Supply Paper No. 301.

*Surveyed but not yet published.

ANDROSCOGGIN RIVER AT ERROL, N. H.

The record of flow of Androscoggin River at Errol Dam, N. H., has been furnished by the Union Water Power Co. since 1905. The computations are based on coefficients applied to 14 gates in the dam as computed from a few discharge measurements. The gate ratings are not as thorough as could be desired but the records as published are believed to approximate the true discharge and are considered fair. Run-off data from 1905 to 1909 inclusive are published in the 1st Annual Report, page 321. Monthly discharge estimates for 1910 and 1911 are given below.

Monthly discharge of Androscoggin River at Errol, N. H.

[DRAINAGE AREA, 1095 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910					
January	1,210	914	1,120	1.02	1.18
February	1,270	1,060	1,190	1.08	1.12
March	1,360	738	1,150	1.05	1.21
April	6,840	1,390	3,390	3.10	3.46
May	3,990	1,590	2,800	2.56	2.95
June	4,340	1,340	2,760	2.52	2.81
July	1,610	884	1,220	1.11	1.28
August	1,310	972	1,120	1.02	1.18
September	1,590	1,040	1,180	1.08	1.20
October	1,110	937	980	0.895	1.03
November	1,320	325	1,030	0.942	1.05
December	1,340	928	1,190	1.09	1.26
The year	6,840	325	1,590	1.46	19.73
1911.					
January	1,080	681	864	0.789	.91
February	815	641	718	.656	.68
March	850	626	716	.654	.75
April	2,330	742	1,150	1.05	1.17
May	4,370	907	2,140	1.95	2.25
June	1,280	266	763	.697	.78
July	1,410	428	1,070	.977	1.13
August	2,440	205	971	.887	1.02
September	1,280	562	902	.824	.92
October	1,340	414	973	.889	1.02
November	1,230	560	903	.825	.92
December	2,070	344	1,190	1.09	1.26
The year	4,370	205	1,030	.941	12.81

ANDROSCOGGIN RIVER AT RUMFORD FALLS.

The discharge of the Androscoggin River at Rumford Falls since 1892 has been furnished through the courtesy of Mr. Charles A. Mixer, Rumford Falls Power Co.

Monthly discharge of Androscoggin River at Rumford, Me.

[DRAINAGE AREA, 2090 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	14,223	1,340	2,669	1.28	1.48
February	2,298	1,737	1,965	.940	.98
March	10,370	2,199	3,923	1.88	2.17
April	14,253	3,710	8,417	4.03	4.50
May	8,034	3,120	4,419	2.11	2.43
June	5,225	2,057	3,672	1.76	1.96
July	2,094	1,301	1,678	.803	.93
August	3,445	1,308	1,770	.847	.98
September	2,094	1,352	1,676	.802	.90
October	1,663	1,162	1,447	.692	.80
November	2,425	1,388	1,646	.788	.88
December	1,904	1,116	1,436	.687	.79
The year	14,253	1,116	2,893	1.38	18.80
1911.					
January	2,770	925	1,440	0.689	0.79
February	1,040	830	951	.455	.47
March	1,760	625	789	.378	.44
April	14,800	1,190	5,080	2.43	2.71
May	15,000	1,710	5,020	2.40	2.77
June	2,400	1,380	1,790	.856	.96
July	1,670	1,120	1,380	.660	.76
August	2,290	1,140	1,450	.694	.80
September	1,730	1,340	1,540	.737	.82
October	2,820	1,630	2,020	.967	1.11
November	3,600	1,720	2,240	1.07	1.19
December	4,360	1,140	2,620	1.25	1.44
The year	15,000	625	2,200	1.05	14.26

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper, No. 281, and for 1911 in Water Supply Paper No. 301.

PRESUMPSCOT DRAINAGE BASIN.

DESCRIPTION.

Presumpscot River, the outlet of Sebago Lake, rises about 17 miles northwest of Portland. The principal tributary of the lake is Crooked River, a stream heading 35 miles farther north and within 3 miles of the Androscoggin. The area of the lake is 46 square miles. The total water surface in the drainage basin is 78 square miles. The area of the drainage basin at the outlet of the lake is 436 square miles, and at the mouth of the river 616 square miles.

The northern part of the basin is mountainous and wooded; the southern part is moderately hilly and mostly in farm land. Granite gneiss, and mica-schists appear in many places, and the soil is gravelly and sandy. The fall from Sebago Lake to tide-water is about 265 feet in a distance of nearly 22 miles, or an average of about 12 feet per mile.

The mean annual precipitation is probably about 42 inches. The river and lake generally freeze over during the winter.

Sebago Lake is a magnificent natural storage reservoir, and its utilization for this purpose has made the regimen of flow of the Presumpscot extremely regular. Nowhere in the United States is there a better example of efficient regulation of storage than on the Presumpscot.

A record of flow from Sebago Lake has been kept since 1887. During this period of over 20 years the dryest season was that of 1911 and the wettest 1902, the total flow for these two years being about in the ratio of 1 to 3.11.

STREAM FLOW.

PRESUMPSCOT RIVER AT OUTLET OF SEBAGO LAKE.

A record of flow from Sebago Lake has been kept since 1887 and has been furnished from time to time by the S. D. Warren Company. The run-off figures as published in the 1st Annual Report and in the various Water Supply Papers of the U. S. Geological Survey for years prior to 1904 were computed on a 6 day basis instead of a 7 day basis as usually adopted, and therefore the entire series of records have been recomputed for this report. Slight changes have also occasionally been made in the monthly figures since 1904 on the basis of a better understanding of the Sunday flow.

Run-off data as recomputed from 1887 to 1909 inclusive, are given below as second feet per square mile and depth in inches. For 1910 and 1911 data are given as complete monthly estimates in the form usually adopted in the Water Supply Papers of the U. S. Geological Survey and elsewhere in this report.

A continuous record of the fluctuations of the surface of Sebago Lake has been kept since 1887 and office computations were made to determine the natural flow of Presumpscot River as it would have been if not modified by the operation of the lake as a storage reservoir. Such computations have been described previously, especially for the Kennebec River at the outlet of Moosehead Lake [see page 160] and the West Branch of Penobscot River at Millinocket. (a)

The results as finally determined for the natural flow did not seem consistent or in conformity with the regimen of the other river basins of the State. Often certain months in the fall of the year would show an extremely low run-off whereas the next month would suddenly increase. An investigation of the conditions controlling the flow in the basin were then made and it was discovered that the seeming discrepancies were due to control of reservoirs above Sebago Lake. For instance, the dam controlling the discharge of Long Lake that empties into Sebago Lake is often shut, allowing practically no flow through the gates. In such a month the computed natural run-off would be low. The next month, as Sebago Lake was drawn down, water would be released from Long Lake and several other storage basins above, thus accounting for the large increase in the computed flow. Records of the levels of Long Lake and the other storage basins above have not been kept and it is therefore believed to be impossible to correctly compute the natural flow of Presumpscot River. The computed figures for the natural flow based on Sebago Lake levels alone are absolutely misleading and are not worth publishing. The only reliable data are the figures for the observed flow as given below.

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a. See Water Supply Paper No. 279, U. S. Geological Survey. Water Resources of the Penobscot River Basin by H. K. Barrows and C. C. Babb.

Run-off of Presumpscot River at Outlet Sebago Lake, in Second-feet per Square Mile and Depth in Inches.

[DRAINAGE AREA, 436 SQUARE MILES.]

	1887.		1888.		1889.		1890.		1891.		1892.		1893.		1894.		1895.		1896.		1897.	
	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.
January	1.74	2.01	1.86	2.14	1.97	2.27	1.86	2.14	1.96	2.26	1.52	1.75	1.23	1.42	1.78	2.05	1.52	1.75	1.09	1.26	1.64	1.89
February	1.83	1.91	1.70	1.83	2.26	2.35	1.92	2.00	1.89	1.97	1.60	1.73	1.26	1.31	1.66	1.73	1.49	1.55	1.13	1.22	1.63	1.70
March	1.84	2.12	1.82	2.10	2.52	2.90	1.79	2.06	1.84	2.12	1.54	1.78	1.18	1.36	1.19	1.37	1.34	1.54	3.07	3.54	1.56	1.80
April	1.85	2.06	1.74	1.94	2.29	2.56	2.41	2.69	3.33	3.72	1.44	1.61	1.18	1.32	1.11	1.24	1.22	1.36	1.48	1.65	0.98	1.09
May	2.10	2.42	2.94	3.39	2.28	2.63	3.05	3.52	2.32	2.68	1.41	1.63	1.37	1.58	1.46	1.68	1.49	1.72	1.82	2.10	1.27	1.46
June	2.17	2.42	2.48	2.77	2.07	2.31	1.87	2.09	1.94	2.16	1.44	1.61	1.73	1.93	1.54	1.72	1.42	1.58	1.87	2.09	1.60	1.78
July	1.73	1.99	1.70	1.96	1.86	2.14	1.60	1.84	1.67	1.92	1.52	1.75	1.51	1.74	1.45	1.67	1.23	1.42	1.77	2.04	1.80	2.08
August	1.80	2.08	1.67	1.92	1.84	2.12	1.65	1.90	1.70	1.96	1.66	1.91	1.50	1.73	1.41	1.63	1.22	1.41	1.60	1.84	2.29	2.64
September	1.85	2.06	1.68	1.87	1.63	1.82	1.73	1.93	1.79	2.00	1.48	1.65	1.69	1.89	1.18	1.32	1.22	1.36	1.44	1.61	1.94	2.16
October	1.80	2.08	1.48	1.71	1.69	1.95	1.91	2.20	1.82	2.10	1.17	1.35	1.59	1.83	1.17	1.35	1.06	1.22	1.46	1.68	1.87	2.16
November	1.85	2.06	1.65	1.84	1.75	1.95	1.83	2.04	1.66	1.85	1.14	1.27	1.54	1.72	1.11	1.24	1.06	1.18	1.53	1.71	1.66	1.85
December	1.90	2.19	1.82	2.10	1.68	1.94	1.99	2.29	1.52	1.75	1.15	1.33	1.71	1.97	1.40	1.61	1.02	1.18	1.65	1.90	1.83	2.11
Total		25.40		25.57		26.94		26.70		26.49		19.37		19.80		18.61		17.27		22.64		22.72
Mean	1.87		1.88		1.99		1.97		1.95		1.42		1.46		1.37		1.28		1.66		1.67	

Run-off of Presumpscot River at Outlet Sebago Lake, in Second-feet per Square Mile and Depth in Inches—Concluded.

[DRAINAGE AREA, 436 SQUARE MILES.]

	1898.		1899.		1900.		1901.		1902.		1903.		1904.		1905.		1906.		1907.		1908.		1909.	
	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.	Second-feet per square mile.	Depth in inches.
January........	1.92	2.21	1.58	1.82	1.06	1.22	1.42	1.64	1.38	1.59	1.42	1.64	1.29	1.49	1.11	1.28	1.13	1.30	1.16	1.34	1.55	1.79	1.15	1.33
February.......	2.05	2.14	1.58	1.64	1.14	1.19	1.49	1.55	1.35	1.41	1.41	1.47	0.98	1.06	.94	.98	1.41	1.47	1.08	1.12	1.76	1.90	1.19	1.24
March..........	1.77	2.04	1.43	1.65	1.34	1.54	1.43	1.65	1.54	1.78	1.45	1.67	1.08	1.24	.79	.91	1.23	1.42	.68	.78	1.27	1.46	1.39	1.60
April..........	2.50	2.79	1.13	1.26	2.04	2.28	1.00	1.12	9.64	10.76	1.46	1.63	1.30	1.45	1.06	1.18	1.17	1.30	.82	.92	1.20	1.34	1.12	1.25
May............	2.72	3.14	1.40	1.61	3.07	3.54	1.39	1.60	2.73	3.15	1.38	1.59	1.37	1.58	1.12	1.29	1.21	1.40	1.10	1.27	1.28	1.48	1.41	1.63
June...........	2.12	2.36	1.43	1.60	1.80	2.01	1.66	1.85	1.34	1.50	1.49	1.66	1.52	1.70	1.12	1.25	1.27	1.42	1.20	1.34	1.46	1.63	1.56	1.74
July...........	2.03	2.34	1.41	1.63	1.65	1.90	1.54	1.78	1.49	1.72	1.53	1.76	1.37	1.58	1.05	1.21	1.43	1.65	1.16	1.34	1.29	1.49	1.49	1.72
August.........	2.07	2.39	1.43	1.65	1.44	1.66	1.32	1.52	1.56	1.80	1.53	1.76	1.40	1.61	1.06	1.22	1.56	1.80	.97	1.12	1.56	1.80	1.49	1.72
September......	1.95	2.18	1.42	1.58	1.37	1.53	1.37	1.53	1.46	1.63	1.57	1.75	1.48	1.65	1.06	1.18	1.56	1.74	.77	.86	1.65	1.84	1.46	1.63
October........	1.89	2.18	1.35	1.56	1.37	1.58	1.32	1.52	1.37	1.58	1.56	1.80	1.41	1.63	1.05	1.21	1.60	1.84	1.12	1.29	1.60	1.84	1.47	1.70
November.......	1.61	1.80	1.38	1.54	1.40	1.56	1.42	1.58	1.55	1.73	1.48	1.65	1.51	1.68	.93	1.04	1.43	1.60	1.36	1.52	1.52	1.70	1.52	1.70
December.......	1.62	1.87	1.32	1.52	1.41	1.63	1.41	1.63	1.34	1.54	1.40	1.61	1.26	1.45	.88	1.02	1.07	1.23	1.40	1.61	1.35	1.56	1.48	1.71
Total.........		27.44		19.06		21.64		18.97		30.19		19.99		18.12		13.77		18.17		14.51		19.83		18.97
Mean...........	2.02		1.40		1.60		1.39		2.23		1.47		1.33		1.01		1.34		1.07		1.46		1.39	

Monthly discharge of Presumpscot River at Outlet of Sebago Lake.

[DRAINAGE AREA, 436 SQUARE MILES.]

MONTH.	DISCHARGE IN SECOND-FEET.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	708	226	624	1.43	1.65
February	708	357	641	1.47	1.53
March	649	278	515	1.18	1.36
April	563	310	508	1.17	1.30
May	567	205	512	1.17	1.35
June	575	307	527	1.21	1.35
July	560	258	508	1.17	1.35
August	555	315	521	1.19	1.37
September	552	306	518	1.19	1.33
October	615	117	493	1.13	1.30
November	535	295	474	1.09	1.22
December	437	125	358	.821	.95
The year	708	117	517	1.18	16.06
1911.					
January	343	123	309	0.709	0.82
February	430	143	375	.860	.90
March	422	162	316	.725	.84
April	350	103	286	.656	.73
May	347	73	310	.711	.82
June	362	107	317	.727	.81
July	395	42	215	.493	.57
August	207	58	159	.365	.42
September	425	67	273	.626	.70
October	547	122	316	.725	.84
November	545	187	489	1.12	1.25
December	457	137	383	.878	1.01
The year	547	42	312	.716	9.71

NOTE.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

SACO DRAINAGE BASIN.

DESCRIPTION.

Saco River rises in the White Mountain region of New Hampshire at an elevation of about 1,900 feet above the sea and has a general southeasterly course to the Atlantic Ocean. It is about 105 miles long, the maximum width of its drainage basin is about 30 miles, and its drainage area, comprising 1,720 square miles, lies about equally in Maine and New Hampshire. Ossipee River, the largest tributary of the Saco, enters the main stream at Cornish, Me.

The headwaters of the Saco are in one of the highest and roughest mountain regions in the eastern portion of the United States, with steep wooded slopes and narrow river valleys, and with heavy falls to the mountain streams. The mountains grow gradually lower as the ocean is approached, becoming undulating hills in the central portions of the basin and comparatively flat land near the sea. The southern half of the drainage basin has been practically cleared of forests, but the remainder is still largely wooded. The prevailing rock is granite, which makes excellent building materials for dams and foundations. The surface material covering the larger part of the region is sand and gravel.

The mean annual precipitation is about 43 inches. Winter conditions in the mountainous part of the basin are quite rigorous and snowfall usually deep.

The Saco River drainage basin has about 43 square miles of lake surface, of which Great Ossipee and Moose lakes are the most important. In its upper courses the river falls very rapidly, but the regimen of flow is variable and typical of the mountain stream. In the lower part of the basin, particularly below the entrance of Ossipee River, the stream is more stable in regimen.

RIVER PROFILE.

Saco River, in the lower portion of its course, from Steep Falls dam to the mouth has a fall of 257 feet in 28 1-2 miles, or an average of about 9 feet to the mile. Power has been developed for many years at certain points on the river, especially at Biddeford and Saco, at Bar Mills and Steep Falls. More recently notable hydro-electric plants have been built, especially the West Buxton plant of the Portland Electric Company in 1906 and the Bonnie Eagle plant of the Cumberland County Power & Light Company completed in 1911. The river will undoubtedly receive further development in the next few years as its power is adjacent to Portland and other cities where a good market is available.

It has been the wish of this department that its special river and lake surveys could be extended to this basin but at the present time funds are not sufficient for the purpose. The need of a working profile has been felt in the general discussion of water power possibilities and in the study of existing power developments. Such a profile has been compiled from various sources and is shown as plate V. This profile is not based on a continuous line of levels and is simply considered a preliminary one. The distances were obtained by stepping off with spring dividers distances along the river from the following U. S. Geological Survey topographic sheets: Biddeford, Portland, Kennebunk, Buxton, Sebago, Kezar Falls, and Fryeburg. The elevations are from various sources. From tide water to Salmon Falls dam the elevations are given by W. S. Dennett of Saco, with a check from another source from the crest of Bradbury dam to Union Falls dam. The datum plane for these elevations was assumed as the creast of the old York dam at 50.00 feet. The zero of this datum is 7.00 feet below mean sea level as determined by R. W. Libby of Saco, therefore making the crest of the old York dam as 43.00 feet and the crest of Salmon Falls dam as 130.2 feet.

In order to clear up an uncertainty in the difference of elevation between the crest of Salmon Falls dam and the crest of Bar Mills dam, levels were run in January 1912 between the two points in question under the direction of the State Water Storage Commission.

The relative elevations from Bar Mills dam have been furnished by J. A. Fleet, General Manager, Portland Electric Co. The elevation of crest of Steep Falls dam is thus determined as 257 feet.

The profile from 35.0 to the 81.0 mile is taken directly from water surface elevations and contour crossings shown on the lithographic copies of the Fryeburg and Kezar Falls quadrangles. These two topographic sheets of the U. S. Geological Survey have recently been mapped in accordance with the accurate and modern methods of surveying as practiced by this Federal department. These two sheets are much more accurate in details and elevations than the atlas sheets publishd in the earlier years. Elevations are based on accurate lines of primary levels and are adjusted to close allowable percentages of error.

The following table gives the elevations and distances of controlling points along the Saco River from tide water to the New Hampshire line, the graphical representation being shown as plate V, in the pocket at the end of the volume.

Elevations and Distances along Saco River.

Locality.	Distance.		Elevation.	
	Total miles.	Difference, miles.	Above sea level.	Difference, feet.
Saco, lower highway bridge	0		10.0	
		0		0.0
York Mfg. Co., tail-race	0		10.0	
		0.1		0.0
Pepperell Mfg. Co., Laconia tail-race	0.1		10.0	
		0.1		16.8
Pepperell Mfg. Co., Laconia overfall	0.2		26.8	
		0.1		0.2
Lower dam, crest	0.3		27.0	
		0.0		17.3
Pepperell Mfg. Co., Pepperell overfall	0.3		44.3	
		0.1		0.0
York dam, present crest	0.4		44.3	
		0.0		2.0
York dam, flashboards	0.4		46.3	
		0.0		-0.8
Cataract dam, crest	0.4		45.5	
		0.2		5.7
Spring dam, crest	0.6		51.2	
		0.0		0.8
Bradbury dam, crest	0.6		52.0	
		0.35		0.0
B. & M. R. R. bridge, Eastern Division water surface	0.95		52.0	
		3.05		0.0
Little Falls, foot	4.00		52.0	
		0.05		1.0
Little Falls, head	4.05		53.0	
		2.65		1.0
Highway bridge, water surface	6.7		54.0	
		0.4		0.2
Biddeford-Dayton town line	7.1		54.2	
		1.0		0.4
Creek	8.1		54.6	
		0.5		0.4
Saco-Buxton town line	8.6		55.0	
		1.1		0.4
Union Falls, highway bridge, water surface	9.7		55.4	
		0.0		....
Union Falls highway bridge, floor	9.7		(87.9)	
		0.1		0.4
Union Falls dam, foot	9.8		55.8	
		0.0		1.8
Union Falls dam, gate sills	9.8		57.6	
		0.0		12.7
Union Falls dam, spillway	9.8		70.3	
		0.0		....
Union Falls dam, crest	9.8		(80.1)	
		1.05		0.7
Cooks Brook—Dayton-Hollis town line	10.85		71.0	
		0.6		....
Salmon Falls highway bridge, floor	11.45		(146.0)	
		0.05		39.0
Salmon Falls dam, foot, approximate	11.5		110.0	
		0.0		20.2
Salmon Falls dam, crest	11.5		130.2	
		1.2		....
Highway bridge, floor	12.7		(150.0)	
		0.0		3.6
Bar mills dam, tail-race	12.7		133.8	
		0.0		15.3
Bar Mills dam, crest	12.7		149.1	
		0.0		1.9
Bar Mills dam, flashboards	12.7		151.0	
		0.3		0.0
B. & M. R. R. bridge, water surface	13.0		151.0	
		0.6		0.0
Creek from east	13.6		151.0	
		0.35		1.0

Elevations and Distances along Saco River—Continued.

Locality.	Distance. Total miles.	Distance. Difference, miles.	Elevation. Above sea level.	Elevation. Difference, feet.
Creek from west	13.95	1.85	152.0	1.0
Creek from west	15.8	1.6	153.0	0.0
West Buxton dam, tail-race	17.4	0.0	153.0	25.0
West Buxton dam, crest	17.4	0.0	178.0	2.0
West Buxton dam, flashboards	17.4	0.8	180.0	0.0
Creek from west	18.2	0.2	180.0	0.0
Eagle Pond outlet	18.4	0.2	180.0	0.0
Cumberland-York County and Standish-Buxton town lines	18.6	0.45	180.0	0.0
Bonnie Eagle Plant, tail-race	19.05	0.15	180.0	36.0
Bonnie Eagle dam, crest	19.2	0.0	216.0	5.0
Bonnie Eagle dam, flashboards	19.2	0.8	221.0	0.0
Creek from north	20.0	0.5	221.0	0.0
Hollis-Limington town line	20.5	0.65	221.0	0.0
Creek from North Hollis	21.15	2.45	221.0	0.0
Little Ossipee River	23.6	0.1	221.0	0.0
Limington rips	23.7	0.3	221.0	1.0
East Limington highway bridge, water surface	24.0	1.3	222.0	5.0
Watchic Pond outlet	25.3	2.0	227.0	8.0
Strout Brook	27.3	1.2	235.0	5.0
Steep Falls dam, tail-race	28.5	0.0	240.0	17.0
Steep Falls dam, crest	28.5	0.6	257.0	0.0
Standish-Baldwin town line	29.1	1.25	257.0	0.0
Quaker Brook	30.35	2.65	257.0	0.0
Creek from north	33.0	0.1	257.0	0.0
Creek from Chase	33.1	1.25	257.0	1.0
Back Brook	34.35	0.75	258.0	2.0
Eastern edge, U. S. G. S Kezar Falls quadrangle	35.1	0.75	260.0	2.0
Pease Brook	35.85	0.15	262.0	1.0
Limington-Cornish town line	36.0	1.35	263.0	3.0
Cornish highway bridge, water surface	37.35	0.5	266.0	1.0
Ossipee River	37.85	0.7	267.0	1.0
Dug Hill Brook	38.55	0.7	268.0	2.0
Breakneck Creek	39.25	1.55	270.0	3.0

Elevations and Distances along Saco River—Concluded.

Locality.	Distance.		Elevation.	
	Total miles.	Difference, miles.	Above sea level.	Difference, feet.
Great Falls, foot	40.8		273.0	
Great Falls, head	41.0	0.2	342.0	69.0
Burnes Brook	41.2	0.2	342.0	0.0
Oxford-Cumberland County, & Hiram-Baldwin town lines	42.25	1.05	343.0	1.0
Maine Central Railroad bridge, water surface	43.0	0.75	344.0	1.0
Hancock Brook	43.5	0.5	344.0	0.0
Hiram highway bridge, water surface	43.6	0.1	344.0	0.0
Bryant Pond outlet	45.0	1.4	345.0	1.0
Rattlesnake Pond outlet	47.85	2.85	348.0	3.0
Hiram-Denmark-Brownfield town line	48.0	0.15	348.0	0.0
Dragon Meadow Brook	48.7	0.7	348.0	0.0
Moose Pond Brook	50.2	1.5	350.0	2.0
Horseshoe Pond outlet	50.85	0.65	350.0	0.0
Ten Mile River	52.0	1.15	351.0	1.0
Buck Meadow Brook	54.95	2.95	354.0	3.0
Brownfield-Denmark town line	55.05	0.1	354.0	0.0
Burnt Meadow Brook	56.95	1.9	355.0	1.0
Highway bridge, water surface	57.35	0.4	355.0	0.0
Shepards River	59.0	1.65	357.0	2.0
Fryeburg-Brownfield town line	60.45	1.45	358.0	1.0
Little Saco River	60.60	0.15	358.0	0.0
Lovewell Pond outlet	60.9	0.3	358.0	0.0
Highway bridge, water surface	62.85	1.95	360.0	2.0
Pleasant Pond outlet	63.2	0.35	361.0	1.0
Highway bridge, water surface	65.5	2.3	367.0	6.0
Mouth old channel	69.5	4.0	372.0	5.0
Bog Pond outlet	72.1	2.6	376.0	4.0
Highway bridge, water surface	73.0	0.9	377.0	1.0
Pinehurst	75.7	2.7	379.0	2.0
Swan Falls Water Power Co. dam, foot	76.9	1.2	382.0	3.0
Swan Falls Water Power Co. dam, crest	76.9	0.0	393.0	11.0
Weeks Brook	77.15	0.25	393.0	0.0
Highway bridge, water surface	80.1	2.95	394.0	1.0
Maine-New Hampshire state line	81.05	0.95	394.0	0.0

Stream Flow.

The following gaging stations have been maintained in this river basin:

Saco River near Center Conway, N. H. (1903-1910).
Saco River at West Buxton, Maine. (1907-1911).

SACO RIVER AT WEST BUXTON.

Records of flow at the hydro-electric plant of the Portland Electric Co. have been furnished since the completion of the plant in 1907, through the courtesy of Mr. J. A. Fleet, General Manager.

Run-off data from 1907 to 1910 were published in the 1st Annual Report, page 344. There are given below, the usual complete monthly discharge estimates for 1910 and 1911.

Monthly discharge of Saco River at West Buxton.

[Drainage area, 1550 square miles.]

Month.	Discharge in Second-Feet.				Run-off—Depth in inches on drainage area.
	Maximum.	Minimum.	Mean.	Per square mile.	
1910.					
January	2,370	465	1,170	.755	.87
February	2,010	681	1,160	.748	.78
March	9,100	3,770	5,660	3.65	4.21
April	13,100	2,720	8,180	5.28	5.89
May	10,800	2,100	4,990	3.22	3.71
June	4,360	1,760	3,100	2.00	2.23
July	1,760	521	1,040	.671	.77
August	1,870	566	1,170	.755	.87
September	1,420	460	930	.600	.67
October	1,030	265	709	.457	.53
November	1,690	445	1,030	.665	.74
December	1,310	208	792	.511	.59
The year	13,100	208	2,490	1.61	21.86
1911.					
January	2,100	290	1,420	0.916	1.06
February	1,230	520	880	.568	.59
March	3,410	510	995	.642	.74
April	10,140	2,600	6,640	4.28	4.78
May	11,020	1,860	5,450	3.52	4.06
June	2,700	1,020	1,870	1.21	1.35
July	1,420	310	894	.577	.67
August	1,100	190	634	.409	.47
September	850	260	576	.372	.42
October	1,880	250	1,130	.729	.84
November	2,220	1,030	1,680	1.08	1.20
December	3,510	960	2,160	1.39	1.60
The year	11,020	190	2,030	1.31	17.78

Note.—The complete hydrographic data for this station, including descriptions, list of discharge measurements, daily gage heights and rating tables for 1910 will be published in Water Supply Paper No. 281, and for 1911 in Water Supply Paper No. 301.

THE COST OF POWER. (*a*)

BY SETH A. MOULTON. (*b*)

INTRODUCTION.

The value of Maine's abundant water power and the wisdom of utilizing this natural asset can be determined only by comparing the cost of water generated power with that derived from other sources. Modern civilization would be an impossibility without the present effective transformation and application of nature's resources to perform the work essential for the operation of our varied industries, for transporting the commodities which they produce, for lighting our streets and homes and for rapid transit. The modern steam and electric locomotives are vital factors, as they bridge time and space, making the inhabitants of our country neighbors from ocean to ocean. The advent of the electric railway eliminated the congestion of our large cities and revived the suburban communities which would otherwise have remained in obscure stagnation. All of these activities depend upon mechanical energy, which in turn must owe its existence to the dissipation of natural forces.

The accomplishments of the day will be future history as epoch making achievements; but the gratification of present demands has been accompanied by a lavish expenditure of our natural wealth, and scientific prophets see in the horizon a cloud which forebodes evil to posterity, unless the principles of true conservation are applied now for the purpose of securing to future generations their birthright. To attain this end without restricting the full development of the country, it is necessary

(*a*) This article has been contributed by Mr. Moulton, his conclusions being based on several years' experience in connection with his engineering investigations of certain water power developments and power plant designs, comprising a number of completed projects with others in process of construction and under consideration.

(*b*) Of firm of Sawyer & Moulton, Consulting and Designing Engineers, Portland, Maine.

that coal should be burned without wasting a large percentage of its energy in useless smoke, which not only smears our faces today but will smirch our reputations in the eyes of our descendants when they are bearing the burden imposed by our prodigality. To attain this end we must confine the waters in our rivers and divert their energy into useful work instead of allowing it to be expended in eroding the land and transporting valuable soil into the ocean, piling up formidable obstructions at the mouths of the great rivers.

True conservation means utilization, not restriction, and to judiciously utilize, a workable knowledge of the questions involved is essential. Not the technical knowledge of the specialist, but the laical sort that can be evaluated and utilized by the public; and this is the excuse proffered for the existence of this paper, although the nature of the subject is such that the use of technical terms cannot be entirely obviated.

Man has converted into mechanical power the potential energy stored in the sun's rays, the rise and fall of the tides, the wind, the rivers and in the numerous fuels. Each and all of these elements have been commercially employed with varying degrees of success. The translation of solar heat into useful work is still in an experimental stage, although it has been successfully accomplished in hot countries where the periods of sunshine are reasonably determinable and constant, but the efficient utilization of the sun's rays can never be effected in the temperate and northern zones, due to the unstable climatic conditions. For centuries the windmill has been used where small amounts of power were required and where continuity of service was not essential. The tides have been effectively harnessed with water air compressing plants that are now operating successfully on a commercial scale; but the resulting compressed air must be transformed into mechanical power by means of the reciprocating or rotating engine, and again into electric current if the power is to be transmitted any distance from the generating station. These conditions occasion a low total efficiency of conversion, which, combined with the fixed charges due to the very expensive development cost, eliminates this power from competition with other classes; with the possible exception of some special cases where inaccessibility makes the cost of other forms of power excessive, or where the primary compressed air can be used to operate rock drills and other tools such as would be required for large quarrying operations. It is to be anticipated that the energy expended daily by the tides will be practically utilized at some future date, but the immediate present offers no promise of such an event.

Classes of Power.

Before passing to those classes of power which can be termed as commercially successful, mention should be made of the research work that is now being conducted by experimenters with the object of securing power direct from fuels by an electrochemical process that will eliminate all intermediate stages of conversion, producing the desired energy in a form commercially applicable both as to character and cost.

To fully comprehend the evolution, perfection and present relative status of the several commercial prime movers, it is advisable to scan the country's industrial history and observe its influence on power generation.

Our forefathers followed the water ways and river courses in the settlement of New England and research through the records of pioneer days will reveal the fact that the most accessible water powers were early employed, and that the establishment of permanent communities was controlled, in a large measure, by the existence of available water powers. Small industries with inexpensive low dams and primitive waterwheel installations gradually increased in number and magnitude until every inch of the available fall had been utilized on such rivers as the Blackstone in Massachusetts. Simultaneous with the growth of manufacturing came the perfection of the prime mover, and the transition was rapid from the large, slow speed, inefficient overshot or breast waterwheel to the small, more efficient and faster rotating prototype of the modern turbine. As the country expanded and its wealth increased, comprehensive schemes were perfected, at favorable locations on the larger rivers, that anticipated the establishment of varied industries on a coordinated system of canals so arranged that the entire energy of the available water would be expended in useful work as it passed from the headwater level of the dam through the canals to the turbines in the mills situated on the canal banks, thence to a second group of canals that conveyed the water to the wheels in other mills, and so continuing until it discharged into the river at an elevation many feet below the crest of the dam. Thus the cities of Lowell, Lawrence, Holyoke and Lewiston were all created and today exemplify the soundness of the projectors' judgment and the skill of their engineers. The perfection of electrical apparatus precludes the application of such a system to a modern development, but this fact does not detract from the merits of that which has gone before and much of New England's industrial stability must be attributed to the existence of those projects which have occasioned allied investments so extensive that their perpetuity is assured.

About forty years ago the increased economical workings of the extensive coal deposits, combined with increased transportation facilities and the development of the reciprocating steam engine, caused the manufacturer to locate his plant either nearer to the large centers of population, or where fuels, raw materials and the markets for the finished product were more accessible. Gradually the growth of the mills made the water power insufficient to supply the demands made upon it and steam power gained the ascendency, until in some instances once thriving communities became practically abandoned villages because an industry had outgrown its environments, occasioning the permanent shutdown of the water driven mill upon which the prosperity of the locality depended.

Many water powers were unwisely abandoned for the steam substitute and a reflex sentiment existed that temporarily placed water power in disrepute. During this period the development of new water powers practically ceased; but the rapid growth of the newspaper, the magazine and the popular novel soon created a demand for cheap paper in vast quantities, then the water powers of the wilderness were requisitioned to supply the cheap power required to masticate the surrounding forests. Water power development received a new impetus while in the timberland sections its value rapidly appreciated, and the hydraulic installations made in connection with the large paper mills exceeded anything previously conceived in magnitude, efficiency and details of design.

Coincident with the activity in the paper trade came the successful application of electric power generation, the most wonderful engineering feat of the age, but at first its significance was not appreciated and its ultimate influence on the value of water power was not generally comprehended until about ten years ago when the problem of long distance transmission was practically solved and the feasibility of delivering remote water power by electricity to accessible plants was fully realized. The advent of the electric generator accelerated the investigations and experiments which were being conducted, both in this country and Europe, in connection with the design of practical steam turbines, with the result that we see in this generation another triumph of scientific engineering in the high speed, compact, efficient and economical steam turbine units; already built up to 40,000 horsepower capacity in a single machine with prospects that units of greater magnitude can be successfully constructed. To provide the maximum of vacuum, so much to be desired in connection with the steam turbine, excellent condensing apparatus has been devised which will continuously maintain 28 inches and more of vacuum without incurring prohibitive expense for first cost and upkeep.

The competition arising from the introduction of the steam turbine compelled the manufacturer of reciprocating engines to perfect the details of his apparatus to place it on par with its formidable rival, for those ranges of power within the possible capacity of steam engine units; that is, for sizes of from 1 to 5,000 horsepower capacity, beyond this latter figure the field of the steam turbine is not encroached upon by any type of prime mover except by the most recent hydraulic turbines that have been built with capacities as high as 22,000 horsepower in a single unit, and may be constructed of still greater power where the magnitude and other conditions of the development will warrant such equipment.

The advancements made during the last decade have resulted in the attainment of what is in all probability the maximum of operating efficiency for steam-electric, hydro-electric and high tension power transmission equipment; and we can safely assume that it has approched perfection in this respect as nearly as can be expected. It is also probable that the gas and oil engine apparatus has nearly reached the point of maximum thermal efficiency and that future advancement in these lines will be in the direction of improving the mechanical details to insure reliability of service and economy in operation, with a material increase in the unit capacities in order to reduce first cost and secure maximum operating economy.

The gas engine development must be largely attributed to the use of natural and blast furnace gases, particularly the latter, although the more recent perfection of the equipment for manufactured, or producer, gas has greatly enlarged the field of application open for gas engine installations. Gas engines can be constructed with capacities as high as 7,000 horsepower, but the largest engine within the writer's knowledge, used in connection with a producer, is rated at 1,500 horsepower.

Crude petroleum and fuel oil have long been recognized as valuable fuels for use in an internal combustion engine, although no American inventor seemed able to cope successfully with the practical problems of construction involved in its application; but the "Diesel" type has been employed in Europe and is satisfactorily operated in a few small plants in this country. For inexplicable reasons the art of oil engine design has remained almost stationary in the United States, while there has been evolved in Europe numerous makes of "Diesel" oil engines with capacities up to 3,000 horsepower. The "Diesel" engine has been used on about sixty-five merchant and trading vessels, on not less than one hundred submarines and on over twenty warships. Experiments conducted by the Krupps in Germany and other foreign shops demonstrate that 2,500 horsepower can be developed with a single cylinder oil engine and on this basis that a six cylinder engine can be built which will give 15,000 horsepower. The writer is firm in his belief that the oil engine will prove an important factor where economical power generation is a consideration, that the American mechanical engineers and manufacturers will soon attack the oil engine problem in earnest to produce large efficient units, and that they will prove worthy contestants against the intrenched steam and gas rivals.

From the foregoing it will be seen that there are now commercially available four distinct classes of power:—Steam, Water, Gas, and Oil, naming them in the order of their prestige. These afford the following systems:—

Steam.

Reciprocating Engines:

1. Simple Non-condensing.
   For small plants where fuel is cheap or where all, or the greater part, of the exhaust steam can be utilized for heating purposes.
2. Simple Condensing.
   For small plants using cheap fuel.

3. Compound Non-condensing.
   For plants using cheap fuel, or where the exhaust steam can be utilized.
4. Compound Condensing.

From Nos. 1 to 4 inclusive the power may be delivered to machines with either mechanical or electrical drives.

Turbines.

5. High Pressure Condensing.
6. Low Pressure Condensing.
   Ordinarily employed in connection with reciprocating engines in old plants to increase the capacity, with a minimum expense, by utilizing the heat from the engine exhaust in the turbine.
7. Bleeder Turbines.
   Designed to permit the diversion of a portion of the steam after it has reached a stage in the turbine which will give the desired pressure for heating purposes.

From Nos. 5 to 7 inclusive the power is usually delivered to the machines electrically.

8. Non-condensing Turbines.
   Used principally for driving boiler feed water or condenser pumps where the exhaust from the turbine can be utilized for heating.

Water.

9. Mechanical Drive.
10. Local Electrical Distribution.
11. Long Distance Electrical Transmission.

Gas.

12. Reciprocating Engines.
    With mechanical or electrical distribution or long distance transmission.
13. Reciprocating Engines and Low Pressure Steam Turbines.
    The steam turbines utilizing the waste heat from exhaust and jacket cooling water. The principal application is for central electric stations or industries using electrical power distribution.

Oil.

14. Reciprocating Engines.
    Mechanical or local electrical distribution or long distance electric transmission.

EFFICIENCIES.

Efficiency defined in its broadest sense means not only the most complete utilization of the elements converted but also the most economical combination of appliances and labor to effect the conversion. To secure in power generation a maximum efficiency and economy does not imply that the last vestige

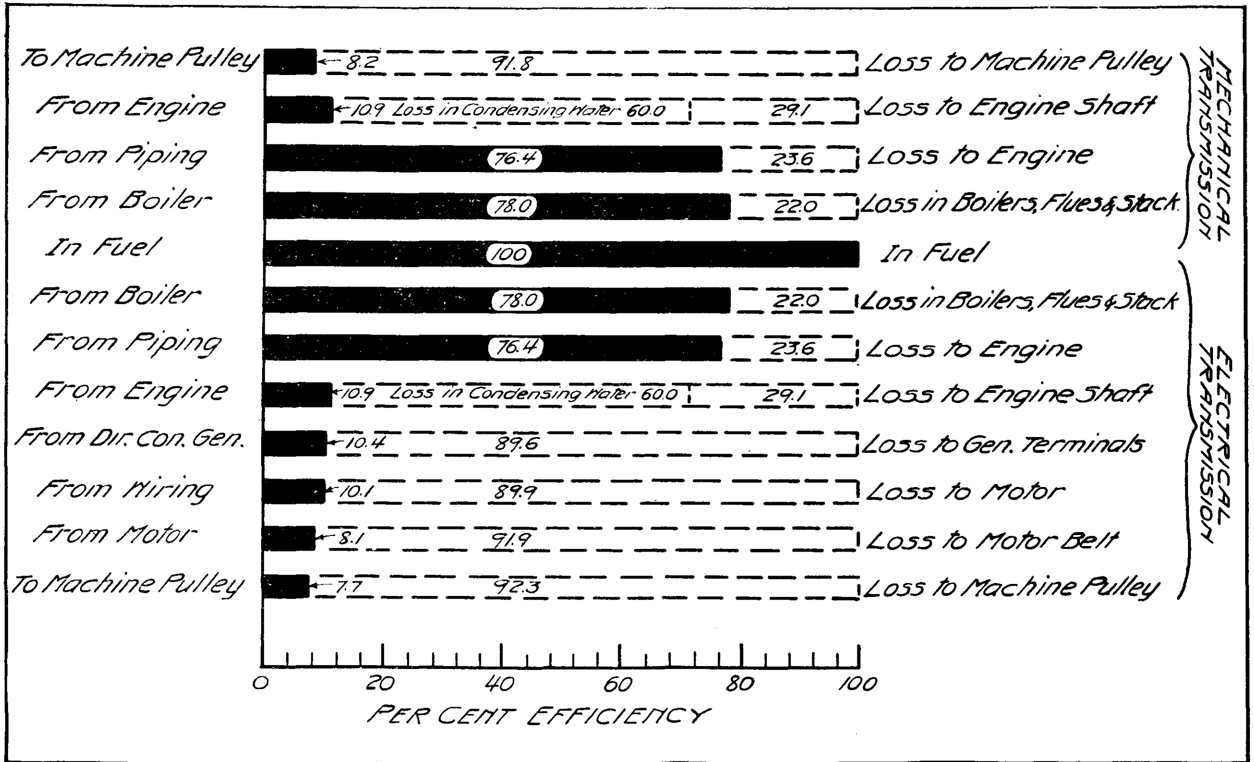


FIG 2. POWER EFFICIENCIES: STEAM.

of available energy must be extracted from the fuel or water element, with the unwarranted refinements of equipment and attention which such an impractical course would impose; or that the other extreme should be applied by using the cheapest apparatus and labor procurable in a vain attempt to economize; but it is necessary to carefully balance all of the factors involved, endeavoring always to deliver to the point of final application a maximum amount of the energy originally expended, at a minimum cost.

Figures 2 to 4 inclusive and plate VI (*a*) inclusive show graphically the efficiencies which may be expected to obtain in the practical running of steam, producer gas, oil and water power plants, with first-class installations, supplying a service where a fairly constant loading exists and when operated by competent mechanics. It is true that the average power plant does not attain the heat efficiencies indicated on the diagrams, but they are well within results which have been excelled in a few plants and can be usually obtained in plants of 1,000 or more horsepower capacity.

The diagram for "Power Efficiencies" Fig. 2 shows the thermal efficiency obtained at the several stages of transposition in a steam plant, from the 100 per cent. of heat value in the fuel, as placed under the boilers to the mechanical energy delievered to the machines. The plottings on the diagram above the fuel line are for mechanical transmission and those below for local electrical distribution. To secure the operating economies indicated by Fig. 2 the plant must be equal to or in excess of 1,000 horsepower capacity. For smaller plants the efficiencies would be less, probably falling as low as 5 or 6 per cent. of the theoretical energy in the fuel when delivered as mechanical energy to the machine or other point of use. It is also improbable that these efficiencies can be realized in central stations that distribute power for all classes of service, owing to the fluctuations of the demand. The average load in these stations does not ordinarily exceed 30 per cent. of the power required to maintain the maximum, or so-called "peak" load, which will exist only for a short period during each day. It is also very difficult to maintain the high boiler efficiency of 78 per cent., as

(*a*) All of the diagrams used in connection with this paper were prepared under the supervision of Mr. George L. Freeman, to whom full credit should be given for the valuable service rendered.

this requires constant cleaning and very careful operation, with the application of the most scientific methods for the manipulation of drafts and firing of the boilers. The average boiler efficiency will probably not exceed 75 per cent. in plants of the better class.

Up to the engines all of the losses are thermal; at the engines the losses are both mechanical and thermal; and a general inspection of the diagram would indicate that the steam turbine or engine is a very inefficient mechanism, as the total heat and mechanical efficiency drops from 76.4 per cent. to only 10.9 per cent. This is not true, however, for it must be remembered that the 60 per cent. noted on the diagram as lost in the condensing water should not be charged against the engine, as the heat energy so expended is latent or liquid heat, for the exhaust steam from an engine has practically the same pressure as the medium into which it is discharged and the temperature of the steam is controlled by this pressure. It is obvious that there will be no available potential energy from such exhaust steam, as this energy is neutralized by the opposing back pressure which may be either above, below or equal to the atmospheric pressure, depending upon the conditions at the exhaust outlet; but under all circumstances the full heat value of the steam remains unimpaired. Crediting the engine with this 60 per cent. by deducting it from the 76.4 per cent. (the thermal efficiency delivered from the piping) leaves 16.4 per cent. of heat energy actually delivered to the engine which may be converted into mechanical power; then the combined efficiency of the engine and its auxiliaries becomes $(10.9\% \div 16.4\%) \times 100 = 66\%$. An appreciation of this condition is most essential because it explains why the steam engine can never compete in heat efficiency with the internal combustion engine, either gas or oil. This condition is also of paramount inportance when selecting the type of apparatus or determining the character of the power to adopt for an industry that requires heat for manufacturing or process purposes. Referring to the diagram it will be noted that 76.4 per cent. of the heat in the fuel is admitted to the engine throttle and that only 10.9 per cent. of the total heat in the fuel is converted to mechanical power; therefore, the waste heat rejected by the engine exhaust is 65.5 per cent. of the total in the fuel, and there remains in the exhaust steam $65.5\% \div 76.4\%$, or 85 per cent. of the heat that was delivered to the engine. It is conservative to state that there is available for process purposes at least 75 per cent. of the heat value in steam after all available potential energy has been extracted from it, and maximum economy demands that this heat should be used as heat if possible, rather than dissipate it in the cooling water of a condenser to secure the comparatively small percentage of mechanical energy thus acquired.

To indicate the gain secured by utilizing exhaust steam for heating purposes, the following Table No. 1 is given.

Table No. 1.

Per cent. of exhaust steam used for heating purposes.	Pounds of coal per one horsepower per hour. All coal charged to power.	Net pounds of coal per one horsepower per hour after deducting for exhaust steam used.
0	1.75	1.75
25	2.06	1.50
50	2.38	1.25
75	2.69	1.00
100	3.00	0.75

This table was compiled by Mr. Charles T. Main, a prominent civil engineer, who has long advocated and made practical application of engine exhaust for industrial heating purposes.

Where all or a greater part of the exhaust can be utilized, simple non-condensing engines or turbines should be installed, and where lesser amounts, down to 25 per cent. of the steam required for power purposes, the exhaust can be taken from the "bleeder turbines" or the intermediate receivers between the cylinders of a compound engine, operating either non-condensing or condensing whichever proves the most economical.

Fig. 3 illustrates the efficiency of producer gas plants in the same general manner as that previously described for steam. The great advantage of the gas equipment lies in the fact that for all plant capacities there can be maintained practically the same efficiencies, making the smaller producer gas plant proportionately more efficient than the steam. In addition, cheap grades of fuel can be efficiently used in a gas producer which could not be burned with any degree of economy under a boiler, and the higher grades of fuel can be more efficiently used in a producer than in a boiler.

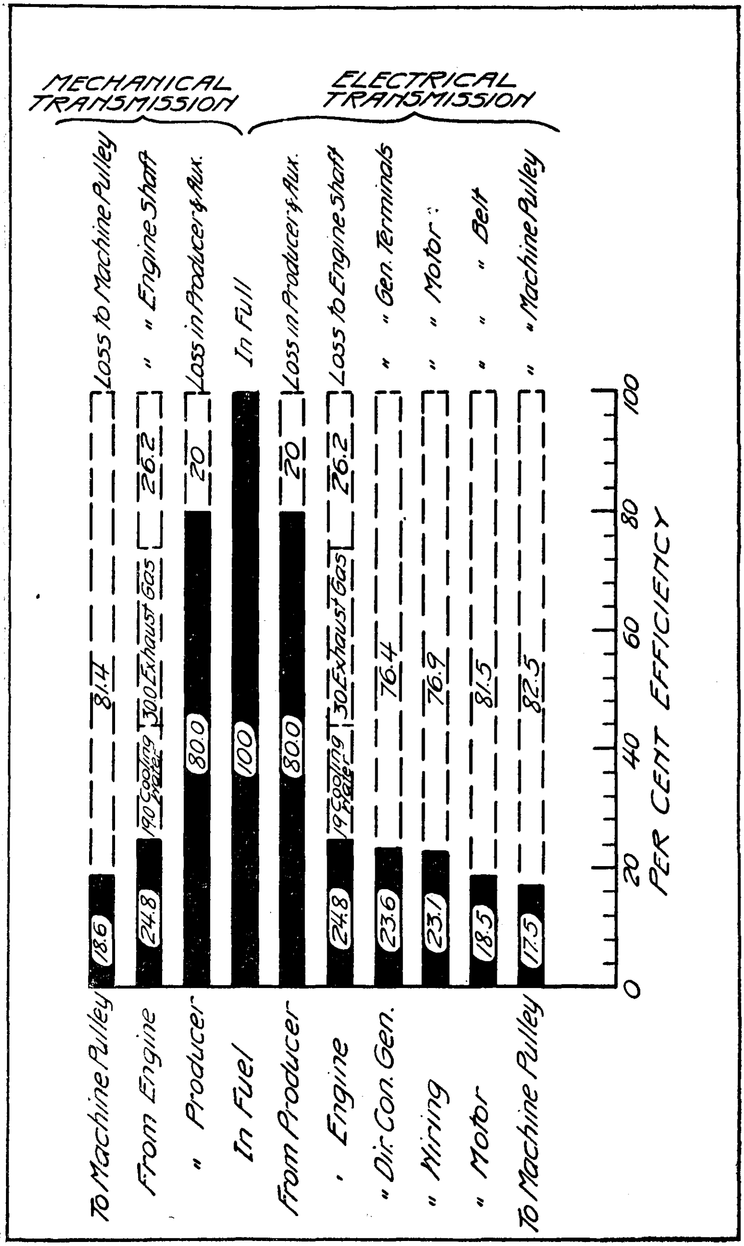


Fig. 3. Power Efficiencies: Producer Gas.

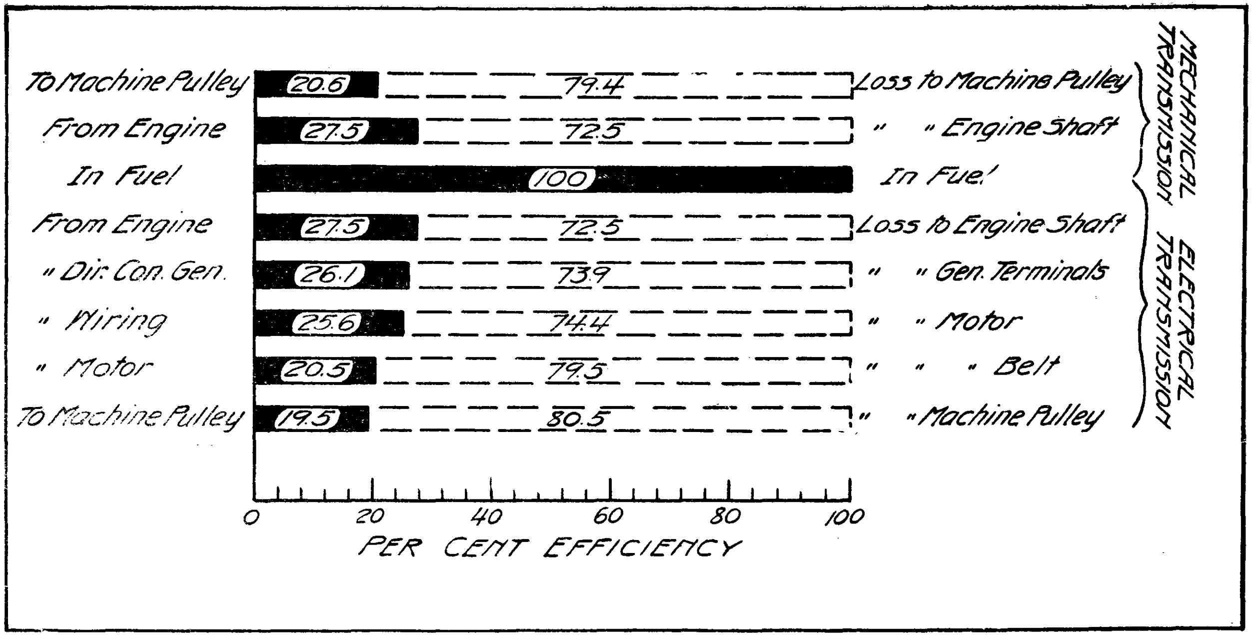


FIG. 4. POWER EFFICIENCIES: OIL.

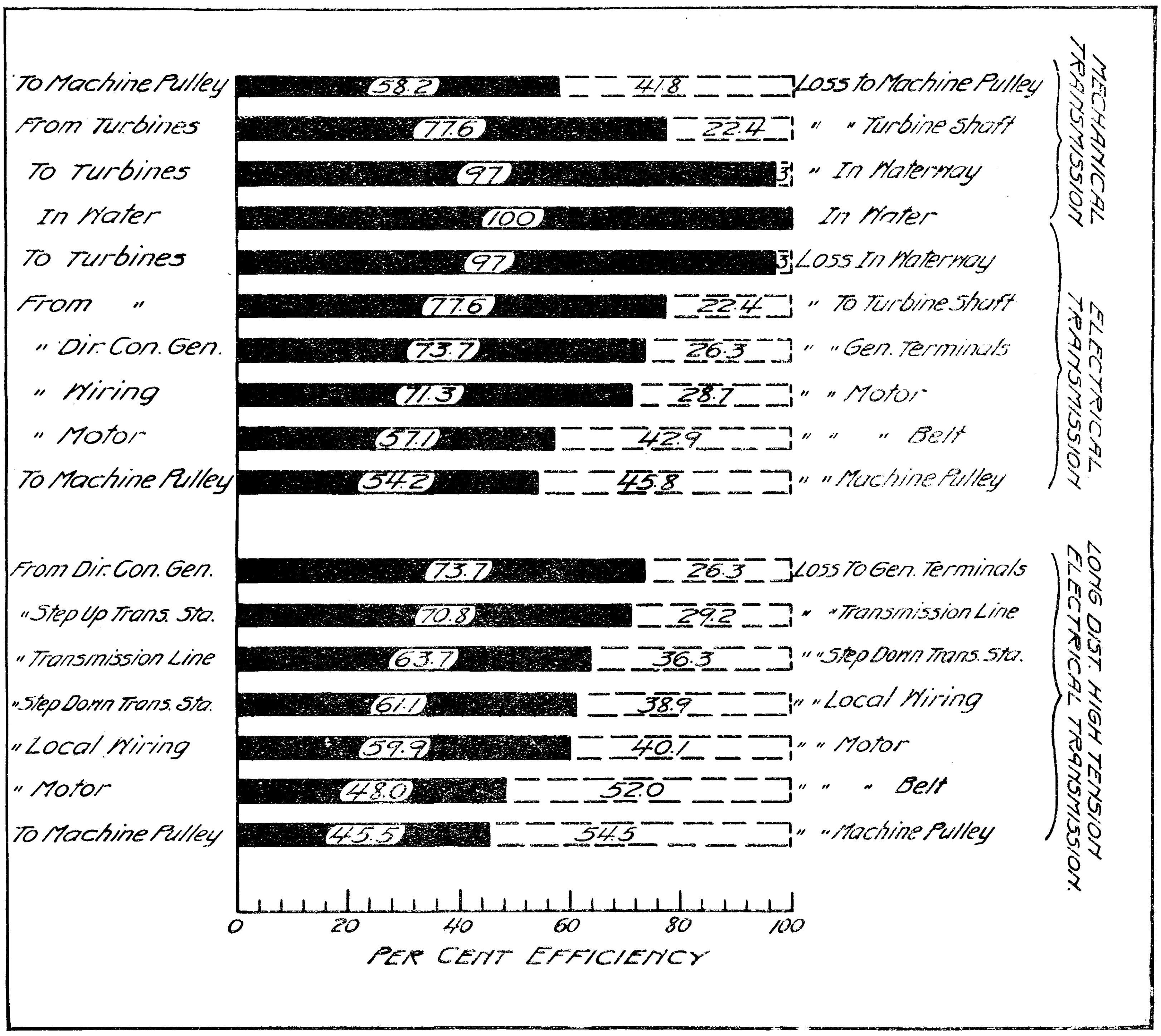
What has been said in regard to the producer gas plant applies generally to the efficiency of oil engines, with the exception that such an equipment is still more efficient than the gas, as is shown on Fig. 4.

Plate VI, illustrating the efficiency of hydraulic or hydro-electric power plants, is self-explanatory. It shows more stages than the foregoing plates, because it includes long distance electrical transmission, as given on the lower sections of the diagram. If desired, this diagram can be used to obtain the losses or the net efficiency for long distance transmission in connection with any of the previously described diagrams.

Fig. 5 forcibly depicts the superior efficacy of water power, indicating that it is 604 per cent. more efficient than steam power at its best, 209 per cent, more efficient than producer gas power and 178 per cent, more efficient than oil power. In addition, nature continually replenishes the "white coal" for the water power, while man constantly depletes nature's storehouses to supply the fuel for the other classes.

Although the comparisons indicated by this last diagram are startling and would make it appear that water power had an almost immeasurable value, it must be remembered that the cost of installation is in most instances large and that the water supply must be utilized as it is afforded by nature, unless storage reservoirs are provided of ample capacity to impound the freshets at situations on the stream or river where a maximum amount of the runoff from a given watershed can be retained, with ample pondage facilities at the plant to regulate daily fluctuations. All these facts tend to increase the cost of hydraulic power and decrease the value of power sites, except in sections especially favored by nature, remote from a fuel supply, where a maximum storage and pondage can be obtained or where a demand exists for a volume of high grade power within reasonable transmission range.

All of the diagrams previously described show only what may be termed the "physical efficiency" of the several plants; but there is another factor of greater importance, as indicated by the above statement in regard to the cost of water power, this has been called "investment efficiency." Physical efficiency applies only to the utilization of the elemental factors, investment efficiency considers the cost necessary to control and apply these elements; and the ideal power to be selected for a given



POWER EFFICIENCIES: WATER

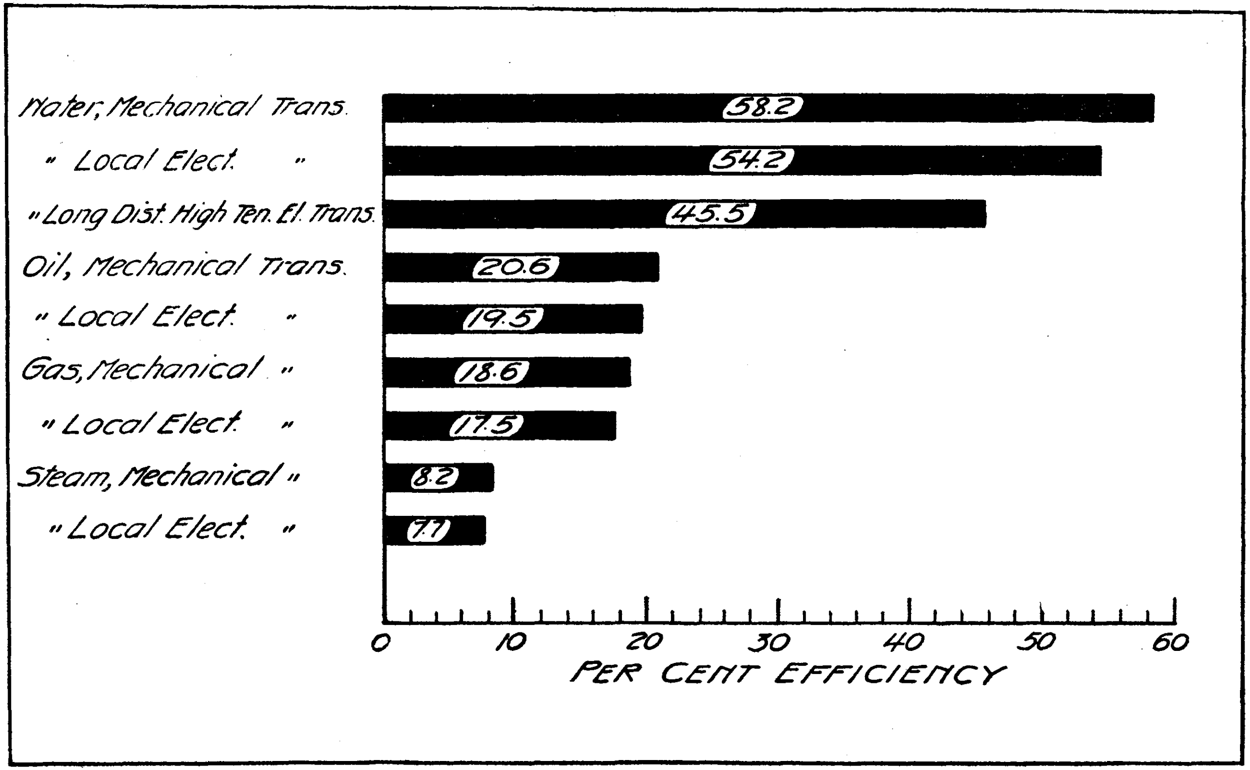


FIG. 5. COMPARATIVE EFFICIENCIES OF VARIOUS SOURCES OF POWER.

situation will be that which shows the greatest economy when both the "physical" and "investment" efficiencies are maximum.

The "investment efficiency" has no definite base for unity, such as the heat value of a fuel or the potential energy of water, but is obtained by determining the ratio between one or more known capitalized costs; the "capitalized cost" being the capital invested in the project plus the sum obtained by capitalizing the total annual expenditures at the rate of interest allowed on the capital invested. To illustrate:—A steam power plant costs \$100,000.00 and the rate of interest is 5 per cent. The annual expenditure to operate this plant is \$50,000.00; then the "capitalized cost" will be \$100,000.00 + (50,000.00 ÷ 0.05), or \$100,000.00 + \$1,000,000.00 = \$1,100,000.00. A hydraulic plant to supply the same service costs \$150,000.00 and the annual operating expense is \$20,000.00. At the same rate of interest previously allowed, the "capitalized cost" will be \$150,000.00 + (\$20,000 ÷ 0.05) = \$550,000.00. The "capitalized cost" of the steam plant is \$550,000.00 more than that for the hydraulic installation, and calling the hydraulic plant capitalization unity the steam plant has a 50 per cent. "investment efficiency."

The above method is the simplest way to determine the best investment, and it can be proved to be accurate by making a more detailed analysis. For example:—Each of the above plants has a rated capacity of 1,800 horsepower and delivers annually 6,000,000 horsepower hours; then the expenditure per horsepower hour for the steam plant will be \$50,000.00 ÷ 6,000,000 = \$0.00833, or 8 1-3 mills, and the interest charges, \$100,000.00 × (0.05 ÷ 6,000,000) = \$0.0008, making the total cost per horsepower hour \$0.00913. For the hydraulic plant the expenditure per hosepower hour will be \$20,000.00 ÷ 6,000,000 = \$0.00333, or 3 1-3 mills, and the interest charges, \$150,000.00 × (0.05 ÷ 6,000,000) = \$0.00124, making the total cost per horsepower hour \$0.00333 + \$0.00124 = \$0.00457. From the above it will be seen that the steam power costs twice as much as the hydraulic, and, accordingly, it has an "investment efficiency" of only 50 per cent.

Measurements and Terms.

The manufacturer of power equipment usually presents to the prospective purchaser the economies of his apparatus viewed from the standpoint of "physical efficiency," claiming that this is the most important factor to consider in securing low cost power. The central station managers purport to fix their charges for power below the apparent cost of other forms of power, and they are disposed to exaggerate the cost of such power, placing particular emphasis on the "investment efficiency," in order that they may secure a maximum return for their commodity. The consulting engineer is constantly confronted with inaccurate statements in regard to the cost of power that are devised to convey erroneous impressions, either through intent or otherwise, with every advantage taken of bookkeeping ambiguities. In this manner reports are circulated that are incomplete or compiled with the specific purpose of misleading, and it is almost impossible to dispel these influences and convince a client that the advanced claims cannot be substantiated in actual practice. The greatest discrepancies are encountered in the figures given for the cost of steam power, and within certain limits this is to be anticipated, on account of the many controlling factors later enumerated; but with a fair comprehension of the premises any competent engineer should be able to analyze given conditions and compile an estimate which will be sufficiently accurate for all practical purposes. Should two reliable engineers report on the same project, it is likely that their figures for the cost of power would not vary more than 5 per cent. and probably less, if the general conditions governing the layout were sufficiently well defined by the local surroundings to occasion the presentation of two similar designs. We do not mean by the above statement that the estimated cost of the installations would necessarily be within 5 per cent., but that the cost for *a unit of power for a given period of time* would be within these limits.

An engine salesman blandly informs the prospective purchaser that he can furnish an engine which will generate one horsepower, meaning indicated horsepower, using only 16 pounds of steam per hour, and that with reasonably efficient boilers this would mean about 1 3-4 pounds of coal per hour per horsepower. The central station representative disputes this claim, stating that it will require at least 23 pounds of steam, or 2 1-2 pounds of coal, per hour per horsepower. The latter had considered the mechanical losses in the engine, the losses in the auxiliaries, the generator losses, the wiring losses and the motor losses, figuring on the power delivered to the line shafting or machines where it was to be utilized. Somewhat disturbed the victim seeks the advice of a specialist, only to learn that both statements are correct. Then confusion becomes chaos and a task is set for the counselor if he tries to convince his client that each adviser has told him nothing but the truth, although both have deceived him.

The prospective purchaser of power or power equipment will naturally question the reliability of information received from either equipment manufacturers or the central station agents, as he appreciates that the opinions advanced may be biased; accordingly, the influence of inaccurate statements from these sources is somewhat restricted; but when a company, generating power for its own use, becomes imbued with the idea that it has succeeded, by some special dispensation, in overthrowing the laws which regulate costs and thus has accomplished results that have not and cannot be attained, it is almost impossible to refute such statements or to convince the self-deceived party as to the error of its ways, and prevent the conversion of others into an acceptance of the false theories. Admitting the difficulties encountered in endeavoring to secure records and accurate information in regard to the cost of power, due to the many variables that effect such costs, it is absurd to assume that it is impossible to compute or predetermine with reaonable accuracy the cost of power for a given service or to claim that the secret of efficient and economical power generation is the special knowledge of an esoteric few. What has been once accomplished can be repeated; yet from the evidence which has been placed before us purporting to be accurate records of power costs, this logic seems to be refuted.

Much of the difficulty encountered in refuting inaccurate costs can be attributed to a confusion of the technical terms used in connection with power measurement and a lack of understanding in regard to the units of power measurement. In most instances the difficulty of comparison would be removed if the point of power measurement was clearly defined. It has been an almost universal custom to compute and compare power costs on the basis of one horsepower per year, using the term "cost per horsepower year," an absolutely meaningless expression having no significance unless it be specifically defined by the number of hours operation per year, the point of measuring the power and whether or not it be indicated, brake or electric horsepower, and if transmitted electric power whether it is metered on the high or low tension side of the consumer's transformers. The only true unit for the measurement of power or for comparison of cost is the kilowatt or horsepower hour, then it does not matter what the hours of the service may be, for at the same point of delivery any class of power can be compared without confusion or conveying false impressions.

In view of the above noted conditions, the following definitions are inserted:—

Indicated Horsepower. Notation: I. H. P.

This is the power generated in the cylinder, or cylinders, of a reciprocating or rotating engine and is the measure of the energy exerted by the steam or gas as determined by an indicating mechanism which does not record the mechanical or friction loss in the engine itself.

Brake Horsepower. Notation: B. H. P.

This is the mechanical energy delivered by an engine, waterwheel, motor or at any other mechanical appliance, as determined by applying a friction brake or electrical resistance, thus weighing the power. For an engine the B. H. P. will be the I. H. P. minus the losses in the engine itself, and the B. H. P. is usually from 90 to 95 per cent. of the I. H. P.

Electrical Horsepower. Notation: E. H. P.

This is the power in the electric current which is delivered at the terminals of the electric generator, at the switchboard or at the motors, and is the B. H. P. minus the mechanical and electrical losses in the generator; or, if delivered to the motors, the above losses plus the losses in the wiring.

For electric generators the efficiencies will be from 90 to 96 per cent. of the B. H. P. of the driving element, if the generator is directly connected to the prime mover without intervening belts or gearing.

Horsepower Hours. Notation: h. p. hours.

This is the number of horsepowers utilized in one hour, or the numbers of hours during which one horsepower is utilized.

To illustrate:—A plant operates for 300 days of 10 hours each, or for a total of 3,000 hours, and generates continuously during this period 10 horsepower. This is equal to 10 x 3,000, or 30,000 h. p. hours. Another plant operates for 1 day of 10 hours, or a total of 10 hours, and generates continuously during this period 3,000 horsepower; then 3,000 x 10 = 30.000 h. p. hours.

Kilowatt Hours. Notation: kw. hours.

Same as above, multiplied by the decimal 0.746.

In other words, 3-4 of 1 kilowatt is approximately equal to 1 horsepower, or 1 kilowatt equals 1 1-3 horsepower.

Rated Capacity. Notation: R. C.

The term rated capacity as herein used is the maximum normal capacity of the plant equipment, expressed as horsepower for the size of the plant, or as h. p. hours for the load it will carry during a given period of time.

Nominal Capacity. Notation: N. C.

The nominal capacity of a plant is the output from the equipment when operating at its maximum efficiency, or with the load for which it was designed.

Capacity Factor. Notation: C. F.

This is the ratio between the total output of the plant if run at its "rated capacity" for 365 days of 24 hours, or for 8,760 hours per year, and the actual output of the plant in the same period.

For example:—A plant with equipment to generate 100 horsepower "rated capacity" has sufficient capacity to deliver 8,760 x 100 = 876,000 h. p. hours per year, but it is in operation 300 days of 10 hours each per year with an average load of 80 horsepower; thus its total annual output is 300 x 10 x 80 = 240,000 h. p. hours, and the "capacity factor" will be (240,000 ÷ 876,000) x 100 = 27.4 per cent.

Load Factor. Notation: L. F.

This is the ratio between the average output of the station and the maximum, or "peak," load which is imposed upon it.

For example:—In the foregoing plant mentioned under "Capacity Factor" there was an average load of 80 horsepower, but it was designed to carry continuously a load of 100 horsepower; therefore, the L. F. is (80 ÷ 100) x 100 = 80 per cent. The L. F. for central stations varies from 30 to 50 per cent., seldom exceeding the latter figure in the best managed plants. For industrial plants the L. F. will vary from 60 to 90 per cent., averaging at least 75 per cent. and seldom falling below 60 per cent.

Power Factor. Notation: P. F.

This factor has no direct relation to the cost of power, except as it is an element which must be considered in selecting the generator and motor equipment for a given service. It is a condition peculiar to alternating current apparatus, very difficult to define intelligibly except to those familiar with the theory of alternating currents. The current in an alternating circuit may or may not be in phase (in step) with the electro-motive force, or the pressure which forces the current through the circuit. The volt is the unit of measure for the electro-motive force, and the ampere for the current. The amperage may either lead or fall behind the voltage. This condition is due to the magnetizing wattless (that is powerless) current required by alternating apparatus. It will be noted that this magnetizing current is powerless, and it, accordingly, does not appreciably effect the capacity of the prime mover; but it does have material effect upon the size of generator that is driven by the prime mover, as the wattless current causes heating in the generator, and, therefore the greater this wattless current the larger will be the generator required.

The power factor is the ratio of the useful power in watts, as recorded by the wattmeter, to the apparent power in volt-amperes, determined by readings from the volt and ammeters.

The power factor of a plant depends largely on the character of the motor installation, and to maintain a high P. F. it is important that the motors operate continuously at or near their full load capacity. If the average "load factor" of a mill is 60 per cent. of the maximum load, the motors should be installed with "nominal capacities" to carry this 60 per cent. load; but they should have "rated capacities" sufficient to temporarily withstand the overload which will be imposed when the L. F. becomes unity, or 100 per cent.; that is, motors had better be too small rather than too large. Conversely, the generator must have ample surplus capacity, in order to avoid overheating when delivering current to a system with a low average P. F.

The P. F. can never be more than 100 per cent., but with an incandescent lamp, or non-inductive load, it can attain this figure. A good average P. F. for a motor installation is 80 per cent.; many plants do not exceed 75 per cent., and 60 per cent. is considered a low P. F.

Factors.

The general factors which control the cost of power are the investment required, the fixed charges necessary to maintain the investment, the operating charges, the load factor and the capacity factor. These are sub-divided as follows:—

Investment	Cost of Equipment,	Capacity Factor.
	Cost of Buildings,	
	Value of Land,	
Fixed Charges	Interest,	
	Taxes,	
	Insurance,	
	Renewals-(Sinking Fund)	
Operating Charges	Repairs,	Load Factor.
	Labor,	
	Supplies,	
	Fuel,	
	Water,	

Both the capacity and load factors have important influence on the cost of power, as will be noted by referring to the definitions previously given for these terms. The C. F. effects more specifically the investment and fixed charges, while the L. F. has more effect upon the operating charges.

In addition to the above, there are specific factors which effect water power and power transmitted electrically from central stations or water powers remote from the place of usage.

These are as follows:—

Water Power.

Water Rental
Storage Charges

Transmitted Power.

Transmission Charges:
Patrol of lines
Repairs of Lines
Distribution Charges:
Sub-station Operation including labor, repairs and supplies.
Local Line Patrol and Repairs.
Overhead Charges:
Management
Clerical or Office.

General Considerations.

The prospective power user may have three means of securing the desired power:—First, by purchasing power from a public service or other distributing company; second, if water power is available, by thus generating his own power; or third, by installing a fuel operated plant. Oft times he must select from two only of the above, and in many instances from the latter class only.

It is obviously impossible to give any general rules or even approximate average figures which will apply to the cost of a hydraulic installation, and, hence, the cost of the power generated thereby, as each project presents problems occasioned by the natural conditions which require special engineering study. The cost of a number of existing power developments is given on pages 51 to 54. The cost for hydraulic and hydro-electric developments constructed in the past has varied from $30.00 to $300.00 per horsepower of rated capacity, a range of 1000 per cent., and the cost per h. p. hour varies accordingly. In a few instances contracts have been made for the delivery of hydro-electric power at the switchboards in the generating stations for $9.00 per horsepower year of 8,760 hours, or for slightly more than one mill per h. p. hour; and a cost of five mills per h. p. hour for 8,760 hours can be considered a reasonable figure.

Fortunately the other commercial systems of power generation are not surrounded by any such uncertainties as exist in connection with hydraulic plants. Local conditions will have some effect on the cost of installation, such as unstable foundation material, remoteness from base of supplies with insufficient transportation facilities, dearth or impurity of water for boiler feed, etc., and scarcity of competent labor; but such obstructions will occur only in isolated instances. The cost of fuel, water and labor for a given location is usually readily predetermined, and the cost of installation under ordinary circumstances will very closely approach an average for a plant of given size.

The scope of this paper is limited to those power users who have the alternative of purchasing power from some commercial plant, or of generating their own power from fuel, and as an aid in determining which type of apparatus to adopt when fuel is to be employed.

It is impossible in this article to enter into the technical details of analysis whereby the accompanying data are secured; but the deductions herein recorded are all derived from the results of actual practice and not by theoretical computations. While this paper is abbreviated and does not include all of the data which it is proposed ultimately to issue in connection with this subject, it does contain the information that a mill owner or manufacturer might desire if he wished to determine with a reasonable degree of accuracy the approximate cost for a given class of power, in order to compare the same with any other class on which the price per horsepower hour is established.

It appears advisable to touch upon a few of the salient features pertaining to the design of power plants in general and to particularly mention the advantages and disadvantages of the different types of installations herein discussed.

There is a prevailing tendency towards the almost universal adoption of the electric drive by all industries of any magnitude; accordingly, all of the accompanying diagrams for cost of installation and labor are compiled on this basis. The convenience, cleanliness, flexibility and reliability of the electric drive, combined with its high efficiency, as noted on figures 2, 3, and 4 and plate VI, fully justify its use. While the efficiencies given on the diagrams indicate that mechanical transmission is somewhat more efficient than electrical, it must be remembered that intermittent service, occasioning low load factor, the segregation of equipment and other practical conditions may be such that the electric drive may equal the mechanical drive, or perhaps excel it in efficiency.

The aim to be sought in designing any type of power plant is to secure as simple an arrangement of equipment and structures as can be obtained to produce the desired results without sacrificing efficiency, flexibility and reliability. To attain simplicity and economy of operation the equipment should consist of a few large units, the total power being so sub-divided by the apparatus employed that a maximum of working efficiency can be obtained under the conditions imposed by the load factor. The units should be selected with the intention of operating them continuously at their "normal capacity," so far as practicable, with a "rated capacity" sufficient to accommodate the "peak" load without excessive overloading or falling off in efficiency.

The merits of water power are almost self-evident, the principal expense of operation being confined to the investment and fixed charges, as the labor cost is very small and there is no fuel bill. The disadvantages of water power are the high cost of development; restriction of application, due to limited radius of distribution; and last, but not least, the intermittent stream flow which exists on most rivers, causing fluctuations in the available power. In many instances the last condition can be ameliorated to a large extent for a comparatively small expenditure, if the magnitude of the river is sufficient to warrant the construction of storage reservoirs and the users on the stream are broad enough to combine forces for the attainment of a mutual benefit.

The value of storage is not well understood; if it were, much more active steps would be taken to derive the benefits which it affords. Properly controlled storage is utilized to augment the stream flow at periods of low water, and in most cases it keeps in operation equipment which would otherwise lie idle, or be partially operated only; therefore, the only cost required to utilize storage water is the reservoir charges.

One million cubic feet of water falling one foot will theoretically develop 62,500,000 foot pounds, or 1,894 H. P. for one minute, which is equivalent to 31.56 h. p. hours. If this water is used in a hydro-electric installation having efficiencies as shown on Plate VI, there would be delivered to the generator terminals, or the station switchboard, $31.56 \times (73.7 \div 100) = 23.26$ h. p. hours. On the basis of one mill per h. p. hour (the lowest price for power within the writer's knowledge, as previously quoted), this amount of water would be worth 2 1-3 cents if used with a fall of one foot.

Tabulations Nos. 2 and 3 give the capacities and costs for most of the large American and foreign reservoirs, and it will be noted that the average cost for the American reservoirs is

TABLE No. 2.

Cost of American Storage Reservoirs.

(FROM JAMES D. SCHUYLER.)

NAME AND LOCATION.	Character.	Cost.	Capacity million cubic feet.	Cost per million cubic feet.
Ashokan Reservoir, New York	Masonry and Earth	$12,669,775	16,030	$792
Belle Four che Dam, So. Dakota	Earth	879,164	9,360	94
Wachusett Dam, Massachusetts	Masonry	2,270,116	8,420	269
Aziscohos Dam, Maine	Masonry and Earth	1,000,000	8,000	125
New Croton Dam, New York	Masonry	7,631,000	7,840	973
Buena Vista Lake, California	Earth	150,000	7,400	21
Laramie River Dam, Wyoming	Earth	117,200	5,230	23
Indian River, New York	Masonry and Earth	83,555	4,460	19
Croton, New York	Masonry and Earth	4,150,573	4,270	972
Lake McMillan, Pecos River, N. M	Rock Fill and Earth	180,000	3,880	47
Bear Valley Dam, California	Masonry	68,000	1,740	39
Windsor, Colorado	Earth	75,000	1,000	75
Sweetwater, California	Masonry	264,500	980	269
Titicus, New York	Masonry and Earth	933,065	960	972
Bowman, California	Rock Fill Crib	151,521	920	164
Eureka Lake, California	Rock Fill	35,000	660	53
Sodom, New York	Masonry and Earth	366,990	650	565
English, California	Rock Fill Crib	155,000	650	239
San Leandro, California	Earth	900,000	580	1,550
Bog Brook, New York	Earth	510,430	550	927
Larimer and Weld, Colorado	Earth	89,782	500	179
Cuyamaca, California	Earth	54,400	490	111
Hemet, California	Masonry	150,000	460	326
Canistear, New Jersey	Earth	341,000	322	1,060
Lake Avalon, New Mexico	Rock Fill and Earth	176,000	274	642
Cache la Poudre, Colorado	Earth	110,266	246	447
Round Hill, Pennsylvania	Masonry and Earth	240,548	176	1,367
Glenwild, New York	Earth	47,360	160	296
Escondido, California	Rock Fill	100,059	152	658
Cedar Grove Reservoir, New Jersey	Earth	660,000	94	7,020
Tyler, Texas	Hydraulic Fill	1,140	77	15
Faucherie, California	Rock Fill	8,000	59	136
La Mesa, California	Hydraulic Fill	17,000	57	298
Yuba, California	Hydraulic Fill	38,000	51	745
Pedlar River, Virginia	Masonry	103,708	49	2,115
Wigwam, Connecticut	Masonry	150,000	45	3,333
Saguache, Colorado	Earth	30,000	41	732
Monument, Colorado	Earth	33,121	39	849
Seligman, Arizona	Masonry	150,000	31	4,835
Walnut Canyon, Arizona	Masonry	55,000	21	2,620
Apishapa, Colorado	Earth	14,772	20	739
Williams, Arizona	Masonry	52,838	15	3,522
Boss Lake, Colorado	Earth	14,654	9	1,628
Ash Fork, Arizona	Steel	45,776	5	9,155
Hardscrable, Colorado	Earth	9,997	5	1,999
	Average	$784,096	1,933	$406

TABLE No. 3.

Cost of Foreign Storage Reservoirs.

(FROM JAMES D. SCHUYLER.)

NAME AND LOCATION.	Character.	Cost.	Capacity million cubic feet.	Cost per million cubic feet.
Assouan, Egypt	Masonry	$11,907,000	37,600	$317
Ekruk, India	Earth and Masonry	666,000	3,310	201
Lake Fife, India	Masonry	630,000	3,290	192
Chumbrumbaukum, India	Earth	312,000	2,780	113
Tansa, India	Masonry	988,000	2,290	432
Vyrnwy, Wales	Masonry	3,334,000	1,950	1,710
Betwa, India	Masonry	160,000	1,600	100
Ashti, India	Earth	270,000	1,420	190
Liez, France	Earth	598,418	568	1,054
Villar, Spain	Masonry	390,000	568	687
Talla Res, Edinburgh	Earth	1,220,000	448	2,720
Gilleppe, Belgium	Masonry	874,000	424	2,060
Mouche, France	Masonry	1,003,657	305	3,290
Lake Oredon, France	Earth	142,000	257	553
Chartrain, France	Masonry	420,000	159	2,640
Beetaloo, Australia	Masonry	573,300	128	4,480
Ternay, France	Masonry	204,372	106	1,934
Burrator, England	Masonry and Earth	602,300	105	5,730
Belubula, Australia	Brick and Concrete	45,000	87	517
Wassy, France	Earth	138,940	76	1,826
Ban, France	Masonry	190,000	66	2,880
Cousin, France	Masonry	247,600	57	4,340
Furens, France	Masonry	318,000	57	5,580
Pas du Roit, France	Masonry	256,000	46	5,570
Remscheid, Germany	Masonry	91,154	35	2,600
Sand River, South Africa	Masonry	140,000	29	4,830
Lauchemsee, Germany	Masonry	243,750	27	9,020
Patas, India	Earth	15,925	14	1,137
Burraga, Australia	Masonry	46,500	13.5	3,445
	Average	$897,514	1,994	$450

$406.00 per million cubic feet of capacity. The annual charges for the upkeep and attendance of a storage dam should not exceed 3 per cent. of the cost, or $12.18 per annum per million cubic feet of capacity, on the basis of the above reservoir cost, and $12.18 ÷ 0.0233 = 523 feet fall, the amount which must be developed below the reservoir to pay the entire cost of operation; 1046 feet fall would pay an additional 3 per cent. on the investment; and 1569 feet fall, 6 per cent. net on the investment. A study of tabulation No. 2 will reveal the fact that the average cost of $406.00 per million cubic feet is much in excess of the cost which would be incurred by constructing dams for storage only, because the high cost dams, such as the Ashokan, Wachusett, New Croton, Croton, Titicus, Sodom, Canistear, Round Hill, Cedar Grove, Wigwam and Pedlar River, are all potable water supply reservoirs, while the Seligman, Walnut Canyon, Williams and Ash Fork dams were constructed in the dry lands of Arizona and Colorado to supply water for the Sante Fe Pacific Railway loeomotives. It is safe to state that the average storage dam would not exceed in cost $200.00 per million cubic feet of capacity.

Taking the specific case of the Aziscohos storage reservoir, costing $125.00 per million cubic feet, the water would have to be used on a fall of 161 feet only to pay the annual expenses, on 322 feet to return 3 per cent. on the investment, on 483 feet to return 6 per cent., and on 644 feet to show 9 per cent. net.

It can be proven easily that developed Maine water power is worth not less than 2 mills per e. h. p. hour, or $17.52 per year of 8760 hours, and in most instances it is worth more than 3 mills, or $26.28 per year. With the value of power at the latter figure and with storage basins costing not in excess of $125.00 per million cubic feet of capacity, it will only be necessary to utilize the water on a head of one-third of that above cited, or under 161 ft. to show a net return of at least 6 per cent. on the investment, in addition to an allowance of 3 per cent. for the cost of maintenance and operation; and in many cases it will be found commercially profitable to develop extensive storage on streams where the total utilized fall does not exceed 100 feet.

Next to storage in importance, if not of equal importance, is the securing of ample pondage at or near the hydraulic power station to compensate for the daily fluctuations of stream flow, in order that the full quantity of water which passes the plant during a given period may be used in varying quantities through the wheels to satisfy the irregular load factor, which is bound to exist, without permitting any of the water to be wasted over the dam, except in case of freshets. Certain industries, such as ground wood pulp mills and electrochemical works, are not dependent to any extent upon pondage, as the output can be varied to suit the water conditions; but all industries are directly benefited by storage, because the stored water is that which would have been wasted during the high water seasons.

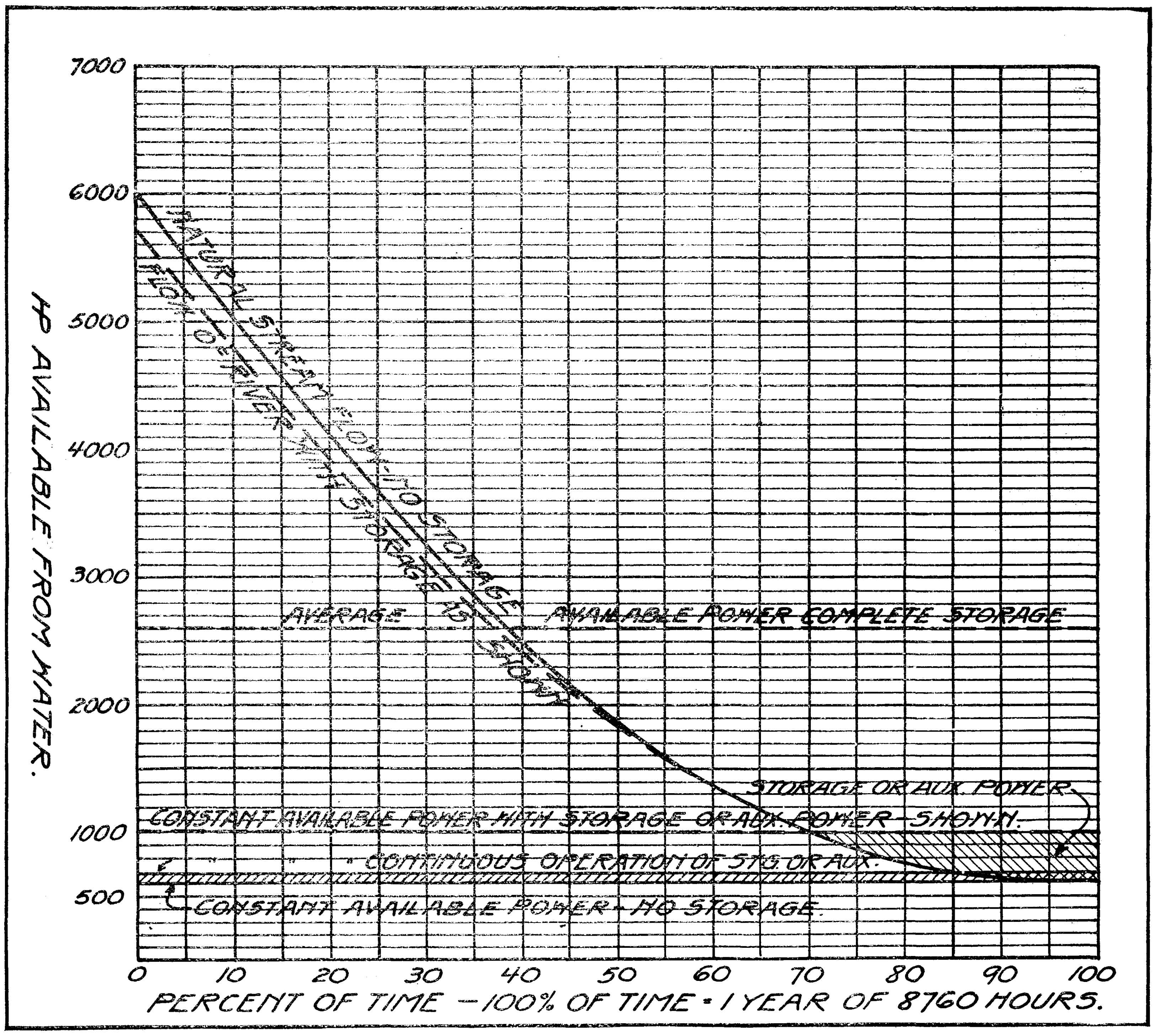
The value of water power has been often over-estimated, resulting in the consummation of developments that never could show a proper return on the investment. It has been, however, more often undervalued and unwisely abandoned or disregarded, particularly in connection with those mills that require steam for the partial preparation of their product.

Probably the realization of the full benefits to be derived from water power is best secured when it is operated in conjunction with auxiliary power in some form; with steam power if there is a use for the exhaust, or when cheap fuel is available; and with gas or oil engines where fuel is high.

Auxiliary power bears a relation to water power similar to that occupied by the storage reservoir, for it not only provides power during the periods of low water, but it *increases the average amount of water power* that can be economically utilized *continuously*. This latter feature was not mentioned in connection with the foregoing comments on storage reservoirs, as at that time we were endeavoring to show only the value of the storage to existing or contemplated installations, without incurring any additional expense for increased plant capacity; but there is afforded by the creation of storage a still further power increase which is best illustrated by the diagram Plate VII. This diagram shows the amount of horse power that can be obtained from a typical river, with the natural stream flow arranged in order of its magnitude and not according to seasonal fluctuations. The verticle lines represent time; the total 100 per cent. being equal to the 8,760 hours in one year. Any volume of power, as indicated by the figures on the left-hand margin of the diagram and the corresponding horizontal line, can be obtained for a period of time equivalent to that designated by the figures on the lower margin for all amounts below and to the left of the curve marked "natural stream flow."

For example:—Following up the line 10 from the lower margin until it intersects the upper solid line curve, then reading the figures horizontally opposite on the left margin, shows that 5,000 H. P. can be secured for 10 per cent. of one year, or during $0.10 \times 8,760 = 876$ hours; that is, there can be obtained a total of $876 \times 5,000 = 4,380,000$ h. p. hours. The total area of the diagram below the "stream flow" curve represents the total quantity of power which the water could develop in the year of 8,760 hours.

The horizontal line marked "average available power, complete storage" cuts the above "stream flow" curve at the point where the area of the enclosed space above the horizontal line between the left margin and the full line curve is equal to the area of the space below the horizontal line confined between



EFFECT OF STORAGE AND AUXILIARY POWER

the "stream flow" curve and the right margin of the diagram, and, therefore, shows the average amount of power in the water if it could be distributed uniformly throughout the year, or for the 100 per cent. time period. This shows that the average power is 2,600 H. P., or 43 1-2 per cent. of the maximum 6,000 H. P.

The whole rectangle below the horizontal line at 600 H. P., which is the intersection of the flow curve with the 100 per cent. time factor line, shows the quantity of power that can be utilized continuously without the aid of storage or auxiliary power, and this is equal to only 23 per cent. of the average power available and but 10 per cent. of the maximum power. The area of the above rectangle represents graphically the h. p. hours, amounting in total to 600 × 8,760 = 5,256,000 h. p. hours per year. Assume that a storage reservoir be constructed of sufficient capacity to impound the equivalent of 700,000 h. p. hours; this amount, if uniformly distributed throughout the year, would make the total yield 5,956,000 h. p. hours, or would increase the available power 13.3 per cent., making a total of 680 H. P.; but this is not the actual increase. The storage volume in terms of h. p. hours can be represented on the diagram in two ways; either by placing a rectangular area equivalent to the quantity of h. p. hours above the rectangle which indicates the constant power available, or by plotting an irregular figure of the same area to the right and above the "stream flow" curve, the end on the 100 per cent. time line with the top a horizontal line meeting the "stream flow" curve. It will be noted that the horizontal boundary line of the storage area terminates on the "stream flow" curve at the point of intersection between it and the 70 per cent. time factor vertical, and that for the balance or for 70 per cent. of the time that the vertical distance from the base or zero power line to the power curve is always greater than that at the above point of intersection; hence, there will always be a sufficient volume of water from the natural stream flow to develop continuously in conjunction with the storage or auxiliary power the amount determined by the altitude of the power scale at the previously described point of intersection, or for 1,000 H. P. as shown on the diagram. If the horizontal boundary of the storage area be projected across the diagram, the area of that portion of the diagram below this line will represent the total number of h. p. hours available.

This area is 1,000 × 8,760 = 8,760,000 h. p. hours; therefore, the reservoir actually has increased the available power from 5,256,000 to the above amount, or by 66.5 per cent. instead of 13.5 per cent., as was shown by the uniform distribution of the conserved water employed for the previously given storage values. The existence of storage will alter the profile of the "stream flow" curve, increasing it at the minimum flow and decreasing it at the maximum, making it conform to the lower dotted curve shown on the diagram; the area between the two curves being equal to the area of the storage.

As previously stated, auxiliary power in any form has the same effect as storage on the available power, and by considering the 700,000 h. p. hours on the diagram as derived from steam or other source, the annual output will be the same. The capacity of the auxiliary plant can be determined readily from the diagram, for the maximum altitude of the storage area as measured by the power scale indicates the greatest amount of power that will be required, and by finding the mean altitude of the storage area the average power is obtained; these are for the case under discussion, respectively 400 H. P. and 266 + H. P.

No attempt will be made to compare the relative merits of steam apparatus other than to state what modern engineering practice would indicate to be the best equipment to select for a given service. Both water tube and fire tube boilers have practically the same efficiency when properly designed. Water tube boilers can be economically built for much larger unit capacities than the fire tube; hence, they occupy less space and afford a simplicity in general design which is desirable for large installations. They are also more immune from the danger of explosion than other types. As a unit the water tube boiler and setting is more complicated than the horizontal return tubular or vertical "Manning" type of boiler; accordingly, for a small plant the latter types are generally more economical, both to install and operate.

In most cases reciprocating steam engines will prove the most economical for small plants having from one to three units of not more than 500 H. P. each. For installations requiring units of from 500 to 2,000 H. P. capacity, it is debatable whether or not the reciprocating engine or steam turbine should be adopted. In case the electric drive is not readily applicable, it is safe to assume that the reciprocating engine is the best; but if the electric drive is applicable and particularly if the L. F. is such that the equipment cannot be consistently operated at or near its "nominal capacity" then the steam turbine is the natural selection, on account of its ability to operate on fractional or overloads without sustaining the efficiency losses incident to operating steam engines under similar conditions.

In addition to the advantage of working range afforded by the steam turbine, it occupies much less space than the reciprocating engine and with the present state of perfection it is a simpler machine. On the other hand, the condensing equipment for the turbine must be more refined than that provided for an engine, on account of the high vacuum which must be maintained if the turbine is operated efficiently. This condition incurs additional upkeep and operation expenses, as well as first cost.

For units of more than 2,000 H. P. capacity, the steam turbine will usually prove to be the most economical.

The cost per horsepower for turbine and engine equipments with generators will be approximately the same for the smaller sizes up to units of about 800 H. P. capacity; above this size the turbine will cost somewhat less than the engine, and as the unit size still further increases the proportionate cost will constantly change in favor of the turbine outfit.

The gas engine has by no means received the recognition in this country which it deserves, while in Europe it has been accepted and utilized most successfully. The abundance of cheap high grade fuels available in what appeared until recently to be unlimited quantities has caused the consumer to be lethargic toward any attempt at economizing in its use. Further than this, to speak plainly, the American manufacturer, in spite of his boasted acumen, canny business deals and claims to progressiveness, is most loathe to adopt many of the so-called "new ideas" that have long since become ancient history to our more scientific competitors in both England and Continental Europe.

Producers and gas engines are more efficient under working conditions than the corresponding steam equipment. Gas power plants require no high pressure piping and suffer no leak or condensation losses. As an auxiliary the gas plant has no superior, for large quantities of gas can be stored in holders and be ready for service with the fires dead:—the standby losses are less than for the steam plant and the smoke nuisance is eliminated; no small factor when one considers the pall which now hangs over most of our cities.

The waste heat from the gas engine exhaust can be utilized for heating purposes and from 2 to 3 pounds of steam can be generated with any desired pressure up to 50 pounds per each B. H. P. hour.

The disadvantages of the gas plant are its high cost of installation and the fact that the engines must be operated at practically their "nominal capacity" with a "rated," or overload, capacity about 10 per cent. in excess of the "nominal." Reliability of service was at one time a formidable stumbling block which checked the progress of gas power plants, but this obstacle has now become a myth that need not be seriously regarded.

The producer gas plant should appeal particularly to all Maine power users, for many sections of the state are provided with an abundant supply of peat in accessible bogs, and this low grade fuel can be utilized most efficiently in a properly designed producer. (*a*) The word "peat" undoubtedly has a discordant sound to some of my readers, owing to the many fake schemes which have been exploited having the ostensible purpose of drying, preparing and distributing peat for commercial uses. But this impression we trust will be dispelled by stating that instead of transporting the peat the gas plant should be located at the bog or mine, and the power generated should be transmitted electrically to its destination; following the same principle applied when a water power station is constructed on a river at some favorable site.

The peat for a producer requires no artificial preparation or manipulation other than that necessary to excavate, air dry and deliver to the furnace, because it can be fired when containing from 30 to 50 per cent. of moisture; a feat now being successfully accomplished in Europe on a commercial scale.

The cost for mining peat should not exceed One Dollar per ton, including delivering to the plant, and this cost can be entirely obliterated by the return from the by-products which can be derived if the installation is of sufficient size to warrant the cost of constructing a recovery plant for extracting the procurable sulphate of ammonia.

(*a*) For a treatise on this subject see Bulletin 376, U. S. Geological Survey, Peat deposits of Maine, by E. S. Bastin & C. A. Davis.

There is from 2 to 3 per cent. of nitrogen in American peats; as sulphate of ammonia, this material has a market price of three cents per pound, costing about one cent per pound for reclamation. In each short ton of peat there is from 180 to 280 pounds of sulphate of ammonia, and not less than 90 pounds per ton can be produced commercially, having a value of $2.70 and costing about $0.90, showing a gross profit of $1.80 per ton of peat used as fuel. It is safe to state that the cost for fuel in a peat gas plant would be nothing if it has 4,000 H. P. or more capacity, which is an amount sufficient to insure the economical production of ammonium sulphate.

The ordinary grades of bituminous coals contain about 80 pounds of available sulphate of ammonia per short ton, and its recovery shows a corresponding return.

The writer feels certain that gas engine, peat or coal fired, auxiliary power plants will be extensively utilized locally in connection with hydro-electric installations at no remote future date.

From a theoretical standpoint there is no fuel power so attractive as that afforded by the oil engine, and the ideal is now partially realized in actual practice, although the application of the oil engine has been much restricted on account of the exorbitant costs which have been maintained by the manufacturers holding the patent rights on the most successful types of oil engine equipment. Following the policy usually applied for determining the value of power, the cost of steam generated power has been taken as the base from which the sale price of oil engines was determined, establishing the cost for the oil apparatus at a figure just low enough to show a small margin of saving by its adoption, but in reality absurdly high when compared with the true cost of the equipment required. Such a procedure is shortsighted in the writer's opinion and this conclusion is apparently sustained by the purchasing public, if we take the slow growth of the oil engine field in this country as a criterion upon which to base our decision.

The oil engine plant is very simple, comprising the engine proper, an air compressor and a fuel storage tank. It is ready for instant service without standby losses; there is no smoke nuisance; there is no dirt or dust such as accompanies the generating equipment of the steam and gas plants with their incumbent coal storage; and a minimum amount of operating labor is required. As against these advantages there exists the high cost of installation, with correspondingly excessive cost for repairs, and large single units have not yet been perfected in America. In all probability these two considerations will not long continue to offer obstructions against the more general application of this excellent prime mover, for the expiration of the "Diesel" patents already has created an undercurrent of activity on the part of the heavy machinery and engine builders which bids fair to cause brisk competition in the manufacture and sale of oil engine equipment, a condition that will of necessity incite perfection in design and reduce the initial cost.

It has been claimed that the future of the oil engine was threatened by the uncertainty regarding the ultimate cost for its fuel, on the ground that its extensive introduction would so increase the demand for oil that the supply would prove inadequate. At this time no one can foretell how much oil is available, but it is certain that there exist vast oil beds still undiscovered and that with a perceptible increase in consumption there will be an incentive to locate "strikes" which will substantially augment the present supply, and no reason can be seen for anticipating any material increase in the cost of fuel oil.

Cost of Installations.

The average cost for complete electric power plants of known "rated" H. P. capacity are given on Fig. 6. To obtain the cost for a contemplated plant it is necessary to determine the "load factor" which will establish the "nominal" and the "rated," or full, capacity required.

To secure a uniformity of comparison in illustrating the application of the diagrams which follow, three hypothetical operating conditions will be assumed for a proposed installation having a "rated capacity" of 4,000 E. H. P. and a "load factor" of 80 per cent., making the "nominal" or "working capacity" 3,200 E. H. P. In the first case the plant operates for 300 days of 10 hours per year, or for a total of 3,000 hours, and produces $3{,}200 \times 3{,}000 = 9{,}600{,}000$ h. p. hours per year. The total full capacity of the plant is $4{,}000 \times 8{,}760 = 35{,}040{,}000$ h. p. hours per year; hence the "capacity factor is $(9{,}600{,}000 \div 35{,}040{,}000) \times 100 = 27.4$ per cent. In the second case the plant operates for 365 days of 18 hours, or for a total of

6,570 hours, producing 6,570 × 3,200 = 21,024,000 h. p. hours per annum, making the "capacity factor" 60 per cent. In the third case the plant operates at its full "nominal capacity" for 365 days of 24 hours, producing 28,032,000 h. p. hours per annum and having a "capacity factor" of practically 80 per

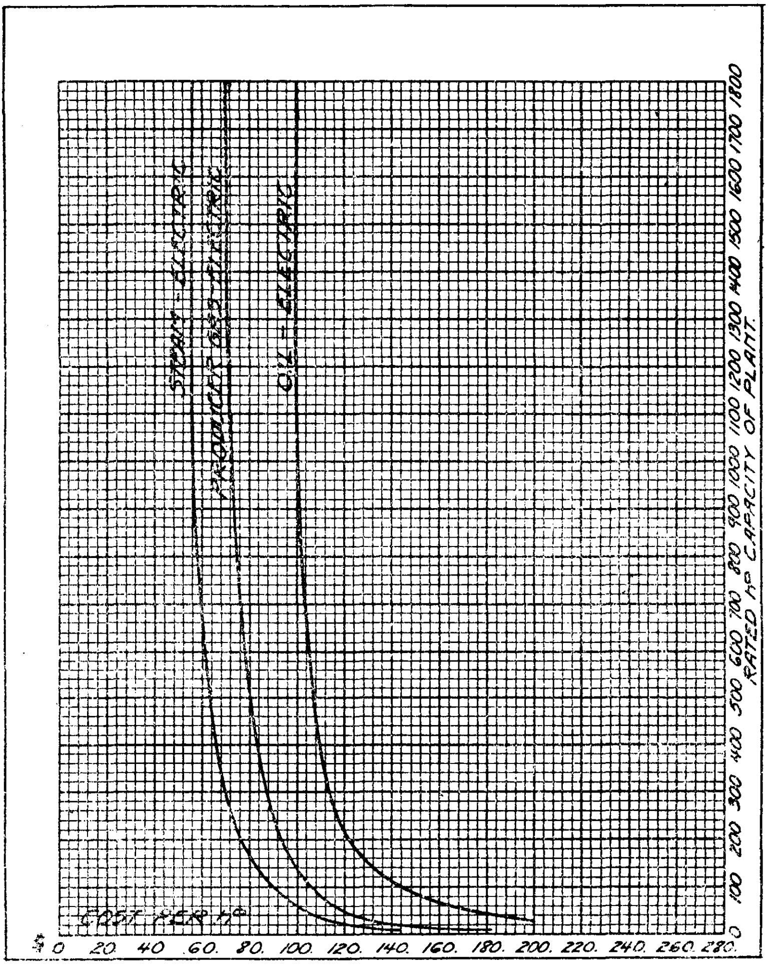


FIG. 6. COST OF COMPLETE ELECTRIC POWER PLANTS.

cent.; all of the foregoing powers being measured at the station switchboard. The "capacity factor" can never be maintained continuously at 100 per cent. in any installation, because it would be impossible to design a plant which could be practically operated at its full "rated" capacity.

To obtain the costs of installation from the diagram Fig. 6, select the rated H. P. capacity of the plant as designated on the right-hand vertical margin and trace the horizontal line opposite the desired capacity to the intersection of the curves, then follow down the vertical line at these intersections to the cost per H. P. which is given on the lower margin. For example:—The 1,500 H. P. horizontal intersects the "steam electric" curve at $56.00, the "producer gas" at $70.00 and the "oil electric" at $100.00, while for a 500 H. P. plant the intersections are at $63.00, $80.00 and $108.00 respectively. It will be noted that for "rated" capacities in excess of 1,500 H. P. the cost is practically constant, and, therefore, the cost for the 4,000 H. P. plant will be 4,000 × $56.00 = $224,000.00 for steam; 4,000 × $70.00 = $280,000.00 for gas; and 4,000 × $100.00 = $400,000.00 for oil.

Fuels.

Fuel has a most important influence in effecting the cost of power and every effort should be made to reduce its consumption to the minimum amount consistent with the practical economical operation of the given system; but the necessity of utilizing fuel with a maximum economy has often been advocated when the expense of so doing would increase the cost per h. p. hour for the power, owing to the refined apparatus required, with the greater interest and repair charges thus incurred, in addition to an increased labor cost due to the skillful mechanics required to properly operate the more complicated equipment.

It is lamentable to observe the painstaking efforts made by coal users to reduce the inroads into the coal pile by improving the mechanical conditions at their power stations, at the same time permitting the most slipshod methods to prevail when purchasing the commodity they so cherish. To purchase coal, or any form of fuel, by securing bids from reputable dealers for a certain trade grade shows an ignorance not encountered in the valuation of any other material. No buyer would pay for an ore except on the showing of its assay, which would be determined and certified by an expert. The merchant selects and pays for his cotton on the basis of its staple, not because it was grown in Alabama or Mississippi, but the manufacturer ordinarily make his coal selection on name and price only, utterly disregarding the fact that he should endeavor to obtain a heat value return for his expenditure, and that no specific name, such as "New River, West Virginia, coal," or a dealer's business integrity will be a guarantee that he is getting his money's worth.

The measure of any fuel depends entirely on the number of available heat units which it contains, and it should be paid for on this basis. A unit of heat value is the British Thermal Unit (Notation B. T. U.) and it is an inexpensive process to determine the quality of a fuel by making a "proximate analysis" that will show its B. T. U. content.

Consumers receiving their coal in consignments of 300 tons or over should always purchase under contract specifications that state the price to be paid for the B. T. U. content of the coal; the actual price paid per ton for the coal supplied to be established pro rata by test. It might be assumed that a single careful test of the coal from a given mine would be sufficient to insure a uniform quality, if it could be definitely proved that each shipment was made from the same mine; but this is not true, because the method of handling coal at the mines, in addition to the variation of the physical and chemical properties of the coal strata from the same mine, will occasion variation in quality which can only be determined by independent tests. The quality of the marketed coal depends in a large measure on the care taken in the preparation at the mines. Carelessness in picking slate or other impurities, or in jigging, or washing will produce a coal of inferior quality when compared with that secured from the same mine but carefully prepared; also bituminous coal, exposed to the atmosphere gradually depreciates in value and its moisture content has important bearing upon its available B. T. U. content. Buying coal by the ton in the ordinary manner often necessitates the purchasing of a large percentage of water and other impurities which are paid for and transported as coal, but which in reality have no fuel value.

The accompanying Tabulation No. 4 gives the average composition and heat value of several general classifications of fuels, also the producer gas that can be obtained from certain fuels on which reliable tests have been made.

TABLE IV.

Average Proximate Analyses of Fuels.

CLASS OF FUEL.	Volatile—%.	Fixed carbon—%.	Moisture—%.	Ash—%.	Sulphur—%.	Combustible—%.	Fixed carbon in combustible—%.	B. T. U. per lb. of combustible.	B. T. U. per lb. of fuel as fired.	Cubic feet of gas per lb. Fuel as fired.	B. T. U. per cubic foot of gas.	Specific gravity.	B. T. U. per gallon.
Coal Anthracite, Pa.	3.81	83.80	3.61	8.42	.59	86.20	95.00	15,060	13,300		138		
Semi-Anthracite, Pa.	6.74	85.08	1.41	6.28	.77	92.59	92.00	15,308	14,200	81	138		
Semi-Bituminous, Pa., (Md., Va.)	18.62	72.40	.99	7.11	1.03	92.05	78.70	15,770	14,510				
Semi-Bituminous, (New River, W. Va.)	22.82	73.59	1.13	2.27	.41	96.82	76.00	15,731	15,230	92	153		
Bituminous, Eastern	33.51	57.30	2.34	6.23	1.31	92.12	62.20	14,970	13,800	74	150		
Bituminous, Western	36.10	45.50	7.95	10.48	1.79	83.39	54.60	13,460	11,230	52	147		
Lignite, Texas	45.28	16.30	33.98	8.93	.89	62.47	26.10	13,250	8,280	32	162		
Lignite, Wyoming	42.42	45.66	5.75	6.16	.64	88.72	51.50	13,767	12,200				
Lignite, Colorado	35.00	49.30	11.99	3.76	.61	84.91	58.10	11,311	9,600	42	149		
Lignite, Washington	35.73	53.60	2.52	8.14	.73	90.06	59.50	14,561	13,100				
Peat	51.72	22.11	21.00	5.17	.45	74.28	29.80	10,900	8,127	30.30	175.2		
Petroleum, Heavy, W. Va.		83.50							18,324			0.873	133,300
Light, W. Va.		84.3							18,400			0.8412	129,000
Heavy, Pa.		84.9							19,210			.886	141,900
Light, Pa.		82.0							17,930			.816	122,000
Heavy, Ohio		84.2							18,718			.887	138,600
Lima, Ohio		80.2							21,600			.79	
Shoshone, Wyo.									19,590				
Oil Creek, Pa.		82.0							20,890			0.73	127,200
California									18,000			.95	142,700
Texas, Beaumont		84.6							19,060			.92	146,000
Natural Gas											1,000		

NOTE.—One (1) barrel of oil contains 42 gallons.

The cost of coal has been constantly on the increase and it is most important that we consider its probable future cost by making a brief study of past conditions, for such study may occasion the selection of a power plant equipment that would otherwise be disregarded, if the present conditions alone are used in deducting the probable investment efficiency.

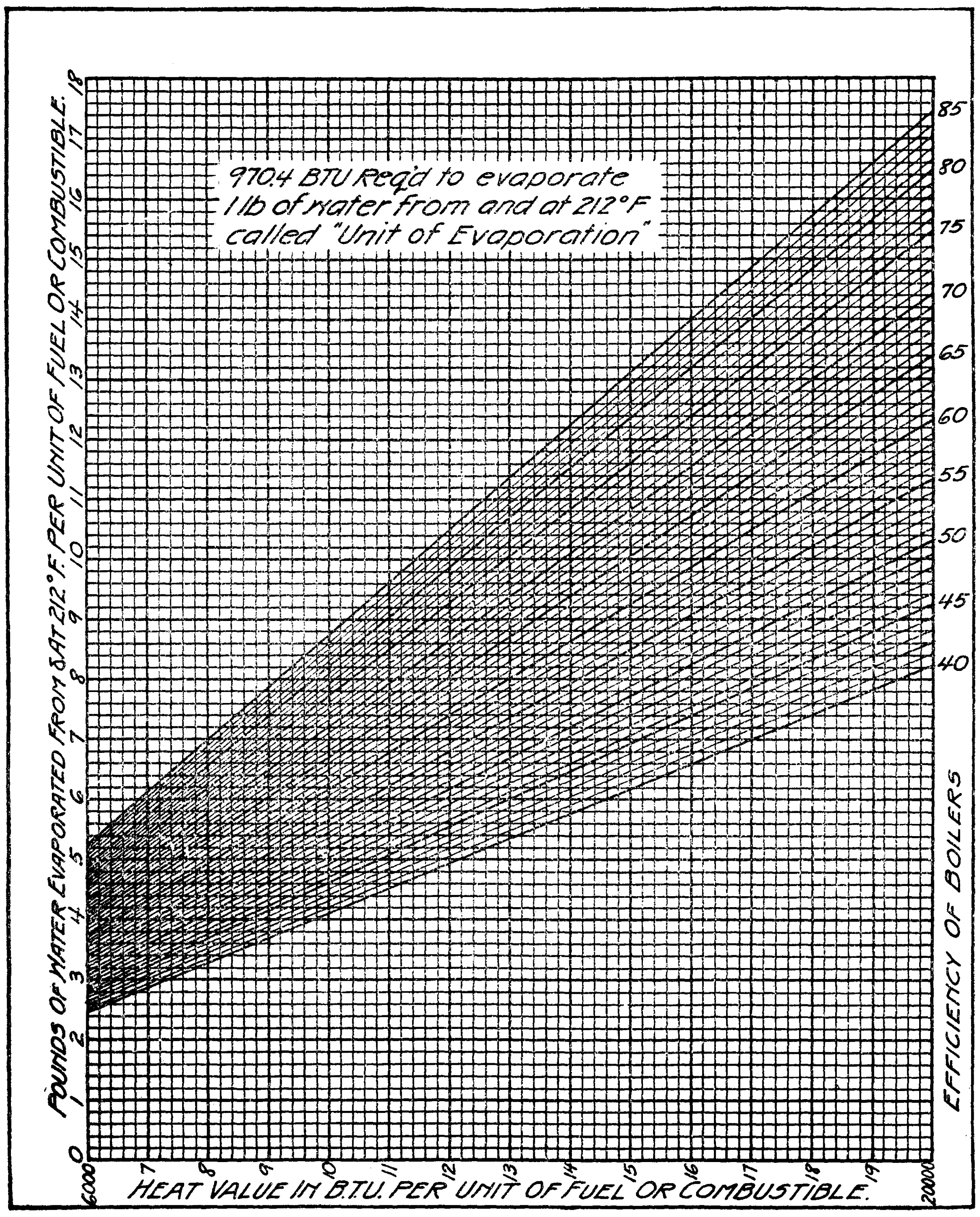
From 1870 to 1910 the population of this country increased from 38,000,000 to 92,000,000, or more than 142 per cent., and the coal consumption increased per capita from 0.85 tons to 5.5 tons, or almost 550 per cent.; hence, in 40 years the coal consumption has increased about four times as fast as the population. During this interval the average value of coal property has increased from $100.00 to $2,000.00 per acre, or 1,900 per cent., which is nearly four times the rate of consumption increase. When it is remembered that this phenomenal change in volume and value has been accompanied by a corresponding wage increase and more difficult engineering work in connection with the greater depth of the mines, it is a tribute to our application of scientific management in both mine working and transportation that we are not paying several hundred per cent. more for coal at this date than we are; but "coming events cast their shadows before" and the abnormal rise in mine values, together with the continual labor agitation, makes it almost certain that within a short period the cost of coal at the mines will be increased from 25 to 50 per cent. and that a greater proportionate increment of cost will be added as the coal passes the several go-betweens in its transition from the mine to the ultimate consumer.

Bituminous coal containing about 14,400 B. T. U. per pound of fuel can now be purchased at the Maine coast for $3.00 per long ton and it can be delivered to the station bunkers in most of our inland cities for a total of about $4.60 per long ton. If this fuel is used under boilers of 78 per cent. efficiency, the pounds of water evaporated, or the pounds of steam generated, can be determined from the "boiler efficiency chart" Plate VIII, as follows:—Locate on the lower margin of the diagram the vertical over the 14,400 B. T. U. and follow up on this line to the intersection of the diagonal line representing 78 per cent. boiler efficiency, and read on the left margin the water evaporated, which is in this instance 11.5 pounds.

Any reputable boiler manufacturer can guarantee the efficiency of a boiler if he knows the quality of coal that will be used, for with this information the proper ratio of grate and heating surface area can be provided.

The selection of a boiler, including its setting, must be made with the same care and application of the specialists' knowledge as is devoted to any other accessory in a power plant. In many instances it can be shown, upon making a careful study of a problem, that a cheap grade of fuel with a low boiler efficiency is more economical than an expensive fuel yielding a high boiler efficiency. To prove this we will take a semi-bituminous fuel containing 14,400 B. T. U. per pound, costing $4.60 per ton at the bunkers, and a low grade bituminous, such as Western (See Table No. 4), containing 11,230 B. T. U. per pound and costing $2.50 per ton delivered, using both in the same boiler furnace. The higher grade of coal will permit the practical operation of the boilers at an efficiency of 75 per cent. and the cheap grade with an efficiency of 60 per cent. Referring to the diagram Plate VIII, it will be found that 11.2 pounds of water can be evaporated with the good coal and 6.9 pounds with the poor. This shows that the relative fuel value is as $6.9 \div 11.2 = 0.616$, and it will be necessary to use $1.00 \div 0.616 = 1.623$ tons of the cheap fuel to generate the steam that can be procuced with one ton of the higher grade; therefore, $1.623 \times \$2.50 = \$4.06$ will be the cost for an equivalent amount of the lower grade coal. This shows that the supposedly poor fuel will yield $[(\$4.60 - \$4.06) \div \$4.06] \times 100 = 13.3$ per cent. better return for the same expenditure than the good. With the cheaper fuel more coal and ashes must be handled, increasing the labor expense proportionately, but this will not ordinarily be a sufficient amount to off-set a saving so great as that indicated above.

Holding to the examples cited under "Cost of Installations", page 228 and the efficiencies given on the "Power Efficiency Diagram, Figure 2," the cost for fuel can be derived from the diagram Plate IX, as follows:—One B. T. U. (heat unit) is equivalent to 778 foot pounds of energy, and one theoretical H. P. requires 33,000 foot pounds of energy per minute, and $33{,}000 \div 778 = 42.416 +$ B. T. U., or 2,545 B. T. U. per hour. From Fig. 2 the total efficiency at the generator terminals, which will be practically the same as that at the switchboard, is



BOILER EFFICIENCY CHART

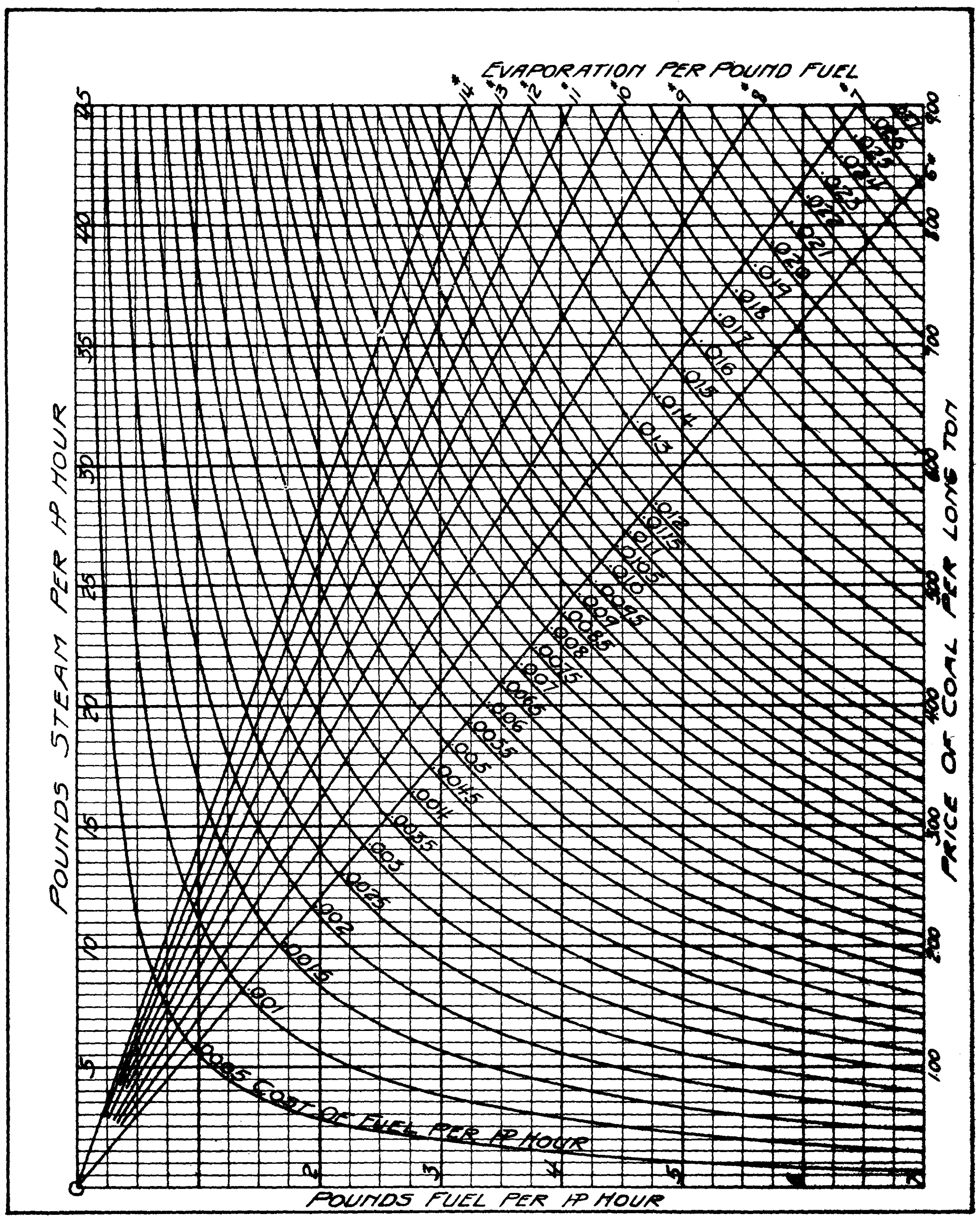
shown on the fourth reading from the bottom to be 10.4 per cent.; hence the heat required to generate one E. H. P. at the switchboard will be $(2,545 \div 10.4) \times 100 = 24,471$ B. T. U., which will necessitate the consumption of $24,471 \div 14,400 = 1.7$ pounds of coal per e. h. p. hour. It has already been found from Plate VIII that 11.5 pounds of steam can be derived from one pound of the above coal, and with this data from Plate IX can be determined the cost for fuel per e. h. p. hour and the pounds of steam generated per e. h. p. hour. Locating on the lower margin the 1.7 pounds of fuel per h. p. hour and following up this line until it meets the diagonal or the interpolated diagonal representing 11.5 pounds evaporation, the steam consumption is found by following the horizontal lines to the left margin, reading in this instance 19.5 pounds of steam per e. h. p. hour. To obtain the cost of fuel per h. p. hour, follow up the vertical corresponding to the required coal consumption until it meets the horizontal line corresponding to the cost per long ton of coal as given on the right-hand margin, reading on the curved lines, or interpolating between them if necessary, the cost per h. p. hour in cents and mills. With coal at $4.60 per ton the cost will be $0.0035 per e. h. p. hour.

If the manufacturers of the boilers and engines state definite guarantees in specifications covering the operating conditions for their equipments, then Plate IX can be used directly for determining the cost of fuel. For example:—The boilers are guaranteed to evaporate, with a given coal containing 14,400 B. T. U. and costing $4.60 per ton, 10 pounds of water per pound of fuel. The boiler efficiency can be obtained from Plate VIII by reading the nearest diagonal to the intersection of the vertical line corresponding to the 14,400 B. T. U. and the horizontal line reading 10 pounds on the left margin, which will be 67.5 per cent. The engine manufacturer guarantees that the engine alone will require 16 pounds of steam per I. H. P. hour, that the engine will have a mechanical efficiency of 95 per cent., or that the steam per B. H. P. hour will be 16.84 pounds, and with a generator of 95 per cent. efficiency the steam consumption per e. h. p. hour will be $16.84 \div 0.95 = 17.73$ pounds. To this steam must be added the amount lost in radiation, pipe friction and auxiliaries, including the condenser, exciter, feed-water pumps, etc.; an amount varying from 5 to 15 per cent. of the steam required for the engines, depending upon the size of plant and the character of the auxiliaries; a fair average figure being about 9 per cent.; hence the total steam consumption per e. h. p. hour will be 17.73 × 1.09 = 19.33 pounds. On Plate IX, tracing horizontally from 19.33 pounds reading on the left margin to the intersection of the diagonal corresponding to 10 pounds evaporation, the coal consumption per e. h. p. hour is read from the lower margin and is 1.93 pounds. Following up vertically opposite the same point of intersection to the line corresponding to $4.60 on the right margin and reading the nearest curve cutting this last intersection, we find that the cost for fuel per e. h. p. hour will be $0.004.

It will be noted that in almost all cases it will be necessary to interpolate the readings between the verticals representing the pounds of fuel per h. p. hour which are sub-divided in divisions of 0.25 pounds each; and also the curves giving the cost for fuel per h. p. hour which are sub-divided into one-half mill divisions, and this condition holds for all of the fuel Diagram Plates IX, X, and XI. With a little care in reading, the results should be accurate within one-half of one per cent.

The total annual cost for coal in the three hypothetical operating conditions for the 4,000 e. h. p. capacity steam plant previously described will be as follows:—Case I—9,600,000 e. h. p. hours × $0.0035 = $33,600.00; Case II—21,024,000 e. h. p. hours × $0.0035 = $73,584.00 and Case III—28,032,000 e. h.p. hours × $0.0035 = $98,112.00.

The fuel required in a gas plant of corresponding rated capacity can be determined from Fig. 3 and Plate X. From Fig. 3 the net efficiency of the gas electric plant at the generator terminals, or the switchboards is 23.6%. Using the same grade of bituminous coal, as that employed in the steam plants, having 14,400 B. T. U. per pound of fuel, the amount of coal required per e. h. p. hour will be (2,545 ÷ 0.236) ÷ 14,400 = .75 lbs. For one theoretical horse power requires 2,545 B. T. U. per hour, and with 23.6% efficiency, 2,545 ÷ 0.236 = 10,783 B. T. U. will be required per e. h. p. hour, or 10,783 ÷ 14,400 = 0.75 lbs. of coal per e. h. p. hour. With coal costing $4.60 per ton, the cost per e. h. p. hour from Plate X can be obtained as follows:—Locate on the lower margin the pounds of fuel per h. p. hour and trace vertically to the intersection of the horizontal line corresponding to the price of $4.60 on the right margin. The point of intersection in this instance falls about mid-



STEAM POWER—COST OF FUEL PER H. P. HOUR

way between the curves \$0.001 and \$0.002, hence the cost for fuel per e. h. p. hour is \$0.0015, or per year for Case I—9,600,000 e. h. p. hour × \$0.0015 = \$14,400.00; for Case II—21,024,000 × \$0.0015 = \$31,536.00 and for Case III— 28,032,-000 × \$0.0015 = \$42,048.00.

The producer manufacturer can give definite guarantees for the efficiency of his equipment with a stipulated quantity of fuel. This efficiency will range from 60 to 80 per cent. depending upon the grade of fuel. From coal containing 14,400 B. T. U. with a producer efficiency of 80% — 11,520 B. T. U. will be delivered in the gas. The volumetric quality of the gas must be determined by test, and with the high grade fuel under consideration, approximately 80 cu. ft. of gas can be generated from one pound of coal and one cubic foot of gas will contain 11,520 ÷ 80 = 144 B. T. U.

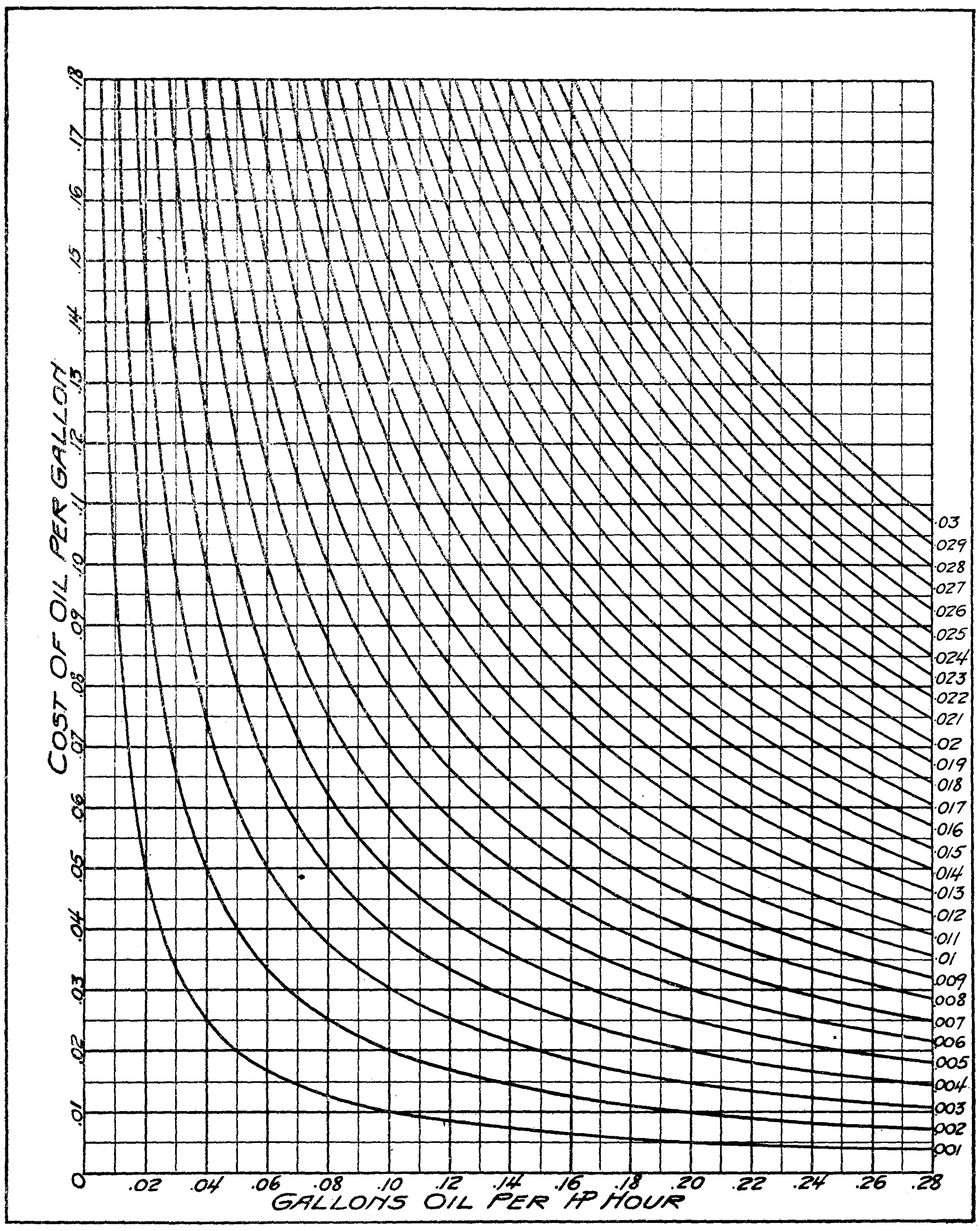
It is customary to guarantee gas engines on the basis of the gas consumption per B. H. P. hour. On Fig. 3 the efficiency at the engine shaft is given as 24.8% hence the efficiency of the engine is (24.8 ÷ 80) × 100 = 31% and 2,545 ÷ 0.31 B. T. U. will be required per B. H. P. hour, or 8210 ÷ 144 = 57 + cubic feet of gas containing 144 B. T. U. per pound. With electric generators of 95% efficiency the cu. ft. of gas per E. H. P. hour will be 57 ÷ 0.95 = 60. This figure can be checked from Fig. 3, as follows:—23.6 ÷ 0.80 = 29.5 and 2545 ÷ 29.5 = 8627 B. T. U. required per E. H. P. hour, or 8627 ÷ 144 = 59.91 cu. ft. of gas which is practically 60 cu. ft as previously determined.

It must be remembered that the efficiencies given on Fig. 3 are for a gas electric power plant in perfect physical condition and skilfully operated. In ordinary practice it is to be expected that the figures would not obtain, particularly the engine efficiencies as the manufacturers would be inclined to offer as a maximum guarantee the equivalent of 10 cu. feet of gas containing 1000 B. T. U. which is equivalent to an efficiency of 2545 ÷ (10 × 1000) × 100 = 25.45% making the total efficiency to the switchboard 25.45 × .8 (the producer efficiency) × .95 (the gen. efficiency) = 19.25% instead of 23.6% as given on Fig. 3, and the coal consumption (2545 ÷ 0.1925) ÷ 14,400 = 0.92 pound per e. h. p. hour instead of the 0.75 pound previously given. To apply the diagram Plate X with a known engine guarantee and quality of fuel the following example is cited:—Given, a peat fuel from which 30.3 cubic feet of gas containing 175.2 B. T. U. can be generated per pound of fuel (see Table IV, page 232), costing $2.00 per long ton; an engine which is guaranteed to develop one B. H. P. hour with 12,264 B. T. U. or with 12,264 ÷ 175.2 = 70 cu. ft. of gas, and an electric generator efficiency of 91% making the cu. ft. of gas per e. h. p. hour 70 ÷ 0.91 = 77. Locate on the left hand margin the 77 cu. ft. per h. p. follow horizontally to the right until the line intersects the diagonal representing 30.3 cu. ft. of gas per pound of fuel, as noted at the top of the diagram; from this point of intersection drop vertically to the horizontal line corresponding to the price for the fuel, as noted on the left margin, i. e. $2.00, and read from the curve the cost of fuel per h. p. hour which is in this case $0.002.

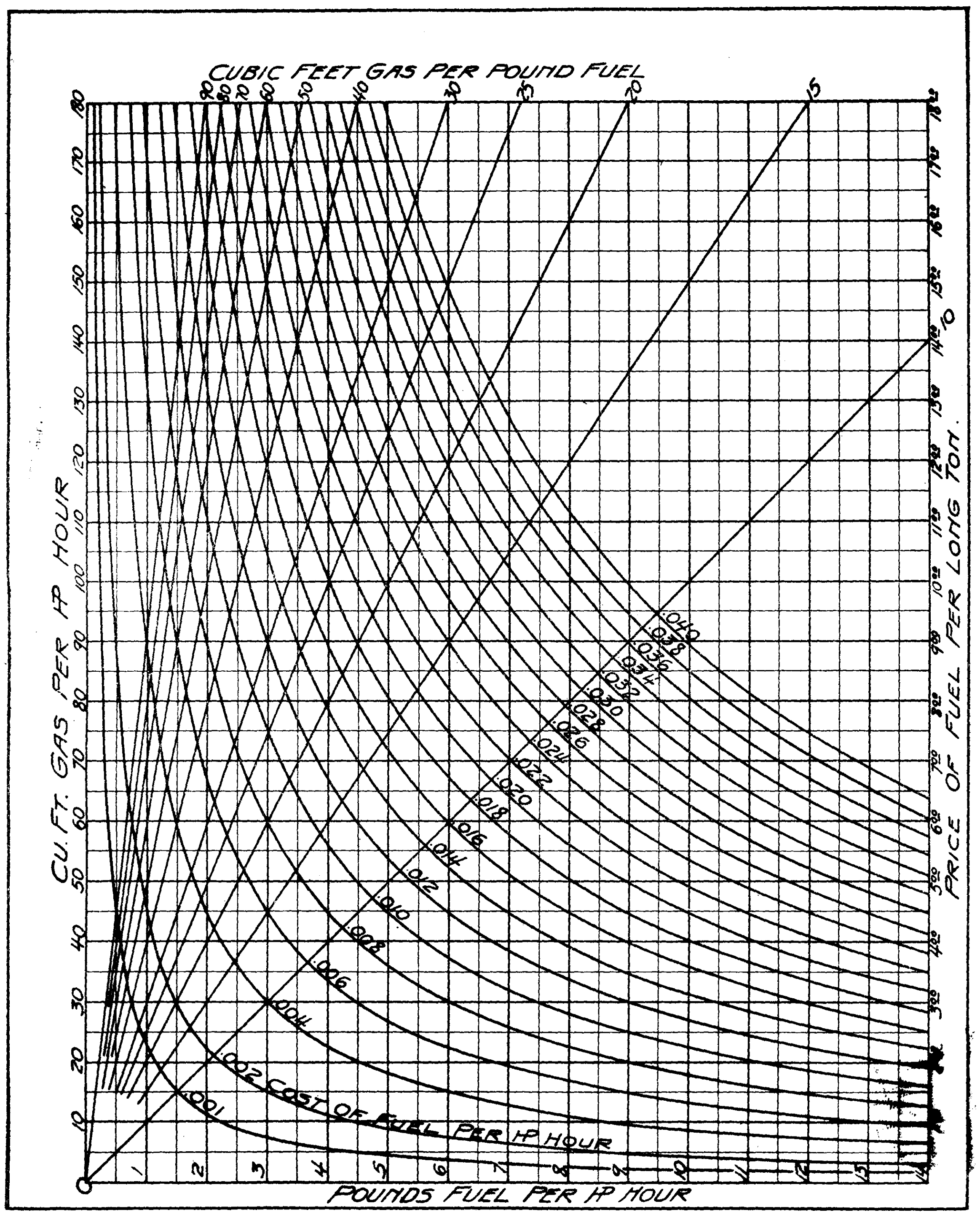
Fuel oil can be purchased locally for somewhat less than 3 cents per gallon and the oil engine manufacturers will guarantee a consumption of 0.0755 gals. per E. H. P. hour, including the auxiliaries, when the engine is direct connected to a generator of 95% efficiency. Knowing the cost of oil and the engine ecconomy the cost per E. H. P. hour for fuel can be obtained from Plate XI as follows: Locate the gallons of fuel per h. p. hour on the bottom of the diagram and trace up vertically to the intersection of the horizontal corresponding to the price per gallon for oil as given on the left hand margin, reading the cost per H. P. hour from the curved line at the above intersection which is with the foregoing conditions $0.0023. Then the fuel cost per year for a plant of 4,000 E. H. P. rated capacity will be:—Case I—9,600,000 × $0.0023 = $22,080.00; Case II—$48,355.00 and Case III—$64,474.00.

LABOR.

The operators, including all of the laborers employed in connection with the operation of a plant, exclusive of those engaged on its repairs, are the sole influence which can make it produce power with efficiency and economy. No matter how carefully the designing engineer selects the equipment and arranges the layout; no matter how finely balanced and adjustable the entire scheme may be, to meet the requirements of a particular service, unless the controlling labor organization is trained to realize to the best advantage all of the facilities afforded, no amount of perfected appliances can compensate for unskillful



OIL—COST OF FUEL PER H. P. HOUR



PRODUCER GAS—COST OF FUEL PER H. P. HOUR

manipulation! This statement does not mean that a power station must be manned by a crew of skilled mechanics, or power experts, or that it must be operated by a set of theoretical rules, that would, undoubtedly, defeat the very purpose for which they were created; but it does mean that each department must be under the control of men who know what the apparatus is supposed to accomplish and who are fully conversant with the various combinations and adjustments that will yield the desired result. It is not even necessary and often inadvisable for the attendants to know *why* certain conditions obtain with a given combination provided they are certain that they *do* accomplish certain results.

It is important that one man should be thoroughly familiar with each and every detail of a given plant, and that he have full charge of its operation. Beyond this single competent operator, or supervisor, the assistants need not be specialists except as they become trained to deftly perform the certain specific duties placed upon them. The proverb that "a little learning is a dangerous thing" applies aptly to the station operator who has acquired a sufficient insight into the mechanics of his work to incite his constant tinkering with the equipment, making minor adjustments and changes here and there, until he inadvertently oversteps his knowledge and causes a mixup which damages or demolishes thousands of dollars' worth of machinery. A skillful commander, with a corps of well trained privates, faithful in the performance of the duties consigned to them, forms a much more satisfactory and safe working crew for a power station than a contingent of petty officers each impressed with the importance of his position and ability.

The labor required for a given plant depends upon the "rated" working capacity and the hours of operation per year. The rated or normal capacity of the 4000 h. p. plant under consideration is 3,200 E. H. P. Figures 7, 8 and 9 show the number of men required per shift, and the average wages per shift per hour for steam, gas and oil electric power plants. These diagrams do not include the repair crew, which may or may not comprise part of the station organization depending on whether or not the plant is co-related to some industry, or is an isolated proposition. From Fig. 7 the cost for labor per E. H. P. hour in a steam electric plant of 3200 h. p. working capacity is found by locating on the left margin 3200 h. p., and following this

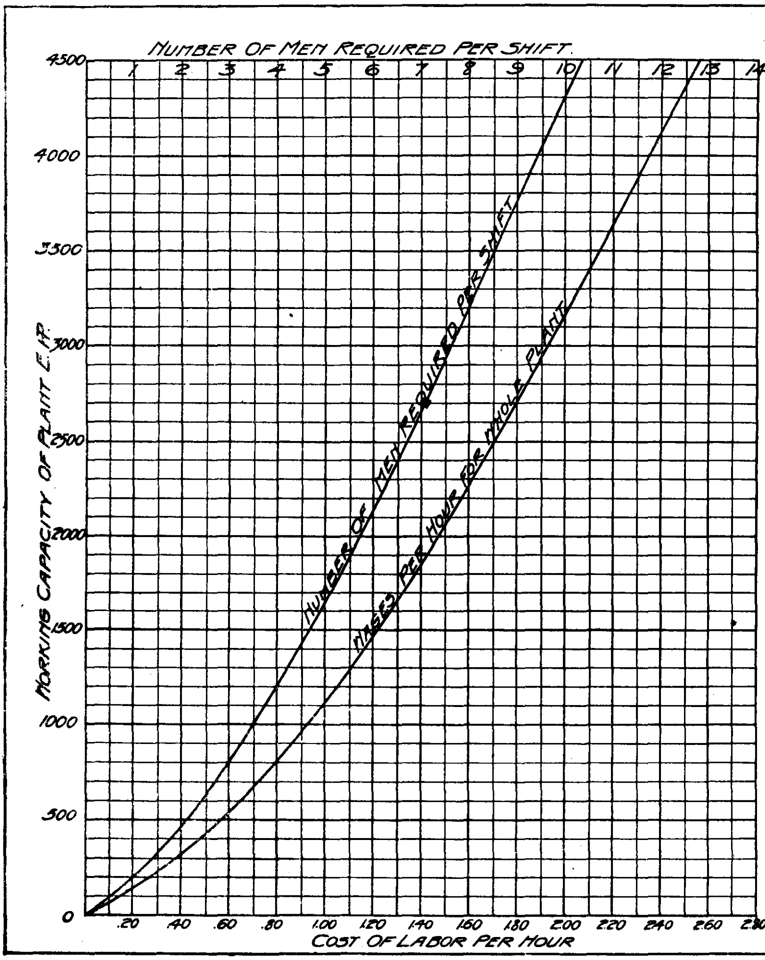


FIG. 7. COST OF LABOR: STEAM ELECTRIC PLANTS.

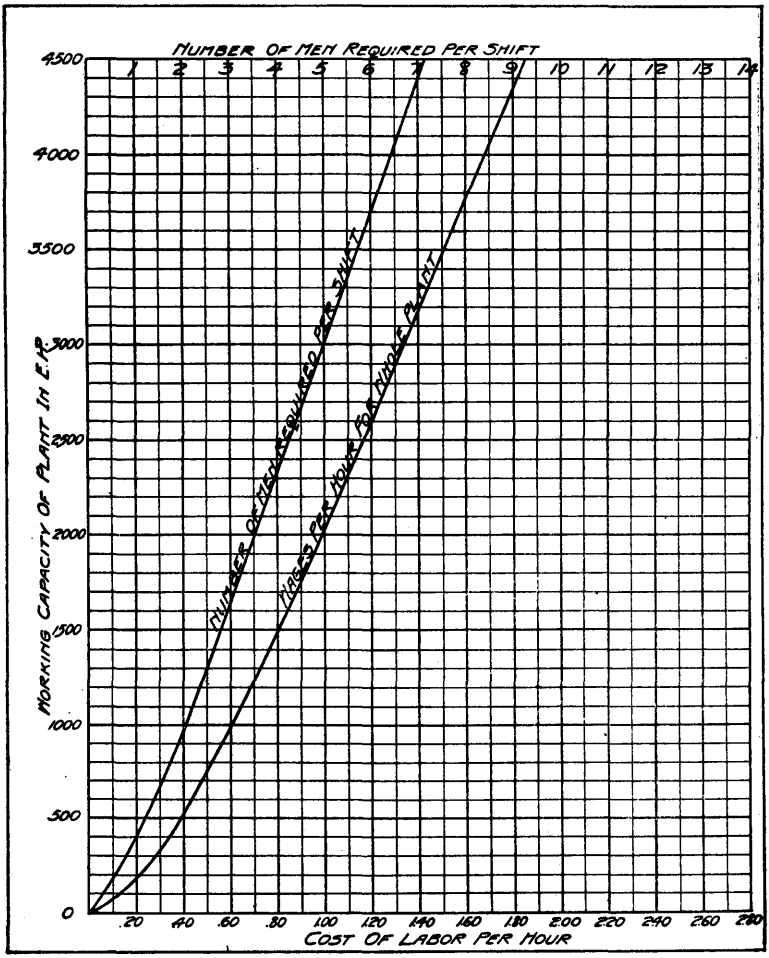


FIG. 8. COST OF LABOR: PRODUCER GAS ELECTRIC PLANTS.

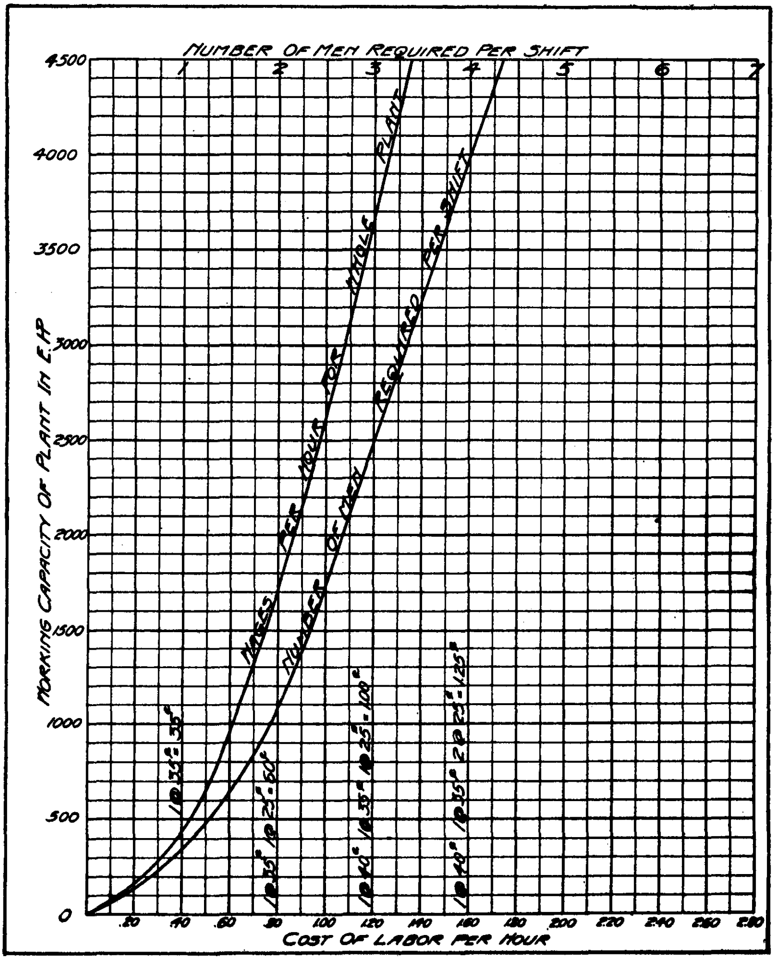


FIG. 9. COST OF LABOR: OIL ELECTRIC PLANTS.

line horizontally to the right to the intersection of the curve marked "Wages per hour for whole plant" and reading from the vertical at this intersection, on the lower margin the amount, which is $2.02. Then the cost per year for labor will be in Case I—3,000 hrs. × $2.02 = $6,060.00; Case II—6,570 hrs. × $2.02 = $13,271.00, and Case III—8,760 hrs. × $2.02 = $17,-695.00.

The wages for gas and oil plant operation is similarly determined from Figures 8 and 9 and are as follows:—for gas, Case I—3,000 × $1.41 = $4,230.00; Case II—6,420 × $1.41 = $9,-264.00 and Case III—8,760 × $1.41 = $12,352.00, and for oil, Case I—3,000 × $1.12 = $3,360.00; Case II—6,570 × $1.12 = $7,358.00 and Case III—8,760 × $1.12 = $9,811.00.

When the oil engine is constructed in larger units than the present standard, the operating labor cost will be reduced.

Depreciation, Repairs and Improvements.

There is a wide divergence of opinion as to the method of computing or allowing for depreciation in connection with power plants, and, in fact, as to the true meaning of the term "depreciation." Its literal definition is "the act of lessening the worth of;" hence all factors which lessen the value of a plant must be taken into consideration, including wear, inadequacy, age and obsolescence. It is claimed by many managers that the repairs and improvements made in the ordinary course of operation cover all that it is necessary to allow for depreciation, reasoning on the theory that if a plant is kept in prime physical condition it appreciates. This logic may at first sound reasonable and it is practically true so far as the immediate physical condition is concerned, but in time if this policy was pursued to its ultimate limit, it will be found that repairs will not longer keep the equipment in working order and renewals become imperative, hence age occasions an expenditure which is chargeable to the *past* operation.

Sould the growth of a power service be rapid, the demands upon the equipment and buildings may soon exceed their capacity, then the value of a plant in perfect condition may be suddenly reduced, due to its inadequacy, and its compulsory abandonment incurs an expense which is chargable to *past* operation.

If improvements in apparatus are devised which make the equipment of a plant inefficient when compared with the more recent developments, economy demands that the inferior outfit should be supplanted, and the discarding of apparatus mechanically in excellent preservation, occasions a depreciation in its value, due to obsolescence which is chargeable only to *past* operation.

A depreciation allowance does not mean expenditure, but the setting aside of certain sums in anticipation of future losses from any or all of the above causes, thus making the project self-sustaining from its inception.

There is no definite basis or established standard for determining the amount of depreciation to be allowed per annum for the several component parts of a power plant, this condition is largely due to the contradictory decisions that have been rendered by the courts in relation to this subject, combined with the entirely different view-points which must be assumed when placing the depreciation on a projected plant and on a "going" proposition. In the first instance it becomes necessary to assume a reasonable period of normal life, and to distribute the depreciation reservations in some equitable manner over this period, so that at the end of the predetermined time there will be available a sum sufficient to replace the property. In the case of a "going" proposition the theoretical depreciation as previously outlined cannot be justly applied, for a plant may have nearly reached its theoretical limit of life yet still be in such excellent physical condition that it fully meets the requirements of the imposed service, and to deduct from its cost the theoretical depreciation would make its present worth only the scrap value of the equipment, an appraisal which the actual conditions controverts.

For buildings of a permanent character from 1 to 1 1-2% of the cost per annum has been found to be a sufficient allowance for depreciation; for steam engines and turbines from 3 to 6%; for electric generators, from 3 to 7%; for boilers, from 5 to 10%; for steam pumps from 5 to 7%; for switchboards, from 3 to 5%; for condensers, from 4 to 10%; for gas producers, from 3 to 8%; for gas and oil engines from 4 to 7% and for machinery foundations, the same as that allowed for the apparatus which they support.

The average depreciation per annum for a complete steam electric power plant will be about 4% of its total cost; for a gas electric plant, 5 % and for an oil electric plant 5 1-2%; provided the property is kept in good physical condition by proper maintenance and repairs.

On the basis of the above percentages, the annual depreciation for the hypothetical plants cited, will be as follows:—for steam, \$224,000.00 × 0.04 = \$8,960.00; for gas, \$280,000.00 × 0.05 = \$14, 000.00 and for oil, \$400,000.00 × 0.055 = \$22,000.00.

The hours of operation have but slight bearing on the depreciation of equipment, for if kept in proper repair, continuous operation does not cause much greater deterioration then that occasioned by intermittent service, in fact, power equipment operating for only a portion of the time is subjected to temperature strains that are more conducive to its destruction than the mechanical wear that is imposed upon it by continuous operation; but the cost of maintenance, repairs and supplies varies proportionally with the "capacity" factor.

The repairs and supplies, including labor and materials, for steam plants having from 80 to 100% "capacity" factor, will be about 2% of the first cost; for from 50 to 80% cap. factor, 1.75% of cost and for from 20 to 50% cap. factor, 1.5% of cost; and for oil and gas plants, with 80 to 100% cap. factor, 2 1-2%, from 50 to 80% cap. factor, 2%, and from 20 to 50% cap. factor, 1.75%.

Then for the hypothetical plants, the annual repairs and supply cost will be:—

CASE I.

Steam,	\$224,000.00 ×	0.015	=	\$3,360.00
Gas,	280,000.00 ×	0.0175	=	4,900.00
Oil,	400,000.00 ×	0.0175	=	7,000.00

CASE II.

Steam,	\$224,000.00 ×	0.0175	=	\$3,920.00
Gas,	280,000.00 ×	0.02	=	5,600.00
Oil,	400,000.00 ×	0.02	=	8,000.00

CASE III.

Steam,	\$224,000.00 ×	0.02	=	\$4,480.00
Gas,	280,000.00 ×	0.025	=	7,000.00
Oil,	400,000.00 ×	0.025	=	10,000.00

Taxes, Insurance and Interest.

The taxation charges depend entirely upon local conditions, but it is safe to assume that the valuation placed upon power plant property will not exceed 60% of its first cost, or the replacement cost, and that a fair average rate of taxation in Maine will be 2%. Insurance rates also depend upon local conditions, but 1-2 of one per cent. on 60% of the property cost is about a fair average allowance. Estimating on 2 1-2% of 60% of the cost for the plants under discussion, the annual charges for taxes and insurance will be as follows:—

Steam,	0.60 ×	$224,000.00 ×	0.025 =	$3,360.00
Gas,	0.06 ×	280,000.00 ×	0.025 =	4,200.00
Oil,	0.60 ×	400,000.00 ×	0.025 =	6,000.00

The interest charges are readily obtained for an independent power plant depending for its solvency on an income from the sale of power, as the capitalization and the accounting are not involved with other branches of industry; but a power plant built and operated in conjunction with a mill offers a more difficult problem, as the separation of accounts will usually demand some abstruse disbursements of costs which may either favor or handicap its showing. The thoughtful business man will concede that the power plant should pay for itself, and that the power to adopt will be that which yields a maximum return on the *total investment* for the entire mill property.

A shoe manufacturer would not entertain a proposition for the preparation of his own leather if by so doing he reduced the net per cent of profit on the whole plant investment, even though the annual expenditure for leather was materially reduced, and the same process of reasoning should be applied to the generation of power. To illustrate this point more clearly; we will take the specific case of an industry which has a total capitalization of $500,000.00 and yields a net profit of 15% on the investment, when run with purchased power. By making an additional investment of $100,000.00 the power can be produced on the mill premises for a cost sufficiently less than that paid for the purchased power to yield a return of 6% on the power plant investment. The total capitalization for the industry now becomes $600,000.00 and the net profit ($500,000.00 × 0.15) + ($100,000.00 × 0.06) = $81,000.00, or a return on the total investment of 13.5%, and the relative earning power of the property has been reduced (15 — 13.5 ÷ 15) × 100 = 10%.

It follows that while it is justifiable to use a uniform rate of interest when comparing the cost for several different classes of power, in adopting a power to be used in connection with any industry, it is important that it be selected on the basis of its intrisic value to the entire project, and not on its relative power value.

For the purposes of comparison, we have assumed an interest of 5% on the cost of the projects, as follows:—

Steam,	\$224,000.00	×	0.05	=	\$11,200.00
Gas,	280,000.00	×	0.05	=	14,000.00
Oil,	400,000.00	×	0.05	=	20,000.00

Water, Land Rental and General Expenses.

In the estimates for cost which accompany this paper, no allowance has been made for water charges, land rental or general expense. These items will vary for each locality and are readily ascertained, with the exception of general expenses which will be regulated by the policy of the managers. If large quantities of fuel and supplies are constantly maintained, the interest on the money thus invested should be charged to the plant operation; and if a large volume of coal is stored for a considerable period, a deterioration of about 5% for each six months in storage should be added to the power cost; as should also be the costs for clerical work devoted to the ordering and disbursing of supplies and materials, and employed in compiling the records of the plant operation.

In most sections of Maine, water for boiler feed, condensing and cooling purposes can be secured without other cost than that required to provide proper facilities for delivering it to the desired point of use. If the water must be purchased, or if it becomes an item of considerable expense, provision should be made for its economical utilization, and cooling towers, or pools, should be installed to conserve the condensing water for steam plants and the cooling water for gas plants. The use of surface condensers will permit the return of all the condensed steam to the boiler with the exception of about 5% which will be lost mechanically while passing through the system. Provision should be made for supplying the condensers with about 50 times the amount of water required for steam, and for supplying gas plants about 200 pounds of water per E. H. P. hour.

The land rental is not ordinarily an important factor in local power costs except in congested cities where real estate is high; and the proper amount to be added for this item is readily obtained for any specific case.

CONCLUSIONS.

The Table V gives a resumé and summation of the figures relating to the hypothetical plants, which are distributed through the preceeding text, and it shows the *lowest* costs that can be realized when generating power in plants of the several types outlined, and operating under the most favorable conditions. The only items that can be reduced being the fuel charges. The writer wishes to place particular emphasis on the foregoing statement and to impress upon the readers' attention the fact that the final figures, under items Nos. 35 and 36, for the cost per H. P. and K. W. hour, are minimum, and that the average cost for power as produced by plants running in connection with an industry will be about 20 per cent. higher than those recorded in the tabulation.

As intimated in the introductory remarks, this paper is prepared with the object in view of aiding in the education of the public in regard to the real value of Maine's waterpowers, at the same time we hope its perusal will dispel any illusions that may exist as to the possibility of generating steam power in Maine for $15.00 or $16.00 per H. P. year of 3,000 hours, a falsity which we know has been occasionally credulously accepted; but such an accomplishment is impossible unless a portion of the power expenditure is eliminated by disbursing it with process accounts; a procedure justified only when steam is required for process, or heating purposes.

It is more than probable that the necessity of insuring continuous operation will compel the installation of reserve equipment in plants working under the conditions outlined for Cases II and III, although no allowance has been made for this contingency in the plants cited. The need for surplus apparatus is more urgent (becoming almost imperative if power interruptions are to be avoided) in gas and oil plants, on account of the small overload capacity of the engines; when compared with the steam engine or turbine that can carry as high as 50% overload in an emergency by sacrificing efficiency. To meet the requirements by installing surplus apparatus will add materially to the cost per H. P. hour, as items Nos. 27 to 33 inclusive will be increased.

Fully appreciating all of the foregoing facts, the author deemed it advisable to adhere to the simple cases adopted rather than enter into the details of the more involved problem with the attendant discussion; because the examples given quite clearly illustrate the application of the diagrams, with less opportunity for confusion in demonstrating their use than would exist if the problems were more complex.

Obviously the data presented cannot be applied indiscriminately, for it is not to be expected that any sterotyped code of rules can be made which will eliminate the need of applying discerning judgment; or that the information given will obviate the necessity and advisability of obtaining the counsel of an expert when a proposition of importance is under consideration.

Table V.

Comparison of Hypothetical Plants.

Item.	Case I.			Case II.			Case III.		
	Steam.	Gas.	Oil.	Steam.	Gas.	Oil.	Steam.	Gas.	Oil.
1. Rated E. H. P. Capacity of plant	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
2. Normal E. H. P. Capacity of plant	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
3. Hours Operation per year	3,000	3,000	3,000	6,570	6,570	6,570	8,760	8,760	8,760
4. Load Factor	80%	80%	80%	80%	80%	80%	80%	80%	80%
5. E. H. P. hours generated per year	9,600,000	9,600,000	9,600,000	21,024,000	21,024,000	21,024,000	28,032,000	28,032,000	28,032,000
6. Capacity Factor	27.4%	27.4%	27.4%	60%	60%	60%	80%	80%	80%
7. Cost of Plant per E. H. P. of rated capacity	$56 00	$70 00	$100 00	$56 00	$70 00	$100 00	$56 00	$70 00	$100 00
8. Cost of complete plant	$224,000 00	$280,000 00	$400,000 00	$224,000 00	$280,000 00	$400,000 00	$224,000 00	$280,000 00	$400,000 00
9. Price of fuel per long ton	$4 60	$4 60	$9 60	$4 60	$4.60	$9 60	$4 60	$4 60	$9 60
10. Price of oil per gal.			$0.03			$0.03			$0 03
11. Efficiency of Boilers or Gas Producers	78%	80%		78%	80%		78%	80%	
12. Efficiency of Complete Oil Equipment			26.1%			26.1%			26.1%
13. B. T. U. per pound of fuel	14,400	14,400	18,400	14,400	14,400	18,400	14,400	14,400	18,400
14. Pounds of steam per pounds of coal	11.5			11.5			11.5		
15. Pounds of fuel per E. H. P. hour	1.7	0.75	0.53	1.7	0.75	0.53	1.7	0.75	0.53
16. Pounds of steam per E. H. P. hour	19.5			19.5			19.5		
17. Cubic feet of gas per pound of fuel		80			80			80	
18. B. T. U. per cubic foot of gas		144			144			144	
19. Cubic feet of gas per E. H. P. hour		60			60			60	
20. B. T. U. per gal. of oil			129,000			129,000			129,000
21. Weight of one gal. of oil, lbs.			7.03			7.03			7.03
22. Gals. of oil per E. H. P. hour			0.0755			0.0755			0.0755
23. Cost of fuel per E. H. P. hour	$0.0035	$0.0015*	$0.0023	$0.0035	$0.0015*	$0.0023	$0.0035	$0.0015*	$0.0023
24. Cost of fuel per year, No. 5 x No. 23	$33,600 00	$14,400 00	$22,080 00	$73,584 00	$31,536 00	$48,355 00	$98,112 00	$42,048 00	$64,474 00
25. Cost of labor per hour	$2 02	$1 41	$1 12	$2 02	$1 41	$1 12	$2 02	$1 41	$1 12
26. Cost of labor per year, No. 3 x No. 25	$6,060 00	$4,230 00	$3,360 00	$13,271 00	$9,264 00	$7,358 00	$17,695 00	$12,352 00	$9,811 00

27. Percentage of First Cost allowed for depreciation	4%	5%	5½%	4%	5%	5½%	4%	5%	5½%
28. Annual Depreciation	$8,960 00	$14,000 00	$22,000 00	$8,960 00	$14,000 00	$22,000 00	$8,960 00	$14,000 00	$22,000 00
29. Percentage of First Cost allowed for repairs and supplies	1.5%	1.75%	1.75%	1.75%	2%	2%	2%	2.5%	2.5%
30. Annual Repair and Supply Cost	$3,360 00	$4,900 00	$7,000 00	$3,920 00	$5,600 00	$8,000 00	$4,480 00	$7,000 00	$10,000 00
31. Taxes and Insurance at 2½% of Item No. 8 x 0.6	$3,360 00	$4,200 00	$6,000 00	$3,360 00	$4,200 00	$6,000 00	$3,360 00	$4,200 00	$6,000 00
32. Interest on Cost at 5%	$11,200 00	$14,000 00	$20,000 00	$11,200 00	$14,000 00	$20,000 00	$11,200 00	$14,000 00	$20,000 00
33. Total Annual Expenditure Items, Nos. 24+26+28+30+31+32	$66,540 00	$55,730 00	$80,440 00	$114,295 00	$78,600 00	$111,713 00	$143,807 00	$93,600 00	$132,285 00
34. Cost per E. H. P. year, No. 33÷No. 2	$20 79	$17 42	$25 14	$35 72	$24 57	$34 91	$44 94	$29 25	$41 34
35. Cost per E. H. P. hour, No. 33÷No. 5	$0.00693	$0.0058+	$0.00838	$0.00544	$0.00374	$0.00532-	$0.00513	$0.00334	$0.00472
36. Cost per K. W. hour, Item 35×1.25	$0.00866	$0.00725+	$0.01047+	$0.00680	$0.00467	$0.00665-	$0.00641	$0.00417	$0.0059

NOTE.—* No allowance has been made for the return from reclaiming sulphate of ammonia. See Text page 227.

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