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CHARLES D. WALCOTT, DIRECTOR

REPORT OF PROGRESS

OF THE

DIVISION OF HYDROGRAPHY

FOR

THE CALENDAR YEAR 1895

BY

FREDERICK HAYNES NEWELL

HYDROGRAPHER IN CHARGE

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., February 29, 1896.

SIR: I have the honor to transmit herewith a manuscript entitled "Report of progress of the Division of Hydrography for the calendar year 1895," and to request that it be published as a bulletin of the Survey.

Very respectfully, yours,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

REPORT OF PROGRESS OF THE DIVISION OF HYDROGRAPHY FOR 1895.

By F. H. NEWELL.

INTRODUCTION.

The following report gives the results of operations of the Division of Hydrography for the calendar year 1895. It is similar in form to the preceding report—that for the years 1893 and 1894—issued as Bulletin No. 131 of this Survey. Like that bulletin, its purpose is to present at as early a date as possible a statement in detail of the localities at which work has been undertaken, the character of the investigations, and the results obtained. To expedite the printing of the bulletin, all illustrations have been omitted, these being reserved, together with the general deductions, for papers accompanying the Annual Report of the Director. The present report is printed mainly for the use of the assistants on this Survey and of persons cooperating or immediately interested in the details of the work. The broader questions of the application of the data and their completion by the addition of collateral facts are reserved for the more widely distributed annual reports.

The following pages contain, after general remarks on the drainage basin or stream, a description of the location of the river stations and of the measurements carried on at each, followed by lists of discharge measurements, rating tables, and other material relating to river work. The compilations of well schedules and correspondence in reference to underground waters, together with descriptions of the field work, have been reserved for a later publication.

ORGANIZATION OF FIELD WORK.

In an investigation of this kind, which from its very nature must be carried on over widely scattered portions of country, it is impracticable, with the small appropriations available, to employ salaried hydrographers to carry on all of the field work. An attempt is therefore made to secure gratuitous or inexpensive cooperation, and to place the local charge and oversight of the work under the direction of resident hydrographers—men who have not only a strong personal interest in and inclination toward investigations of this character, but who also have some permanent occupation or position by which a living is assured. For example, assistance of this kind is sought from professors of geology or of hydrographic engineering, who have practical acquaintance with the difficulties and methods of water measurements and with the behavior of streams and underground sources of supply. These men are paid for the time actually employed a moderate compensation, which includes their incidental expenses, and are furnished with the necessary instruments and blanks.

The observers of river height and of other phenomena in each State report directly to the resident hydrographer. Their observations are received by him each week and forwarded to the Washington office. From time to time the resident hydrographer visits each river station, measures the discharge, learns from the observer any facts which may not have been reported, and at all times keeps a direct supervision of the work within the district allotted to him. He also compiles the daily reports of gage heights, and constructs from the discharge measurements a rating table showing the relation between the height of river and the discharge, modifying this table from time to time and applying it as occasion demands. Copies of these reports and tables are sent to the office at Washington and are placed upon the records, being scrutinized and compared in order to bring all such data into similar form.

The resident hydrographers are kept in touch with the work of each other and with that of the office force through the assistance and advice given by the inspecting hydrographers regularly employed by this Survey, who constantly travel from point to point, assisting in establishing river stations, making measurements, repairing damages caused by floods, rating current meters, and perfecting methods and devices. By this means improvements suggested by the experience of one man are communicated in turn to all the rest, and especial attention can be given to difficult problems.

The oversight of the stream measurements of the West has been placed in the hands of Mr. Arthur P. Davis, and that of those of the Appalachian area has been intrusted to Mr. Cyrus C. Babb. The general direction of work and the especial consideration of questions relating to artesian wells and underground waters have been assigned to the writer, who has had the assistance or cooperation of a number of the geologists of the Survey.

INSTRUMENTS AND METHODS.

CURRENT METERS.

The instruments used during this year have not been essentially different from those described in the Eleventh Annual Report of this Survey, Part II, pages 5–10, and in the Fourteenth Annual Report, Part II, pages 96–98. The large Haskell electric meter figured upon page 9 of the Eleventh Annual Report, Part II, has been used only to a small extent, its large size and high rate of revolution during floods giving rise to objections on the part of hydrographers. Attempts have been made to improve the electric registering devices, but it has been found impracticable to use the ordinary form of recorders or registers where the revolutions are more than five or six per second. At a greater speed than this the ratchet movement of the electrical devices is apt to skip, and either the wheel fails to advance or else the indicator hand is pushed forward two places. To obviate this difficulty one of the large Haskell meters has been altered by the insertion of a small five-tooth wheel in front of the contact spring in the spindle of the meter. Every fifth revolution of the head causes this small wheel to open and close the circuit once, thus allowing the register to run with one-fifth the speed of the head. The small five-tooth wheel can be readily taken out, and the meter will then, as originally, open and close the circuit at every revolution.

The small Haskell meter figured on page 97 of the Fourteenth Annual Report, Part II, has had the greatest use, on account of its lightness and the ease with which it can be employed from a bridge or suspended car. It does not, however, turn in sluggish currents, owing to the relatively high friction, and it has not been found practicable to use this form of meter in streams whose velocity is less than one-half foot per second. Most of these instruments have been altered somewhat from the form shown on the page above referred to by unscrewing the lower vertical standard and boring a hole horizontally through the meter immediately in front of the tail. A bolt is inserted through this hole, and upon this the meter revolves in a vertical plane, being hung in a clevis to which weights can be attached below and the cord for suspending the meter fastened above. An extra tail has also been inserted at right angles to the one shown in the illustration, extending slightly beyond this and balancing the head of the meter, so that the instrument is kept horizontal when in the water. The experiment of nickel-plating these meters in order to prevent corrosion has also been tried, but without marked advantage.

The Colorado current meter shown on page 7 of the Eleventh Annual Report, Part II, more properly known as the Bailey meter, has been used occasionally in the smaller streams and ditches. The instrument possesses certain advantages in that it can be placed immediately upon the bottom of a shallow stream, and not being provided with electric devices it can be used without the annoyance inseparable from such mechanism. The instruments of this make owned by the Survey are, however, so delicate that the cost of repairs has become a serious matter, and on the score of economy it has seemed advisable to condemn them as they become worn.

A single Buff & Berger meter of the Ellis type has been successfully used. It is light and easily handled, and has been found of advantage in some of the deeper rivers whose maximum velocity is not excessive. The Buff & Berger register has been used for a number of years with various electric current meters, and seems to be the pattern favored by the hydrographers of this Survey.

The Price electric meter, with 6-inch wheel, illustrated in catalogue of W. & L. E. Gurley, has been successfully used, and although heavier than the small Haskell meter, mainly employed during the preceding years, has been highly approved by the field parties because the same meter can be used in high or low velocities. It has been possible to make a number of flood measurements where the speeds were far greater than those previously obtained with other instruments. The little Price acoustic meter, lately introduced, has also been successfully used, even under unusual difficulties. The instrument has commended itself by its extreme lightness and its sensitiveness, and it has been found possible to employ it from bridges by suspension from the end of long rods made of gas pipe.

REGISTERS AND BATTERIES.

One of the chief sources of objection to electric current meters has been the weight of the necessary batteries and the difficulty in handling them. Dry batteries of various make have been used and found to be unreliable or inefficient, especially after exposure to the hot sun in dry climates. Whether these dry batteries could be depended upon during an extended trip could never be ascertained in advance, and therefore a large number were carried, adding considerably to the weight and bulk of the field equipment. It was finally decided to use the wet batteries and charge them each time; but this, too, was a source of considerable annoyance, owing to breakage of jars and the loss of chemicals. During the past year, however, a small battery cell has been found which has proved highly efficient. It consists of a small rectangular hard-rubber box, about 1.5 inches high, 1.7 inches wide, and 1.3 inches thick. This is closed by a soft-rubber stopper carrying the zinc pole of the battery. The opposite pole is made by a metallic point projecting through the bottom, connected with the carbon lining the cell. The battery is charged with a small quantity of bisulphate of mercury powder and water whenever it is to be used. As employed by the Survey, two of these cells are placed side by side in a small wooden box 4 inches wide and 3 inches high, so arranged that when hooked to the end of the registers the electric connection is made with the batteries. The batteries and box complete, with all the connections, weigh only a little over 6 ounces. The single objection so far discovered is that these hard-rubber cells may be easily cracked, but the cost of replacing them is far less than the expense incident to any other form of battery yet tried.

The Buff & Berger register above mentioned has been used to a considerable extent, and also instruments of smaller design, in which a stop watch has been inserted. The latter, known as watch registers, are so arranged that when the watch is started the circuit is closed, and when stopped the circuit is opened, cutting off the electric current from the register. A third pressure upon the stem of the watch sends the hands back to zero, but leaves the connection to the register open for another observation. Most of these instruments have been provided with small bisulphate of mercury batteries, adding greatly to their efficiency. Yet another successful device employs ordinary telegraphic sounders in place of registers. These sounders, having a base about 3 by 5 inches and giving a loud click, have been mounted upon the small boxes containing bisulphate of mercury batteries; the battery and sounder together do not weigh more than a pound, and being in compact form there is very little annoyance from wires and loose connections. When in use this sounder can be placed on the hand rail of a bridge or fastened to the front of the observer's coat in such a position that he can readily hear it. Instead of reading the register before and after each observation the hydrographer merely counts the number of clicks during a given period. This possesses certain advantages in that the attention is fixed upon the behavior of the meter, and the fluctuations or irregularities in the rate of flow can be readily noted, and also any accident which may happen to the meter. Time is saved also in that it is possible to jot down the number of revolutions and continue to take check measurements without stopping. After some experience the hydrographer finds it practicable to count revolutions up to four or five per second.

SOUNDING LINES.

Experience has shown that for sounding rivers at high stages a very fine line is required and a lead weight of from 3 to 5 pounds. The best results so far obtained have been with the fine-braided silk trout line.

MEASUREMENTS FROM BRIDGES OR BOATS.

In the measurement of streams by this Survey the velocity of the water is ordinarily obtained by the use of current meters; the width of the stream is usually measured by stretching a line across it, and the depth is computed by soundings, at proper intervals, by a pole or a lead-weighted line. In a few instances floats have been employed to measure the velocity, and occasionally computations have been based upon weir formulas; but such cases are exceptional, and the methods developed have been dependent upon the use of the instruments above described. There is a tendency toward the exclusive use of electric or acoustic meters, which record the number of revolutions by sound or by other suitable registers. These can be used from a bridge, boat, or suspended car, and do not require such near approach to the surface of the water as is necessary with meters in which the number of revolutions is recorded by dials within the instrument itself.

Measurements have been made from bridges, wherever possible, on account of convenience and small expense involved. Often, however, a river channel is badly obstructed by piers, which set up cross currents and render it impossible to obtain accurate results. In such cases, and at localities where bridges have not been constructed, it is necessary to employ other means. Where the streams are deep, boats are used, or cables are suspended out of the reach of flood water. In some localities boats possess a certain advantage; but where they can not be hired at moderate outlay it has been deemed inadvisable to purchase and keep them, as they are liable to be injured or stolen during the intervals between measurements. A light canvas folding boat has been advantageously used by Prof. Elwood Mead in Wyoming. This boat complete, with oars and seats, may be rolled into a cylindrical package weighing only 60 pounds.

CABLES.

The cables in use at the various river stations are usually from one-half to five-eighths of an inch in diameter. Wherever possible, a steel standing cable has been employed, this being cheaper than a hoisting cable. It is preferable to have these cables galvanized or protected from the weather, as they are used only at intervals. The spans are usually from 200 to 300 feet, although several are nearer 400 feet. The cables are suspended at both ends, usually by passing over tall vertical timbers or light structures, but occasionally they are held up by growing trees or tall sound stumps. The ends are firmly attached to anchors of timber or stone buried securely in the earth. Each cable is made as taut as possible by means of block and tackle.

The car used with the cable is a box about 3 feet square and from 2 to 4 feet deep. It is hung from two pulley blocks running on the cable, and is moved from side to side by the hydrographer, who grasps the cable above his head and pulls in the direction in which he wishes to go. The river is sounded and the current meter is used from this suspended car. Near the cable is what is known as the "tagged wire." This consists of a stout wire upon which marks or numbered tags are placed at intervals of 10 or 20 feet. It has been found advantageous to use common barbed fence wire for this purpose, as the tags can be held in place more readily and this wire is less liable to be stolen or injured than the smooth forms. Where the current is swift, a third wire or light cable is stretched across the river at a distance of from 50 to 100 feet above the main cable. This serves to support a small pulley block or trolley from which a wire runs to the meter to prevent it from being swept downstream when the current is very swift.

POINTS OF OBSERVATION.

The best point at which to take meter observations is still undetermined. In streams having a depth of 5 feet or less, it has been customary to take observations at a distance below the surface sufficient to immerse the meter approximately 0.5 of a foot, and at a distance above the bottom sufficiently great that the wheel is free to turn. With meters having large lead weights the center of the wheel is usually 0.8 of a foot above the bottom. The average velocity thus obtained has been assumed to represent the mean velocity of this portion of the river. In deeper rivers the attempt is usually made to determine velocities at points near the surface and at intervals of about 5 feet to the bottom, the mean velocity being obtained by averaging these. In the case of a wide, deep river it is desirable to select points sufficiently far apart to fairly represent the variations in velocity, and yet not sufficiently numerous to necessitate spending more than three or four hours, at the outside, in velocity observations, exclusive of the time required for preparation. In the case of rapidly fluctuating rivers it is desirable that the series of measurements be completed as quickly as possible.

Mr. J. B. Lippincott states that his experience in the case of the Sacramento River is that if surface and bottom velocities are taken as described above, the result obtained when the discharge is, say, 10,000 second-feet, is about 2 per cent too small as compared with the result obtained by reading surface, mid-depth, and bottom velocities. It is, however, difficult to definitely locate the meter at mid-depth on account of the tendency of the current to swing the meter out of its proper position. Where observations are made from a bridge at considerable elevation above a stream, the effect of the moving water in swinging the meter is large, and it is almost impossible to properly estimate the true position of the instrument. In order to steady the meter in the current, devices have been tried consisting of inclined vanes attached above or below the meter in such position as to tend to force the meter downward and partly upstream. None of these devices, however, have proved wholly satisfactory, and they have been abandoned in favor of the extra stay line of fine wire run from a point immediately above the meter to some point of support upstream, as described in the Eleventh Annual Report, Part II, Irrigation, page 17.

CALIFORNIA METHODS.

The following is a description of the method employed by the State engineering department of California to obtain the results furnished in the report on physical data and statistics:

Three wire marking or tag lines were first stretched across the stream where the gaging was to be made. These marking wires were from 50 to 100 feet apart, the distance depending on the width of the stream. In large streams a boat was used from which to drop floats. This boat, made of canvas, could be folded into small bulk, and was very light and portable. The wires were hung low, so that the position of the passing floats could be easily located. Surface floats only were used, no effort being made to obtain bottom velocities in the gagings of streams near the foothills. Observers were stationed at each wire as well as in the boat. The observer in the boat placed the float and gave a signal at the time it crossed the first line. The observer at each of the other lines gave a signal at the moment it crossed his line, both the time and position being recorded by the engineer in charge. The floats were dropped into the water across the stream at distances of from 10 to 20 feet, depending on the total width. On the smallest streams or brooks smaller intervals were taken. The observations for velocity were repeated three times. The average of the three observations at each locality was taken as the mean surface velocity of this portion of the stream. The mean velocity was taken as from 75 to 80 per cent of the surface velocities.

Soundings were made at each of the three wire crossings, at intervals of 20 feet in the larger streams and of from 5 to 10 feet in the smaller ones. Areas were computed for each of the three sections, and were averaged in order to determine a mean area. This mean area was then multiplied by the mean velocity obtained as above, giving the total discharge. In the large trunk streams in the lower valleys, such as the Sacramento, elaborate experiments were made, especial pains being taken to determine velocities at all depths and at all points. In this work the velocities were obtained chiefly by the use of a meter similar to the Haskell meter. Double floats were tried, but abandoned as unreliable. A full description of the methods pursued has been given by Messrs. Marsden Manson and C. E. Grunsky.[1]

INSTRUCTIONS.

In order to unify and facilitate work the following suggestions have been made to the hydrographers from time to time, and as they cover points which are constantly arising they are inserted for general information.

DATA TO BE RECORDED.

It must be borne in mind at all times that the object of the hydrographic work is to produce a report which will give clearly and concisely data of the most value to the public. Work which has only local application or limited scope should not be undertaken. In entering upon any investigation or reporting any detail or result of field work, full information should be given as to the purpose of the work, and statement should be made of all the circumstances which may in any way affect its value. The bare fact that a given stream was carrying at a certain time a stated amount of water is in itself an important item; but its value can be greatly increased by the statement of additional facts concerning the reason for measurement, the character of the drainage basin above and below, and the modifications of behavior of the stream which may have been brought about by annual fluctuations in water conditions or by artificial obstructions or diversions of the water. Such facts are often well known to the hydrographer at the time his report is made, and may appear to him too trivial for statement; but it must be

[1] Report of the Commissioner of Public Works to the Governor of California. A. H. Rose, commissioner; Marsden Manson, C. E. Grunsky, consulting engineers, pp. 79–94. Sacramento, 1894.

remembered that these facts are to be handled again and again by persons who do not understand the local conditions as known to the hydrographer, and who may be tempted to misapply them or to generalize from misapprehension of the conditions.

REPORTS OF RIVER HEIGHT.

The principal work of the hydrographer is the measurement of the streams at selected points. The reasons controlling the selection of the river stations should always be carefully recorded at the outset, and after the work is once begun vigilance should be exercised that the daily heights and their interpretation into quantities of discharge should be complete and accurate. The observers should be required to fill in the blanks fully and carefully, as these are the original records and are to be preserved upon the files of the Washington office. Carelessness in forming the figures or in omitting dates and other details should be promptly checked, and blanks thus sent in should be copied and at once returned to the observer with the request that the lacking details be supplied.

One of the greatest difficulties in the river work as at present conducted is in securing accurate and reliable reports from the observers, whose pay, of course, is not sufficiently large to make them at all times fully alive to the importance of accuracy. Vigilance should be exercised to verify occasionally the readings of observers, and if there is well-founded suspicion that at any time heights are reported which are not actually observed the observer should be reprimanded, and, if necessary, the station discontinued. It is better to discontinue a station than to encourage dishonesty and have records open to suspicion. In cases where it is impracticable for the observer to take regular readings this fact should be noted under the head of "Remarks," and he should be assured that it is far better to report that an observation has been omitted than to attempt to fill it in by guessing at the river height.

The blanks provided for the use of observers have space devoted to remarks. This space is intended, as noted at the bottom of the blank, for the insertion of facts concerning the rain, snow, and change of weather, and other occurrences liable to affect the height of the river. It is also intended that in time of floods some memorandum shall be kept of the rate at which the water rises, the extreme height reached, and the time of day at which this occurs. The observers are liable to carelessly omit making memoranda of this character, and their attention should be called to this from time to time, as it is essential to have these minor details noted in order to correctly interpret the changes in the height of the river. The resident hydrographers are therefore particularly requested to note whether these facts are being entered, and to take steps to have this space properly filled when occasion requires.

The object of the daily observation of river heights is to secure material for the computation of discharge. If the difficulties at any station are such that these computations or estimates can not be made with a reasonable degree of accuracy, the observations should not be continued. These difficulties may arise from several causes—either from the irregularly shifting character of the channel, or from the impossibility of securing proper observations of river height and soundings of the channel, or from the inability of the resident hydrographer to reach the point at proper times and seasons. It is therefore necessary to carefully consider from time to time the advisability of maintaining stations once established, in order that efforts may not be wasted in keeping up readings of dubious value.

BENCH MARKS.

All river rods should be referred to one or more permanent bench marks, so located as to be easily found and identified. These should be, if possible, within from 100 to 200 feet of the locality and at an elevation slightly above high water, so that the marks on the rod can be easily and quickly referred to the permanent bench mark in order to detect possible changes due to the action of floods or driftwood. These bench marks should be fully described by reference to conspicuous objects, and by course and distance from the river rod. If the gaging station is near bridges having stone abutments, one of the bench marks can with advantage be placed on the iron or stone work.

COMPUTATIONS OF DISCHARGE.

The ordinary method of computing the total discharge from the observations is indicated by the small field notebooks (Form 9-198) ruled for the purpose. The velocity at each section of the stream is ascertained by observations at various depths, and the area is obtained by multiplying the width by the mean depth. The total discharge of the section is the product of the velocity by the area, and the discharge of the whole river is the sum of these products. This has been found to be, under usual circumstances, the most convenient method of computation, as the field notes can be written up at leisure moments. Prof. O. V. P. Stout, however, suggests a method of computation which offers a number of advantages. This is mainly by graphic methods, and is as follows:

On rectangularly ruled paper plot the depth as measured at intervals across the stream and sketch a free-hand line through the points, thus showing the vertical cross section at the point of measurement. Plot also the mean of the measured velocities obtained in each vertical plane in their proper relative positions across the stream and sketch through these points a curve which represents the mean discharge for all vertical planes. The discharge for any plane or section is the product of the ordinates of these two curves. The total discharge of the stream is proportional to the area of a figure constructed by taking as a base a line whose length is proportional to the width of the stream, laying off the products obtained above as ordinates to this base, and drawing a free-hand line through the extremities of these ordinates. The area of the figures thus obtained may be computed by Simpson's rule, or measured with a planimeter, the arm being set to give discharges without further deduction.

In cases where the depths and velocities are measured in the same vertical, the curve showing depth and that showing velocity may be omitted and only the curve inclosing the area of total discharge drawn.

FIELD NOTES.

For the purpose of uniformity in recording results of current meter work, the small blank book (Form 9-198) has been provided. This is entitled "United States Geological Survey, Division of Hydrography, Current Meter Notes." At the top of the page are spaces for recording the date, name of the hydrographer, the number of the meter, the locality, the height of the water at the time of beginning and ending of the measurement, and the average height; and also for a statement as to whether the river is rising, falling, or stationary. There is also space left for inserting the results, giving the total area, the mean velocity, and the total discharge in cubic feet per second. On the extreme left are double columns for recording the soundings, the first column being for the purpose of giving the distance from the initial point, and the second for the depth at the particular place. At all river stations, besides the bench marks for the zero of the gage rod there should be chosen an initial point at which to begin all soundings, so that they may be made at the same point at all subsequent measurements. This initial point may be some permanent object on the bank, the end of a bridge, or the edge of a pier. A bench mark should be permanent and easily identified, and in such position that it shall always be at a short distance beyond the high-water mark. Starting from this initial point the soundings are usually made at every 10 or 20 feet, or in the case of very small streams, at intervals of 5 feet.

The first sounding should be at the edge of the water, and the notebook should give its distance from the initial point, the sounding being recorded as zero. In the same way the last sounding should be at the further edge of the water, and should be noted as so many feet from the initial point and as zero in depth. If there are any intermediate islands or bars projecting above water the notes should clearly state this fact, giving the distance of both margins from the initial point. This greatly simplifies the comparison of subsequent changes of depth.

To the right of the columns for soundings are spaces for the observations, giving distance, depth of the observation, or number of feet and tenths below the surface of the water at which the meter is read, and also the number of seconds, usually 50 or 100, during which the revolutions of the meter are noted. To the right of these are the three columns for use in case a recording register is used with the meter. In the first of these is to be placed the register reading at the beginning of the observation, in the second the reading at the end of the 50 or 100 or other number of seconds, and in the third the difference between these two readings. In cases where the revolutions of an electric meter are counted by listening to the sounder only this third column of the three is used. It is customary to take two observations of 50 seconds each at a point, and if these do not agree, to take a third or fourth, continuing until it is ascertained whether there may have been any accidental irregularity in the behavior of the instrument. If these observations appear to have equal value the average of all is taken; if one or more are of doubtful value these are rejected when this fact is clearly proved.

The number of revolutions of the meter as recorded in the column of differences divided by the number of seconds gives the revolutions per second to be inserted in the adjacent column. Where two observations of 50 seconds each have been made it is necessary merely to add the revolutions and point off two places. The next column, headed "Coefficient," has been inserted for the purpose of noting the relation for that particular velocity between the revolutions of the meter and the speed of the water. In practice, however, it has been found more convenient to construct a rating table for each meter, giving for various values the velocity of the water corresponding to the revolutions of the meter at different speeds. This column is therefore seldom used, but the revolutions of the meter per second are converted at once into velocity per second. This is then entered upon the opposite page.

The observations for velocity per second are usually taken not only at intervals across the stream, but also at each of these localities at the top, near the bottom, and at intermediate points. Where the stream is shallow it has been found that the average of the observations taken slightly below the surface and above the bottom at a distance where the meter runs freely represents very closely the mean velocity of the section. In deeper streams the mean velocity of the vertical section may be obtained by observations at a large number of points, or by assuming that the measurement obtained at a distance below the surface of three-fifths of the depth is the mean velocity, or by taking 0.98 of the mid-depth velocity. Taking, therefore, the average of the velocities in the vertical plane as obtained in either way, these are assumed to represent the average velocity for a portion of the river on both sides of this plane, which is taken parallel to the course of the stream and as extending halfway to the points of observation on each side. If these points of observations are 10 feet apart, the width of the section is taken as 10 feet, and this is entered in the proper column.

The mean depth of the section is taken, in the case of a broad, smooth channel, as the depth of water at the place where the meter is run, or as an average obtained by adding the depth of water on each side halfway to the next point of observation, adding to this twice the depth where the meter is run, and dividing the whole by four. This mean depth in feet multiplied by the width in feet gives the area of this particular section in square feet. This area multiplied by the velocity per second, as given in the column thus headed, is the discharge in cubic feet per second, or second-feet, to be inserted in the column thus designated. The total of the discharges of the various sections is the total discharge of the river. This amount is inserted at the top of the page. The total of the individual areas is the total area in square feet, to be given also at the top of the page. The mean velocity of the whole stream is the discharge in cubic feet per second divided by the total area thus obtained, but is not the average of the velocities per second as measured by the current meter.

In the sections of the river adjacent to the shore particular care must be used in computing, as the current is often so sluggish that the meter will barely revolve, and at times there are reverse currents creeping up along the bank. Due allowance must be made for all of these, and for still or dead water. In computing the average depth of the triangular sections at each end the depth at the shore is taken as zero, this being added to the other depths and the total divided by four, as in the case above named. Where the current is running diagonally to the channel of the stream due allowance must be made in the width of each section. The notebook is provided with space under the head of "Remarks" for giving these details and for comments upon the accuracy of the measurement.

In making the computations in the notebook it is undesirable to carry them out to a degree of refinement not warranted by the original observations—that is to say, if the meter reading is only to whole numbers it is waste of time to make computations to more than one point of decimals, or, in fact, to employ decimals at all except as assuring that errors do not creep into the last figure of the results.

REPORT OF DISCHARGE MEASUREMENTS.

The field notebooks (Form 9–198) above referred to are to be retained by the hydrographer as long as required, and ultimately forwarded to the office at Washington for preservation among the original records of the division of hydrography. In order to report the results as soon as possible, however, a blank (Form 9–197) has been provided. This gives the date, locality, name of the hydrographer and his assistant, and a memorandum concerning the number and page of the original notebook. Under the head of "Description of river stations" it also gives the location of the station, the date originally established, the name and address of the observer, and his pay, his occupation, and the distance which he is required to traverse in order to make readings; also the time of day at which these readings are usually made. A line is added to express facts as to whether the observer is probably reliable and is taking a proper interest in the results of his work. Space is also given for memoranda concerning the equipment and the condition of any survey property at the point. Attention is also called to the condition of the gage, and descriptive words are inserted in order that by striking out those not applicable the remaining words will indicate whether the gage is in good order or needs attention. Space is also left for comments on the bench marks, as to whether the initial point for sounding is on the right or left bank, and as to whether the channel both above and below the station is straight or curved, the water swift or sluggish; also as to the height of the banks, whether high or low, the character of bed of the stream, and similar details. Comments are also called for as to any changes in the channels shown by soundings. Wherever possible two or more gages have been established at each station, these being connected by level lines, so that the slope of the water surface can be read at various elevations. Assuming a value of "n" for Kutter's formula of discharge, it is possible to estimate the discharge by computation based upon the slope. This should be done and the product compared with the measured result in order that the hydrographer may obtain data as to the application of such formulæ and as to the value of the constant, n, to be applied in each case.

The results of the measurement itself are given in the lower part of the blank, the first item being the height of water and the condition, as to whether rising, falling, or stationary, the superfluous words being stricken out for this purpose. The total width and the number of channels are also to be given. Space is provided for an abstract of the field notes, giving for important points the distance from the initial point, the depth, and the mean velocity. This is for the purpose of showing concisely the character of the stream. It is not intended to insert fully all of the observations, but simply selected ones which shall bring out essential facts most clearly. The make and number of the current meter used are also to be given, or in case measurements are made by means of floats or over a weir this is to be stated. The velocity and direction of the wind are also to be given as of considerable modifying influence upon the behavior of the stream. In some special cases it is desirable to have the temperature of the water and of the air, especially in extremely hot or cold climates. A line is also devoted to the accuracy of the results, in order that the hydrographer may note any possible cause of error; and, finally, a statement is to be given of the mean minimum and maximum velocities, the total area of the section in square feet, and the total discharge in second-feet. The back of this sheet should show a sketch of the relative position of the gage, the bridge, or cable from which measurements are made, the bench marks, the initial point, and other data. Where a number of measurements are made in succession at one point, it is, of course, unnecessary to fill in all of the details every time; but in cases where the hydrographer visits a station at long intervals, and after changes due to floods have taken place, all of these facts should be duly noted in order to show the extent of the changes and to indicate clearly that certain details are unchanged.

In reporting the results of measurement of discharge it is not desirable, except in the case of exceedingly small amounts of water, to report the results to decimals of a second-foot, as a false idea might be given as to accuracy of measurement. Velocities should be given in feet and hundredths of a foot per second, and, for uniformity, the height of water on the gage in feet and hundredths of a foot. In all statements of this kind attention should be paid to the relative accuracy of the data. The field work should be conducted with the very greatest care, but, on the other hand, the computations made in the offices should not be carried out to a degree of refinement inconsistent with the original work.

STATION RATING TABLES.

The immediate object of measurements made at an established river station is the construction of a rating table, or series of tables, which shall show the relation for a given length of time between the height of water and the quantity flowing in the stream. In order to do this, it is of course necessary to obtain the discharge at various stages of water, covering the ordinary range of fluctuation. This is a comparatively small matter if the channel does not change. The simplest method of procedure in constructing a rating table is to plot upon rectangularly-ruled paper each point representing the gage height and discharge for a given measurement, the vertical distance from the bottom line being taken to represent the height of water at the given measurement, and the distance from left to right the quantity of discharge in cubic feet per second. For convenience, the measurements of discharge should be numbered consecutively from No. 1, the earliest, and these numbers should be placed opposite the points upon the rectangularly-ruled paper. If there are a half dozen or more of these points well distributed according to height of water, it will usually be found that they lie approximately in the path of a parabolic curve. This curve can be sketched through or near the points, the hydrographer, from his intimate knowledge, giving greater weight to some points than to others. This curve shows the relation of gage height to discharge for the particular times under consideration.

The rating table is the numerical expression for the curve above described. In order to make this table it is necessary simply to read off the figures from the drawing, starting with the lowest value in the left-hand lower corner of the drawing. To do this the lowest horizontal line representing a tenth of a foot is followed from left to right until it intersects the curve. The value represented by this distance is set opposite the tenth of foot taken. The line representing the next higher tenth of a foot is again followed out, and its length from the margin at the left to the curve at the right is also obtained, and so on, setting opposite each tenth of a foot the corresponding value of discharge. When the table has been prepared in this way it will be found that there is an increasing value for the discharge, and that the difference between the values is also constantly increasing. Owing, however, to the small scale upon which such a sketch is necessarily made, the figures read off from the drawing do not always have this constantly increasing value, some being proportionally too large and others too small. In order, therefore, to smooth out this curve, it is convenient to set off between the lines of the rating table the differences in quantity of discharge, making a third column. Upon running the eye down this column several points are quickly detected where the differences are not regular. Considering these, it will be seen that a slight adjustment of the differences and the addition or subtraction of a small amount from the figures of discharge will smooth out these irregularities. This should be made, and as a check upon the accuracy of the work the resulting figures, after the rating table has been smoothed out, should be plotted upon the original drawing to determine by inspection that the rating table as finally adjusted is accordant with the observations. This method of graphic construction avoids difficulties and liability to blunder in the use of the higher mathematics, and its accuracy is well within that of the original data.

The length of time during which such rating table can be safely applied to the observations should be determined by the hydrographer and noted upon the table in order that attempts may not be made to use it beyond proper limitations. Where the channel is constantly shifting such table can not be used for many weeks or months unless it is referred to the readings of heights as interpreted by the occasional soundings.

TABLES FOR COMPUTING RESULTS FOR PUBLICATION.

The unit employed in the measurement of streams is the cubic foot per second. This has been described in the Eleventh Annual Report, Part II, Irrigation, pages 2–5, and also in the Fourteenth Annual Report, Part II, pages 100, 101. From this fundamental unit others have been derived, and the results of the investigation are shown in these for convenience of comparison. The tables formerly published show the discharge in second-feet for each month, giving the maximum, minimum, and mean. They also usually give the total discharge for the month in acre-feet and the run-off in two terms, the depth in inches, and the rate of flow in second-feet per square mile.

Table for converting second-feet into acre-feet per day.

Days.	Second-feet.								
	1	2	3	4	5	6	7	8	9
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
1...	1.98	3.97	5.95	7.93	9.92	11.90	13.88	15.87	17.85
2...	3.97	7.93	11.90	15.87	19.83	23.80	27.77	31.74	35.70
3...	5.95	11.90	17.85	23.80	29.75	35.70	41.65	47.60	53.55
4...	7.93	15.87	23.80	31.74	39.67	47.60	55.54	63.47	71.40
5...	9.92	19.83	29.75	39.67	49.59	59.50	69.42	79.34	89.26
6...	11.90	23.80	35.70	47.60	59.50	71.40	83.31	95.21	107.11
7...	13.88	27.77	41.65	55.54	69.42	83.31	97.19	111.07	124.96
8...	15.87	31.74	47.60	63.47	79.34	95.21	111.07	126.94	142.81
9...	17.85	35.70	53.55	71.40	89.26	107.11	124.96	142.81	160.66
10...	19.83	39.67	59.50	79.34	99.17	119.01	138.84	158.68	178.51
11...	21.82	43.64	65.45	87.27	109.09	130.91	152.73	174.55	196.36
12...	23.80	47.60	71.40	95.21	119.01	142.81	166.61	190.41	214.21
13...	25.79	51.57	77.35	103.14	128.93	154.71	180.50	206.28	232.07
14...	27.77	55.54	83.31	111.07	138.84	166.61	194.38	222.15	249.92
15...	29.75	59.50	89.26	119.01	148.76	178.51	208.26	238.02	267.77
16...	31.74	63.47	95.21	126.94	158.68	190.41	222.15	253.88	285.62
17...	33.72	67.44	101.16	134.88	168.59	202.31	236.03	269.75	303.47
18...	35.70	71.40	107.11	142.81	178.51	214.21	249.92	285.62	321.32
19...	37.69	75.37	113.06	150.74	188.43	226.12	263.80	301.49	339.17
20...	39.67	79.34	119.01	158.68	198.35	238.02	277.69	317.36	357.02
21...	41.65	83.31	124.96	166.61	208.26	249.92	291.57	333.22	374.88
22...	43.64	87.27	130.91	174.55	218.18	261.82	305.45	349.09	392.73
23...	45.62	91.24	136.86	182.48	228.10	273.72	319.34	364.96	410.58
24...	47.60	95.21	142.81	190.41	238.02	285.62	333.22	380.82	428.43
25...	49.59	99.17	148.76	198.35	247.93	297.52	347.11	396.69	446.28
26...	51.57	103.14	154.71	206.28	257.85	309.42	360.99	412.56	464.13
27...	53.55	107.11	160.66	214.21	267.77	321.32	374.88	428.43	481.98
28...	55.54	111.07	166.61	222.15	277.69	333.22	388.76	444.30	499.83
29...	57.52	115.04	172.56	230.08	287.60	345.12	402.64	460.17	517.68
30...	59.50	119.01	178.51	238.02	297.52	357.02	416.53	476.03	535.54
31...	61.49	122.98	184.46	245.95	307.44	368.93	430.41	491.90	553.39

As the months are of varying length, it is necessary to use three or four factors to convert the average discharge for the month in second-feet into the total in acre-feet. One second-foot flowing for twenty-four hours is equivalent to 86,400 cubic feet. Since there are 43,560 square feet in 1 acre there will be the same number of cubic feet in an acre-foot. Dividing, it is found that 1 second-foot for twenty-four hours very nearly equals 2 acre-feet, or, in exact figures, 1.983471 acre-feet. This multiplied by the number of days in the month will give the total monthly discharge in acre-feet. This quantity, therefore, must be multiplied by 28 for the month of February, or 29 for this month in leap year, and by 30 or 31 for the other months.

For the month of February, when it has 28 days, the factor to be used is 55.537188. For convenience in computation this factor is given as multiplied from 1 to 9.

1	55.53719
2	111.07436
3	166.61154
4	222.14872
5	277.68590
6	333.22308
7	388.76026
8	444.29744
9	499.83462

When February has 29 days the factor to be used is 57.520659. This when multiplied from 1 to 9 is as follows:

1	57.52066
2	115.04132
3	172.56198
4	230.08264
5	287.60330
6	345.12396
7	402.64462
8	460.16528
9	517.68594

Table for converting second-feet into acre-feet per month.

Second-feet.	Acre-feet per 30 days.	Acre-feet per 31 days.	Second-feet.	Acre-feet per 30 days.	Acre-feet per 31 days.
1	59.504	61.488	51	3,034.711	3,135.868
2	119.008	122.975	52	3,094.215	3,197.355
3	178.512	184.463	53	3,153.719	3,258.843
4	238.017	245.950	54	3,213.223	3,320.330
5	297.521	307.438	55	3,272.727	3,381.818
6	357.025	368.926	56	3,332.231	3,443.306
7	416.529	430.413	57	3,391.735	3,504.793
8	476.033	491.901	58	3,451.240	3,566.281
9	535.537	553.388	59	3,510.744	3,627.768
10	595.041	614.876	60	3,570.248	3,689.256
11	654.545	676.364	61	3,629.752	3,750.744
12	714.050	737.851	62	3,689.256	3,812.231
13	773.554	799.339	63	3,748.760	3,873.719
14	833.058	860.826	64	3,808.264	3,935.206
15	892.562	922.314	65	3,867.768	3,996.694
16	952.066	983.802	66	3,927.273	4,058.182
17	1,011.570	1,045.289	67	3,986.777	4,119.669
18	1,071.074	1,106.777	68	4,046.281	4,181.157
19	1,130.578	1,168.264	69	4,105.785	4,242.644
20	1,190.083	1,229.752	70	4,165.289	4,304.132
21	1,249.587	1,291.240	71	4,224.793	4,365.620
22	1,309.091	1,352.727	72	4,284.297	4,427.107
23	1,368.595	1,414.215	73	4,343.801	4,488.595
24	1,428.099	1,475.702	74	4,403.306	4,550.082
25	1,487.603	1,537.190	75	4,462.810	4,611.570
26	1,547.107	1,598.678	76	4,522.314	4,673.058
27	1,606.612	1,660.165	77	4,581.818	4,734.545
28	1,666.116	1,721.653	78	4,641.322	4,796.033
29	1,725.620	1,783.140	79	4,700.826	4,857.520
30	1,785.124	1,844.628	80	4,760.330	4,919.008
31	1,844.628	1,906.116	81	4,819.835	4,980.496
32	1,904.132	1,967.603	82	4,879.339	5,041.983
33	1,963.636	2,029.091	83	4,938.843	5,103.471
34	2,023.140	2,090.578	84	4,998.347	5,164.958
35	2,082.645	2,152.066	85	5,057.851	5,226.446
36	2,142.149	2,213.554	86	5,117.355	5,287.934
37	2,201.653	2,275.041	87	5,176.859	5,349.421
38	2,261.157	2,336.529	88	5,236.363	5,410.909
39	2,320.661	2,398.016	89	5,295.868	5,472.396
40	2,380.165	2,459.504	90	5,355.372	5,533.884
41	2,439.669	2,520.992	91	5,414.876	5,595.372
42	2,499.173	2,582.479	92	5,474.380	5,656.859
43	2,558.678	2,643.967	93	5,533.884	5,718.347
44	2,618.182	2,705.454	94	5,593.388	5,779.834
45	2,677.686	2,766.942	95	5,652.892	5,841.322
46	2,737.190	2,828.430	96	5,712.396	5,902.810
47	2,796.694	2,889.917	97	5,771.901	5,964.297
48	2,856.198	2,951.405	98	5,831.405	6,025.785
49	2,915.702	3,012.892	99	5,890.909	6,087.272
50	2,975.207	3,074.380	100	5,950.413	6,148.760

For the months containing 30 days, viz, April, June, September, and November, the factor to be used is 59.5041300. This when multiplied by the unit figures is as follows:

1	59.50413
2	119.00826
3	178.51239
4	238.01652
5	297.52065
6	357.02478
7	416.52891
8	476.03304
9	535.53717

For the months containing 31 days, viz, January, March, May, July, August, October, and December, the factor to be used is 61.4876010. This when multiplied is as follows:

1	61.48760
2	122.97520
3	184.46280
4	245.95040
5	307.43800
6	368.92560
7	430.41320
8	491.90080
9	553.38841

The run-off per square mile is obtained by simply dividing the average for the month by the total number of square miles in the drainage basin, this number being usually obtained by planimeter measurements from the best map available. Being a rate of flow it is independent of time, and therefore the number of days in each month do not enter into this ratio.

The depth of run-off over the drainage basin is usually computed in inches for convenience of comparison with the depth of rainfall, which is almost invariably given in this unit. This depth can be most conveniently computed from the run-off per square mile by computation based upon the number of days in each month, and the relation between rate of flow and the depth in inches for this quantity were it held during the given number of days. One second-foot for twenty-four hours is equivalent to 86,400 cubic feet in one day. In other words, 1 cubic foot per second run-off from 1 square mile would, if held upon this area, cover it to a depth represented by dividing 86,400 by the number of square feet in a mile, 27,878,400, or 5,280 squared. Completing this division, it is found that 1 second-foot for one day is equivalent to a body of water covering 1 square mile 0.003099173 feet, or 0.037190076 inch. Multiplying this amount by the number of days in a month gives the following factors:

28 days	1.041322128
29 days	1.078512204
30 days	1.115702280
31 days	1.152892356

Table for converting second-feet per square mile into depth in inches per month.

Second-feet per square mile.	28 days.	29 days.	30 days.	31 days.
	Inches.	*Inches.*	*Inches.*	*Inches.*
1	1.041	1.079	1.116	1.153
2	2.083	2.157	2.231	2.306
3	3.124	3.236	3.347	3.459
4	4.165	4.314	4.463	4.612
5	5.207	5.393	5.579	5.764
6	6.248	6.471	6.694	6.917
7	7.289	7.550	7.810	8.070
8	8.331	8.628	8.926	9.223
9	9.372	9.707	10.041	10.376
10	10.413	10.785	11.157	11.529

Table for converting run-off in second-feet per square mile into depth in inches per month of 30 and 31 days.

Second-feet per square mile.	30 days.	31 days.	Second-feet per square mile.	30 days.	31 days.	Second-feet per square mile.	30 days.	31 days.	Second-feet per square mile.	30 days.	31 days.
	Inch.	*Inch.*		*Inch.*	*Inch.*		*Inch.*	*Inch.*		*Inch.*	*Inch.*
0.01	0.01	0.01	0.51	0.57	0.59	1.01	1.13	1.16	1.51	1.68	1.74
.02	.02	.02	.52	.58	.60	1.02	1.14	1.18	1.52	1.70	1.75
.03	.03	.03	.53	.59	.61	1.03	1.15	1.19	1.53	1.71	1.76
.04	.04	.04	.54	.60	.62	1.04	1.16	1.20	1.54	1.72	1.78
.05	.06	.06	.55	.61	.63	1.05	1.17	1.21	1.55	1.73	1.79
.06	.07	.07	.56	.62	.64	1.06	1.18	1.22	1.56	1.74	1.80
.07	.08	.08	.57	.63	.66	1.07	1.19	1.23	1.57	1.75	1.81
.08	.09	.09	.58	.64	.67	1.08	1.20	1.25	1.58	1.76	1.82
.09	.10	.10	.59	.65	.68	1.09	1.22	1.26	1.59	1.77	1.83
.10	.11	.12	.60	.67	.69	1.10	1.23	1.27	1.60	1.79	1.84
.11	.12	.13	.61	.68	.70	1.11	1.24	1.28	1.61	1.80	1.86
.12	.13	.14	.62	.69	.71	1.12	1.25	1.29	1.62	1.81	1.87
.13	.14	.15	.63	.70	.72	1.13	1.26	1.30	1.63	1.82	1.88
.14	.16	.16	.64	.71	.74	1.14	1.27	1.31	1.64	1.83	1.89
.15	.17	.17	.65	.72	.75	1.15	1.28	1.33	1.65	1,84	1.90
.16	.18	.18	.66	.73	.76	1.16	1.29	1.34	1.66	1.85	1.91
.17	.19	.20	.67	.74	.77	1.17	1.31	1.35	1.67	1.86	1.93
.18	.20	.21	.68	.75	.78	1.18	1.32	1.36	1.68	1.87	1.94
.19	.21	.22	.69	.77	.79	1.19	1.33	1.37	1.69	1.89	1.95
.20	.22	.23	.70	.78	.81	1.20	1.34	1.38	1.70	1.90	1.96
.21	.23	.24	.71	.79	.82	1.21	1.35	1.39	1.71	1.91	1.97
.22	.24	.25	.72	.80	.83	1.22	1.36	1.41	1.72	1.92	1.98
.23	.26	.26	.73	.81	.84	1.23	1.37	1.42	1.73	1.93	1.99
.24	.27	.28	.74	.82	.85	1.24	1.38	1.43	1.74	1.94	2.01
.25	.28	.29	.75	.83	.86	1.25	1.39	1.44	1.75	1.95	2.02
.26	.29	.30	.76	.84	.87	1.26	1.41	1.45	1.76	1.96	2.03
.27	.30	.31	.77	.85	.89	1.27	1.42	1.46	1.77	1.97	2.04
.28	.31	.32	.78	.87	.90	1.28	1.43	1.48	1.78	1.99	2.05
.29	.32	.33	.79	.88	.91	1.29	1.44	1.49	1.79	2.00	2.06
.30	.33	.35	.80	.89	.92	1.30	1.45	1.50	1.80	2.01	2.08
.31	.35	.36	.81	.90	.93	1.31	1.46	1.51	1.81	2.02	2.09
.32	.36	.37	.82	.91	.94	1.32	1.47	1.52	1.82	2.03	2.10
.33	.37	.38	.83	.92	.95	1.33	1.48	1.53	1.83	2.04	2.11
.34	.38	.39	.84	.93	.97	1.34	1.50	1.54	1.84	2.05	2.12
.35	.39	.40	.85	.94	.98	1.35	1.51	1.56	1.85	2.06	2.13
.36	.40	.41	.86	.95	.99	1.36	1.52	1.57	1.86	2.08	2.14
.37	.41	.43	.87	.97	1.00	1.37	1.53	1.58	1.87	2.09	2.16
.38	.43	.44	.88	.98	1.01	1.38	1.54	1.59	1.88	2.10	2.17
.39	.44	.45	.89	.99	1.02	1.39	1.55	1.60	1.89	2.11	2.18
.40	.45	.46	.90	1.00	1.04	1.40	1.56	1.61	1.90	2.12	2.19
.41	.46	.47	.91	1.01	1.05	1.41	1.57	1.63	1.91	2.13	2.20
.42	.47	.48	.92	1.02	1.06	1.42	1.58	1.64	1.92	2.14	2.21
.43	.48	.49	.93	1.03	1.07	1.43	1.60	1.65	1.93	2.15	2.22
.44	.49	.51	.94	1.04	1.08	1.44	1.61	1.66	1.94	2.16	2.24
.45	.50	.52	.95	1.05	1.09	1.45	1.62	1.67	1.95	2.18	2.25
.46	.52	.53	.96	1.07	1.10	1.46	1.63	1.68	1.96	2.19	2.26
.47	.53	.54	.97	1.08	1.12	1.47	1.64	1.69	1.97	2.20	2.27
.48	.54	.55	.98	1.09	1.13	1.48	1.65	1.71	1.98	2.21	2.28
.49	.55	.56	.99	1.10	1.14	1.49	1.66	1.72	1.99	2.22	2.29
.50	.56	.58	1.00	1.11	1.15	1.50	1.67	1.73	2.00	2.23	2.31

NORTHEASTERN RIVERS.

There is a lack of definite information regarding the flow of the rivers of the northeastern United States, which is somewhat remarkable when consideration is had of the density of population in that section and the importance of the industries depending upon these streams. A casual preliminary inquiry fails to reveal any notable data in addition to what has already been published in Volume XVI of the Tenth Census of the United States. In this report Prof. George F. Swain has described the water power of eastern New England, and Prof. Dwight Porter the water power of the region tributary to Long Island Sound and of the Hudson River basin and adjacent areas. There is, without a doubt, a large amount of information in the possession of individual engineers or of water-power companies, but it is difficult to procure this for publication, owing to the fact that for the most part it has been obtained as the result of controversies regarding water-power privileges and as material for testimony before courts.

A general inquiry has been made for facts bearing upon the flow of rivers of the Northeast in order to procure material for comparison with data obtained elsewhere, but the inquiry has not been carried sufficiently far to develop any considerable amount of information. On the Kennebec River, the daily discharge at Winslow, Me., has been computed for 1893 and 1894 by Mr. Sumner Hollingsworth. On the Penobscot it is reported that estimates in connection with the improvement on the dam at Bangor have been made by Mr. M. M. Tidd, and on the Androscoggin the daily discharges have been computed for the Union Water Power Company by Mr. Edward Sawyer.

MERRIMAC RIVER.

The longest series of computations of discharge known to exist for any stream in the United States is that for the Merrimac River, at Lawrence, Mass. Mr. Hiram Mills, the engineer for the Essex Company, has maintained observations for fifty years and has computed the daily discharge. This record, however, has never been published in full. In the report of the Massachusetts State Board of Health for 1890, page 656, are given the average monthly discharges in second-feet per square mile from June, 1887, to May, 1889, inclusive. In the annual reports of this board are also given the average weekly discharges from 1888 to 1893 inclusive. The daily discharge from 1892 to 1895 has been obtained from Mr. Mills and his assistant, Mr. R. A. Hale, and is given herewith. The total drainage area above Lawrence is estimated to be 4,634 square miles, including within this a considerable amount of lake area.

Merrimac River at Lawrence, Mass.

[Drainage area, 4,553 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1892.					
January	24,175	3,425	9,108	2.08	1.80
February	6,000	1,620	3,812	0.91	0.84
March	11,820	2,390	7,082	1.80	1.56
April	18,810	4,680	9,030	2.21	1.98
May	30,550	4,900	11,649	2.86	2.56
June	15,640	2,700	6,564	1.61	1.44
July	14,670	620	5,181	1.31	1.14
August	23,700	760	5,132	1.30	1.13
September	9,300	800	4,439	1.09	0.98
October	3,450	480	2,227	0.68	0.59
November	26,500	2,510	7,490	1.84	1.65
December	6,980	2,170	4,594	1.16	1.01
			6,359	18.85	
1893.					
January	6,870	710	2,949	0.75	0.65
February	11,490	1,140	4,994	1.15	1.10
March	25,810	3,100	11,134	2.82	2.45
April	23,730	12,600	17,766	3.46	3.90
May	55,910	8,300	22,741	4.72	4.99
June	7,880	3,400	5,178	1.27	1.14
July	4,100	560	2,496	0.63	0.55
August	4,470	430	2,580	0.66	0.57
September	6,850	1,130	2,738	0.67	0.60
October	12,740	360	4,103	1.04	0.90
November	7,400	1,590	3,889	0.94	0.85
December	8,020	2,250	4,911	1.16	1.01
			7,123	19.27	
1894.					
January	6,880	2,070	3,974	1.00	0.87
February	9,600	1,470	5,131	1.18	1.13
March	27,900	3,100	14,375	3.64	3.16
April	20,880	6,720	11,085	2.72	2.44
May	19,130	2,000	7,060	1.79	1.55
June	15,150	2,650	6,352	1.56	1.40
July	3,628	223	2,278	0.58	0.50
August	2,524	193	1,695	0.43	0.37
September	4,063	104	1,831	0.45	0.40
October	3,561	209	2,254	0.58	0.50
November	5,935	1,479	3,549	0.87	0.78
December	5,198	961	3,033	0.77	0.67
			5,218	15.57	
1895.					
January	5,660	630	3,381	0.85	0.74
February	4,840	600	2,408	0.55	0.53
March	11,700	810	5,891	0.79	0.69
April	86,550	7,300	23,149	5.67	5.08
May	11,175	2,400	6,701	0.53	0.47
June	5,500	570	3,127	0.77	0.69
July	5,275	570	2,714	0.69	0.60
August	3,200	510	2,152	0.54	0.47
September	3,100	360	1,948	0.48	0.43
October	13,560	540	4,185	1.06	0.92
November	22,310	3,060	10,799	2.64	2.37
December	19,530	4,990	10,641	2.70	2.34
			6,425	17.27	

NASHUA RIVER.

The daily discharge of this river for 1892 and 1893 has been computed by Mr. Jos. P. Frizell, but has not as yet been published, as the use of the water is in contention between the mill companies using water power along the river and the metropolitan district of Boston, for which the water supply is desired. These discharges are based largely upon data obtained from the Sudbury Basin, and not upon independent measurements.

CHARLES RIVER, MASSACHUSETTS.

Charles River, in eastern Massachusetts, rises in the vicinity of the town of Dedham. Near its source about one-third of the volume of the stream is diverted into Mother Brook and thence into Neponset River. The drainage area above this point is 200 square miles. The daily discharge for the period from May, 1877, to October, 1886, inclusive, was computed by Mr. Jos. P. Frizell by applying weir formulas to the daily height noted at two points. The first of these was on the dam of Mother Brook, situated about 1 mile below the point of diversion, and the second on the dam at Newton Upper Falls, about 6 miles below the same point. The daily gage height has been kept at the Newton Upper Falls dam from May, 1887, to June, 1890, and from January, 1893, to January, 1895, but the record on Mother Brook was discontinued in 1886, so that the total flow of the river can not be obtained. In the report of the Massachusetts State Board of Health on the examination of water supply,[1] the average monthly discharge of the river in second-feet per square mile drained is given for the period from October, 1887, to December, 1888.

SUDBURY RIVER.

The drainage basin of Sudbury River lies in the eastern end of Massachusetts, immediately adjacent to the thickly-populated towns and cities of the coast. It furnishes the greater portion of the water supply for the city of Boston, and in connection with the study of the water resources for municipal and domestic use has been carefully examined. The records are particularly valuable as furnishing a basis for estimating the yield of other watersheds in Massachusetts. They have been printed in the annual reports of the State Board of Health of Massachusetts, covering the period from June, 1887. The amount of water is given in second-feet per square mile drained. The following table gives the average per week, the week being considered to end on Sunday. The figures for the interval from June, 1887, to the end of May, 1889, have been obtained from the report above named.[1] The figures from June, 1889, to the end of 1890 are from the report of the State Board of Health for 1890. Those for 1891 are from the twenty-third annual report of the State Board of Health of Massachusetts, and those for subsequent years from the twenty-fourth, twenty-fifth, and twenty-sixth annual reports of the same body.

During 1887 and 1888 the rainfall was unusually large, and was favorably distinguished for maintaining a high flow in the streams during that part of the year when the discharge is usually small. For example, the average annual rainfall, including melted snow, in Massachusetts,

[1] Examinations by the State Board of Health of the Water Supplies and Inland Waters of Massachusetts, 1887-1890, Part I, pp. 629, 655-658. Boston, 1890.

deduced from the longest observations in various parts of the State, is 43.17 inches. From June, 1887, to May, 1888, inclusive, the total rainfall was 47.14 inches, and for the next year it was 53.74 inches.

The drainage area from which the flow was measured is 75.2 square miles. Within this area the city of Boston has five reservoirs, which when full have an aggregate area of 1.38 square miles. In estimating the flow due allowance has been made for variations in the height of water in these reservoirs.[1]

The discharge for 1890 and 1891 was above the normal except for a short drought in the summer of 1890. In 1891 the total flow of the streams was in excess of the normal, but the seasonal distribution was very uneven, being excessive in the first four months in the year and below the average in all of the other months.

In 1892 the flow was below the average, being only 73 per cent of the normal. Records have been kept of two drier years, 1880 and 1883, when the corresponding percentages were, respectively, 54 and 50. The greater part of the deficiency occurred in February, March, and April. During 1893 the discharge was a little less than the average for nineteen years, but the distribution was very uneven. In 1894 the records show that the flow was slightly less than for 1892, and was thus, with two exceptions, the least during the past twenty years, the discharge being 73 per cent of the average, the corresponding per cent during 1880 being 55, and during 1883 only 50. The flow was below the average in every month of the year, the deficiency being greatest in the first five months.

Average weekly flow of Sudbury River, Massachusetts, in second-feet per square mile.

[Weeks end on Sunday.]

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
January	....	2.142	3.482	2.057	1.686	2.146	0.514	1.249
	....	3.164	7.162	1.840	2.197	1.720	1.132	0.905
	....	1.162	3.813	2.445	5.905	3.973	0.626	0.947
	....	0.926	3.048	1.664	7.902	3.829	0.460	1.151
	....	0.819	....	....	....	1.679	0.412	....
February	....	0.891	2.961	1.611	4.301	1.260	0.586	1.143
	....	1.241	1.826	2.151	4.854	1.248	4.937	1.134
	....	1.014	1.495	2.261	3.103	1.118	2.580	1.514
	....	7.954	2.435	1.659	6.585	2.150	1.237	2.351
March	....	2.714	1.240	3.727	6.632	1.487	1.248	2.192
	....	1.348	3.555	2.542	4.742	4.522	2.805	7.145
	....	1.652	1.766	5.890	11.024	2.016	10.061	3.039
	....	10.515	1.789	6.978	6.589	3.904	5.164	2.486
	....	....	1.488	7.621	6.515	....	....	....
April	....	8.567	3.005	3.973	5.572	2.755	4.228	1.804
	....	6.618	1.701	4.218	4.519	1.868	3.610	1.585
	....	4.576	1.667	2.198	3.850	1.171	3.472	3.716
	....	3.028	2.165	1.793	2.159	1.003	3.350	3.388
	....	2.117	....	....	....	....	2.677	2.110
May	....	1.627	1.895	1.996	1.405	0.847	7.854	1.226
	....	2.932	1.007	2.790	0.941	1.103	4.209	0.736
	....	3.713	0.615	2.154	0.899	1.001	5.003	0.740
	....	1.827	2.108	1.538	0.916	2.598	2.140	1.612
	....	....	....	....	0.682	2.372	....	....
June	1.454	1.924	1.821	2.059	0.742	1.235	1.161	2.449
	0.722	0.749	1.931	1.218	0.395	0.739	0.636	0.828
	0.276	0.623	0.844	1.189	0.436	0.627	0.676	0.301
	0.409	0.409	0.613	0.743	1.097	0.385	0.657	0.418
	....	....	0.320	0.381	....	....	....	....

[1] Examinations by the State Board of Health of the Water Supplies and Inland Waters of Massachusetts, 1887-1890, Part I, pp. 655-658. Boston, 1890.

Average weekly flow of Sudbury River, Massachusetts, in second-feet per square mile—Continued.

Month.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
July	0.132	0.457	0.549	0.213	0.243	0.506	0.516	0.200
	0.088	0.278	0.333	0.067	0.249	0.433	0.312	0.198
	0.084	0.109	0.944	0.067	0.155	0.316	0.211	0.009
	0.317	0.191	1.294	0.262	0.199	0.194	0.253	0.111
	0.263	0.115	....	....	....	0.281	0.179	0.424
August	0.222	0.101	3.702	0.200	0.312	0.379	0.275	0.418
	0.152	0.288	1.983	0.105	0.198	0.363	0.251	0.174
	0.276	0.646	3.221	0.127	0.209	0.205	0.181	0.035
	0.665	1.399	1.823	0.241	0.233	0.639	0.389	0.326
	....	....	....	0.374	0.353	....	....	....
September	0.140	0.399	0.683	0.469	0.351	0.579	0.234	0.045
	0.208	0.448	0.475	0.731	0.598	0.264	0.184	0.073
	0.218	0.726	1.237	1.245	0.232	0.576	0.175	0.114
	0.123	2.349	2.194	0.427	0.180	0.321	0.128	0.429
	....	4.041	1.307	....	....	....	....	0.004
October	0.206	3.226	1.255	1.186	1.038	0.168	0.162	0.094
	0.152	3.687	2.316	1.378	0.287	0.244	0.155	0.656
	0.206	2.584	2.394	2.599	0.245	0.218	0.184	0.254
	0.455	3.039	1.463	6.953	0.465	0.213	0.197	0.764
	0.354	....	....	....	....	0.129	0.783	....
November	0.261	2.386	1.874	4.345	0.352	0.334	0.538	0.986
	0.422	2.845	1.652	2.209	0.252	1.029	0.566	1.747
	0.837	3.711	1.533	1.715	0.300	1.926	0.425	1.279
	0.650	2.777	3.283	2.059	0.458	0.884	0.453	1.106
	....	....	....	1.150	0.881	....	....	....
December	0.578	9.221	6.421	1.151	0.735	0.867	0.645	0.963
	0.755	2.989	3.542	0.956	0.840	0.956	1.091	0.754
	1.185	2.987	3.607	2.981	0.513	0.971	0.909	1.547
	0.971	9.120	3.574	1.360	0.950	0.665	1.091	1.503
	....	3.820	3.082	....	....	....	1.991	1.081

CONNECTICUT RIVER.

A series of computations of the discharge of Connecticut River have been made at Holyoke, Mass., by the engineers of the Holyoke Water Power Company. This company controls the flow of Connecticut River by means of their dam, as described in Volume XVI of the Tenth Census of the United States (pages 51–56) in the report on the water power of the region tributary to Long Island Sound, prepared by Prof. Dwight Porter. The flow of this river has been discussed in the Fourteenth Annual Report of this Survey, part 2, pages 140–146, the figures relating to the discharge at Hartford, Conn.

The following data have been obtained through the kindness of Mr. A. F. Sickman, assistant engineer of the company, the intention being to discuss the fluctuations in connection with those of other streams at some future time. The quantities given by him were the average daily amounts drawn from the pond above the dam, representing the discharge of the river, except in such times as the surface falls below the crest of the dam when water is ponded overnight and Sunday. From the daily figures the average for each month has been obtained, shown in the following table, together with the maximum and minimum discharges. These minimum quantities especially must be regarded as influenced by the control of the discharge used for power.

Connecticut River at Holyoke, Mass.

[Drainage area, 8,660 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1880.					
January	24,650	6,550	9,647	1.28	1.11
February	24,850	7,300	14,771	1.84	1.71
March	40,150	6,350	15,313	1.97	1.77
April	44,100	7,300	20,663	2.58	2.39
May	23,900	5,550	11,545	1.53	1.33
June	8,700	1,750	4,173	0.54	0.48
July	8,350	1,950	3,663	0.48	0.42
August	4,650	300	7,176	0.94	0.82
September	2,400	600	1,763	0.22	0.20
October	4,950	1,000	2,263	0.30	0.26
November	11,050	2,050	6,093	0.81	0.70
December	3,650	1,800	3,053	0.40	0.35
			8,343	12.89	
1881.					
January	2,950	550	2,537	0.33	0.29
February	13,050	2,950	5,337	0.65	0.62
March	19,500	10,150	13,803	1.83	1.59
April	48,500	7,750	21,575	2.80	2.49
May	49,050	12,350	26,995	3.59	3.11
June	11,450	3,200	6,212	0.83	0.72
July	7,300	1,000	3,953	0.53	0.46
August	7,050	450	3,897	0.52	0.45
September	4,750	450	2,955	0.38	0.34
October	6,600	1,850	3,202	0.43	0.37
November	19,950	5,900	11,508	1.53	1.33
December	46,850	4,750	15,847	2.11	1.83
			9,818	15.53	
1882.					
January	34,000	4,050	8,801	0.94	0.82
February	22,000	4,400	9,105	1.05	1.01
March	43,650	8,950	19,509	2.59	2.25
April	25,800	11,400	18,188	2.34	2.10
May	38,500	12,700	20,216	2.69	2.33
June	35,300	5,750	17,553	2.26	2.03
July	9,250	1,600	5,420	0.72	0.63
August	3,650	250	2,790	0.37	0.32
September	45,000	250	7,888	1.01	0.91
October	6,800	3,500	4,606	0.61	0.53
November	3,850	1,050	3,368	0.45	0.39
December	3,750	850	2,769	0.37	0.32
			10,018	15.40	
1883.					
January	3,700	400	2,473	0.33	0.29
February	5,750	2,150	3,929	0.47	0.45
March	8,400	3,150	5,279	0.70	0.61
April	68,300	7,550	32,950	4.25	3.81
May	29,350	12,200	19,574	2.61	2.26
June	17,200	5,000	10,662	1.37	1.23
July	8,550	1,750	5,508	0.74	0.64
August	4,100	950	3,051	0.40	0.35
September	2,500	250	1,877	0.24	0.22
October	8,350	950	3,420	0.45	0.39
November	10,100	2,650	5,067	0.68	0.59
December	6,650	1,550	3,490	0.46	0.40
			8,107	12.70	
1884.					
January	8,800	4,850	6,118	0.82	0.71
February	28,100	5,450	19,114	2.36	2.19
March	71,900	7,300	22,039	2.93	2.54
April	70,800	20,400	40,237	5.19	4.65
May	35,450	17,550	26,805	3.57	3.10
June	15,500	5,050	8,938	1.15	1.03
July	6,200	3,000	4,540	0.60	0.52
August	5,800	1,000	2,827	0.38	0.33
September	5,450	500	2,847	0.38	0.33
October	6,100	1,100	4,153	0.55	0.48
November	17,650	4,000	8,385	1.08	0.97
December	26,650	4,700	11,007	1.45	1.26
			13,084	20.46	

Connecticut River at Holyoke, Mass.—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1885.					
January	36, 650	7, 050	15, 334	2. 04	1. 77
February	9, 150	5, 250	7, 113	0. 85	0. 82
March	6, 150	3, 600	4, 803	0. 63	0. 55
April	63, 950	8, 500	42, 317	5. 37	4. 89
May	33, 550	7, 100	16, 450	2. 19	1. 90
June	17, 600	3, 100	7, 207	0. 92	0. 83
July	12, 050	2, 950	6, 506	0. 86	0. 75
August	13, 550	2, 950	6, 153	0. 82	0. 71
September	8, 150	3, 050	5, 585	0. 71	0. 64
October	18, 400	3, 750	7, 955	1. 06	0. 92
November	47, 200	7, 500	20, 870	2. 69	2. 41
December	24, 600	4, 750	11, 332	1. 51	1. 31
			12, 635	19. 65	
1886.					
January	58, 950	7, 600	15, 856	2. 11	1. 83
February	37, 500	7, 200	16, 044	1. 92	1. 85
March	22, 750	6, 700	9, 603	1. 28	1. 11
April	80, 150	16, 550	37, 253	4. 80	4. 30
May	19, 600	7, 500	12, 791	1. 71	1. 48
June	12, 900	4, 550	7, 395	0. 94	0. 85
July	4, 350	850	2, 951	0. 39	0. 34
August	3, 950	550	2, 609	0. 35	0. 30
September	5, 100	600	2, 628	0. 31	0. 28
October	8, 850	1, 000	4, 367	0. 58	0. 50
November	34, 800	5, 850	14, 728	1. 96	1. 70
December	21, 050	6, 150	10, 420	1. 38	1. 20
			11, 387	17. 73	
1887.					
January	39, 150	6, 650	11, 741	1. 57	1. 36
February	31, 900	7, 800	13, 569	1. 63	1. 57
March	9, 900	7, 200	8, 162	1. 08	0. 94
April	85, 500	8, 100	43, 194	4. 57	4. 99
May	72, 500	10, 050	31, 106	4. 05	3. 59
June	27, 650	5, 150	12, 653	1. 63	1. 46
July	32, 300	5, 550	11, 033	1. 46	1. 27
August	26, 750	5, 650	11, 942	1. 59	1. 38
September	8, 500	3, 650	5, 356	0. 69	0. 62
October	6, 200	3, 300	4, 521	0. 60	0. 52
November	18, 700	3, 500	6, 771	0. 87	0. 78
December	27, 600	6, 100	11, 900	1. 58	1. 37
			14, 329	21. 32	
1888.					
January	13, 750	6, 850	8, 504	1. 13	0. 98
February	14, 100	6, 600	8, 546	1. 07	0. 99
March	32, 400	5, 650	11, 948	1. 59	1. 38
April	90, 900	27, 150	37, 617	4. 84	4. 34
May	99, 750	16, 700	47, 795	6. 36	5. 52
June	17, 600	6, 300	10, 530	1. 36	1. 22
July	7, 600	1, 600	4, 311	0. 58	0. 50
August	8, 150	1, 100	4, 685	0. 62	0. 54
September	42, 000	4, 900	12, 985	1. 67	1. 50
October	23, 050	13, 600	18, 038	2. 40	2. 08
November	38, 050	10, 950	23, 260	2. 91	2. 69
December	59, 300	5, 700	19, 632	2. 62	2. 27
			17, 320	27. 15	
1889.					
January	31, 000	9, 200	16, 702	2. 22	1. 93
February	11, 100	5, 600	7, 286	0. 87	0. 84
March	24, 600	5, 750	13, 929	1. 86	1. 61
April	36, 650	15, 750	26, 262	3. 38	3. 03
May	29, 050	8, 500	13, 813	1. 84	1. 60
June	21, 750	6, 300	13, 072	1. 68	1. 51
July	18, 500	5, 750	8, 937	1. 19	1. 03
August	21, 050	2, 700	9, 018	0. 97	0. 84
September	17, 450	1, 350	6, 058	0. 78	0. 70
October	22, 350	4, 900	11, 465	1. 52	1. 32
November	37, 250	12, 050	18, 957	2. 35	2. 19
December	37, 650	9, 350	21, 335	2. 84	2. 46
			13, 903	21. 5[illegible]	

Connecticut River at Holyoke, Mass.—Continued.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1890.					
January	23, 200	9, 100	15, 681	2. 09	1. 81
February	35, 800	8, 550	14, 795	1. 78	1. 71
March	37, 250	9, 650	19, 729	2. 62	2. 28
April	46, 250	13, 600	29, 605	3. 82	3. 42
May	46, 750	23, 800	31, 377	4. 17	3. 62
June	25, 950	6, 400	13, 335	1. 72	1. 54
July	7, 450	1, 550	4, 895	0. 66	0. 57
August	18, 450	550	6, 016	0. 79	0. 69
September	32, 100	6, 900	14, 378	1. 85	1. 66
October	44, 000	3, 850	17, 511	2. 10	1. 82
November	26, 950	7, 700	13, 750	1. 77	1. 59
December	7, 250	4, 100	5, 608	0. 75	0. 65
			15, 556	24. 12	
1891.					
January	31, 400	6, 050	14, 208	1. 89	1. 64
February	44, 950	8, 850	16, 961	2. 04	1. 96
March	63, 250	15, 150	29, 942	4. 87	3. 36
April	67, 300	20, 250	41, 178	5. 30	4. 75
May	21, 650	9, 800	15, 131	2. 02	1. 75
June	11, 900	4, 050	7, 408	0. 95	0. 86
July	9, 600	2, 900	5, 132	0. 68	0. 59
August	10, 950	1, 600	5, 303	0. 70	0. 61
September	5, 600	1, 200	3, 890	0. 52	0. 45
October	4, 650	900	3, 039	0. 40	0. 35
November	10, 750	1, 050	4, 980	0. 63	0. 57
December	33, 250	4, 500	11, 106	1. 48	1. 28
			13, 190	21. 48	
1892.					
January	63, 100	9, 000	19, 265	2. 56	2. 22
February	9, 100	4, 900	7, 207	0. 90	0. 83
March	13, 700	5, 550	8, 490	1. 13	0. 98
April	53, 500	10, 650	22, 610	2. 91	2. 61
May	48, 300	11, 300	21, 471	2. 86	2. 48
June	33, 150	6, 050	14, 273	2. 96	2. 65
July	28, 800	2, 750	12, 692	1. 69	1. 47
August	23, 100	2, 350	8, 926	0. 95	0. 83
September	11, 050	1, 800	4, 955	0. 63	0. 57
October	6, 250	3, 450	4, 860	0. 64	0. 56
November	40, 400	5, 900	15, 943	2. 05	1. 84
December	10, 450	2, 550	6, 578	0. 87	0. 76
			12, 273	20. 15	
1893.					
January	6, 850	950	3, 563	0. 47	0. 41
February	14, 750	2, 100	5, 170	0. 62	0. 60
March	26, 450	2, 650	11, 723	1. 56	1. 35
April	52, 000	13, 800	30, 592	3. 94	3. 53
May	94, 350	12, 000	32, 969	4. 39	3. 81
June	11, 850	5, 750	7, 495	0. 97	0. 87
July	5, 050	750	3, 465	0. 46	0. 40
August	17, 800	1, 700	4, 545	0. 61	0. 53
September	12, 800	3, 250	5, 683	0. 73	0. 66
October	11, 800	2, 900	5, 632	0. 75	0. 65
November	9, 900	2, 900	5, 222	0. 70	0. 63
December	17, 550	3, 250	7, 476	0. 99	0. 86
			10, 295	16. 19	
1894.					
January	8, 750	4, 050	6, 245	0. 83	0. 72
February	6, 100	2, 900	4, 639	0. 56	0. 54
March	35, 950	5, 000	22, 251	2. 96	2. 57
April	43, 300	11, 800	20, 973	2. 70	2. 42
May	18, 450	6, 300	10, 889	1. 45	1. 26
June	16, 750	1, 800	8, 701	1. 11	1. 00
July	6, 300	450	3, 845	0. 51	0. 44
August	3, 950	450	2, 321	0. 31	0. 27
September	4, 850	150	2, 697	0. 35	0. 31
October	8, 000	600	4, 610	0. 61	0. 53
November	13, 300	4, 700	7, 528	0. 97	0. 87
December	12, 150	1, 650	6, 061	0. 81	0. 70
			8, 397	13. 17	

Connecticut River at Holyoke, Mass.—Continued.

Month.	Discharge in second-feet.			Run off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1895.					
January	7,100	2,650	4,739	0.63	0.55
February	4,550	750	2,987	0.36	0.35
March	10,250	1,700	6,256	0.83	0.72
April	115,000	8,450	45,290	5.84	5.23
May	21,100	6,050	12,345	1.65	1.43
June	9,800	1,050	6,108	0.83	0.75
July	4,200	350	3,029	0.40	0.35
August	4,600	1,050	3,281	0.44	0.38
September	4,550	350	2,732	0.36	0.32
October	9,550	400	4,098	0.54	0.47
November	37,150	4,000	17,094	2.20	1.97
December	31,600	7,000	15,806	2.11	1.83
			10,314	16.19	

POTOMAC BASIN.

The Potomac River rises in the Alleghany Mountains, its drainage basin embracing portions of the States of Pennsylvania, Maryland, West Virginia, and Virginia. At this part of the system the mountains have a general trend a little north of northeast, the narrow valleys between the ridges are nearly parallel, and thus the streams coming from the mountain sides unite in creeks or rivers flowing either northeasterly or southwesterly. Taking the Potomac Basin as a whole, by far the greater number of the tributaries flow toward the northeast, the streams coming from the northern part of the basin being relatively small. The main river itself, receiving from point to point the tributaries from each side, cuts directly across the mountains, having a southeasterly direction, although in detail its course is very crooked. The course and character of the river and its adaptability for water-power purposes have been described by Prof. George F. Swain in the Report on the Water Power of the Middle Atlantic Watershed, pages 40-54, this being a portion of Volume XVI of the Tenth Census of the United States.

As pointed out by Professor Swain, the absence of lakes, marshes, and of broad valleys renders the tributary streams rapid in their delivery of precipitation upon the basin, the Potomac River being subject to sudden floods and the dry season discharge being very small. For this reason the river as a source of power is not so valuable as might be expected from the size of its drainage area. At the points where the river cuts through the successive mountain ridges the slope is rapid, but there are no falls of considerable magnitude until the stream has passed across the Piedmont plateau and reached the border of the softer Cretaceous rocks. Here, at the fall line, it forms a succession of cataracts, a drop of 90 feet occurring within a short distance at the Great Falls.

POTOMAC RIVER ABOVE SHENANDOAH RIVER.

The Potomac River, as the name is commonly applied, results from the union of the North Branch with the South Branch at a point about 12 miles below Cumberland, Md. In their upper courses these two branches flow in a general northeasterly direction, nearly parallel to each other, the North Branch being to the west of the Alleghany front and the South Branch to the east. The drainage areas have been measured at various points from the topographic sheets of the Geological Survey and from maps of portions of Maryland and Pennsylvania. The drainage area of the North Branch down to Bloomington, Md., above the mouth of Savage River, is 293 square miles. Savage River drains 111 square miles. The total drainage area of the North Branch at Piedmont, where it cuts through the Alleghany front and begins its southeasterly course, is 409 square miles. The first tributary of importance below this point is New Creek, draining the Alleghany front and flowing in a northeasterly course. Its drainage area at its month at Keyser is 56 square miles. From this point the North Branch turns abruptly toward the northeast, and continues in this course to Cumberland, where the total drainage area is 891 square miles. To the east of New Creek is Patterson Creek, also flowing northeasterly. The drainage area above Burlington, below the mouth of Mill Creek, is 155 square miles, and the total area to the point where Patterson Creek enters the North Branch, about 8 miles below Cumberland, is 279 square miles. The total drainage area of the North Branch of the Potomac at the point where it joins the South Branch is 1,365 square miles. The greater portion of the catchment basin of the North Branch is shown on the Piedmont and Romney sheets of the Topographic Atlas.

The drainage area of the South Branch of the Potomac River extends considerably south of that of the North Branch. The principal tributary on the west is what is known as the North Fork of the South Branch, rising in Pendleton County, W. Va., to the east of the Alleghany front. The drainage area below Seneca Creek is 240 square miles, and at the mouth, where it enters South Branch about 4 miles above Petersburg, is 322 square miles. The South Branch, rising to the east, has at Franklin, Pendleton County, a drainage area of 188 square miles, and at the junction with North Fork 318 square miles. To the east of this in turn is Mill Creek, entering near Petersburg and having a drainage area of 101 square miles. The total drainage area of the South Branch at Moorefield is 897 square miles. At this point it receives Moorefield River, which is also known in its upper course as the South Fork of the South Branch. The drainage area of this stream at Fort Seybert is 155 square miles, and at Moorefield is 301 square miles. Following northeasterly down the South Branch the drainage basin contracts, the river flowing in a narrow valley between Mill Creek mountains and South Branch mountains. At Romney, in Hampshire

County, W. Va., the drainage area is 1,407 square miles, and at the railroad bridge, 6 miles below Romney and 3 miles from Springfield, it is 1,443 square miles. The total area drained by the South Branch where it joins the North Branch to form the main Potomac is 1,487 square miles, and the aggregate area of these two branches is 2,852 square miles. This catchment basin is for the most part given on the Franklin, Woodstock, Romney, and Piedmont sheets of the Topographic Atlas.

Following down the Potomac River the drainage areas of the principal tributaries have been measured at their mouths and ascertained to be as follows:

Drainage areas of tributaries of Potomac River.

	Sq. miles.
Little Cacapon	117
Great Cacapon. (Of this, North River has a drainage area of 205 square miles; Lost River, 189 square miles; Cacapon above North River, 401 square miles.)	671
Warm Spring Creek	16
Conoloway Creek	125
Sleepy Creek	146
Licking Creek	195
Back Creek (to Virginia and West Virginia line, 185 square miles)	288
Conococheague at Williamsport	579
Opequon	335
Antietam	305
Shenandoah	3,009
Monocacy	557
Goose Creek	384
Seneca Creek	132
Rock Creek	81

The areas of the Potomac drainage at various points in succession below the union of the North and South Branches are as follows:

	Sq. miles.
Above Great Cacapon River	3,388
At Hancock	4,099
At Williamsport	5,556
At Harpers Ferry above the Shenandoah	6,354
At Harpers Ferry below the Shenandoah	9,363
At Weverton	9,397
At Point of Rocks	9,654
At Edwards Ferry below Goose Creek	10,716
At Great Falls	11,043
At Chain Bridge	11,161

The principal river stations for ascertaining the fluctuation of the stream are stated below in geographic order, and the results obtained at each are shown in concise form.

SPRINGFIELD STATION, ON SOUTH BRANCH OF POTOMAC RIVER.

This point is at the railroad bridge 2 miles above Springfield, W. Va. Observations of river height as described in Bulletin No. 131, page 88, were made during a part of 1894 and were resumed on April 12, 1895.

Measurements of discharge, as shown in the following table, were made, furnishing material for the rating table given below. By the application of this rating table to the observed river heights computations of monthly discharge have been made. At the time of the highest measured discharge, on April 11, 1895, the maximum velocity was 5.01 feet per second.

The measurements of river height are made by means of a wire gage, the scale of which is marked to feet and tenths on the guard rail of the bridge on the lower side, by means of brass tacks. The distance from the pulley to the zero of the gage is 1.66 feet; the length of the gage wire is 34 feet. It is placed in the first panel of the bridge at the third span from the north. Measurements of discharge are made from the same bridge. The channel, both above and below the station, is straight, the water somewhat swift. The banks are liable to overflow at time of high water.

List of discharge measurements made on South Branch of Potomac River, West Virginia.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	May 31	R. H. Chapman.	23 h	4.70	532	2.02	1,074
	1895.						
2	Mar. 29	C. C. Babb......	29 1	5.90	695	2.95	2,049
3	Apr. 11	.....do..........	29 1	8.95	1,488	2.95	4,389
4	Apr. 26	.....do..........	29 1	4.20	395	2.45	968
5	May 3	.....do..........	29 1	7.40	974	3.62	3,539
6	May 9	.....do..........	29 1	5.25	481	3.30	1,588
7	May 22	.....do..........	29 1	8.30	1,238	3.16	3,886
8	June 4	.....do..........	29 h	3.90	330	2.15	710
9	June 6	.....do..........	29 h	3.90	357	2.13	759
10	June 14	.....do..........	29 h	3.47	258	2.27	586
11	June 19	.....do..........	29 h	3.10	195	1.79	349
12	July 16	.....do..........	76	3.10	219	1.73	378
13	July 17	.....do..........	76	3.00	195	1.82	355

Rating table for South Branch of Potomac River.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
2.50	180	4.40	1,030	6.30	2,370	8.20	3,795
2.60	210	4.50	1,090	6.40	2,445	8.30	3,870
2.70	240	4.60	1,160	6.50	2,520	8.40	3,945
2.80	270	4.70	1,230	6.60	2,595	8.50	4,020
2.90	300	4.80	1,300	6.70	2,670	8.60	4,095
3.00	330	4.90	1,370	6.80	2,745	8.70	4,170
3.10	360	5.00	1,440	6.90	2,820	8.80	4,245
3.20	400	5.10	1,510	7.00	2,895	8.90	4,320
3.30	450	5.20	1,580	7.10	2,970	9.00	4,395
3.40	500	5.30	1,650	7.20	3,045	9.10	4,470
3.50	550	5.40	1,720	7.30	3,120	9.20	4,545
3.60	600	5.50	1,790	7.40	3,195	9.30	4,620
3.70	650	5.60	1,860	7.50	3,270	9.40	4,695
3.80	700	5.70	1,930	7.60	3,345	9.50	4,770
3.90	750	5.80	2,000	7.70	3,420	9.60	4,845
4.00	800	5.90	2,070	7.80	3,495	9.70	4,920
4.10	850	6.00	2,145	7.90	3,570	9.80	4,995
4.20	910	6.10	2,220	8.00	3,645	9.90	5,070
4.30	970	6.20	2,295	8.10	3,720		

Daily gage height of South Branch of Potomac River for 1895.

Day.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	....	7.70	4.40	4.80	3.10	2.50	2.00	2.50	2.50
2	....	7.00	4.20	4.50	3.00	2.40	2.00	2.40	2.40
3	....	6.80	4.00	4.20	3.00	2.30	2.00	2.40	2.30
4	....	6.80	3.90	4.00	2.90	2.30	2.00	2.40	2.30
5	....	(b)	3.80	3.80	2.70	2.30	2.00	2.30	2.30
6	....	....	4.20	4.20	2.80	2.30	2.00	2.50	2.30
7	....	....	3.90	3.90	2.70	2.30	2.00	2.40	2.30
8	....	....	3.80	3.50	2.70	....	2.00	2.40	2.30
9	....	5.20	3.70	3.90	2.70	....	2.00	2.40	2.40
10	(a)	5.50	3.50	3.60	2.70	....	2.00	2.50	2.40
11	8.95	5.10	3.40	3.40	2.70	....	2.00	2.40	2.40
12	7.50	5.70	3.40	3.30	2.70	....	2.00	2.30	2.40
13	7.00	6.80	3.30	3.10	2.60	....	2.00	2.30	2.40
14	6.60	6.20	3.50	3.00	2.60	....	2.00	2.20	2.40
15	6.40	6.20	3.50	3.30	2.60	....	2.00	2.20	2.40
16	6.10	6.00	3.40	3.10	2.60	....	2.00	2.30	2.30
17	5.90	5.90	3.40	2.90	2.60	....	2.00	2.30	2.30
18	5.60	6.20	3.30	2.90	2.60	....	2.00	2.30	2.30
19	5.40	6.40	3.20	2.80	2.60	....	2.00	2.30	2.30
20	5.20	6.00	3.00	2.80	2.60	....	2.00	2.30	2.30
21	5.00	5.80	2.90	2.80	2.50	....	2.00	2.30	2.60
22	4.80	7.90	2.90	2.70	2.50	....	2.00	2.30	4.90
23	4.70	7.60	2.90	3.00	2.50	....	2.00	2.30	4.30
24	4.60	6.60	2.80	3.20	2.50	2.00	2.10	2.30	4.00
25	4.40	6.20	3.00	3.20	2.40	2.00	2.10	2.30	....
26	4.20	5.80	3.20	3.30	2.40	2.00	....	2.30	3.40
27	4.15	5.50	4.40	3.40	2.30	2.00	2.00	2.30	3.20
28	4.00	5.40	4.00	3.20	2.30	2.00	2.00	2.30	3.00
29	4.20	5.00	4.70	3.00	2.30	2.00	2.00	2.50	2.80
30	4.90	4.70	3.50	2.90	2.30	2.00	2.10	2.60	3.20
31	....	4.40	....	2.90	2.60	....	2.10	....	3.90

a On April 10, 1895, the scale was altered by 1 foot, so that the readings given on page 88 of bulletin No. 131 must be diminished by 1.00 to make them comparable with those herewith given.
b Repairing bridge; record lost.

Discharge of South Branch of Potomac River.

[Drainage area, 1,443 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1894.					
June	1,720	400	860	0.61	0.55
July (*a*)	700	210	317	0.25	0.22
August	400	180	232	0.18	0.16
September	1,930	180	395	0.30	0.27
October 1 to 20	910	210	500	0.40	0.35
1895.					
April 12 to 30	3,270	800	1,667	1.28	1.15
May	3,570	1,030	2,204	1.76	1.53
June	1,230	270	600	0.47	0.42
July (*b*)	1,300	240	512	0.40	0.35

a Record incomplete; figures missing from July 15 to 21, 1894.
b Computations of low-water flow require more measurements at minimum stages.

CUMBERLAND STATION, POTOMAC RIVER.

This locality is described in Bulletin No. 131, page 88. The observations were continued during the greater part of 1885, and the discharge measurements shown by the following table were made sufficient for the construction of a rating table given below. By means of this the average discharge by months has been computed. The river gage is on the West Virginia Central Railroad bridge, about 200 yards below the dam across the Potomac. It consists of a vertical rod 10 feet long bolted to the east side of the abutment of the head gates above the dam. The top of the rod, or the 10-foot mark, is 5.40 feet below the top of the abutment. The channel at this point is straight, both above and below the bridge, and the water has rapid velocity. Measurements have been made not only of the discharge of the river, but also of the canal feeder taken out above the dam. On June 5, when there was 216 second-feet in the river, there was in the canal feeder 40 second-feet; on June 6 the river discharged 530 second-feet and the canal feeder carried 79 second-feet; on June 13 the river discharged 149 second-feet and the canal feeder carried 38 second-feet; on July 17 the river discharged 266 second-feet and the canal feeder carried 79 second-feet.

List of discharge measurements made on Potomac River at Cumberland, Md.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	May 24	C. C. Babb	23	....	1,166	2.60	3,037
	1895.						
2	Mar. 30	.....do	29 l	4.50	1,088	3.17	3,446
3	Apr. 10	.....do	29 l	5.40	1,560	3.88	6,054
4	Apr. 25	.....do	29 h	3.30	423	1.49	630
5	May 3	.....do	29 h	3.75	722	2.39	1,728
6	May 9	.....do	29 h	3.40	465	1.67	777
7	May 23	.....do	29 h	3.40	569	1.46	831
8	June 5	.....do	29 h	2.95	187	1.16	216
9	June 6	.....do	29 h	3.10	301	1.76	530
10	June 13	.....do	29 h	3.00	179	0.83	149
11	July 17	.....do	76	3.05	200	1.33	266

Rating table of Potomac River at Cumberland, Md.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
2.7	160	3.6	1,285	4.5	3,580	5.4	5,875
2.8	200	3.7	1,540	4.6	3,835	5.5	6,130
2.9	250	3.8	1,795	4.7	4,090	5.6	6,385
3.0	325	3.9	2,050	4.8	4,345	5.7	6,640
3.1	425	4.0	2,305	4.9	4,600	5.8	6,895
3.2	525	4.1	2,560	5.0	4,855	5.9	7,150
3.3	650	4.2	2,815	5.1	5,110	6.0	7,405
3.4	800	4.3	3,070	5.2	5,365		
3.5	1,030	4.4	3,325	5.3	5,620		

Daily gage height of Potomac River at Cumberland, Md., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Dec.
1...	3.00	3.60	6.00	3.90	3.40	3.00	3.10	2.80	1.00	....
2...	3.00	3.60	5.70	3.80	3.80	3.00	3.40	2.70	1.00	....
3...	3.00	3.50	4.90	4.40	3.80	3.00	3.30	2.70	1.00	....
4...	3.00	3.50	4.60	3.90	3.60	2.90	3.10	2.70	1.90	....
5...	3.00	3.50	4.20	3.80	3.60	2.90	3.10	2.70	1.90	....
6...	3.10	3.50	4.00	3.70	3.40	3.00	3.20	2.60	1.90	....
7...	4.80	3.50	3.80	3.60	3.30	3.00	3.20	2.60	1.80	....
8...	6.00	3.50	3.80	3.80	3.20	3.00	3.20	2.60	0.80	....
9...	4.80	3.50	4.20	5.60	3.40	2.90	3.30	2.50	0.70	....
10..	4.70	3.50	4.00	5.50	3.20	2.90	3.70	2.50	0.50	....
11..	4.10	3.50	4.00	4.70	3.20	2.90	3.40	2.40	0.50	....
12..	3.80	3.40	3.80	4.70	3.70	2.80	3.20	2.40	0.60	....
13..	3.50	3.40	3.80	3.90	3.70	2.80	3.20	2.40	1.10	....
14..	3.50	3.40	4.50	3.80	3.70	3.30	3.30	2.30	1.20	....
15..	3.50	3.40	4.80	3.80	3.50	3.30	3.30	2.20	1.00	....
16..	3.90	3.30	5.20	3.80	3.30	3.20	3.30	2.10	0.90	....
17..	3.90	3.40	4.70	3.80	3.40	3.20	3.00	2.00	0.90	....
18..	3.90	3.40	4.50	3.70	3.40	3.10	3.00	1.90	0.80	....
19..	3.80	3.40	4.30	3.60	3.40	3.00	2.90	1.80	0.70	....
20..	3.80	3.40	4.10	3.50	3.30	3.00	2.90	1.70	0.50	....
21..	3.90	3.40	3.80	3.40	3.40	2.90	2.70	1.60	0.40	....
22..	4.60	3.40	3.70	3.40	3.40	3.00	2.70	1.30	0.30	3.00
23..	4.00	3.40	3.70	3.30	3.40	3.00	2.70	1.20	0.20	3.20
24..	3.70	3.40	3.70	3.30	3.40	3.00	2.70	1.10	0.10	2.90
25..	3.60	3.40	3.70	3.20	3.30	2.90	2.70	1.00	(*a*)	2.90
26..	3.50	3.60	4.50	3.30	3.20	3.00	2.70	0.90	....	3.00
27..	3.50	4.10	4.30	3.30	3.30	3.00	2.70	0.90	....	2.90
28..	3.40	5.00	4.30	3.30	3.20	3.30	2.80	0.90	....	2.90
29..	3.40	....	5.10	3.30	3.10	3.20	2.90	0.90	....	2.90
30..	3.70	....	4.50	3.40	3.10	3.00	2.90	0.80	....	3.10
31..	3.70	....	4.50	....	3.10	....	2.80	0.90	....	3.00

a Water 5 inches below gage. Readings discontinued till December 22.

Discharge of Potomac River at Cumberland, Md.

[Drainage area, 891 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1895.					
January	7,405	325	1,844	2.39	2.07
February	4,855	650	1,128	1.32	1.27
March	7,405	1,540	3,185	4.12	3.57
April	6,385	525	1,875	2.35	2.10
May	1,795	425	870	1.13	0.98
June	650	200	355	0.45	0.40
July	1,540	160	431	0.55	0.48

GREAT CACAPON STATION, ON POTOMAC RIVER.

This point is 46 miles by rail below Cumberland, Md., and 10 miles above Hancock, Md., the distance by river being considerably greater. It is thus below the mouth of the South Fork of the Potomac and considerably above the Shenandoah. Measurements are made near Dam No. 6 of the Chesapeake and Ohio Canal. Observations were begun at this point on June 21, 1894, being made by the lockman employed by the canal company. At first river heights were read from an old gage fastened to the side wall of the dam abutment, the foot of the rod resting on the top of the dam. On June 19, 1895, a new rod was placed over the intake of the canal feeder, and from that time observations were made on the new rod. The point 0.4 feet of the old rod is at a height of 0.9 of the new rod. The elevation 2.60 of the rod at the inlet of the canal feeder is on a level with the top of the lower sill of the feeder. Measurements are made of the canal feeder and also of the main river by wading at a point about 1,000 feet below the dam. At the time of the first measurement, that of June 20, 1895, water was not flowing over the West Virginia end of the dam for about one eighth of the total length. The initial point for soundings of the river is on the left bank. Three measurements of discharge were made during 1895, these being at low water. The canal inlet is measured 100 feet above its entrance to the main canal. At the time of measurement made on July 8 there was flowing in the canal feeder 164 second-feet, and at the time of measurement on August 26, 92 second-feet.

List of discharge measurements made on Potomac River at Dam No. 6, Maryland.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 20	C. C. Babb ..	29 h	0.90	367	0.42	331
2	July 18	.....do	76	0.90	650	0.84	543
3	Aug. 26	.....do	76	—0.50	381	0.35	133

Daily gage height of Potomac River at Dam No. 6, Maryland, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	0.10	0.20	a4.50	1.00	1.00	1.00	1.20	0.80	—0.40	—1.20	—1.00	0.60
2..	0.20	0.20	5.50	1.00	1.40	1.00	1.20	0.80	—0.30	—1.20	—0.90	0.70
3..	0.10	0.10	4.90	1.00	1.80	1.00	1.60	0.80	—0.30	—1.20	—0.70	0.70
4..	0.10	0.10	2.50	1.00	1.80	0.80	1.50	0.80	—0.40	—1.20	—0.60	0.70
5..	0.10	0.10	1.40	1.00	1.60	0.80	1.40	0.80	—0.50	—1.20	—0.60	0.70
6..	0.10	0.10	1.00	1.00	1.40	0.80	1.40	0.80	—0.60	—1.30	—0.10	0.70
7..	0.20	0.10	0.10	1.00	1.30	0.80	1.70	0.80	—0.70	—1.30	0.00	0.70
8..	0.20	0.00	0.10	1.00	1.00	0.60	1.70	0.80	—0.70	—1.30	0.00	0.70
9..	b3.80	0.10	0.10	2.00	1.00	0.60	1.80	0.80	—0.70	—1.40	0.00	0.70
10.	3.60	0.00	1.80	5.80	1.00	0.50	1.80	0.80	—0.70	—1.60	0.10	0.70
11.	3.40	0.00	1.40	3.00	1.00	0.30	1.50	0.70	—0.80	—1.70	0.10	0.70
12.	3.00	0.00	1.20	1.00	1.30	0.30	1.40	0.70	—0.80	—1.80	0.30	0.70
13.	3.00	0.00	1.20	1.00	1.10	0.20	1.20	0.70	—0.70	—1.90	0.30	0.70
14.	2.00	0.00	1.00	1.00	1.10	0.20	1.20	0.40	—0.70	—1.90	0.30	0.70
15.	1.50	0.00	2.00	1.00	1.80	0.40	1.20	0.40	—0.70	—1.90	0.30	0.70
16.	1.00	0.00	3.00	1.00	1.80	0.40	1.10	5.40	—0.80	—1.90	0.30	0.60
17.	0.80	0.00	3.40	1.00	1.80	0.40	1.00	0.40	—0.80	—1.80	0.30	0.60
18.	0.80	0.00	1.10	1.00	1.80	0.40	0.90	0.30	—0.80	—1.80	0.30	0.60
19.	0.80	0.00	1.50	1.00	1.80	0.90	0.90	0.30	—0.80	—1.80	0.40	0.60
20.	1.10	0.00	1.00	1.00	1.00	0.90	0.90	0.00	—0.80	—1.70	0.60	0.70
21.	3.00	0.00	1.00	0.80	1.00	0.90	0.90	0.00	—0.60	—1.70	0.50	0.70
22.	3.00	0.00	1.00	0.80	1.40	0.90	0.80	—0.10	—0.60	—1.70	0.50	1.00
23.	3.10	0.00	0.10	0.80	1.80	0.80	0.80	—0.20	—0.70	—1.50	0.60	1.00
24.	2.10	0.00	0.80	0.80	1.80	0.80	0.80	—0.30	—0.70	—1.50	0.60	1.90
25.	1.10	0.00	0.80	0.80	1.50	0.80	0.80	—0.40	—0.80	—1.50	0.60	1.40
26.	1.60	0.10	0.80	0.80	1.50	0.90	0.80	—0.50	—0.90	—1.40	0.60	1.30
27.	1.00	0.20	0.80	0.80	1.50	1.00	0.80	—0.60	—1.00	—1.40	0.60	1.10
28.	0.60	2.80	0.80	0.80	1.50	1.10	1.00	—0.70	—1.00	—1.40	0.60	1.10
29.	0.60	......	2.00	0.80	1.50	1.20	1.00	—0.70	—1.10	—1.40	0.60	1.20
30.	0.60	......	1.80	0.80	1.50	1.20	1.00	—0.70	—1.10	—1.40	0.60	1.20
31.	0.20	......	......	......	1.20	......	0.80	—0.70	......	—1.40	......	1.20

a Ice went out. *b* Ice breaking up.

SHENANDOAH RIVER.

This river, one of the principal tributaries of the Potomac, rises in the broad Shenandoah Valley west of the Blue Ridge and between it and the Shenandoah Mountains. For the greater part it drains the counties of Augusta, Rockingham, Page, Shenandoah, Warren, and Clarke, in Virginia, flowing for a short distance through the extreme eastern part of West Virginia to enter the Potomac at Harpers Ferry. In the southwestern part of Augusta County its higher tributaries interlace with the streams flowing southerly into James River. The courses of these streams are excessively irregular and tortuous, and the confusion at first arising in the mind of the student of the hydrography of the region is further increased by the peculiar nomenclature of the streams of this section. The favorite designation appears to be either North Fork or South Fork, stream after stream in this part of the country being known by one of these terms, as will be shown by an examination of the map.

Following up the Shenandoah from its mouth at Harpers Ferry the river divides at the town of Riverton, near Front Royal, into what is known as the North Fork and the South Fork, both of these flowing in extremely crooked courses in a general northeasterly direction, the first on the northwest and the second on the southeast of Massanutten Mountain. Going up the South Fork for about 60 miles it is found to divide into two streams at Port Republic, near the Augusta County line—into the North River and the South River. The North River, about 4 miles above this point, subdivides into the North and Middle rivers. Continuing up to the head waters of this stream and passing southwesterly over the low divides of the Shenandoah Valley the head waters of North River and its tributary, South River, flowing into the James, are reached.

The drainage area of the Shenandoah has been measured from the topographic sheets of this Survey. The total drainage area of South River above its junction with North River at Port Republic is 246 square miles; the drainage area of Middle River above the point where it flows into North River is 363 square miles; the drainage area of North River above Middle River is 418 square miles, 295 square miles of this amount being above the town of Bridgewater. The total drainage area of the North River, including the Middle River at Port Republic, is 804 square miles. This, added to the drainage area of the South River, gives the total about Port Republic of 1,050 square miles. From this point down to Riverton the stream is known as the South Fork of the Shenandoah. The drainage area at various points going downstream are at Milnes, 1,288 square miles; at Overall, 1,491, and at Riverton, at the mouth of South Fork, 1,587.

In a similar way the drainage area has been ascertained at several points along the North Fork of the Shenandoah. At Brocks Gap, in

Little North Mountain, Rockingham County, the drainage area is 215 square miles; at Mount Jackson, a town in Shenandoah County, it is 511 square miles; at Riverton, where this stream unites with the South Fork to form the Shenandoah, it is 1,037 square miles. The united drainage area of the North and South forks at Riverton is 2,624 square miles. At Millville, about 4 miles above Harpers Ferry, the drainage area is 2,995 square miles, and at Harpers Ferry, at the mouth of the Shenandoah, 3,009 square miles.

A number of measurements have been made of the Shenandoah and its tributaries, and gaging stations have been located near the junction of the North and South rivers at Port Republic, where these two streams unite to form the South Fork of the Shenandoah; also at Millville, near the mouth of the river. A single measurement has been made of the South River about 20 miles above Port Republic, at Basic City, in the extreme part of Augusta County. On August 5, 1895, the stream was waded at a point 200 feet above Basic City iron bridge, and the velocity obtained by means of a current meter. The total discharge was ascertained to be 72 second-feet. At that time the distance from the surface of the water to the top of the foot rail of the bridge, opposite the third or central vertical on the upper side of the bridge, was 19.29 feet.

PORT REPUBLIC STATION, ON NORTH AND SOUTH RIVERS.

On August 6, 1895, gages were established on the North and South rivers, which form the South Fork of the Shenandoah at Port Republic, Va. The gage for the North River is located on the county highway bridge, one-fourth of a mile north of Port Republic. A painted rod was fastened to the third panel of the first span on the lower side of the bridge. It is nailed to the wooden uprights and fastened by wire to the iron diagonals. The zero of the rod is opposite the middle of the third upright, and is 4.50 feet from the outside edge of the pulley. The distance from the end of the weight to the marker is 36.35 feet. When the rod reads 2.20, the distance from the surface of the water to the top of the lower end of the third floor beam from right bank is 22.77 feet. The discharge of North River on August 6, 1895, when the water stood at 2.18, was 375 second-feet. On August 29, 1895, a measurement of the South River was made at the county bridge east of Port Republic, and also a measurement of the main stream below the junction of the North and South rivers. The difference between these—258 second-feet—gave the discharge of North River. The height of water at that time on the gage at the county bridge north of town was 2.09 feet.

The gage for the South River is located on the county iron bridge, about one-fourth of a mile east of the town. It is a wire gage. The edge of the pulley is 2.54 feet from the north edge of the third vertical. The marks on the gage are made by tacks driven into the rail on the upper side of the bridge at the fourth panel. The zero is 1 foot from the edge of the pulley. The distance from the bottom of the weight to the wire marker is 25.80 feet. The distance from the surface of the water to the top of the third floor beam on the upper side is 20.97 feet. On August 6, 1895, the gage height was 1.23 feet and the discharge 114 second-feet. On August 29 the gage height was 1.34 feet and the discharge 87 second-feet.

List of discharge measurements.

NORTH FORK OF SHENANDOAH RIVER AT PORT REPUBLIC, VA.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Aug. 6	C. C. Babb	29	2.18	281	1.33	375
2	Aug. 29	D. C. Humphreys.	N.	2.09	....	....	*a* 258

SOUTH FORK OF SHENANDOAH RIVER.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Aug. 6	C. C. Babb	29	1.22	74	1.55	114
2	Aug. 29	D. C. Humphreys.	N.	1.34	68	1.28	87

a Result obtained by differences, the discharge of the South Fork of the Shenandoah, 87 second-feet, being deducted from the total discharge of the Shenandoah, 345 second-feet, measured below the junction.

Daily gage height of North River at Port Republic, Va., for 1895.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.03	1.90	1.75	1.85
2	....	2.03	1.90	1.75	1.90
3	....	2.00	1.90	1.85	1.90
4	....	2.00	1.90	1.85	1.85
5	....	2.00	1.90	1.85	1.80
6	2.20	2.00	1.90	1.85	1.85
7	2.20	2.00	1.90	1.85	1.85
8	2.15	2.00	1.85	1.85	1.85
9	2.15	4.30	1.85	1.85	1.90
10	2.15	2.20	1.85	1.85	1.80
11	2.15	2.10	1.85	1.90	1.80
12	2.08	2.10	1.85	1.90	1.80
13	2.08	2.00	1.85	1.90	1.80
14	2.08	2.00	1.85	1.90	1.80
15	2.08	2.00	1.85	2.00	1.80
16	2.07	2.00	1.75	2.00	1.80
17	2.07	1.90	1.75	2.00	1.80
18	2.07	1.90	1.75	2.00	1.80
19	2.07	1.90	1.75	2.00	1.80
20	2.07	1.90	1.75	1.90	1.80
21	2.05	1.90	1.75	1.90	1.80
22	2.05	1.90	1.75	1.85	2.10
23	2.05	1.90	1.75	1.85	1.90
24	2.05	1.90	1.75	(*a*)	1.80
25	2.40	1.90	1.75	....	1.80
26	2.30	1.90	1.75	....	1.80
27	2.20	1.90	1.75	....	1.90
28	2.15	1.90	1.75	....	2.40
29	2.09	1.90	1.75	1.85	2.45
30	2.05	1.90	1.75	1.85	2.40
31	2.03	....	1.75	....	2.50

a Put in gage.

Daily gage height of South River at Port Republic, Va., for 1895.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.34	1.20	1.20	1.30
2	....	1.34	1.20	1.20	1.40
3	....	1.34	1.20	1.30	1.40
4	....	1.32	1.20	1.30	1.35
5	....	1.32	1.20	1.30	1.30
6	1.15	1.32	1.20	1.30	1.30
7	1.12	1.30	1.20	1.30	1.30
8	1.10	1.30	1.20	1.30	1.30
9	1.10	1.30	1.20	1.30	1.40
10	1.10	1.45	1.20	1.30	1.30
11	1.10	1.35	1.20	1.30	1.30
12	1.08	1.35	1.20	1.30	1.30
13	1.06	1.32	1.20	1.30	1.30
14	1.06	1.30	1.20	1.30	1.30
15	1.06	1.30	1.20	1.30	1.30
16	1.05	1.30	1.20	1.30	1.30
17	1.05	1.30	1.20	1.30	1.30
18	1.05	1.30	1.20	1.30	1.30
19	1.05	1.25	1.20	1.30	1.30
20	1.05	1.25	1.20	1.25	1.30
21	1.05	1.25	1.20	1.25	1.30
22	1.05	1.25	1.20	1.25	2.10
23	1.05	1.25	1.20	1.25	1.80
24	1.04	1.25	1.20	1.25	1.60
25	1.42	1.25	1.20	1.25	1.60
26	1.40	1.25	1.20	1.30	1.60
27	1.40	1.20	1.20	1.30	1.80
28	1.37	1.20	1.20	1.30	2.10
29	1.34	1.20	1.20	1.30	2.10
30	1.30	1.20	1.20	1.30	2.10
31	1.30	....	1.20	....	2.00

On August 7, 1895, measurements of the North and South forks of the Shenandoah were made at Riverton, Warren County, Va. The county highway bridge over the North Fork at this town is located about 300 feet below a small dam. At the time the discharge was measured the water surface was 44.74 feet below the top of the upper end of the fourth floor beam on the first span of the bridge from the south. The discharge was 362 second-feet. This location is favorable for a permanent station. The county highway bridge over the South Fork is located about 200 feet above a dam and is not suitable for gaging purposes. A measurement of discharge of this fork was made, however, from the Southern Railroad bridge, which is located about 400 feet above the junction of the North and South forks, the quantity found being 791 second-feet. The distance from the water surface to the top of the upper end of the first floor beam on the second span from the west was 43.70 feet. The section is not good for discharge measurements, as the water flows through trestlework in the first and third spans, and at low water is divided into four channels under the second span by old foundations.

The Norfolk and Western Railroad bridge over the main Shenandoah below Riverton is about 200 feet below the junction of the two forks. On August 7 the distance from the water surface to the top of the upper end of the third floor beam of the first span from the east was 47.50 feet. The bridge has 4 spans, each 150 feet long, with two 100-foot spans at each end. The Weather Bureau gage located at this point is painted on the eastern and upper face of the second pier from the east. When inspected the marks were almost obliterated. The reading of 45.90 feet is opposite the top of the fifth floor beam of the second span from the east. This bridge is placed diagonally across the river and is not suitable for river measurements.

MILLVILLE STATION, ON SHENANDOAH RIVER.

A station for measuring Shenandoah River was established at a point 4 miles above Harpers Ferry, where there is a cable stretched across the river, the property of Becker Bros., of Baltimore, Md. Permission was obtained to utilize this cable by swinging from it a suitable box from which discharge measurements could be made. On April 15, 1895, a vertical gage was placed in the river and securely fastened to the overhanging trunk of a tree. A deep notch was cut in the tree opposite the 8-foot mark. Daily observations were begun at this time.

Measurements of discharge were made at short intervals, sufficient to construct the rating table given below; and by means of this, computations were made of the daily discharge. The results by months are shown on page 54. The channel at this station is straight, and the water moves at moderate velocity. The banks are liable to overflow, and the bed of the stream is rocky and shows little change from time to time.

List of discharge measurements made on Shenandoah River at Millville, W. Va.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second.)	Discharge (second-feet).
	1895.						
1	April 24	C. C. Babb	29 h	1.90	1,825	1.18	2,162
2	May 1	do	29 h	7.50	4,843	4.07	19,711
3	May 2	do	29 h	6.80	4,393	3.61	15,859
4	May 4	do	29 h	5.20	3,463	3.17	10,981
5	May 8	do	29 h	3.08	2,397	1.80	4,311
6	May 24	do	29 h	3.60	3,256	1.76	5,745
7	June 8	do	29 h	1.50	1,645	0.92	1,516
8	June 15	do	29 h	2.35	2,135	1.42	3,044
9	June 22	do	29 h	1.10	1,464	0.77	1,126
10	July 12	do	29 h	1.30	1,549	0.74	1,150

Rating table for Shenandoah River at Millville, W. Va.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
0.60	890	2.10	2,560	3.60	5,790	5.10	10,600
0.70	940	2.20	2,670	3.70	6,090	5.20	10,925
0.80	990	2.30	2,840	3.80	6,390	5.30	11,250
0.90	1,040	2.40	3,020	3.90	6,700	5.40	11,575
1.00	1,090	2.50	3,210	4.00	7,025	5.50	11,900
1.10	1,140	2.60	3,400	4.10	7,350	5.60	12,225
1.20	1,200	2.70	3,590	4.20	7,675	5.70	12,550
1.30	1,300	2.80	3,780	4.30	8,000	5.80	12,875
1.40	1,400	2.90	3,980	4.40	8,325	5.90	13,200
1.50	1,510	3.00	4,180	4.50	8,650	6.00	13,525
1.60	1,650	3.10	4,390	4.60	8,975	6.10	13,850
1.70	1,820	3.20	4,630	4.70	9,300	6.20	14,175
1.80	1,990	3.30	4,900	4.80	9,625		
1.90	2,160	3.40	5,190	4.90	9,950		
2.00	2,330	3.50	5,490	5.00	10,275		

Daily gage height of Shenandoah River at Millville, W. Va., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	....	7.40	2.10	2.00	1.10	0.70	0.60	0.50	0.60
2..	....	6.90	1.90	4.10	1.00	1.30	0.60	0.40	0.60
3..	....	6.20	1.80	3.00	1.00	1.00	0.60	0.60	0.60
4..	....	5.45	1.70	2.40	1.00	0.90	0.50	0.60	0.60
5..	....	4.40	1.70	2.00	1.00	0.80	0.50	0.60	0.60
6..	....	3.85	1.60	1.80	1.00	0.60	0.50	0.60	0.60
7..	....	3.30	1.60	1.70	0.90	0.60	0.50	0.60	0.60
8..	....	3.05	1.50	1.50	0.90	0.60	0.50	0.60	0.60
9..	....	2.90	1.40	1.40	0.90	1.00	0.50	0.60	0.60
10..	....	2.60	1.40	1.40	0.90	0.80	0.50	0.70	0.60
11..	....	2.60	1.30	1.40	0.90	0.70	0.50	0.70	0.60
12..	....	2.40	1.30	1.30	0.90	1.00	0.50	0.70	0.60
13..	....	2.40	1.30	1.30	0.90	0.90	0.50	0.70	0.60
14..	....	2.30	1.40	1.30	0.80	0.90	0.50	0.70	0.60
15..	2.80	2.30	2.40	1.20	0.70	0.70	0.50	0.70	0.60
16..	3.00	2.30	1.80	1.10	0.70	0.70	0.50	0.60	0.60
17..	2.70	2.20	1.50	1.20	0.60	0.60	0.50	0.60	0.60
18..	2.50	2.20	1.30	1.50	0.60	0.60	0.50	0.60	0.60
19..	2.40	2.20	1.20	1.20	0.80	0.60	0.50	0.60	0.60
20..	2.30	2.30	1.20	1.10	0.80	0.60	0.50	0.60	0.70
21..	2.30	2.40	1.10	1.00	0.80	0.70	0.50	0.60	0.70
22..	2.00	2.70	1.10	1.00	0.80	0.60	0.50	0.60	0.70
23..	2.00	3.85	1.00	1.00	0.70	0.60	0.50	0.60	0.70
24..	1.90	3.70	1.00	1.20	0.60	0.60	0.50	0.60	0.70
25..	1.80	3.20	1.00	1.20	0.60	0.60	0.50	0.60	1.00
26..	1.80	2.80	1.00	2.10	0.60	0.60	0.50	0.60	1.00
27..	1.80	2.70	1.00	2.20	0.60	0.60	0.40	0.60	1.00
28..	1.70	2.70	2.20	1.90	0.50	0.60	0.40	0.60	1.00
29..	2.00	2.50	1.90	1.70	0.50	0.60	0.40	0.60	1.30
30..	3.10	2.30	1.80	1.50	0.50	0.60	0.40	0.60	1.40
31..	....	2.10	....	1.30	1.50	....	0.40	....	1.40

Discharge of Shenandoah River at Millville, W. Va.

[Drainage area, 2,995 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1895.					
April 15 to 30	4,390	1,820	2,799	1.03	0.93
May	18,075	2,500	5,307	2.04	1.77
June	3,020	1,090	1,599	0.59	0.53
July	7,350	1,090	1,860	0.71	0.62
August	1,510	840	1,000	0.38	0.33
September	1,300	890	954	0.35	0.31

POTOMAC RIVER BELOW SHENANDOAH RIVER.

POINT OF ROCKS STATION, ON POTOMAC RIVER, MARYLAND.

Point of Rocks is the name of a railroad station on the north side of Potomac River, 12 miles below Harpers Ferry and about one-half mile above Washington Junction, where the branch of the Baltimore and Ohio Railroad leaves the main line for the city of Washington. At this point the Potomac River cuts through Catoctin Mountain, forming a deep, narrow gorge. A toll bridge has been erected, crossing the stream just below the mouth of Catoctin Creek. This point is about 6 miles above the mouth of Monocacy River, and also of a number of smaller streams, and therefore the measurements of discharge do not represent the entire flow of the Potomac River. The drainage area here is estimated to be 9,654 square miles.

A wire gage was placed on the toll bridge on February 17, 1895. The 2-foot mark of the rod is opposite the second upright of the third span. The total length of wire is 48 feet, and the distance from the zero of the rod to the pulley is 6 feet. The initial point for sounding is at the left bank. The bed of the stream is rocky and not liable to change. The banks are moderately high, floods overflowing on the right-hand side. Opposite the middle of the sixth span is the head of a long, narrow island, and opposite the end of the seventh span is the head of another island, about 20 feet below the bridge. The measurements are made from the bridge by lowering the current meter suspended by a wire cord. A number of measurements were made during July, 1895—sufficient for the construction of a rating table by which the average discharge has been computed.

List of discharge measurements made on Potomac River at Point of Rocks, Md.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Mar. 25	C. C. Babb......	29 h	3.45	10,524	1.68	10,524
2	Apr. 5	.....do	29 h	3.82	6,338	2.21	14,032
3	Apr. 13	.....do	29 h	4.67	7,851	2.23	17,516
4	Apr. 23	.....do	29 h	2.50	4,765	1.55	7,371
5	May 1	.....do	29 h	4.75	7,717	2.73	21,073
6	May 7	.....do	29 h	3.50	5,780	2.16	12,484
7	May 17	.....do	29 h	2.75	5,118	1.74	8,918
8	May 28	.....do	29 h	2.85	5,290	1.74	9,189
9	June 3	.....do	29 h	1.93	3,998	1.13	4,536
10	June 17	.....do	29 h	1.70	3,793	1.12	4,233
11	July 10	.....do	76	1.90	4,695	1.14	4,695
12	Nov. 6	.....do	62	0.80	2,355	0.51	1,202

Rating table for Potomac River at Point of Rocks, Md.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
0.60	825	3.30	11,400	6.00	24,900	8.70	38,400
0.70	1,000	3.40	11,900	6.10	25,400	8.80	38,900
0.80	1,200	3.50	12,400	6.20	25,900	8.90	39,400
0.90	1,400	3.60	12,900	6.30	26,400	9.00	39,900
1.00	1,650	3.70	13,400	6.40	26,900	9.10	40,400
1.10	1,900	3.80	13,900	6.50	27,400	9.20	40,900
1.20	2,150	3.90	14,400	6.60	27,900	9.30	41,400
1.30	2,400	4.00	14,900	6.70	28,400	9.40	41,900
1.40	2,700	4.10	15,400	6.80	28,900	9.50	42,400
1.50	3,050	4.20	15,900	6.90	29,400	9.60	42,900
1.60	3,400	4.30	16,400	7.00	29,900	9.70	43,400
1.70	3,800	4.40	16,900	7.10	30,400	9.80	43,900
1.80	4,200	4.50	17,400	7.20	30,900	9.90	44,400
1.90	4,600	4.60	17,900	7.30	31,400	10.00	44,900
2.00	5,000	4.70	18,400	7.40	31,900	10.10	45,400
2.10	5,400	4.80	18,900	7.50	32,400	10.20	45,900
2.20	5,900	4.90	19,400	7.60	32,900	10.30	46,400
2.30	6,400	5.00	19,900	7.70	33,400	10.40	46,900
2.40	6,900	5.10	20,400	7.80	33,900	10.50	47,400
2.50	7,400	5.20	20,900	7.90	34,400	10.60	47,900
2.60	7,900	5.30	21,400	8.00	34,900	10.70	48,400
2.70	8,400	5.40	21,900	8.10	35,400	10.80	48,900
2.80	8,900	5.50	22,400	8.20	35,900	10.90	49,400
2.90	9,400	5.60	22,900	8.30	36,400	11.00	49,900
3.00	9,900	5.70	23,400	8.40	36,900	11.10	50,400
3.10	10,400	5.80	23,900	8.50	37,400	11.20	50,900
3.20	10,900	5.90	24,400	8.60	37,900		

Daily gage height of Potomac River at Point of Rocks, Md., for 1895.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	6.50	3.50	3.70	2.20	2.40	1.40	1.00	0.70	0.80	0.80
2	......	10.10	3.40	6.30	2 10	3.10	1.30	1.10	0.70	0.80	0.90
3	......	11.00	3.30	6.20	1.90	2.70	1.20	1.30	0.70	0.70	0.90
4	......	10.00	4.00	5.80	1.80	2.50	1.20	1.10	0.70	0.70	0.90
5	......	7.50	3.90	4.80	1.80	2.30	1.30	1.00	0.70	0.70	0.90
6	......	6.00	3.40	4.10	1.80	2.10	1.20	1.00	0.70	0.80	1.00
7	......	5.20	3.10	3.50	1.60	1.90	1.20	1.00	0.70	0.70	1.20
8	......	4.70	3.00	3.10	1.20	1.90	1.20	0.90	0.70	0.70	1.20
9	......	4.50	3.40	3.10	1.70	2.10	1.50	0.90	0.70	0.70	1.00
10	......	4.50	11.20	3.20	1.60	2.00	1.40	1.00	0.70	0.80	0.90
11	......	4.40	8.30	3.20	1.50	1.90	1.30	0.90	0.70	0.80	0.90
12	......	4.00	6.20	3.10	1.50	1.90	1.20	0.90	0.80	0.90	0.90
13	......	4.00	4.90	3.10	1.60	1.70	1.20	0.90	0.60	0.80	1.00
14	......	4.00	4.20	3.20	1.60	1.60	1.10	0.90	0.60	0.80	2.00
15	......	5.10	3.90	3.40	1.90	1.50	1.10	0.90	0.70	0 80	1.00
16	......	6.30	3.80	3.00	1.70	1.40	1.00	0.90	0.70	0.80	0.90
17	2.00	8.50	3.70	2.80	1.60	1.40	1.00	0.80	0.70	0.80	0.80
18	2.00	7.30	3.40	2.60	1.50	1.40	1.00	0.80	0.70	0.80	0.80
19	2.00	5.80	3.10	2.60	1.50	1.50	1.00	0.90	0.70	0.80	0.70
20	2.00	5.30	3.00	2.80	1.40	1.40	1.00	0.90	0.70	0.80	0.70
21	2.10	4.50	2.80	2.70	1.30	1.40	1.00	0.80	0.60	0.80	0.70
22	2.22	4.20	2.60	2.80	1.40	1.40	0.90	0.80	0.60	0.80	1.00
23	2.40	3.80	2.50	3.20	1.40	1.50	0.90	0.80	0.70	0.80	1.00
24	2.40	3.60	2.40	4.20	1.30	1.30	0.90	0.90	0.70	0.80	1.70
25	2.40	3.40	2.40	3.70	1.20	1.30	0.80	0.90	0.70	0.80	1.70
26	2.50	3.30	2.30	3.00	1.20	1.40	0.80	0.80	0.70	0.80	1.60
27	3.30	3.40	2.20	2.90	1.60	1.60	0.80	0.80	0.70	0.80	1.70
28	4.00	4.20	2.20	2.80	2.50	1.70	0.80	0.80	0.70	0.90	1.80
29	......	3.60	2.20	2.80	2.00	1.60	0.80	0.70	0.70	0.90	1.30
30	......	4.70	2.60	2.60	1.90	1.50	0.90	0.70	0.70	0.80	1.30
31	......	3.90	......	2.40	......	1.50	0.90	......	0.70	......	1.70

Discharge of Potomac River at Point of Rocks, Md.

[Drainage area, 9,654 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1895.					
February 17 to 28	14,900	5,000	7,142	0.77	0.74
March	49,900	11,400	21,884	2.62	2.27
April	50,900	5,900	13,383	1.55	1.39
May	26,400	6,900	12,109	1.45	1.26
June	7,400	2,150	3,655	0.43	0.38
July	10,400	2,400	3,882	0.46	0.40
August	3,050	1,200	1,852	0.22	0.19
September	2,400	1,000	1,428	0.17	0.15
October	1,200	825	984	0.12	0.10
November	1,400	1,000	1,180	0.13	0.12
December	5,000	1,000	2,084	0.25	0.22

CHAIN BRIDGE STATION, ON POTOMAC RIVER.

Chain Bridge crosses the Potomac within the District of Columbia, at a point about 3 miles above Georgetown and a few hundred feet below Little Falls, the head of tide water. The Virginia shore at this place consists of precipitous rocks for a vertical height of about 150 feet. The opposite side consists of a low plain covered with water at time of high floods.

The first attempt at river measurement at this point was made on April 3, 1891, by Mr. Cyrus C. Babb and others. At that time there was an unusual flood, the water being the highest known since the great flood of June, 1889. The water surface extended across the lowlands to the bank of the Chesapeake and Ohio Canal, a width of about 1,200 feet. The average low water width at this point is only about 150 feet. The velocity was so great that it was found to be very difficult to immerse the current meters beneath the surface. A 60-pound iron weight, lowered by means of a rope, would not sink more than a few inches into the water, being carried downstream as far as the rope could be let out. Finally a long iron rod about 1 inch in diameter was procured and the meter firmly fastened to the lower end. This was held in place by stay lines fastened from a point above the meter and running upstream to the upper side of the bridge. The first attempt was with the meter moving freely on the swivel, but owing to the swirling motion of the water the meter was twisted about and injured. The next attempt was with a meter fastened rigidly, pointing upstream, and by this means surface velocities were obtained. Near the abutment the mean of several observations gave the velocity of 11.1 feet per second. At the second point the average of the observations was 14.9 feet per second, and farther out 15.6 feet per second. This latter position was apparently the one of maximum surface velocity. Here a portion of the meter was lost by being carried away by drift. The cross section was obtained by measurement and sounding during time of low water. It was computed to be at this time 16,350 square feet. The estimated average velocity for the entire cross section was 10.9 feet per second, giving a discharge of 178,215 second-feet.

On the 1st of May, 1891, a gaging station was established at this point, and readings were begun on May 4, being continued at intervals since that date. The gage rod, marked in feet and tenths, is fastened horizontally and wired to the tension rods of the bridge. At the lower end of the rod is a small iron pulley. Over this runs a wire rope with weight on the end, the upper end of the rope moving horizontally along the gage, while the weight moves in a direction vertical to the surface of the water. When not in use the weight is drawn up about 15 feet above the surface of the water, and the wire is secured by a lock. When an observation of height is to be taken the weight is lowered until it just touches the surface of the water, and the reading on the rod opposite the brass wire marker is noted. Three readings a day were made at first.

At this point the cable and trolley method of measurement was tested, the apparatus being put in place by Mr. William P. Trowbridge, jr., and Mr. Cyrus C. Babb. The main cable was placed about 150 feet above the bridge. It consisted of a No. 6 galvanized iron wire, having a span of 300 feet. On the southern or Virginia shore this was anchored to an iron rod wedged into the rocks. On the opposite shore it was fastened to a ring, a remnant of the old chain bridge which formerly spanned the river at this place. The wire was elevated above the surface of the flood plain at this side by vertical timbers, in order to keep it approximately level. For the halyards or cords for pulling the meter forward and backward No. 7 B sash cord was used. The stay cable was placed 225 feet above the main cable, and consisted of No. 9 wire, having a span of about 250 feet. The apparatus was worked from the high Virginia shore.

The width of the water surface at low stages under the main cable was 150 feet. The timbers supporting the end of the cable on the low ground were set about 120 feet back from the shore, and 15 feet above low water, allowing for a rise of this amount before submerging this end of the cable supports. From this point the nearly level flood plain extends to the bank of the Chesapeake and Ohio Canal, a distance of about 1,000 feet. This plain is covered with water, however, only in times of extreme flood, like that above described.

The method of stream measurement by the cable and trolley is described in the Eleventh Annual Report of this Survey, Part II, Irrigation, page 17. All of the work is done from shore, the hydrographer placing the meter at any point in the stream by suitable movement of the supporting cords or wires. By means of this apparatus Mr. Babb was able to make measurements of the stream without assistance. On May 22, 1891, he found by this means the discharge to be 5,455 second-feet. Considerable trouble was experienced in the use of the double incandescent electric-light cord by which the meter was raised and lowered, and through which the electric circuit was made, owing to the wearing of the surface covering and consequent short circuiting. He concluded that as a rule it was not advantageous to attempt to make measurements alone on rivers of this size, as there are too many details to be observed. On December 15, 1891, he found a discharge of 6,611 second-feet; on December 22, 3,968 second-feet; and on December 29, 12,378 second-feet.

The computations of discharge at Chain Bridge are complicated by the fact that there is an average daily range of tide of about 3 feet, this tide extending about 700 feet above the bridge to the foot of the rapids, which extend for about 0.2 mile farther upstream. The place selected for the station is the best to be had within a considerable distance. Above these rapids the river widens into a broad sheet of water, extending for several miles up to Great Falls. The observations were made three times a day, and in case of sudden flood at more frequent intervals, the time of observations being such that the height at high and low tide is given.

At Great Falls the Potomac flows through two channels, Conns Island being between them. The dam for the aqueduct supplying the city of Washington, as at first built, extended across the Maryland channel to the island. In 1886 the present dam was finished and the crest of the old dam raised by about 15 inches. A record has been kept of the height of water on the dam since January, 1878, by the aqueduct officials, who have also preserved data as to the condition of the water. Owing to the changes in the dam, the record from 1878 to 1886 can not be used with any considerable degree of confidence for estimating discharge, and is of value mainly in showing the fluctuations of the stream. This indefiniteness of the record is due to the fact that there was usually an unrestricted flow in the Virginia channel, and also occasional changes by the construction of temporary dams during the periods of extreme low water, when the the water supply of the city began to diminish. At such times these were built at the head of Conns Island, to divert water into the Maryland channel and from this into the aqueduct. The records since 1886 are of use, however, as being comparable among themselves. It is possible to estimate the daily discharge with a fair degree of accuracy.

After Mr. Babb had succeeded in making a rating table for the station at Chain Bridge, he compared the record of heights at Chain Bridge and at Great Falls, in this manner obtaining an estimated equivalent discharge for the readings kept at Great Falls since 1886. The results are published in the Fourteenth Annual Report of this Survey, Part II, pages 135-137.

The condition of the water as noted at Great Falls gives in a general way the amount of sediment carried by this stream, and attempts have been made to interpret the arbitrary record into probable quantities of silt transported. The observations on the condition of water were made by means of a horizontal metallic tube 36 inches long, with glass ends. This is filled with water and a ball is placed in the tube, so arranged that it can be moved forward and backward. Looking through the water the observer notes the distance at which the ball can be seen from one end. This distance, which may vary from 1 inch for very muddy water to 36 inches for what is considered clear water, is noted as the condition of the water.

In order to interpret this record into average quantity of sediment, samples were secured at Great Falls through the kindness of Col. G. H. Elliot, in charge of the Washington Aqueduct. These samples were taken in glass jars holding about one quart, and were sent to the chemist of the Geological Survey for the determination of the quantity of water and the weight of the contained sediment. No special refinement was attempted in taking these samples, as the original records which it was desired to interpret were at the best approximate. To take these samples, the clean jar was immersed below the surface, quickly withdrawn, and sealed. Fifty-three samples were examined, these ranging from a condition of water marked 1, or very muddy, up to 36, or clear. The amount of sediment and the corresponding readings for the condition of water were platted on cross-section paper, the ratio of sediment to water as ordinates, and the condition of the water on the arbitrary scale as abscissæ. Through the points thus obtained a smooth curve was drawn, from which a table was constructed giving for each inch read on the arbitrary scale the corresponding ratio of sediment. In order to obtain the total amount of sediment transported by the river for any length of time, the quantity of water discharged during that period was multiplied by the average ratio obtained by this method. The results are published in condensed form in the Fourteenth Annual Report of this Survey, Part II, page 140.[1]

Condition of Potomac water and weight of sediment.

No.	Date.	Condition.	Milligrams per liter.	No.	Date.	Condition.	Milligrams per liter.
	1891.				1892.		
1	Oct. 30	36	10.3	27	Jan. 23	12	20.3
2	....do ...	36	7.6	28	Jan. 29	21	40.6
3	Oct. 31	36	8.2	29	Jan. 30	19	22.0
4	....do ...	36	12.9	30	Feb. 1	20	21.7
5	Nov. 1	36	14.4	31	Feb. 10	6	47.2
6	Nov. 2	36	*a* 27.4	32	Apr. 6	10	48.7
7	Nov. 14	26	24.5	33	Apr. 9	18	43.0
8	Nov. 15	20	25.7	34	Apr. 11	20	31.8
9	Nov. 16	22	26.8	35	Apr. 12	31	16.8
10	Nov. 17	15	22.5	36	Apr. 13	33	18.6
11	Nov. 18	7	41.0	37	Apr. 14	36	14.0
12	Nov. 19	6	48.8	38	Apr. 18	28	22.6
13	Nov. 24	7	61.7	39	Apr. 20	21	39.3
14	Nov. 26	6	89.9	40	....do ...	5	117.7
15	Nov. 28	3	157.6	41	Apr. 21	10	73.8
16	Dec. 6	1	982.6	42	Apr. 22	8	49.3
17	Dec. 7	1	1,165.0	43	June 29	4	96.2
18	Dec. 16	18	20.5	44	June 30	3	110.4
19	Dec. 18	20	10.0	45	July 3	7	59.7
20	Dec. 23	33	9.4	46	July 4	1	811.3
21	Dec. 25	3	93.3	47	July 5	1	268.8
22	Dec. 27	4	120.8	48	July 8	4	82.5
23	Dec. 28	3	122.4	49	July 11	10	30.4
	1892.			50	July 13	22	22.6
24	Jan. 13	13	40.8	51	July 15	8	29.2
25	Jan. 16	1	514.0	52	July 19	33	10.1
26	Jan. 19	2	116.3				

a The sediment consists mainly of fine sand.

Daily low-water gage height of Potomac River at Chain Bridge, District of Columbia, for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	12.0	13.3	20.8	13.2	15.5	12.5	12.0	11.0	11.1	10.0	11.3	11.0
2...	12.6	12.5	24.3	13.3	19.5	11.6	12.4	11.0	11.3	10.2	10.8	11.2
3...	12.1	12.2	......	13.3	18.8	11.0	12.5	11.2	11.6	10.8	11.4	10.5
4...	11.6	13.0	27.3	13.2	17.5	10.9	11.7	11.8	11.3	11.0	11.0	11.6
5...	11.1	13.5	23.0	13.7	17.4	10.7	11.6	11.6	11.1	11.0	11.0	11.0
6...	12.0	12.0	19.7	13.0	14.8	11.5	12.0	11.6	11.1	11.0	11.0	11.0
7...	13.5	......	17.8	12.5	13.8	11.5	12.0	11.4	11.9	11.0	11.0	11.0
8...	13.0	11.0	16.3	13.0	12.9	13.1	11.9	10.9	11.8	10.2	10.8	10.5
9...	14.6	12.0	15.8	16.0	12.8	11.9	11.4	11.3	11.5	10.2	10.8	10.5
10..	21.0	13.0	......	25.8	13.2	12.0	11.4	11.0	11.6	10.3	11.6	10.4
11..	27.2	13.5	16.3	24.0	13.5	11.9	11.2	11.2	10.6	11.5	10.5	10.4
12..	27.2	12.7	16.0	19.4	12.5	11.8	11.2	11.2	10.5	11.2	10.6	11.5
13..	......	11.5	16.0	17.5	12.6	11.7	11.3	11.1	10.5	11.2	10.4	11.0
14..	21.0	......	15.8	15 6	13.0	11.7	11.4	11.0	11.2	11.3	10.8	10.8
15..	19.70	11.8	16.6	14.8	12.5	11.4	11.2	11.2	11.4	10.8	11.0	11.4
16..	18.6	11.7	18.5	15.0	13.5	11.4	11.4	11.3	11.0	10.7	11.0	11.7
17..	18.8	12.5	22.0	15.6	13.0	12.0	11.2	10.9	10.9	10.6	11.0	10.9
18..	19.8	12.2	21.8	14.8	12.5	11.5	11.1	10.5	10.7	10.7	11.1	10.6
19..	18.3	13.1	19.5	14.0	12.7	11.8	10.5	10.6	10.6	11.0	11.1	10.5
20..	......	14.1	16.3	12.2	12.1	11.0	10.8	10.8	12.2	10.6	11.0	10.4
21..	15.4	......	15.4	12.0	12.2	11.4	11.3	10.8	13.0	11.0	10.8	11.8
22..	17.5	......	14.3	11.7	12.1	11.9	11.1	10.8	13.2	10.8	10.6	11.4
23..	16.0	14.1	13.8	12.0	12.2	11.6	11.3	11.1	13.7	10.0	10.7	10.7
24..	18.3	13.5	13.8	12.5	13.7	11.7	11.1	11.8	13.5	10.2	10.8	10.7
25..	17.5	13.6	13.0	13.0	13.6	11.4	11.3	10.8	13.8	11.0	10.6	11.0
26..	17.5	13.0	12.7	12.8	13.1	11.4	11.4	10.7	12.8	11.7	11.5	12.5
27..	17.0	13.7	13.8	12.0	13.0	11.5	11.5	10.8	11.2	12.0	10.5	11.0
28..	13.6	17.5	12.9	15.0	12.5	11.7	11.3	10.7	11.5	11.3	10.9	10.8
29..	13.3	......	12.8	15.0	12.4	12.0	11.0	10.7	10.9	10.5	10.4	11.1
30..	13.4	......	14.0	15.3	12.2	12.0	11.5	10.7	10.7	10.0	10.5	11.9
31..	14.2	......	14.1	1	12.3	......	10.6	11.8	......	11.2	......	11.7

Gage height from June 1 to March 19 from records of wire gage.
Gage height from March 20 to December 31 compiled from nilometer sheets.

[1] See also Science, vol. 21, No. 542, page 342, June 23, 1893. The Sediment of the Potomac River, by Cyrus C. Babb.

During 1895 observations of river height were continued at Chain Bridge by means of a nilometer checked by daily readings of the gage. On March 20, 1895, the old circular-face nilometer was removed and the cylindrical nilometer, which had been repaired, was placed in its stead. The latter instrument has been working satisfactorily during the remainder of the year. This nilometer is inspected daily, and observations of the height of river are made by means of the wire gage in order to check the record. The nilometer has a range of 25 feet and the mechanism can be shifted in times of flood to record greater heights. The bench mark for the wire gage is at the end of the rod at the 10-foot mark, opposite the west edge of the fifth upright of the first span, counting from the west end of the bridge. The distance from the end of the rod to the pulley is 5.20 feet, and from the end of the weight to the wire marker is 54.50 feet, this being the total length of the gage. Measurements of velocity are made from the bridge.

List of discharge measurements made on Potomac River at Chain Bridge, District of Columbia.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Discharge (second-feet).
	1889.					
1	June 2	C. C. Babb	....	50.60	40,812	471,724
	1891.					
2	April 3	.....do	....	33.00	16,350	178,215
3	May 22	.....do	8	13.00	2,363	5,455
4	June 13	.....do	8	14.00	2,825	11,850
5	Dec. 15	.....do	7	13.20	2,447	6,611
6	Dec. 22	.....do	7	12.60	2,579	3,968
7	Dec. 29	.....do	7	14.10	2,843	12,378
	1894.					
8	July 21	.....do	24 h	13.47	2,226	1,781
	1895.					
9	Jan. 23	.....do	29 1	17.10	3,110	20,028

JAMES RIVER BASIN.

JAMES RIVER.

James River, like the Potomac, rises among mountain ridges, having a general northeasterly and southwesterly trend, the tributaries flowing along narrow valleys and finally uniting to cut the mountains transversely, the waters escaping in a southeasterly direction toward the sea. The main stream is formed by the junction of Jackson and Cowpasture rivers, both of these rising in the central part of the western border of Virginia. The river and the water powers along it are fully described by Prof. George F. Swain in his report of the Water Powers of the Middle Atlantic Watershed, pages 13–33, contained in Vol. XVI of the Tenth Census. An examination of the river and some of the tributaries was made in the summer of 1895 for the purpose of choosing points where discharge measurements could be made. As a result, the stations as described in the following pages were established.

GLASGOW STATION, ON NORTH RIVER.

North River is the largest tributary of the James from the north. its drainage basin is mainly within Rockbridge County. The stream as a whole has a southerly course, and enters James River at Balcony Falls. The principal tributary of North River is South River, which flows along the westerly face of South Mountain, emptying into North River about 3 miles below Lexington and 12 miles above its mouth. In July the river was examined above Lexington up to the Kerrs Creek bridge, a distance of about 4 miles. The bridge at Lexington is directly above an old dam, and is therefore a poor locality for discharge measurements, the water being ponded for about a mile upstream. At the upper end of this still water is a series of riffles where it was decided to locate a point for occasional measurement. Low-water discharges can be measured by wading and high water by working from a boat held by a cable. Extreme flood discharges can be estimated by the depth of water on the dam at Lexington.

A number of dams have been built across the river below Lexington, and the next point downstream where measurement can be made is at the East Glasgow county bridge, about 2 miles above the mouth of North River. The bridge, unlike those above, is an open one, and at the time of examination, July 24, 1895, the distance from the water surface to the floor of the bridge was about 25 feet. At that time the depth was 2.5 feet and the current was sluggish, the maximum velocity being about 1 foot per second. A number of measurements have been made, as shown by the following table.

A station was established at the East Glasgow County bridge, about 1 mile above the mouth of North River, and observations were begun on August 21, 1895. The height of water is observed by means of a wire gage, the marks being placed on the guard rail on the lower side of the bridge. From the top of the bridge over the gage to the zero is 32.20 feet. The distance from the end of the weight to the marker of the gage is 27.86 feet. Discharge measurements were made at the rapids, 1 mile above the bridge. The initial point for sounding is on the right bank. The channel above the station is straight about 200 feet and curved below, the water moving with moderate velocity. At the place where observations of height are taken the stream is confined within its channel by the bridge abutments, and the bed is composed of rock and gravel, being fairly permanent.

List of discharge measurements made on North River at Lexington and Glasgow, Va.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Aug. 2	D. C. Humphreys...	29	....	103	1.32	*a* 135
2	Aug. 24	.....do..............	77	0.94	129	1.55	*b* 201
3	Sept. 7	.....do..............	77	....	105	0.78	*c* 82
4	Sept. 17	.....do..............	12	....	90	0.90	*a* 81

a Measurement made below Brown Hole, about 1½ miles from Lexington.
b Measurement made at Glasgow.
c Measurement made at Kerrs Creek bridge, 2 miles.

Daily gage height of North River at Glasgow, Va., for 1895.

Day.	August.	September.	October.	November.	December.
1	....	0.80	0.81	1.05	1.00
2	....	0.88	0.80	0.95	1.00
3	....	0.88	0.83	0.98	1.02
4	....	0.91	0.77	0.98	1.00
5	....	0.91	0.77	0.95	1.00
6	....	0.93	0.77	0.95	0.96
7	....	0.92	0.78	0.98	0.94
8	....	0.90	0.80	1.03	0.95
9	....	0.92	0.83	1.05	0.95
10	....	0.92	0.87	1.05	0.94
11	....	0.90	0.85	1.05	0.95
12	....	0.90	0.83	1.05	0.95
13	....	0.90	0.83	1.05	1.00
14	....	....	0.83	1.05	0.95
15	....	0.90	0.80	1.08	0.90
16	....	0.88	0.85	1.05	0.92
17	....	(*a*)	0.86	1.05	0.87
18	....	....	0.87	1.03	0.90
19	....	....	0.88	1.00	0.97
20	....	....	0.85	1.00	0.98
21	1.00	0.70	0.87	1.02	1.55
22	0.95	0.70	0.84	1.00	2.15
23	0.90	0.72	0.86	0.98	1.85
24	0.94	0.82	0.86	0.95	1.65
25	0.81	0.83	0.87	0.95	....
26	....	8.81	0.89	1.00	1.60
27	0.91	0.90	0.88	1.07	2.00
28	0.92	0.83	0.87	1.12	1.98
29	0.96	0.82	0.90	1.07	1.75
30	0.82	0.82	0.95	1.03	1.73
31	0.87	....	0.95	....	....

a Gage wire and weight stolen; replaced the 21st.

BUCHANAN STATION, ON JAMES RIVER.

This point is on James River about 20 miles above the mouth of North River. Measurements of river discharge were made at this point largely because of the fact that the Weather Bureau has maintained a gage here for about two years with daily observations. The bridge at this point is of wood, is covered, and crosses the river on two spans. The Weather Bureau rod is fastened to the upper face of the pier in the middle of the river, and is therefore about 150 feet from the shore. At the time of inspection in July, 1895, it was found to be very difficult to read, and the estimates at the time of low water were thought to be inaccurate. A wire gage was therefore established at this point. The gage board is nailed on the outer rail on the lower side of the bridge, about 40 feet from the left bank, and referred to the zero of the old gage. The bench mark at this point is the offset in the pier, which is opposite the 4-foot mark of the old rod. Discharge measurements are made at a bridge about three-fourths of a mile above, as the section at the covered bridge where the gage is located is not favorable, owing to the sluggish current during low water. At the point where measurements are made the initial point for soundings is taken on the right bank, the channel is nearly straight both above and below, and the bed of the stream changes but little if any.

List of discharge measurements made on James River at Buchanan, Va.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	July 31	D. C. Humphreys..	29	—0.13	686	0.74	509
2	Aug. 1	.....do	29	—0.19	526	1.04	543
3	Sept. 6	.....do	12	—0.48	386	1.03	397

Daily gage height of James River at Buchanan, Va., for 1895.

Day.	August.	September.	October.	November.	December.
1	....	—0.30	—0.40	—0.30	—0.10
2	....	—0.30	—0.40	—0.20	—0.10
3	....	—0.40	—0.40	—0.20	—0.10
4	....	—0.40	—0.40	—0.20	—0.10
5	....	—0.40	—0.40	—0.20	—0.10
6	....	—0.50	—0.40	—0.20	—0.10
7	....	—0.50	—0.40	—0.20	—0.10
8	....	—0.50	—0.40	—0.20	—0.10
9	....	—0.50	—0.40	—0.20	—0.10
10	....	—0.50	—0.40	—0.20	—0.10
11	....	—0.50	—0.40	—0.20	—0.10
12	....	—0.50	—0.40	—0.10	—0.10
13	....	—0.50	—0.40	—0.10	—0.10
14	....	—0.50	—0.40	—0.10	—0.10
15	....	—0.50	—0.40	—0.10	0.90
16	....	—0.50	—0.40	—0.10	0.92
17	....	—0.40	—0.40	—0.10	0.87
18	....	—0.40	—0.40	—0.10	0.90
19	....	—0.40	—0.40	—0.10	0.97
20	....	—0.40	—0.40	—0.10	0.98
21	....	—0.40	—0.40	—0.10	1.55
22	....	—0.40	—0.40	—0.10	3.00
23	....	—0.40	—0.40	—0.10	2.20
24	....	—0.40	—0.40	—0.10	2.00
25	—0.20	—0.40	—0.40	—0.10	1.80
26	—0.20	—0.40	—0.40	—0.10	1.50
27	—0.20	—0.40	—0.40	—0.10	1.30
28	—0.20	—0.40	—0.40	—0.10	1.10
29	—0.30	—0.40	—0.40	—0.10	....
30	—0.30	—0.40	—0.40	—0.10	....
31	—0.30	....	—0.40	....	....

James River was examined at various points below to determine whether a series of measurements could be made economically and efficiently. At Balcony Falls a dam was found well located for the development of water power, but the nearest point where discharge observations can be had is at Snowden, 4 miles below. Here the railroad bridge crosses the river diagonally, and is not suitable for use in making stream gagings. The examination was continued easterly from Balcony Falls to Lynchburg. At this point two railroad bridges extend diagonally across the river, spanning several large islands. The section under them was not considered favorable for river measurements. The highway bridge is also unfavorably placed for this purpose. It consists of four spans, each 165 feet long. The Weather Bureau has a gage placed on the south and upper side of the first pier from the south. On August 1 the height of water was 0.35 feet. The top of the gage reads at the floor of the bridge 31 feet. Mr. Cyrus C. Babb reports that after examination of the river at Richmond he does not consider it possible to establish river measurements at that point, because of the facts that the stream is nearly 2,000 feet wide and that the channel is cut by numerous islands and is very uneven in cross section. A number of small dams are also located at that point, ponding the water in many places. The nearest bridge above Richmond is about 65 miles up the river, above many important tributaries.

EASTERN NORTH CAROLINA RIVERS.

Concerning the North Carolina rivers in general, Prof. J. A. Holmes, the State geologist, has made the following statements:

During the past few decades the cheapening of coal and the necessity for locating on railroad lines in order to avoid the expensive hauling over poor country roads have led to the greatly increased use of steam, and to a corresponding neglect of water powers in manufacturing enterprises. One after another, a number of corn and flour mills, on the banks of the North Carolina streams, have been abandoned in favor of the mills established about towns and cities and operated by steam on a larger scale.

In spite of this tendency many of the water powers near railroad lines have been developed to their full capacity, as at Rocky Mount, Haw River, and Rockingham; and Weldon and Roanoke Rapids promise soon to be great manufacturing centers. The builders of mills at these places have shown their faith by their works, and in reply to a recent inquiry as to the relative merits of water and steam power for operating cotton mills these men express a preference for water power if a good one can be had sufficiently near the railroad.

This distance of most of the North Carolina water powers from railroad transportation is the factor that has prevented their development; but the transmission of power by electricity promises to do away with this disadvantage by making it practicable to locate the factories on the railroad lines and still operate them by water power, whether 1 or 20 miles away. This new factor is giving a new and greater importance to our water powers than they have had before. It is rendering practicable not only the development and use of the hitherto inaccessible large powers, like the Narrows of the Yadkin, but it also renders possible in many cases the concentration of several small water powers into a single factory, though these water powers may be miles apart on one or more streams. Thus, at Pelzer, S. C., on the Saluda River, three small cotton mills are located on the river bank and are operated in the old style by direct connection with the water wheel. Two other large mills near by, one of them just completed, are to be operated by power transmitted by electricity from one dam, 700 feet long and 50 feet high, more than 2 miles lower down the stream, and also from another about 2 miles above the mills. All of these mills are to be so connected that any surplus of power at one may be transferred to another wherever needed.

On the Tar and Neuse rivers there are but few valuable powers; one on the Tar at Rocky Mount (fully developed) and one or two on the Neuse near Raleigh (partially developed). On the Cape Fear River, Smileys and Buckhorn Falls are undeveloped powers of some magnitude and promise. The first is about 5 and the second about 7 miles from the railroad.

On the Deep and Haw rivers, tributaries of the Cape Fear, are a number of valuable powers both developed and undeveloped; and located at these developed powers are more than a dozen cotton mills and a number of grist and saw mills. The most valuable of these powers on Deep River is that at Lockville, on the Seaboard Air-Line Railroad, about 2 miles above its junction with Haw River. Here the canals formerly used for navigation purposes could now be used for operating extensive machinery. Only a small roller and grist mill is now in operation.

The largest and most important powers in the State are on the Roanoke, the Yadkin, and Catawba rivers. The North Carolina powers on the former stream are limited to that part of it between Gaston and Weldon, where there is a total fall of 84 feet in a distance of about 9 miles; and the possible developments here range in the aggregate, under different conditions, from 12,000 to 20,000 horsepower. Powers are being developed by two companies—one at Weldon and the other at Roanoke Rapids, 5 or 6 miles above—and mills and factories are now being constructed.

The Yadkin River, at and just above the Narrows, is one of the greatest power centers in the State, and will probably be developed in the near future. Here the river has cut its way down, in a narrow gorge, across a series of very hard and tough volcanic rocks to softer rocks below. Starting at the lower end of the Narrows gorge, 3 to 4 miles long and 100 to 500 yards wide, in the distance of 10 miles the river has a fall of more than 200 feet, an average of more than 20 feet to the mile. The conditions do not favor the location of factories directly on the banks of the stream, but in the near future there will be probably 10,000 to 20,000 horsepower developed and transmitted from the Narrows to factories located and operated on the railroad a few miles distant. Above the Southern Railroad crossing, near Salisbury, are a number of smaller powers. Bean shoal, the most prominent power, can only be fully developed at an expense probably too great to warrant the undertaking at the present time.

The next great manufacturing center, after Weldon on the Roanoke and the Narrows region on the Yadkin, should be somewhere on the Western North Carolina Railroad near where it crosses the Catawba River, or west toward Hickory. For several miles below this railroad crossing, and in the long bend for 12 or 15 miles above this point, are a number of shoals or rapids in the Catawba with a fall ranging from 5 to 50 feet in distances of from a few yards to 2 or 3 miles. These might be developed separately to operate independent factories, or, supported by larger capital, the several shoals might all be connected by electric wires and the power concentrated at some central point. There are other important water powers on the Catawba, both above and below this region, several of which operate cotton, grist, and saw mills.

On the smaller rivers and creeks in middle and western North Carolina a considerable number of water powers are already in use in mining or manufacturing establishments, notably on the south fork of the Catawba and the three Broad rivers in Gaston, Lincoln, Cleveland, and Rutherford counties; Green River, the Linville, the Ararat, and many other smaller streams east of the Blue Ridge.

The powers on streams west of the Blue Ridge have been little developed, and individually will not attain the importance of some of those further east; but they are numerous and in the gorges, which are often deep and narrow, dams can be constructed at small cost. Electric transmission will, in the near future, render practicable the concentration of power from several of these smaller developments.

The most unique and interesting of the smaller streams are those in portions of the sand-hill region, such as Hitchcocks Creek, in Richmond, and Rockfish, in Cumberland County. The sand here serves as a sponge for the rain water, which flows by numerous springs into these creeks with but little variation between the winter and summer supply. The former of these streams is only 17 miles long, and yet on it are located six cotton mills and several grist and saw mills. As illustrating the great benefits of such manufacturing establishments to the communities in which they are located, it may be stated that these cotton mills in Richmond County, operated by such small streams, have paid out to the people in wages, taxes, and fuel during the past five years over $1,000,000.

CLARKSVILLE STATIONS, ON DAN AND STAUNTON RIVERS.

At Clarksville, Va., the Dan and Staunton rivers unite, forming the Roanoke. The Southern Railroad bridge crosses the two rivers about

1,000 feet above their junction, the sections being suitable for measurement at both points. The Weather Bureau has a gage on Roanoke River about 400 feet below the railroad crossing. This gage is attached firmly to the projecting trunk of an old tree. It read —0.10 feet on October 3, 1895, and 0.30 feet on October 27: later, 0.59 feet on December 5.

About 4 miles above the junction of the Dan and Staunton rivers is a cut-off, apparently occupying an old channel, diverting water from the Dan to the Staunton. The banks are 10 feet high and about 225 feet apart. At its mouth is a shoal or riffle about 70 feet long, the water being, on December 4, 1895, about 1 foot deep and having an estimated velocity of approximately 3 feet per second, giving a total discharge from the Dan to the Staunton of 200 second-feet. The average width of the water surface in the channel was 150 feet. The total fall between the two rivers was estimated to be approximately 2 feet, this being principally at the riffle at the mouth of the channel. The total length of the channel was about 1,000 feet. This cut-off, by carrying water from the Dan, vitiates the separate computations of discharge made at the stations below, but does not affect the total discharge for the Roanoke.

Gaging stations were established on the Dan and Staunton rivers at Clarksville on October 28, 1895. On Dan River the rod is fastened to the inside of the guard rail of the fourth panel of the third span west of the Southern Railroad bridge. The distance from the zero of the rod to the outside of the pulley wheel is 3 feet; the length of the wire rope is 33.17 feet. The water power from Dan River has been developed to a considerable extent at Clarksville. An examination at points above showed that the dams at Danville pond the water, and as a result modify the natural characteristics of the stream.

The gage on Staunton River is fastened to the inside of the guard rail of the fourth panel of the third span from the west. The distance from the zero to the outside of the pulley wheel is 3 feet; the length of the wire gage is 33 feet; the distance of the water surface below the top and upper end of the third floor beam of the second span from the west was 27.15 feet when the gage height was 0.25 foot. The distance from the east abutment of the Dan River bridge and the west abutment of the Staunton River bridge is 165 feet.

List of discharge measurements made on Dan River at Clarksville, Va.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Oct. 2	C. C. Babb........	29	0.38	591	1.31	773
2	Oct. 28	.....do.............	29	0.65	719	1.44	1,032
3	Dec. 5	.....do.............	62	1.12	865	1.60	1,382

List of discharge measurements made on Staunton River at Clarksville, Va.

No.	Date.	Hydrograper.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Oct. 3	C. C. Babb	29	−0.07	550	0.97	533
2	Oct. 28	do	76	0.28	659	1.31	861
3	Dec. 5	do	62	0.61	917	1.25	1,151

Daily gage height of Dan River at Clarksville, Va., for 1895.

Day.	October.	November.	December.	Day.	October.	November.	December.
1		1.00	1.20	17		1.19	1.05
2		1.38	1.10	18		1.10	1.02
3		1.70	1.10	19		1.19	1.20
4		1.50	1.10	20		1.05	1.10
5		1.32	1.15	21		1.09	1.15
6		1.15	1.00	22		1.05	2.55
7		1.05	1.00	23		1.05	4.28
8		1.00	1.00	24		1.08	3.88
9		1.05	0.90	25		1.00	2.15
10		1.05	1.35	26		1.15	1.80
11		2.23	1.35	27		1.15	1.62
12		2.30	1.35	28	0.65	1.20	1.60
13		2.09	1.25	29	0.65	1.80	1.95
14		1.58	1.15	30	0.70	1.40	2.00
15		1.32	1.05	31	0.63		3.92
16		1.23	1.02				

Daily gage height of Staunton River at Clarksville, Va., for 1895.

Day.	October.	November.	December.	Day.	October.	November.	December.
1		0.59	0.70	17		0.68	0.55
2		0.89	0.60	18		0.60	0.52
3		1.23	0.60	19		0.68	0.70
4		1.03	0.60	20		0.55	0.60
5		0.82	0.65	21		0.57	0.65
6		0.65	0.55	22		0.55	2.05
7		0.55	0.50	23		0.55	3.78
8		0.50	0.50	24		0.58	3.38
9		0.52	0.40	25		0.50	1.65
10		0.52	0.85	26		0.65	1.30
11		1.77	0.85	27		0.65	1.12
12		1.79	0.85	28	0.25	0.70	1.10
13		1.59	0.75	29	0.25	1.25	1.47
14		1.08	0.65	30	0.27	0.90	1.50
15		0.82	0.55	31	0.20		3.48
16		0.73	0.52				

It is desirable that a gaging station be established on Roanoke River in the vicinity of Weldon, on account of the excellent water-power sites near that place. The Weather Bureau has maintained observations of river heights here. At the time of inspection on October 1 the reading was 0.9 foot, the water being below the end of the rod. The section at the railroad bridge is not suitable for measurement, as the channel is very uneven and the water is ponded over considerable areas in the vicinity of the piers.

A single measurement was made of Meherrin River, a tributary of the Chowan. This was at Belfield, near Emporia, in Greenesville County, Va., on October 2, 1895. The meter was used from the railroad bridge, one-fourth of a mile south of town. The mean velocity was found to be 1.08 feet per second, and the total discharge 72 second-feet.

FAYETTEVILLE STATION, ON CAPE FEAR RIVER.

Cape Fear River and its tributaries are described by Prof. George F. Swain in his report on the Water Powers of the Southern Atlantic Watershed, pages 55-76, published as part of Volume XVI of the Tenth Census. In the summer of 1895 an examination was made of the river, and a station for measuring the flow was established near Fayetteville. This town is about a mile from the river. The Weather Bureau has a substantial gage fastened to the lower side of the east abutment of the covered highway bridge, this being about 400 feet above the railroad bridge, from which discharge measurements are made. For the lower 29 feet this gage consists of a rod divided into tenths and firmly fastened to the abutment. Above the 29-foot mark a scale is painted on the rock. The first measurement of discharge was made on September 26, showing for a gage height of 1.59 feet a discharge of 489 second-feet. On December 7 a second measurement at a height of 2.90 feet gave a discharge of 1,109 second-feet.

The Neuse River was measured on September 27, 1895, at Smithfield, N. C., this point being about 25 miles southeasterly from Raleigh. The discharge as measured from the covered railroad bridge was found to be 110 second-feet.

Daily gage height of Cape Fear River near Fayetteville, N. C., for 1895.

Day.	September.	October.	November.	December.
1	....	1.20	4.20	3.60
2	....	1.10	5.00	3.10
3	....	1.00	6.00	3.20
4	....	1.00	7.00	3.00
5	....	0.70	6.00	3.00
6	....	0.90	4.80	3.00
8	....	1.10	4.10	2.90
7	....	1.30	3.60	2.80
9	....	1.60	3.20	2.60
10	....	1.90	3.10	3.90
11	....	1.70	3.70	10.60
12	....	1.60	7.00	13.20
13	....	2.00	8.90	10.60
14	....	2.00	6.60	8.20
15	....	1.80	5.40	6.20
16	....	1.60	4.40	5.20
17	....	1.50	4.00	4.70
18	....	1.30	3.80	4.30
19	....	1.50	3.50	4.10
20	....	1.50	3.20	4.20
21	....	1.20	3.10	4.00
22	....	1.30	3.10	4.00
23	....	1.40	3.00	a 18.50
24	....	1.30	2.90	13.40
25	....	1.30	2.80	9.20
26	....	1.10	2.80	7.00
27	....	1.30	3.00	5.80
28	....	1.20	4.50	5.00
29	1.35	1.40	4.00	4.90
30	1.35	1.30	4.00	4.80
31	....	1.60	....	6.00

a Began rising about 9.30 a. m. Dec. 22, and reached the highest point about 6 a. m. Dec. 23.

HOLTSBURG STATION, ON YADKIN RIVER.

The point of measurement for Yadkin River is at the Southern Railroad bridge at Holtsburg, about 4 miles from Salisbury, N. C. The section here is favorable, being the only desirable one found in an examination of the river covering some considerable distance. A gage rod was located here September 24, 1895. The 10-foot mark of the rod is opposite the center of the sixth floor beam on the lower side of the first span from the west end. The distance from the zero of the rod to the outside of the pulley wheel is 1.85 feet. The length of the wire rope and weight is 55.10 feet. The post-office address of the observer is Salisbury, N. C., the nearest railroad station, Holtsburg, being merely a siding. The locality is reached by wagon from Salisbury.

This river is known as the Yadkin for about 30 miles below this point, or to the mouth of Uharie River, entering from the north in Montgomery County, N. C. Below this point it is known as the Peedee. The crossing of the river at the railroad station known as Peedee, N. C., was examined, but was found not to be suitable for measurement, as the space under the railroad bridge is obstructed by dams and fish ways between some of the piers and by old crib works under the other spans. The next accessible point below this is at Cheraw, S. C., about 8 miles south of the State line. There are two bridges over the Peedee within a short distance of each other, one being used for the railroad and the other being a covered toll bridge. The river channel under these bridges is about 300 feet wide, the depth being approximately 15 feet. The maximum surface velocity when the locality was inspected was very slow, about 1 foot a second. Daily observations are being taken at this point by the Weather Bureau. The rod is graduated to feet and halves and is read with difficulty. The height on September 20, 1895, was 1.5 feet.

List of discharge measurements made on Yadkin River near Holtsburg, N. C.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Oct. 5	C. C. Babb	29	1.44	1,190	1.22	1,457
2	Oct. 26	.....do	76	1.45	1,159	1.33	1,538
3	Dec. 10	.....do	62	1.74	1,534	1.57	2,415

Daily gage height of Yadkin River at Holtsburg, N. C., for 1895.

Day.	September.	October.	November.	December.
1			1.60	1.70
2			1.80	1.70
3			1.80	1.70
4			1.60	1.70
5		1.40	1.50	1.70
6		1.40	1.50	1.60
7		1.40	1.50	1.60
8		1.40	1.50	1.60
9		1.40	1.50	1.60
10		1.50	1.90	1.60
11		1.50	2.20	1.60
12		1.40	2.20	1.70
13		1.40	1.90	1.70
14		1.50	1.80	1.70
15		1.50	1.60	1.60
16		1.50	1.60	1.60
17		1.50	1.60	1.60
18		1.50	1.60	1.60
19		1.40	1.60	1.60
20		1.40	1.60	1.60
21		1.40	1.60	2.10
22		1.40	1.60	2.30
23		1.40	1.60	1.90
24	1.40	1.40	1.60	2.10
25	1.40	1.40	1.60	2.00
26	1.40	1.40	1.60	2.20
27	1.40	1,40	1.80	1.90
28	1.40	1.40	2.30	2.10
29	1.40	1.40	1.90	2.40
30		1.40	1.70	2.30
31		1.50		4.10

FORT MILL STATION, ON CATAWBA RIVER.

The Catawba River a short distance south of the North Carolina State line is crossed by three railroad bridges, these being in succession down stream, the bridge of the Southern Railway, 3 miles south of Fort Mill, the bridge of the Seaboard Air Line (Georgia, Carolina and Northern) about 3 miles from Catawba Junction, and below this the bridge of the Ohio River and Charleston Railroad. Each of these was examined to ascertain the most desirable points for making river measurements. It was decided that the highest of these, crossing near Fort Mill, was most desirable. A gage was placed here on September 3, 1895. It is fastened to the upper side of the guard rail, the 2-foot mark of the rod being about the center of the second vertical of the second truss from the south end of the bridge. The distance from the zero of the rod to the outside edge of the pulley wheel is 1.30 feet, and the length of wire rope to the end of the weight is 52.96 feet. The observer is W. A. Morris, Rockhill, S. C. It is most convenient, however, to reach the railroad bridge from the station of Fort Mill, about 3 miles distant. A measurement of discharge was made on September 23, when with a gage height of 1.58 feet a quantity of 1,340 second-feet was found; a second measurement, on October 25, gave, with a height of 1.51, a discharge of 1,477 second-feet.

Above this point observations of river height have been kept by the Weather Bureau at Mount Holly, N. C., this point being 5 miles north of the State line, and nearly 25 miles above the Fort Mill station. A gage here is attached to one of the river piers, but readings have not been made since about 1884. Measurements of discharge could not be satisfactorily made at this point, as the river is ponded under the bridge by a dam located about 1 mile below. The average depth on September 19, 1895, was 7 feet, and the maximum surface velocity was less than 1 foot per second. The reading of the rod on that day was 1.80 feet.

Daily gage height of Catawba River at Fort Mill, S. C., for 1895.

Day.	September.	October.	November.	December.
1	....	1.50	1.50	1.70
2	....	1.50	1.60	1.70
3	....	1.50	1.70	1.70
4	....	1.50	1.70	1.70
5	....	1.50	1.60	1.70
6	....	1.50	1.60	1.60
7	....	1.50	1.60	1.60
8	....	1.50	2.05	1.60
9	....	1.50	2.10	1.60
10	....	1.50	....	1.80
11	....	1.50	....	1.80
12	....	1.60	....	1.70
13	....	1.50	....	1.70
14	....	1.50	....	1.70
15	....	1.50	....	1.70
16	....	1.50	....	1.60
17	....	1.50	1.70	1.60
18	....	1.50	1.60	1.60
19	....	1.50	1.60	1.60
20	....	1.50	1.60	1.60
21	....	1.50	1.60	1.80
22	....	1.50	1.60	3.40
23	1.60	1.50	1.60	3.60
24	1.60	1.50	1.60	2.60
25	1.60	1.50	1.60	2.20
26	1.50	1.50	1.60	2.10
27	1.50	1.50	1.70	2.00
28	1.50	1.50	2.00	2.00
29	1.50	1.50	1.90	2.30
30	1.50	1.50	1.70	2.20
31	....	1.50	....	3.50

GEORGIA RIVERS.

A number of the rivers of Georgia have been described by Prof. George F. Swain in his report on the Water Powers of the Southern Atlantic Watershed, published as Volume XVI of the Tenth Census. Descriptions of the Savannah, Oconee, and Ocmulgee Rivers are given on pages 126–162. The remaining streams in the State are described by Prof. Dwight Porter in his report on the Water Powers of the Eastern Gulf Slope, this also forming a portion of Volume XVI of the Tenth Census. In this Professor Porter has described the Chattahoochee and its tributaries. A reconnoissance was made during the fall for the purpose of selecting points at which discharge measurements might be had. This covered the Savannah River near Augusta, the Oconee near Milledgeville, the Ocmulgee near Macon, and the Chattahoochee at various points above and below the vicinity of Atlanta.

Computations of the discharge of Savannah River at Augusta, covering the period from 1884 to 1891, were made by Mr. Cyrus C. Babb, and published in the Fourteenth Annual Report of the United States Geological Survey, Part II, pages 147–149. They are based upon discharge measurements made by the Engineer Corps of the United States Army and upon the daily observations of river height made by the Weather Bureau. The channel of the river, which is about 800 feet wide, has, however, been improved within recent years by building below the city a number of wing walls from the northern shore, these being placed 300 to 400 feet apart. As a result the channel has deepened on the Georgia side, and it is probable that reliable computations can not be made of the discharge within the past few years based upon observations of the height of water.

The Weather Bureau observations of river height are made at the lowest of four bridges within the city of Augusta. A gage rod is fastened to the south pier of this bridge and is divided into feet and inches, graduations extending to 39 feet, this point being opposite the floor of the bridge. Satisfactory discharge measurements could not be made from this bridge or from the one above owing to obstructions by piles, but might be made from the upper of the two railroad bridges. There is, however, a considerable fluctuation of river height at this point, owing to the fact that a canal takes water from the river about 9 miles above to furnish power for manufacturing purposes. This water returns to the river about 1 mile above the lower bridge. During the night the lower gates of the canal are closed and a large pond is filled, sufficient to run the mills during the day time. The observer takes three observations a day, at 6 a. m., at noon, and at 6 p. m. The 6 a. m. observation is reported to the Weather Bureau. This reading does not give, therefore, the average for the day, there being considerable fluctuation, as is shown by the following table covering the period from October 11 to 24, 1895. The difference of about 0.6 foot between the morning and noon observation is due to the letting out of the water ponded during the night.

Recorded gage heights of Savannah River at Augusta, Ga.

Date.	6 a. m.	12 m.	6 p. m.
1895.			
Oct. 11	4.75	5.75	5.42
12	4.92	5.83	5.25
13	5.17	5.00	4.83
14	5.17	5.75	5.58
15	4.92	5.75	5.50
16	4.67	5.67	5.42
17	4.58	5.67	5.58
18	4.67	5.75	5.58
19	4.83	5.75	5.00
20	4.92	4.83	4.75
21	4.83	5.67	5.33
22	4.58	5.67	5.25
23	4.67	5.50	4.17
24	4.58	5.50	....

On October 19, 1895, Mr. Cyrus C. Babb made a measurement of the Oconee River at Milledgeville, Ga., from the highway bridge, about 1.7 miles from town. At that time the water was 37.78 feet below the top and lower end of the third floor beam of the first span from the east. The bridge has three spans, each 150 feet long. The mean velocity was 1.75 feet per second, and the total measured discharge was 1,108 second-feet. The section is not highly favorable for permanent measurements.

MACON STATION, ON OCMULGEE RIVER.

Three bridges cross the Ocmulgee at Macon. The upper one is a partially covered highway bridge of two spans, each 200 feet long. At a point 200 feet below is a decked bridge of the Georgia Railroad Company, and 150 feet below that is a wooden truss bridge of the Macon, Dublin and Savannah Railroad. The Weather Bureau has a gage on the middle bridge. It is fastened firmly to the lower side of the south abutment, but is useless at low stages, the bottom of the rod being buried in mud to the 5-foot mark. On October 18 the observer estimated the gage height at 2.50, but Mr. Cyrus C. Babb placed it at about 0.0. The graduation of the rod extends up to 29 feet.

On October 23, 1895, a 10-foot rod for a wire gage was established at the lower bridge—that of the Macon, Dublin and Savannah Railroad. It is fastened to the upper side of the guard rail in the sixth panel of the first span from the south. The distance from the outside of the pulley wheel to the zero of the rod is 3.85 feet; the distance from the end of the weight to the wire marker is 35.30 feet. The height of water at that time was 0.22 foot, the water surface being 28.62 feet below the top and upper end of the triangular casting at the foot of the seventh tie rod of the first span from the south. The zero of this new gage was made to correspond with the zero of the Weather Bureau rod.

Twenty-five miles above Macon, on the Ocmulgee at Juliette, is a fine undeveloped water power, but as there is no bridge convenient to this locality measurements have not been made.

The drainage area above Macon has been ascertained by Mr. B. M. Hall by means of measurements of county maps, as follows:

Watershed of Ocmulgee River above Macon, Ga.

Counties.	Square miles.	Counties.	Square miles.
Fulton	28	Butts	185
Dekalb	169	Jasper	158
Gwinnett	256	Pike	32
Walton	166	Monroe	265
Rockdale	150	Jones	97
Clayton	56	Bibb	27
Henry	339		
Newton	400	Total	2,425
Spalding	97		

Daily gage height of Ocmulgee River at Macon, Ga., for 1895.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	0.50	0.50	17	....	0.57	0.58
2	....	0.77	0.50	18	....	0.55	0.64
3	....	0.85	0.55	19	....	0.50	0.61
4	....	0.67	0.62	20	....	0.50	0.59
5	....	0.55	0.54	21	....	0.50	2.02
6	....	0.45	0.51	22	....	0.50	3.10
7	....	0.36	0.44	23	0.21	0.50	2.68
8	....	0.47	0.40	24	0.21	0.50	1.70
9	....	0.55	0.46	25	0.17	0.49	1.48
10	....	0.63	1.45	26	0.19	0.49	1.01
11	....	0.65	2.50	27	0.18	0.47	1.10
12	....	0.60	2.29	28	0.18	0.43	1.28
13	....	0.77	1.51	29	0.17	0.55	1.30
14	....	0.94	1.11	30	0.22	0.54	1.35
15	....	0.72	1.01	31	0.22	....	1.16
16	....	0.65	0.72				

List of discharge measurements made on Ocmulgee River at Macon, Ga.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Oct. 18	C. C. Babb	76	0.39	784	1.04	813
2	Oct. 23	.....do	76	0.20	726	1.06	767
3	Dec. 13	.....do	62	1.59	1,045	1.46	1,530

OAKDALE STATION, ON CHATTAHOOCHEE RIVER.

The Chattahoochee was examined at various points from Roswell, 25 miles north of Atlanta, down to Westpoint, on the State line between Georgia and Alabama. At Roswell a covered highway bridge crosses the river, but it is impossible to make discharge measurements from it, as the section is not suitable. The width of the river is 600 feet. At this point is an old gage, belonging to the Georgia geological survey, fastened to the lower end of the first pier from the east. It is offset about 3 feet from the pier and faces the east shore. The lower marks are obliterated, so that the height could not be read when inspected on October 12, 1895.

At Bolton, about 6 miles northerly from Atlanta, are two bridges, one for the railroad, the other for the highway. The section at each of these is, however, unsuitable for measurement of discharge, the channels being obstructed and the current sluggish. About 2 miles below these bridges is the Southern Railroad bridge at Oakdale, where it was finally determined to locate the river station, a number of measurements being made at this place. There are several bridges below this, but the next inspection was made at Westpoint, 80 miles or more downstream, where the Atlanta and West Point Railroad crosses the Chattahoochee. The bridge here has five spans and crosses the river diagonally. About 900 feet below an iron highway bridge crosses the stream. This has three spans, each 140 feet long. On October 22, 1895, the water surface was 26.64 feet below the outside edge of the foot rail on the lower side, opposite the center of the fourth panel of the first span from the west. This is not a very desirable section for measurement on account of the sluggish current. The depth at time of measurement varied from 5 to 10 feet. The total discharge was ascertained to be 1,404 feet.

At Oakdale, about 6 miles from Atlanta, the Southern Railroad bridge crossing the Chattahoochee is decked and consists of two spans, each 135 feet long. The current under the bridge had a moderate velocity, and therefore it was decided to establish a station here, after removing the driftwood which had collected at the end of the pier. The top of the bridge is about 56 feet above the water. Measurements are made from a plank walk extending through the bridge and resting on the lower members at a height of about 30 feet above the water. The gage was put in place on October 17, 1895, the pulley and rod being attached to the lower guard rail on the second panel of the second span from the east. The water at that time was 29 feet below the top of the upper end of the third floor beam of the first span from the east. This measurement was taken from the casting at the end of the floor beam close to the tie rod. The length of the wire gage is 58.85 feet. The distance from the pulley to the zero of the rod is 2.20 feet. The reading of the gage on October 17, when established, was 0.35 foot. The drainage area above this point has been computed by Mr. B. M. Hall from the county maps.

Watershed of Chattahoochee River above Oakdale, Ga.

Counties.	Square miles.	Counties.	Square miles.
Lumpkin	182	Gwinnett	116
White	230	Cobb	90
Habersham	233	Fulton	78
Hall	280	Dekalb	83
Dawson	18		
Forsyth	181	Total	1,560
Milton	69		

List of discharge measurements made on Chattahoochee River at Oakdale, Ga.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Oct. 15	C. C. Babb	76	0.40	663	1.66	1,096
2	Oct. 22	do	76		2,802	0.51	*a*1,404
3	Dec. 14	do	62	0.69	796	1.73	1,380

a Measurement made at Westpoint, Ga., at highway bridge in town.

Daily gage height of Chattahoochee River at Oakdale, Ga., for 1895.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	0.75	0.50	17	0.35	0.55	0.55
2	....	1.70	0.50	18	0.30	0.60	0.50
3	....	1.00	0.55	19	0.25	0.50	0.40
4	....	0.60	0.60	20	0.30	0.55	0.50
5	....	0.50	0.60	21	0.20	0.50	0.65
6	....	0.55	0.50	22	0.25	0.50	1.00
7	....	0.45	0.45	23	0.20	0.50	2.00
8	....	0.40	0.40	24	0.30	0.50	1.20
9	....	0.60	0.40	25	0.25	0.50	1.00
10	....	0.80	0.60	26	0.20	0.55	0.55
11	....	1.00	1.30	27	0.25	0.55	0.80
12	....	1.35	1.10	28	0.25	0.70	0.75
13	....	1.00	1.00	29	0.30	0.75	0.70
14	....	0.75	0.65	30	0.50	0.45	2.00
15	0.40	0.60	0.60	31	0.50	....	2.95
16	0.40	0.60	0.55				

OHIO RIVER TRIBUTARIES.

Great Kanawha River rises in the Alleghany Mountains near the line between Virginia and North Carolina. The upper portion, known as New River, flows northwesterly, transverse to the mountain ridges. The principal head-water tributary is Greenbrier River, which flows southwesterly parallel to the main range of the Alleghanies. A short distance below the junction of these streams is the town of Hinton. Below this point the first large tributary is the Gauley, coming in from the north. An examination of these streams was made by Mr. Cyrus C. Babb and Prof. D. C. Humphreys in July, 1895, for the purpose of selecting a point at which measurements of discharge could be carried on economically and efficiently. The Greenbrier was examined and a locality for measurement chosen at Alderson, about 20 miles above the point where it empties into New River. At a point about 2 miles above its mouth is a good location for measurement by means of a cable and car. The width of the river was found to be 292 feet. The first bridge, that of the Chesapeake and Ohio Railway Company, crosses the river at Lowell. This is not a desirable point for measurement, as the bridge is not straight and the channel is irregular. At the Greenbrier Stock Yards, above Lowell, a cable ferry is in operation.

ALDERSON STATION ON GREENBRIER RIVER.

On July 30 a wire gage was established on the county bridge at Alderson, W. Va., 21 miles above Hinton. It is placed on the third panel of the second span, and the edge of the pulley over which the wire passes is 0.75 foot south of the second vertical strut. The zero of the gage is 2 feet from the edge of the pulley. The distance from the end of the weight to the wire marker is 28.37 feet. When the reading of water was 1.88 feet the distance from the surface of the water to the top of the floor beam at the end of the third panel is 20.59 feet. The bridge consists of 4 spans, each 108 feet long and with 7 panels to a span, making a total width of 432 feet. At ordinary stages the water flows in two channels, there being an island 600 feet long and 75 feet in width between them. The water surface extends from the middle of the sixth panel of the third span to the end of the third panel of the fourth span, counting from the south. This island is submerged at a gage height of 7 feet. Two measurements have been made at this point, the first on July 30, when at a gage height of 1.89 feet the discharge was found to be 457 second-feet; the second on September 7, 1895, when the gage height was 1.36 feet and the discharge 106 second-feet.

Daily gage height of Greenbrier River at Alderson, W. Va., for 1895.

Day.	August.	September.	October.	November.	December.
1	1.85	1.60	1.25	1.32	1.70
2	1.73	1.50	1.20	1.34	1.67
3	1.65	1.45	1.20	1.35	1.60
4	1.60	1.40	1.20	1.40	1.57
5	1.55	1.40	1.20	1.40	1.57
6	1.50	1.50	1.25	1.43	1.50
7	1.40	1.48	1.22	1.45	1.43
8	1.53	1.48	1.27	1.48	1.48
9	1.63	1.45	1.27	1.45	1.53
10	1.60	1.50	1.20	1.47	1.53
11	1.63	2.27	1.20	1.47	1.58
12	1.70	1.73	1.25	1.47	1.58
13	1.70	1.65	1.25	1.45	1.55
14	1.67	1.60	1.23	1.43	1.50
15	1.80	1.53	1.23	1.45	1.43
16	1.70	1.40	1.20	1.42	1.43
17	1.70	1.45	1.25	1.43	1.50
18	1.70	1.43	1.25	1.43	1.48
19	1.65	1.40	1.25	1.43	1.50
20	1.65	1.40	1.25	1.43	1.50
21	1.70	1.40	1.25	1.45	1.55
22	1.65	1.37	1.25	1.49	1.63
23	1.65	1.35	1.25	1.52	3.55
24	1.70	1.35	1.28	1.53	2.65
25	1.60	1.30	1.32	1.53	2.40
26	1.50	1.30	1.30	1.53	2.20
27	1.65	1.28	1.30	1.50	2.10
28	1.75	1.25	1.30	1.53	2.25
29	1.70	1.25	1.30	1.58	2.70
30	1.65	1.25	1.30	1.63	2.40
31	1.65	....	1.30	....	2.30

FAYETTE STATION, ON NEW RIVER.

New River above the Greenbrier was examined as far as the mouth of Bluestone River. Two ferries cross the river in this distance, but neither of these are equipped with cables. The section examined was about 1,000 feet wide except at the lower ferry, where it was 700 feet across. The width of the Greenbrier at its mouth is about 600 feet, and of the New just above the Greenbrier about 1,200 feet. At this point a ferry is located, but this does not have a cable. A series of long islands extends from this point down to the upper ferry above Hinton, W. Va., a distance of about a mile.

At Hinton, on New River, 2 miles below its junction with the Greenbrier, the Weather Bureau has a gage. On this heights are read up to 10 feet by means of a rod fastened to a pier in the river, this being about 50 feet from shore at the time of low water. The heights above 10 feet are read on a rod fastened to a tree on shore. The pier in the stream consists of a wooden crib about 25 feet square and 10 feet high, filled with rock. There are no bridges across New River in this vicinity. This point is one of the widest places on the river, the width being about 1,900 feet. A cable ferry in constant use is located near the railroad station, and there is a second a mile above. It was considered impracticable to attempt river measurement at this point, and the inspection of the river was made down as far as Gauley. The first bridge, that of a small branch coal railroad running up Upper Loop Creek, is at Thurmond, W. Va., and crosses New River diagonally. The river has a restricted channel, and the velocity, especially at high water, is too great for accurate measurement.

The next bridge, that at Fayette, W. Va., 47 miles below Hinton, is well located for measurements. It is a highway bridge of one span, having a total length of 261 feet. A gage was established here July 29, and a measurement of discharge subsequently made. The zero of the gage is opposite the south edge of the second vertical strut from the north end of the bridge, and is 5.20 feet from the pulley. The distance vertically of the zero to the bottom plate of the girder at the end of the first panel on the lower side is 55.06 feet. Two measurements have been made here, the first on July 29, when with a gage height of 4.07 feet the discharge was found to be 7,128 second-feet; the second on September 3, when the water stood at 1.71 feet and the discharge was 3,030 second-feet.

The next bridge below Fayette, that of the Chesapeake and Ohio Railway at Hawksnest, crosses the river diagonally, and the location is not favorable for measurement. At Gauley Junction an iron viaduct crosses New River about 2 miles above the mouth of Gauley River. The channel of the river is narrow and the velocity of the current too great for accurate measurement. Measurements of the Gauley could not be made from the railroad bridge crossing at its mouth owing to the ponding of the water under the bridge.

Daily gage height of New River at Fayette, W. Va., for 1895.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.83	1.90	0.30	0.50	1.80
2	....	2.40	1.85	0.25	0.50	1.70
3	....	2.22	1.87	0.20	0.55	1.75
4	....	1.95	1.72	0.20	0.70	1.10
5	....	1.72	1.65	0.20	1.15	1.20
6	....	1.40	1.65	0.20	1.40	1.40
7	....	1.47	1.70	0.30	1.10	1.85
8	....	1.57	3.45	0.35	0.80	1.05
9	....	2.00	2.95	0.30	0.70	0.50
10	....	1.90	2.05	0.30	0.90	0.75
11	....	2.00	1.60	0.40	0.80	1.25
12	....	2.05	1.65	0.45	1.35	1.40
13	....	2.15	1.55	0.55	1.45	1.50
14	....	2.10	1.35	0.60	2.00	1.75
15	....	2.10	1.15	0.50	1.90	1.10
16	....	2.00	1.00	0.45	1.50	0.80
17	....	1.85	0.95	0.50	1.30	0.65
18	....	1.65	1.10	0.40	1.20	0.55
19	....	6.55	0.95	0.40	1.00	0.40
20	....	6.40	0.90	0.30	1.10	1.30
21	....	4.00	0.80	0.10	1.10	1.10
22	....	4.10	0.55	0.00	0.90	1.30
23	....	3.95	0.50	0.20	1.10	9.75
24	....	5.80	0.45	0.45	1.20	9.40
25	....	4.20	0.45	0.25	1.00	5.80
26	....	3.40	0.40	0.20	1.05	3.90
27	....	2.95	0.40	0.30	0.80	4.15
28	....	3.15	0.35	0.45	0.90	3.00
29	4.12	2.65	0.35	0.40	2.50	2.75
30	3.45	2.60	0.35	0.20	2.00	2.60
31	2.95	3.30	....	0.45	....	2.40

Concerning the water resources of this region Prof. D. C. Humphreys[1] states that the largest power he has seen, and probably the finest in Virginia and West Virginia, is in the canyon of New River, where the fall is over 11 feet per mile and the distance about 64 miles. Taking the results of the smallest measurement, that of September 4, 1895, the total horsepower going to waste in the canyon is 440,000—sufficient to move about 550 trains, to do which with present mechanical appliances would require over 550 tons of coal per hour. This vast power is situated in the midst of one of the finest coal fields in the world, where steam production is cheap, so that the utilization of the water power may be postponed.

ASHEVILLE STATION, ON FRENCH BROAD RIVER.

The French Broad River rises in Western North Carolina and flows northeasterly, crossing the State line into Tennessee, where it empties into Tennessee River. An examination was made from about Asheville down to the State line to determine the best point for making continuous measurements of discharge. The principal points examined were at the bridges at Asheville, at Marshall, 22 miles below, and at Hot Springs, 16 miles farther down.

At Asheville four bridges cross the river. The uppermost of these is located just below the mouth of Swannanoa River, about 1.5 miles above the city. This locality would be desirable for making measurements except for the fact that the current is modified and ponded on the south side by a log boom directly under the bridge. The river has a broad bend to the south above the bridge, tending to throw the greatest velocity toward the north shore during high water. This place can be reached from town by electric cars. The old three-span highway bridge one-fourth of a mile below the railroad station is at a poor section, the bottom being rough and uneven. The railroad four-pier bridge one-fourth of a mile below this is at a still poorer place, and crosses the river diagonally. The Bingham School Bridge, 1.5 miles below town, reached by electric cars, offers the best opportunity for measurement presented by any one of the four bridges, although the bed of the river is rough and rocky. This bridge has three spans, each 91 feet in length. The two piers in the stream are made of cylindrical columns 2 feet in diameter, and thus offer little resistance to the current. It was therefore decided to locate a measuring station at this point, after an inspection of the river as far down as Hot Springs. A measurement of the river was made at this point on September 2, 1895, the water surface being at 4.30 feet, or 16.10 feet below the top and lower end of the second floor beam in the first span from the east. The total discharge was 1,192 second-feet. A second measurement on September 17, at a gage height of 3.22, gave a discharge of 1,006 sec-

[1] "Stream measurements and water power of Virginia and West Virginia," in Journal of the Association of Engineering Societies, November 9, 1895, page 187.

ond-feet. The zero of the rod here is opposite the east edge of the fifth upright of the first span from the east from the upper side. The edge of the pulley is 3 feet from the end of the rod. The length of the wire rope and weight is 26.03 feet.

On September 3 Mr. Babb measured the French Broad at Hot Springs, N. C., 38 miles below Asheville, the water at that time being 22.80 feet below the top of the sixth iron support in the foot rail on the lower side, opposite the middle member of the first truss from the railroad side. The total discharge was ascertained to be 1,359 second-feet. On the same day a measurement was made at Marshall, 16 miles above Hot Springs and 22 miles below Asheville. At that time the water surface was 19.69 feet below the upper end of the second floor beam of the second span from the north side. The discharge was computed to be 1,490 second-feet. The section at this place, however, is poor, the bottom rough, and it is not considered that the results are as accurate as those obtained at Hot Springs.

Daily gage height of French Broad River near Asheville, N. C., for 1895.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	....	2.60	3.30	2.70	17	3.20	2.55	2.67	2.60
2	....	2.60	2.80	2.70	18	3.00	2.55	2.65	2.60
3	....	2.60	2.65	2.70	19	2.85	2.55	2.60	2.70
4	....	2.60	2.60	2.75	20	2.85	2.52	2.65	3.00
5	....	2.60	2.62	2.75	21	2.80	2.50	2.65	*a* 5.40
6	....	2.60	2.62	2.63	22	2.80	2.50	2.60	4.40
7	....	2.60	2.60	2.60	23	2.70	2.50	2.60	3.56
8	....	2.60	3.28	2.65	24	2.72	2.50	2.60	3.40
9	....	2.60	2.98	2.65	25	2.75	2.50	2.60	3.15
10	....	2.60	2.70	2.75	26	2.70	2.52	2.75	3.20
11	....	2.55	3.30	2.75	27	2.63	2.50	3.25	4.50
12	....	2.63	3.02	2.67	28	2.60	2.58	2.85	3.85
13	....	2.55	2.80	2.67	29	2.60	2.55	2.85	3.55
14	....	2.55	2.75	2.65	30	2.60	2.58	2.70	3.70
15	....	2.55	2.73	2.60	31	....	2.70	....	4.30
16	....	2.55	2.70	2.60					

a Heavy rains.

WESTERN NORTH CAROLINA STREAMS.

A reconnoissance of the streams of the western part of North Carolina was made in September, 1895, by Mr. Cyrus C. Babb, in company with Messrs. J. V. Lewis and Edward W. Myers, of the State geological survey. The general route was from Asheville to Clyde, then across the mountains, up the head water of the Tuckaseegee River in Jackson County, N. C., across to the Little Tennessee in Macon County, down the valley of that stream, across to the Nantahalah, and from there down to Murphy on the Hiwassee, in Cherokee County, in the extreme western portion of the State. Pigeon River was measured on September 5, 1895, at a bridge 6 miles below Clyde, N. C. The discharge was ascertained to be 254 second-feet. On September 6 a measurement at Clyde by means of floats gave a result of 159 second-feet.

Measurements of the Tuckaseegee were made at various points, given below in geographic order downstream. At Dillsboro, N. C., a measurement was made September 9, 1895, at the railroad bridge, 1 mile below the town. The section is poor, for the channel is rough and divided into several portions by foundations of an old bridge. The present bridge has two spans. The measured discharge was 399 second-feet. At Whittier, 10 miles below Dillsboro, is a dilapidated highway bridge having three spans with narrow wooden piers. The river, however, is small at this point, and it was decided not to attempt measurements.

The Tuckaseegee at Bryson City, 6 miles below Whittier, is ponded under the highway bridge and is from 12 to 14 feet deep. The maximum velocity on September 6, 1895, was found to be less than 1 foot a second. The railroad bridge over the river 5 miles above Bryson has four spans. The channel is rough and the place is difficult of access. It was decided, therefore, that the locality was not suitable for permanent observations. An examination for a gaging station was made at Bushnell, N. C., 13 miles below Bryson, this being at the mouth of the river. The railroad crosses at this point, but it was found that the section was unfavorable, the bridge crossing on a curve and passing over several islands. The channel under the bridge is obstructed by a number of old foundations and crib work.

The Little Tennessee was measured on September 13, 1895, at Franklin, from the highway bridge, the discharge being 427 second-feet. The section here is fairly good for accurate measurements. On the next day the Nantahalah was measured at Aquone from a covered bridge. The total discharge is 117 second-feet. On September 16 the Nantahalah was again measured, this time at its mouth near Almond, N. C., 6 miles from Bushnell, the meters being used from the railroad bridge crossing at this point. The locality is not very favorable, owing to the diagonal position of the bridge. The total discharge was 187 second-feet. The Little Tennessee was also measured on September 16 at the railroad bridge 4 miles below Almond. The discharge was 750 second-feet. The water surface was 20.15 feet below the top of small triangular casting at the bottom of the first tension member of the second truss from the north end from the lower side of the bridge. This bridge is three-fourths of a mile from the station of Judson.

On September 14 a measurement of the Hiwassee at Murphy gave a discharge of 414 second-feet. This point is suitable for discharge measurements, but a station has not been established, as the locality is one of minor importance.

TEXAS RIVERS.

A number of measurements of Texas rivers were made during November, 1894, and December, 1895, these being described below in geographic order from east to west.

COLORADO RIVER AT AUSTIN.

On December 17, 1895, a measurement was made by Mr. Cyrus C. Babb from the International and Great Northern Railroad bridge.

This is about 3 miles below the Austin dam, across the river, which holds back the greater part of the water. A number of large springs supply the river channel with water below this point. The measured discharge was 507 second-feet. At a point about a mile above the railroad bridge, on the south side of the river, the water from Barton Springs flows into the river channel. The discharge as measured on November 13, 1894, was 17 second-feet, and on December 18, 1895, 25 second-feet. The channel of Barton Creek above the springs was dry each time when measurements were made. There are three well-marked springs, the water being held back at the upper one, the larg est of the three, by a dam. The water of the lowest spring is utilized to furnish power for a small mill. Measurements were made below this spring at a short distance above the mouth of the creek.

A number of large springs occur in and adjacent to the river channel near the dam. The water from one of these springs issues at the east end of the foundation of the dam itself and has been conducted away through a 12-inch pipe. It is discharged from the side wall of the power house into the river below the dam. A number of estimates place the discharge of this spring at 2,800,000 gallons a day, equivalent in round numbers to 4.3 second-feet.

SAN MARÇOS SPRING.

A measurement of San Marcos Spring was made on November 14, 1894, at a point immediately above the railroad bridge at San Marcos, the flow being in round numbers, 150-second-feet. The spring is controlled by means of an old mill dam, water being held back and utilized for furnishing power to a mill and electric-light plant. The second measurement was made by Mr. Cyrus C. Babb on December 19, 1895, early in the morning, after the storage of the previous day above the dam had been drawn down. The gates of the mill were so regulated as to give approximately the average discharge of the springs. The measurement was made in the tailrace, 50 feet below the head gates, this being the only available place, as the water is divided a short distance below for irrigation purposes. This point is about 1 mile northwest of the town of San Marcos. During the day the water is used in part by a grist mill and in part held back, being used during the night for the electric-light plant, which requires more power. The measured discharge was found to be 89 second-feet. This spring is reported to have an annual rise and fall. During March the volume of water increases, and continues to do so until the middle of May, the total rise being about 18 inches. It maintains this level until September, and then gradually falls. Measurements were made during low-water stage. The head at that time on the wheel was 7.5 feet, the summer head being 9 feet. This spring did not rise during 1892, 1893, and 1894, but did rise during 1895. The river is reported to have been 2 feet higher than during past years, the supply having decreased within six or seven years.

COMAL RIVER.

The Comal River was measured on December 20, 1895, by Mr. Cyrus C. Babb, at the highway bridge, one-fourth of a mile from the town of New Braunfels. The current was very swift, the mean velocity being 3.81 feet per second and the maximum velocity 8.73 feet per second. The discharge was 328 second-feet, this being considered the normal flow of the springs. The largest spring is located about 1½ miles above the point of measurement, smaller springs occurring at intervals along the river. This measurement was made about 200 yards below the lower dam and a mile above the junction with the Guadalupe.

SAN ANTONIO AND SAN PEDRO SPRINGS AT SAN ANTONIO.

It is a matter of some difficulty to select the best locality for measurements, on account of the irregular distribution of the springs and of the ditches diverting water. The Upper San Antonio Springs are located about 3 miles north of the city. About one-half mile below this, on San Antonio River, are other springs, most of these being covered by ponded water held back by a dam immediately below the lowest spring. Two ditches, the Alamo on the left or eastern side and the Upper Labor on the opposite side of the river, divert water from the pond thus formed. Half a mile below this dam is another, diverting nearly the entire flow of San Antonio River into the canal of the lower pumping works of the city water supply. The river was measured on December 21, 1895, by Mr. Cyrus C. Babb, at the head of this latter canal, where the water passes under an arch bridge and through a concrete conduit, the amount found being 34.3 second-feet. To this should be added the amount seeping through the dam, about 1.2 second-feet. The Upper Labor ditch, which comes out above the upper dam, was measured 50 feet below its head works, the discharge being found to be 4 second-feet. The Alamo ditch was also measured 50 feet below its head and ascertained to be carrying 2 second-feet. The entire discharge of the San Antonio Springs was ascertained to be a little less than 42 second-feet.

The San Pedro Springs occur in a park about 2 miles westerly from springs just mentioned. A dam has been constructed across the outlet of these springs, and water has been diverted into the San Pedro ditch. The discharge of the San Pedro River on the day given, December 21, 1895, was 2.8 second-feet. There were in San Pedro ditch 6.5 second-feet, giving a total discharge from San Pedro Springs of a little more than 9 second-feet.

SABINAL RIVER.

This stream was measured on December 23, 1895, at a point 1¼ miles west of the town of Sabinal, Tex., at the highway ford about 200 yards below the railroad bridge. No springs occur at this place, but directly under the railroad bridge is a pool of clear water 15 feet deep. The river is dry above this pool, but a small stream was flowing 0.6 second-feet from the lower end of it. Water is pumped from the pool to supply a railroad tank, the estimated amount being at the rate of 8,000 gallons an hour. The water apparently issues from a sand bank in the immediate vicinity. In 1892 and 1893 this pool was 12 feet lower than at the ordinary stage, thus having a greatest depth of only about 3 feet, the ordinary depth, as above stated, being 15 feet. Below this point the river gradually increased in volume.

LEONA RIVER.

The location of the Leona Spring, in the southern suburbs of Uvalde, was visited on December 23, 1895, but was found to be dry, and it was stated that there had been no water in it for two or three years. The Leona River, 1½ miles east of the town of Uvalde, was dry under the railroad bridge, but water issues from the sands, beginning immediately below the bridge. At a point 1½ miles south of the town, at the road crossing, the discharge was found to be 11 second-feet. The Sabinal and Leona are similar streams in that they have no large springs from which the greater part of the water takes its source, but gradually increase in size from about the locality where the line of the Southern Pacific Railroad crosses them, the water apparently seeping from the sands in the bed. At the time visited it was stated that in the hill country, 15 miles to the westward, the Leona was a constant stream throughout the year, but between that point and Uvalde the water disappeared in the sands.

LAS MORAS SPRING.

This spring is located at Fort Clark, near Brackettvile, Tex., 10 miles distant from Spofford, on the Southern Pacific Railroad. A measurement of this spring was made on December 24, 1895, at a point 300 yards below the dam, in the spring, and under the footbridge leading from the village to the military post. The discharge at that time was ascertained to be 21 second-feet. It was stated that usually in April the river rises gradually until in July it is 1 foot higher, falling again through the winter.

SAN FELIPE SPRINGS.

Del Rio has its source in four large springs, the upper one being 2 miles above the railroad bridge, the others being within about 200 yards of the bridge at the town of Del Rio. A measurement of the total discharge was made on December 24, 1895, at a point a short distance below the junction of the two streams issuing from the four main springs. A ditch is diverted from one of these springs above this point, this being ascertained to carry 19 second-feet. The total discharge of the stream below the ditch, at a point 1½ miles east of town and 200 yards below the railroad bridge, was ascertained to be 80 second-feet. The quantity in the ditch added to this gives a total discharge from the springs of 99 second-feet.

List of discharge measurements on various Texas streams.

Date.	Stream.	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1895.				
Dec. 17	Colorado	463	1.10	507
18	Barton Springs	37	0.68	25
19	San Marcos	53	1.68	89
20	Comal	86	3.81	328
21	San Antonio			42
21	San Pedro			9
23	Sabinal			0.6
23	Leona			11
24	Los Moras Spring	51	0.41	21
24	Del Rio Ditch	24	0.79	19
24	San Felipe Spring	40	2.00	80

UPPER MISSOURI RIVER BASIN.

The drainage basin of the Missouri River has been described briefly in the Thirteenth Annual Report, Part III, Irrigation, beginning on page 34, and the results of stream measurements up to 1892 have been given. Most of the old river stations have been abandoned, but measurements of discharge have been carried on at a few points, the work being under the supervision of Prof. A. M. Ryon.

GALLATIN, MADISON, AND JEFFERSON RIVERS.

SALESVILLE STATION, ON WEST GALLATIN RIVER.

A river station was established on West Gallatin River, near Williams's ranch, this being about 16 miles southwest of Bozeman and near a highway bridge crossing the stream about 5 miles south of Salesville. A gage rod was erected in July, 1895, and observations were begun on August 1 by Ira T. Williams, a ranchman living about 600 feet away. The gage is spiked to a tree and is not liable to be washed out. The bench mark consists of a 6-inch spike driven in the top of a stump 5 feet north of the gage post. It is 6.71 feet above the zero of the gage, as lowered 5 feet from the original position. A second bench mark consists of a 6-inch spike driven into the east bridge abutment. This is 9.26 feet above the zero of the gage. The initial point for soundings is on the right bank. In flood the water flows behind the bridge abutments on the right bank, but at other times is confined within the channel. The bed of the stream is composed of bowlders and is not liable to change. The velocity is great, rendering discharge measurements somewhat difficult. The channel is nearly straight, with slight curves both above and below. Two measurements have been made at this point, the first on July 23 and the second on November 29. At the time of the first there was a discharge of 1,153 second-feet, and at the second 398 second-feet. Between these dates several inches of loose material had accumulated. Prof. A. M. Ryon has made a rating table which may be considered as fairly applicable in estimates of the monthly discharge, making allowance for the filling up of the channel.

Two canals are taken out above this station, the West Gallatin Company carrying about 125 second-feet between July 1 and September 15, and the Kleinschmidt carrying about 50 second-feet between July 1 and August 15. In the following table of gage heights 5 feet has been added, as the original observations were made at points below zero. This has been done in order to give plus values and obviate the use of the minus sign.

Although the observer's returns show but little fluctuation in the height of water in the West Gallatin River, it was found that the bottom had filled on an average 0.86 feet in depth for the entire width. Professor Ryon has assumed that the rate of deposition has been constant from July 23 to November 30, and has subtracted from the observer's returns every two weeks an amount equal to this filling, and has called this the probable reading of the gage, assuming that the bottom remained stationary and the gage rod fell.

Daily gage height of the West Gallatin River, above Salesville, Montana, for 1895.

Day.	August.	September.	October.	November.	December.
1	3.65	3.40	3.30	3.20	3.00
2	3.65	3.40	3.40	3.20	2.90
3	3.70	3.40	3.50	3.20	2.70
4	3.60	3.40	3.45	3.15	2.75
5	3.60	3.40	3.40	3.10	2.95
6	3.55	3.40	3.40	3.00	3.10
7	3.55	3.40	3.40	2.90	3.05
8	3.65	3.40	3.40	2.50	3.00
9	3.80	3.40	3.30	3.15	3.00
10	3.70	3.50	3.30	3.10	3.00
11	3.70	3.40	3.30	3.10	3.00
12	3.70	3.40	3.30	3.20	3.00
13	3.70	3.40	3.30	3.20	3.00
14	3.55	3.75	3.30	3.20	2.90
15	3.55	3.60	3.30	3.20	2.90
16	3.50	3.45	3.30	3.20	2.90
17	3.50	3.40	3.30	3.20	2.90
18	3.50	3.35	3.30	3.20	2.90
19	3.50	3.30	3.30	3.10	3.00
20	3.50	3.70	3.25	3.10	3.00
21	3.50	3.50	3.20	3.10	3.00
22	3.50	3.40	3.15	2.80	3.00
23	3.50	3.50	3.10	2.60	(a)
24	3.50	3.50	3.10	2.75	....
25	3.50	3.50	3.10	2.90	....
26	3.45	3.45	3.15	2.90	....
27	3.55	3.40	3.05	3.00	....
28	3.60	3.40	3.10	3.10	....
29	3.55	3.40	3.10	2.95	....
30	3.50	3.30	3.10	2.95	....
31	3.40	....	3.10	....	....

a Valueless, caused by backing up of ice.

Rating table of the West Gallatin River above Salesville, Montana, for 1895.

Gage height.	Discharge in second-feet.	Gage height.	Discharge in second-feet.	Gage height.	Discharge in second-feet.
2.00	384	2.60	589	3.20	990
2.10	400	2.70	645	3.30	1,070
2.20	424	2.80	706	3.40	1,153
2.30	455	2.90	771	3.50	1,237
2.40	493	3.00	840	3.60	1,322
2.50	538	3.10	913		

Estimated discharge of West Gallatin River above Salesville, Mont.

[Drainage area, 860 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
August	1,322	913	1,088	66,899	1.45	1.26
September	1,112	706	835	49,686	1.08	0.97
October	771	474	602	37,016	1.02	0.89
November	645	300	441	26,241	0.72	0.65
December (1 to 23)	424	352	393	24,165	0.67	0.58

BOZEMAN STATION, ON MIDDLE CREEK.

Middle Creek is one of the most important streams on the east side of Gallatin Valley. It is torrential in character, and for the greater part of its length the bottom is covered with bowlders. Professor Ryon, however, succeeded in finding a locality where the stream was narrow and deep, and where measurements of discharge could be made by constructing a temporary bridge. This station was established here on August 3, 1895. The point of measurement is at Middle Creek Canyon, 9 miles from Bozeman and one-eight of a mile above the old sawmill dam on the road from Bozeman. The gage is about half a mile upstream from the point of discharge measurement. The observer is H. S. McElroy, a ranchman, living about 2 miles away. He notes the height of water only once a week. A small footbridge has been placed across the stream for convenience of making discharge measurements. The gage consists of a vertical post 4 inches square, secured to a tree stump, and protected by the latter from the full force of the current. The bench mark consists of a spike driven horizontally into a stump 5 feet high, about 80 feet east of the gage rod. The middle of this spike is at an elevation of 7.03 feet of the gage. Another bench mark consists of an 8-inch bridge spike driven horizontally into a charred stump about 25 feet northeast of the gage. The top of the spike is at an elevation of 3.58 feet. The initial point for sounding is on the left bank. The water moves swiftly on one side; the left bank is low and liable to overflow. The bed of the stream is of gravel and is liable to change. Three measurements have been made: the first on August 3, when the height of water stood at 0.45 and the discharge was 84 second-feet; the second on September 8, at a gage height of 0.22 feet and a discharge of 49 second-feet; the third on October 6, when the gage height was 0.28 feet and the discharge 53 second-feet. From these Professor Ryon has constructed a rating table giving the approximate discharge. The drainage area as measured by him from the topographic atlas sheets is 55 square miles.

Daily gage height and discharge of Middle Creek above Bozeman, Mont., for 1895.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
Aug. 3	0.45	84	Sept. 24	0.30	56
Aug. 6	0.40	72	Oct. 3	0.30	56
Aug. 9	0.30	56	Oct. 6	0.28	53
Aug. 13	0.30	56	Oct. 16	0.20	48
Aug. 16	0.20	48	Oct. 25	0.23	50
Aug. 20	0.25	52	Oct. 30	0.18	46
Aug. 24	0.20	48	Nov. 8	0.15	45
Aug. 27	0.30	56	Nov. 16	0.20	48
Aug. 30	0.20	48	Nov. 23	0.18	46
Sept. 8	0.22	49	Nov. 27	0.15	45
Sept. 10	0.20	48	Dec. 5	*a* 0.70	......
Sept. 17	0.15	45			

a This reading not reliable, as the ice backed up the water.

Estimated discharge of Middle Creek above Bozeman, Mont.

[Drainage area, 55 square miles.]

Month.	Mean discharge in second-feet.	Total for month in acre-feet.	Run-off.	
			Depth in inches.	Second-feet per square mile.
1895.				
August	58	3,566	1.21	1.05
September	50	2,975	1.00	0.90
October	51	3,136	1.06	0.92
November	46	2,737	0.93	0.84

LOGAN STATION, ON GALLATIN RIVER.

This station has been described in Bulletin No. 131, page 16. The gage is under the northeast corner of the railroad bridge of the main line of the Northern Pacific Railroad crossing the Gallatin River. A cable has been placed by Mr. A. P. Davis across the stream, about 300 feet above the railroad bridge. The lower portion of the gage is inclined, and is graduated from 0.6 to 7.1 feet. The vertical portion from 7 feet to 12.3 is spiked to piles. The bench mark consists of the head of a bridge spike driven vertically into the top of the pile stump, to which the lower end of the inclined gage is fastened. This is 0.38 feet below the 2-foot mark on the gage. A second bench mark is the head of a bridge spike driven horizontally into the north end of the pier. It is 7.32 feet above the 2-foot mark. Five measurements of river heights have been made during 1895, and from this a rating table has been constructed. The cross sections of the river show that a small amount of scouring took place between May 11 and June 26, but the measurements of July 29 showed a general return to former conditions.

List of discharge measurements made on Gallatin River at Logan, Mont.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	Nov. 17	A. P. Davis	24	1.11	....	1.82	772
	1895.						
2	Apr. 28	A. M. Ryon	20	2.00	533	2.74	1,461
3	May 11	P. Sieh	20	2.60	630	3.37	2,113
4	June 26	.....do	20	3.45	790	4.17	3,289
5	July 29	A. M. Ryon	20	0.80	346	1.37	477
6	Sept. 28	P Sieh	20	1.20	404	1.83	741

Rating table for the Gallatin River at Logan, Mont., for 1895.

Gage height.	Discharge in second-feet.	Gage height.	Discharge in second-feet.	Gage height.	Discharge in second-feet.	Gage height.	Discharge in second-feet.
0.80	480	1.50	956	2.20	1,690	2.90	2,546
0.90	530	1.60	1,048	2.30	1,806	3.00	2,676
1.00	586	1.70	1,146	2.40	1,924	3.10	2,808
1.10	648	1.80	1,248	2.50	2,044	3.20	2,942
1.20	716	1.90	1,354	2.60	2,168	3.30	3,078
1.30	790	2.00	1,464	2.70	2,292	3.40	3,216
1.40	870	2.10	1,576	2.80	2,418	3.50	3,356

Daily gage height of Gallatin River at Logan, Mont., for 1895.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	1.40	1.70	2.35	2.50	3.15	0.80	1.10	1.30	1.20	1.00
2	......	1.30	1.70	2.40	2.40	2.90	0.80	1.10	1.30	1.20	1.00
3	......	1.40	1.60	2.45	2.40	2.85	0.70	1.10	1.20	1.10	1.00
4	......	1.40	1.60	2.50	2.50	2.65	0.60	1.10	1.20	1.10	0.90
5	......	1.40	1.60	2.40	2.65	2.50	0.50	1.00	1.20	1.10	0.90
6	......	1.30	1.60	2.40	2.70	2.40	0.40	1.00	1.20	1.10	0.90
7	......	1.30	1.60	2.55	2.85	2.25	0.40	1.00	1.20	1.10	0.90
8	......	1.20	1.60	2.75	2.75	2.10	0.40	1.00	1.10	1.10	1.00
9	......	1.20	1.50	2.80	2.75	1.85	0.40	1.00	1.10	1.10	1.00
10	......	1.20	1.50	2.50	2.70	1.55	0.40	1.00	1.10	1.10	1.00
11	......	1.20	1.50	2.50	2.60	1.40	0.50	1.10	1.10	1.10	1.10
12	......	1.20	1.50	2.50	2.60	1.40	0.50	1.10	1.10	1.20	1.10
13	......	1.20	1.40	2.50	2.60	1.40	0.60	1.10	1.20	1.20	1.10
14	......	1.20	1.50	2.70	2.50	1.30	0.60	1.10	1.20	1.30	1.10
15	......	1.20	1.50	2.80	2.40	1.20	0.90	1.20	1.20	1.30	1.00
16	......	1.20	1.50	2.80	2.40	1.20	0.90	1.20	1.10	1.30	1.00
17	......	1.20	1.60	2.70	2.85	1.20	0.90	1.20	1.10	1.30	1.00
18	......	1.20	1.60	2.70	2.90	1.15	0.80	1.30	1.10	1.30	1.00
19	......	1.20	1.60	2.80	2.80	1.10	0.80	1.30	1.10	1.30	(a)
20	......	1.20	1.60	3.15	2.90	1.10	0.90	1.30	1.20	1.20	....
21	......	1.10	1.60	3.65	3.00	0.95	0.90	1.30	1.20	1.20	....
22	......	1.10	1.60	3.65	3.30	0.90	0.90	1.20	1.10	1.20	....
23	......	1.10	1.70	3.30	3.75	0.90	0.90	1.20	1.10	1.20	....
24	1.80	1.10	1.80	3.20	3.90	0.90	0.90	1.30	1.10	1.20	....
25	1.80	1.10	1.90	3.05	3.85	0.80	0.90	1.30	1.10	1.10	....
26	1.60	1.20	2.00	3.05	3.45	0.80	0.90	1.30	1.10	1.10	....
27	1.40	1.30	2.00	3.35	3.25	0.70	1.00	1.30	1.10	1.10	....
28	1.50	1.60	2.10	3.25	3.45	0.80	1.00	1.30	1.10	1.00	....
29	......	1.80	2.20	2.90	3.50	0.80	1.10	1.30	1.10	1.00	....
30	......	1.80	2.20	2.70	3.20	0.75	1.10	1.30	1.10	1.00	....
31	......	1.70	......	2.60	......	0.70	1.10	......	1.20	......	....

a River frozen.

Estimated discharge of Gallatin River at Logan, Mont.

[Drainage area, 1,620 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
March	....	....	*a* 950	58,413	0.68	0.59
April	1,656	953	1,162	69,084	0.80	0.72
May	3,548	1,814	2,407	148,001	1.71	1.48
June	3,904	1,866	2,537	150,962	1.74	1.56
July	2,868	436	1,051	64,623	0.79	0.69
August	664	352	480	29,514	0.35	0.30
September	826	592	722	42,962	0.49	0.44
October	826	664	702	43,164	0.49	0.43
November	826	592	712	42,367	0.49	0.44
December	664	528	610	37,507	0.44	0.38

a Approximate.

THREEFORKS STATION, ON MADISON RIVER.

A description of this station has been given in Bulletin No. 131, page 20. The gage is at the bridge of the Northern Pacific Railroad Company, one-half mile from the town of Threeforks. The greater part of the discharge of the river flows under this bridge, but there are a number of small side channels branching off at points above through which some water flows, especially in time of flood. The Madison River has a very steady discharge, and for this reason it is very difficult to assure attention on the part of observers. According to the report, there was no change from July 26 to November 1.

List of discharge measurements made on Madison River at Threeforks, Mont.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1893.						
1	Aug. 24	F. H. Newell	24	0.30	582	2.15	1,251
	1894.						
2	Nov. 4	A. P. Davis	24	0.57	751	1.99	1,494
	1895.						
3	May 12	P. Sieh	20	0.80	964	3.28	3,114
4	June 27	.....do	20	1.00	941	3.49	3,287
5	July 30	A. M. Ryon	20	0.10	780	2.18	1,693
6	...do	P. Sieh	20	0.10	780	2.18	1,695
7	Sept. 29	.....do	20	—0.10	723	1.99	1,440

Daily gage height of Madison River at Threeforks, Mont., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	......	0.50	0.50	0.50	0.80	0.80	0.65	—0.10	—0.10	—0.10	0.03	0.80
2..	......	0.50	0.50	0.50	0.80	0.70	0.60	—0.10	—0.10	—0.10	0.03	0.75
3..	......	0.50	0.50	0.50	0.80	0.70	0.60	—0.10	—0.10	—0.10	0.00	0.65
4..	......	0.50	0.50	0.50	0.80	0.80	0.50	—0.10	—0.10	—0.10	0.00	0.55
5..	0.96	0.50	0.50	0.50	0.80	0.80	0.40	—0.10	—0.10	—0.10	0.00	0.50
6..	*a*0.60	0.50	0.50	0.50	0.80	0.90	0.40	—0.10	—0.10	—0.10	0.10	0.75
7..	0.60	0.50	0.50	0.50	0.80	0.90	0.40	—0.10	—0.10	—0.10	0.10	1.10
8..	0.50	0.50	0.50	0.50	0.80	0.90	0.40	—0.10	—0.10	—0.10	0.25	(*d*)
9..	0.50	0.50	0.50	0.50	0.80	0.90	0.30	—0.10	—0.10	—0.10	0.55	......
10.	0.50	0.50	0.50	0.50	0.80	0.90	0.30	—0.10	—0.10	—0.10	0.65	......
11.	0.50	0.50	0.50	0.50	0.80	0.95	0.30	—0.10	—0.10	—0.10	0.75	......
12.	0.50	0.50	0.50	0.50	0.80	1.00	0.30	—0.10	—0.10	—0.10	0.85	......
13.	0.50	0.50	0.50	0.50	0.80	1.05	0.30	—0.10	—0.10	—0.10	0.95	......
14.	0.50	0.50	0.50	0.50	0.80	1.10	0.30	—0.10	—0.10	—0.10	1.00	......
15.	0.50	0.50	0.50	0.45	0.85	1.10	0.30	—0.10	—0.10	—0.10	0.80	......
16.	0.50	0.50	0.50	0.40	0.90	1.10	0.20	—0.10	—0.10	—0.10	0.50	......
17.	0.50	0.50	0.50	0.40	0.90	1.10	0.20	—0.10	—0.10	—0.10	0.40	......
18.	0.50	0.50	0.50	0.30	0.90	1.10	0.10	—0.10	—0.10	—0.10	0.35	......
19.	0.50	0.50	0.50	0.30	0.90	1.00	0.10	—0.10	—0.10	—0.10	0.30	......
20.	0.50	0.50	0.50	0.30	0.95	1.00	0.10	—0.10	—0.10	—0.03	0.30	......
21.	0.50	0.50	0.50	0.30	1.15	0.95	0.10	—0.10	—0.10	—0.03	0.30	......
22.	0.50	0.50	0.50	0.30	1.30	0.90	0.10	—0.10	—0.10	—0.03	0.75	......
23.	0.50	0.50	0.50	0.30	1.30	0.90	0.05	—0.10	—0.10	—0.03	0.90	......
24.	0.50	0.50	0.50	0.30	1.30	0.90	0.05	—0.10	—0.10	—0.03	1.00	......
25.	0.50	0.50	0.50	0.30	1.30	0.95	(*c*)	—0.10	—0.10	—0.03	1.05	......
26.	0.50	0.50	0.50	0.30	1.30	1.00	......	—0.10	—0.10	—0.03	1.10	......
27.	0.50	0.50	0.50	0.30	1.30	1.00	......	—0.10	—0.10	—0.03	1.15	......
28.	*a*0.50	0.50	*b*0.80	0.45	1.25	1.00	......	—0.10	—0.10	—0.03	1.20	......
29.	0.50	......	0.70	0.65	1.05	1.00	......	—0.10	—0.10	—0.03	1.05	......
30.	0.50	......	0.50	0.80	0.90	0.85	......	—0.10	—0.10	—0.03	0.85	......
31.	0.50	......	0.50	......	0.80	......	......	—0.10	......	—0.03	......	......

a River frozen at this height.
b Ice going out of river.
c Water below gage.
d Water backed up by ice.

Estimated discharge of Madison River at Threeforks, Mont.

[Drainage area 2,420 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	....	....	*a* 2,310	142,098	1.09	0.95
February	....	....	*a* 2,310	128,291	0.99	0.95
March	....	....	*a* 2,310	142,098	1.09	0.95
April	2,880	1,980	2,214	131,742	1.02	0.92
May	3,880	2,880	3,166	200,880	1.50	1.30
June	3,480	2,680	3,163	188,212	1.45	1.30
July	2,680	1,440	1,882	121,930	0.90	0.78
August	....	....	*a* 1,440	94,752	0.69	0.60
September	....	....	*a* 1,440	85,686	0.67	0.60
October	....	....	*a* 1,541	100,962	0.78	0.68
November	....	....	*a* 1,500	89,256	0.69	0.62
December	....	....	*a* 1,500	92,231	0.72	0.62

a Approximate.

SAPPINGTON STTAION, ON JEFFERSON RIVER.

This station has been described in Bulletin No. 131, on page 22. Measurements have been continued at this point by Prof. A. M. Ryon and his assistant, Mr. Peter Sieh. The results, however, have not been sufficiently detailed to afford material for constructing a rating table or for making estimates of the monthly flow. On April 28, 1895, Professor Ryon found that the entire bridge abutment had been rebuilt, destroying not only the old gage but also both bench marks. He reset the gage in a vertical position, fastening it to the crib work forming the middle pier of the Northern Pacific Railroad bridge, one-fourth of a mile north of Sappington Station. One bench mark consists of a 6-inch wire nail driven horizontally in the east side of the blocking which forms the south abutment of the railroad bridge. It is level with the 6.9-foot mark of the gage. The second bench mark is a 6-inch wire nail driven horizontally into a telegraph pole about 30 feet south and east of the south abutment of the bridge. This nail is at the elevation of the 7-foot mark. The observations are of doubtful value, as they have not agreed with the heights noted by the assistant hydrographer. The cable at this point is short, allowing the box to touch the water at high stages, so that measurements can not be made during floods.

List of discharge measurements made on Jefferson River at Sappington, Mont.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1889.						
a	Aug. 19	J. B. Williams	103	....	107	1.89	*a* 202
b	Oct. 15	.....do	105	....	154	2.16	*b* 333
	1893.						
c	Aug. 24	F. H. Newell	24	....	442	1.83	*c* 808
	1894.						
1	Nov. 14	A. P. Davis	24	1.08	732	2.67	1,952
	1895.						
3	July 31	P. Sieh	20	0.80	558	2.02	1,028
4	Nov. 30	.....do	20	0.95	602	1.99	1,200

a Measurements made at Willow Creek, 20 miles above Threeforks.
b Measurements made 4 miles from Threeforks.

TOWNSEND STATION, ON MISSOURI RIVER.

This locality is described in Bulletin No. 131, page 22. The Missouri River Commission has maintained observations of river height at this point during 1895, and the copy of the record has been obtained from Capt. J. C. Sanford, secretary of the Commission. In this the elevations are referred to sea level, but the first two figures have been dropped. The figures 3,300 should be added to the heights given in the following table to give the true elevation. On June 29, 1895, a measurement was made by Mr. Peter Sieh at the wagon bridge 1 mile north of Townsend and a short distance below the railroad bridge. At the time the water stood at a height of 91.05 feet and the discharge was 10,699 second-feet.

List of discharge measurements made on Missouri River at Townsend, Mont.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1893.						
1	Aug. 25	F. H. Newell	24	88.75	1,352	2.22	3,008
	1894.						
2	Nov. 18	A. P. Davis	24	89.00	1,546	2.44	3,766
3	June 29	P. Sieh	20	91.05	2,290	4.67	10,699

Daily gage height of the Missouri River at Townsend, Mont., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	*a*90.60	91.40	91.60	89.20	90.80	90.80	91.00	88.80	88.60	88.80	88.80	88.60
2...	91.20	91.40	91.60	89.20	90.80	90.80	90.90	88.80	88.60	88.80	88.80	88.60
3...	91.20	91.40	91.60	89.20	90.80	90.90	90.80	88.80	88.60	88.80	88.80	88.60
4...	91.20	91.40	91.60	89.10	90.80	91.00	90.60	88.80	88.60	88.80	88.80	*b*91.60
5...	91.20	91.40	91.60	89.00	90.80	91.10	90.50	88.80	88.60	88.80	88.80	91.60
6...	91.20	91.40	91.60	89.00	90.80	91.20	90.40	88.80	88.60	88.80	88.80	91.60
7...	91.40	91.40	91.40	89.00	90.90	91.20	90.40	88.80	88.60	88.80	88.70	91.60
8...	91.60	91.40	91.40	89.00	91.00	91.20	90.40	88.80	88.60	88.80	88.60	*c*95.40
9...	91.60	91.40	90.30	89.00	91.00	91.20	90.20	88.80	88.70	88.80	88.60	95.60
10..	91.60	91.40	89.00	89.20	91.00	91.20	90.10	88.70	88.80	88.80	88.60	95.50
11..	91.60	91.40	89.00	89.20	91.00	91.10	89.90	88.70	88.80	88.80	88.70	95.40
12..	91.60	91.40	89.60	89.20	91.20	91.20	89.70	88.60	88.80	88.80	88.80	95.40
13..	91.60	91.40	*d*92.80	89.20	91.00	91.30	89.60	88.60	88.80	88.80	88.80	90.40
14..	91.60	91.40	92.80	89.20	90.80	91.40	89.50	88.60	88.80	88.80	88.80	90.40
15..	91.60	91.40	92.80	89.40	90.80	91.40	89.40	88.60	88.80	88.80	88.80	90.40
16..	91.60	91.40	92.80	89.60	90.90	91.30	89.40	88.60	88.80	88.80	88.80	*e*91.60
17..	91.60	91.60	93.00	89.60	91.00	91.20	89.40	88.50	88.80	88.80	88.80	92.40
18..	91.60	91.70	93.00	89.70	91.00	91.10	89.30	88.40	88.80	88.80	88.80	92.40
19..	91.60	91.80	89.00	89.70	91.10	90.80	89.20	88.40	88.80	88.80	88.80	92.40
20..	91.40	91.80	88.90	89.80	91.20	90.80	89.20	88.40	88.80	88.80	88.80	92.40
21..	91.40	91.80	88.80	89.80	91.50	90.90	89.10	88.40	88.80	88.80	88.80	92.40
22..	91.40	92.00	88.80	89.80	91.90	91.10	89.00	88.40	88.80	88.80	88.80	92.30
23..	91.40	92.00	88.80	89.80	91.80	91.00	89.00	88.40	88.80	88.80	88.70	92.20
24..	91.40	92.00	88.80	89.90	91.60	91.00	89.00	88.40	88.80	88.80	88.60	92.20
25..	91.40	92.00	89.00	90.00	91.40	91.00	88.90	88.40	88.80	88.80	88.60	92.20
26..	91.40	91.80	89.20	90.20	91.40	91.00	88.80	88.40	88.80	88.80	88.60	92.20
27..	91.40	91.70	89.40	90.40	91.20	91.00	88.80	88.40	88.80	88.80	88.60	92.20
28..	91.40	91.60	89.60	90.40	91.20	91.00	88.80	88.40	88.80	88.80	88.60	92.20
29..	91.40	....	89.60	90.50	91.20	91.00	88.80	88.50	88.80	88.80	88.60	92.20
30..	91.40	....	89.60	90.70	91.00	91.00	88.80	88.50	88.80	88.80	88.60	92.20
31..	91.40	....	89.40	....	90.90	....	88.80	88,60	....	88.80	....	92.20

a Ice readings, January 1 to March 8, inclusive.
b Ice readings, December 4 to 11, inclusive.
c Gorges, December 8 to 11.
d Ice readings, March 13 to 18, inclusive.
e Ice readings, December 16 to 31.

SHERIDAN STATION, ON BIG GOOSE CREEK.

The discharge of Big Goose Creek at the bridge, in the northern part of Sheridan, Wyo., at the crossing of Fifth avenue, has been measured by Mr. E. Gillette, the superintendent of water division No. 2 of Wyoming. On September 1, 1895, he found a discharge of 275 second-feet, and he estimates the average discharge for August and September as approximately this amount. The total width at the time of measurement was 57.8 feet, and the greatest depth 2.2 feet. The fall of the creek was about 2 feet in a thousand, and the value of n in Kutter's formula was 0.025. The amount of water at this place represents the waste or surplus from irrigation systems above. There are a few small ditches below, but in the main the valley is narrow and bounded by "bad lands."

Daily gage height of the Big Goose Creek at Sheridan, Wyo., for 1895.

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1..........	2.40	2.30	2.50	2.50	17..........	2.20	2.10	2.50	....
2..........	2.30	2.30	2.50	2.40	18..........	2.20	2.20	2.50	....
3..........	2.40	2.20	2.60	2.40	19..........	2.30	2.20	2.50	....
4..........	2.50	2.20	2.70	2.50	20..........	2.40	2.20	2.50	....
5..........	2.50	2.30	2.60	2.50	21..........	2.10	2.40	2.50	....
6..........	2.40	2.20	2.60	2.60	22..........	2.20	2.30	2.40	....
7..........	2.30	2.30	2.60	2.60	23..........	2.10	2.40	2.40	....
8..........	2.20	2.20	2.70	2.70	24..........	2.20	2.50	2.40	....
9..........	2.20	2.30	2.60	2.70	25..........	2.20	2.50	2.50	....
10..........	2.20	2.30	2.60	....	26..........	2.10	2.50	2.40	....
11..........	2.20	2.20	2.60	....	27..........	2.50	2.50	2.50	....
12..........	2.20	2.20	2.60	....	28..........	2.30	2.50	2.50	....
13..........	2.20	2.20	2.50	....	29..........	2.30	2 50	2.60	....
14..........	2.20	2.20	2.60	....	30..........	2.20	2.50	2.50	....
15..........	2.20	2.20	2.50	....	31..........	2.30	....	2.50	....
16..........	2.20	2.10	2.50	....					

PLATTE BASIN.

The drainage basin of the Platte River occupies the southeastern portion of Wyoming, the central and northeastern part of Colorado, and about one-half of the area of Nebraska. It has been described at some length in the Thirteenth Annual Report of this Survey, Part III, Irrigation, pages 73 to 91, where are given diagrams of discharge at various points and a general map of the basin. The main river is formed by the junction of the North Platte and South Platte in the western-central part of Nebraska. At this point the north river, as regards volume, is by far the larger, the waters of the south river being diverted for irrigation to a relatively greater extent than those of the other branch.

NORTH PLATTE RIVER.

The drainage areas tributary to North Platte River have been estimated by measurements made by means of a planimeter from the land office maps of Wyoming, Colorado, and Nebraska. At the head waters these catchment areas can be outlined with a considerable degree of precision, but after the rivers leave the mountains and begin to cross the plains the dividing lines between the various catchment basins become less and less defined, flattening out into broad areas over which it is difficult, if not impossible, to determine in which way the water flows. For this reason the figures showing the extent of the drainage area of the plains streams are rarely given twice alike by different authorities, each person exercising his judgment as to how much or how little should be included within the catchment basin.

Drainage area of North Platte.

	Square miles.
In Colorado	1,696
Above Sweetwater River	7,668
Below mouth of Sweetwater River (Sweetwater, 2,929)	10,597
Above Douglas, Wyo	14,255
Above Orin Junction, Wyo	14,828
Above Fort Laramie, Wyo	16,416
Below Laramie River (Laramie, 4,076)	20,492
In Wyoming and Colorado	23,643
To North Platte, Nebr	28,517

Laramie River.

Above Woods Landing, Wyo. (of this 343 square miles in Colorado)	435
Above Uva, Wyo. (of this 428 square miles in Colorado)	3,179
Above Fort Laramie (mouth of river, not including 500 square miles of lost drainage to James Lake, Cooper Lake, etc.)	4,076

WOODS LANDING STATION, ON LARAMIE RIVER.

This station has been described in Bulletin No. 131, on page 28. Observations of river height at this point have been continued during the greater part of 1895, and a number of discharge measurements made at intervals. There has not been a sufficient number of measurements, however, to give means for computing the monthly discharge at this point.

List of discharge measurements made on Laramie River at Woods Landing, Wyo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	Sept. 27	W. M. Gilcrest	....	....	....	....	a 27
2	Sept. 28	.....do	....	....	....	....	b 57
3	Nov. 3	.....do	104	....	....	1.47	c 80
	1895.						
4	May 24	.....do	104	2.80	238	4.74	1,129
5	Oct. 23	.....do	....	0.80	41	1.19	49

a Measurement made at Laramie City, Wyo. Biennial report of State engineer of Wyoming, 1894, p. 25.
b Measurement at Woods Landing.
c This result of doubtful value, as meter was not in good order.

Daily gage height of Laramie River at Woods Landing, Wyo., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	1.05	2.35	3.10	2.40	1.35	1.00	0.60	0.80
2	1.00	2.25	3.20	2.20	1.35	1.00	0.60	0.80
3	1.00	2.35	3.20	2.20	1.40	0.90	0.65	0.80
4	1.15	2.15	3.15	2.10	1.25	0.80	0.80	0.80
5	1.10	2.05	3.20	2.20	1.20	0.80	1.00	0.90
6	1.20	2.15	3.25	1.95	1.20	0.70	1.00	0.90
7	1.25	2.15	3.40	1.80	1.20	0.70	1.10	0.80
8	1.15	2.60	3.20	1.85	1.15	0.75	0.95	0.80
9	1.20	3.65	3.35	1.70	1.25	0.75	0.90	0.80
10	1.15	3.30	3.75	1.75	1.15	0.80	0.80	0.90
11	1.20	3.15	3.50	1.85	1.05	0.80	0.80	0.85
12	1.25	3.55	3.55	2.00	1.00	0.80	0.70	0.80
13	1.35	3.45	3.40	1.95	1.00	0.75	0.70	0.80
14	1.40	3.30	3.45	2.00	1.00	0.70	0.70	0.75
15	1.30	3.55	3.45	1.90	1.00	0.65	0.70	0.80
16	1.40	3.30	3.50	1.70	1.00	0.70	0.70	0.70
17	1.50	3.00	3.20	1.65	1.00	0.65	0.75	0.70
18	1.60	2.85	3.05	1.45	1.00	0.65	0.70	0.80
19	1.75	2.85	2.85	1.50	0.90	0.63	0.70	0.80
20	1.55	3.05	2.75	1.50	0.90	0.60	0.75	0.80
21	1.55	3.25	2.70	1.50	0.90	0.60	0.75	....
22	1.60	3.25	2.55	1.50	0.90	0.65	0.75	....
23	1.65	3.30	2.60	1.50	0.90	0.60	0.75	....
24	1.75	3.30	2.65	1.40	0.90	0.60	0.60	....
25	1.85	3.10	2.60	1.35	0.90	0.60	0.60	....
26	2.15	2.80	2.55	1.25	0.90	0.60	0.60	....
27	2.25	3.00	2.45	1.20	0.95	0.60	0.60	....
28	....	3.45	2.55	1.20	1.05	0.60	0.60	....
29	2.65	3.15	2.65	1.20	1.10	0.60	0.70	....
30	2.65	3.10	2.50	1.30	1.20	0.60	0.70	....
31	....	3.00	....	1.35	1.15	....	0.70	....

UVA STATION, ON LARAMIE RIVER.

Occasional measurements have been made at the railroad bridge at Uva, and observations of river height were maintained from April 22 to November 20, 1895. In the biennial report of the State engineer of Wyoming for 1894, on page xxv, results of measurements of Laramie River are given. On August 20, 1894, the discharge near Fort Laramie, as measured by John Hunton, was 51 second-feet, and on October 7, 1894, it was 23 second-feet, these measurements being in addition to those given in the following list:

List of discharge measurements made on Laramie River at Uva, Wyo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second.)	Discharge (second-feet).
	1894.						
1	June 6	W. M. Gilcrest..	....	....	....	....	a 1,845
2	Oct. 24	.....do...........	104	....	7	2.06	14
	1895.						
3	June 14	.....do...........	Floats.	4.75	438	4.04	1,417
4	July 15	.....do...........	(b)	1.60	87	1.65	146
5	Sept. 27	.....do...........	(b)	0.75	4	1.51	6

a Biennial report of State engineer of Wyoming, 1894, p. xxv.
b Measurements made with small Price acoustic meter.

Daily gage height of Laramie River at Uva, Wyo., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	....	2.90	4.90	2.40	1.30	0.85	0.75	0.85
2	....	3.20	5.30	2.80	1.20	0.85	0.75	0.85
3	....	3.60	5.90	2.65	1.30	0.85	0.75	0.85
4	....	3.40	5.60	2.50	1.20	0.85	0.75	0.85
5	....	3.70	5.70	2.40	1.20	0.80	0.75	0.85
6	....	3.20	5.20	2.40	1.40	0.80	0.80	0.85
7	....	2.90	4.80	2.30	1.25	0.80	0.80	0.85
8	....	2.60	4.50	2.15	1.20	0.80	0.80	0.90
9	....	2.40	4.30	2.20	1.20	0.80	0.80	0.90
10	....	2.40	4.80	1.80	1.00	0.80	0.80	0.90
11	....	2.60	4.80	1.65	1.00	0.80	0.80	0.90
12	....	3.10	4.80	1.60	1.00	0.80	0.85	0.90
13	....	3.20	4.80	1.50	1.00	0.80	0.85	0.90
14	....	3.10	4.75	1.50	1.00	0.80	0.85	0.85
15	....	3.00	4.50	1.60	1.00	0.80	0.85	0.85
16	....	2.90	4.40	2.10	0.95	0.80	0.85	0.85
17	....	3.10	4.20	2.00	0.95	0.80	0.85	0.85
18	....	3.40	4.20	1.90	0.95	0.80	0.85	0.85
19	....	3.30	4.00	1.60	0.95	0.75	0.85	0.90
20	....	3.10	3.90	1.55	0.90	0.75	0.85	0.90
21	....	2.90	3.70	1.40	0.90	0.75	0.85	....
22	1.90	3.00	3.40	1.30	0.85	0.75	0.85	....
23	1.80	3.10	3.10	1.30	0.85	0.75	0.85	....
24	1.90	2.90	2.85	1.25	0.85	0.75	0.85	....
25	2.20	3.20	2.65	1.25	0.85	0.75	0.85	....
26	2.00	3.40	2.60	1.20	0.85	0.75	0.85	....
27	1.90	3.20	2.40	1.20	0.85	0.75	0.85	....
28	2.10	3.10	2.30	1.20	0.85	0.75	0.85	....
29	2.40	3.40	3.00	1.15	0.85	0.75	0.85	....
30	3.00	3.50	2.50	2.10	0.85	0.75	0.85	....
31	....	4.50	....	1.60	0.85	....	0.85	....

Rating table for Laramie River at Uva, Wyo.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
0.6	3	1.7	165	2.8	475	3.8	870
0.7	10	1.8	190	2.9	510	3.9	930
0.8	15	1.9	220	3.0	542	4.0	970
0.9	20	2.0	245	3.1	575	4.1	1,025
1.0	33	2.1	265	3.2	620	4.2	1,075
1.1	45	2.2	300	3.3	660	4.3	1,130
1.2	58	2.3	325	3.4	700	4.4	1,190
1.3	70	2.4	350	3.5	740	4.5	1,250
1.4	91	2.5	380	3.6	780	4.6	1,310
1.5	125	2.6	410	3.7	833	4.7	1,370
1.6	146	2.7	446				

Estimated discharge of Laramie River at Uva, Wyo.

[Drainage area, 3,179 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
April (22 to 30)	542	190	283	16,840	0.10	0.09
May	1,250	350	605	37,200	0.22	0.19
June	(a)	380	....	....	....	....
July	475	52	196	12,052	0.07	0.06
August	91	18	36	2,214	0.01	0.01
September	18	13	15	892	....	....
October	18	13	17	1,045	....	....
November (1 to 20)	20	18	19	1,130	....	....

a Measurements at high water have not been obtained sufficient for the estimation of the June discharge.

ORIN STATION, ON NORTH PLATTE RIVER.

This station has been described in Bulletin No. 131, on page 29. Observations were continued at this point during 1895, and measurements of discharge were made as shown in the following table:

List of discharge measurements made on North Platte River at Orin Junction, Wyo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	May 8	E. Mead					a 6,823
2	June 7	.....do					12,823
3	Aug. 15	C. Johnson					816
4	Oct. 26	W. M. Gilcrest	104			1.42	b 502
	1895.						
5	June 27	.....do	(c)	3.80	959	4.29	4,110
6	July 17	.....do	(c)	2.90	769	3.20	2,475
7	Sept. 26	.....do	(c)	0.65	258	1.97	508

a Biennial report of State engineer of Wyoming, 1894, p. xxv.
b This result of doubtful value, as meter was not in good order.
c Measurements made with small Price acoustic meter.

Rating table for North Platte River at Orin Junction, Wyo.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
0.1	280	1.2	820	2.3	1,780	3.4	3,310
0.2	315	1.3	880	2.4	1,890	3.5	3,525
0.3	350	1.4	958	2.5	1,990	3.6	3,760
0.4	390	1.5	1,025	2.6	2,100	3.7	4,000
0.5	425	1.6	1,105	2.7	2,215	3.8	4,240
0 6	480	1.7	1,195	2.8	2,345	3.9	4,475
0.7	522	1.8	1,270	2.9	2,480	4.0	4,720
0.8	580	1.9	1,358	3.0	2,615	4.1	5,000
0.9	635	2.0	1,460	3.1	2,760	4.2	5,280
1.0	695	2.1	1,560	3.2	2,940		
1.1	760	2.2	1,675	3.3	3,110		

Daily gage height of North Platte River at Orin Junction, Wyo., for 1895.

Day.	Jan.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1 ..	1.00	2.20	5.55	5.22	3.87	2.10	....	0.92	0.90
2 ..	1.00	1.85	5.45	....	3.80	1.97	0.90	0.95	0.90
3 ..	1.00	1.52	5.10	6.15	3.80	1.85	0.90	0.95	....
4 ..	1.00	1.57	4.25	6.10	3.75	....	0.90	0.95	0.85
5 ..	1.00	1.95	....	5.65	3.67	2.50	0.90	1.00	0.87
6 ..	(a)	2.00	4.55	5.45	3.45	2.22	0.90	....	0.97
7 ..	....	....	4.25	5.25	....	2.07	1.00	0.97	1.00
8 ..	....	2.00	4.05	4.95	3.05	1.87	....	0.95	1.00
9 ..	....	2.00	3.97	....	2.90	1.82	0.90	0.97	1.00
10 .	....	2.00	4.05	4.85	2.82	1.67	0.85	1.00	....
11 .	....	2.55	4.20	4.85	2.67	....	0.80	1.00	1.00
12 .	....	2.75	....	4.80	2.57	1.47	0.72	1.00	1.00
13 .	....	2.65	4.95	5.05	2.47	1.42	0.70	....	1.00
14 .	....	....	4.75	4.90	....	1.40	0.70	1.00	1.00
15 .	....	3.60	4.45	4.80	2.55	1.40	....	0.97	1.00
16 .	....	3.85	4.52	....	2.95	1.35	0.65	0.95	1.00
17 .	....	3.85	4.55	4.72	2.92	1.32	0.60	0.95	....
18 .	....	4.05	4.65	4.57	2.80	....	0.55	0.95	1.00
19 .	....	3.90	....	4.47	2.62	1.27	0.55	0.92	1.25
20 .	....	3.65	4.45	4.37	2.40	1.22	0.50	....	1.25
21 .	....	....	4.37	4.27	....	1.20	0.50	0.90	....
22 .	....	3.90	4.35	4.17	2.17	1.20	....	0.90	....
23 .	....	4.15	4.37	....	2.07	1.20	0.55	0.90	....
24 .	....	4.22	4.62	3.87	2.00	1.17	0.55	0.87	....
25 .	....	4.05	4.65	3.80	2.00	....	0.60	0.85	....
26 .	....	3.85	....	3.80	2.00	1.05	0.65	0.87	....
27 .	....	3.85	4.50	3.80	1.97	1.00	0.70	....	....
28 .	....	....	4.45	3.82	....	0.95	0.77	0.90	....
29	....	4.25	4.55	3.80	1.95	0.95	....	0.90	....
30 .	....	5.45	4.67	....	1.95	0.95	0.87	0.90	....
31 .	....	....	5.05	....	1.92	0.92	....	0.90	....

a River frozen from January 6 to March 31, inclusive.

Estimated discharge of North Platte River at Orin Junction, Wyo.

[Drainage area, 14,828 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July...........	4,405	1,378	2,397	147,386	0.18	0.16
August.........	1,990	647	1,038	63,821	0.08	0.07
September.....	635	425	544	32,370	0.04	0.04
October.........	695	608	657	33,449	0.06	0.05
November	695	608	695	41,355	0.06	0.05

NORTH PLATTE STATION, ON NORTH PLATTE RIVER.

Mention has been made of this station on page 30 of Bulletin No. 131. The measurements at this point have been under the charge of Mr. Charles P. Ross. Before the station was established a number of measurements of the quantity of water in the stream were made by topographers of this Survey. These are given in the table below, in connection with those made during 1895.

All of the discharge measurements have been made from the wagon bridge 1 mile north of the town of North Platte, this bridge being in section 28, T. 14 N., R. 30 W. It is a long, low, pile bridge, having 87 spans of approximately 20 feet each, crossing the main channel of the river. North of this, at a distance of about 440 feet, is another bridge crossing a smaller branch or slough, and having six spans of about 20 feet each. The water, except in times of flood, does not pass under all of the spans of the long bridge, but usually the greater part flows under two or three of these, spreading out in shallow pools or streamlets under others, the greater number being over dry sand. The initial point for soundings is on the right bank and consists of a mark on the railing on the upstream side of the bridge. The channel is nearly straight for about 500 feet both above and below the station. The banks are low, but are rarely, if ever, overflowed. In addition to the measurements given, Mr. Ross reports that on December 6, 1894, the ice on the river was about 3 inches thick, and that there were two open channels. At that time the water was two-tenths of a foot higher than at the time of the measurement on November 6. He also states that on January 5, 1895, the ice was 8 inches thick, with no open channels, the height of water being the same as that on December 6.

The observations of river height are made at the Union Pacific Railroad bridge, this being about 2 miles below the wagon-road bridge, from which the velocity of the water is measured. This railroad bridge is 3 miles above the junction of the North and South Platte rivers The gage is vertical, marked to tenths of a foot, and is fastened by screws to the piling under the bridge. The top of the east rail directly over the gage is 12 feet above the zero.

List of discharge measurements made on North Platte River at North Platte, Nebr.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1892.						
a	Sept. 14	Cyrus C. Babb	29		473	1.63	770
b	Nov. 2	do	29		660	1.62	1,070
c	Nov. 22	do	109		590	2.32	1,370
	1894.						
1	Oct. 5	C. P. Ross	23		393	1.58	620
2	Nov. 6	do	23		712	1.72	1,227
	1895.						
3	Mar. 27	do	23		1,238	1.88	2,329
4	Apr. 29	do	23		2,631	2.16	5,695
5	May 28	do	23		2,601	2.43	6,320
6	June 8	do	23	4.00	5,702	2.85	16,261
7	Sept. 14	O. V. P. Stout	105	1.30		1.64	200

During September and October, 1892, Mr. William P. Trowbridge, jr., assisted by Mr. Cyrus C. Babb, made a reconnoissance of the North Platte Valley from the town of North Platte nearly to the Wyoming State line, constructing a topographic map and making a number of measurements of the flow of water in the main stream, in its tributaries, and in some of the principal ditches. The following list gives the most important of these measurements. In 1895 Prof. O. V. P. Stout also made a reconnoissance of a portion of this area and obtained two measurements of the discharge of North Platte River at Gering. These also are shown in the list.

List of discharge measurements above North Platte, Nebr.

Date.	Stream.	Locality.	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1892.					
Sept. 24	Birdwood Creek	Roberts's ranch	68	1.86	*a* 126
Oct. 8	Pumpkinseed Creek.	Carey's ranch	15	2.13	*b* 32
Oct. 8	North Platte	Camp Clarke	211	1.58	333
Oct. 16	Mitchell Canal	Horse Creek	12	2.00	*c* 24
Oct. 16	Horse Creek	Mitchell flume	36	2.40	*d* 86
Nov. 5	Blue Creek	Lown bridge	49	2.14	*e* 105
1895.					
June 14	North Platte	Gering	3,984	2.85	*f* 11,350
June 17	do	do	3,351	3.27	10,963

a This measurement of Birdwood Creek was made from a foot bridge in the northeast quarter of section 34, T. 15 N., R. 33 W., on William Roberts's ranch. This stream is reported to have a constant flow throughout the year, a heavy rain causing it to rise only about 8 inches. The creek is formed by the union of the East Fork, about 14 miles long, with the West Fork, about 16 miles long, these carrying approximately equal volumes of water. Its length from the junction to the point where it enters North Platte River is about 10 miles. It is typical of the northern tributaries of North Platte River, these rising in the sand hills and maintaining a nearly constant discharge.

b This measurement of Pumpkinseed Creek was made at L. B. Carey's ranch, section 12, T. 19 N., R. 50 W.

c This measurement of Mitchell Canal was made at the flume over Horse Creek.

d The measurement of Horse Creek was made at the point where the flume of Mitchell Canal crosses. The volume of water is usually large for the late summer season, having been measured shortly after a heavy rain.

e Mr. Babb states that Blue Creek is similar to Birdwood Creek noted above, as it is fed by springs and maintains a constant volume throughout the year, except in times of a heavy rain, when the volume may be somewhat increased. It heads in what is locally known as the lake region, a section of country dotted by lakes—some fresh, some alkaline—many several miles in extent. A few of them are deep, bottom not having been found at 200 feet. Others can be forded on horseback. Although Blue Creek has no visible head in any of these lakes, yet it is generally believed that there are underground connections between these lakes and the head of the creek. Many of these lakes have a peculiar behavior, in the autumn the water level gradually rising from 1 to 3 feet. Although Blue Creek does not carry as much water as Birdwood Creek, its valley is much better adapted to irrigation. The valley of Blue Creek, extending from 5 miles above its mouth northward, is flanked on either side by precipitous bluffs from 150 to 200 feet high. In the lower course of the creek the land has a fall of 20 feet to the mile on the average, but owing to the meander of the creek the water surface has decidedly less fall.

f The surface of the water at the time of this measurement was 4.33 feet below the top of the upstream end of the cap of the first river bent on the south or right bank, this being 24 spans from the south bank. The height of water on June 17, at the time of the second measurement, was practically the same.

Rating table for North Platte River at North Platte, Nebr.

[Prepared by O. V. P. Stout.]

Gage.	Discharge. *a*	Gage.	Discharge. *a*	Gage.	Discharge. *a*	Gage.	Discharge. *a*
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
1.30	200	2.00	1,551	2.70	4,878	3.40	10,180
1.40	272	2.10	1,905	2.80	5,514	3.50	11,100
1.50	384	2.20	2,300	2.90	6,191	3.60	12,058
1.60	537	2.30	2,735	3.00	6,908	3.70	13,057
1.70	730	2.40	3,210	3.10	7,665	3.80	14,097
1.80	963	2.50	3,725	3.20	8,464	3.90	15,177
1.90	1,237	2.60	4,282	3.30	9,302	4.00	16,297

a Discharge $= 2,935 - 4,725g + 2,016g^2$.

Daily gage height of North Platte River at North Platte, Nebr., for 1895.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1...	......	3.40	2.05	2.75	3.35	2.75	1.65	1.45	1.40	1.85	2.10
2...	......	3.15	2.25	2.85	3.20	2.65	1.60	1.45	1.30	1.80	2.00
3...	......	2.70	2.00	2.85	3.15	2.50	1.85	1.45	1.35	1.85	1.90
4...	......	2.70	2.00	3.20	3.65	2.60	1.70	1.30	1.50	1.95	2.10
5...	......	2.70	2.10	3.35	3.65	2.65	1.60	1.30	1.50	2.00	2.35
6...	......	2.55	2.35	3.45	3.60	2.55	1.65	1.30	1.50	1.95	2.30
7...	......	2.40	2.45	3.45	4.05	2.55	1.75	1.20	1.50	1.85	2.40
8...	......	2.65	2.40	3.25	3.95	2.65	1.75	1.20	1.60	1.85	2.45
9...	......	2.35	2.20	3.00	3.95	2.75	1.65	1.25	1.70	1.95	2.50
10..	......	2.05	2.00	3.05	3.90	2.85	1.65	1.25	1.70	1.80	2.45
11..	......	2.45	2.30	3.05	3.85	2.75	1.65	1.25	1.60	1.85	2.45
12..	......	2.35	2.30	2.90	3.65	2.65	1.65	1.25	1.75	1.90	2.45
13..	......	1.80	2.35	2.80	3.55	2.55	1.60	1.30	1.70	2.10	2.50
14..	......	1.60	2.25	2.70	3.65	2.55	1.50	1.30	1.75	2.00	2.65
15..	......	1.55	2.05	2.85	3.55	2.45	1.55	1 25	1.75	2.00	2.45
16..	......	1.95	2.25	2.85	3.55	2.35	1.65	1.40	1,85	2.00	2.45
17..	......	2.05	2.40	3.00	3.65	2.15	1.55	1.40	1.85	1.90	2.45
18..	......	2.20	2.50	3.15	3.45	2.00	1.50	1.30	1.85	1.95	2.45
19..	......	2.25	2.45	2.95	3.45	2.00	1.45	1.30	1.80	1.90	2.45
20..	......	2.35	2.35	3.00	3.35	2.10	1.50	1.20	1.75	1.95	2.50
21..	......	2.20	2.60	2.95	3.25	2.00	1.40	1.30	1.75	1.80	2.60
22..	......	2.15	2.75	3.00	3.40	2.05	1.35	1 35	1.75	1.85	2.55
23..	......	2.15	2.75	3.00	3.25	2.15	1.40	1.55	1.85	1.90	2.60
24..	......	2.20	2.70	3.05	3.25	2.35	1.35	1.50	1.85	2.00	2.65
25..	3.25	2.20	2.70	2.95	3.20	2.35	1.40	1.45	1.90	2.10	2.65
26..	3.40	2.45	2.60	2.90	3.10	2.15	1.30	1.40	1.90	2.10	2.55
27..	3.30	2.25	2.75	2.90	3.10	2.00	1.25	1.40	1.95	2.00	2.50
28..	3.20	2.20	2.85	2.85	3.05	2.00	1.60	1.30	1.85	2.00	2.45
29..	......	2.15	2.95	2.75	2.90	1.95	1.55	1.35	1.85	1.90	(a)
30..	......	2.05	2.95	3.05	2.85	1.90	1.50	1.45	1.75	2.00	(a)
31..	......	1.95	......	3.35	......	1.75	1.45	......	1.90	......	(a)

a Frozen.

Estimated discharge of North Platte River at North Platte, Nebr.[1]

[Drainage area, 28,517 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
February (25 to 28)	10,180	8,364	9,181	509,887	0.33	0.32
March	10,180	455	3,005	184,770	0.13	0.11
April	6,544	1,723	3,470	206,479	0.13	0.12
May	9,735	4,878	7,033	432,442	0.29	0.25
June	16,580	6,191	10,991	654,010	0.44	0.39
July	5,848	1,237	3,137	192,887	0.13	0.11
August	1,095	231	492	30,252	0.02	0.02
September	455	170	241	14,340	0.01	0.01
October	1,389	200	810	49,805	0.02	0.02
November	1,905	963	1,357	80,747	0.06	0.05
December	4,575	1,237	3,405	209,365	0.14	0.12

[1] Annual Report of the Nebraska State Board of Agriculture, 1895, Report of the Engineer, pp. 326–328, gives rates of discharge for ten-day periods from March 15 to November 30, 1895.

SOUTH PLATTE RIVER.

South Platte River rises in South Park within the main range of the Rocky Mountains, and, flowing northeast, passes out through a narrow canyon in the Front Range. It then flows in a general northerly course, receiving from time to time tributary creeks draining the main range and coming out through narrow canyons. The waters of the main stream and of each of the tributaries are diverted by numerous canals and ditches, many of them heading well up in the canyons and utilizing the greater part of the flow of the stream.

A number of points for the measurement of the river and its tributaries have been established by the State engineer of Colorado. The first of these is at Deansbury, in the canyon of the South Platte, 27 miles above Denver, and the second is at the city of Denver, below the mouth of Cherry Creek. The tributaries measured are Bear Creek, which enters 6 miles above Denver, Boulder and South Boulder, St. Vrain, and Big Thompson creeks. Cache la Poudre River has been measured for a number of years by Prof. L. G. Carpenter at a point about 12 miles above Fort Collins, the record here being the most complete of any in this part of the country. The main South Platte itself has also been measured at a point below the mouth of Cache la Poudre River, this being near the line between Weld and Morgan counties.

The drainage area of South Platte River has been measured by means of a planimeter from the land office maps of Colorado and Wyoming, dated 1892, and from the map of Nebraska dated 1890. The mountainous catchment areas are easily defined, but that portion of the basin lying upon the Great Plain is not so readily outlined, and it is possible for estimates to differ widely from the fact that in this nearly level country it is difficult to decide in which way the waters run. There are large areas which probably do not contribute water to any streams, but these have usually been included within one basin or another.

Drainage area of South Platte River.

	Square miles.
Above Deansbury, Colo	2,600
At Denver, Colo., below the mouth of Cherry Creek	3,840
At Greeley, Colo, above the mouth of Cache la Poudre	7,110
Below Greeley, Colo. (of this Cache la Poudre River at gaging station above Fort Collins 1,060 square miles and at mouth 2,465 square miles)	9,575
At Orchard or Green River City Bridge	12,260
At mouth below North Platte, Nebr. (of this amount, in Wyoming 2,089 square miles and in Nebraska 2,658 square miles)	23,294

DEANSBURY STATION, ON SOUTH PLATTE.

The gaging station at this point is located about 2½ miles northeast of Symes and 1,000 feet southwest of the station of Deansbury, on the Denver, Leadville and Gunnison Railroad, 27 miles from Denver. It was established by L. R. Hope on November 15, 1895, near the place where stream measurements have formerly been made by the State engineer of Colorado. Observations of river height are made three or more times a day. The discharge measurements are made from the footbridge crossing the stream. The gage consists of a plank 3 by 6 inches, marked to 0.05 of a foot. The channel both above and below the station is straight for about 100 feet, and the water moves swiftly.

The right bank is high and rocky, the railroad track being about 12 feet above low water on this side. The left bank is also rocky, a dry wall being laid up for about 5 feet above the bed of the river. The water flows over gravel and small bowlders, the section not changing perceptibly from time to time.

List of discharge measurements made on South Platte River at Deansbury, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Nov. 30	L. R. Hope	21	4.00	4.03	197
2	Dec. 1	.....do	21	3.20	2.78	102
3	Dec. 7	.....do	21	3.60	3.59	160
4	Dec. 8	.....do	21	3.65	3.71	166
5	Dec. 14	.....do	21	3.80	3.88	183
6	Dec. 20	.....do	21	3.35	3.51	135

Daily gage height of the South Platte River at Deansbury, Colo., for 1895.

Day.	Nov.	Dec.	Day.	Nov.	Dec.	Day.	Nov.	Dec.
1		3.57	12		3.69	23	3.82	3.44
2		3.48	13		3.65	24	4.15	3.33
3		3.25	14		3.74	25	3.82	3.05
4		3.05	15	4.00	3.50	26	3.92	3.00
5		3.48	16	4.15	3.65	27	4.17	3.01
6		4.03	17	4.20	3.25	28	4.34	3.34
7		3.78	18	4.20	3.47	29	4.05	3.28
8		3.67	19	4.69	3.07	30	3.99	3.18
9		3.39	20	4.58	3.35	31		3.03
10		3.71	21	4.40	3.80			
11		3.77	22	4.42	3.58			

DENVER STATION, ON SOUTH PLATTE.

In the spring of 1895 a river station was established at the Twenty-third street viaduct in the city of Denver, but observations were discontinued on June 18, as the location was found to be unfavorable for accurate measurements, and the water had fallen below the gage. On May 7, when the height was 1.10 feet on this gage, the discharge was found to be 168 second-feet. In July a station was established at the Fifteenth street bridge and observations were begun, these being made in the morning and in the afternoon. Stream measurements are being made from the lower side of the bridge. The gage consists of two 6 by 2 inch timbers spiked together, inclined and graduated to vertical tenths of a foot. The space between the marks is 0.156 foot. The timbers are fastened to posts driven into the bank. The bench mark is 107 feet southwesterly from the gage and is a cross mark on top of the east abutment of the Fifteenth street bridge on the north corner. It is marked B. M. and is 6.15 feet above the 9-foot mark of the gage rod. The initial point for soundings is on the right bank at the post of the iron railing. The channel is straight for about 1,000 feet above and below and the water moves with moderate velocity. The bed of the stream is sandy and shifting. This point is immediately below the mouth of Cherry Creek, which enters between the Fourteenth and Fifteenth street bridges. The stream at this point is confined between artificial embankments of furnace slag. The measurement on November 9 was made by wading at a point between the Fifteenth and Sixteenth street bridges, this being one of a series of measurements made with especial reference to the amount of seepage along the South Platte.

List of discharge measurements made on South Platte River at Denver, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	May 7	P. J. Preston	21	....	1.48	168
2	July 23	F. Cogswell	14	5.40	3.63	1,490
3	Aug. 7	P. J. Preston	14	4.60	3.33	876
4	Aug. 22	.....do	14	3.90	2.75	447
5	Nov. 9	.....do	21	4.30	2.56	430
6	Nov. 29	.....do	14	3.90	2.37	303

Rating table for the South Platte River at Fifteenth street bridge, Denver, Colo., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
2.90	11	3.70	227	4.40	642	5.10	1,287
3.00	34	3.80	262	4.50	760	5.20	1,355
3.10	58	3.90	303	4.60	870	5.30	1,423
3.20	82	4.00	350	4.70	965	5.40	1,490
3.30	108	4.10	404	4.80	1,050	5.50	1,560
3.40	135	4.20	468	4.90	1,135	5.60	1,630
3.50	163	4.30	545	5.00	1,215	5.70	1,700
3.60	194						

Daily gage height of South Platte River at Denver, Colo., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.40	....	5.85	4.85	4.25	4.50	3.80
2	....	3.50	....	6.05	5.00	3.95	4.50	3.70
3	....	4.90	....	5.55	4.50	4.40	4.50	3.60
4	....	5.00	....	5.20	4.45	4.45	4.50	3.45
5	....	4.60	....	5.05	4.60	4.20	4.60	3.45
6	....	4.30	....	4.75	4.15	4.20	4.50	3.75
7	*a*1.10	4.05	....	4.60	3.95	4.85	4.40	3.95
8	1.05	3.90	....	4.55	3.85	4.65	4.35	3.70
9	0.90	3.50	....	4.75	3.75	4.35	4.35	3.85
10	1.00	3.95	....	4.60	3.80	4.65	4.30	4.00
11	1.05	3.55	....	4.50	3.75	4.75	4.30	3.75
12	1.20	3.50	....	4.40	3.60	4.65	4.20	3.60
13	1.20	3.35	....	4.30	3.60	4.60	4.10	3.70
14	1.00	3.10	....	4.35	3.70	4.50	4.00	3.60
15	0.90	2.70	4.40	4.20	3.65	4.40	3.90	3.80
16	0.85	2.45	4.25	4.20	3.70	4.30	3.50	3.60
17	0.95	2.40	4.00	4.20	3.65	4.20	4.10	3.80
18	0.90	2.33	4.00	4.10	3.60	4.45	4.25	3.85
19	0.90	....	4.10	4.05	3.70	4.45	4.20	3.70
20	0.95	....	3.80	4.10	3.70	4.45	4.05	3.55
21	0.70	....	4.10	4.00	3.60	4.30	4.00	3.50
22	1.00	....	5.40	3.90	4.00	4.45	3.80	3.40
23	1.30	....	5.20	3.95	4.10	4.45	3.70	3.30
24	1.70	....	5.35	4.05	4.20	4.30	3.75	3.35
25	1.85	....	5.30	4.00	4.10	4.55	3.75	3.45
26	1.70	....	4.95	3.90	3.80	4.50	3.70	3.65
27	1.35	....	4.60	3.75	4.45	4.50	3.70	3.50
28	0.95	....	4.50	3.70	4.25	4.45	3.85	3.45
29	0.90	....	4.45	4.30	4.35	4.50	3.90	3.50
30	1.95	....	4.65	4.95	4.30	4.40	3.80	3.45
31	2.50	....	5.35	4.95	....	4.50	....	3.40

a Readings from May 7 to June 18 were on a gage at Twenty-third street. This point was then abandoned, as the water receded from the gage.

Estimated discharge of South Platte River at Denver, Colo.

[Drainage area, 3,840 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July (15 to 31)..	1,490	262	854	52,510	0.25	0.22
August........	1,945	227	742	45,624	0.22	0.19
September.....	1,215	194	426	25,340	0.12	0.11
October........	1,093	327	698	42,918	0.21	0.18
November	870	163	456	27,134	0.13	0.12
December......	350	108	204	12,544	0.06	0.05

MORRISON STATION, ON BEAR CREEK.

This station was established in the upper part of the town of Morrison by Porter J. Preston on May 19, 1895. Observations are made twice a day, morning and afternoon. Stream measurements are made by wading or, in time of high water, from a foot bridge about 1,000 feet below the gage. The rod is placed on the right-hand bank, and consists of inclined 2 by 4 inch timbers divided into vertical tenths of a foot, the space between the marks being 0.188 foot. It is fastened by iron pins driven between the rocks. There is a bench mark on the stone on the right bank about 15 feet southeast of the gage, this being 6.80 feet above the zero. The initial point for sounding is at the 4-foot mark on the gage. The channel is straight for 400 feet above this point and for about 150 feet below. The banks are high and rocky; the bed is composed of large stones, and the water moves with considerable velocity.

List of discharge measurements made on Bear Creek at Morrison, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	May 18	P. J. Preston	21	0.90	2.17	47
2	June 12	.....do	21	2.05	4.77	331
3	July 24	.....do	21	1.65	2.96	171
4	Oct. 9	.....do	21	1.05	2.15	64

Rating table for Bear Creek at Morrison, Colo., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet*	*Sec. feet.*
0.60	11	1.20	86	1.80	213
0.70	23	1.30	101	1.90	249
0.80	34	1.40	118	2.00	299
0.90	46	1.50	137	2.10	370
1.00	58	1.60	159	2.15	417
1.10	71	1.70	184		

Daily gage height of Bear Creek at Morrison, Colo., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1		1.55	1.62	1.87	1.25	0.95
2		1.96	1.46	1.87	1.25	0.94
3		3.00	1.46	1.87	1.25	0.92
4			1.44	1.60	1.22	1.17
5			1.37	1.55	1.20	1.12
6			1.28	1.52	1.20	
7			1.20	1.55	1.20	
8			1.25	1.57	1.15	
9			1.12	1.52	1.10	
10			1.40	1.47	1.10	
11			1.50	1.45	1.10	
12			1.50	1.45	1.10	
13		1.95	1.50	1.41	1.05	
14		1.85	1.40	1.34	1.05	
15		1.80	1.37	1.30	1.08	
16		1.81	1.35	1.28	1.00	
17		1.85	1.32	1.22	1.00	
18		1.75	1.30	1.17	0.95	
19	0.87	1.75	1.35	1.15	0.95	
20	0.86	1.60	1.45	1.22	0.90	
21	1.05	1.60	1.67	1.20	0.90	
22	1.05	1.50	1.60	1.15	1.05	
23	1.01	1.52	1.72	1.42	1.12	
24	1.09	1.55	1.72	1.17	1.12	
25	1.05	1.50	1.60	1.12	1.08	
26	1.12	1.48	1.47	1.00	1.04	
27	1.17	1.42	1.45	1.00	1.02	
28	1.20	1.53	1.46	1.57	1.00	
29	1.11	1.80	1.47	1.32	1.00	
30	1.31	1.65	1.90	1.45	0.93	
31	1.23		1.85	1.27		

Estimated discharge of Bear Creek at Morrison, Colo.

[Drainage area, 170 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
May (19 to 31)	103	40	72	4,427	0.48	0.42
June (19 days)		122	180	10,711	1.18	1.06
July	249	74	134	8,240	0.91	0.79
August	238	58	126	7,747	0.85	0.74
September	97	46	69	4,106	0.46	0.41
October (1 to 5)	82	48	61	3,751	0.41	0.36

MARSHALL STATION, ON SOUTH BOULDER CREEK.

South Boulder Creek issues from a canyon in the foothills 6 miles south of Boulder Creek. Its general course is easterly through the canyon, and upon leaving this it turns toward the northeast and north, uniting with Boulder Creek about 7 miles below the mouth of Boulder Canyon, this being below the town of Boulder. Measurements of South Boulder Creek have been made at a point about 3 miles west of Marshall. A station was established here on May 14, 1895, by Porter J. Preston. Observations have been taken in the morning and afternoon. The point of measurement is at a foot bridge 20 feet above the gage. At times of low water the stream can be waded. The gage is inclined and consists of 2 by 6 inch timbers firmly spiked to stakes driven into the ground and also fastened to a tree. The distance between the marks is 0.220 foot. The bench mark consists of a stone 15 feet northwest of the gage, marked with black paint. This point is 1.99 feet above the 5-foot mark on the rod. The initial point for soundings is at a tree on the left bank just below the gage. The channel is straight for 200 feet above and 100 feet below the station. The banks and bed are rocky and the water moves swiftly.

List of discharge measurements made on South Boulder Creek near Marshall, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	May 14	P. J. Preston	21	2.00	3.09	164
2	July 18	....do	21	2.00	3.19	196
3	Oct. 10	....do	21	1.05	1.68	42

Daily gage height of South Boulder Creek near Marshall, Colo., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1		2.90	2.50	1.85	1.30	0.85
2		3.35	2.50	1.80	1.25	0.90
3		3.95	2.40	1.70	1.15	0.90
4		3.75	2.35	1.75	1.10	1.35
5		3.55	2.45	1.65	1.10	1.30
6		3.55	2.25	1.65	1.10	1.15
7		3.50	2.20	1.55	1.00	1.05
8		3.45	2.15	1.45	1.00	1.10
9		3.55	2.05	1.50	1.00	1.10
10		3.55	2.10	1.50	1.00	1.10
11		3.50	2.05	1.45	1.00	1.00
12		3.15	2.10	1.55	1.00	1.00
13		2.95	2.05	1.45	1.00	1.00
14		2.90	2.05	1.45	0.95	1.00
15	2.10	2.85	1.95	1.45	1.00	1.00
16	2.10	2.95	2.05	1.40	1.00	1.00
17	2.00	3.05	2.10	1.35	0.90	1.00
18	1.85	2.80	2.00	1.30	0.90	1.00
19	1.75	2.65	1.95	1.40	0.90	1.00
20	1.80	2.40	2.05	1.35	0.90	1.00
21	2.10	2.30	2.05	1.25	0.90	1.00
22	2.15	2.35	1.95	1.30	1.10	1.00
23	2.10	2.55	1.85	1.30	1.10	1.00
24	2.15	2.65	1.75	1.25	1.10	0.95
25	2.15	2.60	1.80	1.20	1.10	0.96
26	2.10	2.50	1.75	1.20	1.10	0.95
27	2.30	2.55	1.70	1.20	1.00	1.00
28	2.40	2.85	1.65	1.45	0.95	0.95
29	2.35	2.80	1.70	1.35	0.90	0.95
30	2.65	2.65	1.75	1.35	0.90	1.00
31	2.90		1.85	1.35		0.95

BOULDER STATION, ON BOULDER CREEK.

This creek has been measured at a point about 1½ miles west of the town of Boulder, this locality being well up in the canyon and about 6 miles above the junction of South Boulder Creek. Observations of the height of water are made twice a day. The gage consists of an inclined rod 2 by 6 inches, marked to vertical feet and tenths, the distance between the marks being 0.207 foot. This is nailed to sticks driven into the bank. The bench mark is on a large stone 20 feet north of the gage, and is 4.95 feet above the 5-foot mark on the rod. The initial point for soundings is at a large post on the right bank.

The water is straight for about 500 feet above and 50 feet below the station, and has a moderate velocity. The banks are high and rocky and the bed is composed of large stones. Two measurements have been made, the first on July 17, when the water stood at a height of 1.90 feet, the total discharge being 317 second-feet. This was made by wading, at a point about 400 feet below the gage rod and above the head of the ditch, taking water out of the right-hand side of the stream. The second measurement was made on October 13, the height of water being 0.50 foot and the discharge 36 second-feet. At time of high water measurements can be made at a bridge about 40 feet above the gage.

Daily gage height of Boulder Creek above Boulder, Colo., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1	....	2.35	2.57	1.95	1.17	0.60
2	....	2.75	2.50	2.00	1.12	0.60
3	....	3.05	2.50	1.95	1.07	0.60
4	....	2.60	2.43	1.85	1.02	1.00
5	....	2.55	2.30	1.75	0.97	0.95
6	....	2.42	2.20	1.65	0.95	0.80
7	....	2.38	2.18	1.60	0.90	0.80
8	....	2.42	2.10	1.57	0.87	0.75
9	....	2.50	2.00	1.55	0.85	0.70
10	....	2.55	2.17	1.52	0.80	0.65
11	....	2.52	2.03	1.52	0.72	0.62
12	....	2.52	2.00	1.37	0.70	0.60
13	....	2.47	1.92	1.35	0.70	0.60
14	1.82	2.50	1.87	1.50	0.70	0.60
15	1.90	2.52	1.78	1.45	0.70	0.57
16	1.83	2.52	1.87	1.42	0.77	0.55
17	1.60	2.52	2.00	1.37	0.77	0.55
18	1.62	2.32	2.02	1.37	0.75	0.55
19	1.57	2.22	1.95	1.37	0.75	0.55
20	1.70	2.12	1.90	1.35	0.77	0.55
21	1.82	2.15	1.95	1.32	0.80	0.55
22	1.78	2.20	1.95	1.30	0.90	0.50
23	1.78	2.22	1.95	1.27	0.90	0.48
24	1.83	2.30	1.85	1.20	0.87	0.43
25	1.82	2.35	1.75	1.17	0.82	0.38
26	1.88	2.30	1.75	1.12	0.72	0.33
27	2.23	2.28	1.80	1.12	0.67	0.30
28	2.20	2.57	1.70	1.10	0.65	0.25
29	2.12	2.55	1.80	1.27	0.65	0.25
30	2.22	2.57	1.82	1.27	0.65	0.25
31	2.22	....	1.85	1.22	....	0.25

LYONS STATION, ON ST. VRAIN CREEK.

The town of Lyons is situated between the North and South forks of St. Vrain Creek, this stream uniting at a point about 1 mile east of the center of the town. Observations of river height have been made at a point just below the intersection of the two forks, the gage being placed below the head of Supply Ditch, which takes water out on the left-hand side of the stream. Observations of the height of water are made at 7 in the morning and evening. Measurements are made at a foot bridge about 400 feet below the gage rod, this being above the head of the Highland Ditch taking out water below Supply Ditch. The gage consists of an inclined rod marked to vertical feet and tenths, the distance between the marks being 0.134 foot. The bench mark is on the railroad bridge and is 9.55 feet above the zero of the gage. The initial point for soundings is on the left bank at the edge of the log crib. The channel is composed of gravel, the banks are low and liable to overflow, and the conditions are not favorable for obtaining accurate results. The flood of 1894 washed out the bed of the South Fork, so that there are no localities suitable for a station for some distance above Lyons. The road along this fork has been impassable during the greater part of 1895, preventing the establishment of a station higher up. There is an excellent locality for a measuring station on the North Fork in Lyons, and therefore it is highly desirable to find a suitable place on the South Fork, in order to get the total discharge of the stream.

List of discharge measurements made on St. Vrain River at Lyons, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895					
1	May 11	P. J. Preston	21	1.65	3.33	260
2	July 20	do	21	3.40	3.27	336
3	Oct. 2	do	21	2.10	2.78	65

Daily gage height of St. Vrain River at Lyons, Colo., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1		2.70	3.90	3.85	2.47	2.25
2		(a)	4.00	3.75	2.45	2.20
3			4.25	3.67	2.40	2.22
4			4.20	3.45	2.37	2.30
5			3.95	3.40	2.35	2.65
6			3.80	3.42	2.32	2.78
7			3.57	3.22	2.32	2.75
8			3.50	3.10	2.30	2.78
9			3.42	3.05	2.27	2.80
10			3.30	3.07	2.22	2.80
11			3.40	2.95	2.22	2.83
12			3.52	2.92	2.17	2.83
13	1.50	4.55	3.60	2.77	2.17	2.80
14	1.72	4.90	3.60	2.65	2.15	2.80
15	1.75	4.65	3.45	2.62	2.22	2.85
16	1.72	4.92	3.32	2.57	2.22	2.85
17	1.65	4.70	3.27	2.55	2.20	2.85
18	1.60	4.57	3.35	2.97	2.17	2.90
19	1.62	4.35	3.20	2.95	2.22	2.90
20	1.78	4.30	3.12	2.92	2.27	2.90
21	2.00	3.75	4.10	2.82	2.22	2.90
22	1.85	3.72	4.20	2.80	2.30	2.95
23	1.92	3.70	3.77	2.77	2.30	2.95
24	1.92	3.82	3.37	2.75	2.30	2.95
25	1.95	4.45	3.27	2.72	2.35	3.00
26	1.97	4.30	3.25	2.65	2.35	3.00
27	2.25	4.17	3.35	2.62	2.30	3.00
28	2.15	4.27	3.35	2.75	2.35	3.00
29	2.30	4.05	3.42	2.67	2.27	3.00
30	2.85	4.10	3.30	2.62	2.22	3.00
31	2.65		4.25	2.52		3.00

a Gage rod washed out.

ARKINS STATION, ON BIG THOMPSON CREEK.

Measurements of Big Thompson Creek have been made at a point about 9 miles west of Loveland and 600 feet below the dam at the head of Home Supply Ditch. Some distance above, the Handy Ditch takes out water on the right-hand side above Home Supply Ditch, and thus the amount of water in the stream at the point of measurement is diminished to the extent of the diversion of these two irrigating systems.

Observations of the height of water are made in the morning and evening. The gage is vertical and is nailed to the timbers of a bridge. The bench mark consists of a notch in a tree about 50 feet below the gage, on the left-hand side of the stream. This mark is 3.92 feet above the 1-foot mark on the rod. The initial point for soundings is on the right bank at the end of the crib pier. The left bank is low and liable to overflow at high water, and the bed of the stream is of gravel, containing bowlders.

List of discharge measurements made on Big Thompson Creek near Home Supply Dam, Colorado.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	May 9	P. J. Preston	21	1.25	2.17	260
2	July 19	do	21	1.90	3.59	499
3	Oct. 1	do	21	0.45	0.75	42

Rating table for the Big Thompson Creek near Home Supply Dam for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
0.40	32	1.30	276	2.20	633
0.50	55	1.40	310	2.30	676
0.60	80	1.50	344	2.40	716
0.70	105	1.60	380	2.50	757
0.80	132	1.70	420	2.60	800
0.90	160	1.80	460	2.70	846
1.00	189	1.90	500	2.80	900
1.10	217	2.00	543		
1.20	246	2.10	588		

Daily gage height of Big Thompson Creek near Home Supply Dam, Colorado, for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.
1		1.55	1.95	2.35	1.10	0.40
2		2.65	1.90	2.20	1.00	0.35
3		2.65	1.65	2.10	1.05	0.45
4		2.30	1.85	1.95	1.05	0.75
5		2.20	1.75	1.80	0.95	0.80
6		2.20	1.65	1.65	0.95	0.80
7		2.05	1.60	1.70	0.90	0.80
8		2.15	1.50	1.60	0.85	0.70
9		2.05	1.50	1.75	0.80	0.70
10	1.25	2.10	1.75	1.55	0.80	0.65
11	1.10	2.20	1.80	1.35	0.80	0.60
12	1.20	2.00	2.55	1.05	0.90	0.60
13	1.25	2.25	2.15	1.45	0.90	0.70
14	1.30	2.15	2.05	1.20	0.90	0.70
15	1.45	2.30	2.05	1.05	0.80	0.70
16	1.40	2.35	2.05	0.95	0.75	0.70
17	1.35	2.25	2.15	1.00	0.70	0.70
18	1.20	1.90	2.00	1.00	0.80	0.70
19	1.25	1.60	1.85	1.25	0.80	0.65
20	1.45	1.50	1.85	1.35	1.00	0.60
21	1.55	1.75	1.95	1.15	1.05	0.65
22	1.50	1.60	2.00	1.05	1.00	0.60
23	1.50	1.90	1.75	1.35	0.95	0.55
24	1.50	2.00	1.55	1.20	0.95	0.45
25	1.40	1.90	1.35	1.10	0.95	0.45
26	1.55	1.95	1.40	1.05	0.75	0.55
27	1.55	2.15	1.40	1.05	0.50	0.45
28	1.70	2.00	1.35	1.35	0.40	0.40
29	1.50	1.90	1.55	1.30	0.55	0.40
30	1.65	2.10	1.90	1.15	0.40	0.40
31	1.60		2.05	1.10		0.50

Estimated discharge of Big Thompson Creek, near Loveland, Colo.

[Drainage area, 305 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square inch.
1895.						
May (10 to 31)..	420	217	318	19,553	1.20	1.04
June...........	823	261	547	32,549	2.00	1.79
July...........	778	293	465	28,592	1.75	1.52
August........	696	161	316	19,430	1.20	1.04
September.....	217	32	146	8,688	0.54	0.48
October........	132	25	80	4,919	0.30	0.26

FORT COLLINS STATION, ON CACHE LA POUDRE RIVER.

A description of this station, together with the estimated daily mean discharge for 1893 and 1894, has been given on page 30 of Bulletin No. 131. Measurements at this point have been continued by Prof. L. G. Carpenter, who has furnished the preliminary figures of the average monthly flow for 1895, as given below. These are subject to revision, but are approximately correct.

Discharge of Cache la Poudre River at the canyon above Fort Collins.

1895.	Average flow.	1895.	Average flow.
	Second-feet.		*Second-feet.*
January................	90	August.................	495
February...............	90	September..............	219
March..................	90	October................	160
April..................	330	November...............	110
May....................	1,216	December...............	90
June...................	2,382		
July...................	1,117	Mean...............	537

Professor Carpenter states that he has had a number of rain gages distributed at various points in the cachement area of this stream for the purpose of ascertaining the amount and distribution of the precipitation. It has been difficult, however, to obtain volunteer observers, and the records are incomplete. Nevertheless they furnish the basis for estimating the average rainfall and snowfall. During 1895 the precipitation was probably 20 inches, being certainly between 18 and 22 inches. The run-off, as shown above, averaged 537 second-feet, this being equivalent to a depth on the drainage basin of slightly over 7 inches. The records so far obtained tend to show that the average rainfall on the head waters of Cache la Poudre River, and by inference on the mountain areas of Colorado, is by no means so great as has often been estimated.

GREEN CITY AND ORCHARD STATIONS, ON SOUTH PLATTE RIVER.

Two stations have been established on South Platte River near Orchard, Colo., a town on the Union Pacific, Denver and Gulf Railway, 80 miles from Denver. This point is near the line between Weld and Morgan counties, being about 20 miles above Fort Morgan. The upper of the two points is at the Green City bridge, 6 miles westerly from Orchard. This bridge crosses two channels of the South Platte, the more northerly being designated as Channel A, and the southerly as Channel B, an island lying between these. Observations are made at both of these channels daily. The gage rod at Channel A consists of a 2 by 4 inch timber, spiked to a pile on the downstream side of the bridge. The bench mark is on the northeast corner of the bridge, and is marked B. M. with blue paint. This bench mark is 9.55 feet above the zero of the rod. The stream has been measured by wading at a point 75 feet east of the bridge. The initial point for soundings is on the right shore. The channel is straight for about 50 feet above and 100 feet below the bridge. The velocity is moderate and the banks are sufficiently high to retain the water at ordinary stages.

On Channel B the gage also consists of a 2 by 4 inch timber spiked to a pile on the downstream side of the bridge. The bench mark is on the northeast corner of this bridge, being 10.91 feet above the zero of the gage. Measurements have been made by wading at a place 100 feet east of the bridge, the current both above and below this point being nearly straight. The right bank is high, but the left bank is low and liable to overflow.

Measurements made at these bridges on November 21, gave for Channel A, at a height of 2.30 feet, a discharge of 294 second-feet, and for Channel B, at a height of 3.10 feet, a discharge of 578 feet, making a total in the river at that time of 872 feet.

At Orchard the river station is one-fourth of a mile southwesterly from the railroad station. There is no bridge at this point, but the river is measured by wading. Observations of height are made once a day. The gage consists of 2 by 4 inch timbers, spiked together and inclined. This is graduated to vertical tenths of a foot, the space between the marks being 0.127 foot. The gage is firmly spiked to pieces driven into the bank. The bench mark consists of a 2 by 4 inch stick driven almost to the surface of the ground 8 feet back from the rod. The top of this is 0.30 foot above the 8-foot mark on the rod. The initial point for soundings is on the right shore. The channel is straight both above and below the station, and the current has moderate velocity. Two measurements have been made, the first on November 20, when the height of water was 4 feet and the discharge 829 second-feet; the second on December 22, 1885, when the height was 3.83 feet and the discharge 667 second-feet.

A few measurements of South Platte River were made by Mr. Cyrus C. Babb during 1892. This river is usually dry in Nebraska during the months of July, August, and September. In 1892 the first water found flowing in the river after the summer drought resulted from a storm in the early part of October. Later in this month a measurement was made at Julesburg, Colo., as shown in the following table, and a few days after this another at the bridge across the river south of the town of North Platte. A second measurement at the same place was made on November 22, while ice was floating in the stream.

Discharge measurements made on South Platte River.

Date.	River.	Locality.	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1892.					
Oct. 27	South Platte	Julesburg, Colo	362	1.53	653
Nov. 2	do	North Platte, Nebr	266	1.36	460
Nov. 22	do	do	358	1.80	645

LOUP RIVER.

Drainage area of Loup River.

	Square miles.
Middle Loup River at St. Paul, Nebr	6,849
North Loup River at St. Paul, Nebr	4,024
Loup River at mouth, at Columbus, Nebr	13,542

ST. PAUL STATION, ON NORTH LOUP RIVER.

This station is on the left bank, at the lower side of the wagon bridge, 4 miles north of St. Paul, Nebr. The river gage consists of a piece of oak 2 by 3 inches, 16 feet long, with the face inclined 30 degrees to the horizontal. This rests upon cross-ties well bedded and covered, the bottom of the rod being thrust into the bed of the river. The zero of this rod is 15.01 feet below the top of the lower horizontal projecting part of the foot-plate at the north end of the west truss of the north span of the bridge.

The channel is nearly straight. The bridge consists of four spans supported upon pile piers 100 feet apart. The first measurement was made from this bridge on May 4, 1895, when the water stood at a height of 3.27 feet. The mean velocity was 2.64 feet per second and the total discharge 1,520 second-feet. The next measurement was on June 28, the mean velocity being 2.26 feet per second and the total discharge 1,127 second-feet. A third measurement, on September 6, gave for a gage height of 3.04 feet a discharge of 816 second-feet. A rating table has been constructed by Professor Stout, this being considered as applicable to the record of heights kept during the summer of 1895.

Rating table for the North Loup River at St. Paul, Nebr., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
2.90	437	3.30	1,618	3.70	3,117
3.00	702	3.40	1,962	3.80	3,542
3.10	987	3.50	2,327	3.90	3,991
3.20	1,293	3.60	2,712	4.00	4,456

Daily gage height of North Loup River at St. Paul, Nebr., for 1895

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	....	3.25	3.11	3.00	3.10	3.15	3.10
2	....	4.00	3.09	3.05	3.10	3.15	3.37
3	....	3.85	3.14	3.07	3.05	3.18	3.20
4	....	3.40	3.09	3.20	2.98	3.20	3.20
5	3.27	3.35	3.07	3.12	3.00	3.20	3.20
6	3.26	3.22	3.05	3.10	3.00	3.25	3.17
7	3.24	3.25	3.12	3.07	3.02	3.20	3.19
8	3.20	3.25	3.09	3.00	3.10	3.19	3.17
9	3.15	3.30	3.10	3.30	3.10	3.18	3.15
10	3.20	3.25	3.10	3.25	3.07	3.20	3.12
11	3.30	3.25	3.10	3.07	3.07	3.20	3.10
12	3.24	3.25	3.09	3.00	3.06	3.20	3.10
13	3.20	3.22	3.13	3.30	3.00	3.20	3.07
14	3.20	3.23	3.14	3.15	3.00	3.21	3.02
15	3.20	3.20	3.14	3.10	3.12	3.20	3.05
16	3.15	3.22	3.10	3.13	3.21	3.22	3.05
17	3.15	3.35	3.07	3.10	3.12	3.23	3.00
18	3.16	3.30	3.05	3.02	3.14	3.20	3.02
19	3.10	3.10	3.04	3.00	3.07	3.20	3.00
20	3.12	3.15	3.05	2.99	3.15	3.02	3.00
21	3.10	3.10	3.00	3.00	3.12	3.09	2.95
22	3.05	3.10	3.05	3.00	3.90	3.10	2.66
23	3.06	3.12	3.05	3.35	3.35	3.10	2.50
24	3.05	3.13	3.05	3.23	3.20	3.07	2.49
25	3.08	3.10	3.00	3.00	3.20	3.08	2.45
26	3.05	3.12	2.99	2.98	3.19	3.08	a3.70
27	3.06	3.18	2.97	2.96	3.17	3.05	3.85
28	3.08	3.21	2.90	3.05	3.15	3.07	3.85
29	3.06	3.15	2.95	3.00	3.11	3.05	3.85
30	3.40	3.17	2.95	3.25	3.10	3.07	3.85
31	3.30	....	2.97	3.10	....	3.05	....

a Change due to melting ice.

By applying this rating table to the record of river heights and averaging the amounts thus obtained the following mean discharges have been computed:

Mean monthly discharge of North Loup River at St. Paul, Nebr.[1]

Month.	Discharge
1895.	*Second-feet.*
May (27 days)	1,189
June	1,531
July	864
August	984
September	1,094
October	1,146

A measurement of North Loup River was made on May 5, 1895, at the wagon bridge at Ord, Nebr., this being about 40 miles from St. Paul. At that time the water was flowing in three channels; the bed of the stream consisted of mud and sand. The mean velocity was 2.38 feet per second, the total discharge 1,367 second-feet.

ST. PAUL STATION, ON MIDDLE LOUP RIVER.

This station is located on the right bank of the stream at the lower side of the wagon and railroad bridge, 1 mile south of St. Paul, Nebr. The gage consists of an oak stick 2 by 3 inches, 16 feet long, inclined

[1] Annual Report Nebraska State Board of Agriculture, 1895, Report of the Engineer, pages 319-320, gives rates of discharge for ten-day periods from May 4 to November 20, 1895.

30° to the horizon. This is securely fastened to cross-ties bedded in the soil. The zero of this rod is 9.62 feet below the bottom of the downstream end of the cap of the first river bent at the south end of the bridge.

The character of the channel is not especially favorable for making discharge measurements, as cross currents occur. A measurement on June 28 showed that the mean velocity was 1.93 feet per second and the total discharge 1,046 second-feet. On September 7, 1895, when at a height of 1.62 feet, the discharge was 863 second-feet. A rating table has been tentatively prepared by Prof. O. V. P. Stout, giving the relation between gage height and discharge.

Rating table for Middle Loup at St. Paul, Nebr., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
1.50	614	2.10	1,628	2.70	2,815
1.60	771	2.20	1,814	2.80	3,030
1.70	933	2.30	2,005	2.90	3,250
1.80	1,100	2.40	2,200	3.00	3,475
1.90	1,271	2.50	2,400	3.10	3,705
2.00	1,447	2.60	2,605	3.20	3,940

Daily gage height of Middle Loup River at St. Paul, Nebr., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	....	2.40	1.80	1.62	1.82	1.53	1.78
2	....	2.39	1.77	1.61	1.75	1.52	1.72
3	....	3.21	1.74	1.61	1.74	1.53	1.70
4	....	2.78	1.74	1.60	1.70	1.58	1.70
5	1.96	2.45	1.78	1.72	1.69	1.62	1.74
6	1.93	2.15	1.72	1.61	1.65	1.65	1.70
7	1.89	1.92	1.71	1.62	1.62	1.62	1.71
8	1.81	1.81	1.70	1.64	1.58	1.62	1.65
9	1.75	1.76	1.64	1.50	1.58	1.64	1.60
10	1.75	1.81	1.63	1.51	1.56	1.55	1.51
11	1.78	1.83	1.61	1.63	1.52	1.59	1.47
12	1.79	1.85	1.59	1.61	1.50	1.58	1.46
13	1.83	1.82	1.63	1.84	1.53	1.56	1.42
14	1.84	1.81	1.75	1.81	1.52	1.62	1.75
15	1.82	1.76	1.70	1.94	1.51	1.67	1.73
16	1.80	1.78	1.65	1.93	1.60	1.67	1.57
17	1.83	1.97	1.60	1.81	1.62	1.65	1.52
18	1.82	2.07	1.50	1.71	1.63	1.61	1.35
19	1.82	1.92	1.54	1.70	1.65	1.60	1.25
20	1.86	1.89	1.55	1.71	1.59	1.58	1.30
21	1.85	1.86	1.55	1.61	1.82	1.60	1.12
22	1.85	1.78	1.60	1.62	1.87	1.63	1.11
23	1.83	1.69	1.65	1.90	2.27	1.63	1.03
24	1.83	1.70	1.70	1.73	1.90	1.72	1.46
25	1.86	1.72	1.68	1.74	1.73	1.72	1.45
26	1.87	1.65	1.67	1.84	1.67	1.72	1.60
27	1.83	1.63	1.65	1.83	1.58	1.74	1.80
28	1.77	1.77	1.60	1.84	1.55	1.80	2.15
29	1.70	1.89	1.64	1.82	1.58	1.87	2.54
30	1.94	1.83	1.61	1.91	1.53	1.68	2.86
31	2.12	....	1.60	1.81	....	1.80	....

By applying this table computations have been made of the average flow, as shown below:

Mean monthly discharge of Middle Loup River at St. Paul, Nebr.[1]

Month.	Discharge.
1895.	*Second-feet.*
May (27 days)	1,173
June	1,396
July	861
August	973
September	877
October	843

A series of measurements was made by Professor Stout on Middle Loup River for the purpose of obtaining data concerning the increase of discharge due to percolation from underground sources. The results are given in round numbers in the following table. The first measurement was made at the forks of the stream, about 8.5 miles above Mullen, Hooker County, Nebr.; the second point of measurement was at the bridge opposite Mullen; the third at the bridge at Seneca; the fourth at Thedford, Thomas County; the fifth at the bridge at Dunning, Blaine County; and the sixth at a point 1½ miles north of Loup City, Sherman County. The approximate distances between these points are given in the table. No surface tributaries, except Dismal River, were received in this distance of 131 miles. There are, however, a number of small lakes and springs in the vicinity of Seneca. The last measurement, that at Loup City, six days after the one at Dunning, is not strictly comparable with those preceding, because of the length of time intervening. Moreover, the daily record at St. Paul shows a rise during this period—much of this added flow, however, coming from South Loup.

Measurements showing increase of discharge of Middle Loup River from underground sources, August 20 to 29, 1895.

Date.	Locality.	Distance between points.	Discharge.	Increase in flow— Between points.	Per mile.
1895.		*Miles.*	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*
Aug. 20	At forks	0	42		
20	Mullen	8	120	78	9.7
21	Seneca	11	216	96	8.7
22	Thedford	15	284	68	4.5
23	Dunning	27	322	38	1.4
23	....do	0	615		
29	Loup City	70	879	264	3.8

Two measurements are given for the flow at Dunning; the first, 322 second-feet, being the flow of the Middle Loup, and the second, 615 second-feet, the combined flow of that stream with Dismal River which enters at that place. This affords a comparison with the discharge at Loup City below.

[1] Annual Report of the Nebraska State Board of Agriculture, 1895, Report of Engineer, page 331, gives rates of discharge for ten-day periods from May 4 to October 31, 1895.

Further comparison with the discharge of the Loup River at St. Paul can not be made, as there are no contemporaneous measurements of the flow of South Loup, which enters about 15 miles above. The only measurement of the South Loup was that at Ravenna, Buffalo County, Nebr., on August 31, at which time the river was discharging at the rate of 296 second-feet. This was considerably above the normal, owing to heavy rains in the upper valley about August 28.

COLUMBUS STATION, ON LOUP RIVER.

The conditions at this station have been described in Bulletin No. 131, page 32. Observations begun at this point on October 13, 1894, were continued throughout 1895. From the measurements of discharge Prof. O. V. P. Stout has constructed rating tables covering a portion of this time. These, however, can not be applied to the readings of river height up to March 29, owing to the action of ice and the shifting of the channel. For the time from March 29 to April 21, 1895, the mean velocity in the channel has been computed by Professor Stout from the equation $v = 1.58\ (g - 2.40)$, where v is the velocity and g the gage height. The area, in square, feet of the main channel is taken as $a = 150\ g - 17 - 2.7\ x$, where a is the area and x the number of days since March 29. The discharge of the minor channel is also estimated and added to the product av. For the period from April 21 to June 12, 1895, the corresponding equations are $v = 1.58\ (g - 2.40)$ and $a = 150\ g - 67.5 + 4\ x$, where x is the number of days since April 21. The rating table herewith given shows the relation between discharge and gage height for the period following June 12, 1895. These and similar ratings made for streams with shifting channels can only be claimed to be fairly accurate and accordant among themselves.

The first measurement of this stream was made on March 29, 1895, at the Union Pacific Railway bridge, west of Columbus, by Prof. O. V. P. Stout, assisted by Otis Weeks, the instrument used being the Price electric meter. The bed was reported to be sandy and muddy, and piles, stumps, and rocks detracted from the accuracy of result. The next measurement, that of April 21, was made at the same place, the water at this time being in two channels separated by the bridge pier. Later measurements were made on June 12 and June 29, as shown by the appended table:

List of discharge measurements made on Loup River at Columbus, Nebr.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	Mar. 29	O. V. P. Stout	Price	4.77	3.75	2,790
2	Apr. 21	do	Price	4.65	3.41	2,303
3	June 12	do	Price	4.55	3.39	2,835
4	June 29	do	Price	4.50	3.27	2,715
5	Sept. 7	do	Price	4.17	2.58	1,896

Rating table of Loup River at Columbus, Nebr., for period following June 12, 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
3.50	640	4.20	1,957	4.90	3,823
3.60	795	4.30	2,191	5.00	4,135
3.70	960	4.40	2,434	5.10	4,457
3.80	1,137	4.50	2,690	5.20	4,789
3.90	1,326	4.60	2,955	5.30	5,133
4.00	1,525	4.70	3,234	5.40	5,490
4.10	1,736	4.80	3,523		

Daily gage height of Loup River at Columbus, Nebr., for 1894.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	4.66	5.00	17	4.60	4.73	4.81
2	....	4.65	4.72	18	4.60	4.71	4.80
3	....	4.67	4.72	19	4.60	5.00	4.83
4	....	4.75	4.76	20	4.65	4.63	4.75
5	....	4.77	4.72	21	4.65	4.74	4.75
6	....	4.73	4.71	22	4.65	4.83	4.63
7	....	4.70	4.72	23	4.65	4.85	4.72
8	....	4.72	4.67	24	4.65	4.80	4.71
9	....	4.78	4.63	25	4.70	4.73	4.65
10	....	4.76	4.72	26	4.65	4.67	4.54
11	....	5.00	4.75	27	4.60	4.72	4.52
12	....	4.82	4.80	28	4.65	4.68	4.78
13	....	4.65	4.82	29	4.67	4.81	4.78
14	4.7	4.78	4.83	30	5.00	4.78	4.94
15	4.65	4.74	4.75	31	4.10	....	5.4
16	4.65	4.57	4.77				

Daily gage height of Loup River at Columbus, Nebr., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	5.10	6.10	6.75	4.95	4.80	5.27	4.55	4.01	4.62	4.31	4.46	5.10
2	5.23	6.10	5.69	4.92	5.44	5.15	4.56	4.01	4.56	4.28	4.47	5.33
3	5.31	6.15	4.75	4.75	5.47	*a*7.10	4.47	4.01	4.38	4.21	4.49	5.47
4	5.21	6.24	3.89	4.74	5.18	6.42	4.45	4.98	4.30	4.18	4.56	5.43
5	5.32	6.21	3.95	4.77	5.15	5.78	4.46	4.03	4.29	4.35	4.59	5.27
6	5.15	6.15	4.73	4.67	4.95	5.43	4.45	4.33	4.20	4.34	4.56	5.15
7	5.50	6.13	4.85	4.77	4.80	5.01	4.40	4.20	4.18	4.40	4.57	5.16
8	4.95	6.13	4.87	5.31	4.76	4.79	4.32	4.17	4.19	4.36	4.60	5.20
9	5.70	6.13	5.23	5.20	4.68	4.64	4.35	4.15	4.23	4.34	4.62	5.29
10	5.23	6.13	5.15	5.14	4.63	4.55	4.23	4.25	4.17	4.40	4.62	5.44
11	5.32	6.10	4.89	5.50	4.64	4.59	4.24	4.44	4.16	4.42	4.64	5.56
12	5.83	6.20	4.87	4.95	4.69	4.56	4.24	4.38	4.11	4.40	4.65	5.60
13	6.50	6.26	4.73	4.86	4.65	4.70	4.21	4.17	4.10	4.42	4.68	5.71
14	6.50	6.30	3.10	4.90	4.62	4.75	4.36	4.21	4.07	4.42	4.72	5.66
15	6.10	6.35	3.15	4.78	4.56	4.69	4.45	4.53	4.10	4.45	4.76	5.63
16	6.35	6.42	3.18	4.80	4.57	4.55	4.37	4.53	4.09	4.50	4.80	5.66
17	6.55	6.48	3.75	5.94	4.60	4.69	4.30	4.34	4.20	4.44	4.84	5.37
18	7.01	6.32	4.73	4.95	4.62	5.04	4.25	4.34	4.25	4.41	4.75	5.36
19	6.85	6.39	5.85	4.86	4.65	5.04	4.22	4.30	4.26	4.42	4.65	5.25
20	6.63	6.63	5.33	4.82	4.64	4.74	4.21	4.32	4.27	4.44	4.58	5.12
21	6.53	6.65	4.75	4.66	4.58	4.63	4.13	4.30	4.55	4.43	4.55	5.04
22	7.00	6.98	4,78	4.67	4.62	4.45	4.10	4.25	4.89	4.45	4.57	4.98
23	6.81	7.15	4.63	4.69	4.63	4.61	4.11	4.41	4.78	4.47	4.50	4.98
24	6.76	7.10	4.65	4.69	4.59	4.56	4.15	4.52	5.04	4.48	3.68	4.81
25	6.64	7.30	4.62	4.65	4.63	4.36	4.17	4.58	5.26	4.50	3.32	4.65
26	6.59	7.33	4.66	4.63	4.54	4.37	4.19	4.48	4.55	4.50	3.45	4.50
27	6.35	7.45	4.65	4.62	4.54	4.36	4.22	4.33	4.44	4.48	3.63	4.45
28	6.23	8.68	4.65	4.64	4.53	4.46	4.03	4.43	4.36	4.43	4.21	4.49
29	6.22	......	4.78	4.72	4.46	4.45	4.02	4.41	4.31	4.40	4.64	....
30	6.15	......	4.76	4.66	4.82	4.49	4.00	4.35	4.35	4.44	4.84	....
31	6.10	......	4.79	......	4.88	......	3.96	4.47	......	4.47	......	....

a Heavy rain.

By applying the rating equations and table above given the following results of average monthly flow have been obtained:

Mean monthly discharge of Loup River at Columbus, Nebr.[1]

Month.	Discharge.
1895.	*Second-feet.*
April	2, 754
May	2, 966
June	3, 591
July	2, 122
August	2, 289
September	2, 427
October	2, 450

Prof. O. V. P. Stout has compared the combined monthly flows of the North and Middle Loup at St. Paul with that of the Loup at Columbus from May to October, inclusive. The distance from St. Paul to Columbus, omitting the smaller windings of the river, is about 65 miles. The principal streams received by the Loup in this portion of its course are the Cedar and Beaver creeks, both coming from the north. The following table shows the ratio between the combined flow of the Middle and North Loup at St. Paul and of the Loup at Columbus, this being expressed in percentages:

Month.	Per cent.
1895.	
May (27 days)	83. 1
June	81. 5
July	81. 3
August	85. 5
September	81. 2
October	81. 1

As shown by the above table, from 18.9 to 14.5 per cent of the discharge at Columbus during these months has been contributed by Cedar, Beaver, and other creeks and by underground sources. Measurements made during September, 1894, show approximately the same ratio of discharge, these being as follows:

Month.	River.	Locality.	Discharge.
1894.			*Sec. feet.*
Sept. 15	Cedar Creek	Fullerton, Nebr	210
Sept. 17	Beaver Creek	Genoa, Nebr	71
Sept. 16	Loup River	Fullerton, Nebr	1, 704

The ratio of flow of the two creeks to that of Loup River is approximately 14 per cent. These facts seem to indicate that the Loup below St. Paul is largely beyond the region of copious underground contributions.

[1] Annual Report of Nebraska State Board of Agriculture, 1895, Report of Engineer, pages 318-319, gives rate of discharge for ten-day periods from March 28 to November 23, 1895.

PLATTE RIVER.

COLUMBUS STATION, ON PLATTE RIVER.

The station is located about 3 miles southwest of the town of Columbus, Nebr., on the right bank of Platte River, immediately below the wagon bridge which crosses the main channel on or near the sixth meridian, and is above the mouth of Loup River. South of the main channel are two smaller channels. The station was established by Prof. O. V. P. Stout, observations being begun on June 9, 1895, and continued through July and August. The river gage consists of an oak rod, 3 by 6 inches and 16 feet long; the face is inclined 30° to the horizontal, the footmarks being thus 2 feet apart along the slope; the rod rests directly upon beveled blocks which in turn are supported by cross-ties bedded horizontally in the sand; lag screws through the rod, blocks, and ties bind all together firmly. The first bench mark is the top of the dowel in an old pile 40 feet east and 7 feet north of the end of the south truss. This is 1.59 feet above the zero of the gage. The second bench mark consists of a spike driven horizontally into the west side of the same pile. It is 0.65 foot above the zero. In the fall of 1895 the lower part of this gage was destroyed.

The channel is straight both above and below the station. It is composed of loose sand shifting rapidly. In the summer of 1894 the main body of water was against the right bank; in 1895 the sand had accumulated and the water was against the left bank.

Professor Stout has made a rating table which applies satisfactorily in spite of the changes in channel, as follows: From the point at which the stream is dry up to a gage height (g) of 0.30 he uses values deduced from a curve joining the plotted point $g = -0.22$ and q (discharge) $= 75$, with the curve $q = 8226\ (g - 0.02)^{1.22}$; from a height of 0.30 to 1.42 he uses the equation $q = 8226\ (g - 0.02)^{1.22}$; and from gage height of 1.42 to 2.28 feet he applies $q = 8226\ (g - 0.02)^{1.22} + 5250 \left(\frac{g - 1.42}{0.86}\right)^2$.

The first measurement was made on March 29 by Otis Weeks, with the Price electric meter. At that time the water was flowing in five channels, necessitating five different measurements. Later measurements were made on May 3 and May 22, under approximately the same conditions. On June 11 measurement was made during flood when the water was in three channels, the principal portion being in the main or north channel, where the flow was at that time 25,281 second-feet. The mean velocity in this channel was very nearly 4 feet per second, and the maximum velocity 5.08 feet per second. The middle channel was measured at a point nearly 2 miles from the gage in the main or north channel. Here the mean velocity was 2.34 feet per second and the total discharge 865 second-feet. In the south channel the mean velocity was very nearly 3 feet per second and the total discharge 1,068 second-feet.

Measurements were again made on June 25, when the water was in two channels, and on July 15, when the water had fallen considerably. On August 13 the river was nearly dry. The total visible flow was estimated by Professor Stout as not exceeding 75 second-feet. The readings of water height were therefore suspended until the flow increased. At this time the discharge at Grand Island, as noted from the train in crossing, was much greater than at Columbus.

List of discharge measurements made on Platte River at Columbus, Nebr.

No.	Date.	Hydrographer.	Meter number.	Gage height.	Discharge.
	1895.				
1	Mar. 29	Otis Weeks	Price	0.40	2,531
2	May 3	O. V. P. Stout	Price		5,550
3	May 22	do			5,896
4	June 11	do	105	2.28	27,214
5	June 25	do		1.42	12,431
6	July 15	do	105	0.72	5,338
7	Aug. 13	do			*a* 75

a Estimate, letter August 15, 1895.

Rating table for Platte River at Columbus, Nebr., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
−0.25	0	0.40	2,530	1.40	12,250
−0.20	120	0.45	2,950	1.50	13,350
−0.10	360	0.50	3,375	1.60	14,680
0.00	620	0.60	4,255	1.70	16,150
0.05	750	0.70	5,170	1.80	17,780
0.10	910	0.80	6,110	1.90	19,440
0.15	1,070	0.90	7,100	2.00	21,400
0.20	1,250	1.00	8,100	2.10	23,440
0.25	1,470	1.10	9,100	2.20	25,720
0.30	1,745	1.20	10,150	2.30	28,100
0.35	2,135	1.30	11,250		

Daily gage height of Platte River at Columbus, Nebr., for 1895.

Day.	June.	July.	Aug.	Day.	June.	July.	Aug.
1		1.12	0.20	17	1.76	0.50	0.08
2		0.98	0.12	18	1.70	0.45	0.08
3		0.85	−0.01	19	1.75	0.52	0.09
4		0.81	0.03	20	1.69	0.48	0.02
5		0.69	0.07	21	1.62	0.42	−0.02
6		0.59	0.08	22	1.57	0.39	0.09
7		0.56	−0.04	23	1.50	0.35	0.19
8		0.61	−0.07	24	1.43	0.33	0.22
9	1.30	0.54	−0.12	25	1.45	0.33	0.15
10	1.43	0.54	−0.06	26	1.40	0.29	0.04
11	2.03	0.49	−0.11	27	1.25	0.23	−0.04
12	2.05	0.62	−0.14	28	1.35	0.24	−0.07
13	2.05	0.61	−0.22	29	1.35	0.26	−0.10
14	1.90	0.64	0.17	30	1.31	0.26	−0.11
15	1.78	0.68	0.10	31		0.26	0.17
16	1.74	0.59	0.09				

From the above rating table and list of river heights computations have been made showing that the mean monthly discharge for twenty-seven days in June was 14,027 second-feet, for July 3,685 second-feet, and for August 722 second-feet.[1]

SALT CREEK AT LINCOLN.

On April 30, 1895, Prof. O. V. P. Stout measured Salt Creek at the Twelfth Street Bridge, Lincoln, Nebr. The height of water at that time was 1 foot below the second seam from the top of the upstream cylinder pier at the south end of the bridge. The width of the stream was 84 feet, the mean depth 6.3 feet, the maximum depth 8.2 feet, the mean velocity 2.83 feet per second, the maximum velocity 3.21 feet per second, and the total discharge was 1,500 second-feet. The water surface at this time was 0.2 foot below the high-water mark of the flood of that date. This flood was caused by a rainfall of from 1.5 to 2 inches over the drainage area, which has an extent of from 600 to 700 square miles. During dry weather of this spring the flow has averaged about 40 second-feet.

KANSAS BASIN.

The drainage basin of Kansas River lies between that of the Platte and Arkansas, but, unlike these, does not extend back to the mountains, being wholly included within the Great Plains area. The name Kansas is applied only to the portion of the main stream below the union of the Republican and Smoky Hill rivers. Junction City is located near this point of intersection. The principal tributary below this point is Blue River, coming in from the north and draining a portion of the States of Nebraska and Kansas. The Kansas River and its tributaries are described at length in the paper by Dwight Porter in Volume XVII, Tenth Census, entitled "Report on the water power of the region tributary to the Mississippi River to the west below Dubuque, Iowa," pages 56–77.

The Kansas is one of the best examples of a plains stream, its drainage basin lying entirely within the region of the Great Plains, and principally within the arid or semiarid area. It has no mountain tributaries, but depends entirely for its water supply upon the water which, falling within or near the basin, percolates slowly to the drainage channels. The catchment area extends from eastern Colorado to the Missouri River, a distance from east to west of 485 miles. The width at the extreme points is nearly 200 miles. The area drained, as measured from the maps of the General Land Office, is 61,440 square miles, of which 34,526 are in Kansas, 17,455 in Nebraska, and 9,459 in Colorado.

The altitude of the drainage basin, as shown by the Gannett Contour Map of the United States and published altitudes, varies from 750 feet at Kansas City to over 5,000 feet in Colorado, the average elevation

[1] Annual Report of Nebraska State Board of Agriculture, 1895, Report of the Engineer, pages 325-326, gives daily discharge from June 4 to July 31, 1896, and estimate for August.

being about 2,500 feet. The area with reference to elevation is distributed as follows:

Altitude of drainage area of the Kansas River Basin.

Altitude.	Area.
	Sq. miles.
Under 1,000 feet	1,250
Between 1,000 and 2,000	26,200
Between 2,000 and 3,000	14,300
Between 3,000 and 4,000	12,560
Between 4,000 and 5,000	5,620
Over 5,000 feet	1,510
Total	61,440

The mean annual precipitation of this basin varies from about 10 inches at the western extremity to nearly 40 inches at the Missouri River, averaging in round numbers 20 inches. The conditions as regards rainfall are in this basin the reverse of those within the drainage area of most of the Western streams of value for power or irrigation. The greater part of these rise in high mountains where the precipitation is heavy and flow to lands where the rainfall is slight. As they leave the elevated land, the smaller tributaries of such streams can be used to advantage where their volume is greatest, but in the case of the Kansas River the tributaries for the most part rise in the arid portion of the basin and drain a gently undulating or nearly flat country. They are thus almost insignificant in size, excepting during the wettest season, until they reach the region where the precipitation is so great that the requirements of agriculture are nearly satisfied. These streams attain great volume only in the eastern portion of the State, where irrigation is not important, and where nearly all of the water is concentrated into one stream, this being so large and having such a gentle slope that its diversion is exceedingly difficult, if not impracticable.

The Kansas River proper, as the name is commonly applied, is formed by the junction of the Smoky Hill and Republican forks at Fort Riley, near Junction City. Its entire length from this point to the place where it empties into the Missouri is about 140 miles. Three large rivers of eastern Kansas flow directly into the Kansas: the Blue, from the north, joining it at Manhattan; the Republican, from the northwest, and the Smoky Hill, from the west. The Blue has a drainage of 9,490 square miles, of which 2,450 are in Kansas and 7,040 in Nebraska. In volume of water the Blue River is by far the most important of the tributaries of the Kansas. The discharge of this river is being measured at Rocky Ford, about 5 miles above its mouth. The minimum discharge is about 300 cubic feet per second.

The next stream in order, and also in amount of water delivered, is the Republican, draining an area of 25,837 square miles, and showing a minimum flow, as observed at Junction City, of about 200 cubic feet per second. It will be noticed that though draining over two and a half times the area, its discharge at low water is less than that of the Blue. This is due to the fact that the Blue drains the northern and eastern part of the basin, where the rainfall is heaviest, while the Republican rises in the most western extremity of the Kansas basin and flows for hundreds of miles through arid sand hills that yield very little run-off, except in times of excessive rainfall, and no part of its basin receives precipitation equal to the average of the basin of the Blue, so that though the basins adjoin each other, and the rivers empty within 20 miles of each other, the ratio of run-off to area is several times as great for the Blue as for the Republican.

The Smoky Hill River rises in eastern Colorado, and drains an area of 20,428 square miles. It has two considerable tributaries, the Saline and the Solomon, draining, respectively, 3,311 and 6,882 square miles. Gaging stations have been established on all three of these streams. The station at Ellsworth, on the Smoky Hill, intercepts the drainage of 7,980 square miles, 6,447 of which are in Kansas and 1,533 in Colorado. A minimum discharge sometimes occurs here of 10 cubic feet per second. At the gage on the Saline River at Beverly the area drained is 2,730 square miles, and a low-water discharge of 6 second-feet is shown. The gage on the Solomon is at Beloit. The area draining past this point is 5,539 square miles, and the low-water flow is 7 cubic feet per second.

There are many water-power developments in the Kansas basin, the most numerous and important occurring on the Solomon and Blue rivers. These developments are in their infancy, only a small proportion of the favorable sites being improved.

Drainage areas, Kansas Basin.[1]

Basin.	Total area.	Area in Kansas.	Area in Nebraska.	Area in Colorado.
Kansas River	61,440	34,526	17,455	9,459
Kansas, above Lawrence	59,841	33,927	17,455	9,459
Blue, above Manhattan	9,490	2,450	7,040	
Republican	25,837	7,496	10,415	7,926
Smoky Hill, entire basin	20,428	18,895		1,533
Smoky Hill, above Ellsworth	7,980	6,447		1,533
Saline, entire basin	3,311	3,311		
Saline, above Beverley	2,730	2,730		
Solomon, entire basin	6,882	6,882		
Solomon, above Beloit	5,539	5,539		

REPUBLICAN RIVER.

BENKELMAN STATION, ON NORTH FORK OF REPUBLICAN RIVER.

This station has been described in Bulletin No. 131, page 33. The location is essentially the same, although the gage rod has been replaced. Observations have been carried on continuously from November 4,

[1] As measured from Land Office maps; Kansas, edition of 1891; Nebraska, edition of 1890; Colorado, edition of 1892.

1894, to September 1, 1895, the gage heights being shown in the table on page 129. The channel at this point is described as being composed of loose and shifting sand.

List of discharge measurements made on North Fork of Republican River at Benkelman, Nebr.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.					
1	Dec. 9	O. V. P. Stout	105	1.74	2.81	*a* 75
2	Mar. 23	.....do	105	1.89	2.01	*b* 72
	1895.					
3	June 4	.....do	105	1.68	2.83	*c* 141
4	June 24	.....do	105	1.06	1.45	36
5	Aug. 7	.....do	105	0.96	2.02	64

a At the time of this measurement the stream was in two channels, the greater part of the water being in that toward the right bank. Slush ice and small cakes interfered somewhat with the accuracy of the results of this measurement.

b At this time, also, the stream was flowing in two channels, containing, respectively, 70.6 and 0.9 second-feet.

c Measurement immediately after flood.

The above list of discharge measurements and the observations made at this point show plainly that reliable computations of daily discharge can not be made if based only upon occasional measurements of gage height and discharge. The difficulties encountered at this station and at Palisade, on Frenchman River, are fairly representative of those met elsewhere on streams with shifting channels. As noted on page 28, a single rating table can not be used at such stations for many weeks or months in succession; rather a series of such tables must be constructed, taking into account the shifting character of the bed. A somewhat detailed description is therefore given of the methods of computation employed at this place and at Palisade.

The changes in the bed of a stream are by no means regularly progressive in one direction or another, as they depend upon the change in volume and velocity of the stream, these fluctuating irregularly. In time of flood the channel may scour in a few hours and then remain fairly constant during the whole period of high water. Experience has shown that for medium and high stages a rating table can be used for a considerable period of time—far longer than when the river is low—and therefore, as shown by Professor Stout on page 134, it is often safe to assume that after the river rises to a certain point the old rating table is applicable. In any event, the percentage of error and the necessity of accuracy are less at flood time, since the volume is fluctuating from hour to hour.

At time of low water, when the quantity is small and the bed is silting, and as a rule rising slowly relative to the gage, it is highly essential to attain greater accuracy in computations of daily discharge. To facilitate this, it has been deemed advisable to make occasional soundings of the section in addition to the daily readings of height. For this purpose a blank notebook, Form 9-208, has been provided. This is to be placed in the hands of the observer, who usually can wade the stream at such times and obtain the depth at designated points. Such points are referred to the initial point, from which all soundings are measured. These soundings should be taken at intervals of, say, a week or ten days between the times of measurements of discharge. If properly made and recorded, they serve as a basis for the preparation of a rating table or formula by which to compute the daily amount flowing in the stream.

The ratings made by Professor Stout have been put in two forms; first, as formulas, shown on pages 121 and 133, and, second, as a series of rating tables applicable to consecutive periods. The latter is probably the simpler and more convenient form, and one which most hydrographers prefer. The following rating tables, designated as A, B, C, D, and E, as well as those given on page 134, are inserted as examples of this method of computing the discharge. In deriving the formulas for discharge shown on page 133, it has been assumed that the mean elevation of the bed of the stream, as seen in cross section, is constant throughout any subperiod, so that the mean depth at any time during the subperiod may be obtained by subtracting from the gage height at that time the difference between the gage height and mean depth at time of the gaging. It has also been assumed that the discharge is proportional to the three-half power of the mean depth. The justification of this assumption, so far as it can be justified, is found in the form to which the common formulas for flow reduce in the case of shallow streams of constant width.

Table A, given below, covers the period from November 4 to December 10, 1894. The general character of the channel varied but little. The division between this subperiod and the succeeding one is marked by the occurrence of slush ice in the river, causing an increase in gage height without any corresponding increase in discharge, so far as could be ascertained. From December 10 to March 2, 1895, the ice in one form or another was almost always in the river. The effect of this to increase the gage height is shown in the record. With the single exception of a storm on February 25, there was no precipitation of sufficient magnitude to contribute materially to the discharge of the stream. In view of this fact, it is probable that the discharge for the latter part of the preceding subperiod and the earlier part of the succeeding subperiod furnishes a more reliable indication of the discharge than the gage heights during the period in question. The division between this and the succeeding subperiod is marked by the disappearance of ice from the river.

Table B covers the period from March 2 to May 29, 1895, when no violent floods occurred. The disappearance of the water, as noted by the observer on May 15, occurred when the gage height was 1.25. This substituted in the formula for discharge gives the zero of flow. The division between this and the succeeding subperiod is marked by the occurrence of a flood on May 30 and 31, June 1 and 2. The measurement of June 4 shows that this flood deranged the relation between gage height and discharge.

Table C covers the period from May 29 to June 13, 1893. The division between this and the succeeding subperiod is marked by a flood which caused alterations of the relation of gage height to discharge. Table D covers the period to July 2, a change at the latter date being necessitated by a violent flood occurring on July 1–2. The last table, E, is used for the time up to September 1, during which interval no floods occurred. At the latter date the stream was practically dry.

Rating tables for Benkelman Station, on North Fork of Republican River, used for successive periods during 1895.

Gage height.	Discharge in second-feet.				
	A.	B.	C.	D.	E
0.40	....	....	....	....	1.2
0.50	....	....	....	....	5.5
0.60	....	....	....	....	15.0
0.70	....	....	....	....	26.0
0.80	....	....	....	....	40.0
0.90	....	....	....	....	54.0
1.00	....	....	....	28	70.0
1.10	....	....	....	41	89.0
1.20	....	0	....	55	110.0
1.30	....	4.5	....	70	130.0
1.40	....	8.1	....	86	....
1.50	....	17.3	....	103	....
1.60	....	28.8	123	121	....
1.70	70	42.0	146	140	....
1.80	83	57.0	170	160	....
1.90	97	73.0	195	182	....
2.00	112	91.0	222	204	303.0
2.10	....	110.0	250	228	....
2.20	....	130.0	280	252	....
2.30	....	152.0	310	292	....
2.40	....	175.0	342	332	....
2.50	....	....	374	374	....
2.60	....	....	406	....	....
2.70	....	....	440	....	....
2.80	....	....	475	....	....
2.90	....	....	510	....	....
3.00	....	....	550	....	....
3.10	....	....	590	....	....
3.60	....	....	....	656	....

Daily gage height of North Fork of Republican River at Benkelman, Nebr., 1894 and 1895.

Day.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	1.72	1.92	*a*2.00	2.60	2.30	1.78	1.70	*b*2.52	*c*2.35	1.17
2	1.72	1.91	2.50	2.60	1.92	1.78	1.63	2.30	1.80	1.10
3	1.72	1.90	2.58	2.60	1.85	1.77	1.60	1.80	1.17	1.10
4	1.72	1.85	2.60	2.60	1.60	1.80	1.60	1.68	1.17	1.04
5	1.73	1.80	2.65	2.60	1.65	1.85	1.60	1.70	1.04	1.01
6	1.76	1.83	2.65	2.65	1.70	1.95	1.54	1.65	1.04	0.97
7	1.75	1.80	2.65	2.65	1.78	2.00	1.50	1.62	0.91	0.96
8	1.74	1.82	2.65	2.65	1.76	1.95	1.50	1.58	0.91	0.92
9	1.72	1.80	2.68	2.65	1.80	1.95	1.46	1.60	0.94	0.66
10	1.73	1.84	2.65	2.65	1.80	1.90	1.40	1.65	1.10	0.61
11	1.72	2.80	2.65	2.65	1.80	1.85	1.36	*d*3.70	1.17	0.60
12	1.72	2.75	2.65	2.65	1.75	1.80	1.34	3.00	1.17	0.61
13	1.71	2.70	2.65	2.65	1.75	1.78	1.33	2.50	1.17	0.60
14	1.71	2.65	2.65	2.65	2.10	1.77	1.30	1.60	2.00	0.92
15	1.72	2.00	2.70	2.65	2.20	1.76	1.25	1.50	1.14	0.83
16	2.01	1.90	2.76	2.65	2.30	1.78	1.25	1.50	1.11	0.72
17	2.04	1.85	2.76	2.80	2.35	1.80	1.20	1.45	0.91	0.71
18	1.77	1.85	2.76	2.80	2.30	1.82	1.20	1.60	0.88	0.60
19	1.77	1.82	2.76	2.80	2.30	1.74	1.21	1.40	0.86	0.57
20	1.75	1.81	2.76	3.00	2.10	1.76	1.20	1.20	0.91	0.73
21	1.72	1.75	2.76	*e*3.05	2.00	*f*1.78	1.25	1.20	1.17	0.42
22	1.72	1.80	2.70	3.14	1.90	1.75	1.30	1.20	1.42	0.60
23	1.72	1.95	2.70	3.15	1.92	1.70	1.30	1.08	1.29	0.96
24	1.73	1.92	2.65	3.30	1.91	1.64	1.35	1.08	1.23	0.60
25	1.73	1.87	2.60	3.25	1.90	1.64	1.30	1.09	1.23	0.57
26	1.73	2.07	......	3.15	1.90	1.63	1.30	1.08	1.10	0.55
27	1.75	1.97	2.60	2.94	1.89	2.02	1.25	1.05	1.08	0.38
28	1.84	1.97	2.60	2.63	1.85	1.95	1.22	1.05	1.04	0.33
29	1.95	1.97	2.60	......	1.83	1.90	1.22	1.08	1.01	0.32
30	1.93	1.97	2.60	......	1.80	1.75	2.00	1.08	0.97	0.42
31	......	1.97	2.60	......	1.75	......	2.20	......	1.01	0.17

a From January 1 to 5 there was a slight thaw, but on the 6th the river was frozen, thawing again on the 10th, slight thaws continuing through January. On the last day of this month it was reported that the thermometer was 17° below zero. During the early part of February the river was frozen, thawing about February 17.

b On June 1 there was a heavy rainfall, the river rising to 2.80 feet at 5 p. m.

c On July 1 the river stood at 1.10 feet in the morning and at 5 p. m. at 3.60 feet, being then out of its banks. The maximum height was reached at noon, probably being about 4.50 feet. At this time the river rod was loosened, but it was subsequently replaced, corrections being made for errors of reading.

d On June 11 the showers caused the river to rise to 3.70 feet and break over its banks. By June 19 the floods had deepened the channel, a large amount of water running in the stream.

e On February 21 the river at 4 p. m. was reported to be at the height of 3.20 feet and out of its banks in the low places, continuing thus for four days. On the 26th the ice had mostly disappeared.

f On April 21 it was reported that the water was being taken out in ditches, and that there was less water in the river than indicated by the reading of the gage. On May 11 the river was remarkably low, owing to lack of rain, and on May 15 the greater part of the stream had disappeared into the sand.

By applying the above rating tables to the observations of river height, the following averages have been obtained:

Mean monthly discharge of North Fork of Republican River at Benkelman, Nebr.[1]

Month.	Discharge.
1895.	*Sec.-feet.*
March	78
April	59
May	25
June	155
July	120
August	34
September	Dry.

[1] Annual Report of Nebraska State Board of Agriculture, 1895, report of the engineer, p. 322, gives rate of discharge for ten-day periods from November 3, 1894, at intervals to September 7, 1895.

BENKELMAN STATION, ON SOUTH FORK OF REPUBLICAN RIVER.

This station, described in Bulletin No. 131, page 33, has been maintained with short breaks up to the end of September, 1895. During June the freshets washed out the gage previously established, and on June 21 a new gage was erected about 3,000 feet below the location of the former one. The new gage consists of a vertical rod of oak, spiked to a pile forming a part of the ruined wagon bridge. The channel at this point is sandy and shifting. During high water it is fairly straight for about 300 feet above and below, the width from bank to bank being a little more than 350 feet. The right bank is high, but the left bank is low and subject to frequent overflow. The bench mark consists of the top of a screw in the root of a tree to the left of the road leading to Benkelman, and 200 feet from the river bank. The elevation of this screw is 6.12 feet above the zero of the gage. Levels taken on July 3, 1895, when the river height at the new gage was 2.60 feet, showed that the height on the old gage would have been 1.39. The fall of the water surface in this distance of 3,000 feet between the two gages was found to be 4.76 feet. The zero of the old gage was 5.97 feet above the zero of the new gage.

List of discharge measurements made on South Fork of Republican River at Benkelman, Nebr.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.					
1	Dec. 9	O. V. P. Stout				1
	1895.					
2	Mar. 23	do	105	1.89	1.70	41
3	June 4	do	105	(a)	2.90	348
4	June 24	do	105	1.50	1.79	75
5	July 3	do	105	2.60	2.48	278
6	Aug. 7	do	105	1.75	1.30	22

a Old gage washed out; new one erected June 2.

Daily gage height of South Fork of Republican River at Benkelman, Nebr., for 1894.

Day.	Nov.	Dec.	Day.	Nov.	Dec.
1	0.97	1.06	17	1.08	1.07
2	1.06	1.06	18	1.08	1.08
3	1.06	1.06	19	1.07	1.26
4	1.05	1.06	20	1.08	1.24
5	1.05	1.06	21	1.08	1.54
6	1.05	1.06	22	1.07	1.52
7	1.06	1.06	23	1.07	1.51
8	1.06	1.06	24	1.08	1.43
9	1.06	(a)	25	1.07	1.54
10	1.06		26	1.06	1.31
11	1.06		27	1.06	1.12
12	1.06		28	1.07	1.09
13	1.06		29	1.06	1.09
14	1.06		30	1.06	1.09
15	1.06		31		1.08
16	1.08	1.07			

a December 9, 1894, O. V. P. Stout reports less than 1 second-foot.

Daily gage height of South Fork of Republican River at Benkelman, Nebr., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	1.06	1.42	2.42	1.87	1.65	1.88	1.34	1.90
2	1.06	1.54	2.13	1.92	1.63	....	3.12	1.90
3	1.06	1.56	2.12	1.86	1.56	....	2.70	1.89
4	1.06	1.68	2.12	1.83	1.45	....	2.30	1.89
5	1.06	1.74	2.09	1.78	1.43	....	2.01	1.89
6	1.23	0.00	2.07	1.79	1.42	....	1.90	1.88
7	1.25	1.97	1.97	2.17	1.41	....	1.89	1.75
8	1.26	1.86	1.96	2.06	1.40	....	1.89	1.68
9	1.56	1.64	1.94	1.99	1.39	....	1.80	1.68
10	1.58	1.59	1.89	1.89	1.40	....	1.80	1.65
11	1.63	1.39	2.11	1.86	1.39	....	1.89	1.03
12	1.60	1.36	1.94	1.79	1.36	....	1.89	1.60
13	1.74	1.32	1.63	1.74	1.39	....	2.00	1.58
14	1.73	1.26	1.64	1.70	1.36	....	3.12	1.55
15	1.76	1.23	1.66	1.72	1.37	....	2.88	1.55
16	1.76	1.23	1.68	1.82	1.36	....	2.30	1.55
17	1.79	1.25	1.95	1.88	1.37	....	2.20	1.54
18	1.85	1.29	2.12	1.84	1.37	....	2.10	1.54
19	1.82	1.29	2.09	1.77	1.37	....	2.01	1.54
20	2.00	2.13	2.05	1.75	1.36	....	2.12	1.54
21	2.06	2.14	1.99	1.71	1.35	*a* 1.50	2.20	1.58
22	2.09	2.24	1.98	1.71	1.35	1.50	2.30	1.50
23	2.19	2.29	1.89	1.70	1.35	1.45	2.60	1.50
24	2.04	2.34	1.89	1.74	1.36	1.50	2.30	1.50
25	1.68	2.37	1.90	1.68	1.37	1.45	2.30	....
26	1.68	2.39	1.87	1.61	1.39	1.45	2.05	....
27	1.67	2.54	1.83	1.58	1.37	1.45	2.04	....
28	1.61	2.68	1.83	1.70	1.37	1.40	2.00	....
29	1.59	....	1.78	1.88	1.37	1.40	1.90	....
30	1.54	....	1.69	1.76	1.55	1.40	1.89	....
31	1.44	....	1.73	....	2.27	....	1.89	....

a On June 21 a new gage rod was erected to replace the one washed out about June 1.

WAUNETA STATION, ON FRENCHMAN RIVER.

This station is the highest on the Frenchman River. It was established on August 8 by Prof. O. V. P. Stout, at a point about 100 yards below Wauneta Mill and Wauneta Falls, in the town of Wauneta. The observer is W. W. Fisher, justice of the peace. The gage rod consists of oak, 2 by 4 inches, and is 12 feet long. The lower end is buried in the sand of the bottom and the upper part is fastened by lag screws to the south pile of the bent at the edge of the water. The channel at this point is straight for 600 feet above the gage and for 150 feet below it. The bed is composed of sand and silt, there being, however, a small amount of loose rock from the old bridge pier in the vicinity of the gage. One of the bench marks is the stone doorstep of a concrete house which stands below the gage on the right bank, the elevation of this being 19.99 feet above the zero of the gage. A second bench mark is the top of a stake at the northwest corner of the lot in which this house stands, this point being 19.33 above the zero of the gage.

Measurements were made at this point on August 9, 1895, showing that for a reading of 1.40 feet the discharge was 61 second-feet. These measurements were made from a bridge which stands at a height of about 12 feet above the ordinary stage of the water. On September 10 a measurement at a gage height of 0.92 foot gave a discharge of 56 second-feet. The station at this point was established after that at Palisade, as it was found that the channel was better adapted for accurate and convenient measurement. The relation between gage height and discharge is probably more constant here than at the other points examined. At Palisade the river is wide, the banks are comparatively low, and the bed is of shifting sand, while at Wauneta the river is narrow and the banks are high. Both of these stations have been maintained in order that data might be had concerning the amount of underground water contributed to the stream between the two points. The surface tributaries in this section of the river carry no water except during and after storms.

Daily gage height of Frenchman River at Wauneta, Nebr., for 1895.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	0.82	1.14	1.06	1.04
2	....	0.84	1.12	1.06	1.08
3	....	0.84	1.12	1.06	1.06
4	....	0.84	1.16	1.06	1.08
5	....	0.84	1.16	1.06	1.12
6	....	0.88	1.22	1.06	1.16
7	....	0.90	1.20	1.06	1.16
8	....	0.92	1.18	1.06	1.24
9	....	0.92	1.16	1.06	1.28
10	....	0.92	1.16	1.06	1.16
11	1.68	0.92	1.14	1.06	1.12
12	1.66	0.92	1.14	1.06	1.12
13	1.42	0.94	1.12	1.06	1.12
14	1.40	0.94	1.12	1.06	1.12
15	1.36	0.94	1.12	1.06	1.12
16	1.30	0.94	1.10	1.06	1.12
17	1.28	0.94	1.08	1.06	1.10
18	1.22	0.96	1.08	1.06	1.10
19	1.20	1.00	1.08	1.06	1.10
20	1.16	0.98	1.08	1.06	1.10
21	1.14	0.98	1.10	1.06	1.10
22	1.12	1.00	1.08	1.06	1.10
23	1.10	1.04	1.08	1.06	1.10
24	1.10	1.10	1.08	1.06	1.10
25	1.08	1.10	1.08	1.08	1.10
26	1.08	1.08	1.08	1.10	1.16
27	1.10	1.08	1.06	1.32	1.16
28	1.14	1.08	1.06	1.24	1.16
29	1.16	1.14	1.06	1.16	1.12
30	1.16	1.16	1.06	1.08	1.10
31	1.18	....	1.06	....	1.10

PALISADE STATION, ON FRENCHMAN RIVER.

This station, described in Bulletin No. 131, page 33, is about 16 miles below the locality at Wauneta where a number of measurements have been made. The observations at this point have been continued since October 14, 1894, and a number of discharge measurements made, as shown by the table. The bed of the stream at this point is of loose, shifting sand, and changes considerably from time to time. Both banks are relatively low and liable to overflow at times of high water.

List of discharge measurements made on Frenchman River at Palisade, Nebr.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	Dec. 8	O. V. P. Stout	105	1.87	82	1.41	116
	1895.						
2	Mar. 22	do	105	1.52	54	1.88	100
3	June 5	do	105	1.76	100	1.55	154
4	July 4	do	105	1.61	47	1.59	74
5	Aug. 9	do	105	1.50	55	1.23	68
6	Aug. 10	do	105	1.50	43	1.69	72

Prof. O. V. P. Stout has prepared rating tables, given below, for this station, based upon the measurements and upon assumption as to changes in the bed of the stream, these being in form similar to those shown on page 128. He states that column A of this table is wholly independent of the others, because the river carried ice during a large part of the period, October 14 to December 25, to which this relates. The discharge is assumed to be about as the three-half power of the mean depth; that is to say, if q represents the discharge and g the gage height the relation will be

$$q = 116 \left(\frac{g-1.26}{0.61}\right)^{\frac{3}{2}}.$$

In filling out columns C, D, E, and F it was assumed that the shifting of the sandy bed of the river caused less proportional discrepancy at high stages than at low, and that the measurements show that it is safe to assume that the rating above a certain gage height is fairly constant. In other words, at times of high water the bottom is soon scoured out to about the area which it had on previous occasions. This area may be shifted in position, but the relation of gage height to discharge, as pointed out on page 126, is reasonably constant. Professor Stout has therefore assumed that the rating at Palisade does not vary for gage heights above 2 feet, and from consideration of quantities at the time of greatest measured discharge on June 5, 1895, he has adopted the equation $q = 154 \left(\frac{g-1.2}{0.56}\right)^{\frac{3}{2}}$ to represent this rating. This equation is used for the whole of column D, and for columns C, E, and F when g equals or exceeds 2 feet.

When g is less than 2 feet the quantities in column C are calculated from the equation $q = 154 \left(\frac{g-1.2}{0.56}\right)^{\frac{3}{2}} + 33 \left(\frac{2.00-g}{0.48}\right)^{\frac{3}{2}}$. Those in column F are calculated from equation $q = 154 \left(\frac{g-1.2}{0.56}\right)^{\frac{3}{2}} + 11 \left(\frac{2.00-g}{0.50}\right)^{\frac{3}{2}}$ and those in column E from the equation $q = 263 - 485\,(2.00-g)$. To the period from December 25, 1894, to February 27, 1895, must be assigned an estimated mean discharge based upon the computation for a few weeks immediately preceding and succeeding this period.

Rating tables for Frenchman River at Palisade, Nebr., used for successive periods during 1894 and 1895.

[Discharge in second-feet.]

Gage height.	A. Oct. 14, Dec. 25, 1894.	C. Feb. 27, May 30, 1895.	D. May 31, June 11, 1895.	E. June 12, July 14, 1895.	F. July 15, 1895.
1.40	....	79	33	....	48
1.45	....	86	46	....	59
1.50	....	95	60	....	71
1.55	....	106	76	....	85
1.60	....	118	93	69	101
1.65	....	131	111	94	117
1.70	....	146	130	118	135
1.75	83	162	150	142	154
1.80	97	180	171	166	174
1.85	111	199	193	190	195
1.90	125	218	215	215	216
1.95	....	240	239	239	239
2.00	....	263	263	263	263
2.10	....	....	315	....	....
2.20	....	....	368	....	....
2.30	....	....	425	....	....
2.40	....	....	483	....	....
2.50	....	....	544	....	....
2.60	....	....	607	....	....
2.70	....	....	673	....	....
2.80	....	....	740	....	....
2.90	....	....	810	....	....
3.00	....	....	883	....	....

Daily gage height of Frenchman River at Palisade, Nebr., for 1894.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	1.86	1.78	17	1.84	1.81	1.80
2	....	1.85	1.80	18	1.85	1.83	1.77
3	....	1.84	1.82	19	1.82	1.85	1.79
4	....	1.85	1.84	20	1.81	1.81	1.72
5	....	1.85	1.81	21	1.80	1.83	1.71
6	....	1.83	1.80	22	1.82	1.83	1.75
7	....	1.82	1.81	23	1.81	1.84	1.73
8	....	1.83	1.83	24	1.84	1.85	1.73
9	....	1.83	1.83	25	1.85	1.81	1.72
10	....	1.81	1.84	26	1.85	1.80	2.22
11	....	1.81	1.83	27	1.86	1.81	2.18
12	....	1.82	1.84	28	1.90	1.80	1.89
13	....	1.80	1.85	29	1.89	1.83	2.13
14	1.82	1.82	2.28	30	1.89	1.85	2.20
15	1.83	1.81	1.90	31	1.88	....	2.25
16	1.85	1.85	1.88				

Daily gage height of Frenchman River at Palisade, Nebr., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	2.31	2.50	1.60	1.55	1.63	[a]1.75	1.65	1.55	1.49	1.60	......
2	2.35	2.58	1.58	1.59	1.72	1.90	1.65	1.58	1.49	......	1.64
3	2.38	2.58	1.55	1.58	1.63	1.80	1.63	1.63	1.50	......	......
4	2.40	2.59	1.60	1.59	1.66	1.70	1.61	1.60	1.51	......	......
5	2.42	2.60	1.60	1.60	1.66	1.72	1.60	1.55	1.52	1.61	1.60
6	2.36	2.55	1.60	1.70	1.73	1.75	1.60	1.55	1.50	......	......
7	2.38	2.50	1.55	1.75	1.70	1.73	1.81	1.55	1.50	......	......
8	2.40	2.45	1.52	1.75	1.68	1.68	1.75	1.53	1.50	1.62	......
9	2.42	2.50	1.53	1.77	1.67	1.68	1.57	1.55	1.50	......	1.60
10	2.45	2.62	1.53	1.75	1.65	1.70	1.60	1.50	1.50	......	......
11	2.45	2.72	1.55	1.74	1.65	1.93	1.65	1.51	1.51	......	......
12	2.46	2.82	1.53	1.73	1.66	1.72	1.65	1.50	1.50	1.62	1.60
13	2.42	2.83	1.54	1.74	1.66	1.68	1.65	[b]2.05	1.49	......	......
14	2.48	2.84	2.00	1.73	1.66	1.67	2.69	1.90	1.50	......	......
15	2.48	2.85	1.90	1.72	1.64	1.67	1.95	1.55	1.50	1.62	......
16	2.48	2.89	1.94	1.72	1.63	1.68	1.85	1.55	1.50	......	1.60
17	2.50	2.90	1.72	1.71	1.64	1.70	1.75	1.55	1.51	......	......
18	2.50	2.90	1.60	1.72	1.64	1.68	1.70	1.54	1.53	......	......
19	2.48	2.90	1.56	1.72	1.65	1.67	1.66	1.52	1.52	1.63	1.60
20	2.45	2.90	1.56	1.74	1.68	1.65	1.63	1.52	1.53	......	......
21	2.33	2.95	1.55	1.75	1.66	1.68	1.64	1.47	1.55	......	......
22	2.26	2.95	1.55	1.77	1.64	1.66	2.56	1.48	1.56	1.65	......
23	2.20	2.94	1.52	1.70	1.64	1.65	2.45	1.50	1.57	......	2.00
24	1.93	2.92	1.52	1.68	1.64	1.63	1.87	1.50	1.58	......	......
25	1.98	2.75	1.51	1.70	1.66	1.64	1.80	1.50	1.57	......	......
26	[c]1.90	2.68	1.50	1.68	1.60	1.60	1.72	1.51	1.57	1.68	2.20
27	2.08	[d]1.58	1.52	1.62	1.60	1.57	1.70	1.50	1.55	......	......
28	2.30	1.58	1.52	1.62	1.62	1.55	1.65	1.50	1.56	......	......
29	2.28	......	1.53	1.60	1.57	1.59	1.61	1.49	1.58	1.66	......
30	2.35	......	1.52	1.66	1.62	1.63	1.60	1.50	1.59	......	1.90
31	2.43	......	1.53	1.78	......	......	1.57	1.50	......	......	......

a On June 1 at 1 o'clock the water stood at 1.75 feet; at 2 o'clock, 3 feet; at 2.45, 3.35 feet; at 2.55, 4.10 feet; at 3.10, 4.35 feet, the highest during the flood. It is reported that the rain continued for eighteen hours, at times coming with great violence.

b On August 13 the water stood at 6 a. m. at 1.55 feet; at 9 p. m. at 2.55 feet, during the night reaching a height of 2.85 feet.

c During the latter part of January the ice in going out of the river tended to pond and raise the water, so that the readings were higher than corresponding discharges. In the early part of February the height of water fluctuated in accordance with changes of weather.

d On February 27 the ice went out of the river, resulting in a decided fall of the water. The lower gage reading is probably due largely to the washing out of the sand about this time, as the observer reports that the volume was not apparently lessened.

By applying the tables given above to the observations of height of water the following averages have been obtained:

Mean monthly discharge of Frenchman River at Palisade, Nebr.[1]

Month.	Discharge.
1895.	*Sec.-feet.*
April	137
May	129
June	117
July	99
August	78
September	74

Frenchman River flows into Republican River about 18 miles below the station at Palisade. The town of Culbertson, Nebr., is near this point. A measurement of Frenchman River and one of Republican River, above the junction, were made on November 25, 1892, by Mr.

[1] Annual Report of Nebraska State Board of Agriculture, 1895, report of engineer, p. 323, gives rate of discharge for ten-day periods from October 13, 1894, at intervals, to November 13, 1895.

Cyrus C. Babb, at the highway bridges. At that time he found the mean velocity of the Frenchman to be 1.68 feet per second, and the total discharge 177 second-feet, this being a little larger than the average summer flow. The mean velocity of the Republican was 1.81 feet per second, and the total discharge 209 second-feet. On March 22, 1895, Prof. O. V. P. Stout found a flow of 120 second-feet in the Frenchman at Culbertson.

A single measurement of Republican River was made June 3, 1895, by Professor Stout, at Oxford, Nebr., about 83 miles by rail below Palisade. This was at the wagon bridge south of the town, where the channel was sandy and comparatively straight. The surface of the water at that time was 3.25 feet below the outside chord bar on the east side of the north panel of the north span of the bridge. The height was then reported to be the greatest known in nineteen years. The total discharge was, in round numbers, 16,000 second-feet. The total width of the river was 340 feet, mean velocity 7.67 feet per second, and the maximum 8.50 feet per second. This flood, following severe storms, deranged the relation of discharge to gage height at most of the stations. On September 12, at the same place, the discharge was only 55 second-feet.

List of discharge measurements made on Frenchman and Republican rivers.

Date.	River.	Locality.	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1892.					
Nov. 25	Frenchman	Culbertson, Nebr.	105	1.68	177
Nov. 25	Republican	do	115	1.81	209
1895.					
Mar. 22	Frenchman	do			120
June 3	Republican	Oxford, Nebr.		7.67	16,000
Sept. 12	do	do	50	1.09	55

JUNCTION CITY STATION, ON THE REPUBLICAN RIVER.

This station was established on April 26, 1895, by Mr. Arthur P. Davis. It is located at the wagon bridge at the north end of Washington street, Junction City, Kans., and is near the junction of the river with the Smoky Hill, forming the Kansas River. The measurements therefore give the total run off of the Republican Basin. The observer is John Davis, living near the station. The gage consists of two oak timbers, 4 inches by 4 inches, one inclined, the other nearly vertical. The former is bolted to a post driven into the bed of the river, and bolted and braced to a cottonwood tree; the vertical portion is spiked to the same tree. The scale is painted on pine boards, firmly nailed to the oak timbers. The inclined scale is marked in tenths of a foot from 1 to 10 feet, and the vertical portion from 10 feet to 27 feet. The bench mark consists of a 60-penny nail driven into the base of the tree at an elevation of 10.67 feet on the scale. Another bench mark is the top of the stone in the base of the bridge abutment, 18 feet south of the gage; the elevation is 14.51 feet.

A subsidiary gage has been placed 507 feet upstream. It consists of a vertical oak stick with a painted scale nailed to it and referred to the same datum as the lower gage. The difference in reading therefore gives the slope of the river for this distance. The initial point for soundings is on the right bank at the end of the bridge. The channel above the station is straight for about 100 feet, then curving from the northwest. Below the station it is straight for about 300 feet. The right bank is high, consisting of a sandy loam, and is not likely to overflow. The left bank is low and sandy and may be overflowed in high water. The bed of the stream, especially from the center to the left bank, is sandy and shifting. The measurements of discharge made during the year are shown by the following table:

List of discharge measurements made on Republican River at Junction City, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Apr. 27	A. P. Davis	28	3.00	144	1.52	219
2	Aug. 20	W. G. Russell	28	4.75	701	2.72	1,911
3	Oct. 11	....do	61	2.57	144	1.95	281
4	Nov. 11	....do	28	2.60	147	1.95	286
5	Dec. 13	....do	28	2.95	187	2.02	378
6	Dec. 27	....do	28	3.18	187	2.38	445

Daily gage height of Republican River at Junction, Kans., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.95	2.60	3.85	3.85	5.40	2.40	2.35	2.60
2	....	2.95	2.70	3.75	3.85	5.01	2.30	2.40	2.60
3	....	2 90	3.00	3.65	3.70	4.15	2.65	2.45	2.60
4	....	2.95	2.90	3.55	3.55	3.85	2.75	2.40	2.60
5	....	2.90	[a] 6.65	5.05	3.75	3.75	2.60	2.35	2.60
6	....	3.15	9.10	4.55	3.45	3.75	2.60	2.50	2.65
7	....	3.20	9.50	3.65	3.30	3.45	2.50	2.60	2.75
8	....	3.10	9.25	3.60	3.20	3.50	2.50	2.55	2.95
9	....	3.05	8.15	5.20	3.15	3.55	2.50	2.40	2.85
10	....	3.00	8.35	4.75	3.70	3.30	2.50	2.50	3.00
11	....	3.05	8.55	4.75	4.85	3.00	2.55	2.60	2.90
12	....	3.05	6.75	5.25	5.60	2.85	2.50	2.50	2.85
13	....	2.95	6.05	5.20	5.50	2.80	2.50	2.60	2.85
14	....	2.90	5.60	4.50	4.90	2.75	2.50	2.60	2.95
15	....	2.80	5.25	4.25	4.55	2.70	2.50	2.60	2.90
16	....	2.80	4.95	4.05	6.65	2.55	2.50	2.60	2.90
17	....	2.75	5.90	3.95	7.25	2.60	2.40	2.70	3.05
18	....	2.70	6.15	5.20	5.65	2.65	2.40	2.70	3.00
19	....	2.70	5.45	5.30	5.85	2.45	2.30	2.60	3.05
20	....	2.70	5.05	5.35	4.55	2.45	2.30	2.70	3.40
21	....	2.70	4.80	5.70	4.05	2.35	2.30	2.80	3.55
22	....	2.65	4.55	5.45	3.75	2.50	2.30	2.85	3.45
23	....	2.60	4.40	5.00	3.75	2.45	2.30	2.80	3.40
24	....	2.60	4.25	4.60	3.85	2.30	2.30	2.60	3.45
25	....	2.70	4.05	4.40	3.70	2.40	2.35	2.60	3.55
26	3.00	2.65	3.95	4.15	3.65	2.35	2.30	2.70	3.40
27	3.00	2.55	4.45	4.00	3.45	2.35	2.35	2.70	3.20
28	2.95	2.45	4.45	3.85	3.40	2.45	2.40	2.55	3.20
29	2.90	2.50	4.15	3.75	3.65	2.45	2.40	2.50	3.10
30	2.90	2.60	3.95	3.70	6.05	2.40	2.40	2.50	2.60
31	....	2.70	....	3.60	5.85	....	2.40	....	2.35

[a] On June 5, at 7.30 a. m., height of water, 5.40; at 9 a. m., 5.70; 11.45 a. m., 6.40; 7.20 p. m.. 7.90, and 10.35 p. m., 8.30. June 6, 7.30 a. m., 8.80; 11.50 a. m., 9.00; 7.30 p.m., 9.20; 10 p. m., 9.30.

Estimated discharge of Republican River at Junction City, Kans.

[Drainage area, 25,837 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	6,000	439	1,800	110,678	0.07	0.06
August	a 25,000	265	3,192	196,268	0.14	0.12
September	4,170	219	542	32,251	0.02	0.02
October	326	220	249	15,310	0.01	0.01
November	355	230	282	16,780	0.01	0.01
December	575	230	392	24,103	0.02	0.02

a Approximate.

SMOKY HILL RIVER.

This stream drains the southern portion of the Kansas River basin. It rises in the extreme westerly part of the State, and flows in a course nearly due east. Its principal tributaries are Solomon and Saline rivers, each of these draining narrow areas lying parallel and to the north of the main stream. Saline River empties into Smoky Hill a short distance below the town of Salina, and Solomon River also enters about 12 miles farther east, near the town of Solomon. Examinations have been made along Saline River for the purpose of finding a point for river measurement. At Lincoln, the county seat of Lincoln County, about 40 miles above the mouth, the bridge was found to be unfavorable, as it is just below a mill dam and the bottom is rough, rendering discharge measurement inaccurate. Going downstream from this point examinations were made at Rocky Hill and at Beverly; the latter, the point selected for measurements, being 11 miles below Lincoln and near the county line.

BELOIT STATION, ON SOLOMON RIVER.

This station was established on April 22, 1895, by Mr. Arthur P. Davis, at the wagon bridge on the south edge of the town of Beloit, Kans. The observer is Emmett Grover, living in that vicinity. The gage consists of an inclined oak timber bolted to a post and to a buried log. It is marked from 2 feet to 5.3 feet, the scale being continued on the bridge pier. The readings on the timber can be made from the bridge, and those on the bridge from the bank of the stream. The bench mark consists of a tenpenny nail driven into the base of a cottonwood tree 35 feet northwest of the pier upon which the marks are made. Its elevation is 13.70 feet. Measurements of discharge are made from the bridge. The initial point for soundings is on the left bank at the south edge of the stone abutment. The channel both above and below the station is straight for about 200 feet. Both banks are high and not likely to overflow. The bed of the stream is gravelly and not liable to change. The first measurement, that made on April

20, 1895, gave for a height of 2.90 feet a discharge of 148 second-feet; the second measurement, made August 19, at 3.27 feet, showed 195 second-feet, the channel having silted up considerably. On October 31 the stream was reduced so greatly, owing to the shutting down of the mill, that it was impossible to make measurements by means of a meter. The water passing at that time was merely the leakage from the dam. A float measurement showed this amount to be very nearly 8 second-feet, the height of the water being 2.1 feet.

In the case of this stream it is a matter of considerable difficulty to obtain accurate data for computations of the mean daily discharge, owing to the large number of mill dams located at short intervals along it. Each of these backs up the water for considerable distance, and modifies the amount discharged from time to time by holding the water until a sufficient amount accumulates to overflow. During the day the mills run irregularly, sometimes with one or more wheels, and thus rapid fluctuations are caused. In view of the importance of the data to be obtained it was decided, however, to locate this station at Beloit, and to attempt to make allowances for the unequal use of the water by the mill located a few hundred yards above. Readings are taken twice a day, and it is assumed that by averaging these the errors through a month or a season will tend to balance one another and will fairly represent the prevailing height of the water, furnishing data from which the discharge can be estimated. In the morning, when the mill is in operation, the water is drawn down rapidly, causing an excessive height on the gage; but at night the mill is usually not running with full head, and the volume delivered is less than that entering the pond above. Shortly after shutting down the mill the water accumulates and overflows, continuing during the night at the rate of the quantity coming into the pond.

List of discharge measurements made on Solomon River at Beloit, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Apr. 20	A. P. Davis	28	2.90	....	1.60	148
2	Aug. 19	W. G. Russell	28	3.27	119	1.64	195
3	Oct. 31	.....do	3	2.10	25	0.33	8
4	Nov. 1	.....do	3	2.93	63	1.24	78
5	Dec. 13	.....do	28	2.85	91	1.19	109
6	Dec. 27	.....do	28	2.80	98	1.07	105

Daily gage height of Solomon River at Beloit, Kans., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.15	4.85	3.00	3.40	4.80	2.65	2.55	2.05
2	....	6.55	14.85	3.20	3.40	4.45	2.65	2.55	2.45
3	....	3.00	16.80	3.30	5.80	3.80	2.65	2.05	2.45
4	....	2.65	19.85	3.05	5.80	3.70	2.65	2.55	2.55
5	....	2.15	21.60	16.50	6.90	3.55	2.65	2.55	2.55
6	....	2.80	23.85	12.45	6.35	3.50	2.65	2.55	2.55
7	....	2.85	20.80	5.40	4.80	3.40	3.85	2.55	2.55
8	....	2.65	8.60	3.95	4.25	3.10	2.80	2.55	2.20
9	....	2.65	7.15	4.00	4.10	3.20	2.55	2.55	2.95
10	....	2.25	6.50	4.25	4.10	3.20	2.55	2.05	2.95
11	....	2.70	6.65	4.10	4.15	3.10	2.55	2.45	2.95
12	....	2.25	14 80	3.90	5.60	3.05	2.60	2.55	2.95
13	....	1.90	9.30	3.80	5.80	3.05	2.10	2.55	2.95
14	....	2.20	8.15	3.75	4.45	3.00	2.50	2.55	3.45
15	....	1.80	5.40	7.60	4.05	3.00	2.55	2.55	2.85
16	....	1.80	4.85	6.90	3.65	2.95	2.55	2.55	2.95
17	....	2.20	4.15	5.20	3.70	3.00	2.50	2.05	2.80
18	....	2.20	3.75	4.10	3.55	3.10	2.55	2.45	2.65
19	....	1.80	3.40	3.95	3.40	3.05	2.55	2.55	2.90
20	....	1.80	3.35	3.80	3.25	2.65	2.05	2.55	3.00
21	....	2.20	3.55	7.85	3.20	2.30	2.55	2.55	3.00
22	2.80	1.85	3.30	9.70	3.20	2.60	2.55	2.55	2.35
23	2.75	2.05	3.25	6.60	3.20	2.70	2.55	2.55	2.80
24	2.55	2.20	3.45	4.50	3.20	2.70	2.55	2.05	3.00
25	2.15	2.15	3.65	4.20	3.10	2.30	2.55	2.45	2.40
26	2.15	1.85	3.30	4.00	3.10	2.65	2.50	2.45	2.70
27	2.15	1.80	3.10	3.85	3.10	2.65	2.05	2.55	3.00
28	2.15	1.80	2.65	3.65	3.15	2.65	2.45	2.55	3.00
29	2.10	1.85	3.05	3.65	17.50	2.50	2.55	2.55	2.35
30	2.10	2.20	3.05	3.60	10.00	2.45	2.55	2.55	2.25
31	....	2.20	....	3.45	4.70	....	2.55	....	2.75

Estimated discharge of Solomon River at Beloit, Kans.

[Drainage area, 5,539 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	a 21,000	159	2,202	135,396	0.46	0.40
August	a 24,000	172	1,629	100,163	0.33	0.29
September	615	14	156	9,283	0.03	0.03
October	62	7	28	1,722	0.01	0.01
November	26	7	23	1,369	....	....
December	250	7	114	7,010	0.02	0.02

a Approximate.

BEVERLY STATION, ON SALINE RIVER.

This station was established on April 18, 1895, by Mr. Arthur P. Davis, for the purpose of ascertaining the discharge of Saline River at a point as near as possible to the ninety-eighth meridian, Beverly being within a mile or two of this line. The locality chosen was at the iron highway bridge, half a mile southwest of town. The observer is Charles Reid, a farmer living about 200 yards distant. The gage as first placed consisted of an inclined rod fastened to trestles set in the ground. It was graduated up to 13 feet and the scale continued on the vertical iron caisson of the bridge up to 25 feet, the marks being plainly read from the bridge. The channel is muddy and shifting, and the high water of July 4 to 6 cut out all of the bank back of the piers and down to the tree to which the gage was originally fastened. The bank, tree, and gage sunk into the channel about 2 feet without disturbing the relative position. When the gage read 4.1 feet there was more than 5 feet of water in depth in the channel. The large amount of earth had partially filled the bed, forcing the water to excavate a deep hole. It was therefore necessary to reset the gage, as it was probable that low water would not reach the bottom of the gage if raised to its former position. The north bank of the river being no longer suitable for the location of a gage, it was placed on the other side. The bench mark is at the north end on the top of the lower iron strut connecting the piers on the south side of the river. The elevation is 13.295 feet above the zero of the old rod. After being reset in August the bench mark was 18.95 feet above the zero of the new rod on the south side.

List of discharge measurements made on Saline River at Beverly, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Apr. 18	A. P. Davis	28	*a* 1.50	162	1.35	22
2	June 8	W. G. Russell	19	*a* 9.90	448	2.77	1,238
3	July 22	do	19	6.10	129	1.76	226
4	Aug. 22	do	19	4.70	50	1.52	76
5	Sept. 21	do	19	3.85	30	0.42	13
6	Nov. 12	do	19	4.30	52	1.09	56
7	Dec. 14	do	28	4.60	60	1.19	70
8	Dec. 23	do	19	4.10	44	0.57	25

a Old gage before injury by flood.

Daily gage height of Saline River at Beverly, Kans., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	*a* 1.85	*a* 2.10	2.85	4.60	4.70	4.05	4.25	3.85
2	....	2.00	1.80	2.80	4.75	4.95	3.85	4.10	4.00
3	....	1.75	1.80	2.80	5.55	4.80	3.85	4.20	3.95
4	....	1.95	4.45	2.85	7.00	4.95	3.95	4.20	3.95
5	....	2.40	9.80	*b* 11.35	5.95	4.80	4.00	4.20	4.10
6	....	2.00	6.80	17.15	5.50	4.55	4.20	3.90	4.15
7	....	2.20	*c* 12.05	9.45	5.05	4.55	4.05	4.05	4.15
8	....	2.85	9.40	8.80	4.80	4.45	4.10	4.45	4.05
9	....	2.45	6.45	5.90	4.65	4.15	4.25	4.35	3.95
10	....	2.25	5.10	5.55	5.15	4.25	4.25	4.15	4.20
11	....	2.15	7.55	5.80	5.10	4.35	4.20	3.85	4.15
12	....	2.05	8.10	6.00	6.50	4.20	3.95	4.25	4.00
13	....	1.70	6.45	5.85	5.35	4.15	3.80	4.20	4.20
14	....	1.45	6.85	5.65	5.35	4.10	4.35	4.30	4.40
15	....	1.95	5.20	5.60	4.95	4.05	4.20	4.30	4.50
16	....	1.45	4.05	5.30	4.85	4.00	4.15	3.75	4.20
17	....	1.95	3.75	5.25	4.70	4.00	4.10	4.20	4.20
18	*a* 1.90	1.25	4.35	5.05	4.80	4.00	3.60	4.20	4.40
19	2.30	1.65	4.25	5.00	4.60	4.00	4.00	4.20	4.25
20	1.90	1.90	3.90	4.95	4.75	3.95	4.30	3.95	4.30
21	1.90	1.25	3.55	4.95	4.60	3.95	3.95	3.95	4.30
22	1.45	1.25	3.35	6.10	4.50	3.90	4.00	3.90	3.95
23	1.75	1.55	1.55	6.90	4.40	4.20	3.90	4.10	4.10
24	1.90	1.80	1.80	6.30	4.65	3.80	4.15	3.80	4.25
25	1.70	1.45	1.45	5.40	4.40	3.95	4.05	3.85	4.30
26	1.40	1.50	1.50	5.15	4.40	3.80	4.10	3.95	4.45
27	1.60	1.50	1.50	4.95	4.35	3.80	3.90	4.20	4.35
28	1.95	1.75	1.75	4.70	4.40	3.75	3.90	3.90	4.50
29	1.85	1.65	1.65	4.80	4.40	3.75	3.80	4.15	4.35
30	1.65	1.25	3.00	4.70	4.45	3.80	3.95	3.95	4.20
31	....	2.25	....	4.65	4.45	....	4.15	....	3.85

a Old gage.
b New gage; readings adjusted to changed conditions.
c River rose at rate of 1 foot per hour.

Discharge of Saline River at Beverly, Kans., for 1895.

[Drainage area, 2,730 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
July	*a* 10,000	73	574	35,284	0.24	0.21
August	339	58	101	6,210	.04	.04
September	92	9	38	2,261	.01	.01
October	58	6	27	1,660	.01	.01
November	62	9	33	1,964	.01	.01
December	57	13	33	2,029	.01	.01

a Estimated.

ELLSWORTH STATION, ON SMOKY HILL RIVER.

This station was established on April 17, 1895, by Mr. Arthur P. Davis, for the purpose of obtaining the discharge of the Smoky Hill near the ninety-eighth meridian, this being above the point where the Saline and Solomon empty into it. It is at the highway bridge on Douglas avenue, Ellsworth, Kans. The observer is Robert Martin, who lives about 100 yards north of the bridge. The gage consists of an inclined ash timber spiked to a post driven in the bed of the river and bolted to the iron bridge pier and to an oak post set in the south bank of the river. It is marked from 1 foot up to 4.5 feet, and the scale is continued on the bridge pier, which is slightly inclined. Discharge measurements are made from the bridge. The bench mark consists of a nail driven in the base of a large box-elder tree near the southeast corner of the bridge, 90 feet from the gage. It is 13.07 feet above the zero of the rod. The channel is nearly straight both above and below the bridge, but the banks are low and liable to overflow. The bed of the stream is sandy and shifting, tending to deepen toward the left bank, there being a slight change reported in the channel at various times of measurement.

A second gage was established on October 23, 1895. It was fastened to the east or downstream pile of the fourth bent from the south end of the Frisco railroad bridge west or upstream from the old gage 2,536 feet, being referred to the same elevation as the old gage. The difference of water height on October 23 was 1.44 feet, the slope being 0.000568.

A single measurement has been made of Smoky Hill River at Junction City. At the time, April 27, 1895, the water was too sluggish for accurate determination by the meter, but the quantity was estimated to be 188 second-feet.

List of discharge measurements made on Smoky Hill River at Ellsworth, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Apr. 16	A. P. Davis	28	1.50	....	0.84	12
2	Apr. 27	.....do	Floats.	....	....	0.33	*a* 188
3	June 5	W. G. Russell	19	9.05	1,854	2.91	5,402
4	July 3	.....do	19	2.60	115	1.89	217
5	Aug. 21	.....do	19	2.10	77	1.34	104
6	Sept. 20	.....do	19	1.50	28	0.94	26
7	Oct. 23	.....do	19	1.35	21	0.84	17
8	Dec. 6	.....do	19	1.35	19	0.94	18
9	Dec. 28	.....do	19	1.30	19	0.95	18

a Smoky Hill River at Junction City.

Daily gage height of Smoky Hill River at Ellsworth, Kan., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.50	1.40	2.55	3.25	2.27	1.40	1.40	1.35
2	....	1.50	1.45	2.75	3.25	2.15	1.40	1.40	1.35
3	....	1.50	1.65	2.55	3.07	2.05	1.40	1.40	1.30
4	....	1.50	4.75	3.30	2.95	1.98	1.45	1.35	1.32
5	....	1.45	*a* 8.85	16.55	2.95	1.92	1.45	1.40	1.40
6	....	1.45	7.15	9.75	2.95	1.88	1.45	1.40	1.45
7	....	1.90	5.50	7.25	2.95	1.80	1.45	1.40	1.38
8	....	1.75	4.65	6.00	2.82	1.80	1.45	1.40	1.25
9	....	1.60	4.35	5.05	2.83	1.77	1.42	1.40	1.25
10	....	1.55	4.00	4.50	2.77	1.73	1.40	1.40	1.35
11	....	1.50	4.70	4.20	3.00	1.70	1.40	1.35	1.35
12	....	1.50	4.60	3.95	2.75	1.70	1.40	1.35	1.35
13	....	1.50	5.75	3.65	2.55	1.67	1.40	1.40	1.32
14	....	1.50	5.40	3.52	2.43	1.65	1.40	1.40	1.37
15	....	1.45	5.55	3.35	2.40	1.62	1.40	1.40	1.35
16	....	1.45	5.25	3.15	2.47	1.60	1.40	1.40	1.35
17	1.50	1.45	4.35	3.05	2.28	1.57	1.40	1.40	1.40
18	1.50	1.40	3.80	3.00	2.20	1.55	1.38	1.40	1.40
19	1.50	1.40	3.50	3.05	2.12	1.53	1.35	1.40	1.40
20	1.50	1.40	3.25	3.65	2.10	1.50	1.35	1.35	1.40
21	1.45	1.40	3.05	4.75	2.10	1.50	1.35	1.35	1.38
22	1.60	1.40	2.95	3.15	2.08	1.50	1.35	1.35	1.37
23	1.57	1.40	2.85	3.05	2.07	1.50	1.35	1.40	1.40
24	1.56	1.40	2.70	3.80	2.08	1.50	1.35	1.30	1.37
25	1.50	1.40	2.65	4.80	2.07	1.47	1.32	1.30	1.35
26	1.50	1.40	2.55	4.30	2.00	1.45	1.30	1.27	1.35
27	1.50	1.40	2.50	4.33	1.93	1.45	1.30	1.30	1.35
28	1.50	1.40	2.50	4.40	1.92	1.43	1.30	1.30	1.35
29	1.50	1.35	2.50	4.00	1.90	1.40	1.30	1.33	1.30
30	1.50	1.40	2.40	3.70	1.92	1.40	1.38	1.35	1.33
31	....	1.40	....	3.30	3.00	....	1.40	....	1.30

a Heavy rains. 12.30 p. m., June 4, gage was 5.30; 1.30 p. m., 5.40; the 5th, at 9.30 a. m., 9.60; 12.30 p. m., 10.30.

Estimated discharge of Smoky Hill River at Ellsworth, Kans., for 1895.

[Drainage area, 7,980 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	*a* 21,000	202	1,438	88,419	0.21	0.18
August	344	65	186	11,437	0.02	0.02
September	135	19	44	2,618	0.01	0.01
October	22	14	18	1,107	0.00	0.00
November	19	12	17	1,012	0.00	0.00
December	22	11	17	1,045	0.00	0.00

a Approximate.

BLUE RIVER.

This stream flows into Kansas River from the north at a point about 15 miles below the junction of the Smoky Hill and Republican rivers. The town of Manhattan is at the mouth of the river. The stream and its water powers are described by Prof. Dwight Porter in his report in Volume XVII, Tenth Census, on the Region Tributary to the Mississippi River on the West below Dubuque, pages 60–65.

MANHATTAN STATION, ON BLUE RIVER.

This station is located at Rocky Ford, 4 miles north of Manhattan, Kans., at the county highway bridge. It was established April 12, 1895, by Mr. Arthur P. Davis, as being the nearest available point to the mouth of Blue River, giving the run-off for the entire drainage basin. The observer is J. D. Bush, a farmer, living about 100 yards from the bridge. The gage consists of three parts, the lower being an ash stick driven into the bottom of the river and bolted to an overhanging cottonwood tree 30 feet east of the bridge. It is slightly inclined and marked from 2.10 to 11.30 feet. The second part consists of an oak board spiked to the same tree, inclined and marked from 11.30 to 17 feet. The upper portion is a vertical oak stick bolted to the south side of the south pier and marked from 17 to 30 feet. Measurements of discharge are made from the bridge. The channel is sandy and shifting, somewhat broken by piles left after the construction of the bridge. O. P. Hood, professor of mechanics and engineering at the Kansas State Agricultural College, Manhattan, Kans., has assumed the oversight of this station and has made a number of discharge measurements.

The first measurement was made on April 12, 1895, at which time the water stood at the height of 3.60 feet and the discharge was 542 second-feet. An attempt was made on July 11 to make a measurement, but the work was not wholly satisfactory, owing to the failure of the instruments. A partial measurement was made on August 17 and a complete measurement on August 24. At that time the height of water was 5.70 feet and the total discharge 1,512 second-feet.

List of discharge measurements made on Blue River at Manhattan, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Apr. 12	A. P. Davis	28	3.60	367	1.48	542
2	July 11	O. P. Hood	4	3.70	304	1.38	450
3	Aug. 17	.....do	4	6.90	1,077		
4	Aug. 24	.....do	4	5.70	966	1.61	1,512

Daily gage height of Blue River at Manhattan, Kan., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	....	3.45	4.55	3.80	3.55	13.30	3.55	2.85	3.65
2..	....	3.45	3.75	3.75	3.55	9.60	3.55	2.85	3.65
3..	....	3.60	3.60	3.70	3.45	8.20	3.45	2.85	3.55
4..	....	3.60	4.05	3.70	3.35	6.45	3.55	2.85	3.55
5..	....	3.60	3.75	7.35	3.35	5.80	3.55	2.90	3.65
6..	....	3.60	5.55	5.80	3.35	5.65	3.55	3.25	3.75
7..	....	3.65	6.35	4.25	3.35	6.40	3.45	3.50	3.75
8..	....	4.85	5.85	4.00	3.35	5.75	3.45	3.65	3.75
9..	....	4.70	7.05	3.70	3.25	5.35	3.45	3.65	3.65
10..	....	4.05	8.75	3.60	3.25	5.05	3.55	3.60	3.70
11..	....	3.85	10.55	3.55	3.25	4.75	3.55	3.60	3.80
12..	....	3.75	12.60	3.60	4.40	4.50	3.55	3.60	3.75
13..	....	3.60	9.30	3.55	6.40	4.35	3.55	3.70	3.55
14..	3.55	3.60	7.55	3.70	5.50	4.25	3.55	3.60	3.55
15..	3.55	3.50	6.70	3.60	5.55	4.10	3.50	3.60	3.75
16..	3.55	3.50	6.35	3.50	5.60	3.90	3.50	3.70	3.70
17..	3.50	3.40	5.75	3.45	6.70	3.85	3.40	3.60	3.65
18..	3.55	3.40	5.45	3.40	6.20	3.80	3.35	3.60	3.65
19..	3.60	3.40	5.20	5.85	5.55	3.70	3.35	3.60	3.65
20..	3.80	3.35	4.85	6.50	15.05	3.75	3.30	3.60	3.65
21..	3.75	3.30	4.75	4.05	12.55	3.75	3.30	3.75	3.75
22..	3.60	3.30	4.65	4.40	9.70	3.75	3.25	3.70	3.70
23..	3.70	3.30	4.60	4.70	7.70	3.75	3.25	3.60	3.70
24..	3.50	3.30	4.60	4.40	5.75	3.75	3.25	3.60	3.70
25..	3.55	3.30	4.65	4.00	5.15	3.65	3.20	3.40	3.70
26..	3.45	3.30	4.55	3.80	4.85	3.65	2.90	3.65	3.75
27..	3.50	3.15	4.25	3.75	4.70	3.55	2.90	3.70	3.60
28..	3.50	3.10	4.15	3.65	4.55	3.60	2.90	3.75	3.65
29..	3.40	3.10	4.00	3.50	7.20	3.60	2.90	3.70	3.65
30..	3.45	3.10	3.90	3.50	14.25	3.55	2.85	3.65	3.55
31..	....	4.00	....	3.55	12.30	....	2.85	....	3.35

KANSAS RIVER.

LAWRENCE STATION, ON KANSAS RIVER.

The conditions at this locality have been described by Prof. Dwight Porter in his "Report on the water power of the region tributary to the Mississippi River." From this report, completed in 1883, the following paragraphs are taken:[1]

The only point at which water power is used on the Kansas River is at Lawrence, in Douglas County. At an early day it was considered an available site, and various surveys were made with a view to developing it. The river is there about 600 feet wide, with banks of only moderate height on the north side, while on the south side, on which the city is located, they rise quite abruptly 50 feet or more from the water. A road bridge spans the river immediately above the dam. The Atchison, Topeka and Santa Fe Railroad runs along the south bank, and on the north side of the river is the Kansas Pacific line.

The original dam was built in 1872, of logs and brush, after the usual style of brush dams. It rested directly upon sand, however, and in 1874, during a heavy flood, water worked under it, washed away the sand, and carried off 300 feet of the dam. In 1877 the remaining 300 feet was carried away in the same manner. The damage in each case was, perhaps, $5,000. The scour at the time of these accidents swept away the sandy bed upon which the old structure had rested, and left a firm foundation for the present one. The new dam was built as the old one gave way, consequently 300 feet of it was constructed in 1874 and 300 feet in 1877. It has a total length of 600 feet, with an average height of 8 feet. The cost of the entire work, including dam and race way, is roughly estimated at $100,000.

[1] "Report on the water power of the region tributary to the Mississippi River on the west below Dubuqe, Iowa," by Dwight Porter, in Volume XVII, Tenth Census of the United States, 1880. Washington, 1887.

One-half the length of the dam rests upon a rock ledge and one-half upon hardpan. That portion upon rock is built of large stones laid in cement, is 20 feet wide at the base and 6 feet at the top, sloping both ways. The remainder of the dam is a framed superstructure, resting on cribs filled with stone. These cribs are 50 feet long and are laid with the stream; they project below the dam and are planked over so as to form an apron. The crib-work foundation extends from the river bed up to about the level of low water. Above the dam the bed is covered to a distance of 40 feet with loose rock; below the dam the river banks are protected by riprap. On the south side of the stream the dam abuts upon the heavy masonry wall of the race way and upon the opposite side upon a timber crib filled with stone. The bulkhead at the entrance to the race is protected from ice and drift by a short wing dam of crib work. In February, 1881, the river was visited for forty-eight hours by a heavy run of ice 15 inches thick, which carried away from the south end of the dam two courses in depth of stone for a length of 200 feet from the shore.

The dam causes slack water for some 6 miles upstream, thus furnishing storage over a surface of 300 to 400 acres, with an average depth estimated at 6 to 8 feet. The race way is 60 feet wide and inclosed by heavy masonry walls 18 feet high. It is estimated to carry sufficient water for 500 horse-power.

A gage was established at Lawrence, Kans., by Mr. J. D. Bowersock, in the summer of 1880. It consisted of a vertical board, marked to feet and inches, fastened to the east end of the south pier of the carriage bridge. The zero of this gage was on a level with a large stone in the crest of the dam. Daily readings were made and recorded only when there was a perceptible change in height of water. At times when the water was rising or falling rapidly readings were had at two or more times during the day. The weekly averages, given in the following table, were made from these observations. The readings as given by Mr. Bowersock are in feet and inches, but for uniformity the inches have been reduced to the nearest tenths of a foot. At times when the reading is given as 0.00 the mills were generally running, using water through the flume. This is 60 feet wide in the clear and water was on an average 7 feet deep. The total length of overflow of the dam is 595 feet.

Stream measurements were begun by Prof. E. C. Murphy at this point in July, 1895, and a number of results were obtained sufficient to construct a rating table, given on page 147. There have been no repairs of any considerable magnitude made on the dam since the beginning of the observations of height of water, and it is probable that the discharges measured during 1895 and the rating tables based on these represent fairly well the quantities passing at the same gage heights in previous years. Soundings show that the bed of the river, excepting at the banks, is of hard material, not liable to change. An estimate of the monthly and the annual discharge has been prepared by using the weekly record and the rating table. Professor Murphy first plotted the mean daily gage readings for August, September, and October, 1895, as a sample of the fluctuation. He then plotted the weekly means given by Mr. Bowersock, and sketched a curve similar to that for August, September, and October in such a way that the mean of the seven daily coordinates was equal to the weekly mean given in the record. These probable daily means, as given on pages 149–151, have been used for the period from January 1, 1891, to August 1, 1895. For the five years previous to January, 1891, Professor Murphy obtained the weekly discharge by multiplying the quantity corresponding to the mean weekly gage readings by seven. The mean monthly discharge as computed in this manner is given on pages 151–153.

List of discharge measurements made on Kansas River at Lawrence, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895						
1	July 19	E. C. Murphy	6	2.70	5,632	1.60	8,994
2	July 27	.....do.............	19	1.90	5,335	1.20	6,411
3	Aug. 6	.....do.............	17	1.10	4,705	0.64	3,025
4	Aug. 22	.....do.............	17	4.10	6,529	2.76	17,945
5	Aug. 24	.....do.............	17	2.35	5,443	1.44	7,869
6	Aug. 27	.....do.............	17	1.47	4,991	0.86	4,277
7	Sept. 3	.....do.............	17	3.24	6,058	2.14	12,935
8	Sept. 4	.....do.............	17	2.63	5,716	1.74	9,960
9	Oct. 5	.....do.............	17	0.35	....	2.68	*a* 1,286
10	Oct. 25	.....do.............	17	0.20	....	1.90	*a* 963
11	Nov. 1	.....do.............	17	0.20	....	1.35	*b* 376

a Measurements at Lecompton.
b Measurement of flume at Lawrence.

Rating table for Kansas River at Lawrence, Kans., based on discharge measurements made during 1895.

Gage height	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
0.00	787	1.80	5,623	3.60	14,890	5.30	26,620
0.10	863	1.90	6,051	3.70	15,500	5.40	27,400
0.20	967	2.00	6,490	3.80	16,120	5.50	28,190
0.30	1,098	2.10	6,940	3.90	16,750	5.60	28,990
0.40	1,255	2.20	7,400	4.00	17,390	5.70	29,800
0.50	1,437	2.30	7,870	4.10	18,040	5.80	30,620
0.60	1,643	2.40	8,350	4.20	18,700	5.90	31,450
0.70	1,872	2.50	8,840	4.30	19,370	6.00	32,290
0.80	2,123	2.60	9,440	4.40	20,050	6.10	33,140
0.90	2,395	2.70	9,850	4.50	20,740	6.20	34,000
1.00	2,687	2.80	10,370	4.60	21,440	6.30	34,870
1.10	2,998	2.90	10,900	4.70	22,150	6.40	35,750
1.20	3,327	3.00	11,440	4.80	22,870	6.50	36,640
1.30	3,673	3.10	11,990	4.90	23,600	6.60	37,540
1.40	4,035	3.20	12,550	5.00	24,340	6.70	38,450
1.50	4,412	3.30	13,120	5.10	25,090	6.80	39,370
1.60	4,803	3.40	13,700	5.20	25,850	6.90	40,300
1.70	5,207	3.50	14,290				

Average weekly gage height of Kansas River at Lawrence, Kans.

Month.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
January	.....	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.5	0.7	0.5	0.6	0.3	0.3	0.0
	.....	0.5	0.0	0.3	1.5	0.2	0.0	0.0	0.5	2.7	0.4	0.5	0.5	0.3	0.0
	.....	0.0	0.0	0.3	0.5	0.0	0.0	0.0	0.7	0.9	0.3	0.7	0.5	0.5	0.0
	.....	0.2	0.0	0.4	0.5	0.3	0.3	0.0	0.6	2.4	0.7	0.5	0.3	0.5	0.0
	.....	0.0	0.2	0.5	.....	.....	0.3	1.0	0.4	.....	.....	.....	0.4	0.0	.....
February	3.0	0.0	0.3	0.5	3.3	0.3	0.0	0.8	0.4	2.1	0.7	1.0	0.5	0.4	0.0
	1.0	0.0	1.5	0.2	1.0	2.5	0.3	1.0	0.6	1.3	0.4	2.0	1.7	0.2	0.0
	1.3	0.0	2.0	1.0	0.7	3.7	0.3	2.5	0.3	1.0	2.0	1.4	1.9	0.4	0.0
	3.3	0.4	3.7	1.3	0.0	3.5	2.0	2.0	0.6	0.5	1.6	1.6	.....	0.7	0.3
March	4.2	0.3	3.5	0.8	3.5	3.0	1.0	1.0	0.6	0.5	0.9	2.3	1.0	.....	0.5
	3.7	0.5	2.0	1.0	2.1	2.5	0.7	1.5	0.5	2.3	0.6	3.0	0.5	0.6	0.3
	1.7	0.2	0.8	2.5	1.0	4.0	0.7	2.5	0.6	1.6	2.0	2.3	0.4	0.5	0.5
	2.2	0.0	0.5	1.7	1.0	3.4	0.5	2.9	0.7	1.3	2.8	3.2	0.3	1.3	0.5
	.....	.....	.....	0.9	0.7	2.5	.....	.....	.....	1.0	2.7	4.6	.....	0.8	.....
April	2.1	0.8	0.5	1.0	0.8	1.7	1.0	2.0	0.7	0.8	1.8	3.5	0.8	0.7	0.6
	0.7	4.3	0.7	1.4	1.1	4.3	0.5	1.8	0.8	0.8	2.5	3.1	0.4	2.0	0.7
	0.5	1.1	0.4	3.5	1.5	3.3	0.5	1.0	0.7	1.1	3.0	3.4	1.0	0.7	0.3
	0.3	0.6	0.5	3.3	3.7	2.7	0.7	0.8	0.7	0.9	2.3	2.5	0.7	0.7	0.3
	.....	.....	0.3	.....	.....	.....	.....	1.3	0.7	.....	.....	.....	.....	0.8	0.4
May	0.8	0.3	0.3	3.7	0.5	3.5	1.0	1.7	1.0	0.8	1.7	4.2	0.7	0.4	0.4
	0.3	0.4	1.3	3.3	0.7	4.3	0.8	3.0	5.0	1.0	1.5	8.5	1.3	0.3	0.5
	1.5	0.3	1.7	2.3	3.0	3.3	2.0	1.5	4.5	1.4	2.7	8.8	1.0	0.3	0.0
	0.5	0.8	1.3	2.0	3.5	2.3	2.5	2.7	3.0	1.4	3.4	5.3	1.5	0.0	0.0
	0.4	2.5	.....	.....	.....	2.0	1.5	.....	.....	.....	.....	3.7	1.0	.....	.....
June	0.5	0.5	3.5	2.3	2.5	1.7	1.5	1.7	2.5	1.3	6.0	3.1	4.3	0.7	0.3
	0.3	1.6	4.3	2.5	1.0	1.3	2.4	2.0	2.0	1.0	3.5	2.3	2.0	1.2	4.0
	1.7	3.5	3.7	1.6	1.0	1.7	2.0	2.3	1.5	0.7	4.9	2.0	1.3	1.7	1.7
	0.8	1.2	4.3	1.7	1.0	1.5	1.0	3.5	1.5	1.5	5.5	1.1	2.5	5.3	1.0
	.....	.....	.....	1.6	1.7	.....	.....	.....	.....	1.0	4.6	.....	.....	.....	.....
July	0.7	0.4	2.7	1.3	2.5	1.0	0.0	3.0	1.3	0.0	3.7	0.7	4.3	3.1	1.0
	0.0	0.7	1.7	1.0	2.0	0.5	0.5	1.7	1.0	0.0	3.5	0.9	2.3	1.7	1.7
	0.0	2.5	0.8	2.3	2.5	0.5	0.5	1.0	4.2	0.1	3.4	0.8	1.7	1.3	2.5
	0.0	0.7	1.0	2.3	2.1	0.5	0.5	1.0	5.0	0.5	2.9	0.7	2.3	0.7	2.0
	.....	3.0	1.5	.....	.....	.....	.....	1.0	4.5	.....	.....	.....	1.3	0.6	1.5
August	0.0	0.7	1.3	1.3	2.4	0.8	0.7	2.0	3.7	0.0	2.4	0.6	0.7	0.7	1.5
	0.0	0.2	2.4	0.8	2.7	1.3	0.5	2.5	4.0	0.0	1.7	0.7	3.4	0.9	2.8
	0.0	0.2	2.5	0.8	0.5	1.0	0.5	1.0	2.7	0.0	1.4	0.5	2.0	0.0	4.0
	0.0	0.0	1.0	1.5	0.5	0.8	0.5	0.8	1.7	0.6	1.7	0.7	1.3	0.0	.....
	1.0	.....	.....	.....	0.8	0.0	1.0	.....	.....	.....	1.4	1.2	.....	.....	.....
September	0.0	0.0	0.7	1.5	2.5	0.5	1.0	0.5	1.0	0.5	1.0	1.0	1.0	0.5	.....
	0.0	0.0	0.5	1.3	2.3	1.0	1.0	0.5	0.8	0.5	0.8	0.5	0.7	0.5	.....
	0.0	0.0	0.8	1.3	2.1	0.0	0.3	0.0	3.5	0.0	0.5	0.0	0.0	0.4	.....
	1.0	0.0	0.3	3.5	1.5	0.0	0.5	0.0	1.3	1.0	1.6	0.0	0.4	0.7	.....
	.....	.....	.....	2.4	.....	.....	.....	.....	1.0	0.5	.....	.....	.....	.....	.....
October	0.3	0.0	0.4	1.6	1.5	0.0	0.5	0.5	0.8	0.0	2.7	0.0	2.7	0.2	.....
	0.3	0.0	1.3	0.7	1.0	0.3	1.0	0.3	0.5	0.6	2.3	*a*0.0	1.9	0.6	.....
	0.8	0.3	1.0	0.7	1.0	0.3	0.7	0.3	0.5	0.4	1.3	0.4	0.5	0.0	.....
	0.8	0.3	1.7	0.7	1.5	0.3	0.5	0.5	0.7	0.3	1.3	0.3	0.3	0.3	.....
	1.7	0.0	1.7	.....	.....	.....	0.5	0.5	.....	.....	.....	0.6	0.4	0.0	.....
November	0.3	0.3	1.7	0.6	1.0	0.3	0.5	1.0	2.0	0.4	1.0	0.4	0.6	0.0	.....
	0.6	0.5	1.0	0.4	1.3	0.5	0.5	0.5	1.5	0.3	0.9	0.5	0.4	0.0	.....
	0.5	0.3	0.8	0.3	0.5	0.5	0.5	0.5	0.8	0.6	0.7	0.7	0.4	0.0	.....
	0.3	0.2	1.0	0.8	0.5	0.5	0.0	0.5	0.5	0.5	1.0	0.5	0.7	0.0	.....
	.....	.....	.....	.....	0.8	0.5	.....	.....	.....	.....	1.0	.....	.....	.....	.....
December	.....	0.0	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.3	1.5	0.4	0.0	0.0	.....
	.....	0.0	0.5	0.8	1.0	0.5	0.3	0.5	0.7	0.0	1.3	0.5	0.0	0.0	.....
	.....	0.4	0.4	0.0	0.5	0.5	0.0	0.5	0.4	0.0	1.0	0.5	0.0	0.0	.....
	.....	0.3	0.4	0.5	0.4	0.0	0.0	0.5	0.5	0.0	0.8	0.0	0.6	0.0	.....
	.....	.....	.....	0.4	.....	.....	.....	.....	0.5	0.5	.....	.....	.....	0.0	.....

a Only water enough to run half of the wheels.

Daily gage height of Kansas River at Lawrence, Kans., for 1891.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	0.50	0.70	0.90	2.60	2.00	6.40	4.30	2.60	1.40	2.10	1.00	0.90
2.....	0.50	0.80	0.80	2.40	1.90	5.90	4.20	2.50	1.30	2.30	0.90	1.10
3.....	0.50	0.70	0.80	2.20	1.70	5.50	4.10	2.50	1.20	2.50	0.90	1.20
4.....	0.50	0.60	0.80	2.00	1.70	5.00	4.00	2.40	1.10	2.70	0.90	1.30
5.....	0.60	0.60	0.80	1.80	1.70	4.70	3.80	2.30	1.00	2.90	0.90	1.40
6.....	0.50	0.50	0.80	1.70	1.70	4.20	3.50	2.10	1.00	2.70	0.90	1.50
7.....	0.50	0.40	0.70	1.80	1.70	3.90	3.60	2.00	0.90	2.60	1.00	1.60
8.....	0.40	0.40	0.60	2.00	1.60	3.50	3.60	1.90	0.90	2.50	1.00	1.50
9.....	0.40	0.30	0.50	2.10	1.60	3.30	3.60	1.70	0.90	2.40	1.00	1.50
10....	0.40	0.40	0.60	2.20	1.50	3.60	3.60	1.60	0.90	2.40	0.90	1.40
11....	0.50	0.70	0.90	2.40	1.40	3.90	3.50	1.60	0.90	2.30	0.90	1.30
12....	0.50	1.00	1.10	2.50	1.60	4.20	3.50	1.60	0.90	2.30	0.80	1.30
13....	0.50	1.30	1.40	2.60	1.80	4.40	3.40	1.60	0.90	2.20	0.80	1.20
14....	0.40	1.60	1.70	2.60	2.00	4.60	3.40	1.60	0.90	2.00	0.80	1.20
15....	0.40	1.90	1.90	2.60	2.30	4.80	3.40	1.50	0.80	1.90	0.70	1.20
16....	0.40	2.20	2.20	2.60	2.60	4.90	3.50	1.40	0.80	1.70	0.70	1.20
17....	0.30	2.00	2.10	2.70	2.90	5.00	3.50	1.30	0.70	1.60	0.70	1.20
18....	0.30	1.90	2.10	2.90	3.00	5.10	3.50	1.30	0.60	1.40	0.80	1.10
19....	0.20	1.80	2.20	3.00	2.90	5.20	3.50	1.40	0.60	1.20	0.80	1.10
20....	0.30	1.70	2.30	3.20	3.00	5.40	3.50	1.50	0.50	1.20	0.90	1.00
21....	0.40	1.70	2.50	3.00	3.10	5.50	3.40	1.60	0.40	1.30	0.90	1.00
22....	0.50	1.70	2.80	2.90	3.10	5.70	3.30	1.60	0.50	1.30	1.00	0.90
23....	0.50	1.70	3.00	2.70	3.10	5.50	3.20	1.70	0.70	1.30	1.10	0.90
24....	0.60	1.50	2.90	2.50	3.20	5.30	3.10	1.80	0.80	1.30	1.10	0.90
25....	0.70	1.40	2.80	2.40	3.20	5.10	3.00	1.70	1.00	1.30	1.00	0.90
26....	0.80	1.30	2.70	2.20	3.30	5.00	2.90	1.60	1.20	1.30	1.00	0.90
27....	0.70	1.20	2.70	2.20	3.70	4.80	2.90	1.50	1.40	1.30	1.00	0.90
28....	0.60	1.00	2.80	2.10	4.20	4.60	2.80	1.50	1.50	1.20	0.90	0.90
29....	0.60	....	2.80	2.10	4.90	4.50	2.80	1.50	1.80	1.20	0.90	0.90
30....	0.60	....	2.90	2.10	5.50	4.40	2.70	1.50	2.00	1.10	0.90	0.80
31....	0.70	....	2.80	....	6.00	....	2.60	1.50	....	1.00	....	0.70

Daily gage height of Kansas River at Lawrence, Kans., for 1892.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	0.70	0.90	2.40	4.00	3.70	3.60	0.90	0.50	1.10	—0.20	0.60	0.50
2.....	0.60	1.00	2.50	3.80	3.80	3.50	0.90	0.50	1.10	—0.20	0.60	0.50
3.....	0.60	1.20	2.50	3.50	3.90	3.50	0.80	0.60	1.10	—0.20	0.50	0.40
4.....	0.50	1.30	2.60	3.40	4.20	3.40	0.70	0.70	1.00	—0.10	0.50	0.40
5.....	0.50	1.60	2.80	3.40	4.90	3.30	0.70	0.70	1.00	—0.10	0.40	0.30
6.....	0.50	1.80	3.00	3.40	5.70	3.30	0.80	0.80	1.00	—0.10	0.40	0.40
7.....	0.60	2.00	3.20	3.40	6.60	3.20	0.80	0.80	0.90	—0.10	0.30	0.40
8.....	0.60	2.20	3.00	3.30	7.30	3.10	0.90	0.90	0.70	—0.10	0.40	0.40
9.....	0.50	2.00	2.90	3.20	8.10	2.90	0.90	0.80	0.70	0.00	0.40	0.50
10....	0.50	1.90	2.70	3.10	8.80	2.70	1.00	0.70	0.60	0.00	0.50	0.50
11....	0.40	1.80	2.50	3.00	8.60	2.60	1.00	0.70	0.60	0.00	0.50	0.50
12....	0.50	1.60	2.40	3.00	8.60	2.50	0.90	0.60	0.60	0.10	0.50	0.50
13....	0.50	1.50	2.30	3.10	8.50	2.30	0.90	0.50	0.50	0.20	0.50	0.50
14....	0.60	1.40	2.10	3.20	8.50	2.20	0.80	0.40	0.40	0.30	0.50	0.50
15....	0.60	1.30	2.30	3.20	8.60	2.20	0.80	0.40	0.30	0.30	0.50	0.50
16....	0.70	1.40	2.50	3.30	8.80	2.20	0.80	0.50	0.20	0.40	0.50	0.50
17....	0.70	1.50	2.70	3.40	9.20	2.20	0.90	0.60	0.10	0.50	0.50	0.50
18....	0.80	1.50	2.90	3.50	8.50	2.10	0.90	0.60	0.00	0.40	0.60	0.50
19....	0.70	1.50	3.00	3.40	8.00	2.10	0.80	0.60	0.00	0.40	0.60	0.60
20....	0.70	1.50	3.00	3.20	7.40	2.10	0.80	0.60	0.00	0.40	0.70	0.50
21....	0.60	1.50	3.10	3.00	6.50	2.00	0.70	0.60	—0.10	0.30	0.70	0.40
22....	0.60	1.50	3.20	2.90	6.00	1.80	0.70	0.60	—0.10	0.30	0.70	0.30
23....	0.50	1.60	3.50	2.70	5.40	1.60	0.60	0.60	—0.10	0.30	0.60	0.20
24....	0.40	1.70	3.70	2.50	5.30	1.50	0.60	0.70	—0.10	0.20	0.60	0.10
25....	0.40	1.90	4.00	2.30	5.10	1.30	0.60	0.80	—0.10	0.30	0.60	0.00
26....	0.50	2.00	4.20	2.60	5.00	1.10	0.60	1.00	—0.10	0.30	0.50	0.00
27....	0.60	2.20	4.50	3.20	4.80	1.00	0.60	1.10	—0.10	0.40	0.50	0.10
28....	0.70	2.30	4.90	3.40	4.60	1.00	0.70	1.20	—0.10	0.50	0.40	0.10
29....	0.80	2.40	4.70	3.50	4.10	1.00	0.60	1.30	—0.10	0.50	0.50	0.10
30....	0.90	....	4.40	3.60	3.80	1.00	0.60	1.20	—0.20	0.60	0.50	0.20
31....	0.90	....	4.20	....	3.60	....	0.50	1.10	....	0.60	....	0.20

[1] Computed by Prof. E. C. Murphy from weekly averages given by Mr. J. D. Bowersock.

Daily gage height of Kansas River at Lawrence, Kans., for 1893.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	0.30	0.40	0.80	0.70	0.60	2.30	3.80	1.20	1.10	2.50	0.40	0.30
2.....	0.30	0.50	0.80	0.80	0.70	2.90	4.20	1.10	1.10	2.90	0.50	0.10
3.....	0.30	0.50	0.70	0.90	0.80	3.50	4.60	1.10	1.00	2.60	0.50	0.00
4.....	0.30	0.50	0.60	0.80	0.90	4.00	4.10	1.00	1.00	2.40	0.60	0.00
5.....	0.30	0.40	0.50	0.80	1.00	4.60	3.70	0.90	0.90	2.30	0.60	0.00
6.....	0.40	0.40	0.40	0.70	1.10	4.10	3.40	0.80	0.90	2.20	0.60	—0.10
7.....	0.40	0.50	0.40	0.60	1.20	3.70	2.90	0.60	0.90	2.10	0.60	—0.10
8.....	0.50	0.70	0.50	0.60	1.30	3.30	2.50	0.80	0.80	2.00	0.50	—0.10
9.....	0.50	0.90	0.50	0.50	1.30	2.90	2.20	1.30	0.80	2.00	0.50	—0.10
10....	0.50	1.20	0.40	0.40	1.20	2.40	2.10	1.80	0.80	1.80	0.50	0.00
11....	0.50	1.40	0.40	0.50	1.10	2.00	2.10	2.30	0.80	1.60	0.40	0.00
12....	0.50	1.60	0.40	0.60	1.10	1.90	2.10	2.80	0.70	1.30	0.40	0.00
13....	0.50	1.80	0.30	0.70	1.00	1.90	2.10	3.20	0.60	1.00	0.30	—0.10
14....	0.50	1.80	0.30	0.80	1.00	1.90	2.00	3.70	0.40	0.80	0.40	—0.10
15....	0.50	1.70	0.30	0.90	0.90	1.80	1.90	3.40	0.30	0.50	0.40	—0.10
16....	0.50	1.70	0.40	1.00	1.00	1.70	1.80	3.10	0.10	0.50	0.40	—0.10
17....	0.50	1.80	0.40	1.10	1.10	1.50	1.70	2.80	0.00	0.50	0.40	0.00
18....	0.40	1.80	0.40	1.00	1.20	1.30	1.70	2.50	0.00	0.50	0.40	0.00
19....	0.40	1.90	0.40	0.90	1.30	1.20	1.80	2.20	0.00	0.50	0.40	0.10
20....	0.40	2.00	0.40	0.90	1.40	1.50	1.90	2.00	0.10	0.40	0.30	0.10
21....	0.40	1.90	0.40	0.80	1.50	1.80	2.00	1.90	0.20	0.40	0.40	0.20
22....	0.40	1.70	0.40	0.80	1.60	1.90	2.10	1.90	0.30	0.40	0.40	0.40
23....	0.30	1.50	0.40	0.70	1.50	2.10	2.20	1.80	0.30	0.30	0.50	0.50
24....	0.30	1.40	0.30	0.70	1.40	2.20	2.30	1.80	0.30	0.30	0.60	0.60
25....	0.40	1.20	0.30	0.70	1.30	2.30	2.20	1.70	0.40	0.40	0.60	0.70
26....	0.40	1.10	0.30	0.70	1.20	2.40	2.00	1.60	0.60	0.40	0.70	0.60
27....	0.40	0.90	0.30	0.70	1.10	2.60	1.80	1.40	0.90	0.40	0.70	0.60
28....	0.40	0.90	0.30	0.70	1.00	2.90	1.60	1.20	1.40	0.40	0.70	0.50
29....	0.40	....	0.40	0.70	0.90	3.20	1.40	1.20	1.80	0.40	0.50	0.50
30....	0.40	....	0.50	0.70	1.20	3.50	1.30	1.20	2.10	0.40	0.40	0.40
31....	0.40	....	0.60	....	1.70	....	1.20	1.20	....	0.40	....	0.40

Daily gage height of Kansas River at Lawrence, Kans., for 1894.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	0.30	0.10	0.70	0.60	0.80	0.40	3.10	0.60	0.40	0.10	0.00	0.00
2.....	0.40	0.20	0.70	0.50	0.70	0.50	3.00	0.60	0.50	0.20	0.00	0.00
3.....	0.40	0.30	0.60	0.70	0.70	0.60	2.90	0.70	0.60	0.30	0.00	0.00
4.....	0.40	0.40	0.50	0.90	0.60	0.60	2.80	0.70	0.60	0.40	0.00	0.00
5.....	0.40	0.50	0.50	1.10	0.50	0.60	2.60	0.80	0.50	0.50	0.00	0.00
6.....	0.40	0.40	0.50	1.40	0.40	0.70	2.50	0.80	0.40	0.60	0.00	0.00
7.....	0.40	0.30	0.60	1.60	0.30	0.80	2.30	0.80	0.40	0.90	0.00	0.00
8.....	0.40	0.30	0.60	1.90	0.40	0.90	2.00	0.80	0.50	1.20	0.00	0.00
9.....	0.40	0.20	0.60	2.20	0.40	1.00	1.70	0.80	0.50	0.90	0.00	0.00
10....	0.40	0.20	0.50	1.90	0.40	1.10	1.60	0.80	0.60	0.70	0.00	0.00
11....	0.40	0.20	0.50	1.70	0.40	1.20	1.60	0.80	0.50	0.50	0.00	0.00
12....	0.50	0.10	0.40	1.50	0.40	1.30	1.60	0.90	0.50	0.30	0.00	0.00
13....	0.50	0.20	0.50	1.20	0.40	1.30	1.50	1.00	0.50	0.10	0.00	0.00
14....	0.50	0.20	0.60	1.00	0.30	1.40	1.50	0.90	0.40	0.00	0.00	0.00
15....	0.50	0.30	0.80	0.80	0.30	1.50	1.50	0.70	0.40	0.00	0.00	0.00
16....	0.50	0.30	0.90	0.60	0.30	1.50	1.40	0.60	0.40	0.00	0.00	0.00
17....	0.50	0.40	1.10	0.70	0.30	1.60	1.30	0.40	0.30	0.00	0.00	0.00
18....	0.40	0.40	1.20	0.80	0.30	1.60	1.20	0.20	0.30	0.10	0.00	0.00
19....	0.40	0.40	1.40	0.80	0.40	1.80	1.10	0.10	0.50	0.20	0.00	0.00
20....	0.50	0.40	1.30	0.80	0.40	2.40	1.00	0.00	0.60	0.20	0.00	0.00
21....	0.50	0.50	1.20	0.80	0.40	3.20	0.90	0.00	0.60	0.30	0.00	0.00
22....	0.60	0.60	1.10	0.70	0.40	3.80	0.80	0.00	0.60	0.40	0.00	0.00
23....	0.50	0.60	1.00	0.70	0.30	4.40	0.70	—0.10	0.70	0.30	0.00	0.00
24....	0.40	0.70	0.90	0.70	0.20	5.00	0.70	—0.10	0.80	0.20	0.00	0.00
25....	0.30	0.70	0.80	0.70	0.10	5.60	0.70	—0.10	0.70	0.20	0.00	0.00
26....	0.20	0.80	0.70	0.80	0.10	5.20	0.70	0.00	0.60	0.10	0.00	0.00
27....	0.10	0.80	0.80	0.80	0.00	4.90	0.70	0.00	0.50	0.10	0.00	0.00
28....	0.00	0.80	0.80	0.80	0.00	4.50	0.60	0.00	0.40	0.00	0.00	0.00
29....	0.00	....	0.80	0.90	0.00	4.60	0.60	0.10	0.30	0.00	0.00	0.00
30....	0.00	....	0.80	0.90	0.10	3.60	0.50	0.20	0.20	0.00	0.00	0.00
31....	0.10	....	0.70	....	0.30	....	0.50	0.30	....	0.00	....	0.00

[1] Computed by Prof. E. C. Murphy from monthly averages given by Mr. J. D. Bowersock.

Daily gage height of Kansas River at Lawrence, Kans., for 1895.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1.....	0.00	0.00	0.40	0.50	0.40	0.20	0.90	1.50	4.40	0.40	0.20	0.00
2.....	0.00	0.00	0.50	0.60	0.40	0.20	1.00	1.50	3.70	0.40	0.25	0.40
3.....	0.00	0.00	0.50	0.60	0.40	0.20	1.20	1.50	3.05	0.35	0.30	*a*2.55
4.....	0.00	0.00	0.60	0.60	0.40	0.40	1.30	1.40	2.65	0.30	0.25	2.75
5.....	0.00	0.00	0.50	0.60	0.40	1.00	1.40	1.40	2.30	0.30	0.20	0.60
6.....	0.00	0.00	0.50	0.70	0.30	1.60	1.50	1.50	2.80	0.35	0.20	0.20
7.....	0.00	0.00	0.40	0.70	0.40	2.40	1.50	1.70	2.50	0.45	0.25	0.30
8.....	0.00	0.00	0.40	0.70	0.40	3.10	1.60	2.00	2.35	0.40	0.20	0.30
9.....	0.00	0.00	0.30	0.70	0.40	3.60	1.70	2.20	2.50	0.30	0.20	0.30
10....	0.00	0.00	0.20	0.60	0.50	4.40	1.80	2.50	2.15	0.30	0.20	0.20
11....	0.00	0.00	0.20	0.50	0.50	3.80	2.00	2.80	1.90	0.30	0.25	0.20
12....	0.00	0.00	0.30	0.50	0.50	3.40	2.10	2.90	1.45	0.30	0.25	0.30
13....	0.00	0.00	0.30	0.40	0.50	3.00	2.30	3.00	1.10	0.30	0.20	0.30
14....	0.00	0.00	0.40	0.40	0.50	2.50	2.50	3.10	1.05	0.30	0.20	0.30
15....	0.00	0.00	0.40	0.30	0.40	2.10	2.80	3.20	0.95	0.30	0.20	0.20
16....	0.00	0.00	0.50	0.40	0.30	1.70	2.50	3.30	0.85	0.30	0.30	0.20
17....	0.00	0.00	0.50	0.40	0.20	1.70	2.30	3.50	0.75	0.30	0.30	0.20
18....	0.00	0.00	0.60	0.40	0.10	1.60	2.20	3.90	0.70	0.25	0.30	0.30
19....	0.00	0.00	0.60	0.30	0.00	1.60	2.10	4.50	0.65	0.20	0.30	0.40
20....	0.00	0.10	0.50	0.30	0.00	1.60	2.10	5.50	0.55	0.20	0.30	0.30
21....	0.00	0.10	0.50	0.20	0.00	1.50	2.10	5.55	0.50	0.20	0.30	0.35
22....	0.00	0.10	0.50	0.20	0.00	1.30	2.00	5.00	0.60	0.20	0.30	0.40
23....	0.00	0.20	0.50	0.20	0.10	1.00	2.00	4.70	0.50	0.30	0.30	0.40
24....	0.00	0.20	0.50	0.30	0.10	0.90	1.80	4.50	0.50	0.30	*b*0.30	0.40
25....	0.00	0.20	0.50	0.30	0.00	0.90	1.70	3.50	0.50	0.30	0.30	0.35
26....	0.00	0.20	0.50	0.30	0.00	1.00	1.60	2.50	0.45	0.30	*b*0.20	0.20
27....	0.00	0.30	0.50	0.40	0.10	1.10	1.50	1.80	0.40	0.25	0.10	0.30
28....	0.00	0.30	0.50	0.40	0.00	1.00	1.40	*c*1.30	0.40	0.25	0.35	0.20
29....	0.00	....	0.50	0.50	0.10	1.00	1.40	1.20	0.40	0.20	0.45	0.20
30....	0.00	....	0.50	0.50	0.10	0.90	1.40	1.15	0.40	0.20	0.25	0.10
31....	0.00	....	0.50	....	0.20	....	1.50	3.20	....	0.20	....	0.20

a Fall of 3 inches due to extreme cold weather and starting of mills.
b River frozen over for first time this season.
c New gage put in place August 27, 1895, and observations reported on blank Form 9-176.

Estimated discharge of Kansas River at Lawrence, Kans.

[Drainage area, 59,841 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1891.						
January	2,123	967	1,445	88,850	0.02	0.02
February	7,400	1,098	3,538	196,491	0.06	0.06
March	11,440	1,437	6,144	377,780	0.12	0.10
April	12,550	5,207	8,455	503,107	0.16	0.14
May	32,290	4,037	10,560	649,309	0.21	0.18
June	35,750	13,120	23,102	1,374,664	0.44	0.39
July	19,370	9,440	13,846	851,357	0.26	0.23
August	9,440	3,673	5,444	334,739	0.10	0.09
September	6,490	1,255	2,768	164,707	0.60	0.05
October	10,900	2,687	5,925	364,314	0.12	0.10
November	2,998	1,872	2,382	141,739	0.04	0.04
December	4,803	1,870	3,129	192,395	0.06	0.05
Per annum	35,750	967	7,228	5,239,452	2.19	0.12
1892.						
January	2,395	1,255	1,669	102,623	0.03	0.03
February	8,350	2,395	5,292	304,399	0.09	0.09
March	23,600	6,940	12,581	773,576	0.24	0.21
April	17,390	7,870	12,712	756,417	0.23	0.21
May	....	14,890	37,005	2,275,348	0.70	0.61
June	14,890	2,687	8,134	484,007	0.11	0.10
July	2,687	1,437	2,059	126,603	0.03	0.03
August	3,673	1,255	2,010	123,590	0.03	0.03
September	2,998	787	1,448	86,262	0.02	0.02
October	1,643	787	1,042	64,070	0.02	0.02
November	1,872	1,098	1,487	88,483	0.02	0.02
December	1,643	787	1,225	75,322	0.02	0.02
Per annum	....	787	7,222	5,260,700	1.54	0.12

[1] Computed by Prof. E. C. Murphy from monthly averages given by Mr. J. D. Bowersock.

Estimated discharge of Kansas River at Lawrence, Kans.—Continued.

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1893.						
January	1,437	1,098	1,278	78,581	0.02	0.02
February	6,490	1,255	3,650	202,711	0.06	0.06
March	2,123	1,098	1,339	82,332	0.02	0.02
April	2,998	1,255	2,011	119,663	0.03	0.03
May	5,207	1,643	3 209	197,314	0.06	0.05
June	21,440	3,327	9,284	553,031	0.18	0.16
July	21,440	3,327	8,474	521,046	0.16	0.14
August	15,500	1,643	5,980	368,311	0.12	0.10
September	6,940	787	2,072	123,293	0.03	0.03
October	10,900	1,098	3,663	225,844	0.07	0.06
November	1,872	1,098	1,426	84,853	0.02	0.02
December	1,872	787	1,021	62,779	0.02	0.02
Per annum	21,440	787	3,617	2,619,758	0.79	0.06
1894.						
January	1,643	787	1,230	75,630	0.02	0.02
February	2,123	863	1,315	78,248	0.02	0.02
March	4,035	1,255	2,134	131,215	0.04	0.04
April	7,400	1,437	2,903	172,741	0.06	0.05
May	2,123	787	1,208	74,277	0.02	0.02
June	28,990	1,255	9,044	538,155	0.17	0.15
July	11,990	1,437	4,740	291,451	0.09	0.08
August	2,687	787	1,478	90,879	0.03	0.03
September	2,123	967	1,445	85,984	0.02	0.02
October	3,327	787	1,189	73,109	0.02	0.02
November	....	....	787	46,830	0.01	0.01
December	....	....	550	33,818	0.01	0.01
Per annum	....	....	2,326	1,692,337	0.51	0.04
1895.						
January	....	....	500	33,818	0.01	0.01
February	1,098	550	680	37,765	0.01	0.01
March	1,643	967	1,364	83,869	0.02	0.02
April	1,872	967	1,372	81,640	0.02	0.02
May	1,437	787	1,074	66,038	0.02	0.02
June	20,050	967	5,927	352,681	0.11	0.10
July	10,370	2,395	5,666	348,389	0.12	0.10
August	28,190	3,163	11,318	695,917	0.22	0.19
September	20,050	1,255	5,088	302,757	0.10	0.09
October	1,346	967	1,090	67,022	0.02	0.02
November	1,346	863	1,044	62,122	0.02	0.02
December	1,255	863	926	56,938	0.02	0.02
Per annum	....	....	3,008	2,188,956	0.69	0.05

Mean monthly and annual discharge in acre-feet of Kansas River at Lawrence, Kans.[1]

Month.	1886.	1887.	1888.	1889.	1890.
January	56,273	50,946	63,637	94,703	332,500
February	620,568	83,956	275,797	78,274	193,648
March	750,198	137,491	419,909	105,675	265,304
April	694,438	117,308	232,756	117,336	152,579
May	767,327	316,428	453,620	847,806	212,342
June	287,615	322,033	514,589	337,550	194,939
July	114,294	83,386	292,712	887,899	69,758
August	143,368	108,637	293,071	730,336	63,427
September	81,508	117,951	67,438	326,769	93,807
October	60,165	111,713	75,185	111,324	74,582
November	83,454	77,742	102,823	206,444	79,453
December	76,525	61,719	88,319	91,840	57,876
Total	3,735,733	1,589,310	2,879,856	3,935,956	1,790,215

[1] The figures for the years 1886 to 1890, inclusive, have been taken from the Kansas University Quarterly, Volume IV, No. 3, January, 1896. Notes on discharge of the Kansas River at Lawrence, Kans., since 1881, by E. C. Murphy, page 166.

Mean monthly and annual discharge in acre-feet of Kansas River at Lawrence, Kans.—Continued.

Month.	1891.	1892.	1893.	1894.	1895.
January	88, 850	102, 623	78, 581	75, 630	33, 818
February	196, 491	304, 399	202, 711	78, 248	37, 765
March	377, 780	773, 576	82, 332	131, 215	83, 869
April	503, 107	756, 417	119, 663	172, 741	81, 640
May	649, 309	2, 275, 348	197, 314	74, 277	66, 038
June	1, 374, 664	484, 007	553, 031	538, 155	352, 681
July	851, 357	126, 603	521, 046	291, 451	348, 389
August	334, 739	123, 590	368, 311	90, 879	695, 917
September	164, 707	86, 262	123, 293	85, 984	302, 757
October	364, 314	64, 070	225, 844	73, 109	67, 022
November	141, 739	88, 483	84, 853	46, 830	62, 122
December	192, 395	75, 322	62, 779	33, 818	56, 938
Total	5, 239, 452	5, 260, 700	2, 619, 758	1, 692, 337	2, 188, 956

Run-off, in inches, and discharge ratios of Kansas River at Lawrence, Kans.

[Estimated by Prof. E. C. Murphy, using as effective drainage area 56,082 square miles.]

Months.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum monthly run-off, in inches, in 10 years	*Inch.* .11	*Inch.* .21	*Inch.* .26	*Inch.* .25	*Inch.* .72	*Inch.* .18	*Inch.* .29	*Inch.* .24	*Inch.* .11	*Inch.* .12	*Inch.* .07	*Inch.* .06
Minimum monthly run-off, in inches, in 10 years	.01	.01	.03	.02	.02	.03	.02	.02	.02	.02	.01	.01
Mean monthly run-off, in inches, in 10 years	.03	.07	.11	.10	.19	.12	.12	.10	.05	.04	.03	.03
Ratios of mean monthly discharges in 10 years	.40	.84	1.27	1.19	2.38	1.44	1.46	1.19	.59	.50	.39	.33

ARKANSAS BASIN.

The Arkansas River rises in the Rocky Mountain region of central Colorado, the city of Leadville being situated in the upper portion of its catchment basin. Measurements of the discharge of this river have been made at various points on the tributaries near Leadville and on the main stream below this, as described in the Eleventh Annual Report United States Geological Survey, Part II, Irrigation, pages 45–47. The river flows in a general southerly and southeasterly direction, then turning toward the east passes out from the mountains through the Grand Canyon of the Arkansas above Canyon City. From this point it continues easterly, crossing the Great Plains. Measurements of its volume have been made at intervals in Colorado and Kansas, as shown in the following pages.

ARKANSAS RIVER.

The drainage area of Arkansas River has been measured from the land office map of Colorado dated 1892, the basin being subdivided into smaller catchment areas, and each of these measured by means of a planimeter. The results are as follows:

Drainage area of Arkansas River.

	Square miles.
At Granite, Colo	425
At Salida (above South Fork)	1,160
At Canyon City	3,060
At Swallows	4,300
At Pueblo	4,600
At La Junta (including Fountain Creek drainage, 1,011 square miles)	12,200
At railroad bridge above Holly (of this, Animas River, 3,337)	23,500
At State line	24,600

GRANITE STATION, ON ARKANSAS RIVER.

This station is located about 4 miles below the old station at Hayden, described in Bulletin 131, page 34. This upper station was abandoned, owing to the difficulty of securing accurate records of river height and of discharge. Hayden is above the creek which serves as the outlet of Twin Lakes, while Granite is below this point; the measurements of discharge at the latter locality give the amount coming from Twin Lakes as well as from the upper basin of the Arkansas.

The gage at Granite was established by the Denver and Rio Grande Railroad engineers on April 11, 1895. The height of river is recorded by the station agent at 7 a. m. and 4 p. m., the readings being telegraphed to the superintendent at Salida. The gage is attached to a wagon bridge 250 feet from the depot. The banks of the stream are low and liable to overflow, the bed is very rocky, and the velocity of the water is high. Two measurements of discharge have been made at Granite, the first on July 3, 1895, the height of water being 0.50 feet, the mean velocity 5.49 feet per second, and the total discharge 1,065 second-feet. The second was on September 26, when the water stood at a height of 3.10 feet on the new gage. The average velocity was 2.55 feet per second, and the total discharge 215 second-feet.

On September 26, 1895, Mr. Arthur P. Davis put in a new gage, as the water had fallen below the old one. This was spiked to the upper end of the center pier of the wagon bridge and referred to a bench mark on the highest point of the huge bowlder 100 yards southeast of the bridge, marked X. This is 10.91 feet above the zero of the gage.

Daily gage height of Arkansas River near Granite, Colo., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	....	0.50	0.50	0.58	0.00	—0.25	2.90
2	....	0.42	0.46	0.50	0.00	—0.25	2.80
3	....	0.29	0.42	0.50	0.00	—0.25	3.00
4	....	0.25	0.42	0.45	0.00	—0.25	3.00
5	....	0.42	0.29	0.40	0.00	—0.25	3.00
6	....	0.00	0.25	0.38	—0.10	—0.30	3.00
7	....	0.08	0.29	0.35	—0.13	—0.35	3.00
8	....	0.16	0.29	0.25	—0.15	—0.35	3.00
9	....	0.46	0.46	0.25	0.00	—0.35	3.00
10	....	0.83	0.50	0.25	—0.13	—0.35	3.00
11	0.50	0.50	0.58	0.60	—0.13	—0.35	3.00
12	0.58	0.90	0.58	0.38	—0.15	—0.35	3.00
13	1.00	0.67	0.75	0.25	—0.15	—0.35	3.00
14	0.75	0.83	0.75	0.25	—0.15	—0.35	3.00
15	0.68	0.91	0.87	0.15	—0.15	—0.35	3.00
16	0.41	0.87	0.96	0.15	—0.10	—0.35	3.00
17	0.91	0.62	0.96	0.18	—0.15	—0.35	3.00
18	1.33	0.58	0.83	0.10	—0.15	—0.35	3.00
19	1.16	0.54	0.75	0.10	—0.15	—0.35	3.00
20	1.50	0.67	0.58	0.00	—0.25	—0.35	3.00
21	1.25	0.75	0.58	0.00	—0.25	—0.35	3.00
22	1.42	0.66	0.54	0.05	—0.25	—0.35	3.00
23	0.50	0.83	0.50	0.10	—0.25	—0.35	3.00
24	0.50	0.66	0.58	0.00	—0.25	—0.35	3.00
25	0.91	0.50	0.58	0.00	—0.25	—0.35	....
26	1.08	0.50	0.58	0.00	—0.25	*a*3.10	....
27	1.16	0.50	0.58	—0.10	—0.25	3.10	....
28	1.25	0.50	0.58	—0.10	—0.25	3.05	....
29	1.25	0.50	0.58	—0.05	—0.25	3.00	....
30	0.50	0.50	0.67	0.00	—0.25	3.00	....
31	....	0.50	0.54	0.00	—0.25	....	....

a New gage erected by Mr. A. P. Davis.

SALIDA STATION, ON ARKANSAS RIVER.

The river rod at Salida is about 3 miles above the mouth of the south fork of Arkansas River. It is located back of the railroad yards at a suspension foot-bridge. It was originally established by the Denver and Rio Grande Railroad Company on April 11, 1895. The gage is divided to feet and tenths, is vertical, and is bolted to the left hand abutment of the bridge. On December 24, 1895, the surface of the water was 0.20 below zero of the rod. At that time the river was partly frozen, and there was too much floating ice to make measurements of discharge. The channel both above and below the station is curved, the banks are high and rocky, the bed of the stream covered with coarse material, and the water moves generally with somewhat high velocity.

Daily gage height of Arkansas River near Salida, Colo., for 1895.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.
1	....	1.33	1.46	1.58	1.25	0.65	0.10
2	....	1.21	1.37	1.50	1.25	0.50	0.10
3	....	1.04	1.37	1.50	1.00	0.60	0.10
4	....	1.41	1.29	1.45	0.95	0.50	0.10
5	....	0.83	1.21	1.35	0.83	0.50	0.10
6	....	0.83	1.29	1.30	0.75	0.40	0.10
7	....	0.83	1.37	1.13	0.70	0.40	0.10
8	....	0.96	1.46	1.13	0.60	0.40	0.10
9	....	1.54	1.50	0.95	0.60	0.35	0.10
10	....	2.08	1.83	1.05	0.73	0.35	0.10
11	0.25	1.87	1.75	1.59	0.60	0.35	0.10
12	0.29	1.91	1.83	1.65	0.60	0.35	0.10
13	0.42	2.12	2.00	1.25	0.50	0.35	0.10
14	0.58	2.62	1.46	1.25	0.55	0.25	0.10
15	0.54	2.62	2.33	1.00	1.02	0.15	0.10
16	0.37	2.00	2.08	1.00	0.88	0.25	0.10
17	0.54	1.83	2.00	0.90	0.70	0.25	0.10
18	1.04	1.46	1.87	1.00	0.63	0.25	0.10
19	1.41	1.41	1.62	0.90	0.60	0.15	0.10
20	1.46	1.62	1.50	0.90	0.55	0.15	0.10
21	1.50	1.83	1.50	0.85	0.50	0.15	0.10
22	1.08	1.75	1.50	0.90	0.50	0.15	0.10
23	1.04	1.58	1.50	1.05	0.55	0.15	0.10
24	1.00	1.58	1.50	1.00	0.63	0.15	0.10
25	1.25	1.41	1.50	0.88	0.60	0.15	0.10
26	1.42	1.33	1.50	0.80	0.55	0.15	0.10
27	1.46	1.33	1.50	0.75	0.50	0.25	....
28	1.54	1.46	1.83	0.65	0.65	0.15	....
29	1.91	1.32	1.87	0.65	0.63	0.15	....
30	1.46	1.41	1.75	0.85	0.65	0.15	....
31	....	1.46	....	0.85	0.65	....	....

CANYON STATION, ON ARKANSAS RIVER.

This locality is described in Bulletin No. 131, page 35. Observations of river height have been maintained by Dr. J. L. Prentiss at the gage under the suspension bridge in front of Hot Springs Hotel. At the time of the measurement, on October 4, 1895, it was found that the top of the gage had been broken off, necessitating its renewal for readings during high water. The channel was found to be filled with sand and gravel in front of the gage, requiring considerable work in order to make the water flow to the rod. It was decided, therefore, to put in a new gage where the stream could not deposit material. A point was chosen about 100 feet below the bridge, on the left bank, and a crib was built, anchored in place by rocks and bolts, the lower end of the gage being fastened to it. The upper end of the inclined portion was attached to a juniper tree. On December 27 the station was inspected, and it was found that readings had been made from the old rod, which, at the stage of water prevailing, recorded about 0.40 above the new rod on the opposite side of the river. When the water is high and extends with unbroken surface from bank to bank the readings are the same, but at low water the observations on the old rod are misleading, owing to the accumulation of sand and gravel in front of it. The measurements of discharge are made from the suspension bridge, the old cable and car placed there before the bridge was erected not being needed.

List of discharge measurements made on Arkansas River at Canyon City, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1889.						
1	July 26	Robert Robertson.	100	2.25	....	....	421
2	....	.....do.............	100	3.00	....	....	833
	1890.						
3	Apr. 1	.....do.............	105	1.62	95	2.34	222
4	Apr. 2	.....do.............	105	1.70	114	2.51	286
5	Apr. 3	.....do.............	105	1.88	120	3.00	360
6	Apr. 28	.....do.............	105	2.93	168	4.43	744
7	May 1	.....do.............	105	2.73	192	4.04	775
8	May 2	.....do.............	105	2.80	200	4.45	891
9	May 2	.....do.............	105	2.78	196	4.40	862
10	May 23	.....do.............	105	4.77	403	6.71	2,705
11	June 5	.....do.............	105	4.85	411	6.43	2,641
12	June 12	.....do.............	105	4.53	378	5.74	2,220
13	June 14	.....do.............	105	4.65	392	6.63	2,598
14	June 19	.....do.............	105	4.48	375	6.35	2,380
15	June 23	.....do.............	105	4.55	371	6.43	2,386
16	June 27	.....do.............	105	4.55	372	6.44	2,394
17	June 30	.....do.............	105	4.23	350	5.84	2,055
18	July 9	.....do.............	105	4.22	345	5.76	1,988
19	July 12	.....do.............	105	4.05	357	5.21	1,806
20	July 16	.....do.............	105	3.82	311	4.97	1,546
	1891.						
21	Apr. 13	T. M. Bannon	110	3.00	187	4.16	777
22	Dec. 4	.....do.............	103	1.85	152	2.16	328
	1893.						
23	Sept. 22	F. H. Newell......	24	2.45	129	2.26	291
	1894.						
24	May 15	.....do.............	24	4.20	329	7.28	2,395
25	May 18	.....do.............	24	3.80	290	6.71	1,940
26	June 18	.....do.............	24	4.80	385	6.19	2,387
27	Sept. 20	A. P. Davis........	21	2.65	140	2.86	395
28	Oct. 15	.....do.............	21	2.40	125	2.56	319
	1895.						
29	May 31	.....do.............	55	4.35	343	7.10	2,434
30	June 13	.....do.............	55	4.50	356	6.73	2,397
31	Oct. 4	.....do.............	61	2.70	157	3.70	585

NOTE.—Measurements Nos. 1 to 22 are shown graphically in the Fourteenth Annual Report of this Survey, Part II, page 106, fig. 9, and numerical values are given on page 107.

Daily gage height of Arkansas River at Canyon City, Colo., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.30	2.30	2.50	2.60	3.70	4.10	3.95	4.25	3.20	2.50	2.40	2.60
2..	2.30	2.30	2.50	2.50	3.50	4.00	4.10	4.10	3.20	2.40	2.40	2.60
3..	2.20	2.30	2.40	2.50	3.30	3.90	3.95	3.85	3.20	2.40	2.50	2.60
4..	2.20	2.30	2.40	2.60	3.20	3.80	3.80	3.60	3.20	2.70	2.50	2.60
5..	2.20	2.30	2.40	2.60	3.20	3.70	3.80	3.50	3.10	3.05	2.50	2.60
6..	2.20	2.30	2.40	2.60	3.10	3.60	3.70	3.40	3.00	2.90	2.50	2.60
7..	2.20	2.30	2.40	2.60	3.10	3.80	3.50	3.30	3.00	2.80	2.50	2.60
8..	2.20	2.30	2.40	2.70	3.00	4.10	3.55	3.35	3.00	2.70	2.50	2.60
9..	2.20	2.30	2.40	2.70	3.40	3.95	3.50	3.40	2.90	2.70	2.60	2.60
10.	2.20	2.30	2.40	2.70	3.70	4.35	3.55	3.30	2.90	2.70	2.60	2.50
11.	2.30	2.20	2.50	2.70	4.00	4.50	4.20	3.30	2.90	2.70	2.60	2.50
12.	2.30	2.20	2.50	2.70	4.10	4.43	4.30	3.20	2.80	2.70	2.60	2.50
13.	2.40	2.20	2.50	2.80	4.00	4.48	4.05	3.20	2.80	2.60	2.60	2.50
14.	2.30	2.20	2.40	2.80	4.00	4.50	3.90	3.20	2.70	2.60	2.60	2.50
15.	2.30	2.30	2.50	2.90	4.10	4.43	3.80	3.20	2.70	2.60	2.60	2.50
16.	2.30	2.30	2.50	2.80	4.20	4.45	3.70	3.40	2.70	2.60	2.60	2.50
17.	2.30	2.30	2.50	2.90	4.30	4.45	3.70	3.30	2.60	2.60	2.60	2.50
18.	2.40	2.30	2.50	3.25	3.80	4.43	3.50	3.20	2.60	2.60	2.60	2.50
19.	2.40	2.30	2.50	3.40	3.60	4.30	3.40	3.20	2.60	2.50	2.60	2.50
20.	2.40	2.40	2.50	3.50	3.60	4.00	3.40	3.20	2.60	2.50	2.60	2.50
21.	2.40	2.40	2.50	3.50	4.00	4.03	3.35	3.10	2.60	2.50	2.60	2.50
22.	2.30	2.40	2.60	3.60	4.10	3.85	3.35	3.10	2.60	2.50	2.60	2.50
23.	2.30	2.50	2.60	3.30	4.00	3.75	3.80	3.00	2.60	2.50	2.60	2.40
24.	2.30	2.50	2.60	3.30	4.10	3.75	3.90	3.00	2.50	2.50	2.60	2.35
25.	2.40	2.50	2.60	3.40	4.00	3.75	3.65	3.10	2.50	2.50	2.60	2.20
26.	2.40	2.40	2.60	3.50	3.80	3.75	3.50	3.30	2.50	2.40	2.60	2.10
27.	2.30	2.40	2.70	3.60	3.70	3.80	3.40	3.40	2.50	2.40	2.60	2.20
28.	2.30	2.40	2.70	3.70	3.60	3.90	3.35	3.40	2.50	2.40	2.60	2.45
29.	2.30	......	2.70	3.80	3.60	3.85	3.30	3.45	2.50	2.40	2.60	2.30
30.	2.30	......	2.70	4.00	3.70	3.90	3.40	3.35	2.50	2.40	2.60	2.30
31.	2.30	......	2.70	......	4.40	......	3.60	3.30	......	2.40	......	2.40

PUEBLO STATION, ON ARKANSAS RIVER.

A number of gages have been placed on the Arkansas River along the line of the Denver and Rio Grande Railroad, in the vicinity of Pueblo. The first of these is at Bridge No. 3, this being 997 feet above milepost 146. It was located on June 6, 1895. The 4-foot mark is at an elevation of 5,040 feet. The next gage below this is at Swallows, at bridge 135A. This is 1,180 feet above milepost 135. It was located June 7, 1895. The 6-foot mark is at an elevation of 4,880 feet. The next gage is at the West Fourth street viaduct, above the central part of the city of Pueblo. It is 1,980 feet above milepost 120. The 6-foot mark on this rod is at an elevation of 4,674 feet. Of these three localities only one, that at Swallows, is of value for discharge measurements, owing to unfavorable conditions. The next gage is that set by Mr. Arthur P. Davis at the Victoria street bridge, and below this the station at the Santa Fe avenue bridge, in the lower part of the city of Pueblo. This is 872 feet above milepost 119. The elevation of the 6-foot mark is 4,662.31 feet.

The gage at Santa Fe avenue bridge was established by Mr. Arthur P. Davis in September, 1894. It consists of a vertical timber bolted to the stone abutment of the railroad bridge in the acute angle between that and the highway bridge, and is on the left-hand side of the stream. The 12-foot mark of this gage is opposite the top of the large capstone. The channel both above and below this station is nearly straight, being revetted on both sides with furnace slag. The bed is composed of gravel and slag, and does not change except during unusual floods.

The measurement of September 5, 1895, was made from the Main street bridge, the first bridge west of Santa Fe avenue. The bridge is marked for each 5 feet in width across the stream. At the Victoria avenue bridge, the second west of Main street, is the upper rod, placed in June, 1895, for the purpose of obtaining the slope of the water surface. This point is favorable for low-water measurements, the surface of the water being only 70 feet wide, while it is 118 feet wide at Main street.

List of discharge measurements made on Arkansas River at Pueblo, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.					
(*a*)	Apr. 24	J. P. Preston		(*a*)	1.95	322
1	Sept. 19	A. P. Davis	21	0.35	2.50	378
2	Oct. 13	.....do	22	0.39	2.36	370
	1895.					
3	Feb. 6	.....do	24	0.40	2.75	411
4	May 20	.....do	28	1.65	4.78	1,435
5	June 3	.....do	55	(*b*)	5.30	2,261
6	June 4	.....do	55	(*c*)	3.18	1,973
7	June 4	.....do	55	(*d*)	5.46	2,022
8	June 11	.....do	55	2.80	6.89	2,758
9	Sept. 5	F. Cogswell	14	0.70	3.35	570

a Measurement made at Main Street bridge.
b Measurement made at Swallows.
c Measurement made at Bridge No. 3, section poor.
d Measurement made at Bridge 155 B.

Daily gage height of Arkansas River at Pueblo, Colo., for 1894.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1...	....	0.4	0.4	0.4	17....	....	0.4	0.4	0.3
2...	....	0.4	0.4	0.4	18....	....	0.4	0.4	0.4
3...	....	0.5	0.43	0.4	19....	0.4	0.3	0.4	0.4
4...	....	0.5	0.4	0.3	20....	0.4	0.4	0.4	0.35
5...	....	0.5	0.4	0.25	21....	0.4	0.4	0.4	0.35
6...	....	0.5	0.4	0.2	22....	0.3	0.4	0.4	0.3
7...	....	0.5	0.4	0.35	23....	0.3	0.4	0.4	0.2
8...	....	0.5	0.4	0.3	24....	0.3	0.4	0.4	0.2
9...	....	0.5	0.4	0.3	25....	0.3	0.4	0.4	0.35
10..	....	0.5	0.4	0.25	26....	0.2	0.3	0.4	0.4
11..	....	0.5	0.4	0.3	27....	0.2	0.3	0.4	0.3
12..	....	0.4	0.4	0.4	28....	0.2	0.4	0.4	0.3
13..	....	0.4	0.4	0.35	29....	0.2	0.4	0.4	0.3
14..	....	0.4	0.4	0.4	30....	0.4	0.3	0.4	0.4
15..	....	0.4	0.4	0.4	31....	....	0.3	....	0.4
16..	....	0.4	0.4	0.4					

Daily gage height of Arkansas River at Pueblo, Colo., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	0.40	0.50	0.40	0.30	1.80	2.35	2.60	3.05	1.05	0.40	0.55	0.55
2..	0.50	0.45	0.30	0.20	1.45	2.35	2.35	3.00	1.10	0.45	0.60	0.50
3..	0.90	0.45	0.30	0.20	1.25	2.15	2.35	3.05	0.85	0.40	0.50	0.50
4..	0.85	0.55	0.30	0.20	1.20	2.15	2.20	2.70	0.80	0.65	0.50	0.45
5..	0.85	0.60	0.30	0.20	0.95	2.00	2.05	2.05	0.70	0.75	0.50	0.40
6..	0.65	0.45	0.30	0.30	0.95	1.90	1.75	1.90	0.60	0.85	0.55	0.50
7..	0.50	0.60	0.30	0.25	1.00	1.95	1.60	1.85	0.50	0.80	0.55	0.60
8..	0.40	0.50	0.25	0.20	0.70	2.05	1.40	1.65	0.50	0.80	0.55	0.60
9..	0.35	0.45	0.25	0.20	0.95	2.10	1.30	1.50	0.50	0.80	0.65	0.55
10.	0.35	0.50	0.30	0.30	1.75	3.40	1.75	1.45	0.45	0.70	0.55	0.55
11.	0.45	0.35	0.30	0.30	2.15	3.05	2.55	1.50	0.35	0.75	0.50	0.50
12.	0.45	0.40	0.30	0.25	2.05	2.70	2.95	1.40	0.45	0.70	0.55	0.60
13.	0.50	0.25	0.35	0.45	2.00	2.70	2.80	1.20	0.50	0.70	0.60	0.55
14.	0.55	0.35	0.40	0.45	2.10	2.90	2.50	1.10	0.50	0.60	0.60	0.60
15.	0.55	0.30	0.35	0.75	2.25	2.75	2.20	1.10	0.45	0.60	0.60	0.50
16.	0.45	0.30	0.35	0.60	2.30	2.75	1.95	1.20	0.50	0.60	0.60	0.40
17.	0.50	0.30	0.30	0.50	2.30	2.65	1.80	1.25	0.50	0.60	0.65	0.40
18.	0.50	0.55	0.30	0.50	1.90	2.55	1.80	1.20	0.40	0.60	0.70	0.40
19.	0.50	0.60	0.30	1.00	1.75	2.35	1.65	1.00	0.40	0.60	0.70	0.40
20.	0.40	0.50	0.30	1.55	1.70	2.15	1.50	0.95	0.40	0.60	0.70	0.40
21.	0.50	0.50	0.30	1.65	2.00	2.15	1.45	0.95	0.35	0.60	0.65	0.45
22.	0.40	0.60	0.20	1.75	2.15	1.95	1.40	0.85	0.40	0.60	0.60	0.60
23.	0.45	0.60	0.20	1.45	2.25	1.75	2.55	0.85	0.40	0.60	0.60	0.65
24.	0.45	0.70	0.30	1.25	2.30	1.75	2.30	0.90	0.40	0.65	0.55	0.55
25.	0.35	0.70	0.20	1.45	2.30	1.75	2.20	0.95	0.40	0.65	0.50	0.45
26.	0.30	0.80	0.20	1.50	2.05	1.75	2.05	0.90	0.50	0.60	0.60	0.60
27.	0.30	0.70	0.25	1.65	1.90	1.75	1.70	0.75	0.55	0.50	0.60	0.50
28.	0.30	0.50	0.30	1.70	1.80	2.95	1.50	0.65	0.50	0.50	0.65	0.40
29.	0.25	......	0.40	1.75	1.90	2.95	1.35	2.00	0.45	0.50	0.65	0.25
30.	0.35	......	0.40	2.05	1.95	1.95	2.90	1.30	0.40	0.50	0.60	0.25
31.	0.45	......	0.40	......	2.60	......	4.60	1.10	......	0.60	......	0.25

LA JUNTA STATION, ON ARKANSAS RIVER.

This station is described in Bulletin No. 131, page 37. Observations of river height have been maintained during the year and a number of discharge measurements have been made, but owing to the shifting of the channel and the unstable bed, composed largely of soft material, it has not been possible to construct a rating table. The first measurement of the year was made on February 6, 1895. At this time the height of water was 1.95 feet and the discharge 182 second-feet. On May 19 the height was 1.90 feet and the discharge 658 second-feet, the bottom having scoured as result of high water. On December 2, with the height of water 1.50 feet, the discharge was found to be 455 second-feet. Records of the river height are kept at the gage near the pump house in the yard of the Santa Fe Railway Company and measurements of discharge are made at the county bridge, about half a mile below the town.

According to statements from Mr. George W. Swink, the year 1895 has been marked by a large supply of water in the Arkansas River. From Pueblo to Nepesta the water was not as high by about 22 inches as during 1894; from Fowler to the mouth of Timpas Creek the water was about 16 inches higher, on account of the flood in the Apishapa, the highest known in twenty years.

Daily gage height of Arkansas River at La Junta, Colo., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.20	1.50	1.30	0.30	0.30	3.80	3.40	3.90	1.80	1.20	1.45	2.50
2..	1.30	1.40	1.20	0.30	0.30	2.40	2.95	3.70	1.40	1.20	1.50	2.65
3..	1.30	1.70	0.50	0.30	0.30	2.50	2.50	3.50	1.30	1.20	1.55	2.20
4..	1.30	1.60	0.45	0.30	0.30	2.60	2.30	3.90	1.20	1.20	1.50	2.00
5..	1.30	1.70	0.45	0.30	0.30	2.80	2.10	3.40	1.00	1.15	1.50	2.40
6..	1.50	1.95	0.50	0.30	0.30	2.30	1.70	2.80	0.90	1.20	1.60	2.50
7..	1.50	1.60	0.45	0.30	0.30	1.90	1.50	2.90	0.80	1.20	1.60	2.25
8..	1.95	1.70	0.45	0.30	0.30	1.80	1.00	3.40	0.80	1.20	1.55	2.30
9..	1.80	1.95	0.50	0.25	0.30	1.95	0.75	2.40	0.65	1.80	1.55	2.10
10.	1.75	1.60	0.45	0.20	0.30	2.15	1.45	2.50	0.40	1.45	1.55	2.20
11.	1.60	1.60	0.40	0.20	0.30	4.10	1.30	3.60	0.30	1.30	1.55	2.15
12.	1.40	1.65	0.35	0.20	0.45	2.45	3.90	2.65	0.30	1.90	1.55	2.15
13.	1.30	1.60	0.35	0.20	0.70	4.30	4.70	2.20	0.30	1.30	1.55	2.20
14.	1.30	1.60	0.40	0.30	0.70	3.30	4.00	2.20	0.30	1.45	1.40	1.70
15.	1.40	1.55	0.25	0.30	0.70	2.90	2.80	1.85	0.90	1.15	1.45	1.70
16.	1.40	1.50	0.25	0.30	1.60	3.10	2.60	1.65	0.90	1.10	1.45	1.65
17.	1.50	1.80	1.45	0.30	2.00	2.95	2.55	1.60	0.80	1.10	1.40	1.70
18.	1.50	1.80	1.35	0.25	2.10	2.50	2.30	1.70	0.80	1.00	1.40	1.70
19.	1.50	1.75	1.20	0.25	2.00	2.00	2.30	1.65	0.80	1.35	1.40	1.70
20.	1.50	1.90	1.00	0.30	1.60	1.80	1.70	1.45	0.80	1.35	1.45	2.00
21.	1.40	1.90	0.95	0.25	1.10	1.55	2.00	1.30	0.80	1.35	1.45	2.50
22.	1.50	2.50	0.80	0.45	1.80	1.40	3.80	1.25	0.95	1.35	1.45	2.50
23.	1.40	1.85	0.35	0.65	1.70	1.15	a9.15	1.15	0.90	1.65	1.45	2.45
24.	1.30	2.10	0.35	0.60	1.90	1.00	6.10	1.00	0.90	1.60	1.50	2.50
25.	1.45	2.15	0.35	0.60	1.80	0.75	3.80	1.00	0.85	1.65	2.00	2.50
26.	1.45	2.30	0.35	0.50	2.40	0.70	3.20	1.00	0.80	1.60	2.30	2.55
27.	2.00	2.00	0.35	0.40	1.60	0.65	2.60	1.00	0.80	1.55	2.50	2.55
28.	1.90	1.50	0.30	0.50	0.95	1.20	2.30	1.40	0.80	1.55	2.50	2.45
29.	1.60	......	0.30	0.50	0.70	a3.00	1.90	1.20	1.25	1.50	2.35	2.20
30.	1.80	......	0.30	0.40	1.90	4.00	2.30	1.40	1.20	1.50	1.35	2.40
31.	1.70	......	0.30	......	2.80	......	3.05	1.60	......	1.35	......	2.45

a Heavy rains.

HOLLY STATION, ON ARKANSAS RIVER.

This station is described on page 39 of Bulletin 131. Observations were continued during the greater part of 1895, but owing to the broad, sandy character of the channel and the changes made in the location of the rod to bring it to the places where the water was flowing, the results are not considered as sufficiently reliable for publication. The observations of river height were suspended on October 1 until such time as arrangements could be made for a series of soundings and for more detailed notice as to the condition of the stream from day to day.

HUTCHINSON STATION, ON ARKANSAS RIVER.

This station was established on May 13, 1895, by Mr. Arthur P. Davis. It is at the south end of Main street, at the wagon bridge.

The observer is Daniel Lauer, who lives in the immediate vicinity. The gage consists of an oak timber painted white and spiked to the oak pile of a triangular pier. It can be easily observed from the bridge. The bench mark is the upper crosspiece of the pier guard. It is 8.35 feet above zero. A second bench mark consists of the top of the iron doorsill on the first brick building. This is at an elevation of 8.12 feet above zero. Measurements of discharge are made from the bridge at times of high water, and at low water they can be made by wading. The channel is straight both above and below the bridge; the banks are low and liable to overflow. The channel is of sand and shifts from side to side, necessitating frequent discharge measurements and soundings. At time of low water the stream subdivides into a number of threads.

List of discharge measurements made on Arkansas River at Hutchinson, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	May 13	A. P. Davis	19	1.30	....	0.90	10
2	June 20	W. G. Russell	19	3.40	749	1.98	1,471
3	July 27	.....do	19	5.65	3,127	3.93	12,300
4	Aug. 31	.....do	19	2.73	557	1.86	1,037
5	Oct. 1	.....do	19	1.60	71	0.80	57
6	Nov. 13	.....do	19	1.50	63	0.73	46
7	Dec. 20	.....do	19	2.15	94	1.33	125
8	Dec. 31	.....do	19	1.75	76	0.64	49

Daily gage height of Arkansas River at Hutchinson, Kans., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.35	2.50	4.60	3.00	1.60	1.60	1.50
2	....	1.75	2.40	4.45	3.00	1.60	1.55	1.50
3	....	2.10	2.65	4.40	2.85	1.60	1.60	(a)
4	....	2.15	2.50	4.65	2.65	1.70	1.60	(a)
5	....	2.00	3.20	4.75	2.55	1.75	1.60	(a)
6	....	1.75	3.10	4.40	2.50	1.70	1.60	1.60
7	....	1.65	3.35	4.75	2.40	1.70	1.60	1.60
8	....	2.80	3.90	5.20	2.40	1.70	1.55	(a)
9	....	2.95	3.80	4.70	2.50	1.70	1.50	(a)
10	....	3.00	3.75	4.40	2.50	1.70	1.50	1.60
11	....	3.00	3.40	4.30	2.50	1.60	1.50	1.50
12	....	3.00	3.20	4.10	2.50	1.60	1.50	1.50
13	1.30	3.10	3.10	4.00	2.35	1.60	1.50	1.40
14	1.30	3.10	2.95	4.00	2.20	1.60	1.50	1.40
15	1.30	3.10	2.80	3.80	2.20	1.60	1.50	1.40
16	1.20	3.00	2.65	3.80	2.15	1.60	1.50	1.60
17	1.20	2.95	2.55	3.75	2.00	1.60	1.50	1.80
18	1.20	3.05	3.25	3.70	1.95	1.55	1.40	2.05
19	1.20	3.45	3.90	3.55	1.90	1.50	1.40	2.30
20	1.20	3.50	3.75	3.40	1.80	1.50	1.40	2.25
21	1.20	3.25	3.55	3.35	1.80	1.50	1.30	2.15
22	1.20	3.10	3.45	3.15	1.80	1.50	1.30	2.10
23	1.20	2.95	3.40	3.00	1.80	1.50	1.30	2.00
24	1.20	2.85	3.50	2.85	1.80	1.50	(a)	2.00
25	1.30	2.80	3.65	2.80	1.70	1.50	(a)	2.00
26	1.30	2.70	5.20	2.70	1.70	1.50	(a)	2.40
27	1.20	2.60	5.65	2.75	1.70	1.45	(a)	2.35
28	1.35	2.60	5.95	2.85	1.70	1.40	(a)	2.05
29	1.40	2.55	6.15	2.80	1.60	1.40	1.50	1.80
30	1.45	2.50	6.15	2.75	1.60	1.50	1.50	1.80
31	1.40	....	5.40	2.80	....	1.60	....	1.75

a Frozen.

Estimated discharge of Arkansas River at Hutchinson, Kans.

[Drainage area, 34,000 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
1895.				
July	19,600	444	3,848	236,613
August	8,040	958	2,712	166,761
September	1,203	57	375	22,313
October	84	37	56	3,443
November	57	29	43	2,559
December	157	37	71	4,366

VERDIGRIS AND NEOSHO RIVERS.

These two streams, rising in eastern Kansas and flowing southerly into Indian Territory, enter Arkansas River within a short distance of each other and a few miles above Fort Gibson. Measurements have been made of both of these streams, the first at Liberty, near the town of Independence, Montgomery County, Kans.. and the second near Iola, in Allen County, Kans.

LIBERTY STATION, ON VERDIGRIS RIVER.

This station is located 7 miles east of Independence and 3 miles southwest of the town of Liberty, at a wagon bridge 250 feet below McTaggart's milldam. It was established by Prof. E. C. Murphy in August, 1895. The observer is J. G. Kaull, a miller living in the vicinity. The gage consists of two parts, one spiked to the flume and graduated up to 8 feet, the second painted on the wheel house. The bench mark consists of 3 nails driven into the horizontal timber at the top of the vertical post to which the gage is fastened. It is 12.46 feet above the zero of the gage. Measurements are made from the bridge. The channel is straight both above and below, and the water moves with considerable velocity. The banks are low and liable to overflow. The bed is rocky and not subject to change.

In May, 1895, an examination was made by Mr. Arthur P. Davis, of Walnut Creek, at Winfield, Cowley County, Kans. He found that the locality is favorable for stream measurements, there being no bridge piers in the creek. The discharge at this point on May 4, 1895, was approximately 100 second-feet. There had been heavy rains the night before, but the stream did not appear to be swollen. There is a milldam about 2 miles above this point.

List of discharge measurements made on Verdigris River at Liberty, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
1	Aug. 2	E. C. Murphy	19	2.40	0.88	107
2	Sept. 7	do	17	3.44	1.59	443
3	Nov. 15	do	17	2.70	1.16	218

Daily gage height of the Verdigris River at Liberty, Kans., for 1895.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.70	2.60	2.20	2.60
2	2.00	2.50	2.65	2.20	2.60
3	2.10	2.55	2.60	2.20	2.55
4	2.15	2.75	2.60	2.20	2.50
5	2.45	2.55	2.55	2.20	2.40
6	2.85	2.95	2.50	2.20	2.40
7	2.65	3.50	2.50	2.45	2.50
8	2.35	4.20	2.50	2.65	2.55
9	2.35	*a*27.00	2.50	2.70	2.60
10	2.45	34.00	2.55	2.70	2.50
11	2.55	35.50	2.50	2.60	2.50
12	2.25	35.00	2.50	2.60	2.50
13	2.25	27.70	2.40	2.60	2.40
14	2.15	15.40	2.40	2.80	2.40
15	*b*5.45	6.75	2.40	2.80	2.40
16	6.15	4.45	2.35	2.50	2.40
17	4.60	4.10	2.30	2.60	2.45
18	4.20	4.00	2.30	2.60	*c*10.00
19	3.37	3.75	2.30	2.40	23.15
20	3.20	3.55	2.30	2.40	22.40
21	6.80	3.35	2.30	2.40	10.95
22	*d*12.05	3.30	2.20	2.40	7.80
23	7.35	3.20	2.20	2.40	7.80
24	4.20	3.05	2.20	2.40	*e*17.50
25	3.50	3.05	2.20	2.40	29.25
26	3.20	3.00	2.20	2.35	27.40
27	3.25	2.90	2.20	2.30	13.65
28	3.45	2.75	2.20	2.30	6.95
29	3.15	2.80	2.20	2.40	5.95
30	2.95	2.75	2.20	2.40	5.40
31	2.75	....	2.20	....	4.95

a Flood—Highest 36.40 (higher than 1885).
b Rain—Extreme height 8.80, 8 p. m.
c Flood—24.80, highest at 9 p. m. 19th, first 10 feet at rate of 1 foot per hour.
d Heavy rain—13 feet highest, 11 a. m. to 4 p. m. stationary.
e Flood—25th 30.10 at 12 p. m. highest.

IOLA STATION, ON NEOSHO RIVER.

The gage rod is placed at a highway bridge 1 mile west of the city of Iola, Kans. The station was established in July, 1895, by Prof. E. C. Murphy. The observer is Elias Bruner, a miller living near by. The gage consists of two parts. The lower portion is a graduated board fastened to a flume, serving to give the ordinary heights of water. Above this the graduations are continued on the smooth stone wall, giving opportunity for observing high water. The bench mark consists of three nails in the horizontal at the top of the upright to which the gage is fastened. Its elevation above zero is 13.30 feet. On November 15 a new rod was put in place, the mark having been washed off from the old one. The zero was made coincident with that of the old rod.

List of discharge measurements made on Neosho River at Iola, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second.	Discharge (second-feet).
1	July 30	E. C. Murphy	19	2.75	0.57	257
2	Aug. 3	.....do	19	3.10	0.98	521
3	Sept. 6	.....do	17	2.80	0.79	358
4	Nov. 15	.....do	17	1.40	0.56	267

Daily gage height of Neosho River at Iola, Kans., for 1895.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.75	3.40	2.37	2.10	2.50
2	2.60	3.25	2.40	2.08	2.45
3	3.05	3.20	2.37	2.05	2.35
4	2.85	3.15	2.43	2.08	2.30
5	2.92	2.95	2.37	2.08	2.30
6	3.10	2.85	2.40	2.20	2.30
7	2.72	2.82	2.40	2.25	2.25
8	2.50	3.40	2.40	2.35	2.25
9	2.42	a16.50	2.37	2.43	2.25
10	2.45	18.40	2.30	2.45	2.25
11	2.50	20.25	2.30	2.43	2.25
12	2.50	20.80	2.32	2.39	2.25
13	2.50	12.30	2.32	2.39	2.25
14	2.60	4.70	2.33	2.25	2.25
15	2.85	4.00	2.38	2.25	2.20
16	3.60	3.70	2.50	2.23	2.20
17	3.90	3.45	2.48	2.25	2.25
18	4.40	3.30	2.45	2.25	3.30
19	3.75	3.15	2.30	2.20	8.05
20	6.10	3.05	2.23	2.20	6.20
21	11.50	2.85	2.18	2.25	4.70
22	8.85	2.62	2.18	2.25	3.85
23	7.35	2.55	2.10	2.15	4.00
24	4.55	2.57	2.05	2.25	7.45
25	7.35	2.50	2.08	2.30	13.25
26	7.65	2.42	2.05	2.30	7.10
27	4.80	2.45	2.05	2.30	4.65
28	3.95	2.47	2.08	2.45	3.80
29	3.50	2.47	2.05	2.45	3.70
30	3.30	2.42	2.03	2.45	3.45
31	3.27	....	2.13	....	3.15

a Heavy rain; river highest the 12th—21 at 10 a. m.

CHIKASKIA, MEDICINE, AND CIMARRON RIVERS.

These streams, draining the portion of Kansas south of the Arkansas River, flow in a general southeasterly direction through Oklahoma and enter Arkansas River in succession, the mouth of the Chikaskia, or rather the Salt Fork of the Arkansas, being about 30 miles south of the Kansas State line and that of the Cimarron 60 miles below. An examination was made in May, 1895, by Mr. Arthur P. Davis for the purpose of discovering suitable points for measurement of these streams at about the line between Kansas and Oklahoma.

Chikaskia River near Albion, Harper County, Kans., was found to have a broad, sandy channel, and on May 4, 1895, it was discharging about 20 second-feet at the railroad bridge. On the Medicine River a suitable point for river measurement was found near the town of Kiowa, in Barber County. The Cimarron River was examined at a point south of Coldwater, in Comanche County, near where the river leaves the State of Kansas. The channel was found to consist of an immense sand flat, over which a flow of less than 1 second-foot was meandering, most of this water being from Bluff Creek. The stream shifts its position at every freshet, and there is no bridge or other convenience favorable for measurement. During floods the water spreads out to such an extent that accurate estimates can not be made. A further examination was made near Englewood, in Meade County, Kans. Here it was found that the stream discharged 25 second-feet, but the channel is very wide and sandy, and several ditches take out water at points above. It was therefore decided to establish a gage station at Arkalon, in Seward County, the only place found above all diverting ditches.

A measurement was made of Perry's ditch, near Englewood, on May 10, and a flow of 14.48 second-feet was found. At the same time 8 second-feet were passing down the waste flume and about 1.5 second-feet flowing over the dam, making a total discharge in the Cimarron at this point of 24 second-feet.

KIOWA STATION, ON MEDICINE RIVER.

This station was established on May 6, 1895, by Mr. Arthur P. Davis. It is at the wagon bridge 3½ miles north of the center of the town of Kiowa, Barber County, Kans., this being about 3 miles north of the Oklahoma line. The observer is J. M. Fisher, a farmer living three-fourths of a mile from the bridge. The gage is a vertical oak plank fastened by means of spikes and bolts to the east side of the first pier counting from the south. It is painted and graduated from 0.8 to 13.3 feet. The mark 11.1 of this scale is at the same elevation as the top of the plate or cross timber resting on top of the piles to which the gage is fastened. Measurements of discharge are made from the bridge at time of high water, and at other seasons by wading at any convenient point in the vicinity. The station was located at this place for the purpose of ascertaining the volume of water flowing across the line from Kansas and Oklahoma. The bed of the stream is very wide, and consists entirely of sand. At low water the stream meanders through this sand, changing its course frequently from one part of the bed to another, rendering it impossible to obtain accurate estimates of discharge by means of gage readings alone.

List of discharge measurements made on Medicine River at Kiowa, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	May 6	A. P. Davis	19	2.35	24	0.91	22
2	June 21	W. G. Russell	19	2.40	49	1.34	66
3	July 25	do	19	3.20	173	1.70	294
4	Sept. 1	do	19	2.60	38	1.06	40
5	Oct. 29	do	19	2.40	23	0.68	15
6	Dec. 21	do	19	2.65	45	1.22	54

Daily gage height of Medicine River at Kiowa, Kans., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	2.20	3.95	2.10	2.55	1.00	2.45	2.30
2	....	2.45	3.50	2.10	2.90	1.00	2.65	2.30
3	....	2.50	3.10	2.00	2.85	1.30	2.55	2.20
4	....	3.20	2.90	2.00	2.75	1.50	2.50	2.20
5	....	2.80	2.80	2.00	2.65	1.60	2.50	2.10
6	2.40	2.60	2.75	1.85	2.45	2.20	2.60	2.10
7	2.40	2.55	2.55	1.80	2.40	2.50	2.70	2.10
8	2.30	2.40	2.75	1.75	2.30	2.50	3.00	2.10
9	2.10	2.40	2.65	1.70	2.25	2.40	2.95	2.20
10	2.10	5.30	2.50	2.45	2.10	2.40	2.70	2.20
11	2.20	3.70	2.50	3.40	2.10	2.35	2.65	2.40
12	2.20	*a* 4.65	2.40	2.80	2.00	2.30	2.60	2.40
13	2.30	4.90	2.40	2.70	2.00	2.20	2.50	2.40
14	2.20	3.65	2.50	2.40	1.95	2.20	2.55	2.50
15	2.10	3.05	2.40	2.40	1.90	2.25	2.80	2.50
16	2.10	2.90	2.30	2.35	1.90	2.30	3.00	2.50
17	2.00	2.80	2.30	2.30	1.90	2.40	2.90	2.50
18	2.00	2.70	2.35	2.10	1.90	2.40	2.85	2.60
19	2.00	2.60	2.55	1.85	1.80	2.20	2.75	2.85
20	1.90	2.60	2.55	1.75	1.80	2.20	2.65	2.65
21	1.90	2.50	2.70	1.70	1.60	2.20	2.55	2.60
22	1.90	2.40	3.55	1.70	1.50	2.20	2.50	2.60
23	1.90	2.40	3.50	1.75	1.50	2.30	*b* 2.50	2.60
24	2.10	2.35	3.10	2.30	1.40	2.45	2.50	2.50
25	2.20	2.20	2.95	2.65	1.40	2.55	2.45	2.45
26	2.75	2.20	2.80	2.40	1.30	2.50	2.40	2.40
27	2.65	2.20	2.60	2.25	1.25	2.40	2.40	2.40
28	2.40	3.70	2.40	2.10	1.20	2.40	2.30	2.40
29	2.35	4.85	2.35	1.90	1.10	2.40	2.30	2.40
30	2.30	4.25	2.25	1.95	1.00	2.30	2.30	2.50
31	2.30	....	2.15	2.10	....	2.30	....	2.50

a Raised 2 feet in half an hour. *b* River frozen over November 23.

Estimated discharge of Medicine River at Kiowa, Kans.

[Drainage area, 1,300 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
1895.				
July	1,190	12	170	10,453
August	427	8	30	1,845
September	110	5	20	1,190
October	32	5	15	922
November	154	14	49	2,916
December	156	12	26	1,599

ARKALON STATION, ON CIMARRON RIVER.

The observations of river height at this point were made at the bridge of the Chicago, Rock Island and Pacific Railroad, one-half mile north of Arkalon, Seward County, Kans. The station was established by Mr. Arthur P. Davis on May 14, 1895, it being the most accessible point at which the stream has a clearly defined channel above diverting ditches. The observer is G. W. Siever, railroad agent at Arkalon. The gage consists of a vertical plank fastened to the pier of the bridge under the north side. Measurements of discharge can be made from the bridge at high water, but at usual stages can be more conveniently made by wading. The bench mark is on the top of the sill at the northwest corner of the windmill tower of the railroad water tank. It is at an elevation of 14.43 feet.

List of discharge measurements made on Cimarron River at Arkalon, Kans.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	May 14	A. P. Davis	19	2.50	13	1.31	17
2	June 24	W. G. Russell	19	2.70	13	1.30	16
3	July 23	.....do	19	7.00	178	1.79	317
4	Aug. 29	.....do	19	2.30	10	1.55	16
5	Oct. 3	.....do	19	2.35	16	0.98	16

Daily gage height of Cimarron River at Arkalon, Kans., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.60	2.90	6.00	2.55	2.30	2.50	2.40
2		3.05	2.90	5.35	2.40	2.30	2.40	(a)
3		2.90	2.90	4.00	2.40	2.30	2.40	(a)
4		5.20	3.30	3.85	2.40	2.30	2.40	(a)
5		6.00	4.15	3.60	2.40	2.40	2.40	(a)
6		5.35	3.95	3.00	2.45	2.40	2.40	(a)
7		4.55	3.60	2.80	2.50	2.40	2.40	(a)
8		4.30	3.35	2.75	2.40	2.40	2.40	2.40
9		2.95	2.90	2.70	2.40	2.40	2.40	2.40
10		2.65	2.80	2.70	2.40	2.40	2.40	2.40
11		2.80	2.90	2.70	2.40	2.40	2.40	2.40
12		4.30	2.80	2.70	2.40	2.40	2.40	2.40
13		3.00	2.70	2.70	2.40	2.40	2.50	2.40
14	2.50	4.50	2.20	2.70	2.40	2.40	2.40	2.40
15	2.50	5.35	2.70	2.70	2.40	2.40	2.40	2.40
16	2.50	5.50	2.70	2.70	2.40	2.40	2.40	2.40
17	2.50	4.75	2.60	2.70	2.40	2.40	2.40	2.40
18	2.50	3.25	2.60	2.75	2.40	2.40	2.40	2.40
19	2.50	2.95	2.85	2.80	2.35	2.40	2.40	2.50
20	2.50	2.90	4.60	2.80	2.30	2.40	2.40	2.50
21	2.50	2.80	5.15	2.80	2.30	2.40	2.40	2.50
22	2.50	2.90	4.90	2.70	2.30	2.40	2.40	2.50
23	2.50	2.70	6.45	2.70	2.30	2.40	2.40	2.50
24	2.50	2.70	7.50	2.70	2.30	2.40	2.40	2.50
25	2.50	2.70	7.10	2.70	2.30	2.40	2.40	2.50
26	2.50	2.70	7.25	2.70	2.30	2.40	2.40	2.50
27	2.50	2.60	7.45	2.65	2.30	2.40	2.40	2.50
28	2.50	2.95	8.15	2.70	2.30	2.40	2.40	2.50
29	2.50	3.00	8.15	2.50	2.30	2.40	2.40	2.50
30	2.80	3.00	7.60	2.30	2.30	2.50	2.40	2.50
31	2.70		6.85	2.55		2.50		2.50

a Frozen.

Estimated discharge of Cimarron River at Arkalon, Kans.

[Drainage area, 5,200 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
1895.				
July	659	14	149	9,162
August	170	16	31	1,906
September	19	16	17	1,012
October	18	16	17	1,045
November	18	17	17	1,012
December	18	17	17	1,045

CANADIAN RIVER.

The Canadian River is the largest tributary of the Arkansas, and might properly be considered as draining an independent basin. Its head waters reach back to the mountain, the upper tributary streams rising in the Sangre de Cristo range south and southeasterly from the sources of the Arkansas. Leaving this range the streams flow toward the southeast, and, uniting, form the Canadian, which flows southerly along the front of the foothills. The river finally turns easterly and flows across the north portion of Texas, through Oklahoma and Indian Territory, entering Arkansas River before leaving the latter Territory. Although there are many large perennial streams tributary to the Canadian, yet during the summer season the river loses most of its water, and through Oklahoma it is nearly or quite dry during the hottest part of the year. Comparatively few measurements of the discharge of the stream have been made, although among the mountains and foothills in northeastern New Mexico irrigation has developed to a large extent. A single gaging station has been established, which is upon Mora River, one of the most important mountain feeders of the main stream.

WATROUS STATION, ON MORA RIVER.

This station has been described on page 40 of Bulletin No. 131. During 1895 observations of river height have been maintained and occasional measurements made, as shown by the accompanying list. The bed of the stream is very changeable, so that computations of discharge can not be made with accuracy except by continued series of soundings and by frequent discharge measurements. It has not been possible to construct a rating table for 1895.

List of discharge measurements made on Mora River at Watrous, N. Mex.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	Oct. 4	A. P. Davis	21	1.68	33	1.05	35
	1895.						
2	May 18	.....do	28	1.50	20	0.89	18
3	July 15	P. E. Harroun	25	2.00	156	0.85	131
4	Sept. 4	.....do	25	2.30	108	1.49	160
5	Sept. 30	.....do	25	1.50	25	0.66	15
6	Nov. 16	.....do	25	1.90	46	0.86	39
7	Dec. 13	.....do	26	1.90	60	1.01	61

Daily gage height of Mora River at Watrous, N. Mex., for 1894.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1			1.44	17	1.55	1.44	1.50
2			1.44	18	1.50	1.44	1.50
3			1.45	19	1.50	1.44	1.50
4	1.68	1.51	1.46	20	1.49	1.44	1.50
5	1.60	1.49	1.49	21	1.48	1.44	1.50
6	1.62	1.48	1.50	22	1.48	1.44	1.50
7	1.61	1.48	1.50	23	1.47	1.44	1.50
8	1.66	1.48	1.50	24	1.45	1.46	1.50
9	1.65	1.48	1.50	25	1.44	1.46	1.50
10	1.66	1.46	1.50	26	1.42	1.50	1.50
11	1.68	1.46	1.50	27	1.44	1.51	1.50
12	1.68	1.46	1.50	28		1.49	1.50
13	1.68	1.45	1.50	29		1.46	1.50
14	1.65	1.45	1.50	30		1.45	1.50
15	1.63	1.45	1.50	31			1.50
16	1.62	1.44	1.50				

Daily gage height of Mora River at Watrous, N. Mex., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.50	1.46	1.60	1.44	1.56	2.76	1.75	4.85	3.65	1.50	1.80	1.70
2..	1.50	1.46	1.60	1.44	1.56	3.10	1.90	4.30	3.30	1.50	1.80	1.70
3..	1.50	1.46	1.60	1.44	1.56	3.10	1.90	4.15	3.00	1.50	1.70	1.70
4..	1.50	1.46	1.60	1.44	1.56	2.85	1.90	4.00	2.60	1.55	1.70	1.80
5..	1.50	1.46	1.60	1.44	1.56	2.60	1.90	3.95	2.30	2.00	1.70	1.90
6..	1.50	1.46	1.60	1.44	1.56	2.55	1.90	4.10	1.95	1.90	1.70	1.90
7..	1.50	1.46	1.60	1.44	1.56	2.50	1.90	4.00	1.90	1.80	1.70	1.90
8..	1.50	1.46	1.56	1.44	1.56	2.50	1.90	4.20	1.90	1.70	1.70	1.90
9..	1.50	1.46	1.56	1.44	1.56	2.50	1.90	4.20	1.90	1.55	1.70	1.90
10.	1.50	1.46	1.56	1.44	1.56	2.46	*a*4.30	4.50	1.90	1.56	1.70	1.90
11.	1.50	1.48	1.56	1.44	1.56	2.34	3.50	4.20	1.90	1.56	1.70	1.90
12.	1.50	1.59	1.56	1.44	1.56	2.30	4.25	4.05	1.90	1.56	1.70	1.90
13.	1.48	1.68	1.56	1.44	1.58	2.30	2.75	3.90	1.90	1.55	1.70	1.90
14.	1.48	1.68	1.56	1.44	1.66	2.30	1.90	3.90	1.90	1.55	1.70	1.90
15.	1.48	1.74	1.56	1.44	1.68	2.30	1.90	3.90	1.90	1.55	1.70	1.90
16.	1.48	1.80	1.56	1.44	1.68	2.00	1.75	4.90	1.90	1.55	1.70	1.90
17.	1.48	1.80	1.51	1.44	1.68	1.65	1.70	4.10	1.80	1.55	1.70	1.90
18.	1.48	1.80	1.56	1.44	1.68	1.60	1.70	3.80	1.70	1.55	1.70	1.90
19.	1.48	1.80	1.56	1.44	1.68	1.60	1.70	3.60	1.70	1.55	1.70	1.90
20.	1.48	1.79	1.44	1.44	1.79	1.60	2.20	3.60	1.67	1.55	1.70	1.90
21.	1.48	1.78	1.44	1.44	2.15	1.60	3.25	3.60	1.60	1.68	1.70	1.90
22.	1.48	1.70	1.44	1.46	3.20	1.60	5.40	3.90	1.60	1.80	1.70	1.90
23.	1.46	1.70	1.44	1.46	3.45	1.60	3.80	4.00	1.55	1.80	1.70	1.90
24.	1.46	1.70	1.44	1.46	3.55	1.60	3.70	3.50	1.55	1.80	1.70	1.90
25.	1.46	1.68	1.44	1.46	3.55	1.60	3.60	3.42	1.52	1.80	1.70	1.90
26.	1.46	1.68	1.44	1.46	3.55	1.60	3.30	3.45	1.52	1.80	1.70	1.90
27.	1.46	1.68	1.44	1.46	3.50	1.60	2.95	3.40	1.50	1.80	1.70	1.90
28.	1.46	1.68	1.44	1.46	3.40	1.60	2.90	3.40	1.52	1.80	1.70	1.90
29.	1.46	......	1.44	1.46	3.40	1.60	2.90	3.40	1.50	1.80	1.70	1.90
30.	1.46	......	1.44	1.56	3.40	1.60	2.90	4.90	1.50	1.80	1.70	1.90
31.	1.46	......	1.44	......	3.30	......	2.90	4.00	......	1.80	......	1.90

a Caused by heavy rain.

RIO GRANDE BASIN.

The Rio Grande, rising in the mountains of southern Colorado, runs in a general southerly course through the Territory of New Mexico, and, turning southeasterly, forms the boundary between the State of Texas and the Republic of Mexico. At various points from its source in the mountains water is diverted for irrigation. The largest canals are in the San Luis Valley of Colorado, near the head waters. These canals and the agriculture dependent upon them are described in the report upon agriculture by irrigation prepared for the Eleventh Census. The basin as a whole is also described at some length in the Twelfth Annual Report of the United States Geological Survey, Part II, Irrigation, pages 240–290. Although a perennial stream in its upper course, the river becomes nearly or quite dry in southern New Mexico, and its broad, sandy channel has little water in it during the hottest months of the year for many miles below El Paso. The question as to the amount of water in the stream is of peculiar importance, not only as related to agriculture, but also as related to interstate and to international distribution of water. A number of gaging stations have been maintained along this river for several years, the most important being at Del Norte, on the upper edge of the San Luis Valley; at Embudo, in northern New Mexico; and at El Paso, where the river first becomes a portion of the international boundary.

DEL NORTE STATION, ON RIO GRANDE.

Observations of river height have been continued at this station as described in Bulletin No. 131, page 41. A number of discharge measurements have been made, but not sufficient to furnish material for a rating table. The observations are not taken every day, as the river does not fluctuate rapidly, especially during the summer season, and readings every second day are considered sufficient. The section is excellent for discharge measurements, as the channel is nearly straight and does not change perceptibly.

List of discharge measurements made on the Rio Grande at Del Norte, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1891.						
32	Apr. 10	T. M. Bannon	110	2.20	224	2.35	527
	1892.						
33	Oct. 27	....do	103	1.58	231	1.14	274
	1894.						
34	June 13	F. H. Newell	24	2.68	(*a*)	....	968
35	Sept. 27	A. P. Davis	21	1.52	115	2.32	267
	1895.						
36	June 14	F. Cogswell	55	4.00	480	5.88	2,818
37	Oct. 13	....do	14	1.80	164	2.53	414

a Measurements made at iron bridge, mill race, and canal, and total taken as discharge of river.

Daily gage height of Rio Grande at Del Norte, Colo., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.24	......	......	2.18	3.98	......	......	2.72	......	......	1.74	1.76
2	......	2.58	2.70	......	......	3.74	2.72	......	2.06	1.76	......	......
3	2.32	......	......	2.26	3.26	......	......	2.64	......	......	1.70	2.56
4	......	2.64	2.62	......	......	3.56	2.64	......	1.96	1.80	......	......
5	2.48	......	......	2.34	3.32	......	......	2.46	......	......	1.66	2.50
6	......	2.60	2.54	......	......	4.10	2.50	......	1.94	1.86	......	......
7	2.52	......	......	2.28	3.38	......	......	2.42	......	......	1.68	2.54
8	......	2.58	2.48	......	......	4.46	2.56	......	1.86	1.90	......	......
9	2.44	......	......	2.74	3.74	......	......	2.40	......	......	1.64	2.68
10	......	2.60	2.32	......	......	4.52	2.86	......	1.78	1.88	......	......
11	2.38	......	......	3.32	4.18	......	......	2.28	......	......	1.60	2.94
12	......	2.64	2.12	......	......	4.68	3.12	......	1.82	1.80	......	......
13	2.44	......	......	3.72	4.24	......	......	2.18	......	......	1.64	2.96
14	......	2.64	1.98	......	......	4.18	3.04	......	1.74	1.80	......	......
15	2.56	......	......	3.54	4.16	......	......	2.40	......	......	1.66	2.98
16	......	2.66	2.06	......	......	3.96	2.88	......	1.72	1.78	......	......
17	2.62	......	......	3.82	4.02	......	......	2.24	......	......	1.64	2.76
18	......	2.74	1.96	......	......	3.84	2.60	......	1.70	1.74	......	......
19	2.58	......	......	4.26	3.88	......	......	2.10	......	......	1.68	2.70
20	......	2.70	1.88	......	......	3.64	2.42	......	1.78	1.78	......	......
21	2.46	......	......	4.10	3.76	......	......	2.04	......	......	1.60	2.82
22	......	2.86	1.82	......	......	3.20	2.56	......	1.96	1 82	......	......
23	2.42	......	......	3.82	3.64	......	......	2.48	......	......	1.68	2.96
24	......	2.82	1.74	......	......	3.00	2.60	......	1.92	1.84	......	......
25	2.38	......	......	4.14	3.50	......	......	2.22	......	......	1.60	2.88
26	......	2.78	1.92	......	......	2.98	2.64	......	1.88	1.80	......	......
27	2.40	......	......	4.22	3.58	......	......	2.04	......	......	1.62	3.02
28	......	2.74	2.18	......	......	3.02	2.58	......	1.82	1.78	......	......
29	2.46	......	......	4.18	3.52	......	......	2.16	......	......	1.66	2.98
30	......	......	2.22	......	......	2.94	2.66	......	1.78	1.76	......	......
31	2.52	......	......	......	3.36	......	......	2.18	......	......	......	3.04

ALAMOSA STATION, ON THE RIO GRANDE.

This station is at the railroad bridge about one-half mile east of Alamosa, Colo., and is below the heads of most of the large irrigating canals of the San Luis Valley. The measurements of discharge give, therefore, what may be considered as the volume of waste or seepage water from ditches above. Measurements of discharge are made at the wagon bridge about one-fourth of a mile above the railroad bridge. A small ditch is taken out between the bridges, and at the time of measurement, on June 16, it was carrying 30 second-feet. In October the old gage was disturbed, a new railroad bridge being built. At the time of the measurement made on October 14 the surface of the water was 8.38 feet below the top of the cap of the third bent from the east end of the bridge. Assuming that this cap is at the same elevation as the old one, the rod reading would be 2.90.

The first measurement at this point was on September 28, 1894. Mr. Arthur P. Davis found at that time a discharge of 10 second-feet. The second was on June 16, 1895, when Mr. F. Cogswell found 1,176 second-feet at a gage height of 5.18 feet. The third was on October 14, and gave 92 second-feet.

Daily gage height of Rio Grande at Alamosa, Colo., for 1894.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	......	2.25	2.10	3.10	17	......	2.10	2.90	3.00
2	......	2.10	2.10	3.10	18	......	2.10	2.90	3.00
3	......	2.20	2.20	3.10	19	......	2.10	2.90	3.00
4	......	2.25	2.20	3.00	20	......	2.10	2.95	3.00
5	......	2.20	2.35	3.00	21	......	2.10	2.95	3.20
6	......	2.10	2.60	3.00	22	......	2.10	2.90	3.20
7	......	2.10	2.75	3.00	23	......	2.10	3.00	3.20
8	......	2.10	2.80	3.00	24	......	2.10	3.00	3.20
9	......	2.10	2.80	3.00	25	......	2.10	3.00	3.20
10	......	2.10	2.80	3.00	26	......	2.10	3.00	3.20
11	......	2.10	2.80	3.00	27	......	2.10	3.00	3.20
12	......	2.10	2.80	3.00	28	......	2.10	3.00	3.20
13	......	2.10	2.75	3.00	29	......	2.10	3.00	3.20
14	......	2.10	2.80	3.00	30	2.25	2.15	3.10	3.20
15	......	2.10	2.80	3.00	31	......	2.10	......	3.20
16	......	2.10	2.80	3.00					

Daily gage height of Rio Grande at Alamosa, Colo., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.20	3.20	3.60	4.32	4.00	4.00	3.00	3.10	3.30	3.00	2.00	2.00
2	3.20	3.20	3.60	4.35	4.00	4.60	3.00	3.10	3.00	3.00	2.00	2.00
3	3.20	3.20	3.65	4.42	3.10	5.00	3.00	3.10	3.00	3.00	2.00	2.00
4	3.20	3.20	3.65	4.46	3.60	4.55	3.00	3.10	3.00	3.00	2.00	2.00
5	3.20	3.20	3.65	4.52	3.00	4.10	3.00	3.10	3.00	3.00	2.00	2.00
6	3.20	3.20	3.70	4.60	3.00	5.00	3.00	3.90	3.00	3.00	2.00	2.00
7	3.20	3.20	3.70	4.67	2.10	5.30	3.00	3.60	3.00	3.00	2.00	2.00
8	3.20	3.20	3.75	4.70	2.90	5.75	3.00	3.60	3.00	3.00	2.00	2.00
9	3.20	3.20	3.75	4.75	3.20	6.00	3.00	3.30	3.00	3.00	2.00	2.00
10	3.20	3.20	3.90	4.80	3.60	6.00	3.30	3.00	2.11	3.00	2.00	2.00
11	3.20	3.20	3.90	4.85	4.00	6.15	3.60	3.00	2.90	3.00	2.00	2.00
12	3.20	3.20	3.95	4.90	4.00	6.15	4.00	3.00	2.90	3.00	2.00	2.00
13	3.20	3.20	3.95	4.97	4.60	5.95	4.90	3.00	2.90	3.00	2.00	2.00
14	3.20	3.20	3.90	5.40	4.50	5.75	4.90	3.00	2.90	2.11	2.00	2.00
15	3.20	3.20	3.85	5.80	4.00	5.35	4.90	3.00	2.90	2.80	2.00	2.00
16	3.20	3.20	3.80	5.00	3.60	5.40	4.60	3.00	2.90	2.60	2.00	2.00
17	3.20	3.40	3.90	4.10	3.40	4.55	4.40	3.00	2.90	2.40	2.00	2.00
18	3.20	3.40	3.90	5.30	3.60	4.70	4.40	3.00	2.90	2.20	2.00	2.00
19	3.20	3.40	3.95	5.80	3.60	4.20	4.00	3.00	2.90	2.00	2.00	2.00
20	3.20	3.40	3.95	6.60	3.60	3.50	3.10	3.00	3.00	2.00	2.00	2.00
21	3.20	3.45	3.95	6.60	3.20	3.90	3.10	3.00	3.00	2.00	2.00	2.00
22	3.20	3.45	4.00	6.00	3.20	3.60	3.10	3.00	3.00	2.00	2.00	2.00
23	3.20	3.50	4.00	5.60	3.40	3.30	4.00	3.00	3.00	2.00	2.00	2.00
24	3.20	3.50	4.00	4.90	3.80	3.00	4.60	3.00	3.00	2.00	2.00	2.00
25	3.20	3.50	4.05	4.60	3.60	3.00	4.30	3.00	3.00	2.00	2.00	2.00
26	3.20	3.55	4.05	5.00	3.60	2.11	4.00	3.00	3.00	2.00	2.00	2.00
27	3.20	3.55	4.10	5.15	3.60	2.90	4.00	3.00	3.00	2.00	2.00	2.00
28	3.20	3.60	4.15	5.00	3.60	2.11	4.00	3.00	3.00	2.00	2.00	2.00
29	3.20	......	4.20	4.10	3.40	3.00	4.00	3.00	3.00	2.00	2.00	2.00
30	3.20	......	4.20	4.10	3.60	3.00	4.00	3.00	3.00	2.00	2.00	2.00
31	3.20	......	4.25	......	3.45	......	4.00	3.60	......	2.00	......	2.00

EMBUDO STATION, ON THE RIO GRANDE.

This station and others in New Mexico have been in charge of Mr. P. E. Harroun, of Santa Fe, N. Mex. The early work carried on at this place has been described in Bulletin No. 131, on page 43, and also in the annual reports of the United States Irrigation Survey, published as portions of the annual reports of the United States Geological Survey. A number of measurements have been made during 1895 by Mr. A. P. Davis and Mr. P. E. Harroun, and from these a rating table has been constructed, by means of which computations of the monthly discharge have been made.

List of discharge measurements made on Rio Grande at Embudo, N. Mex.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1891.					
40	Apr. 8	T. M. Bannon	110	9.42	4.51	1,314
41	Dec. 10	....do	103	8.50	3.84	575
	1892.					
42	Oct. 30	....do	103	7.80	3.40	333
43	Oct. 30	....do	103	7.80	3.66	313
44	Nov. 1	....do	103	7.80	3.72	355
	1894.					
45	Sept. 30	A. P. Davis	21	a 7.70	1.50	284
46	Oct. 1	....do	21	b 9.30	3.25	1,138
	1895.					
47	Feb. 2	....do	24	7.98	2.23	464
48	Feb. 4	....do	24	8.01	2.25	453
49	Apr. 8	P. E. Harroun	25	9.40	2.94	1,175
50	May 14	....do	25	11.20	4.39	3,219
51	July 27	....do	25	9.90	3.88	1,669
52	Aug. 19	....do	25	8.80	2.34	908
53	Oct. 26	....do	25	8.10	1.65	494
54	Nov. 28	....do	25	8.40	1.82	617

a The river is stated to have been 6 inches lower in June, 1894, or about 7.2. The Mexicans living near asserted that it was then at the lowest known point.

b A heavy rain occurred during the night of September 30, causing the river to rise. At the beginning of the measurement, at 8.30 a. m., the height was 9.65 feet, and at the end, at 11.45 a. m., it was 8.95 feet. The mean is taken at 9.30 feet.

Rating table of the Rio Grande at Embudo, N. Mex.

Gage height.	Discharge.	Gage height.	Discharge.
Sec.	*Feet.*	*Sec.*	*Feet.*
7.80	380	9.20	1,020
7.90	420	9.40	1,160
8.00	460	9.60	1,330
8.10	500	9.80	1,540
8.20	540	10.00	1,760
8.30	580	10.20	1,980
8.40	620	10.40	2,220
8.50	660	10.60	2,470
8.60	700	10.80	2,720
8.70	750	11.00	2,980
8.80	800	11.50	3,660
8.90	850	12.00	4,360
9.00	900	12.50	5,090

Daily gage height of the Rio Grande at Embudo, N. Mex., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	7.95	8.10	8.55	9.90	11.07	11.28	8.95	9.73	9.38	8.05	8.20	8.25
2..	7.93	8.05	8.45	9.75	11.95	11.30	9.10	10.03	9.18	8.05	8.20	8.20
3..	8.08	7.93	8.48	9.15	10.48	11.48	8.93	9.88	9.08	8.05	8.23	8.08
4..	7.98	7.90	8.50	8.95	10.18	11.73	8.83	9.78	8.98	8.25	8.30	8.00
5..	7.95	7.90	8.50	8.58	9.83	11.75	8.73	9.78	8.88	8.28	8.40	8.00
6..	7.98	......	8.48	8.33	9.83	11.83	8.73	9.73	8.78	8.18	8.40	8.00
7..	8.03	......	8.57	8.67	9.98	11.93	8.38	9.63	8.68	8.15	8.40	8.00
8..	7.93	......	8.68	9.08	9.93	11.95	8.58	9.48	8.60	8.10	8.40	8.00
9..	7.95	......	8.78	9.50	9.93	12.03	9.30	9.23	8.53	8.10	8.40	8.10
10.	7.98	7.93	8.88	9.75	10.03	12.20	9.85	9.20	8.43	8.05	8.40	8.18
11.	7.93	7.93	8.75	9.90	10.18	12.38	9.68	9.30	8.40	8.05	8.40	8.20
12.	8.03	7.98	8.65	10.25	10.48	12.43	9.78	9.00	8.35	8.05	8.40	8.20
13.	8.03	8.03	8.63	10.60	10.85	12.35	9.58	9.25	8.30	8.05	8.40	8.20
14.	8.05	8.00	8.55	11.00	11.13	12.15	9.53	10.05	8.25	8.05	8.33	8.23
15.	8.08	8.08	8.53	11.17	11.23	11.80	9.93	9.60	8.20	8.05	8.23	8.25
16.	8.13	7.95	8.48	11.33	11.18	11.48	9.95	9.23	8.15	8.05	8.20	8.15
17.	8.23	7.93	8.43	11.25	11.13	11.30	9.80	8.95	8.15	8.05	8.23	8.10
18.	8.13	8.05	8.50	11.38	11.88	11.05	9.65	8.85	8.13	8.05	8.27	8.08
19.	8.00	8.13	8.48	11.63	10.63	10.85	9.63	8.83	8.13	8.03	8.37	8.00
20.	8.03	8.13	8.48	11.88	10.48	10.60	9.60	8.73	8.17	8.00	8.52	7.90
21.	8.05	8.13	8.50	11.95	10.65	10.25	9.65	8.63	8.10	8.00	8.60	8.15
22.	8.07	8.05	8.50	11.78	10.85	9.93	9.78	8.53	8.10	8.00	8.60	8.30
23.	8.13	8.18	8.53	11.68	10.00	9.65	9.82	8.48	8.10	8.05	8.60	8.30
24.	8.08	8.30	8.63	11.75	11.03	9.45	10.00	8.58	8.50	8.05	8.60	8.28
25.	8.03	8.43	8.68	11.45	11.08	9.28	9.88	8.58	8.13	8.05	8.57	8.25
26.	7.98	8.48	8.80	11.43	11.10	9.15	9.80	8.58	8.20	8.10	8.47	8.25
27.	8.05	8.48	8.93	11.33	11.08	9.08	9.98	8.63	8.15	8.10	8.37	8.28
28.	8.03	8.53	9.03	11.18	11.13	8.98	9.80	8.78	8.13	8.13	8.30	8.23
29.	8.05	......	9.23	11.03	11.23	8.80	9.75	9.23	8.08	8.15	8.25	8.30
30.	8.13	......	9.50	11.13	11.25	8.78	9.40	9.18	8.05	8.15	8.25	8.25
31.	8.17	......	9.68	......	11.30	......	10.65	9.28	......	8.15	......	8.25

Discharge of Rio Grande at Embudo, N. Mex., for 1895.

[Drainage area, 7,000 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
January	552	432	475	29,207	0.08	0.07
February	672	420	503	27,935	0.07	0.07
March	1,410	640	759	46,646	0.13	0.11
April	4,290	592	2,541	151,200	0.40	0.36
May	4,290	1,573	2,679	164,725	0.44	0.38
June	4,985	790	3,021	179,762	0.48	0.43
July	2,530	612	1,335	82,086	0.22	0.19
August	2,016	652	1,080	66,407	0.17	0.15
September	1,146	480	636	37,845	0.10	0.09
October	572	460	494	30,375	0.08	0.07
November	700	540	611	36,357	0.10	0.09
December	580	420	534	32,834	0.09	0.08

ABIQUIU STATION, ON CHAMA RIVER.

Chama River is the principal tributary of the Rio Grande entering in northern New Mexico. In volume it is reported to be about a third that of the Rio Grande at the point where the two unite. The river carries a large amount of sediment, the water being very muddy in times of flood and the channel unstable from constant erosion or deposition of the soft material. For several years attempts have been made to obtain measurements of this stream, but owing to the comparative inaccessibility and the consequent expense, systematic work was not undertaken until the spring of 1895. On March 9, 1889, a single measurement was made near Abiquiu and a discharge of 945 second-feet was found. The total area drained above this point as measured on the land office map is 2,300 square miles.

In April, 1895, an examination for a suitable point for discharge measurements was made by Mr. P. E. Harroun. He found a locality about 200 yards above the town of Abiquiu. The east bank of the river is steep, but the west bank is low and liable to overflow at times of excessive floods. A cable was stretched across at this point and a car suspended from it, from which measurements can be made. It is probable that the supports of the cable on the low side will be washed out at intervals. This lowland, however, has not been overflowed for about five years. The gage originally established was spiked to the pier of an unfinished and abandoned bridge. The cable is about 150 feet above this old bridge foundation. The total length between the points of attachment is 235 feet. The cable is supported on posts 6 inches by 8 inches, 16 feet long, set from 4 to 5 feet in the ground. The ends are attached to timbers 8 feet long and 2.5 feet in diameter, set from 4 to 5 feet in the ground. On the east bank the cable runs under the traveled road.

On August 8 the gage was washed away by a flood, which is reported by the observer, Mr. Henry Grant, to have been the highest water ever known in the river. This carried away the old foundations of the bridge. A new gage was put in place on August 18, about 100 feet above the cable, on the right bank of the river. The flood brought such quantities of material that the old bench mark was completely buried, and therefore the new gage could not be referred to the old. This is less to be regretted from the fact that the channel of the stream must have been completely changed by the scouring action. The new gage consists of two sections, each 12 feet long, inclined to the slope of the bank. It is spiked to hand-driven piles, and is held in place by large rocks on each side. It is as substantial as can be made at this locality. The bench mark is on a sandstone, 25 feet to the right, marked B. M. The 7-foot mark on the gage is 4.17 feet below this bench mark.

As previously stated, the changes in the channel are such that a rating table can not be made from the discharge measurements. In the case of this and other similar rivers it will be necessary to make a large number of measurements and to have a systematic series of soundings, in connection with daily observations of height of water, to give the changes in the channel. The effect of the filling and scouring is shown by the figures given below. For example, on June 21, with height of water at 2.50 feet there was a discharge of 404 second-feet; on July 25, at a higher stage, 2.90 feet, the discharge was only 206 second-feet, the bottom being raised by the silt deposited in the channel. The last measurement of the year, that of November 26, was made while ice was floating in the river, and the water was so cold as to freeze on the meter, rendering the results of somewhat doubtful value.

List of discharge measurements made on Chama River, at Abiquiu, N. Mex.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	June 21	P. E. Harroun	25	2.50	1.59	404
2	July 25	.....do	25	2.90	1.33	206
3	Aug. 18	.....do	25	1.30	1.77	209
4	Oct. 29	.....do	25	1.10	1.31	72
5	Nov. 26	.....do	25	1.80	0.64	77

Daily gage height of Chama River at Abiquiu, N. Mex., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		2.50	3.35	3.35	1.70	1.05	1.35
2		2.10	3.85	3.85	1.25	1.05	1.25
3		a3.00	2.95	2.95	1.05	1.15	1.20
4		2.70	3.85	3.05	1.40	1.45	0.95
5		2.45	3.15	3.15	b2.40	1.20	1.15
6		1.90	3.10	3.10	1.90	1.20	1.30
7		1.55	4.15	4.15	1.40	1.10	1.10
8		1.20	(c)	0.85	1.20	1.05	0.95
9		3.35		0.95	1.05	1.10	1.30
10		3.60		0.85	1.05	1.10	1.25
11		5.95		1.40	1.05	1.05	1.10
12		5.40		1.10	1.15	1.20	1.30
13		3.00		0.95	1.10	1.15	1.15
14		2.85		0.90	1.10	1.10	1.15
15		2.80		0.85	1.00	1.15	1.15
16		2.55		1.10	0.95	1.25	1.10
17		2.70		0.85	1.10	1.25	1.10
18		2.80	1.30	0.80	1.15	1.30	1.40
19		2.45	1.20	0.90	1.00	1.25	1.30
20		2.45	1.15	0.95	1.15	1.30	1.15
21		3.25	1.20	1.55	1.05	1.25	1.30
22		4.35	1.55	0.95	1.15	1.25	0.90
23	2.67	4.90	d1.80	0.85	0.95	1.45	1.20
24	1.35	4.80	1.85	0.95	0.90	1.70	1.15
25	1.30	2.85	2.05	0.80	0.95	1.45	1.10
26	2.10	2.65	1.35	0.95	1.10	1.70	1.00
27	2.50	2.70	1.60	0.85	1.15	1.45	1.00
28	2.10	2.70	e2.09	0.90	0.95	1.35	0.95
29	1.95	2.75	1.35	0.85	1.10	1.85	1.05
30	1.95	3.10	1.45	1.05	1.00	1.75	0.90
31		f4.15	1.65		1.05		0.95

a At 8 a. m., 1.80; 6 p. m., 4.20. Cloud-burst above Abiquiu.
b Raised through the night 4 feet.
c Gage carried away by flood.
d River raised about 5 feet from 10 a. m. to 4 p. m.
e River raised 6 feet from 12 m. to 5 p. m.
f Cloud-burst; river raised 7 feet from 2 p. m. to 4 p. m.

RIO GRANDE STATION, ON THE RIO GRANDE.

This station has been described in Bulletin No. 131, page 45, under the name of Water Tank station. It is about one-fourth of a mile above the railroad station formerly known as Water Tank and recently named Rio Grande. Observations were begun on February 3, 1895, and continued with short breaks throughout the year. A number of discharge measurements have been made, and from them a rating table has been constructed from which the monthly discharges have been computed. The gage is inclined, and consists of two timbers 4 inches square fastened to hand-driven piles and wired to solid rocks. The bench mark is on the top of a bowlder, against which the upper portion of the gage rests. The channel is straight, both above and below the station, and the banks are high and rocky, so that the stream is always confined. The bed is rocky on the east side and sandy on the west, and liable to change. Measurements are made from a car suspended from a cable placed at this point.

List of discharge measurements made on the Rio Grande at Rio Grande, N. Mex.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	Feb. 1	P. E. Harroun	24	4.60	3.11	652
2	Apr. 19	.....do	25	9.80	6.55	5,174
3	May 11	.....do	25	8.00	5.86	4,249
4	June 5	.....do	25	9.10	5.86	6,689
5	July 23	.....do	25	6.60	4.41	2,095
6	Aug. 21	.....do	25	5.50	3.92	933
7	Sept. 10	.....do	25	5.10	3.43	739
8	Oct. 24	.....do	25	4.90	2.23	629
9	Nov. 30	.....do	25	4.90	2.84	639

Rating table of the Rio Grande at Rio Grande, N. Mex., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
4.60	480	6.60	2,070
4.70	530	6.80	2,350
4.80	580	7.00	2,640
4.90	630	7.20	2,940.
5.00	680	7.40	3,250
5.20	780	7.60	3,570
5.40	880	3.80	3,900
5.60	1,005	8.00	4,250
5.80	1,160	8.50	5,250
6.00	1,340	9.00	6,430
6.20	1,550	9.50	7,750
6.40	1,800	10.00	9,240

Daily gage height of the Rio Grande at Rio Grande, N. Mex., for 1895.

Day.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	6.15	6.75	8.85	8.75	5.95	6.65	5.80	4.90	5.10	5.15
2	......	5.90	6.50	8.60	9.00	5.95	6.55	5.80	4.80	5.05	5.25
3	4.60	5.90	6.35	8.20	9.30	6.00	6.45	5.55	4.80	5.10	5.15
4	4.55	5.40	6.30	7.90	9.30	6.00	6.30	5.55	5.30	5.15	4.55
5	4.55	5.30	6.40	7.70	9.20	5.75	6.45	5.45	5.40	5.35	4.85
6	4.55	5.40	6.35	7.40	9.00	5.70	6.45	5.35	5.40	5.30	4.70
7	4.55	5.85	6.40	7.25	8.90	5.60	6.70	5.35	5.40	5.25	4.80
8	4.60	5.75	6.25	7.25	8.90	5.70	6.65	5.30	5.40	5.35	4.90
9	4.60	5.75	6.90	7.50	9.20	5.65	6.90	5.25	5.30	5.40	5.05
10	4.80	5.80	7.40	7.65	9.30	*a*6.30	6.30	5.15	5.00	5.25	5.10
11	4.60	5.80	8.00	8.00	9.30	6.80	6.00	5.10	4.90	5.25	5.25
12	4.65	5.85	8.55	8.50	9.25	7.60	6.55	5.00	5.00	5.30	5.25
13	4.45	5.45	9.10	8.80	9.25	6.70	6.35	5.00	4.90	5.45	5.30
14	4.35	5.40	9.70	8.55	9.20	6.70	6.65	4.95	4.90	5.40	5.35
15	4.45	5.25	9.45	8.65	9.00	6.60	6.85	4.90	5.00	5.40	5.35
16	4.50	5.25	9.30	8.45	8.70	6.55	6.30	4.80	5.00	5.35	5.25
17	4.60	5.10	......	8.55	8.25	6.50	5.90	4.80	4.90	5.25	5.20
18	4.75	5.10	......	8.35	7.90	6.35	5.50	4.70	......	5.20	5.15
19	4.65	5.10	......	8.00	7.65	6.15	5.45	4.80	......	5.30	5.20
20	4.90	5.75	......	7.60	7.45	6.00	5.55	4.90	......	5.40	5.20
21	4.85	5.50	9.80	7.85	7.10	5.90	5.65	4.90	......	5.45	5.20
22	4.85	5.80	9.80	8.30	6.80	5.95	5.35	4.80	......	5.50	5.25
23	4.85	6.00	9.80	8.50	6.50	6.00	5.15	4.80	......	5.50	5.25
24	4.90	7.00	9.30	8.70	6.25	6.30	5.05	4.80	......	5.50	5.15
25	5.10	6.90	9.05	8.65	6.10	6.30	5.20	4.80	......	5.45	4.95
26	5.30	6.80	9.00	8.50	6.00	6.40	5.40	4.95	......	5.45	4.90
27	6.00	6.60	9.00	8.45	5.75	6.30	5.50	4.95	4.90	5.45	4.85
28	6.10	6.70	9.10	8.40	5.85	6.30	5.65	4.90	4.95	5.25	4.85
29	......	6.85	9.10	8.25	5.90	6.15	5.85	4.90	4.90	4.95	4.85
30	......	6.75	8.95	8.55	5.80	*b*7.45	5.85	4.90	5.00	5.05	4.85
31	......	7.00	......	8.85	......	8.10	5.85	......	5.15	......	4.90

a Mountain flood water raised 3 feet during the night; height at 6 p. m. was 7 feet.
b Raised 3 feet during the night.

Estimated discharge of the Rio Grande at Rio Grande, N. Mex., for 1895.

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Max.	Min.	Mean.	
February	1,440	355	591	32,822
March	2,640	730	1,371	84,294
April	8,630	1,610	5,073	301,864
May	6,055	2,420	4,616	283,827
June	7,200	1,120	4,630	275,504
July	4,430	1,005	1,768	108,710
August	2,490	705	1,481	91,063
September	1,160	530	723	43,021
October	880	630	707	43,472
November	940	655	834	49,626
December	855	605	713	43,841

SAN MARCIAL STATION, ON THE RIO GRANDE.

The observations at this point are made at a gage attached to the pier of the railroad bridge about one-half mile south of San Marcial, N. Mex. The locality is described in Bulletin No. 131, on page 46. A number of discharge measurements have been made at this point during 1895 by Mr. P. E. Harroun, but, owing to the shifting character of the channel, it has not been possible to compute the monthly discharge. The bridge piers at this point break the current of the stream so that it is difficult to obtain satisfactory measurements at times of high water and the river is so broad that it is impossible to stretch a cable across it from which to suspend a car or light ferry.

List of discharge measurements made on Rio Grande at San Marcial, N. Mex.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second)	Discharge (second-feet).
	1889.					
1	Aug. 8	G. T. Quinby	104	1.60	....	19
	1895.					
2	Jan. 29	A. P. Davis	24	6.40	0.38	89
3	Apr. 22	P. E. Harroun	25	9.50	6.07	7,805
4	May 19	.....do	25	7.60	5.49	3,458
5	June 1	.....do	25	8.60	4.12	4,714
6	July 16	.....do	25	6.60	2.38	1,503
7	Sept. 5	.....do	25	6.90	1.99	626
8	Oct. 1	.....do	25	5.30	1.47	15
9	Nov. 17	.....do	25	7.20	2.17	674
10	Dec. 14	.....do	25	7.20	3.12	602

Daily gage height of Rio Grande at San Marcial, N. Mex., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	......	5.80	6.80	7.70	9.00	8.00	7.00	8.75	8.00	5.70	6.60	7.60
2..	......	5.75	7.05	7.45	8.75	8.30	7.00	9.00	7.50	5.70	6.60	7.50
3..	......	6.25	7.35	7.50	8.50	8.40	6.45	7.85	7.35	5.70	6.70	7.30
4..	......	6.40	7.35	7.40	8.35	8.50	6.40	8.45	7.00	5.80	6.75	7.00
5..	......	6.20	7 35	7.30	8.05	8.50	6.35	8.55	6.90	5.70	7.00	6.90
6..	......	6.20	7.15	7.40	7.60	8.70	6.30	7.40	6.80	6.80	7.00	6.90
7..	......	6.25	7.00	7.50	7.50	8.90	6.30	7.55	6.80	6.00	7.00	7.20
8..	......	6.25	6.95	7.50	7.35	8.90	6.25	7.30	6.70	6.50	7.00	7.20
9..	......	6.25	7.05	7.10	7.15	8.50	6.25	8.10	6.50	6.55	7.00	7.00
10.	......	6.30	6.80	7.00	6.95	8.50	7.15	8.15	6.50	6.65	6.95	7.00
11.	......	6.20	6.80	7.10	6.95	8.60	9.35	7.40	6.55	6.65	6.90	7.05
12.	......	6.25	6.90	7.55	7.05	8.70	9.20	7.35	6.50	6.65	6.95	7.25
13.	......	6.25	6.95	7.80	7.25	8.90	7.60	7.25	6.75	6.50	7.20	7.20
14.	......	5.20	6.95	8.35	7.60	8.60	7.00	7.80	6.45	6.50	7.20	7.30
15.	......	5.15	6.85	8.80	7.85	8.50	6.35	7.75	6.10	6.50	7.20	7.40
16.	......	5.10	6.95	8.95	7.90	8.25	6.55	7.35	6.00	6.80	7.20	7.60
17.	......	5.15	6.90	9.00	7.80	8.20	6.30	7.00	5.70	6.75	7.20	7.60
18.	......	5.95	6.80	8.95	7.65	8.00	6.20	6.45	5.60	6.70	7.35	7.65
19.	......	6.00	6.70	9.00	7.60	8.00	6.35	6.75	5.45	6.70	7.40	7.60
20.	......	6.25	6.55	9.20	7.60	8.00	6.50	6.25	5.00	6.70	7.40	7.50
21.	......	6.30	6.70	9.40	7.45	7.30	6.50	6.50	5.00	6.70	7.30	7.50
22.	......	6.45	6.85	9.40	7.45	7.30	7.25	6.50	4.80	6.70	7.25	7.50
23.	......	6.60	6.65	9.50	8.00	7.00	7.50	6.45	4.70	6.70	7.20	7.90
24.	......	6.65	6.60	9.45	7.85	7.00	8.35	6.60	4.70	6.60	7.40	7.80
25.	......	6.60	6.50	9.10	8.40	6.30	8.55	6.40	4.60	6.80	7.50	7.55
26.	......	6.50	6.75	8.65	8.00	6.70	8.00	6.65	4.50	6.50	7.60	6.50
27.	......	6.65	6.95	8.50	8.40	6.75	7.20	6.50	4.50	6.50	7.50	6.85
28.	......	6.75	7.10	8.50	8.05	7.10	7.50	7.05	4.25	6.60	7.60	7.00
29.	6.40	......	7.20	8.50	8.20	7.35	7.10	7.00	5.80	6.60	7.65	......
30.	5.85	......	7.40	8.65	8.35	7.00	7.10	7.95	5.70	6.50	7.60	......
31.	5.50	......	7.55	......	8.15	......	7 80	7.45	......	6.70	......	......

EL PASO STATION, ON THE RIO GRANDE.[1]

Measurements have been continued at this point at intervals during the year, but, as in the case of the localities above mentioned, the shifting character of the channel has prevented the making of satisfactory computations of daily discharge. A system of frequent soundings of the channel has been put in operation, and by means of this, combined with daily observations of height of water and frequent measurements of the quantity flowing in the stream, it is probable that satisfactory data can be obtained. At the time of the last measurement—that of December 27—the river was partly frozen.

[1] Described in Bulletin No. 131, p. 46.

Daily gage height of Rio Grande at El Paso, Tex., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	......	......	7.05	7.85	9.60	9.40	7.55	8.95	9.55	5.15	5.45	7.55
2..	......	6.25	7.10	8.35	9.65	9.70	8.15	8.85	8.85	5.40	5.50	7.55
3..	......	6.05	7.35	8.65	9.80	9.80	8.15	9.85	8.45	5.40	5.50	7.50
4..	......	5.75	7.75	8.90	9.80	10.05	7.55	10.95	8.05	5.35	5.50	7.45
5..	......	5.70	8.00	8.60	9.55	10.05	7.40	9.85	7.90	5.35	5.50	7.35
6..	......	6.50	8.50	8.50	9.45	10.00	7.40	9.60	7.70	5.10	5.60	7.20
7..	......	6.50	8.40	8.35	9.20	10.00	7.05	9.65	7.45	5.10	5.60	7.10
8..	......	6.95	8.25	8.20	8.85	10.00	6.85	9.10	7.25	5.05	5.70	6.90
9..	......	6.65	8.15	8.35	8.65	10.10	7.05	8.75	7.40	5.10	5.85	6.90
10.	......	6.60	7.80	8.55	8.40	10.00	7.90	8.55	7.45	5.10	5.90	6.95
11.	......	6.45	7.75	8.30	8.25	9.75	9.05	8.85	6.80	5.05	6.00	7.05
12.	......	6.55	7.90	8.05	8.20	9.75	9.35	9.10	6.65	5.10	6.30	7.00
13.	......	6.50	7.90	7.80	8.20	9.65	10.45	8.95	6.45	5.10	6.30	6.90
14.	......	6.55	7.90	7.55	8.40	9.80	11.60	8.40	6.40	5.10	6.40	6.80
15.	......	7.05	7.90	8.50	8.55	9.90	12.00	8.35	6.30	5.00	6.55	6.80
16.	......	7.10	7.90	9.00	8.80	10.05	11.75	8.50	6.20	5.00	6.60	6.80
17.	......	7.55	7.85	9.70	9.10	9.95	9.25	8.75	6.10	5.00	6.60	6.85
18.	......	6.45	7.75	10.05	9.05	9.80	8.55	8.60	5.95	5.60	6.70	7.00
19.	......	6.00	7.50	10.25	9.15	9.60	8.15	8.65	5.80	5.60	6.90	6.95
20	......	5.75	7.35	10.40	9.20	9.45	7.90	8.60	5.70	5.55	6.90	6.95
21.	......	5.70	7.15	10.30	9.25	9.20	7.60	8.20	5.65	5.50	6.90	7.00
22.	......	5.70	6.90	10.30	9.35	9.05	8.05	8.15	5.55	5.50	6.90	7.25
23.	......	5.60	6.70	10.55	9.30	8.85	8.10	7.65	5.45	5.45	6.90	7.30
24.	......	5.60	6.50	10.75	9.05	8.70	9.00	7.50	5.35	5.35	7.00	7.30
25.	6.50	6.55	6.30	10.80	9.30	8.55	9.60	8.25	5.30	5.25	7.00	7.25
26.	6.40	7.35	6.15	10.85	9.60	8.35	10.10	7.90	5.30	5.20	7.05	7.60
27.	6.45	6.95	6.00	10.75	9.55	8.10	10.35	7.25	5.15	5.20	7.40	7.40
28.	6.40	7.05	6.00	10.25	9.50	7.85	9.95	7.25	5.10	5.20	7.70	7.25
29.	6.50	......	5.85	9.80	9.45	8.05	8.90	7.40	5.05	5.20	7.75	7.15
30.	6.60	......	5.70	9.65	9.30	7.65	8.55	7.40	5.05	5.30	7.65	6.35
31.	6.50	......	7.40	......	9.40	......	8.30	8.25	......	5.40	......	6.10

List of discharge measurements made on Rio Grande at El Paso, Tex.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	Jan. 25	A. P. Davis	24	6.40	0.87	230
2	July 19	P. E. Harroun	25	8.10	0.71	1,039
3	Sept. 6	.....do	25	7.90	1.63	761
4	Oct. 3	.....do	25	5.70	0.23	26
5	Nov. 21	.....do	25	6.90	1.55	392
6	Dec. 4	A. P. Davis	61	7.50	1.37	423
7	Dec. 16	P. E. Harroun	26	6.80	1.13	266
8	Dec. 27	C. C. Babb	62	7.42	1.50	386

RIO GRANDE VALLEY, NEAR ALBUQUERQUE.

By Philip E. Harroun.

The portion of the valley of the Rio Grande on the east side of the river, between Albuquerque and the Pueblo village of San Felipe, affords a typical illustration of the method of irrigation practiced by the Mexican communities of this portion of the Territory at the present time.

The valley is long and narrow, extending in a general north-and-south direction. Its altitude ranges from 4,950 at Albuquerque on the south to 5,200 feet at San Felipe on the north. The cultivated land varies from one-fourth of a mile to 3 miles in width between the river and the foothills on the east. The soil is alluvial and sandy and is very fertile, but has some traces of alkali, which experience has shown to be successfully overcome by proper drainage and washing. Meteorological observations have not as yet been extended over a sufficient period to determine accurately the rainfall, but the average is about 7.2 inches annually, about 4.6 inches falling in the so-called rainy season during June, July, August, and September. The precipitation in these months, however, occurs mostly in sudden showers, and is of little benefit to agriculture on this account. The winters are in general dry and bright, snow falling occasionally, but soon melting. In the spring the valley is subject to severe hot windstorms from the south and west, the effect of which is deleterious to vegetation.

The water supply of the valley is derived from the Rio Grande by means of numerous small canals ranging in capacity from 10 to 30 cubic feet per second. The order of these canals from north to south is the Algodones, Santa Ana, Bernalillo, Sandilla, La Ladera or Alamida, Los Ranchos, Los Griegos de Candelaria, La Varela, Duranis, and Albuquerque, of which the Santa Ana and Sandilla are controlled entirely by the Indians of those pueblos, but these canals differ in no respect from those constructed by the Mexicans. The heads of these canals are of two kinds—open cuts in the bank and diverting dams of brush. Of the former class are the Santa Ana, Sandilla, Los Ranchos, Los Griegos, and La Varela, having no head-works of any description. A cut is made in a bend of the river bank against which the river impinges and the water is drawn off. The other ditches have diverting dams of brush directing the current into the ditch. These dams are constructed by driving cottonwood or willow stakes into the sandy bottom of the river and placing between them fascines of brush weighted down by heavy bowlders, while sods are distributed along the upper face. These dams are not tight, much of the water finding its way through, but they serve to deflect the current toward the head of the ditch and raise the water level from 0.4 to 1 foot. There is one other method of taking water from the river, as shown in the Algodones ditch. The head of this ditch is at a rapid of the river about one-fourth of a mile below the pueblo of San Felipe. About 25 feet from the east bank and extending downstream parallel to it a brush and bowlder wing dam is carried a distance of about 800 feet to the head of the rapids. At this point the diversion from the river is made and the ditch proper begins.

There are no regulating gates or sluices whatever. When the river falls it is found necessary to carry the ditch upstream in order to secure water, while upon a rise of the river the water often enters the ditch in such volume as to cause it to break its banks and flood the lands below. It will be seen that the position of the head of one of these ditches varies with the height of the river, the variation being at times as great as 2 miles. At each flood these diverting dams are washed out and replaced again when the river has fallen.

After leaving the head these ditches are carried diagonally from the river, as a rule following the contour of the ground toward the land to be irrigated, the distance varying from one-half mile to 3 miles. The irrigated lands lie directly under the ditch, the water being taken from small sluice boxes directly onto the land. There are no laterals in the proper sense, but on each side of every field is usually a small ditch carrying from one-half to 1½ cubic feet per second to the more distant lands, rarely more than 1,200 feet away. These distributing ditches are from 100 to 400 feet apart, but are not permanent, and are likely to be changed after each irrigation.

The method of applying the water is wholly that of flooding. When water is needed the sluice boxes are opened and it is allowed to flow over the land until the irrigator is satisfied. The practice is usually to flood the land to a depth of from 3 to 4 inches over the entire surface. The principal crops are wheat, corn, and alfalfa. Corn and wheat are irrigated once every two weeks, or less frequently, depending upon local climatic conditions, while alfalfa is irrigated about twice as often.

All the ditches carry a surplus of water, and as a consequence the use of water is excessive. The surplus water from the irrigated fields and the ditches is allowed to find its own way to the river, and the result is that during the irrigation season, from April 1 to November 1, the roads are almost impassable, and nearly as much land lies waste in swamps as is under cultivation.

The bed of the Rio Grande in the upper portion of this valley is generally gravelly, the underlying strata being of such a character as to prevent excessive seepage; but below Bernalillo the bed changes to an exceedingly treacherous quicksand and the seepage is excessive. There has never been any scarcity of water in the valley down to the neighborhood of Peralta until 1894, when, for the first time in the memory of the oldest inhabitant, the river went dry near Corrales, and all the ditches from Los Ranchos down were without water.

The amount of land irrigated by these ditches is variable, changing from year to year with the caprice of the people, and it can not be ascertained with any considerable degree of accuracy. There has never been a survey of the ditches or lands under them, and there are no maps or records. The total amount of land under ditch is estimated to be approximately 12,000 acres, of which 3,200 acres are under cultivation. Of the balance, 1,800 are in swamps and meadow lands from the waste water of irrigation and the ditches, while the remainder is uncultivated—not from any lack of water or other natural cause, but apparently from lack of enterprise.

It is impossible to estimate the area supplied by each ditch, for lands lying under one ditch and belonging naturally to its system may be irrigated from a higher one. Should a consumer have difficulty with a major-domo of his community ditch he may apply to the community of any other ditch for admission, and if they consent he may become one of their number, with all the rights and privileges, provided only that he furnish his quota of the labor assessed. This custom makes it exceeding difficult to determine the land served by each ditch.

Each ditch is owned and controlled by the owners of the land irrigated by it. Each fall an election is held, at which is elected a major-domo, who has full control of the ditch for the succeeding season. He assesses the land for the necessary labor to free the ditch from the silt of the preceding year and keep the ditch in repair during the irrigating season, formulates the local regulations, proportions the water to each consumer, and conducts all matters in relation to the ditch. Before the irrigation season opens he makes a "survey" of the land each owner expects to cultivate, and an assessment of labor is then made accordingly. The assessment made in general is such that he who holds a tract of about 6 acres is required to furnish the labor of one man in cleaning and repairing the entire ditch in the spring, while he who holds 12 acres is required to furnish one man's labor on the ditch as it may be required for the entire season. Tracts of greater or less acreage are assessed at about this rate.

The proportioning of water to consumers by the major-domo is entirely arbitrary, although supposed to be based on acreage, no measurements being made. The water is turned onto the land, and when the major-domo considers that enough has been allotted it is turned off again. As all the ditches in this section carry an excess of water this plan has no opponents.

The major-domo is responsible to the consumers in case of damage arising from his negligence in care of the ditch. In this event, a committee is asked for by the injured party. This committee proceeds to inquire into the facts of the case, and should the major-domo be found at fault they assess damages, which the major-domo must pay. The major-domo is paid for his services in the superintendence and care of the ditch by each consumer in accordance with the work assessed, the rate usually being 2 castales of corn (about 2½ bushels), or its equivalent, for each man sent to the ditch. He also receives water for his land free.

These ditches present many features in common, but their individual discharge, area, velocity and similar details are of interest. The following descriptions are based upon the results of a field examination made between August 20 and 30, 1895.

The Algodones ditch supplies the lands adjacent to and below the villages of Algodones and Angostura. It heads about one-fourth of a mile south of the pueblo of San Felipe, on the east side of the river. The head of this ditch is formed by a wing dam constructed by driving cottonwood stakes into the river bottom and interlacing fascines of brush between them. The brush is then weighted with bowlders and the inner slope sodded to make it as tight as possible. This dam extends into the river parallel to and about 25 feet from the east bank for a distance of about 800 feet from the point where the ditch proper begins. Its height averages about 2 feet, and it fulfills the function of a regulator also, as when the river rises the water spills over the entire length of 800 feet and enters the ditch at a fairly constant level. After leaving the head the ditch is carried a distance of 3 miles along the bottom lands to the town of Algodones, where the water is first used for irrigation. Its total length is 4.8 miles, only the lower 1.8 miles of ditch being available for irrigation. At the tail this ditch passes under the Santa Ana ditch through an ordinary box culvert and discharges its surplus waters into the Bernalillo ditch. The Algodones ditch, as gaged 600 feet below the head, carries 9.9 cubic feet per second. Its sectional area is 7.8 square feet; mean depth, 0.82 foot; mean velocity, 1.27 feet; maximum sectional velocity, 1.44 feet; and its surface width, 9.5 feet at full capacity. The mean velocity is such that it does not prevent the growth of weeds or the deposition of silt, the latter being about 12 inches in depth annually.

The Santa Ana ditch is controlled wholly by the Indians of that pueblo, and is used to irrigate their lands, which extend opposite and for some distance below the town of Algodones. This ditch has no head-works of any description, a cut being made in the bank of the river and the water drawn off. At a point 300 feet below the head it has a surface width of 8 feet; sectional area, 7.8 square feet; mean depth, 0.98 foot; mean velocity, 2.69 feet; maximum sectional velocity, 2.90 feet, and a discharge of 21 cubic feet per second. Although this section was in light sand, there was no scour nor was there any deposit of silt. At a distance of 3 miles below the head and immediately above the point from which water is first drawn for irrigation the ditch was found to have a width of 7 feet; sectional area, 8 square feet; mean depth, 1.14 feet; mean velocity, 1.64 feet; maximum sectional velocity, 1.93 feet, and a discharge of 13.1 cubic feet per second. At this point there was found a deposit of silt where the sectional velocity fell below 1.80 feet per second. The total length of this ditch is 8.4 miles; water is drawn from it only occasionally throughout the lower 5.4 miles. At the tail it discharges into the Bernalillo ditch.

The Bernalillo ditch is the next in order, its head being located about 2.2 miles above Algodones. The current of the river is directed toward the mouth by means of a stake and brush dam of the same description as that of the Algodones ditch, except that this dam is carried diagonally across the river from bank to bank. From the head the ditch extends for a distance of 4.4 miles to the upper edge of the town of Bernalillo, where the first service is required. From there it is carried along the edge of the foot hills and finally tails into the Sandilla ditch, 7.9 miles from the head. This is one of the largest ditches in this section, having immediately above its point of service a width of 15 feet; area, 19.5 square feet; mean depth, 1.30 feet; mean velocity, 1.28 feet; maximum sectional velocity, 1.58 feet per second, and a discharge of 25.1 cubic feet per second.

The Sandilla ditch is controlled entirely by the Indians of that pueblo. Its head is immediately opposite the town of Bernalillo, and consists of an open cut, with no dam. Owing to the low state of the river, the ditch was carrying at the time of gaging but 7.4 cubic feet per second, with a surface width of 10.3 feet; area, 4.1 square feet; mean depth, 0.39 foot; mean velocity, 1.80, and maximum sectional velocity 2.14 feet per second. Its discharge, when full, is in the neighborhood of 18 cubic feet per second. Service is first required at the pueblo of Sandilla, 4.2 miles below the head, and is carried from there 3.4 miles below, where the ditch tails into the Alameda.

The Alameda ditch heads opposite the settlement of Corrales on the east branch of the river. It has the ordinary brush-diverting dam common to the section. Its surface width is 13 feet; sectional area, 16.1 square feet; mean depth, 1.24 feet; mean velocity, 1.52 feet; and maximum sectional velocity, 1.86 feet per second, and the discharge is 24.5 cubic feet per second. Irrigation under this ditch first begins one-half mile below the head, and is carried nearly continuously to the tail, a distance of 4.3 miles, where it is turned loose upon the land, much of its water forming swamps, and finally finding its way into Los Ranchos ditch.

Los Ranchos ditch heads immediately above the Rio Grande bridge at Corrales. Its head is in an open cut. At a point one-half mile below, where the section becomes fairly constant its surface width is 12 feet; sectional area, 11.4 square feet; mean depth, 0.95 foot; mean velocity, 1.98, and maximum sectional velocity, 2.11 feet per second, and a discharge of 21.6 cubic feet per second. From the head the ditch is carried a distance of 4.6 miles, where it bifurcates, one branch being carried toward the foothills and through the upper portion of the town of

Albuquerque, while the other branch turns to the west and discharges into the Varela ditch, after passing under Los Griegos ditch. Its total length, including branches, is 13 miles, of which about 10 miles are in service.

Los Griegos ditch heads about 1½ miles above Los Ranchos de Albuquerque, and is also of the open-cut variety. At a point 1½ miles below the head, where service is first required, it has a surface feet of 9 feet; sectional area, 12.3 square feet; mean depth, 1.37 feet; mean velocity, 1.73 feet, and maximum sectional velocity 1.84 feet per second, while its discharge is 21.3 cubic feet per second. Its total length is 6.6 miles. It passes through the town of Albuquerque and discharges through the flats below to the river.

The Varela ditch heads about one-half mile below Los Griegos, in a bend of the river. At the time this ditch was examined there was no water running, as the river had fallen 1 foot below the bottom of the ditch. It was being cleared of silt, deepened, and carried up the river, where a brush dam was to be constructed to overcome the difficulty. Upon completion this ditch will carry about 20 cubic feet per second. Its length is about 4.5 miles, tailing out a short distance above the town of Albuquerque. Service is first required 1 mile below the head.

The Duranes ditch heads 3 miles above the old town of Albuquerque, passes below the town, and tails about 1 mile farther down. Its total length is 4 miles; its service 3.5. It has the common brush diverting dam and carried about 11 cubic feet per second when at its full capacity. At a point about 300 feet below the head its width was 11 feet; area, 8 square feet; mean depth, 0.73 foot; mean velocity, 0.93 foot, and maximum sectional velocity, 1.01 feet per second, and the discharge is 7.6 cubic feet per second.

The Albuquerque ditch, the last of the series, heads 1,500 feet below the Duranes ditch, and is of the same class. Its length is 4.3 miles, of which 3.7 miles are in service. One-half mile below the head it crosses under the Duranes ditch, passes to the east and through between Albuquerque and Old Town, tailing out in the same vicinity as the Duranes. Its flow is about 16 cubic feet per second. At the time visited, in August, 1895, its width was 12 feet; area, 7.8 square feet; mean depth, 0.65 foot; mean velocity, 1.38 feet, and maximum sectional velocity, 1.54 feet per second, and it discharged 10.8 cubic feet per second.

As is apparent, the use of water is in every way excessive, there being in the neighborhood of 3,200 acres cultivated, for which the ditches aggregate 188 cubic feet per second, or about a duty of 17 acres to the second-foot. All ditches carry a quantity greatly in excess of that required to serve the land under them, and as a rule their condition is such that breaks are frequent, allowing the escape of water. The method of irrigation is also exceedingly wasteful, and the quantity of water used is much greater than necessary. Many of the crops present the appearance of having been drowned out. In addition to this, the excessive use of water has caused the appearance of alkali, especially in the Bernalillo section, bringing the salts to the surface and, as there is no drainage, forming the characteristic alkali crust.

With one canal leaving the river at or about the pueblo of San Felipe, constructed on modern principles, and with proper drainage of the land below and proper irrigation methods, the entire valley would be a garden. The maintenance of such a canal would be but a small fraction of that required by the present system, and its cost small in comparison.

COLORADO BASIN.

During 1895 a number of new stations for measuring the flow of Colorado River and its tributaries have been established, and the others described in Bulletin No. 131, on pages 47-52, have been maintained. Most of these stations are in Colorado, there being a few in Utah and Arizona. The most northerly station is that on Green River, at the point of crossing by the Union Pacific Railroad. Next to this is the station on White River, in northwestern Colorado, and farther south the group in the vicinity of Grand Junction, Colo.

GRAND RIVER.[1]

GRAND JUNCTION STATION, ON GRAND RIVER.

This station is described in Bulletin No. 131, on page 48. The gage is located at the north end of the wagon bridge crossing Grand River. Observations are taken by B. W. Vedder, engineer of the city waterworks, at 7 a. m. and 6 p. m. The gage is vertical and is fastened by means of bolts set into the stone pier. The 12-foot mark is on a level with the top of the bridge abutment. The river at this point is very broad, subdivided into two or more channels, the one on the left being usually swift and the other on the right somewhat sluggish. On December 24 it was found that the east channel of the river was frozen. Readings had been stopped on December 20. This river usually opens in March. There is necessity for a second rod to be placed in the left channel about 580 feet from the present rod, as probably 90 per cent of the water flows in this portion.

The drainage area of Grand River has been measured, by means of a planimeter, from the land office map of Colorado dated 1892, giving the following figures:

Drainage area of Grand River.

	Sq. miles.
At Glenwood Springs, Colo	5,838
At Grand Junction, above mouth of Gunnison River	8,644
At Grand Junction below mouth of Gunnison River (of this, above Uncompahgre 497 square miles, and Gunnison River at mouth 7,935 square miles)	16,579

[1] Observations of height of water have been maintained on Grand River at Shoshone, 100 miles above Grand Junction, from July 1 to October 25, 1896, by the Denver and Rio Grande Railroad.

List of discharge measurements made on Grand River at Grand Junction, Colo.

Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1894.						
Oct. 18	A. P. Davis	22	2.10	....	1.10	1,585
1895.						
June 27	.....do	55	4.03	2,860	5.77	16,500
Oct. 1	.....do	61	0.82	1,009	2.04	2,059

Daily gage height of Grand River at Grand Junction, Colo., for 1894, in feet.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	3.05	2.00	17	....	2.05	2.40
2	....	3.00	2.00	18	2.10	2.60	2.50
3	....	2.95	2.00	19	2.20	2.60	2.60
4	....	3.00	2.00	20	2.70	2.60	2.70
5	....	2.95	1.85	21	2.85	2.60	2.80
6	....	2.90	1.80	22	2.75	2.70	2.80
7	....	2.90	1.70	23	2.65	2.70	2.70
8	....	2.95	1.80	24	2.60	2.60	2.60
9	....	2.85	1.80	25	2.60	2.60	2.60
10	....	2.90	1.80	26	2.75	2.40	2.50
11	....	3.10	1.90	27	2.85	2.25	2.40
12	....	3.10	2.00	28	3.30	2.10	2.35
13	....	3.00	2.10	29	3.15	2.05	2.20
14	....	2.85	2.10	30	2.95	2.00	2.10
15	....	2.60	2.10	31	2.90	....	2.10
16	....	2.40	2.20				

Daily gage height of Grand River at Grand Junction, Colo., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.10	2.40	3.00	3.10	5.10	4.10	4.20	2.10	1.80	a0.90	0.50	0.30
2..	2.15	2.40	3.00	3.05	4.95	4.20	4.05	2.30	1.70	0.80	0.50	0.30
3..	2.20	2.40	3.00	3.00	4.60	4.20	3.90	2.20	1.70	0.80	0.50	0.30
4..	2.20	2.40	2.95	3.00	4.35	4.30	3.65	2.10	1.70	0.85	0.50	0.20
5..	2.30	2.40	2.85	3.00	4.25	4.40	3.50	2.10	1.70	0.90	0.55	0.20
6..	2.30	2.40	2.80	3.00	4.15	4.40	3.40	2.00	1.70	0.90	0.60	0.20
7..	2.30	2.40	2.75	3.05	4.10	4.50	3.25	2.00	1.70	0.90	0.60	0.20
8..	2.30	2.40	2.90	3.20	4.20	4.60	3.10	2.00	1.70	0.90	0.60	0.20
9..	2.30	2.40	2.90	3.25	4.40	4.60	2.90	2.00	1.70	0.80	0.50	0.20
10.	2.40	2.35	2.90	3.35	4.75	4.70	2.80	2.00	1.60	0.80	0.50	0.20
11.	2.40	2.30	2.85	3.40	5.10	4.90	2.90	1.90	1.60	0.80	0.50	0.20
12.	2.40	2.20	2.85	3.65	5.25	5.10	3.05	1.90	1.60	0.80	0.50	0.20
13.	2.40	2.15	2.75	3.95	5.40	5.10	3.10	1.90	1.60	0.80	0.55	0.20
14.	2.40	2.10	2.65	4.05	5.55	5.20	2.95	1.90	1.50	0.80	0.60	0.20
15.	2.40	2.10	2.60	4.20	5.70	5.30	2.85	1.90	1.60	0.75	0.60	0.20
16.	2.40	2.10	2.30	4.30	5.50	5.40	2.65	1.90	1.60	0.70	0.60	0.20
17.	2.50	2.20	2.60	4.40	5.20	5.40	2.45	1.90	1.60	0.70	0.60	0.20
18.	2.60	2.30	2.70	4.50	4.80	5.30	2.40	1.90	1.60	0.70	0.50	0.20
19.	2.60	2.35	2.75	4.60	4.70	4.90	2.30	1.80	1.60	0.70	0.50	0.10
20.	2.60	2.40	2.90	4.75	4.60	4.55	2.30	1.80	1.60	0.70	0.60	0.10
21.	2.60	2.40	3.00	4.50	4.50	4.30	2.25	1.95	1.60	0.70	0.60	0.10
22.	2.40	2.55	3.00	4.35	4.55	4.00	2.15	2.25	1.50	0.70	0.60	....
23.	2.40	2.70	3.00	4.20	4.60	4.00	2.10	2.05	1.50	0.70	0.70	....
24.	2.30	2.80	3.00	4.35	4.50	3.90	2.10	1.90	1.50	0.60	......	....
25.	2.30	3.00	3.00	4.50	4.40	3.85	2.00	1.85	1.50	0.60	......	....
26.	2.30	3.25	3.10	4.55	4.40	3.90	2.00	1.85	1.50	0.60	......	....
27.	2.30	3.25	3.15	4.80	4.50	3.95	2.00	1.85	1.50	0.60	......	....
28.	2.30	3.10	4.50	4.95	4.60	3.90	2.00	1.85	1.50	0.60	......	....
29.	2.30	......	3.20	5.00	4.50	4.35	2.00	1.85	1.10	0.60	......	....
30.	2.30	......	3.20	5.10	4.35	4.45	1.90	1.85	1.00	0.60	......	....
31.	2.40	......	3.20	......	4.20	......	2.00	1.85	......	0.50	......	....

a Gage lowered 1.5 by A. P. Davis, as the water had fallen below the zero of the gage. This amount has been added to the original observations from October 18, 1894, to September 30, 1895.

b March 28 the Grass Valley reservoir broke.

GUNNISON RIVER.

Gunnison River is the largest tributary of Grand River. It rises in the mountains of south central Colorado, its head-waters interlacing with those of the Rio Grande and Arkansas. The water supply is large, and in most localities is in excess of the demands made upon it. Measurements of this stream and of its largest branch, the Uncompahgre, have been made during 1895, a station being established on the latter, near Fort Crawford, 8 miles above Montrose, and on the Gunnison itself near the point where it joins the Grand River at Grand Junction.

FORT CRAWFORD STATION, ON UNCOMPAHGRE RIVER.

This station was established by Mr. F. Cogswell in June, 1895. It is about one-half mile east of Fort Crawford switch, on the Denver and Rio Grande Railroad, the nearest post-office being Uncompahgre. The gage is at the railroad bridge, east of the post-office and switch, being bolted to the lower side of one of the piers. Discharge measurements are made from the highway bridge. The bench mark consists of a spike driven in the base of a cottonwood post and is 4.18 feet above the 5-foot mark. A short distance above the bridge is an island. The water of both channels unite at the point of measurement. The Uncompahgre ditch heads a short distance below.

List of discharge measurements made on Uncompahgre River at Fort Crawford, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 25	F. Cogswell	55	4.60	123	6.80	834
2	Aug. 26	.....do	14	3.25	64	3.38	218
3	Oct. 7	.....do	14	2.60	43	2.05	89
4	Nov. 18	.....do	14	2.55	41	2.23	92

A rating table has been made from the above-mentioned measurements by sketching a curve through the point given by measurement No. 1, 0.02 feet below No. 2, 0.01 below No. 3, and 0.07 above No. 4. This is fairly applicable for 1895.

Rating table for Uncompahgre River at Fort Crawford, Colo.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
2.20	21	3.50	287
2.30	38	3.60	315
2.40	55	3.70	346
2.50	72	3.80	379
2.60	90	3.90	415
2.70	108	4.00	454
2.80	127	4.10	497
2.90	147	4.20	547
3.00	167	4.30	601
3.10	188	4.40	665
3.20	211	4.50	740
3.30	235	4.60	835
3.40	260	4.70	955

Daily gage height of the Uncompahgre River at Fort Crawford, Colo., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	4.60	3.90	3.00	2.60	2.50	2.55
2	....	4.60	3.65	3.00	2.55	2.50	2.65
3	....	4.40	3.45	3.00	2.50	2.50	2.60
4	....	4.45	3.40	2.90	2.50	2.50	2.60
5	....	4.50	3.20	2.80	2.55	2.60	2.65
6	....	4.45	3.10	2.80	2.65	2.40	2.60
7	....	4.35	3.05	2.70	2.55	2.50	2.60
8	....	4.30	3.00	2.70	2.50	2.50	2.60
9	....	4.15	3.05	2.70	2.50	2.50	2.50
10	....	4.20	3.00	2.70	2.50	2.50	2.60
11	....	4.40	3.00	2.70	2.50	2.50	2.60
12	....	4.20	3.00	2.60	2.45	2.50	2.60
13	....	4.20	3.15	2.60	2.40	2.60	2.65
14	....	4.10	4.50	2.60	2.40	2.50	2.60
15	....	4.10	4.45	2.60	2.40	2.50	2.60
16	....	4.05	3.95	2.60	2.40	2.60	2.60
17	....	4.00	3.65	2.50	2.40	2.60	2.55
18	....	3.90	3.50	2.50	2.40	2.60	2.60
19	....	3.90	3.40	2.50	2.40	2.60	2.50
20	....	3.80	3.30	3.00	2.40	2.65	2.60
21	....	3.70	3.20	2.75	2.40	2.60	2.75
22	....	3.60	3.30	2.85	2.50	2.60	2.45
23	....	3.55	4.10	2.85	2.60	2.65	2.50
24	....	3.50	3.45	2.85	2.55	2.60	2.50
25	4.60	3.40	3.35	2.80	2.50	2.60	2.80
26	4.75	3.35	3.20	2.80	2.50	2.60	3.10
27	4.75	3.25	3.20	2.75	2.50	2.60	3.45
28	5.05	3.25	3.25	2.70	2.50	2.60	2.90
29	4.85	3.15	3.20	2.70	2.50	2.55	3.20
30	4.65	3.35	3.20	2.70	2.50	2.55	3.00
31	....	3.30	3.05	....	2.50	....	3.40

Estimated discharge of Uncompahgre River at Fort Crawford, Colo.

[Drainage area, 497 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	835	200	465	28,593	1.08	0.94
August	740	167	278	17,094	0.64	0.56
September	167	72	117	6,963	0.27	0.24
October	99	55	70	4,304	0.16	0.14
November	99	55	82	4,879	0.19	0.17
December	260	9	106	6,518	0.24	0.21

WHITEWATER STATION, ON GUNNISON RIVER.

This point of observation is at the railroad station of Whitewater, 13 miles southeasterly from Grand Junction, and is on the right bank of Gunnison River. The gage rod was placed on April 11, 1895, by the Denver and Rio Grande Railroad Company, the station agent being observer. The gage consists of vertical rod graduated to feet and halves. A cable is stretched across the river at this point and is used by the residents of the vicinity for the purpose of crossing the stream. No measurements of discharge have been made at this point.

GRAND JUNCTION STATION, ON GUNNISON RIVER.

This station was originally located at the pump house of the Denver and Rio Grande Railroad, 1 mile from town, beyond the railroad bridge crossing Grand River. It was found, however, that the height on the rod at this point was influenced greatly by high water in the Grand. It was therefore decided to place a new gage at the highway bridge, about one-half mile farther upstream. This was fastened to the pier of the bridge on July 3, 1895, the attempt being made to so place it that the readings should coincide with those on the old gage at the pump house. The observer was instructed to read both gages for one month, in order to obtain comparative results. On October 1 the water had gone down and it was found that the gage at the wagon bridge was of doubtful value, as mud was deposited against it so that it could not be read. The gage at the bridge is vertical and consists of a 2-inch by 6-inch timber divided into tenths of a foot. It is bolted to the stone bridge pier. The initial point for soundings is on the right bank at the end of the bridge. The channel above the station is curved, but below is nearly straight. The right bank is low and liable to overflow, but the left is high and rocky, with still water at low stages. The top of the capstone is 3.6 feet above the 14-foot mark on this gage.

Daily gage height in feet of Gunnison River at Grand Junction, Colo., for 1894.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1		1.60	1.7	17		1.60	1.7
2		1.60	1.7	18		1.60	1.7
3		1.60	1.7	19	1.25	1.60	1.7
4		1.60	1.7	20	1.60	1.60	1.7
5		1.60	1.7	21	1.70	1.60	1.7
6		1.60	1.7	22	1.60	1.60	1.7
7		1.60	1.7	23	1.60	1.60	1.7
8		1.60		24	1.60	1.60	1.7
9		1.60	1.6	25	1.60	1.40	1.7
10		1.60	1.6	26	1.60	1.40	1.7
11		1.60	1.6	27	1.60	1.40	1.7
12		1.60	1.6	28	1.80	1.40	1.7
13		1.60	1.6	29	1.80	1.40	1.7
14		1.60	1.6	30	1.60	1.40	1.6
15		1.60	1.6	31	1.60		1.6
16		1.60	1.6				

List of discharge measurements made on Gunnison River at Grand Junction, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
1	Oct. 17	A. P. Davis	22	1.25		0.80	748
	1895.						
2	June 28	do	55	4.74	1,405	2.94	4,178
3	July 17	do	55	3.60	1,328	1.99	2,642
4	Oct. 1	do	61	1.95	996	0.78	781

Daily gage height of Gunnison River at Grand Junction, Colo., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.60	1.70	1.80	3.20	6.00	5.25	5.30	3.05	1.90	1.60	1.80	1.90
2..	1.60	1.70	1.80	3.00	5.70	5.35	5.05	3.00	1.90	1.60	1.80	1.90
3..	1.60	1.70	1.80	2.10	5.45	5.35	4.85	3.00	1.90	1.60	1.80	1.10
4..	1.60	1.70	1.80	2.90	5.10	5.50	4.55	2.90	1.80	1.60	1.80	1.10
5..	1.60	1.70	1.80	3.20	5.00	5.45	4.25	2.90	1.80	1.60	1.80	1.10
6..	1.60	1.70	1.80	2.90	4.80	5.50	4.15	3.00	1.80	1.80	1.80	1.10
7..	1.60	1.70	1.80	2.65	4.50	5.70	3.85	2.80	1.80	1.80	1.80	1.10
8..	1.60	1.70	1.80	3.20	4.50	6.05	3.85	2.90	1.60	1.80	1.80	1.80
9..	1.60	1.70	1.80	3.25	6.15	6.25	3.75	2.70	1.60	1.80	1.80	1.80
10.	1.60	1.70	1.60	3.60	6.65	6.35	3.95	2.80	1.60	1.80	1.10	1.80
11.	1.60	1.70	1.60	3.75	7.20	6.60	3.95	2.20	1.50	1.70	1.11	1.80
12.	1.60	1.70	1.60	4.20	7.00	6.80	4.15	2.20	1.50	1.70	1.11	1.80
13.	1.70	1.70	1.60	4.65	6.90	6.80	4.25	2.20	1.50	1.80	2.10	1.80
14.	1.70	1.70	1.60	5.05	7.00	6.70	4.50	2.30	1.50	1.80	2.10	1.80
15.	1.70	1.70	1.60	5.60	7.20	6.65	3.80	2.30	1.60	1.80	2.10	1.80
16.	1.70	1.70	1.60	5.15	7.20	6.70	3.65	2.10	1.60	1.80	1.60	1.80
17.	1,70	1.70	1.60	4.70	7.05	6.60	3.55	2.00	1.60	1.80	1.10	1.80
18.	1.70	1.70	1.60	5.40	6.65	6.35	3.50	2.10	1.60	1.80	1.90	1.80
19.	1.70	1.70	1.60	5.90	6.10	5.70	3.35	2.80	1.60	1.80	1.80	1.80
20.	1.70	1.70	1.60	6.85	6.00	5.25	3.05	2.80	1.70	1.70	1.80	1.80
21.	1.70	1.70	1.60	7.05	6.05	5.20	2.90	2.85	1.70	1.70	1.60	a1.80
22.	1.70	1.70	1.60	6.90	6.30	5.00	2.85	3.00	1.60	1.70	1.60	....
23.	1.70	1.70	1.60	6.70	6.00	5.00	2.75	3.20	1.60	1.70	1.60	....
24.	1.70	1.90	1.85	6.55	6.00	4.95	2.65	2.80	1.60	1.70	1.60	....
25.	1.70	1.90	1.50	6.70	5.50	5.05	2.65	2.20	1.60	1.70	1.60	....
26.	1.70	1.90	1.50	6.90	5.25	5.10	2.60	2.10	1.60	1.70	1.60	....
27.	1.70	1.90	2.20	6.90	5.05	5.10	2.60	2.00	1.60	1.80	1.60	....
28.	1.70	1.90	2.60	6.45	5.40	5.00	2.60	2.00	1.60	1.80	1.60	....
29.	1.70	......	2.90	7.05	4.60	5.05	2.55	1.10	1.60	1.80	1.60	....
30.	1.70	......	3.00	6.95	5.25	5.55	2.50	1.10	1.60	1.80	1.60	....
31.	1.70	......	......	......	5.25	......	2.75	1.90	......	1.80	......	....

a Last report; frozen.

DOLORES AND SAN MIGUEL RIVERS.

Dolores River is the last large tributary of Grand River. It rises in southwestern Colorado, adjacent to the head-waters of the Gunnison, and, flowing northwesterly, crosses the Colorado line into Utah, where its waters soon unite with those of Grand River. At its head-waters the stream and its tributaries are used to a considerable extent for irrigation, developments proceeding rapidly as the country is being settled. Two stations for measuring the available water have been established, one upon the Dolores, in the vicinity of the town of Dolores, Montezuma County, and the other on the head-waters of the San Miguel, near Seymour, in San Miguel County.

DOLORES STATION, ON DOLORES RIVER.

This station was established by Mr. F. Cogswell in June, 1895. The gage is located about one-half mile above the railroad station at the footbridge from which the measurements of discharge are made. The gage is vertical, and is spiked to the crib abutment of the bridge on the left bank. The bench mark consists of a nail driven in the base of a cottonwood tree 18 feet southwesterly from the gage. This is 1.60 feet above the 14-foot mark. The locality is especially good for accurate measurement, as the bed of the stream is apparently permanent and the banks are not liable to overflow at moderate stages. A number of measurements have been made during the year from which a rating table has been constructed sufficient to form a basis for estimates of monthly discharge.

List of discharge measurements made on Dolores River at Dolores, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 22	F. Cogswell	55	3.50	223	3.40	756
2	Aug. 28	do	14	2.70	81	2.00	163
3	Oct. 9	do	14	2.50	59	1.51	89
4	Nov. 20	do	14	2.40	51	1.45	75

Rating table for Dolores River at Dolores, Colo., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
2.20	17	3.00	281
2.30	42	3.10	340
2.40	68	3.20	405
2.50	97	3.30	490
2.60	127	3.40	605
2.70	158	3.50	756
2.80	195	3.60	940
2.90	235	3.70	1,115

Daily gage height of Dolores River, at Dolores, Colo., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.20	2.90	2.65	2.40	2.40	3.10
2		3.20	2.70	2.60	2.50	2.40	3.25
3		3.25	3.00	2.60	2.40	2.40	3.35
4		3.30	3.35	2.50	2.40	2.40	3.10
5		3.25	3.20	2.50	2.50	2.50	3.10
6		3.20	3.20	2.50	2.50	2.40	3.35
7		2.60	3.25	2.50	2.50	2.35	3.25
8		3.00	3.30	2.40	2.50	2.30	3.25
9		3.00	3.25	2.40	2.50	2.50	3.15
10		3.00	3.20	2.40	2.50	2.50	3.00
11		3.00	2.70	2.50	2.50	2.50	3.10
12		2.90	2.95	2.50	2.40	2.50	3.20
13		3.00	3.00	2.50	2.40	2.50	3.25
14		3.00	2.85	2.40	2.40	2.45	3.15
15		3.00	3.00	2.40	2.40	2.60	3.20
16		2.95	2.85	2.40	2.40	2.60	3.10
17		2.85	2.75	2.40	2.40	2.60	3.15
18		2.85	2.80	2.40	2.40	2.45	3.10
19		2.85	2.80	2.45	2.40	2.45	3.05
20		2.80	2.80	2.75	2.40	2.50	3.15
21		3.00	2.50	2.65	2.40	2.45	3.25
22		2.85	2.50	2.60	2.45	2.70	3.15
23	3.50	2.85	3.00	2.50	2.50	2.75	3.05
24	3.45	2.80	2.70	2.50	2.50	2.75	3.00
25	3.40	2.80	2.60	2.50	2.50	2.80	3.15
26	3.40	2.80	2.70	2.50	2.40	2.50	3.25
27	3.45	2.90	2.60	2.50	2.40	2.95	3.40
28	3.50	3.00	2.65	2.50	2.40	3.20	3.25
29	3.55	2.70	2.65	2.40	2.40	3.20	3.25
30	3.45	2.75	2.75	2.40	2.40	3.05	3.40
31		2.80	2.75		2.40		3.40

Estimated discharge of Dolores River at Dolores, Colo.

[Drainage area, 562 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	490	127	270	16,602	0.55	0.48
August	548	97	248	15,249	0.51	0.44
September	177	68	99	5,891	0.20	0.18
October	97	68	79	4,858	0.16	0.14
November	405	42	134	7,974	0.27	0.24
December	605	281	419	26,378	0.86	0.75

SEYMOUR STATION, ON SAN MIGUEL RIVER.

This station was established by Mr. F. Cogswell in June, 1895. The gage is about 300 yards southwest of the switch called Fall Creek, on the Denver and Rio Grande Railroad. It is on the opposite side of the river from the post-office of Seymour, located on Fall Creek. The observer is John H. Schofield, an employee of the railroad company. Discharge measurements are made from the bridge on the wagon road between Seymour post-office and Fall Creek switch. The gage is vertical, 4 inches by 4 inches, and is spiked to the bridge abutment on the west side. One bench mark is a bolthead in the north end of the west truss, 1 foot from the gage. It is 1.15 feet above the 10-foot mark. The second bench mark is a spike driven into a tree 200 feet northwest. This is 1.35 feet below the 10-foot mark. As the channel at this point is nearly straight and the banks are rarely overflowed the section is a desirable one for measurements.

List of discharge measurements made on San Miguel River at Seymour, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 24	F. Cogswell	55	4.00	104	4.90	512
2	Aug. 27	.....do	14	3.20	66	3.08	205
3	Oct. 8	.....do	14	2.65	36	2.24	81

A rating table has been constructed for San Miguel River, based upon a curve drawn through the points given by measurements Nos. 1, 2, and 3. This is as follows:

Rating table for San Miguel River at Seymour, Colo.

Gage height.	Discharge.	Gage. height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
2.30	13	3.40	263
2.40	32	3.50	295
2.50	51	3.60	328
2.60	70	3.70	366
2.70	90	3.80	410
2.80	112	3.90	458
2.90	134	4.00	512
3.00	156	4.10	587
3.10	180	4.20	675
3.20	205	4.30	790
3.30	233		

Daily gage height of San Miguel River at Seymour, Colo., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	3.92	3.55	3.05	2.65	2.55	2.00
2	....	4.05	3.55	2.95	2.65	2.55	2.05
3	....	4.50	3.45	2.95	2.65	2.45	2.25
4	....	3.85	3.45	2.80	2.65	2.45	2.05
5	....	3.95	3.35	2.75	2.65	2.45	2.10
6	....	3.95	3.35	2.75	2.65	2.35	2.25
7	....	3.95	3.25	2.75	2.65	2.35	2.30
8	....	3.85	3.35	2.65	2.65	2.25	2.25
9	....	3.75	3.25	2.65	2.55	2.15	2.05
10	....	3.75	3.15	2.55	2.55	2.05	2.05
11	....	3.70	3.05	2.75	2.55	2.05	2.05
12	....	3.45	2.95	2.65	2.55	2.15	2.05
13	....	3.45	3.05	2.75	2.55	2.25	2.10
14	....	3.55	3.50	2.65	2.55	2.15	2.05
15	....	3.55	3.45	2.65	2.55	2.15	2.05
16	....	3.55	3.35	2.65	2.55	2.25	2.00
17	....	3.55	3.45	2.65	2.55	2.35	2.00
18	....	3.55	3.35	2.65	2.55	2.35	2.00
19	....	3.55	3.25	2.85	2.50	2.45	2.00
20	....	3.45	3.15	2.95	2.45	2.55	2.00
21	....	3.45	3.25	2.95	2.55	2.75	2.00
22	....	3.45	3.25	2.85	2.65	2.90	2.00
23	....	3.45	3.25	2.75	2.75	3.10	2.00
24	....	3.45	3.15	2.75	2.65	3.05	2.00
25	4.05	3.35	3.15	2.65	2.55	3.00	2.00
26	4.08	3.15	3.45	2.65	2.55	2.55	2.00
27	4.07	3.25	3.20	2.65	2.45	2.20	2.00
28	4.05	3.25	3.25	2.65	2.45	2.10	2.00
29	4.12	3.45	3.15	2.65	2.45	2.05	2.00
30	4.00	3.45	3.15	2.65	2.45	2.00	2.00
31	....	3.45	3.15	....	2.45	....	2.00

Estimated discharge of San Miguel River at Seymour, Colo.

[Drainage area, 327 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	675	219	347	21,336	1.22	1.06
August	312	145	230	14,142	0.81	0.70
September	168	61	100	5,950	0.35	0.31
October	101	42	64	3,935	0.23	0.20
November	180	....	30	1,785	0.11	0.10
December	....	....	10	615	0.03	0.03

SAN JUAN RIVER.

The San Juan River drains a portion of southwestern Colorado, its principal tributaries flowing southerly across the Colorado line into northern New Mexico. Here they enter the river, which, taking a general westerly course, flows from New Mexico into southern Utah and finally enters into the Colorado within the Grand Canyon region. Comparatively little water is received by this river from the south. The principal streams come from the San Juan and the La Plata mountains. These are, in succession downstream, the Piedra, Animas, La Plata, and Mancos. Systematic measurements have been made at three points, these being on the San Juan at Arboles, on the Piedra at its mouth near Arboles, and on the Animas at Durango.

Rio Florida enters the Animas River from the east about 12 miles south of Durango. On June 20, 1895, it was flowing about 75 second-feet at Florida. It is said that all of the water is used for irrigation during the dry season. A number of ditches are taken out above the railroad. Rio de los Pinos, east of Rio Florida, was examined at Ignacio. The discharge in June was between 100 and 200 second-feet. A large amount of water is diverted above the railroad. No favorable locality for measurement was found. Rio La Plata was examined at Hesperus. It was found that it was flowing about 60 second-feet, considerable amounts of water being diverted at points above. The Mancos River at Mancos was flowing approximately 60 second-feet, much water being taken out.

ARBOLES STATION, ON SAN JUAN RIVER.

This station was established by Mr. F. Cogswell in June, 1895, at a footbridge about 200 yards below the section house on the Denver and Rio Grande Railroad. The observer is T. F. Burke, section foreman. The first gage consisted of a 2-inch by 6-inch plank placed vertically and fastened to the crib pier in the middle of the river. The channel at this point is straight, both above and below the station. More than nine-tenths of the water passes between the right bank and the first crib, where the water is deep and swift. A better point of measurement would be a short distance below the bridge, if a cable could be placed there. On October 11 a new gage 4 inches by 4 inches was fastened to the rocky bank in order to take the place of the old gage, which was not firm.

List of discharge measurements made on San Juan River at Arboles, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 21	F. Cogswell	55	7.30	444	3.50	1,556
2	Aug. 30	.....do	14	6.20	273	1.42	387
3	Oct. 11	.....do	14	5.80	251	0.86	215
4	Nov. 25	.....do	14	5.90	260	0.97	252

Rating table for San Juan River at Arboles, Colo., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
5.30	23	6.40	494
5.40	60	6.50	553
5.50	97	6.60	620
5.60	135	6.70	695
5.70	174	6.80	777
5.80	214	6.90	865
5.90	254	7.00	970
6.00	295	7.10	1,108
6.10	339	7.20	1,298
6.20	388	7.30	1,555
6.30	439	7.40	1,770

Daily gage height of San Juan River at Arboles, Colo., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	6.90	6.45	6.00	5.70	5.70	5.80
2	....	6.80	6.60	6.00	5.70	5.70	5.95
3	....	6.70	6.80	6.00	5.70	5.70	5.95
4	....	6.70	6.50	5.95	5.85	5.75	5.85
5	....	6.70	6.40	5.90	6.10	5.80	5.90
6	....	6.60	6.30	5.90	5.95	5.70	5.80
7	....	6.50	6.30	5.80	5.90	5.70	5.80
8	....	6.50	6.20	5.80	5.90	5.80	....
9	....	6.45	6.20	5.80	5.80	5.75	....
10	....	6.80	6.15	5.80	5.80	5.65	....
11	....	7.25	6.10	5.80	5.80	5.60	....
12	....	7.25	6.10	5.80	5.80	5.70	....
13	....	6.85	6.10	5.80	5.80	5.80	....
14	....	6.70	6.50	5.70	5.75	5.80	....
15	....	6.60	6.60	5.70	5.70	5.70	....
16	....	6.55	6.35	5.70	5.70	5.60	....
17	....	6.50	6.15	5.70	5.70	5.70	....
18	....	6.40	6.05	5.70	5.70	5.75	....
19	7.40	6.40	6.00	5.70	5.70	5.75	....
20	7.35	6.30	5.95	6.00	5.70	5.80	....
21	7.25	6.20	5.90	6.00	5.70	5.80	....
22	7.20	6.55	5.90	5.85	5.70	5.80	....
23	7.20	6.60	6.65	5.80	5.85	5.95	....
24	7.10	6.70	6.45	5.80	5.80	5.90	....
25	7.00	6.75	6.15	5.80	5.80	5.90	....
26	7.00	6.40	6.05	5.80	5.80	5.90	....
27	7.00	6.30	6.00	5.70	5.80	5.80	....
28	7.10	6.30	6.30	5.70	5.80	5.70	....
29	7.20	6.30	6.20	5.70	5.80	5.70	....
30	7.10	6.25	6.20	5.70	5.70	5.80	....
31	....	6.35	6.05	....	5.70	....	....

Estimated discharge of San Juan River at Arboles, Colo.

[Drainage area, 1,394 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	1,427	414	635	39,046	0.53	0.46
August	777	254	422	25,949	0.35	0.30
September	295	174	220	13,090	0.18	0.16
October	339	174	206	12,667	0.17	0.15
November	275	135	197	11,722	0.16	0.14

ARBOLES STATION, ON PIEDRA RIVER.

This station was established by Mr. F. Cogswell in June, 1895, at the point where the Denver and Rio Grande Railroad crosses the river, about one-half mile from the gage on the San Juan. The same observer records the height here and at the other point. The measurements of discharge are made from the railroad bridge. The gage consists of a 2-inch by 6-inch plank spiked to the crib just below the bridge on the east side of the river. The 10-foot mark on the gage is 4.88 feet below a cross cut in the top of the abutment in the southeast corner of the bridge No. 402A. The initial point for soundings is at the east end of the bridge. The channel above the station is straight, but the water is broken by cribs for catching floating logs.

List of discharge measurements made on Piedra River at Arboles, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 21	F. Cogswell	55	3.90	178	3.40	606
2	Aug. 30	do	14	3.20	121	1.94	*a* 235
3	Oct. 11	do	14	2.90	95	1.47	140
4	Nov. 25	do	14	2.80	87	1.31	115

a Water very muddy, affecting meter.

Rating table for Piedra River at Arboles, Colo., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
2.50	33	3.50	342
2.60	60	3.60	385
2.70	87	3.70	432
2.80	114	3.80	483
2.90	141	3.90	539
3.00	170	4.00	602
3.10	200	4.10	670
3.20	233	4.20	744
3.30	267	4.30	828
3.40	303		

Daily gage height of Piedra River at Arboles, Colo., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	3.60	3.30	2.95	2.70	2.70	2.80
2	....	3.50	3.50	2.90	2.70	2.70	2.85
3	....	3.50	3.40	2.95	2.70	2.70	2.85
4	....	3.50	3.30	2.90	2.85	2.80	2.80
5	....	3.50	3.20	2.80	3.05	2.70	2.80
6	....	3.40	3.10	2.80	2.90	2.60	2.80
7	....	3.30	3.05	2.80	2.90	2.80	2.80
8	....	3.25	3.00	2.75	2.90	2.75	....
9	....	3.20	3.10	2.70	2.90	2.70	....
10	....	3.30	3.10	2.70	2.90	2.65	....
11	....	3.85	3.00	2.70	2.90	2.60	....
12	....	4.10	3.00	2.80	2.90	2.65	....
13	....	3.95	3.00	2.70	2.85	2.60	....
14	....	3.95	3.40	2.70	2.80	2.80	....
15	....	3.80	3.30	2.70	2.80	2.70	....
16	....	3.60	3.25	2.70	2.80	2.65	....
17	....	3.60	3.10	2.70	2.80	2.70	....
18	....	3.45	3.00	2.70	2.80	2.65	....
19	4.00	3.30	3.00	2.65	2.80	2.65	....
20	3.95	3.20	2.95	3.05	2.80	2.70	....
21	3.90	3.15	2.95	3.05	2.80	2.75	....
22	3.80	3.40	2.95	2.90	2.80	2.80	....
23	3.70	3.65	3.00	2.90	2.90	2.95	....
24	3.65	3.65	3.00	2.90	2.90	2.90	....
25	3.60	3.45	2.95	2.80	2.95	2.80	....
26	3.50	3.45	2.90	2.80	2.90	2.75	....
27	3.40	3.35	2.90	2.80	2.80	2.70	....
28	3.40	3.30	3.05	2.80	2.80	2.75	....
29	3.80	3.20	2.95	2.75	2.80	2.70	....
30	3.70	3.20	3.05	2.70	2.80	2.80	....
31	....	3.25	3.05	....	2.80	....	....

Estimated discharge of Piedra River at Arboles, Colo

[Drainage area, 650 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
June 19 to 30	602	303	432	25,706	0.73	0.66
July	670	233	346	21,275	0.61	0.53
August	342	141	200	12,298	0.36	0.31
September	185	87	115	6,843	0.20	0.18
October	185	87	125	7,686	0.22	0.19
November	156	60	93	5,534	0.16	0.14
December 1 to 7	127	114	118	7,256	0.21	0.18

DURANGO STATION, ON ANIMAS RIVER.

This point is about 200 yards west of the railroad station, at the wagon bridge crossing Animas River, 200 feet above the Rio Grande Southern Railroad bridge. The observer is George Robertson, a miller at Durango. The gage is spiked to the west side of the south end of the middle pier of the wagon bridge. The 15-foot mark on the gage is 2.24 feet below the head of a bolt at the east abutment of the railroad bridge. The banks are high and rocky and the section is excellent for obtaining accurate measurements of discharge. Lightner Creek enters Animas River from the right about 100 feet below the wagon bridge, and between it and the railroad bridge. On August 12 there was a cloudburst in the drainage basin of this creek, and the resulting flood brought down and deposited in Animas River great quantities of sand and gravel, damming up the west half of the stream and materially reducing the velocity in that part of the channel. As a result, the water stands at the gage on the wagon bridge about 0.30 foot higher than it would if this obstruction had not been formed.

List of discharge measurements made on Animas River at Durango, Colo.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 18	F. Cogswell	55	6.50	535	3.55	1,893
2	Aug. 29	do	14	5.80	415	1.30	543
3	Oct. 10	do	14	5.40	326	1.00	328
4	Nov. 24	do	14	5.20	292	0.89	260

By means of the measurements of discharge Mr. F. Cogswell has constructed a rating table applicable during 1895, this being based upon a curve drawn through the point given by measurement No. 2, 0.30 foot above that by No. 1, slightly above No. 4, and below No. 3. This curve was raised 0.30 foot above the point given by measurement No. 1, because the dam formed in the river by the wash from the cloudburst in Lightner Creek about August 13 caused the water to back up in the river so that the gage indicated a greater height than before.

Rating table for Animas River at Durango, Colo.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
4.40	20	5.70	482
4.50	46	5.80	542
4.60	74	5.90	606
4.70	102	6.00	674
4.80	131	6.10	750
4.90	160	6.20	836
5.00	191	6.30	930
5.10	224	6.40	1,049
5.20	259	6.50	1,214
5.30	296	6.60	1,443
5.40	335	6.70	1,675
5.50	379	6.80	1,892
5.60	429		

Daily gage height of Animas River at Durango, Colo., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	5.85	5.45	5.75	5.35	5.20	5.25
2	....	5.85	5.55	5.70	5.30	5.20	5.25
3	....	5.75	5.45	5.70	5.35	5.10	5.20
4	....	5.75	5.35	5.65	5.45	5.15	5.35
5	....	5.75	5.25	5.60	5.50	5.15	5.30
6	....	5.75	5.20	5.50	5.45	5.15	5.20
7	....	5.70	5.15	5.50	5.50	5.15	5.20
8	....	5.65	5.10	5.45	5.45	5.15	5.10
9	....	5.60	5.10	5.40	5.40	5.10	5.20
10	....	5.45	5.10	5.40	5.40	5.10	5.15
11	....	5.45	5.05	5.40	5.40	5.10	5.20
12	....	5.70	5.05	5.35	5.30	5.15	5.15
13	....	5.55	6.10	5.30	5.30	5.15	5.10
14	....	5.45	6.35	5.30	5.30	5.15	5.15
15	....	5.45	6.35	5.30	5.30	5.10	5.05
16	....	5.45	6.20	5.30	5.30	5.10	5.05
17	....	5.50	6.00	5.30	5.30	5.10	5.05
18	....	5.40	5.95	5.25	5.30	5.10	(*a*)
19	....	5.30	5.90	5.30	5.30	5.10	....
20	6.20	5.30	5.85	5.75	5.30	5.10	....
21	6.05	5.25	5.80	5.70	5.30	5.15	....
22	5.95	5.25	5.80	5.60	5.30	5.15	....
23	5.90	5.35	6.10	5.50	5.30	5.20	....
24	5.85	5.35	6.00	5.50	5.35	5.25	....
25	5.90	5.40	5.90	5.40	5.35	5.25	....
26	5.85	5.35	5.80	5.35	5.30	5.25	....
27	5.95	5.35	5.80	5.35	5.25	5.30	....
28	5.95	5.25	5.85	5.30	5.30	5.25	....
29	5.95	5.45	5.85	5.30	5.25	5.25	....
30	5.95	5.45	5.85	5.30	5.20	5.20	....
31	....	5.40	5.80	....	5.25	....	....

a Frozen from December 18 to 31, inclusive.

GREEN RIVER.

GREENRIVER STATION, ON GREEN RIVER.

Measurements of Green River have been made at intervals by Prof. Elwood Mead, State engineer of Wyoming, as shown in his biennial reports. During 1891 observations were maintained and computations of the daily discharge made from June 10 to September 10. The results are shown on page XXX of the State Engineer's Report for 1894. The average from June 10 to 30, 1891, was 8,743 second-feet. For July it was 6,709 second-feet, for August 2,938 second-feet, and for September 1 to 10 it was 1,624 second-feet. A single measurement of Green River above North Fork on July 21, 1894, gave a discharge of 2,427 second-feet. In the spring of 1895 the station at Greenriver was reestablished and observations continued until the river was frozen in November.

List of discharge measurements made on Green River at Greenriver, Wyo.

Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1895.						
June 20	W. M. Gilcrest........	Colo.	3.30	1,129	3.43	3,866
July 2	.....do	(*a*)	4.25	1,762	3.97	7,011
Oct. 22	.....do	....	1.15	306	1.36	418

a Measurements made with Small Price acoustic meter.

Rating table for Green River at Greenriver, Wyo.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
0.1	11	2.3	1,820
0.2	24	2.4	2,000
0.3	38	2.5	2,168
0.4	57	2.6	2,345
0.5	91	2.7	2,530
0.6	107	2.8	2,735
0.7	146	2.9	2,935
0.8	200	3.0	3,150
0.9	259	3.1	3,375
1.0	321	3.2	3,600
1.1	400	3.3	3,865
1.2	482	3.4	4,120
1.3	560	3.5	4,400
1.4	655	3.6	4,670
1.5	757	3.7	4,950
1.6	865	3.8	5,265
1.7	980	3.9	5,600
1.8	1,105	4.0	6,000
1.9	1,240	4.1	6,400
2.0	1,366	4.2	6,825
2.1	1,510	4.3	7,225
2.2	1,663	4.4	7,740

Daily gage height of Green River at railroad bridge at Greenriver, Wyo., for 1895.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	....	3.40	4.25	2.80	1.70	1.35	1.05
2	2.60	3.40	4.25	2.77	1.65	1.35	1.05
3	2.67	3.37	4.15	2.80	1.60	1.30	1.05
4	2.67	3.37	4.07	2.75	1.55	1.30	1.05
5	2.70	3.30	4.00	2.70	1.50	1.25	1.00
6	2.77	3.35	4.00	2.70	1.45	1.25	1.00
7	2.80	3.37	4.02	2.65	1.45	1.25	0.95
8	2.80	3.45	3.87	2.65	1.40	1.20	0.90
9	2.80	3.60	3.67	2.60	1.35	1.20	(*a*)
10	2.87	3.60	3.55	2.52	1.30	1.20	(*a*)
11	3.05	3.50	3.50	2.45	1.30	1.20	(*a*)
12	3.00	3.40	3.47	2.30	1.25	1.20	(*a*)
13	2.90	3.30	3.37	2.22	1.25	1.20	(*a*)
14	2.87	3.20	3.17	2.10	1.20	1.20	(*a*)
15	2.95	3.30	3.07	2.02	1.20	1.20	(*a*)
16	3.22	3.40	2.97	2.00	1.20	1.20	(*a*)
17	3.45	3.42	3.10	1.95	1.20	1.20	0.90
18	3.50	3.55	3.22	1.90	1.20	1.20	0.95
19	3.42	3.52	3.20	1.85	1.25	1.15	0.95
20	3.45	3.30	3.25	1.80	1.25	1.15	1.00
21	3.77	3.22	3.15	1.80	1.30	1.15	(*a*)
22	4.02	3.20	2.97	1.85	1.30	1.15	(*a*)
23	4.05	3.35	2.87	1.80	1.35	1.15	(*a*)
24	4.00	3.45	2.80	1.75	1.40	1.15	(*a*)
25	3.95	3.67	2.72	1.72	1.45	1.10	(*a*)
26	3.80	4.02	2.70	1.75	1.50	1.10	(*a*)
27	3.70	4.22	2.70	1.80	1.45	1.10	(*a*)
28	3.77	4.20	2.75	1.80	1.40	1.10	(*a*)
29	3.80	4.12	2.77	1.85	1.40	1.10	(*a*)
30	3.72	4.22	2.80	1.80	1.40	1.10	(*a*)
31	3.55	....	2.85	1.72	....	1.10	(*a*)

a River frozen from November 9 to 16, inclusive; also from November 21 to 30.

Estimated discharge of Green River at Greenriver, Wyo.

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
1895.				
May	6,200	2,345	3,968	243,983
June	6,915	3,600	4,547	270,565
July	7,050	2,530	4,119	253,267
August	2,735	1,005	1,704	104,775
September	980	482	638	37,964
October	608	400	472	29,022
November (1 to 8; 17 to 20)	361	230	309	19,000

WHITE RIVER STATION, ON WHITE RIVER.

Observations of the height of water in White River were begun on May 17, 1895, a gage having been put in place by Mr. H. A. Sumner, State engineer of Colorado. This is located about one-half mile by wagon road northeasterly from White River City. Two observations a day are taken by E. G. Foreman, a farmer living about one-eighth of a mile away. Measurements are made at a cable bridge carrying an irrigating flume. The gage is vertical, notched for each foot, and spiked to the root of a tree. The banks are low, but are not liable to overflow. A measurement made on May 16, 1895, by Mr. Sumner, when the water was at a height of 13.10 feet, showed a mean velocity of 5.87 feet per second and a total discharge of 3,047 second-feet.

Daily gage height of White River at White River City, Colo., for 1895, in feet.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	....	11.97	11.40	10.47	10.25	10.10	10.10
2	....	11.80	11.30	10.46	10.20	10.10	10.10
3	....	11.98	11.20	10.37	10.20	10.27	....
4	....	11.90	11.10	10.37	10.20	10.40	....
5	....	11.83	11.00	10.32	10.20	10.27	....
6	....	11.79	10.90	10.30	10.12	10.15	....
7	....	11.85	10.80	10.28	10.10	10.10	....
8	....	11.98	10.70	10.40	10.15	10.10	....
9	....	12.05	10.70	10.40	10.15	10.10	....
10	....	12.35	10.80	10.37	10.12	10.10	....
11	....	12.33	10.95	10.27	10.10	10.10	....
12	....	12.39	11.05	10.25	10.10	10.10	....
13	....	12.58	11.12	10.25	10.10	10.10	....
14	....	12.55	11.35	10.35	10.10	10.10	....
15	....	12.67	11.10	10.37	10.10	10.15	....
16	....	12.70	10.87	10.30	10.10	10.10	....
17	13.02	12.60	10.77	10.25	10.10	10.10	....
18	12.80	12.20	10.75	10.25	10.10	10.10	....
19	12.77	11.90	10.70	10.25	10.15	10.10	....
20	12.92	11.72	10.65	10.30	10.12	10.10	....
21	12.82	11.62	10.70	10.27	10.45	10.15	....
22	12.70	11.53	10.67	10.65	10.25	10.20	....
23	12.55	11.43	10.62	10.40	10.22	10.20	....
24	12.30	11.48	10.57	10.35	10.20	10.18	....
25	12.36	11.50	10.50	10.30	10.17	10.15	....
26	12.37	11.47	10.44	10.20	10.15	10.15	....
27	12.45	11.38	10.40	10.20	10.15	10.15	....
28	12.72	11.52	10.42	10.30	10.15	10.00	....
29	12.58	11.95	10.50	10.30	10.12	10.00	....
30	12.20	11.62	10.47	10.30	10.10	10.00	....
31	12.21	....	10.44	10.25	....	10.00	....

BLAKE STATION, ON GREEN RIVER.

This point is at the crossing of the Rio Grande Western Railroad at Blake, Utah. Observations were begun here on October 21, 1894, and continued through 1895. Two measurements have been made, the first on October 21, 1894, when, at a height of 1.98 feet, there was found to be a discharge of 3,035 second-feet, and the second on June 30, 1895, when the water stood at a height of 5.80 feet and the discharge was 15,065 second-feet.

In May the scale of the gage was struck by a floating tree and broken off. At that time the river was rising, and a temporary gage was put in to read as nearly as possible like the old one. On June 29 Mr. Arthur P. Davis fastened a new gage one-half foot lower than the original, as shown later by relation to the bench mark, making the readings

0.5 feet higher than on the old rod, it being feared that the water would drop below the former zero. From June 30 the readings are taken from the new gage. On September 29 an inclined gage was placed on Green River, as the exposed condition of the vertical gage rendered it liable to be torn away.

Daily gage height of Green River at Blake, Utah, for 1894, in feet.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	2.10	1.50	17	....	1.90	1.05
2	....	2.10	1.50	18	....	1.90	1.10
3	....	2.10	1.50	19	....	1.90	1.30
4	....	2.10	1.50	20	....	1.85	1.40
5	....	2.10	1.50	21	2.00	1.80	1.50
6	....	2.00	1.35	22	2.05	1.80	1.50
7	....	2.00	1.20	23	2.05	1.75	1.50
8	....	2.00	1.20	24	2.05	1.70	1.50
9	....	2.00	1.20	25	2.00	1.60	1.40
10	....	2.00	1.20	26	2.00	1.55	1.50
11	....	2.00	1.30	27	2.10	1.50	1.50
12	....	2.00	1.20	28	2.05	1.50	1.45
13	....	2.00	1.10	29	2.05	1.50	1.40
14	....	2.00	1.25	30	2.05	1.50	1.30
15	....	2.00	0.70	31	2.10	....	1.20
16	....	2.00	0.95				

Daily gage height of Green River at Blake, Utah, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.20	1.20	1.40	3.50	6.15	6.95	6.00	3.70	2.40	2.10	2.00	1.10
2	1.10	1.10	1.45	3.50	6.40	6.75	6.05	3.80	2.40	2.10	2.00	1.20
3	1.10	1.10	1.70	3.50	6.40	6.50	6.15	3.75	2.40	2.10	2.00	1.40
4	1.10	1.10	1.85	3.45	6.30	6.40	6.20	3.70	2.40	2.15	2.15	1.65
5	1.10	1.15	1.90	3.05	6.15	6.25	6.05	3.65	2.35	2.20	2.20	1.70
6	1.20	1.20	2.05	3.00	5.95	5.95	5.75	3.60	2.25	2.30	2.10	1.80
7	1.20	1.20	2.10	3.00	5.65	5.95	5.65	3.55	2.20	2.65	2.00	1.70
8	1.10	1.25	2.10	3.00	5.60	6.10	5.50	3.50	2.20	2.60	2.10	1.70
9	1.30	1.30	2.20	3.00	5.50	6.00	5.40	3.40	2.10	2.50	2.05	1.60
10	1.20	1.30	2.15	3.00	5.55	5.95	5.40	3.40	2.10	2.40	2.00	1.65
11	1.25	1.30	2.10	3.00	5.80	5.90	5.30	3.35	2.00	2.45	2.10	1.70
12	1.30	1.30	2.10	2.95	6.25	6.05	5.35	3.25	2.00	2.65	2.10	1.60
13	1.20	1.20	2.10	2.90	6.75	6.25	5.45	3.20	2.00	2.70	2.10	1.65
14	1.20	1.20	2.10	3.05	7.10	6.40	5.25	3.45	1.90	2.60	2.10	1.70
15	1.20	1.20	2.20	3.15	7.20	6.30	5.25	3.50	1.90	2.55	2.00	1.80
16	1.25	1.20	2.35	3.60	7.25	6.30	5.30	3.20	1.80	2.45	1.90	1.75
17	1.30	1.20	2.25	3.80	7.45	6.20	5.25	2.95	1.80	2.40	1.90	1.80
18	1.40	1.20	2.25	3.95	7.55	6.05	5.15	2.90	1.95	2.25	1.90	1.70
19	1.40	1.20	1.95	4.30	7.60	6.00	4.85	2.85	2.80	2.10	1.90	1.70
20	1.50	1.20	1.90	4.50	7.60	6.05	4.65	2.80	2.25	2.10	1.90	1.80
21	1.50	1.20	2.05	4.40	7.50	5.95	4.45	2.75	2.00	2.10	2.00	1.80
22	1.45	1.20	2.20	4.70	7.50	5.90	4.40	2.70	1.90	2.25	2.00	1.80
23	1.40	1.20	2.70	5.20	7.45	5.75	4.30	2.60	1.90	2.60	2.10	1.70
24	1.30	1.20	3.60	5.40	7.40	5.45	4.30	2.50	1.90	2.20	2.10	1.60
25	1.25	1.35	3.60	5.50	7.45	5.30	4.30	2.45	1.80	2.15	1.90	1.65
26	1.25	1.40	3.30	5.30	7.40	5.30	4.25	2.40	1.90	2.10	1.80	1.70
27	1.30	1.40	3.05	5.20	7.30	5.20	4.15	2.50	1.95	2.10	1.55	1.60
28	1.30	1.40	2.90	5.55	7.20	5.25	4.00	2.45	2.00	2.10	1.25	1.50
29	1.20	......	2.90	5.80	7.20	5.50	3.90	2.40	2.00	2.10	1.15	1.40
30	1.20	......	3.00	5.95	7.10	a5.85	3.80	2.40	2.10	2.05	1.00	1.40
31	1.20	......	3.20	......	7.00	......	3.75	2.40	......	2.00	......	1.45

a New gage.

HELPER STATION, ON PRICE RIVER.

This station has been described on page 48 of Bulletin No. 131. Observations have been continued throughout the year, but it has not been practicable to maintain regular series of discharge measurements. On July 1, 1895, Mr. Arthur P. Davis made a measurement, the total discharge found being 119 second-feet.

GILA RIVER.

The Gila River, draining southern Arizona and a small portion of western New Mexico, flows in a general western course and enters Colorado River near the town of Yuma. This is the lowest and last large tributary of the Colorado. This stream has been described in the Twelfth Annual Report United States Geological Survey, Part II, Irrigation, pages 292–316. Systematic measurements of the volume of this stream and of its tributaries have not been made since the time of those given on page 306 of the report just mentioned. There is a possible exception, however, in the case of the discharge at the Arizona dam, 30 miles above Phœnix, where it is probable that records have been kept, although the results have not been made public.

The development of irrigation by the use of the waters of the Salt and Verde rivers has proceeded rapidly, especially in the vicinity of Phœnix, and the canal systems have been enlarged and extended. To furnish these with a perennial supply of water it has been found necessary to provide storage reservoirs. One of these, under construction by the Rio Verde Canal Company, is situated in T. 8 N., R. 6 E. The height of the dam is 183 feet, the length on top 1,150, the length on bottom 360 feet, and the depth to bed rock is 23 feet. The estimated capacity is 205,000 acre-feet.

The waters stored in this reservoir will be turned into the river again and diverted about 25 miles lower down into a canal which is about 25 feet wide on bottom, with side slopes of 1 to 1. The depth of water is 8 feet and the capacity is estimated to be about 800 second-feet, with a grade of 0.3 foot per 1,000, or 1.584 feet per mile. This canal continues for 65 miles above and approximately parallel to the Arizona Canal, and intersects New River. Here another reservoir is to be built with a capacity of 110,000 acre-feet. The dam is to be 100 feet high and 1,800 feet long on top. The canal continues the Hassayampa, where it sends off a feeder to another reservoir near the mouth of the Hassayampa, with a capacity of 700,000 acre-feet and a dam 90 feet high. All dams are to be of the rock-fill type, including the diversion dam, which will be 90 feet high.

It is claimed that the project complete will irrigate about 400,000 acres. The cost of the dam on the Rio Verde is estimated at $600,000, that of the diversion dam at $200,000, and of the canal at $1,200,000. The whole project complete is estimated to cost between $3,000,000 and $4,000,000. A considerable stretch of the canal is said to be completed, and work is in progress on the rest. Work is also progressing on the tunnel, which is destined to take water from the Rio Verde reservoir. The canal is largely through rough country and will be very expensive.

The Hudson Reservoir and Canal Company have a reservoir site at the junction of Salt River and Tonto Creek. It is asserted that a dam built in the solid-rock gorge below the mouth of Tonto Creek, to a height of 205 feet, would be 610 long on top, and would impound over 800,000 acre-feet of water, in a reservoir covering 11,000 acres. No work has yet been done on construction, but measurements of the Salt and Verde rivers have been carried on by the company for a period of nearly a year. The chief engineer of this company, Mr. A. P. Man, made an examination of the Salt River for some 8 miles above the Verde and also for several miles up Verde River for suitable places at which to measure the discharge of water, seeking a straight reach, uniform cross section, accessibility in time of floods, and other desirable features. For any stage of water under some fifteen or twenty times the normal flow, estimated at 500 to 540 second-feet, and for, say, 340 or 350 days in the year, the most favorable and convenient point found on the Salt River was about 1 mile above the mouth of the Verde, where the bottom is of cobbles and heavy gravel and does not frequently change its form. Gages have been placed there and most of the measurements of the discharge of Salt River have been made at that point. A point about 2 miles further up the river gives a better cross section in time of floods, is then more conveniently accessible, and less liable to interference of back water from the Verde River.

The measurements of the flow of the Verde River were taken at a point about half a mile above its junction with the Salt, gages being also set up there. It has been found impracticable by this company to attempt to measure the velocities of the current by meters. Attempts made in 1893 were so frequently interrupted by failures of the meter and other apparatus that such instruments were regarded as of little practical use on rivers of this character, even during small floods. It was assumed, therefore, that the product of the area of the cross section of the rivers multiplied by eight-tenths of the highest surface velocities measured by floats gave the discharge nearly enough for the purposes of the company. This has been the only method of measurements employed during 1895. The cross sections were remeasured and the velocities taken as frequently as was found necessary, and the results were checked at various times by measurements made at other points on the river.

The measurements of the discharges of the Salt and Verde rivers were began severally on February 4 and 5, 1895, and continued through the year without interruption, excepting on four days from October 4 to 7, inclusive, on Verde River, which was during that time inaccessible. An estimate for those four days has been made from the highest water mark found at the gage and from such other data as were available. Also, for the month of January, one of the most important flood months of the year, estimates have been prepared from the daily record taken at the Arizona dam, about a mile below the junction of the two rivers. It appears from all available data that Salt River furnishes a considerably larger proportion of water than Verde River, either on account of the greater rainfall, or the more rapid run-off, or the less use of water above. From observation on the ground during the heavy floods of January, and because of the fact that the snows pass off earlier from some of the upper water sheds of the Salt River, the assumption has been made that at least 60 per cent of the January flow at the Arizona dam came from Salt River above the Verde.

The minimum flow noted in seven years daily record at the Arizona dam occurred during July, 1895, and it would seem from that record and from other information and data, that there has been less water than usual flowing in these rivers during the year.

The results of the computed discharges for each locality are given in the following tables and also the sums of these, this being taken as the total flow of Salt River above the Arizona dam:

Estimated discharge of Verde River, above Salt River, Ariz.

[Drainage area, 6,000 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	33,000	527	4,037	248,225	0.77	0.67
February	5,800	583	1,688	93,747	0.29	0.28
March	8,400	1,887	3,720	228,734	0.71	0.62
April	2,800	280	750	44,628	0.14	0.13
May	429	127	258	15,864	0.04	0.04
June	180	129	153	9,104	0.03	0.03
July	275	116	145	8,916	0.02	0.02
August	1,426	185	359	22,074	0.07	0.06
September	348	141	176	10,473	0.03	0.03
October	3,912	197	475	29,207	0.09	0.08
November	1,800	241	463	27,550	0.09	0.08
December	881	345	391	24,042	0.08	0.07
Per annum	33,000	116	1,051	762,564	2.36	0.18

Estimated discharge of Salt River above mouth of Verde River, Ariz.

[Drainage area, 6,260 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	49,796	791	5,733	352,508	1.06	0.92
February	3,892	914	1,445	80,251	0.24	0.23
March	3,340	1,319	1,829	112,461	0.33	0.29
April	2,939	1,044	1,860	110,678	0.33	0.30
May	990	505	708	43,533	0.13	0.11
June	500	203	325	19,339	0.06	0.05
July	896	145	204	12,543	0.03	0.03
August	1,516	226	584	35,909	0.10	0.09
September	684	201	329	19,577	0.06	0.05
October	13,205	390	1,624	99,856	0.30	0.26
November	9,620	380	1,376	81,878	0.25	0.22
December	2,055	513	888	54,601	0.16	0.14
Per annum	49,796	145	1,408	1,023,134	3.05	0.22

Estimated discharge of Salt River below Verde River,[1] Arizona.

[Drainage area, 12,260 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	82,000	1,318	10,093	620,594	0.94	0.82
February	9,766	1,497	3,133	173,998	0.27	0.26
March	6,833	3,219	5,532	340,149	0.52	0.45
April	5,769	1,324	2,594	154,354	0.23	0.21
May	1,270	665	966	59,397	0.09	0.08
June	679	340	479	28,502	0.04	0.04
July	1,086	262	350	21,521	0.03	0.03
August	2,223	453	947	58,229	0.09	0.08
September	1,159	354	503	29,931	0.04	0.04
October	17,015	583	2,095	128,817	0.19	0.17
November	10,820	615	1,839	109,428	0.17	0.15
December	2,275	873	1,279	78,643	0.12	0.10
Per annum	82,000	262	2,484	1,803,563	2.73	0.20

BUTTES STATION, ON GILA RIVER.

In the fall of 1895 it was decided to resume measurements of Gila River, and a station was established by Mr. Arthur P. Davis, in December, at the buttes, 16 miles above Florence, Ariz., this work being done in connection with the investigation of the water supply for the Gila River Indian Reservation. A temporary gage was first driven into the river bed, from which observations were begun. The stream is measured from a car suspended from a cable stretched across the river. Two measurements were made, the first on December 28, giving a discharge of 585 second-feet, and the second on December 31, showing 519 second-feet.

LOWER COLORADO RIVER.

YUMA STATION, ON COLORADO RIVER.

This station is described in Bulletin 131, page 51. Records of river height have been maintained by the Southern Pacific Railroad Company at their bridge since April 1, 1878. The heights during 1894 have been published on page 52 of Bulletin 131. The gage at this point, reading from 10 to 22 feet, is nailed to the lower side of the first pier from the south bank of the river; the portion reading from 22 feet to 40 feet is nailed to an 8-inch by 8-inch post on the north side east of the bridge. The figures of gage height plus 100 is the Southern Pacific elevation above sea level. The channel of the river shifts very rapidly, the bed silting[2] and scouring with every change of river height, so that the relation of gage height to discharge is not constant. For example, on April 18, 1895, the area of cross section was 4,870 square feet, and

[1] Computed from data obtained from Mr. A. P. Man, based upon float measurements of Salt and Verde rivers above their junction.

[2] Mr. Hawgood reaches the conclusion that the Colorado River carries enough silt per annum to cover 100 square miles 6½ feet deep. He determines this both by laboratory tests and by a long series of records kept in the settling basins of the railroad tanks pumping stations at Yuma.

on July 10 for the plane of reference 10,704 square feet, showing a total scouring of 5,834 square feet in less than two months.

During 1895 the height of water was not as great as usual, but the spring flood continued for a longer period. The highest water usually occurs in May or June. In the interval between the two measurements mentioned the long-continued high water had evidently been scouring out the channel. In order to obtain reliable estimates of discharge it will be necessary to make frequent measurements of the river. At the time of the second measurement the Gila was reported to be dry, and all of the water was coming from the upper part of the Colorado basin. The velocities at this bridge are great, owing to the contraction of the river by the bluffs immediately above. The locality as a whole is unsatisfactory for discharge measurements, as the velocities are high and the river is deep. The channel is broken by piers and the water is greatly disturbed for 200 feet below the bridge.

List of discharge measurements made on Colorado River at Yuma, Ariz.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1876.					
a	Mar. 20	....	....	....	....	a 7,659
	1895.					
1	Jan. 17	A. P. Davis	24	20.30	3.80	9,737
2	Apr. 18	J. B. Lippincott...........	24	20.25	4.88	21,095
3	July 10	.....do	24	21.20	5.46	45,533

a Twelfth Annual Report United States Geological Survey, Part II, p. 292.

Daily gage height of Colorado River at Yuma, Ariz., for 1891, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	17.58	16.58	23.83	20.50	20.83	22.25	22.67	19.08	18.50	20.25	17.75	17.50
2..	17.75	16.69	22.17	19.00	21.67	21.92	22.67	19.00	18.25	19.92	17.75	17.50
3..	18.50	16.75	21.75	18.83	21.50	22.00	22.50	19.50	18.00	19.67	17.75	17.50
4..	18.92	16.83	20.83	18.75	21.67	21.92	22.25	19.25	17.92	19.67	17.75	17.42
5..	18.17	16.75	20.25	18.67	21.83	21.92	22.17	19.67	17.83	18.92	17.67	17.42
6..	17.92	16.75	20.00	18.58	22.25	22.08	21.92	20.08	17.83	18.50	17.67	17.33
7..	17.83	16.75	19.58	18.25	22.67	22.50	21.83	22.17	17.67	18.08	17.67	17.33
8..	17.75	16.83	19.25	18.00	22.83	22.58	21.67	20.25	17.58	18.00	17.67	17.42
9..	17.75	16.83	18.92	18.00	22.83	22.33	21.33	19.67	17.50	18.00	17.50	17.42
10.	17.67	16.83	18.75	17.92	22.92	22.00	21.33	19.42	17.42	18.50	17.50	17.33
11.	17.75	16.83	18.83	17.92	23.00	21.75	21.17	19.33	17.33	18.58	17.42	17.33
12.	18.50	16.83	19.17	17.83	23.17	21.50	21.00	19.33	17.25	18.08	17.32	17.33
13.	17.92	16.92	18.42	17.83	23.25	21.33	21.00	19.00	17.25	17.92	17.33	17.50
14.	17.92	16.75	18.00	17.92	23.58	21.25	21.00	18.75	17.17	17.75	17.25	17.50
15.	17.83	16.67	19.75	18.17	24.17	21.67	21.00	18.58	17.00	17.67	17.25	17.58
16.	17.83	16.75	19.50	18.75	24.83	22.25	20.92	18.50	16.92	18.00	17.25	17.67
17.	17.83	16.75	19.33	18.67	25.00	22.83	20.83	18.33	16.83	17.75	17.25	17.58
18.	17.75	16.83	19.00	18.50	24.83	23.00	20.75	18.33	16.67	17.75	17.25	17.58
19.	17.67	17.92	19.00	48.25	24.50	23.25	20.67	18.33	16.67	17.75	17.25	17.67
20.	17.50	18.33	19.42	18.50	23.92	23.32	20.42	18.67	16.58	17.75	17.25	17.67
21.	17.42	20.00	19.33	19.33	23.67	23.33	20.42	18.50	16.50	17.75	17.25	17.50
22.	17.33	21.33	19.75	19.08	23.50	22.83	20.33	18.50	16.42	17.75	17.25	17.25
23.	17.33	28.50	19.50	20.33	23.17	22.50	20.17	18.25	16.42	17.75	17.33	16.83
24.	17.25	25.00	19.75	20.00	22.67	22.25	20.08	18.17	16.50	17.75	17.33	16.83
25.	17.17	25.50	18.00	20.00	22.42	22.33	20.00	17.92	17.58	17.75	17.42	16.83
26.	17.17	27.17	18.50	20.50	22.42	22.50	19.83	17.92	16.58	17.67	17.42	16.75
27.	17.00	32.00	19.17	20.50	22.58	22.67	19.67	17.92	16.50	17.83	17.42	17.25
28.	16.75	28.17	19.17	20.00	22.67	22.67	19.42	18.00	18.25	17.83	17.50	17.42
29.	16.67	......	20.17	19.75	22.83	22.58	19.33	18.50	18.00	17.75	17.58	17.50
30.	16.58	......	20.33	19.67	22.58	22.42	19.25	18.50	19.50	17.83	17.50	17.58
31.	16.58	......	20.17	......	22.33	......	19.17	......	......	17.83	......	17.50

Daily gage height of Colorado River at Yuma, Ariz., for 1892, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	17.50	17.67	18.25	18.75	20.17	23.67	25.25	19.50	18.00	16.25	16.42	17.00
2..	17.42	17.50	18.75	18.58	20.08	23.92	25.33	19.42	17.83	16.25	16.42	17.08
3..	17.33	17.50	19.08	18.50	20.00	24.00	25.42	19.75	17.75	16.33	16.58	17.00
4..	17.33	18.00	18.75	18.75	20.50	24.33	25.25	19.75	17.75	16.25	16.67	16.92
5..	17.25	17.83	18.67	18.50	20.92	24.50	25.17	20.17	17.67	16.17	16.67	16.75
6..	17.25	18.00	18.67	18.50	21.00	24.67	25.00	20.17	17.58	16.17	16.75	16.67
7..	17.00	18.17	19.00	18.42	21.08	24.67	24.83	19.67	17.50	16.17	16.92	16.67
8..	16.83	18.25	20.00	18.42	21.67	24.50	24.50	19.50	17.50	16.17	17.17	16.67
9..	16.75	18.83	19.50	18.42	22.00	24.33	24.25	19.25	17.42	16.17	17.08	16.83
10.	16.83	19.00	19.67	18.58	22.17	24.08	24.08	19.17	17.33	16.08	17.00	16.83
11.	16.83	18.75	19.33	19.83	21.83	23.92	23.83	18.83	17.25	16.08	17.00	16.83
12.	16.67	18.83	19.33	19.83	21.67	24.33	23.50	18.67	17.25	16.08	17.08	16.83
13.	16.42	18.67	19.75	19.58	21.47	24.42	23.25	18.50	17.25	16.08	17.08	16.67
14.	16.33	18.58	19.50	19.50	21.17	24.25	22.92	18.42	17.17	16.08	17.08	16.67
15.	17.00	18.33	19.33	19.50	21.25	24.33	22.75	18.42	17.08	16.00	17.08	16.58
16.	17.42	18.33	19.33	19.75	21.42	24.42	22.67	18.17	17.08	16.00	17.25	16.58
17.	17.50	19.17	19.33	19.50	21.50	24.50	22.67	18.25	17.00	16.00	17.42	16.58
18.	17.33	19.17	19.33	19.50	21.50	24.67	22.33	18.17	17.00	15.92	17.33	16.58
19.	17.25	19.00	19.25	19.92	21.67	24.75	22.00	18.17	16.92	15.92	17.25	16.83
20.	17.25	18.75	19.25	20.42	21.83	24.75	21.75	18.17	16.83	15.92	17.17	16.92
21.	17.25	18.67	19.33	20.58	22.17	24.42	21.50	18.08	16.83	15.92	17.17	17.00
22.	17.33	18.58	19.50	20.58	22.17	24.25	21.33	18.17	16.75	15.92	17.08	16.92
23.	17.33	18.50	19.50	20.83	22.25	24.08	21.00	18.17	16.75	15.92	17.08	16.75
24.	17.42	18.50	19.42	21.00	22.42	23.92	20.75	18.08	16.67	16.00	17.08	16.67
25.	17.33	18.42	19.25	20.92	22.42	23.75	20.58	18.08	16.58	16.00	17.08	16.50
26.	17.33	18.42	19.25	20.75	22.42	23.83	20.33	18.08	16.58	16.08	17.08	16.25
27.	17.50	18.42	19.17	20.50	22.50	24.00	20.17	18.08	16.50	16.08	17.00	16.08
28.	17.50	18.33	19.08	20.42	22.67	24.33	20.00	18.08	16.42	16.08	17.00	16.00
29.	17.75	18.33	19.00	20.42	23.00	24.67	19.83	18.08	16.42	16.17	17.00	15.92
30.	17.50	......	18.92	20.33	23.17	25.00	19.50	18.17	16.33	16.17	17.00	15.75
31.	17.67	......	18.75	......	22.42	......	19.33	18.08	......	16.33	......	15.50

Daily gage height of Colorado River at Yuma, Ariz., for 1893,[1] in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	15.50	16.50	16.83	18.50	18.92	23.50	23.00	19.17	19.08	17.00	16.42	16.58
2..	15.50	16.42	16.75	18.50	19.08	23.17	22.58	18.92	18.50	16.83	16.42	16.67
3..	15.50	16.42	16.75	18.50	19.25	23.17	22.17	18.75	17.83	16.75	16.58	16.75
4..	15.58	16.25	16.75	18.67	19.92	22.92	21.83	18.75	17.50	16.67	16.50	16.67
5..	15.58	16.17	16.67	19.25	19.83	22.92	21.67	18.50	17.50	16.42	16.50	16.67
6..	15.75	16.17	16.67	19.17	19.50	23.17	21.33	19.08	17.42	19.83	16.50	16.58
7..	15.75	16.17	16.75	19.00	19.50	23.25	21.00	18.67	17.50	18.75	16.50	16.50
8..	15.92	16.17	16.83	18.92	20.25	23.50	20.83	18.50	17.33	18.00	16.50	16.58
9..	16.00	16.50	16.92	19.08	20.33	23.67	20.60	18.50	17.50	17.83	16.50	16.33
10.	16.08	16.67	16.83	19.08	19.00	23.75	20.33	18.42	17.42	17.42	16.58	16.25
11.	16.33	16.67	16.83	18.83	19.92	23.83	20.08	18.67	17.25	17.08	16.75	16.33
12.	16.42	16.75	16.83	18.83	18.75	23.92	20.00	19.08	17.25	17.00	16.83	16.33
13.	16.50	16.83	16.83	19.58	20.17	23.50	19.83	19.00	17.25	16.92	16.75	16.42
14.	16.33	16.75	17.00	19.50	20.42	23.33	19.67	18.83	17.25	16.92	16.67	16.58
15.	16.33	17.00	17.00	19.25	20.25	23.50	19.50	18.58	16.92	16.83	16.83	16.67
16.	16.33	16.83	17.00	19.08	20.17	23.58	19.50	18.42	17.00	16.67	16.75	16.83
17.	16.33	16.92	16.92	19.25	20.08	23.75	19.25	18.33	17.17	16.58	16.67	16.92
18.	16.33	17.42	16.83	19.17	20.17	24.00	19.17	18.25	16.92	16.58	16.67	17.00
19.	16.33	17.50	16.83	19.08	21.50	24.17	19.17	18.25	16.92	16.42	16.83	17.17
20.	16.42	17.08	16.75	19.00	22.42	24.25	19.00	18.75	16.83	16.33	16.75	17.17
21.	16.42	17.00	16.75	19.00	22.75	24.33	19.17	18.92	16.75	16.25	16.92	16.75
22.	16.42	17.00	17.08	18.92	22.83	24.50	19.50	18.50	16.58	16.33	17.00	16.75
23.	16.42	17.00	17.25	18.75	23.33	24.50	19.17	18.67	16.50	16.42	16.92	16.83
24.	16.33	17.00	17.50	18.67	24.00	24.50	19.08	19.00	16.42	16.42	17.00	16.83
25.	16.42	17.17	19.25	18.67	24.25	24.50	19.08	18.83	16.67	16.50	16.92	16.92
26.	16.42	17.17	18.33	18.67	24.67	24.25	19.25	18.42	16.67	16.42	16.83	17.00
27.	16.33	17.25	18.17	18.58	25.08	24.00	19.25	18.50	16.58	16.50	16.83	17.17
28.	16.33	17.00	18.42	18.83	25.17	23.67	19.25	19.50	16.33	16.42	16.75	17.17
29.	16.33	......	18.33	18.83	25.17	23.50	19.08	18.92	16.42	16.42	16.75	17.17
30.	16.50	......	18.42	18.92	24.83	23.17	18.92	18.50	16.33	16.50	16.67	17.17
31.	16.50	......	18.42	......	24.00	......	18.92	18.83	......	16.50	......	17.17

[1] The gage height for 1894 is published in Bulletin No. 131, on page 52.

Daily gage height of Colorado River at Yuma, Colo., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	18.83	18.08	17.17	18.58	21.92	22.67	21.00	19.92	18.75	17.50	18.25	19.00
2..	18.92	17.83	17.75	18.92	22.00	22.58	21.00	20.00	18.50	17.83	18.17	18.92
3..	19.00	17.75	17.67	19.58	22.33	22.33	21.00	20.00	18.75	17.83	18.33	18.75
4..	19.17	17.67	17.67	19.50	22.42	22.33	20.83	19.83	18.83	18.08	18.42	18.75
5..	19.17	17.42	17.83	19.83	22.67	22.50	20.83	19.75	18.50	18.25	18.50	19.00
6..	19.33	17.25	19.50	19.83	22.83	22.50	21.00	19.67	18.42	19.00	18.50	19.00
7..	19.50	17.17	19.42	19.75	23.00	22.17	21.67	19.50	18.42	19.50	18.33	19.00
8..	19.42	17.08	19.17	19.50	22.75	22.00	21.58	19.58	18.42	19.50	18.25	19.00
9..	19.25	17.00	19.00	19.33	22.50	21.83	21.50	19.75	18.42	18.92	18.33	18.92
10.	19.17	16.83	19.08	19.17	22.17	21.83	21.50	19.83	18.25	18.67	18.25	18.92
11.	19.00	16.83	19.00	19.17	21.83	21.83	21.17	19.83	18.25	18.50	18.25	18.75
12.	19.00	16.75	19.08	19.17	21.75	21.83	20.92	19.83	18.25	18.50	18.33	18.75
13.	18.92	16.75	19.00	19.17	21.50	21.75	20.92	19.67	18.25	18.50	18.33	18.67
14.	18.92	16.75	18.75	19.33	21.33	22.00	20.83	19.58	18.33	19.00	18.33	18.67
15.	18.92	16.83	18.75	19.33	21.33	22.33	20.67	19.50	18.33	18.67	18.50	18.67
16.	18.92	16.83	18.67	19.33	21.83	22.33	20.58	19.42	18.33	18.42	18.50	18.67
17.	19.00	17.00	18.75	19.25	22.50	22.42	20.33	19.25	18.33	18.42	18.42	18.67
18.	22.00	17.50	18.83	19.33	23.00	22.50	20.25	19.25	18.33	18.50	18.67	18.67
19.	24.75	17.58	18.75	20.33	23.25	22.67	20.33	19.33	18.25	18.50	18.58	18.58
20.	25.33	17.75	18.67	20.50	23.42	22.83	20.83	19.17	18.25	18.50	18.50	18.25
21.	26.33	17.67	18.67	20.67	23.58	22.83	20.75	19.17	18.00	18.50	18.50	18.25
22.	23.58	17.67	18.67	21.00	23.67	22.75	20.58	19.33	17.83	18.25	18.50	18.17
23.	23.00	17.50	18.50	20.92	23.75	22.83	20.50	19.33	17.83	18.17	18.50	18.17
24.	21.17	17.50	18.33	21.00	23.67	22.83	20.58	19.17	17.75	18.00	18.50	18.00
25.	20.92	17.33	18.25	21.25	23.42	22.67	20.33	19.25	17.75	18.00	18.42	18.00
26.	20.00	17.25	18.33	22.00	23.42	22.33	20.17	19.17	17.75	18.17	19.25	18.00
27.	19.67	17.25	18.33	22.17	23.33	22.00	20.00	19.17	17.75	18.17	19.50	18.00
28.	19.42	17.25	18.50	22.25	23.33	21.75	19.92	19.25	17.75	18.33	19.42	18.00
29.	19.17	......	18.50	22.25	23.17	21.50	19.92	19.00	17.67	18.33	19.33	18.25
30.	18.75	......	18.50	22.00	23.00	21.17	19.83	18.75	17.58	18.25	19.17	18.33
31.	18.42	......	18.50	......	22.83	......	19.75	18.83	......	18.25	......	18.33

INTERIOR BASIN, IN NEVADA.

The Interior Basin includes that portion of the arid regions from which the rivers, though often of considerable volume, do not escape to the ocean. Their waters, coming mainly from the high mountains through numerous tributaries, unite in a trunk stream, which in its course through the lower valleys gradually shrinks in size through evaporation or flows into a broad shallow lake or sink from which all of the water disappears into the air. The principal rivers of the Interior Basin are, on the west, the Truckee, Carson, and Walker; in the center, the Humboldt, and on the east, the Bear, Weber, Provo, and Sevier. Measurements of the volume of many of these streams have been made in past years, and a number of stations have been maintained during 1895.

TAHOE STATION, ON TRUCKEE RIVER.

An attempt was made during 1895 to ascertain the outflow from Lake Tahoe into Truckee River for the purpose of obtaining data as to the value of this lake for storage purposes. The place of observation chosen was at the dam one-fourth of a mile west from Tahoe City. This dam has been built by a lumber company for the purpose of controlling the amount of water in the river in connection with floating logs. Two gages were established at this point, an inclined one on the upper side of the dam and a vertical one on the lower side, the zero of both of these being at the elevation of the floor of the gates. Observations were kept at both gages for the purpose of obtaining facts from which to compute the probable flow through the gates. The observer was P. Wehrman, a steamboat captain.

In this dam are three gates or passages, the central being 11 feet wide, and those on each side 10 feet wide. In the center of the first and second gates are single upright posts 10 inches square, breaking the flow of the water. The piers or partitions between the passages, as well as the sides and bottom, are planked, giving comparatively smooth surfaces. The length of these passages is about 30 feet. The computations to be made, therefore, are those for the flow of water through smooth rectangular channels about 30 feet long and 10 to 11 feet wide, two of these channels being broken by central upright posts. No formula has been found for computing the flow applicable to these conditions. After determining the velocity in the lower end of the passages as nearly as possible by means of a meter, Mr. L. H. Taylor tried the formula given by Joseph P. Frizell for the flow of water over a dam with wide horizontal crest, introducing the element of velocity of approach and making deduction for contractions due to sharp corners at the point of entry and at the upright post in gates No. 1 and No. 2, thus allowing for three contractions for gate No. 1, two contractions for gate No. 2, and one for gate No. 3. The velocity of approach, as nearly as could be determined, was 4 feet per second to gate No. 1; 3 feet per second to gate No. 2, and 2.54 feet per second to gate No. 3. On July 3, 1895, the total discharge from this computation was 1,180 second-feet, or less than 1.5 per cent less than that determined from the meter measurement.

There were so many uncertainties in connection with the computations at this point that it was decided to make measurements from a cable suspended across the stream, but before this could be placed in position the winter storms prevented further work. The following table gives the height of water at the gage on the upper side of the dam:

Daily gage height of Truckee River near Tahoe, Cal., for 1895, in feet.

Day.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(a)	5.52	5.03	4.62	4.14	3.92
2	....	5.50	5.01	4.61	4.11	3.91
3	5.50	5.49	4.99	4.61	4.09	3.90
4	5.50	5.48	4.98	4.60	4.07	3.89
5	5.50	5.48	4.96	4.58	4.06	3.88
6	5.50	5.47	4.93	4.57	4.04	3.88
7	5.52	5.47	4.90	4.55	4.03	3.88
8	5.52	5.47	4.88	4.54	4.01	3.87
9	5.52	5.46	4.86	4.52	4.00	3.86
10	5.52	5.46	4.82	4.52	3.98	3.86
11	5.50	5.46	4.86	4.51	3.97	3.86
12	5.50	5.45	4.90	4.50	3.95	3.86
13	5.50	5.45	4.88	4.49	3.94	3.85
14	5.50	5.44	4.86	4.47	3.92	3.85
15	5.50	5.43	4.85	4.43	3.90	3.84
16	5.50	5.43	4.84	4.42	3.88	3.83
17	5.49	5.42	4.82	4.40	3.86	3.82
18	5.48	5.39	4.81	4.39	3.85	3.84
19	5.45	5.38	4.80	4.37	3.85	3.86
20	5.42	5.37	4.79	4.30	3.84	3.89
21	5.70	5.36	4.79	4.29	3.83	3.91
22	5.62	5.35	4.76	4.28	3.82	3.91
23	5.61	5.35	4.71	4.26	3.82	3.92
24	5.60	5.34	4.67	4.25	3.81	3.91
25	5.60	5.27	4.66	4.24	3.80	3.91
26	5.64	5.20	4.65	4.22	3.79	3.90
27	5.62	5.14	4.65	4.21	3.77	3.89
28	5.60	5.11	4.64	4.20	3.76	3.88
29	5.58	5.09	4.64	4.19	3.74	3.87
30	5.56	5.05	4.63	4.17	3.72	3.86
31	5.54	5.03	....	4.16	....	3.85

a The fluctuations in the daily discharge of Truckee River are due to the opening and closing of the gates. When they are partly closed the discharge is computed as from an orifice by the same formula as that used for the flow of water through the canal gates on Carson River, as noted on page 600.

Estimated discharge of Truckee River, near Tahoe, Cal.

[Drainage area, 550 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
July	1,185	266	914	56,199	1.91	1.66
August	441	393	425	26,132	0.89	0.77
September	392	357	374	22,255	0.75	0.68
October	496	344	415	25,517	0.86	0.75
November	471	408	470	27,967	0.94	0.85
December	253	246	250	15,372	0.52	0.45

EMPIRE STATION, ON CARSON RIVER.

Measurements of the discharge of Carson River have been made at a point near Empire, this being below Carson and Eagle valleys, and above the canyon or narrow valley through which the river flows to Carson Plains. The measurements at this point show the quantity of water available for irrigation purposes both above and below. The place of measurement was at the Brunswick dam, near Empire, this being about 4 miles easterly from Carson City. This dam is in the form of a weir, with a crest about 2 inches wide and 95 feet in length between the abutments. There are no end contractions, and the conditions are favorable for accuracy of computation. To the amount of water passing over the dam is added that diverted through the head gates of the ditch or mill race, each of these two openings or orifices being 7 feet wide, with square timber sides, and provided with gates made of 2-inch plank. On June 25, 1895, the height of water on the gage above the dam was 4.10 feet. One of the head gates of the ditch was open from the bottom 0.2 foot and the other 1.5 feet, the water issuing from these under a head of 4.3 feet. The depth of water on the weir or overflow of the dam was 3.10 feet. In place of the gage height reported by the observer, Mr. L. H. Taylor has set down the head on the weir and on the orifice. The total discharge over the weir is computed by the Francis formula for sharp-crested weirs without end contractions. The discharge through the orifice is computed from the following formula: $q=c\ a\ \sqrt{2\ gh}$, using 0.66 as the value of c for an orifice with bottom contractions suppressed and with a=11.90. The results are believed to be approximations, and under the conditions nothing more can be expected. The area of the watershed has not been ascertained. The station is about 5 miles below the one established in 1889–90 a short distance above Empire, and receives the drainage of Eagle Valley in addition to that at the old station above referred to.

The following table gives the total discharge of the river at this point, the amount going through the openings to the mill race being added to that flowing over the dam:

Daily gage height of Carson River near Brunswick, Nev., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	(*a*)	3.70	1.80	3.50	3.39	3.41	3.51
2	....	3.75	1.50	3.45	3.20	3.49	3.48
3	....	3.65	1.60	3.50	3.29	3.65	3.45
4	....	3.70	1.60	3.49	3.36	3.60	3.48
5	....	3.30	1.55	3.61	3.30	3.69	3.48
6	....	3.10	1.50	3.40	3.51	3.54	3.47
7	....	3.17	1.50	3.30	3.56	3.59	3.45
8	....	3.10	1.45	3.31	3.61	3.60	3.45
9	....	3.00	1.40	3.20	3.45	3.59	3.41
10	....	3.10	1.15	3.30	3.41	3.60	3.38
11	....	3.00	1.07	3.31	3.46	3.58	3.40
12	....	2.90	1.10	3.28	3.42	3.58	3.41
13	....	2.90	1.30	4.21	3.23	3.60	3.42
14	....	2.80	1.20	3.98	3.21	3.50	3.43
15	....	2.70	1.10	3.70	3.19	3.55	3.41
16	....	2.70	1.08	3.78	3.12	3.52	2.50
17	....	2.70	1.50	3.65	3.22	3.69	2.42
18	....	2.70	1.50	3.60	3.29	3.70	2.10
19	....	2.50	1.50	3.51	3.31	3.67	3.41
20	....	2.30	*b* 3.20	3.50	3.33	3.61	3.65
21	....	2.25	3.10	3.43	3.42	3.58	4.85
22	....	2.30	3.00	3.70	3.51	3.55	3.71
23	....	2.15	2.90	3.54	3.65	3.51	3.68
24	....	2.00	3.45	3.51	3.61	3.47	3.67
25	4.10	1.90	3.45	3.49	3.60	3.28	3.50
26	4.25	1.80	3.40	3.40	3.65	3.40	3.51
27	4.00	1.75	3.45	3.41	3.60	3.50	3.80
28	4.00	1.70	3.40	3.39	3.51	3.49	3.30
29	4.05	1.70	3.45	3.47	3.43	3.43	2.90
30	3.85	1.80	3.41	3.40	3.42	3.45	3.50
31	....	1.90	3.50	....	3.35	....	3.72

a Above weir. *b* Gage reset with weir crest at 3 feet on gage.

Discharge of Carson River at Brunswick, Nev., for 1895.

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
June (25 to 30)	1,980	1,645	1,804	....
July	1,565	244	802	49,313
August	294	62	149	9,162
September	407	107	192	11,425
October	237	71	154	9,469
November	259	124	204	12,139
December	890	63	211	12,974

NORDYKE STATION, ON WALKER RIVER.

This station was established by Mr. L. H. Taylor on June 27, 1895, at a point half a mile below the junction of East and West Walker rivers, and 1 mile below Nordyke, in Mason Valley. The drainage area above this point has not been measured, a great portion of it lying in California. The station is equipped with a cable and tagged wire is stretched below this. The gage is vertical, and is fastened to posts driven well into the left bank of the river. The bench mark is on a willow stump 12 feet north of the gage and at an elevation of 10.77 feet. The channel is straight, both above and below the station. The right bank is low and liable to overflow at very high water, but the left bank is high. The bed of the stream is sandy and shifts considerably.

The first measurement was made on June 27, 1895, when the water was at the highest stage reached that spring and was still slowly rising.

Several irrigation ditches were taking out water from each fork of the river above the station. The greater part of the water was coming from West Walker River, which was at that time rising, while East Walker River was falling.

Very little has been known concerning the actual volume delivered by this stream. In the valleys along this river are probably more than 300,000 acres of land, among the best in the State. As yet, only a small portion of these lands are watered, and as the Walker River is the only source of supply, it is especially desirable to obtain accurate data concerning the fluctuations of this stream. From the discharge measurements made during the year it has been possible to compute the average daily discharge, from which the monthly figures are given.

On December 31 it was decided to discontinue observations on Walker and Carson rivers and concentrate work on the Humboldt, in order to establish stations at Lovelocks, near the lower end of the river, and one on Rock Creek, the last important tributary, which enters the river near Battle Mountain.

List of discharge measurements made on Walker River at Nordyke, Nev.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	June 27	L. H. Taylor	100	3.95	3.84	2,228
2	July 23	.....do	100	2.30	2.74	817
3	Aug. 21	.....do	100	0.95	1.59	177
4	Sept. 29	.....do	100	0.60	1.55	120

Daily gage height of Walker River at Nordyke, Nev., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		3.70	1.60	0.75	0.60	1.15	1.15
2		3.45	1.50	0.70	0.60	1.15	1.15
3		3.50	1.45	0.70	0.60	1.15	1.15
4		3.40	1.40	0.65	0.60	1.15	1.15
5		3.20	1.40	0.60	0,60	1.15	1.15
6		3.15	1.45	0.60	0.60	1.15	1.15
7		3.10	1.50	0.60	0.60	1.15	1.15
8		3.10	1.45	0.50	0.60	1.15	1.15
9		3.05	1.35	0.50	0.55	1.15	1.15
10		3.05	1.30	0.45	0.55	1.15	1.15
11		3.00	1.20	0.45	0.55	1.15	1.15
12		3.00	1.10	0.45	0.50	1.15	1.15
13		2.95	1.35	0.70	0.50	1.15	1.15
14		2.95	1.30	*a*1.80	0.50	1.15	1.15
15		2.90	1.25	1.60	0.50	1.15	1.15
16		2.85	1.20	1.50	0.50	1.15	1.15
17		2.80	1.20	1.40	0.50	1.15	1.15
18		2.80	1.10	1.20	0.50	1.15	1.15
19		2.70	1.00	0.95	0.50	1.15	1.20
20		2.60	1.00	0.90	*b*1.50	1.15	1.20
21		2.70	0.95	0.90	1.50	1.15	1.20
22		2.60	0.95	0.90	1.50	1.15	1.15
23		2.55	0.90	0.85	1.50	1.15	1.15
24		2.45	0.90	0.80	1.50	1.15	1.15
25		2.30	0.80	0.80	1.50	1.15	1.15
26		2.10	0.70	0.75	1.00	1.15	1.15
27	3.95	2.00	0.65	0.60	1.10	1.15	1.15
28	4.25	1.90	0.65	0.60	1.15	1.15	1.15
29	4.30	1.85	0.65	0.60	1.15	1.15	1.15
30	4.15	1.80	0.75	0.60	1.15	1.15	1.15
31		1.75	0.75		1.15		1.15

a Heavy rain. *b* Water turned out of ditches.

Discharge of Walker River at Nordyke, Nev., for 1895.

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
June (27 to 30)	2,591	2,228	2,448	....
July	1,983	474	1,179	72,494
August	398	127	235	14,450
September	500	101	170	10,116
October	353	107	180	11,068
November	227	227	227	13,507
December	242	227	228	14,019

HUMBOLDT RIVER.

The drainage basin of Humboldt River occupies the northern end of the State of Nevada. The river rises in the northeastern corner of the State and flows at first in a general southwesterly course about half way across the State, then turns northwesterly, and again southwesterly, the waters finally disappearing in the Humboldt Lake, or sink. Measurements of discharge have been made at several points along this river, the principal of these being at Elko, near the head waters; at Golconda, about 17 miles east of Winnemucca; and finally at Oreana, a short distance above Lovelocks. For some years previous to 1895 Mr. L. H. Taylor is able to give a few computations of discharge based upon measurements made by himself at a point near Lovelocks, about 18 miles above Humboldt Lake, these being in June, 1890 and 1892; also on April 20, 1893, and June 7, 1893, and one measurement on August 25, 1892.

In 1890 all of the diversion dams in the river in the neighborhood of Lovelocks were washed out. At one of these, a timber and stone crib structure belonging to W. C. Pitt and T. J. Hauskins, a mark was made at the water surface a few hours before the dam gave way, and from this Mr. Taylor was able to ascertain the sectional area of the stream that poured through and over the dam. This was estimated to be 4,252 second-feet. The flow was probably considerably greater some time after the failure of the dam. No record has been kept of the exact date. In August, 1892, Mr. Taylor made measurements to the high-water line at this dam, which had been renewed, and calculated the discharge to have been 2,642 second-feet. This flood occurred in June, and was the maximum for the year.

On August 25, 1892, he made a measurement, using rod floats, at a point a few miles further upstream, above all the canals diverting water for irrigation of lands in the vicinity of Lovelocks, and found the discharge to be 340 second-feet.

On April 20, 1893, at the same point and by the same method, he found the discharge to be 761 second-feet, and on June 7, 1893, 3,054 second-feet. From records kept at that time it appears that the river continued to rise for some time after this last measurement, but as the channel widened considerably by the washing out of one of the banks no estimate of the maximum discharge of that year can be made.

As is the case of many of the western rivers, the Humboldt is much smaller near its mouth than it is farther up. Probably it is the largest about 150 miles by railroad and 600 miles by channel above the point where measurements were made.

In the vicinity of Battle Mountain, Nev., are about 40 flowing wells, mostly shallow, one of these, however, being 110 feet in depth.

ELKO STATION, ON HUMBOLDT RIVER.

This station was established June 17, 1895, by Mr. L. H. Taylor, at a point 1 mile southwest of the town of Elko. The observer was Plato Brewer, the driver of the coach to the Hot Springs. Observations were made each morning. The gage was vertical, spiked to posts on the right bank of the river a short distance above the bridge. The bench mark is on the stone pier of the bridge, this being about 100 feet from the gage. The channel of the stream is straight, both above and below this point; the right bank is low, but the left bank is high and rocky. The bed of the stream is of gravel and sand, shifting slightly from time to time. Computations based upon discharge measurements have been made of the daily and monthly flow from June 17, 1895.

There are in the Humboldt basin, above this station, a number of localities where record of precipitation is kept by the Weather Bureau. These furnish data from which the relation of run-off to rainfall can be computed, and therefore it is especially desirable to continue measurements for some time.

List of discharge measurements made on Humboldt River at Elko, Nev.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	June 17	L. H. Taylor	100	1.50	2.50	186
2	July 13	.....do	100	0.80	1.14	48
3	Sept. 5	.....do	100	0.30	0.25	4
4	Dec. 14	.....do	100	0.55	0.62	19

Daily gage height of Humboldt River at Elko, Nev., for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.70	0.60	0.37	0.34	0.51	0.67
2	....	1.50	0.60	0.37	0.34	0.51	0.67
3	....	1.40	0.55	0.37	0.34	0.60	0.66
4	....	1.60	0.55	0.30	0.33	0.60	0.65
5	....	1.50	0.55	0.30	0.33	0.60	0.64
6	....	1.70	0.55	0.30	0.46	0.60	0.65
7	....	0.95	0.55	0.30	0.45	0.60	0.65
8	....	0.98	0.55	0.30	0.58	0.53	0.64
9	....	0.90	0.56	0.30	0.58	0.52	0.67
10	....	0.85	0.56	0.30	0.58	0.60	0.68
11	....	0.80	0.57	0.30	0.58	0.60	0.70
12	....	0.80	0.58	0.30	0.50	0.60	0.75
13	....	0.80	0.50	0.30	0.50	0.60	0.80
14	....	0.78	0.50	0.30	0.47	0.20	0.74
15	....	0.75	0.44	0.30	0.50	0.20	0.60
16	....	0.85	0.45	0.30	0.50	0.30	0.67
17	1.50	0.76	0.50	0.30	0.58	0.64	0.67
18	1.50	0.67	0.40	0.30	0.57	0.65	0.64
19	1.45	0.70	0.35	0.30	0.56	0.66	0.64
20	1.40	0.70	0.40	0.30	0.55	0.66	0.60
21	1.36	0.65	0.47	0.38	0.55	0.66	0.64
22	1.30	0.65	0.30	0.37	0.54	0.67	0.64
23	1.30	0.65	0.34	0.36	0.54	0.68	0.65
24	1.30	0.65	0.30	0.34	0.54	0.68	0.65
25	1.20	0.65	0.47	0.34	0.54	0.68	0.65
26	1.15	0.63	0.35	0.34	0.54	0.68	0.64
27	1.15	0.65	0.35	0.34	0.54	0.67	0.64
28	1.15	0.60	0.40	0.34	0.53	0.69	0.64
29	1.20	0.65	0.35	0.34	0.52	0.68	0.65
30	1.20	0.60	0.35	0.34	0.52	0.67	0.67
31	....	0.60	0.36	....	0.52	....	0.67

Discharge of Humboldt River at Elko, Nev., for 1895, in feet.

[Drainage area, 2,840 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
June (17 to 30)	186	107	139	....	....	....
July	241	24	72	4,427	0.030	0.025
August	24	4	13	799	0.006	0.005
September	8	4	5	298	0.002	0.002
October	22	540	15	922	0.006	0.005
November	34	150	24	1,428	0.010	0.009
December	48	24	31	1,906	0.013	0.011

GOLCONDA STATION, ON HUMBOLDT RIVER.

This station, described in Bulletin No. 131, page 52, was established by Mr. L. H. Taylor on October 24, 1894. At that time, ordinarily, the lowest water of the year occurs, but during 1894 it was lower than ever before except in 1889. At the highest stage the river was over 4 feet lower than the mean high-water mark. The station is 1¼ miles northerly from the town of Golconda. The observer is Mr. L. Dutertre, a farmer and merchant. The observations are taken each day about 5 p. m. The gage is vertical and is spiked to posts driven into the bank on the left side. Measurements are made from a cable and suspended car. The channel is nearly straight, the right bank is moderately high, but liable to overflow at extreme flood stages, perhaps once in four or five years. The bed of the stream is of gravel and sand, shifting somewhat.

In making the computations of discharge at Golconda, data were not available for the highest stages, as the water fell earlier in the season than was expected, before the hydrographer could make a measurement at the highest stage. The rating table based upon the measurements made is, however, believed to be fairly applicable for the highest stages. The exceedingly small run-off from the district above Golconda during 1895 is due to the fact that this was an excessively dry year, and also to the large area—10,780 square miles—taken as being within the drainage basin. From a large part of this area, however, no water came to the stream. There has been included in this the Reese River Basin and two or three smaller ones to the south of Humboldt River, none of which furnished water to the stream during 1895. This area also includes the Battle Mountain Valley, having an area of 1,000 square miles of level land, from which no water ran off. Thus more than one-third of the total drainage was during this dry season practically unproductive.

The small run-off at Golconda can also be attributed in part to the effect of evaporation from the river and adjacent lowlands. The last tributary, Rock Creek, entering above Golconda, is 50 miles away in a straight line. The course of the river between these points is, however, so crooked that the distance followed by the stream is nearly five times as great. Water from the river flows into a shallow lake near Battle Mountain, this having an area of about 2,000 acres, from which a considerable amount is lost by evaporation. It is estimated by Mr. Taylor that the loss from evaporation alone between Rock Creek and Golconda during the month of June was over 30 second-feet, and during July and August about 50 second-feet.

List of discharge measurements made on Humboldt River at Golconda, Nev.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.					
1	Oct. 24	L. H. Taylor	100	1.30	1.29	57
2	Dec. 4	.....do	100	2.00	1.34	114
	1895.					
3	Mar. 22	.....do	100	3.82	2.12	463
4	June 21	.....do	100	2.55	1.35	204
5	July 12	.....do	100	1.62	1.15	96
6	Aug. 12	.....do	100	0.05	0.91	11
7	Sept. 8	.....do	100	—0.30	1.20	1

Daily gage height of Humboldt River at Golconda, Nev., for 1894, in feet.

Day.	Oct.	Nov.	Dec.	Day.	Oct.	Nov.	Dec.
1	....	1.45	2.25	17	....	1.71	1.80
2	....	1.47	2.20	18	....	1.79	1.70
3	....	1.50	1.90	19	....	1.80	1.80
4	....	1.52	2.05	20	....	1.80	1.90
5	....	1.55	2.02	21	....	1.85	2.00
6	....	1.57	2.12	22	....	1.85	2.10
7	....	1.58	2.15	23	....	1.90	2.15
8	....	1.60	2.10	24	1.30	1.95	2.20
9	....	1.62	2.15	25	1.30	1.97	2.20
10	....	1.67	1.90	26	1.30	1.95	2.15
11	....	1.68	2.12	27	1.30	1.97	2.12
12	....	1.70	2.15	28	1.32	1.97	2.10
13	....	1.72	2.12	29	1.37	2.00	2.00
14	....	1.73	1.30	30	1.40	2.00	2.00
15	....	1.75	1.30	31	1.42	2.25	1.92
16	....	1.73	1.87				

Daily gage height of Humboldt River at Golconda, Nev., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.92	2.10	3.40	4.37	5.00	4.20	2.12	0.55	—0.25	—0.32	—0.30	0.2
2..	1.92	2.10	3.65	4.60	5.00	4.20	2.10	0.45	—0.27	—0.32	—0.30	0.2
3..	1.95	2.15	3.95	4.90	5.00	4.20	2.15	0.42	—0.22	—0.32	—0.30	0.2
4..	1.97	2.20	4.17	5.00	5.02	4.20	2.15	0.40	—0.27	—0.32	—0.30	0.3
5..	2.20	2.25	4.40	5.50	5.00	4.20	1.95	0.40	—0.30	—0.32	—0.30	0.4
6..	2.20	2.30	4.32	5.30	4.95	4.10	1.90	0.30	—0.30	—0.32	—0.30	0.5
7..	2.20	2.35	4.30	5.35	4.90	4.10	1.87	0.25	—0.30	—0.32	—0.30	0.5
8..	2.20	2.40	4.05	5.40	4.70	4.00	1.70	0.17	—0.30	—0.32	—0.30	0.5
9..	2.25	2.45	3.90	5.45	4.60	3.92	1.60	0.12	—0.30	—0.32	—0.30	0.5
10.	2.27	2.47	3.82	5.50	4.60	3.90	1.65	0.10	—0.30	—0.32	—0.28	0.5
11.	2.20	2.45	3.80	5.35	4.50	3.80	1.60	0.02	—0.30	—0.32	—0.28	0.5
12.	2.17	2.40	3.55	5.20	4.55	3.70	1.60	0.05	—0.30	—0.32	—0.28	0.6
13.	2.10	2.42	3.57	5.22	4.60	3.62	1.50	0.05	—0.30	—0.30	—0.28	0.7
14.	2.00	2.42	3.57	5.25	4.65	3.50	1.45	0.05	—0.30	—0.30	—0.25	0.7
15.	2.00	2.42	3.57	5.25	4.65	3.34	1.40	0.05	—0.30	—0.30	—0.28	0.7
16.	2.07	2.40	3.62	5.30	4.55	3.20	1.30	0.07	—0.30	—0.30	—0.25	0.7
17.	2.20	2.40	3.70	5.30	4.50	3.20	1.20	0.07	—0.30	—0.30	—0.25	0.7
18.	2.30	2.40	3.85	5.25	4.40	3.00	1.15	0.06	—0.32	—0.30	—0.25	0.7
19.	2.30	2.42	3.85	5.20	4.30	2.90	1.15	0.05	—0.32	—0.30	—0.25	0.7
20.	2.32	2.45	3.85	5.25	4.20	2.70	1.12	0.04	—0.32	—0.30	—0.25	0.8
21.	2.35	2.47	3.77	5.22	4.20	2.55	1.10	0.03	—0.32	—0.30	—0.25	0.7
22.	2.35	2.47	3.82	5.20	4.25	2.58	1.10	0.02	—0.32	—0.30	—0.25	0.7
23.	2.35	2.50	3.80	5.20	4.25	2.40	1.02	0.02	—0.32	—0.30	—0.25	0.7
24.	2.35	2.55	3.80	5.25	4.27	2.35	1.00	0.02	—0.32	—0.30	—0.25	0.7
25.	2.35	2.50	3.82	5.50	4.27	2.30	0.90	—0.02	—0.32	—0.30	—0.25	0.7
26.	2.35	2.52	3.87	5.50	4.25	2.25	0.85	—0.22	—0.32	—0.30	—0.23	0.7
27.	2.35	2.95	3.90	5.00	4.25	2.20	0.80	—0.25	—0.32	—0.30	—0.23	0.7
28.	2.30	3.50	3.92	5.00	4.22	2.20	0.75	—0.25	—0.32	—0.30	—0.20	0.7
29.	2.30	......	4.00	5.00	4.20	2.17	0.75	—0.25	—0.32	—0.30	—0.10	0.7
30.	2.25	......	4.07	5.00	4.22	2.15	0.72	—0.25	—0.32	—0.30	—0.02	0.7
31.	2.20	......	4.30	......	4.22	......	0.70	—0.25	......	—0.30	......	0.6

Discharge of Humboldt River at Golconda, Nev., for 1894 and 1895.

[Drainage area, 10,780 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1894.						
October (24 to 31)	65	57	60	3,689	0.006	0.005
November	115	67	90	5,355	0.009	0.008
December	147	57	117	7,194	0.012	0.011
1895.						
January	162	106	141	8,669	0.015	0.013
February	385	127	180	9,719	0.017	0.016
March	630	362	478	29,391	0.051	0.044
April	1,035	622	913	54,327	0.094	0.085
May	842	568	672	41,319	0.071	0.062
June	568	153	353	21,005	0.037	0.033
July	153	35	80	4,919	0.008	0.008
August	28	1.60	12	738	0.001	0.001
September	2.00	0.70	0.93	....	....	....
October	0.96	0.70	0.82	....	....	....
November	9.00	0.96	1.80	....	....	....
December	11.50	9.80	10.96	....	....	....

OREANA STATION, ON HUMBOLDT RIVER.

This station is located about 12 miles upstream from the town of Lovelocks, and is above all the irrigating ditches which divert water to supply that district. It is about 25 miles above Humboldt Lake. The river banks on both sides are of earth, rather high, and moderately stable. The station is a quarter of a mile southeast from Oreana at the county bridge. The gage consists of a timber 2 inches by 4 inches, spiked to a pile bent and divided into tenths of a foot. The bench mark is on the cap on the abutment of the pier at the north end of the bridge, 12 feet from the gage. Its elevation is 11.70 feet. The main current is near the right bank. The channel, both above and below the station, is nearly straight; the banks are liable to overflow at extreme high water, which occurs at intervals of a few years, although the water since 1890 has not passed over the wagon road crossing the valley, even at the lowest place.

INTERIOR BASIN, IN UTAH AND IDAHO.

The measurements of rivers forming portions of the eastern part of the Interior Basin drainage have been carried on by Prof. Samuel Fortier. Some of the old river stations originally established by the Irrigation Survey have been discontinued; others have been established at points not previously covered. As far as possible the work has been conducted with a view to obtaining results of general application to the conditions in Utah, but the location of the field work has been governed by considerations of economy. It has not been practicable to measure streams at a very great distance from headquarters in northern Utah on account of the cost of transportation, especially away from certain lines of railroad. Professor Fortier has made a general report upon the conditions of water supply in the Territory, the greater portion of which is given in the following paragraphs:

In Utah, as in adjoining States, agriculture is dependent upon irrigation, irrigation upon the water supply, and the water supply upon the annual rainfall. The value, therefore, of every inch of rainfall can hardly be overestimated. The fall of rain and snow is so unequally distributed that an average over a large area must as a rule be taken in general discussions. It frequently happens that one portion of a valley or county will receive double or even treble the rainfall that falls on another portion. There are, in addition to local differences, the so-called dry and wet counties. For example, the rainfall at St. George, Washington County, during the entire year of 1872 was reported to be less than three-fourths of an inch, whereas on Mount Carmel, in Kane County, in 1874, it was over 36.5 inches. A clearer idea of the main source of all the available water supply may be had by briefly reviewing the precipitation in the several counties in which records have been kept.

Cache County has perhaps the best water supply of all the counties in Utah, but the average rainfall over the irrigated area does not rise above the general average for the whole State. During the past four years of observation at the experiment station at Logan the precipitation has fluctuated between 11 and 15 inches. These figures, however, do not represent the precipitations over the entire area of Cache County. Much of it consists of mountain ranges and elevated table-lands, upon which many feet of snow usually fall, and to which the observed records do not apply. It is the accumulation of snow on the Wasatch range that feeds with so many perennial springs such streams as Paradise, Blacksmith Fork, and Logan, so that the dry seasons in the past have not materially lessened the average summer flow of these streams.

In Boxelder County the rain-gages are located at five stations of the Southern Pacific Railway. At Corinne monthly records have been kept for twenty-five years; at Blue Creek and Kelton for over fifteen years, and at the other stations for shorter periods of time. The general average of all the records is as follows:

	Inches.
Corinne	12.8
Blue Creek	8.3
Kelton	8.2
Promontory	10.1
Terrace	4.8

The average for the whole county is less than 9 inches.

In Weber County the only reliable data come from Ogden, at which monthly observations have been made, with a few exceptions, for twenty-five years. At the close of 1890 the general average for the twenty years preceding was about 13.5 inches, but the excessive rainfall of 1891 (23 inches) and the moderately high rainfall of 1894 (16 inches) have increased the general average. It is impossible to state how nearly the precipitation at Ogden represents Weber County. In all likelihood the towns of Plain City, Harrisville, West Weber, and others in their vicinity have a less rainfall, while the Basin, Liberty, and the main range of the Wasatch have a much greater precipitation, chiefly in the form of snow.

Salt Lake County has always been favored in respect to precipitation. The average annual rainfall at Salt Lake City over the period from 1857 to 1890 is nearly 17 inches. If one excepts particularly favored localities as regards precipitation and portions of the mountain ranges noted for the excess of snow which falls upon them, Salt Lake County includes within its confines the area of maximum rainfall in Utah. In the report on the climate of Utah by General Greely[1] (1891), he indicates as the region of maximum rainfall the elevated table-lands from Mount Carmel in Kane

[1] Fifty-first Congress, second session, Ex. Doc. No. 287. Irrigation and water storage in the arid regions.

County north to Richfield in Sevier County, basing his opinions on the excessive rainfall at Mount Carmel and at Lossee in Garfield County during the years preceding 1890. Since that date, however, the rainfalls at these stations have not been excessive, and the decrease has modified the general results.

Summit County has had three stations, Coalville, Park City, and Wanship, but only a few observations have been taken at Wanship. From 1874 to 1883 Coalville shows an average record of nearly 14 inches. The records at Park City have not been continuous, and it is difficult to give even an approximate average. This much may be said of that region, that it is noted for heavy precipitation during the winter months. In February, 1891, 7.2 inches fell, and in December of the same year 4.9 inches, making a total for the two months of over 12 inches.

Little rain or snow falls on Tooele County. The enormous evaporation from the surface of Great Salt Lake in summer, which takes place adjacent to this large county, is borne by the prevailing winds to more favored localities, and it is rare that a shower of rain moistens the parched sandy soil. The records obtained at Deep Creek from 1877 to 1880 show an average precipitation of less than 5 inches per annum, and those taken at Stockton an average of about 5.5 inches.

The three stations in Emery County show a wide variation: Price, 3.5 inches; Castle Gate, nearly 10 inches, and Schofield over 16 inches.

Judging from the meager statistics that have been collected in eastern Utah, the annual rainfall of that region seldom rises to 10 inches, and in some localities drops below 6 inches. Last year (1894), at Fort Duchesne, in Uinta County, it was not 5 inches, and the general average at that station for the past six or seven years is only 6.5 inches.

At Moab, in Grand County, the average for the past five years is a trifle over 7 inches. The driest as well as the hottest part of Utah is the extreme southwest corner, in the vicinity of St. George, Washington County, where the annual rainfall seldom rises much above 6 inches, and where the average July temperature is 86° F. in the shade, and the yearly average nearly 62° F.

From the foregoing general review of the precipitation it is evident that Utah has no water to waste and little to spare to adjacent States and Territories. If the rain fell only during the irrigating period, and it were possible to convey it all without loss to the portions cultivated, we might then irrigate 40 per cent of the total area. As a matter of fact, little falls during the time of maturing crops, and only a small portion of this, which is called the run-off, can be depended upon. From careful estimates and measurements made by the hydrographers of the Geological Survey, only 0.66 second-foot per square mile runs off from the Utah drainage basins. On the basis that 1 second-foot is required for every 80 acres, this average run-off, if entirely consumed, would irrigate only 1 in every 12 acres. But the summer flow of the streams is very much less than the average throughout the year, and amounts to 0.09 second-foot per square mile. Taking, as before, the basis of 1 second-foot for every 80 acres, the summer run-off of the Utah streams would only irrigate 1 in every 89 acres. In other words, that portion of the annual rainfall upon 89 square miles of surface which flows off during the driest period would not irrigate more than 1 square mile.

There is in this State a land area of 52,601,600 acres, and it has been estimated by the Utah irrigation commission that there are 3,654,000 acres either irrigated or susceptible of irrigation. That is to say, 1 acre in every 14 is both arable and irrigable. The great question to consider is, Can we irrigate this area? Is the water supply sufficient?

The main source of our agricultural wealth is but imperfectly known. The irrigators of Utah have achieved brilliant successes in the intense cultivation of small farms and in many of the practical problems related to irrigation, but they have neglected the larger and more general problems such as the area of the land actually irrigated, the amount of water diverted, and the loss in its conveyance, as well as the area of the land that might be reclaimed and the total available water supply.

Many of these facts can not be determined either by individual irrigators or by corporations. If this work is ever done it must be through State or national aid. Meanwhile, the State is suffering in not possessing the requisite knowledge of her agricultural resources. Company after company is organized to divert water from a particular stream, or to build a large storage reservoir to reclaim extensive areas of land, with little knowledge of the flow of water in the stream to be tapped and the amount already appropriated. There is need of capital, above all things, and possibly of water corporations if the rich arable land can not be rendered productive without their aid, but great care must be exercised if the wild-cat irrigation schemes that have disgraced neighboring States are to be avoided. It is an easy thing for a few promoters to get together, incorporate, and float a million-dollar land scheme. If, however, the water supply, which is really the essential element in all such enterprises, is either lacking or insufficient, not only individuals but the whole State will suffer in consequence.

In this connection, Utah is indebted to the United States Geological Survey. The hydrographers have traveled extensively over the entire cultivated portion, closely studied the methods of irrigation, examined reservoir sites, and measured the principal streams. In nearly every Government publication on irrigation there is an article on Utah, and although all the statements made are conservative they have helped as no other publications have to make known to the world the wonderful resources of the State.

As one of the results of this work, knowledge is had of the volume of water that has flowed through Bear River Narrows into Boxelder County during every day of the year since June of 1889, and upon this continuous record of six and one-half years it is safe to assert that for all ordinary seasons a flow of 800 second-feet can be absolutely depended upon. The duty of water around Brigham City, in the same county, is about 150 acres for each second-foot of water. Upon this basis Bear River would irrigate 120,000 acres in the dryest part of August, and more than 500,000 acres throughout the month of June. Boxelder County will never need the entire flow of Bear River unless during an exceptionally dry summer, and Weber County will eventually learn that it will cost less to convey to the fertile areas of this latter county a portion of the summer flow of this river over the 50 miles of intervening space than to store water in the mountains behind heavy walls of cement and stone. Already $400,000 has been expended upon such an undertaking, and $300,000 more will complete the Great East Side Canal to Ogden City. There are many thousands of acres along the route of the unfinished Bear River Canal whose market value to-day does not exceed $10 per acre, but which, with a reliable water right, would readily sell for $50, $75, and $100 per acre.

Seepage water.—Twenty-four years ago a settlement was formed in Ogden Valley called Eden. Ditches were dug and water diverted from the only two available sources—Wolf Creek and North Fork. In the dry season these ditches were capable of conveying the combined flow of both streams. A few years after the settlement of Eden the present district of Liberty, located a few miles above Eden on the North Fork, began to be settled. When the Liberty farmers commenced to construct a ditch from the North Fork, the lower irrigators objected and threatened to enjoin them from interfering in any way with the main source of their water supply. More generous counsel prevailed, however, and the Liberty irrigators were allowed to complete their ditch. Somewhat curious to relate, the complete diversion above and the application of water to the porous soils of the upper farms has proved a benefit to those below. Although every drop that flows along the surface of North Fork is taken out through the Liberty ditches, an increased quantity, due to seepage and return waters, is to be found at the Eden head gates some 4 miles below.

Some of the richest land in Morgan County skirts East Canyon Creek. The valley is long and narrow and the ditches short. Here the same water is used by different farmers at least three times. In May and June the supply is abundant and the soil and subsoil are thoroughly watered. As the season advances, a portion of this stored water is drained off and is increased by the direct return of a part of the last waterings; hence the threefold duty of the stream.

What is true regarding seepage water from a small tributary like North Fork or East Canyon Creek is often true, only to a less extent, of the large streams. In the dry summer of 1889, when Bear River was dry in Wyoming, there was sufficient water flowing past Corinne to water 60,000 acres. The seepage from Gentile Valley, in Idaho, and from the whole of Cache County increased the flow to that extent.

It is no exaggeration to say that the dry summer flow of Weber River is used two or three times in one summer. Much of the land irrigated in Summit County borders on the Weber, and the excess which is diverted and applied, if not evaporated, returns to the river. In Morgan County also it is the low valley lands adjacent to the Weber that are cultivated. On August 8, 1894, there were about 125 second-feet flowing into Morgan County, and about the same volume flowing out, while the farmers were using about 95 second-feet. That is to say, the Morgan farmers were using more than 75 per cent of the flow of the river without apparently lessening the volume to the Weber County irrigators.

Accurate measurements were begun ten years ago on the South Platte River in Colorado by E. S. Nettleton, then State engineer. These have been continued in most of the years since by his successors in office. The general results up to date show an increase, due to seepage from the hillsides and from irrigated areas of from 250 to 300 per cent in 175 miles of river channel extending from the Platte Canyon in the mountains to Iliff on the plains northeast of Denver. Prof. L. G. Carpenter, of the Colorado Experiment Station, found an increase from a similar cause in the Cache la Poudre River of 3.23 second-feet per mile of river bed, or a total gain of 172 second-feet in 53 miles.

The method followed in determining the gain was to find out the difference in volume between the flow of the river at the starting point and at the end. To this was added the combined flow of all tributaries in the intervening space. When this sum was compared with the total flow of all the canals, the above named increases resulted. The matter is fully discussed in Bulletin No. 33 of the Colorado State Agricultural College Experiment Station, on seepage and return waters from irrigation.

Utah can greatly increase her available supply by means of tunnels intercepting the underground and seepage waters. Of the hundreds of creeks that flow through the side canyons of the main ranges to the valleys beneath, most, if not all, lose a large percentage of their surface water by sinking through the porous mass of débris over which each creek flows. This underflow could be readily brought to the surface at suitable places by building walls to bed rock of cement concrete and conveying the developed water through pipes to an open ditch.

There is little doubt but that large quantities of water flow beneath the beds of such rivers as the Sevier and the Weber. Where suitable locations could be found, with bed rock not too far from the surface, the cost of putting in a submerged dam would not be excessive, and would prove a paying investment.

BEAR RIVER.

Bear River, the largest stream flowing into Great Salt Lake, rises in the Uinta Mountains easterly from this lake and flows northerly from Utah into the southwestern corner of Idaho. Here it receives a number of tributaries, and after meandering backward and forward across the State line between Wyoming and Utah, turns abruptly from Wyoming into Idaho and flows into Bear Lake Valley. In times of floods the waters traverse the marsh at the north end and enter the lake. At other times the water passes through numerous channels, and finally escapes at the north end of the valley, where it takes a general northwesterly, westerly, and southerly course, passing through a corner of Idaho, and flows into Utah. Bear Lake may be considered as being at one side of the main channel and serving as a natural reservoir, receiving flood waters and delivering these again into the lower part of the stream, regulating the flow and diminishing the fluctuations in quantity. Entering the State of Utah, Bear River flows through Cache Valley and escapes from it through the northern end of the Wasatch Mountains. At this place it has cut a narrow canyon, through which the river descends with great rapidity and enters upon the plain at the north end of Great Salt Lake. Flowing through this it loses its water in the lake. Its drainage basin has been described in the Eleventh Annual Report United States Geological Survey, Part II, Irrigation, page 66. Two river stations have been maintained, one at Battle Creek, Idaho, near where the river crosses the State line to enter Cache Valley, Utah, and the other in the canyon where the river leaves Cache Valley, this being a short distance below the head-works of the large canal taking out water to irrigate lands north of Corinne.

BATTLE CREEK STATION, ON BEAR RIVER.

This station has been described in Bulletin 131, on page 53. Measurements at this point have been continued by Prof. Samuel Fortier, and by his assistant, Mr. J. L. Rhead. The station is located 5 miles northwest of Preston, Idaho, from which point it can be reached by wagon road. The observer is Mr. John Murdock, a farmer, living about 1,000 feet from the gage. The station is equipped with a cable, from which a car is suspended, and tag wire shows spaces across the river. The gage consists of a vertical board nailed to a pile. The bench mark consists of a nail driven in a house near by. The channel of the stream is straight, both above and below the point, and the water moves with moderate velocity, the conditions being highly favorable for accurate measurements. The table given below shows the principal measurements made at this point since 1890. On November 30, 1894, two measurements were made. The results in the second are believed to be more accurate than in the first. In the latter the meter was moved vertically from top to bottom in thirty seconds. In the former case readings were taken by the meter at the top, middle, and bottom of the water. A slight difference may be due to change of meters, but the difference may be accounted for principally by the fact that the current does not decrease perceptibly until very near the bottom. Hence, an average of the three readings at top, middle, and bottom is not the true average of the section.

From these measurements a rating table has been computed, and as the gage has not been disturbed since 1890 it is believed this relation holds good.

List of discharge measurements made on Bear River at Battle Creek, Idaho.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1891.					
14	Apr. 29	T. M. Bannon	110	3.25	3.75	3,072
15	Nov. 22	.....do	103	1.60	2.01	721
	1894.					
16	Oct. 29	A. P. Davis	24	1.90	2.12	980
17	Nov. 30	S. Fortier	106	1.80	2.30	1,030
	1895.					
18	Apr. 6	J. L. Rhead	106	2.68	3.38	2,092
19	Apr. 15	.....do	103	3.00	3.57	2,380
20	Apr. 29	.....do	....	2.93	3.50	2,268
21	Oct. 14	.....do	103	1.40	1.87	689

Rating table for Bear River at Battle Creek, Idaho, for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.00	118	1.40	680	2.80	2,106
0.10	134	1.50	750	2.90	2,243
0.20	158	1.60	826	3.00	2,394
0.30	181	1.70	908	3.10	2,550
0.40	206	1.80	993	3.20	2,717
0.50	235	1.90	1,086	3.30	2,887
0.60	269	2.00	1,181	3.40	3,068
0.70	306	2.10	1,262	3.50	3,237
0.80	344	2.20	1,375	3.60	3,425
0.90	389	2.30	1,486	3.70	3,637
1.00	437	2.40	1,600	3.80	3,845
1.10	492	2.50	1,718	3.90	4,050
1.20	551	2.60	1,839	4.00	4,268
1.30	612	2.70	1,970		

Daily gage height of Bear River at Battle Creek, Idaho, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.70	1.70	1.80	2.60	3.20	3.30	2.10	1.50	1.30	1.40	1.40	1.40
2..	1.70	1.70	1.80	2.60	3.30	3.30	2.10	1.50	1.30	1.30	1.40	1.40
3..	1.70	1.70	1.80	2.70	3.55	3.20	2.00	1.50	1.30	1.30	1.40	1.40
4..	1.70	1.70	1.80	2.70	3.70	3.20	2.00	1.50	1.30	1.30	1.40	1.40
5..	1.70	1.70	1.80	2.70	3.70	3.10	2.00	1.50	1.30	1.30	1.40	1.40
6..	1.70	1.70	1.70	2.70	3.60	3.05	2.40	1.40	1.30	1.30	1.40	1.40
7..	1.70	1.70	1.70	2.75	3.50	3.00	1.90	1.40	1.30	1.30	1.40	1.40
8..	1.70	1.70	1.70	2.80	3.50	2.90	1.90	1.40	1.30	1.40	1.40	1.40
9..	1.70	1.70	1.70	2.90	3.40	2.90	1.80	1.40	1.30	1.40	1.40	1.40
10.	1.80	1.70	1.70	3.00	3.40	2.80	1.80	1.40	1.30	1.40	1.40	1.40
11.	1.80	1.70	1.70	3.10	3.30	2.70	1.80	1.40	1.30	1.40	1.40	1.40
12.	1.80	1.70	1.70	3.10	3.30	2.70	1.80	1.40	1.30	1.40	1.40	1.40
13.	1.80	1.70	1.70	3.20	3.40	2.60	1.80	1.40	1.30	1.40	1.40	1.40
14.	1.80	1.70	1.70	3.10	3.45	2.60	1.80	1.40	1.30	1.40	1.40	1.40
15.	1.70	1.70	1.60	3.00	3.50	2.60	1.80	1.40	1.30	1.40	1.40	*a*1.40
16.	1.70	1.70	1.60	3.00	3.40	2.60	1.80	1.40	1.30	1.40	1.40	1.40
17.	1.70	1.70	1.70	3.00	3.30	2.50	1.70	1.30	1.30	1.40	1.40	1.40
18.	1.70	1.70	1.70	3.00	3.30	2.50	1.70	1.30	1.30	1.40	1.40	1.40
19.	1.70	1.70	1.70	3.00	3.30	2.50	1.70	1.30	1.30	1.40	1.40	1.40
20.	1.70	1.70	1.70	3.00	3.30	2.40	1.60	1.30	1.30	1.40	1.40	1.40
21.	1.70	1.70	1.80	3.00	3.40	2.40	1.60	1.30	1.30	1.40	1.40	1.40
22.	1.70	1.70	1.80	2.90	3.40	2.40	1.60	1.30	1.30	1.40	1.40	1.40
23.	1.70	1.70	1.80	2.90	3.40	2.40	1.60	1.30	1.30	1.40	1.40	1.40
24.	1.70	1.70	1.80	2.90	3.40	2.30	1.60	1.30	1.40	1.40	1.40	1.40
25.	1.70	1.70	1.80	2.90	3.40	2.30	1.60	1.30	1.40	1.40	1.40	1.40
26.	1.70	1.70	1.80	2.90	3.40	2.25	1.50	1.30	1.40	1.40	1.40	1.40
27.	1.70	1.70	1.90	2.90	3.40	2.20	1.50	1.30	1.40	1.40	1.40	1.40
28.	1.70	1.80	2.35	2.90	3.40	2.20	1.50	1.30	1.40	1.40	1.40	*b*1.40
29.	1.70	......	2.60	2.95	3.40	2.20	1.50	1.30	1.40	1.40	1.40	1.40
30.	1.70	......	2.60	3.10	3.40	2.20	1.50	1.30	1.40	1.40	......	1.40
31.	1.70	......	2.60	......	3.30	......	1.50	1.30	......	1.40	......	1.40

a Slush ice in river.

b River frozen over.

The amount of water flowing into Cache County from southern Idaho through Bear River is given below:

Estimated discharge of Bear River at Battle Creek, Idaho.

[Drainage area, 4,500 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	993	908	922	56,692	0.23	0.20
February	993	908	911	50,594	0.21	0.20
March	2,977	826	1,095	67,329	0.28	0.24
April	2,717	1,839	2,268	134,955	0.56	0.50
May	3,637	2,717	3,086	189,751	0.79	0.69
June	2,887	1,375	1,932	114,962	0.48	0.43
July	1,600	750	967	59,459	0.24	0.21
August	750	612	658	40,459	0.17	0.15
September	680	612	628	37,369	0.16	0.14
October	680	612	666	40,951	0.17	0.15
November	....	....	680	40,463	0.17	0.15
December	....	....	680	41,812	0.17	0.15
Per annum	3,637	612	1,207	874,796	3.63	0.27

COLLINSTON STATION, ON BEAR RIVER.

This station is in the canyon below Cache Valley, Utah. It is described in Bulletin 131, on page 55. Measurements have been continued at this point, as shown by the accompanying table. The point of measurement is at the engineer's camp of the Bear River Canal Company, 4 miles from the railroad station of Collinston. The observer is James Jardine, ditch rider for the company. The station is equipped with a cable, boat, and tag wire. The gage consists of a vertical iron rod, graduated to tenths of a foot. Bench mark No. 1 is a nail in an oak post 20 feet west of the gage and 20 feet north of the cable. Its elevation is 7.35 feet above the zero of the gage. The initial point for soundings is on the left bank. The banks of the stream are high and the channel is gravelly, with bowlders, the water flowing with moderate velocity. At this point it has a slope of 0.55 foot in 600 feet. The measurements at this point have furnished material for the construction of a new rating curve and table, considered reliable for 1895. The rating curve constructed from earlier measurements is shown graphically in the Fourteenth Annual Report of the United States Geological Survey, Part II, on page 120.

List of discharge measurements made on Bear River at Collinston, Utah.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1891.					
17	Apr. 27	T. M. Bannon	110	4.90	3.84	4,859
18	Nov. 24	.....do	103	2.25	2.14	1,192
	1893.					
19	Sept. 2	F. H. Newell	24	1.70	1.40	715
	1894.					
20	Oct. 6	S. Fortier	106	2.01	2.61	1,800
21	Dec. 22	.....do	103	2.10	2.57	1,875
	1895.					
22	Apr. 8	W. F. Culmer	106	*a* 3.16	3.01	3,041
23	Apr. 15	.....do	106	3.75	3.44	3,853
24	Apr. 22	W. W. McLaughlin	106	3.58	3.27	3,453
25	Apr. 29	S. Fortier	106	3.61	3.27	3,460
26	Aug. 19	J. L. Rhead	106	1.17	2.15	819
27	Sept. 23	S. Fortier	106	1.62	2.14	1,058
28	Dec. 9	.....do	106	1.95	2.21	1,397

a New gage.

Rating table for the Bear River at Collinston, Utah, for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	420	2.20	1,800	3.90	3,945
0.60	460	2.30	1,920	4.00	4,065
0.70	515	2.40	2,055	4.10	4,210
0.80	565	2.50	2,170	4.20	4,340
0.90	625	2.60	2,290	4.30	4,460
1.00	690	2.70	2,415	4.40	4,600
1.10	750	2.80	2,540	4.50	4,725
1.20	820	2.90	2,660	4.60	4,855
1.30	900	3.00	2,790	4.70	4,990
1.40	980	3.10	2,905	4.80	5,120
1.50	1,065	3.20	3,030	4.90	5,250
1.60	1,155	3.30	3,165	5.00	5,385
1.70	1,250	3.40	3,290	5.10	5,500
1.80	1,350	3.50	3,420	5.20	5,635
1.90	1,455	3.60	3,550	5.30	5,765
2.00	1,570	3.70	3,685	5.40	5,905
2.10	1,680	3.80	3,815	5.50	6,030

Daily gage height of Bear River at Collinston, Utah, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.00	1.90	2.10	4.35	3.90	3.70	1.90	1.40	1.10	1.60	1.70	1.90
2..	2.10	1.90	2.10	3.60	4.10	3.70	1.90	1.40	1.10	1.60	1.70	1.90
3..	2.10	2.10	2.00	3.20	4.20	3.70	1.80	1.30	1.10	1.60	1.70	1.90
4..	2.10	2.10	2.00	2.65	4.40	3.70	1.80	1.30	1.10	1.60	1.70	1.90
5..	2.00	2.10	1.90	2.40	4.55	3.60	1.70	1.30	1.10	1.60	1.70	1.90
6..	2.10	2.00	1.90	2.30	4.60	3.55	1.70	1.20	1.10	1.60	1.70	1.90
7..	2.10	2.00	1.80	2.50	4.60	3.50	1.50	1.20	1.10	1.60	1.70	1.90
8..	2.00	2.10	1.90	2.50	4.60	3.50	1.50	1.20	1.10	1.60	1.70	1.90
9..	2.00	2.10	2.10	2.70	4.60	3.30	1.50	1.20	1.10	1.60	1.70	1.90
10.	2.00	2.05	2.00	2.95	4.65	3.20	1.50	1.20	1.10	1.60	1.80	1.90
11.	2.00	2.05	2.00	3.15	4.70	3.10	1.50	1.20	1.10	1.60	1.80	1.90
12.	2.00	2.05	2.10	3.30	4.55	3.10	1.50	1.20	1.20	1.60	1.80	1.90
13.	2.00	2.00	2.10	3.30	4.35	3.00	1.50	1.20	1.20	1.60	1.80	1.90
14.	2.00	2.00	2.00	3.50	4.30	3.00	1.25	1.20	1.25	1.60	1.80	1.90
15.	2.00	1.95	2.00	3.55	4.30	2.90	1.15	1.20	1.20	1.60	1.80	1.90
16.	2.10	2.00	2.00	a3.70	4.30	2.75	1.00	1.20	1.20	1.60	1.80	1.90
17.	2.10	2.00	2.10	3.70	4.30	2.70	1.00	1.20	1.20	1.60	1.80	1.90
18.	2.10	2.00	2.10	3.70	4.30	2.65	0.90	1.20	1.20	1.60	1.80	1.90
19.	2.10	2.10	2.20	3.70	4.30	2.60	0.85	1.20	1.20	1.60	1.80	1.90
20.	2.00	2.10	2.20	3.70	4.20	2.55	0.75	1.20	1.20	1.70	1.80	1.90
21.	2.10	2.10	2.30	3.70	4.20	2.50	1.00	1.10	1.20	1.70	1.80	1.90
22.	2.10	2.00	2.30	3.60	4.10	2.40	1.00	1.10	1.20	1.70	1.80	1.90
23.	2.10	2.00	2.30	3.60	4.05	2.40	1.00	1.10	1.40	1.70	1.80	1.90
24.	2.00	2.20	2.40	3.50	3.70	2.35	1.00	1.10	1.50	1.70	1.80	1.90
25.	2.00	2.20	2.50	3.50	3.80	2.25	1.00	1.10	1.50	1.70	1.90	1.90
26.	2.00	2.20	2.50	3.60	3.80	2.25	1.00	1.10	1.60	1.70	1.90	1.90
27.	2.00	2.10	2.75	3.60	3.80	2.05	1.00	1.10	1.60	1.70	1.90	1.90
28.	2.00	2.10	3.50	3.60	3.70	1.95	1.70	1.10	1.60	1.70	1.90	1.90
29.	2.00	......	3.90	3.60	3.70	1.95	1.60	1.10	1.60	1.70	1.90	1.90
30.	2.00	......	4.30	3.90	3.70	2.00	1.60	1.10	1.60	1.70	1.90	1.90
31.	2.00	......	4.25	......	3.70	......	1.50	1.10	......	1.70	......	1.90

a New gage.

Estimated discharge of Bear River at Collinston, Utah, 1895.

[Drainage area, 6,000 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	1,680	1,570	1,610	98,995	0.31	0.27
February	1,800	1,455	1,630	90,526	0.28	0.27
March	4,460	1,350	2,030	124,820	0.39	0.34
April	3,945	1,920	3,244	193,031	0.60	0.54
May	4,990	3,685	4,329	266,180	0.83	0.72
June	3,685	1,512	2,627	156,317	0.49	0.44
July	1,455	540	961	59,090	0.18	0.16
August	980	750	813	49,989	0.16	0.14
September	1,155	750	873	51,947	0.17	0.15
October	1,250	1,155	1,192	73,293	0.23	0.20
November	1,455	1,250	1,341	79,795	0.24	0.22
December	1,455	1,455	1,455	89,464	0.28	0.24
Per annum	4,990	540	1,842	1,333,447	4.16	0.31

OGDEN, WEBER, AND PROVO RIVERS.

These rivers, rising in the high Wasatch Mountains, flow in a general westerly course, and their waters are employed for irrigation in the valleys through which they pass. The Ogden and Weber unite near the city of Ogden and flow into the Great Salt Lake. The Provo River, farther south, flows into Utah Lake, a body of fresh water, which in turn empties by way of Jordan River into the Great Salt Lake. These rivers are fairly typical of the streams from the mountains, and the results obtained by measurements of their flow may be applied, with necessary limitations, in the consideration of the water supply of the State.

OGDEN STATION, ON OGDEN RIVER.

This station was established by Prof. Samuel Fortier, and observations were begun on June 14, 1895. It is located about 10 miles east of the city of Ogden, near the house of James Ririe, the observer, and is equipped with a cable and a car. The gage is inclined and divided into tenths of a foot. The bench mark is a nail on the top of a stake between the guy post and an upright on the north side of the river. Its elevation is 8.51 feet above the zero of the gage. A second bench mark is on a rock at the edge of the county road, 300 feet northwest of the gage. Its elevation is 18.5 feet above the zero. The channel at this point is gravel, the banks are of earth, and the bed of gravel and sand, the locality being fairly good for accurate results. From the measurements made during 1895 a table of discharge has been computed, although there are no records for the quantity flowing during the flood season.

List of discharge measurements made on Ogden River above Ogden, Utah.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	June 13	J. L. Rhead	103	2.02	1.43	150
2	Sept. 13	S. Fortier	106	1.45	1.09	57
3	Oct. 14	....do	106	1.53	1.20	73
4	Nov. 11	....do	106	1.55	1.26	71

Rating table for Ogden River above Ogden, Utah, for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
1.30	40	1.75	102
1.40	52	1.80	111
1.45	57	1.85	120
1.50	63	1.90	130
1.55	70	1.95	140
1.60	78	2.00	150
1.65	85	2.05	160
1.70	94	2.10	170

Daily gage height of the Ogden River above Ogden, Utah, for 1895, in feet.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.80	1.45	1.40	1.49	1.53	1.56
2	....	1.80	1.50	1.40	1.49	1.53	1.53
3	....	1.80	1.50	1.40	1.50	1.53	1.52
4	....	1.80	1.50	1.40	1.53	1.61	1.54
5	....	1.80	1.50	1.40	1.53	1.59	1.57
6	....	1.80	1.50	1.40	1.53	1.56	1.55
7	....	1.80	1.50	1.45	1.53	1.56	1.51
8	....	1.75	1.50	1.45	1.52	1.56	1.52
9	....	1.75	1.50	1.46	1.52	1.55	1.55
10	....	1.70	1.50	1.46	1.52	1.55	1.52
11	....	1.65	1.45	1.45	1.52	1.55	1.48
12	....	1.70	1.45	1.44	1.52	1.55	1.48
13	....	1.75	1.40	1.43	1.52	1.57	1.48
14	1.90	1.70	1.40	1.43	1.52	1.57	1.48
15	1.85	1.65	1.40	1.44	1.52	1.57	1.48
16	1.85	1.65	1.40	1.42	1.52	1.57	1.48
17	1.85	1.60	1.45	1.40	1.52	1.57	1.49
18	1.85	1.60	1.40	1.40	1.52	1.57	1.50
19	1.80	1.60	1.40	1.45	1.52	1.57	1.50
20	1.80	1.60	1.40	1.48	1.52	1.56	1.50
21	1.75	1.55	1.40	1.51	1.52	1.56	1.50
22	1.75	1.55	1.45	1.50	1.52	1.55	1.50
23	1.75	1.50	1.45	1.50	1.52	1.55	1.49
24	1.70	1.50	1.45	1.50	1.52	1.55	1.49
25	1.70	1.50	1.40	1.50	1.52	1.55	1.49
26	1.70	1.45	1.40	1.48	1.52	1.55	1.49
27	1.70	1.45	1.40	1.48	1.52	1.55	1.49
28	1.70	1.45	1.40	1.48	1.52	1.56	1.49
29	1.70	1.45	1.40	1.48	1.53	1.56	1.48
30	1.70	1.45	1.40	1.48	1.53	1.56	1.48
31	....	....	1.40	1.49	1.53	....	1.46

A gaging station was established on Ogden River above the powder-mill dam, in Ogden Canyon, during August of 1889, and daily observations were taken to the close of 1890.

The discharge in the canyon seldom drops much below 100 second-feet. In 1890 the average for any month never got below 129 second-feet, but the year 1895 was exceptionally dry, with little snow in the mountains, and the flow was much less than it has been since 1889. There were times in August and September when the total discharge from Ogden Valley was only 52 second-feet.

Estimated discharge of Ogden River, above Ogden, Utah, in second-feet.

[Drainage area, 360 square miles.]

Month.	Greatest flow.	Least flow.	Average.
June	154	94	108
July	111	57	84
August	63	52	56
September	64	52	57
October	67	62	66
November	73	67	71
December	73	58	63

UINTA STATION, ON WEBER RIVER.

This station is near the watchman's house at the railroad bridge, 5 miles east of Uinta and about 10 miles by wagon road from Ogden. The point is in the vicinity of the so-called Devil's Gate, on the Union Pacific Railroad. The station has been described in Bulletin 131, page

57. Observations have been continued through 1895, and a number of discharge measurements made. The observer is Morgan Flaherty, a watchman, living about 100 feet from the gage. The equipment consists of a cable, car, and tag wire. The gage is vertical and supported from above by a projecting timber placed out of the reach of high water. At the time of the measurement, on September 14, 1895, it was reported that the river was lower than it has been since 1889. On November 5 the bench marks were checked, and it was found that the mark placed on April 22, 1891, on a staple in a telegraph pole, was at an elevation of 17.44 feet. The old gage at this place has been found to be unreliable, as the ice lifted the bottom. The high-water observations, however, are good, as the upper part of the gage was firmly attached. A new gage was put in place during 1895, and suitable corrections made as far as possible.

List of discharge measurements made on Weber River above Uinta, Utah.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1889.					
a	Aug. 12	T. M. Bannon	110		1.00	a 33
1	Oct. 17	do	110	0.70	2.02	130
	1890.					
2	May 3	do	5	5.40	7.01	4,330
3	May 19	do	3	5.90	7.14	4,804
4	July 21	do	106	1.60	3.12	590
5	Aug. 12	do	106	1.10	2.35	254
6	Sept. 4	do	106	1.00	2.20	220
	1891.					
7	Apr. 23	do	110	3.40	5.81	2,184
8	Nov. 27	do	103	1.40	3.24	402
	1894.					
9	July 20	S. Fortier	106	b 1.10	2.84	396
10	Aug. 15	do	106	0.50	1.73	141
	1895.					
11	Jan. 28	do	106	c 0.85	1.31	166
12	June 17	J. L. Rhead	106	2.20	4.04	955
13	July 23	A. P. Davis	55	1.20	1.93	222
14	Aug. 17	J. L. Rhead	106	0.85	1.40	100
15	Sept. 14	S. Fortier	106	0.85	1.37	94
16	Nov. 5	J. L. Rhead	106	1.41	2.25	274

a Measurement made at county bridge, near Uinta.
b New gage; reading of old gage, 1.20.
c Ice in river makes this of doubtful value.

Rating table for Weber River above Uinta, Utah, for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.50	58	1.70	525	2.90	1,660
0.60	75	1.80	600	3.00	1,765
0.70	90	1.90	680	3.10	1,880
0.80	112	2.00	770	3.20	1,985
0.90	135	2.10	860	3.30	2,090
1.00	165	2.20	955	3.40	2,195
1.10	196	2.30	1,055	3.50	2,300
1.20	232	2.40	1,150	3.60	2,400
1.30	280	2.50	1,250	3.70	2,500
1.40	337	2.60	1,350	3.80	2,605
1.50	390	2.70	1,450	3.90	2,710
1.60	455	2.80	1,555	4.00	2,815

Daily gage height of Weber River above Uinta, Utah, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	0.90	0.80	1.00	3.20	3.50	2.45	1.20	1.10	0.90	1.20	1.30	1.40
2..	0.90	0.80	1.05	2.80	3.40	2.55	1.10	1.10	0.90	1.30	1.30	1.40
3..	0.90	0.80	1.25	2.80	3.50	2.50	1.10	1.10	0.90	1.30	1.40	1.40
4..	1.00	0.80	1.20	2.80	3.60	2.50	1.10	1.10	0.90	1.30	1.40	1.40
5..	1.00	0.80	1.10	2.10	3.50	2.40	1.10	1.10	0.90	1.30	1.40	1.40
6..	1.00	0.80	1.10	1.90	3.35	2.50	1.10	1.10	0.90	1.30	1.40	1.40
7..	1.00	0.80	1.00	2.20	3.30	2.45	0.95	1.10	0.90	1.30	1.40	1.40
8..	1.00	0.85	1.25	2.00	3.30	2.50	0.95	1.10	0.90	1.30	1.40	1.40
9..	1.00	0.85	1.25	2.40	3.35	2.45	0.85	1.10	0.90	1.30	1.40	1.40
10.	0.90	0.85	1.10	2.65	3.50	2.30	0.85	1.10	0.90	1.30	1.40	1.40
11.	0.90	0.85	1.00	2.60	3.50	2.35	0.80	0.95	1.00	1.30	1.40	1.40
12.	1.00	0.85	1.00	2.60	3.40	2.35	0.80	0.90	1.00	1.30	1.40	1.40
13.	1.10	0.80	0.90	2.50	3.35	2.35	0.80	0.80	1.00	1.30	1.40	1.40
14.	1.00	0.80	0.90	2.70	3.30	2.30	0.80	0.90	1.00	1.30	1.40	1.40
15.	1.00	0.80	1.20	2.80	3.40	2.25	0.80	0.85	1.10	1.30	1.40	1.40
16.	1.00	0.80	1.15	2.70	3.45	2.15	0.80	0.90	1.10	1.30	1.40	1.40
17.	1.00	0.80	1.00	2.55	3.45	2.05	0.80	0.90	1.10	1.30	1.40	1.40
18.	0.90	0.82	1.10	2.55	3.35	2.05	0.80	0.90	1.20	1.30	1.40	1.40
19.	1.00	0.85	1.10	2.60	3.25	1.95	0.80	0.90	1.20	1.30	1.40	1.40
20.	1.10	0.90	1.20	2.60	3.30	1.85	1.50	0.90	1.20	1.30	1.40	1.40
21.	1.10	0.90	1.20	3.00	3.45	1.85	1.50	0.90	1.20	1.30	1.40	1.40
22.	1.00	0.80	0.90	a3.00	3.15	1.75	1.45	0.90	1.20	1.30	1.40	1.40
23.	0.80	0.80	1.00	3.00	3.15	1.75	1.35	0.90	1.20	1.30	1.40	1.40
24.	0.70	1.10	1.15	2.90	3.00	1.65	1.25	0.90	1.20	1.30	1.40	1.40
25.	0.80	1.15	1.30	3.00	2.90	1.60	1.10	0.90	1.20	1.30	1.40	1.40
26.	0.80	1.20	1.40	3.00	2.80	1.45	1.10	0.90	1.20	1.30	1.40	1.40
27.	0.80	1.30	1.50	3.00	2.65	1.35	1.10	0.90	1.20	1.30	1.40	1.40
28.	0.80	1.30	1.80	3.50	3.10	1.25	1.10	0.90	1.20	1.30	1.40	1.40
29.	0.80	......	1.20	3.50	3.00	1.25	1.10	0.90	1.20	1.30	1.40	1.40
30.	0.80	......	1.10	3.60	2.20	1.25	1.10	0.90	1.20	1.30	1.40	1.40
31.	0.80	......	3.20	......	2.45	......	1.10	0.90	......	1.30	......	1.50

a New gage.

Weber River was measured during the years 1889, 1890, 1891, and 1892, but the station was abandoned during 1893 and 1894. During 1895 the water was much lower than it has been since 1889, and perhaps long before that date. In 1890 the average summer flow was at least 265 second-feet; in 1891, 338 second-feet, and in 1892, 187 second-feet, but the average flow last August was only 155 second-feet, and for a day or two it dropped to 100 second-feet.

Estimated discharge of Weber River above Uinta, Utah.

[Drainage area, 1,600 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	196	90	146	8,977	0.10	0.09
February	280	112	138	7,664	0.08	0.08
March	1,980	165	279	17,155	0.20	0.17
April	2,400	770	1,512	89,970	1.33	0.95
May	2,400	955	2,007	123,406	1.44	1.25
June	1,300	199	849	50,519	0.59	0.53
July	390	112	188	11,560	0.14	0.12
August	196	112	154	9,469	0.12	0.10
September	232	135	187	11,127	0.13	0.12
October	280	232	278	17,094	0.20	0.17
November	337	337	333	19,815	0.23	0.21
December	390	337	339	20,844	0.21	0.21
Per annum	2,400	90	534	387,600	4.77	0.33

PROVO STATION, ON PROVO RIVER.

This locality is in the canyon, about 6 miles from the city of Provo, as described in Bulletin 131, page 59. The observer is Henry V. Smith, a farmer, living about 1½ miles from the gage. Observations are made each morning. The gage is inclined and fastened to stakes set in the ground. The station is equipped with a cable, a boat, and also a suspended car, so that either boat or car can be used. From the measurements made during 1895, and those of previous years, Professor Fortier has constructed a rating table which is fairly applicable to the observations.

List of discharge measurements made on Provo River in Provo Canyon, Utah.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.					
14	Dec. 24	S. Fortier	103	4.40	2.53	390
	1895.					
15	June 15	J. L. Rhead	106	4.80	3.69	680
16	July 20	A. P. Davis	55	4.10	2.19	270

Rating table of Provo River in Provo Canyon, Utah, for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
3.70	146	4.60	508	5.50	1,204
3.80	168	4.70	580	5.60	1,282
3.90	192	4.80	651	5.70	1,361
4.00	220	4.90	728	5.80	1,440
4.10	254	5.00	800	5.90	1,520
4.20	292	5.10	880	6.00	1,600
4.30	338	5.20	968	6.10	1,680
4.40	389	5.30	1,050	6.20	1,760
4.50	444	5.40	1,130		

Daily gage height of Provo River in Provo Canyon, Utah, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	4.30	4.30	4.40	4.60	5.30	5.20	4.20	4.00	3.90	4.10	4.10	4.30
2..	4.30	4.30	4.40	4.60	5.30	5.10	4.20	4.00	3.90	4.10	4.10	4.30
3..	4.30	4.30	4.40	4.60	5.20	4.90	4.20	4.00	3.90	4.10	4.20	4.30
4..	4.40	4.30	4.40	4.50	5.20	4.80	4.20	4.00	3.90	4.10	4.20	4.30
5..	4.40	4.20	4.30	4.50	5.20	4.80	4.10	4.00	3.90	4.10	4.20	4.30
6..	4.60	4.20	4.30	4.50	5.20	4.80	4.10	4.00	3.90	4.10	4.20	4.30
7..	4.30	4.20	4.30	4.50	5.30	5.00	4.00	4.00	3.90	4.10	4.20	4.30
8..	4.30	4.30	4.30	4.50	5.30	4.90	4.00	4.00	3.90	4.10	4.20	4.20
9..	4.30	4.30	4.30	4.60	5.40	4.80	4.10	4.00	3.90	4.10	4.20	4.20
10.	4.30	4.20	4.30	4.60	5.40	4.80	4.10	4.00	3.90	4.10	4.20	4.20
11.	4.30	4.20	4.30	4.70	5.50	4.70	4.10	4.00	3.90	4.10	4.20	4.20
12.	4.30	4.20	4.30	4.70	5.50	4.70	4.20	4.00	3.90	4.10	4.20	4.20
13.	4.30	4.20	4.30	4.70	5.60	4.80	4.20	4.00	3.90	4.10	4.20	4.20
14.	4.30	4.20	4.30	4.80	5.90	4.80	4.10	4.00	3.90	4.10	4.20	4.20
15.	4.30	4.20	4.20	4.90	6.00	4.80	4.10	4.00	4.00	4.10	4.20	4.20
16.	4.30	4.20	4.20	4.90	6.20	4.70	4.10	4.00	4.00	4.10	4.20	4.20
17.	4.30	4.20	4.20	4.90	5.90	4.60	4.10	4.00	4.00	4.10	4.20	4.20
18.	4.30	4.20	4.30	4.90	5.90	4.60	4.10	4.00	4.00	4.10	4.20	4.20
19.	4.30	4.20	4.30	4.90	5.90	4.50	4.10	4.00	4.00	4.10	4.20	4.20
20.	4.30	4.30	4.30	4.90	5.90	4.50	4.10	4.00	4.00	4.10	4.20	4.20
21.	4.30	4.30	4.40	4.90	5.80	4.40	4.10	4.00	4.00	4.10	4.20	4.30
22.	4.30	4.30	4.40	5.10	5.70	4.40	4.10	4.00	4.00	4.10	4.20	4.20
23.	4.30	4.30	4.40	5.10	5.60	4.30	4.10	4.00	4.00	4.10	4.20	4.20
24.	4.30	4.40	4.50	5.10	5.60	4.30	4.10	4.00	4.00	4.10	4.30	4.20
25.	4.20	4.40	4.50	5.10	5.50	4.30	4.10	4.00	4.00	4.10	4.30	4.20
26.	4.20	4.40	4.60	5.10	5.40	4.30	4.10	3.90	4.00	4.10	4.30	4.20
27.	4.20	4.40	4.60	5.10	5.30	4.20	4.10	3.90	4.00	4.10	4.30	4.20
28.	4.20	4.40	4.90	5.20	5.30	4.20	4.10	3.90	4.00	4.10	4.30	4.20
29.	4.30	......	5.20	5.20	5.20	4.20	4.10	3.90	4.10	4.10	4.30	4.20
30.	4.30	......	5.20	5.30	5.20	2.20	4.10	3.90	4.10	4.10	4.30	4.20
31.	4.30	......	4.60	......	5.20	......	4.00	3.90	......	4.10	......	4.20

A continuous record has been kept of Provo River since July of 1889. The average flow for the driest months of past years are as follows:

	Second-feet.
September, 1889	145
September, 1890	244
September, 1891	314
August, 1892	201

The following is the record for 1895:

Estimated discharge of Provo River in Provo Canyon, Utah.

[Drainage area, 640 square miles.]

Month.	Discharge in second-feet.			Total for month in acre-feet.	Run off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
January	508	292	341	20,967	0.61	0.53
February	389	292	326	18,105	0.62	0.51
March	968	292	421	25,886	0.76	0.66
April	1,050	444	683	40,641	1.19	1.07
May	1,760	968	1,216	74,769	2.19	1.90
June	968	292	542	32,251	0.94	0.85
July	292	220	261	16,048	0.47	0.41
August	220	192	215	13,220	0.39	0.34
September	254	192	209	12,436	0.37	0.33
October	254	254	254	15,618	0.46	0.40
November	338	292	300	17,851	0.53	0.47
December	338	292	303	18,631	0.54	0.47
Per annum	1,760	192	423	306,423	9.07	0.66

COLUMBIA BASIN.

SNAKE RIVER.

Snake River rises in the mountains of western Wyoming, south of Yellowstone Park, its headwaters flowing in a general westerly and southwesterly course, uniting in eastern Idaho. The main river pursues a southwesterly and westerly direction across the lava plains of southern Idaho, into which it has cut a deep, narrow gorge. In western Idaho it is joined by numerous tributaries flowing from the mountains in the central part of the State, and also by streams coming from eastern Oregon. The waters of the main river are used to a small extent for irrigation in eastern Idaho at points above that portion of its course where it has cut deeply into the lava. Farther down, however, it is impossible to divert the water to any considerable extent, as the valley along the stream is too narrow and the fertile uplands are several hundred feet above the bed of the stream. The tributary streams are largely employed, and it is possible in many cases to take out all of the waters, and it may be desirable to hold some of the floods in storage reservoirs. Measurements of the Snake River and its tributaries have been made at points in eastern Idaho, as described in annual reports of this Survey. The principal operations of 1895 have been, however, in the western part of the State, where work has been under the charge of Mr. Gerald F. Sherman, of Boise, Idaho.

BOISE STATION, ON BOISE RIVER.

Measurements of Boise River are made at a point about 8 miles above Boise, the station being at the mouth of Boise Canyon. The gage consists of a vertical rod fastened to stakes set in the ground. The bench mark is a bridge spike driven into a cottonwood tree 20 feet from the gage, 3.40 feet above the 8-foot mark of the gage. The measurements made at this point are shown in the following table.

In the latter part of July, 1895, it was decided to locate a secondary gage on Boise River to obtain the slope of water surface. This was placed 425 feet below the old gage and carefully connected by means of a wye level. Both were referred to the same datum. At that time the lower end of the old gage was found to be warped and was corrected. A gage was also placed on the lower Boise in order to determine the water going by at the lowest stage during the irrigating season. The meter can generally be used by wading, but in high water measurements can be made from a wagon bridge.

List of discharge measurements made on Boise River, above Boise, Idaho.

Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
1895.						
Apr. 20	V. C. Tompkins	26	5.00	....	3.42	4,770
May 11	.....do	26	5.30	....	3.76	5,562
June 24	.....do	23	4.60	....	2.71	4,115
July 18	G. F. Sherman	23	2.80	864	1.98	1,708
July 26	A. P. Davis	55	2.40	705	2.20	1,552
Sept. 7	G. F. Sherman	23	1.75	567	1.75	938

Daily gage height of Boise River above Boise, Idaho, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.55	2.25	2.55	3.53	5.70	4.80	4.30	2.30	1.60	1.80	1.80	1.80
2..	2.47	2.25	2.62	3.43	5.50	4.60	4.20	2.20	1.60	1.80	1.80	1.80
3..	2.30	2.27	2.57	3.52	5.80	4.50	4.20	2.20	1.60	1.80	1.80	1.50
4..	2.35	2.15	2.48	3.60	5.90	4.50	4.20	2.20	1.70	1.80	1.80	1.40
5..	2.37	2.10	2.42	3.42	5.60	4.60	4.00	2.20	1.70	1.70	1.70	1.40
6..	2.25	2.17	2.35	3.32	6.00	4.50	4.00	2.10	1.70	1.70	1.70	1.80
7..	2.15	2.17	2.37	3.24	5.90	4.60	4.20	2.10	1.70	1.70	1.40	1.80
8..	1.85	2.15	2.40	3.35	5.80	4.50	4.20	2.10	1.70	1.70	1.70	1.80
9..	2.05	2.15	2.47	3.57	5.70	4.40	4.10	2.00	1.70	1.80	1.80	1.80
10.	2.25	2.20	2.60	3.80	5.50	4.30	4.10	2.00	1.80	1.80	1.80	1.70
11.	2.30	2.05	2.75	3.93	5.30	4.20	4.00	2.00	2.00	1.80	1.80	1.90
12.	2.37	1.90	2.72	4.08	5.30	4.20	4.00	2.00	2.00	1.80	1.80	1.90
13.	2.60	2.05	2.65	4.25	5.30	4.40	4.00	2.00	2.00	1.80	1.80	1.90
14.	2.77	2.15	2.57	......	5.60	4.30	4.00	2.00	2.00	1.80	1.80	1.50
15.	2.57	2.00	2.47	......	5.70	4.40	4.00	2.00	2.10	1.70	1.90	1.60
16.	2.52	2.05	2.42	......	5.70	4.30	4.00	1.90	2.10	1.70	1.90	1.30
17.	2.50	2.15	2.40	......	5.60	4.20	3.80	1.90	2.00	1.70	1.90	1.20
18.	2.42	2.20	2.42	......	5.50	4.00	3.00	1.80	1.90	1.70	1.80	1.20
19.	2.37	2.15	2.45	......	5.50	3.90	3.00	1.80	1.80	1.80	1.80	1.20
20.	2.30	2.22	2.45	......	5.60	4.00	2.90	1.80	1.90	1.80	1.80	1.20
21.	2.25	2.20	2.45	5.00	5.70	4.10	2.80	1.80	1.80	1.70	1.80	1.20
22.	2.22	2.20	2.45	4.80	5.50	4.30	2.80	1.70	1.80	1.70	1.70	1.30
23.	2.25	2.32	2.45	5.00	5.30	4.60	2.60	1.70	1.80	1.70	1.50	1.30
24.	2.20	2.40	2.50	5.20	5.20	4.60	2.50	1.70	1.80	1.80	1.50	1.50
25.	2.10	2.45	2.65	5.40	5.10	4.60	2.40	1.70	1.90	1.80	1.50	1.60
26.	1.95	2.50	2.87	5.70	5.60	4.60	2.40	1.70	1.90	1.80	1.70	1.80
27.	2.00	2.53	3.18	5.60	6.00	4.50	2.40	1.70	1.80	1.70	1.80	1.80
28.	1.80	2.52	3.92	5.71	5.70	4.50	2.30	1.80	1.80	1.70	1.50	1.50
29.	2.05	......	4.20	5.51	5.30	4.50	2.40	1.70	1.80	1.70	1.80	......
30.	2.10	......	3.82	5.60	5.00	4.40	2.40	1.70	1.80	1.70	1.90	......
31.	2.30	......	3.62	......	4.90	......	2.30	1.70	......	1.70	......	......

CALDWELL STATION, ON BOISE RIVER.

This station was established by Mr. Arthur P. Davis on July 27, 1895, at the highway bridge 1 mile north of Caldwell. The purpose of measurements at this point below most of the irrigation ditches is to obtain the amount of water flowing in the river at the lower end of the valley, this being mainly derived from seepage. Observations were begun on August 18 and maintained until November 20. The gage consists of an inclined rod divided into vertical tenths of a foot, the distance along the rod between the marks being 0.22 foot. The gage is spiked and bolted to two piles and to a stake driven into the river. One bench mark consists of a nail in the top of the pile at the upper end of the gage. Its elevation is 13 feet. The channel above the station is curved, but is nearly straight below. The bed of the stream is of rocks and gravel and does not change perceptibly during low water.

List of discharge measurements made on Boise River at Caldwell, Idaho.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	July 28	A. P. Davis	55	3.80	189	4.00	756
2	Aug. 17	G. F. Sherman	23	3.15	81	2.78	226
3	Oct. 16	do	15	3.35	103	3.05	315

Daily gage height of Boise River at Caldwell, Idaho, for 1895, in feet.

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1		2.90	3.40	3.75	17		3.70	3.60	3.90
2		2.90	3.40	3.75	18	3.10	3.60	3.60	3.85
3		2.90	3.30	3.75	19	3.10	3.60	3.60	3.85
4		2.90	3.35	3.75	20	3.00	3.60	3.60	3.85
5		2.90	3.40	3.70	21	3.00	3.65	3.60	(a)
6		2.90	3.40	3.70	22	3.00	3.65	3.60	
7		3.00	3.40	3.70	23	2.95	3.65	3.65	
8		3.00	3.35	3.75	24	2.90	3.65	3.65	
9		3.05	3.30	3.80	25	2.90	3.60	3.65	
10		3.20	3.30	3.80	26	2.90	3.60	3.70	
11		3.35	3.25	3.80	27	2.90	3.50	3.70	
12		3.70	3.25	3.90	28	3.10	3.40	3.70	
13		3.80	3.30	3.90	29	3.10	3.40	3.70	
14		3.80	3.35	3.90	30	3.00	3.40	3.75	
15		3.90	3.35	3.90	31	2.90		3.80	
16		3.80	3.40	3.90					

a Discontinued for the winter.

PAYETTE STATION, ON PAYETTE RIVER.

This station has been described in Bulletin No. 131, on page 66. Observations have been continued through the greater part of 1895, and measurements made. On June 28, when the water stood at 3.50 feet, the discharge was found to be 3,723 second-feet. On July 22 the water stood at 1.53 feet and the discharge was 1,882 second-feet. On December 11 the water was at 0.36 foot and the discharge 1,003 second-feet. All of these measurements are made from the wagon bridge. The observer at this point is J. A. Ballinger, the town marshal at Payette.

List of discharge measurements made on Payette River at Payette, Idaho.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	June 28	V. C. Tompkins	23	3.50	....	2.35	3,723
2	July 22	G. F. Sherman	23	1.53	819	2.29	1,882
3	Dec. 11	.....do...............	23	0.36	454	2.21	1,003

Daily gage height of Payette River at Payette, Idaho, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.30	1.30	1.80	2.30	......	5.00	3.40	1.20	0.30	0.40	0.30	0.40
2..	1.20	1.30	1.60	2.20	......	4.80	3.30	1.20	0.30	0.40	0.30	0.40
3..	1.20	1.30	1.60	2.10	......	4.40	3.30	1.10	0.20	0.40	0.30	0.40
4..	1.20	1.30	1.60	2.10	......	4.20	3.00	0.90	0.20	0.40	0.30	0.40
5..	1.30	1.40	1.50	2.00	......	4.00	3.00	0.90	0.30	0.40	0.30	0.40
6..	1.30	1.40	1.50	2.00	......	3.90	3.20	0.90	0.30	0.40	0.30	0.40
7..	1.40	1.30	1.60	3.05	......	3.80	3.00	0.90	0.30	0.40	0.30	0.40
8..	1.40	1.30	1.70	2.85	......	3.80	2.80	0.80	0.30	0.40	0.30	0.40
9..	1.50	1.30	1.70	2.85	......	4.00	2.60	0.80	0.30	0.40	0.30	0.40
10.	1.50	1.30	1.70	3.00	......	3.90	2.40	0.80	0.30	0.30	0.30	0.40
11.	1.60	1.40	1.70	3.25	......	3.70	2.30	0.70	0.40	0.30	0.30	0.40
12.	1.60	1.40	1.70	3.30	......	3.60	2.30	0.60	0.70	0.30	0.30	0.40
13.	2.70	1.30	1.60	3.25	......	3.80	2.20	0.60	0.80	0.30	0.30	0.40
14.	2.80	1.30	1.50	......	......	3.90	2.10	0.50	0.90	0.30	0.30	0.40
15.	2.00	1.30	1.40	......	......	4.00	2.10	0.50	0.90	0.30	0.30	0.40
16.	1.60	1.40	1.30	......	......	3.90	2.00	0.50	0.80	0.30	0.30	0.40
17.	1.60	1.40	1.30	......	......	3.80	1.90	0.50	0.80	0.30	0.40	0.40
18.	1.60	1.40	1.30	......	......	3.70	1.90	0.50	0.60	0.30	0.40	0.40
19.	1.50	1.40	1.30	......	......	3.40	1.80	0.40	0.60	0.30	0.40	0.40
20.	1.50	1.50	1.30	......	......	3.30	1.80	0.40	0.50	0.30	0.40	0.40
21.	1.50	1.50	1.40	......	......	3.30	1.40	0.40	0.50	0.30	0.40	0.40
22.	1.40	1.55	1.40	......	......	3.30	1.50	0.40	0.50	0.30	0.40	0.50
23.	1.40	2.10	1.40	......	......	3.30	1.40	0.30	0.50	0.30	0.30	0.50
24.	1.40	2.20	1.40	......	......	3.60	1.30	0.30	0.50	0.30	0.30	0.60
25.	1.40	2.10	1.40	......	5.10	3.70	1.30	0.30	0.50	0.30	0.30	0.60
26.	1.30	2.10	1.50	......	5.60	3.60	1.30	0.30	0.50	0.30	0.30	0.60
27.	1.30	2.00	1.60	......	6.20	3.60	1.30	0.20	0.50	0.30	0.30	0.60
28.	1.40	1.90	1.80	......	6.10	3.50	1.20	0.30	0.50	0.30	0.40	0.60
29.	1.30	......	2.00	......	5.90	3.40	1.20	0.30	0.50	0.30	0.40	0.60
30.	1.30	......	2.20	......	5.70	3.40	1.20	0.30	0.40	0.30	0.40	0.60
31.	1.30	......	2.40	......	5.30	......	1.20	0.30	......	0.30	......	0.60

WEISER STATION, ON WEISER RIVER.

The observations of river height are made at a point about 10 miles from Weiser, Idaho, a short distance above the ford. The station is described in Bulletin No. 131, page 66. The gage originally established by Mr. Davis was disturbed by either ice or driftwood, and found to be out of position when examined in July. The reports of the observer do not indicate when the movement took place, and therefore corrections can not be made with certainty. A new gage was firmly fastened in place on July 28. The 6-foot mark on this gage is 13.46 feet below a bench mark on a large bowlder 30 feet south of the gage. This new gage is at an elevation of 0.90 foot above the old. In the following table of heights 0.90 has been added to the original observations for January, February, and March, and corrections applied to those from

April 30 to July 28 to bring them into accord with the gage located on the latter date. Observations were begun on December 5, 1894. The height of water during the first half of the month was about 1.80 feet. On December 17, 1894, the water rose to 2.60 feet, and gradually fell to 2.20 feet at the end of the month.

List of discharge measurements made on Weiser River above Weiser, Idaho.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
a	Dec. 6	A. P. Davis	24	1.80	....	1.10	277
	1895.						
1	Apr. 24	V. C. Tompkins	26	4.60	....	2.90	2,110
2	May 28	.....do	26	4.95	....	2.55	2,149
3	June 26	.....do	....	2.30	....	1.28	400
4	July 23	G. F. Sherman	23	1.70	222	0.54	121
5	July 29	A. P. Davis	55	1.58	197	0.74	141
6	Dec. 10	G. F. Sherman	23	1.65	241	0.80	171

Daily gage height of Weiser River above Weiser, Idaho, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.30	1.70	3.30	4.60	4.90	3.80	2.10	1.50	1.35	1.60	1.60	1.60
2..	2.30	1.70	3.20	4.50	4.85	3.70	2.10	1.50	1.40	1.60	1.60	1.60
3..	2.30	1.70	3.00	4.40	4.80	3.50	2.05	1.50	1.40	1.60	1.60	1.60
4..	2.40	1.70	3.00	4.20	4.70	3.45	2.05	1.50	1.40	1.60	1.60	1.60
5..	2.40	1.60	2.90	3.30	5.00	3.50	2.05	1.50	1.40	1.60	1.60	1.60
6..	2.80	1.60	3.80	3.70	5.20	3.45	2.05	1.50	1.40	1.60	1.60	1.60
7..	2.70	1.60	2.70	3.60	5.30	3.50	2.05	1.50	1.40	1.60	1.60	1.60
8..	2.50	1.60	2.80	3.60	5.00	3.40	2.05	1.50	1.40	1.60	1.60	1.60
9..	2.50	1.60	3.20	2.70	4.85	3.30	2.05	1.50	1.40	1.60	1.60	1.60
10.	2.50	1.60	3.30	3.80	4.40	3.30	2.05	1.40	1.50	1.60	1.60	1.60
11.	2.60	1.60	3.40	4.00	4.20	3.20	2.05	1.40	1.50	1.60	1.60	1.60
12.	2.80	1.60	3.20	3.90	4.90	3.10	2.05	1.40	1.60	1.60	1.60	1.60
13.	3.65	1.70	2.90	3.90	4.70	3.10	2.05	1.40	1.60	1.60	1.60	1.60
14.	3.80	1.70	2.60	4.30	4.40	3.00	2.05	1.40	1.70	1.60	1.60	1.60
15.	3.20	1.70	2.10	4.60	4.50	2.90	2.05	1.40	1.90	1.60	1.70	1.70
16.	2.90	1.70	2.10	4.50	4.50	2.90	2.05	1.40	1.80	1.60	1.70	1.70
17.	2.80	1.60	2.10	4.60	4.40	2.80	2.00	1.30	1.70	1.60	1.70	1.90
18.	2.00	1.60	2.20	4.60	4.40	2.80	2.00	1.30	1.70	1.60	1.70	2.00
19.	2.40	1.60	2.70	4.50	4.30	2.70	2.00	1.30	1.70	1.60	1.70	2.00
20.	2.30	1.50	3.10	4.50	4.30	2.70	1.90	1.30	1.60	1.60	1.70	2.10
21.	2.20	1.50	4.10	4.50	4.40	2.70	1.90	1.30	1.60	1.60	1.70	2.10
22.	2.10	1.60	3.60	4.50	4.20	2.60	1.90	1.30	1.60	1.60	1.70	2.40
23.	2.00	1.80	3.70	4.50	4.90	2.60	1.90	1.30	1.60	1.60	1.70	2.60
24.	2.00	3.00	4.20	4.60	4.80	2.50	1.90	1.30	1.60	1.60	1.80	2.70
25.	1.90	3.05	5.70	4.80	4.90	2.30	1.90	1.30	1.60	1.60	1.80	2.60
26.	1.90	3.20	5.50	4.85	4.80	2.40	1.90	1.30	1.60	1.60	1.80	2.60
27.	1.80	3.60	5.60	5.00	5.50	2.30	1.80	1.30	1.60	1.60	1.80	2.50
28.	1.80	3.40	6.30	5.30	5.00	2.20	1.80	1.30	1.60	1.60	1.80	2.40
29.	1.80	......	6.30	5.10	4.70	2.20	1.60	1.30	1.60	1.60	1.70	2.30
30.	1.70	......	5.70	5.00	4.30	2.20	1.60	1.30	1.60	1.60	1.70	2.30
31.	1.70	......	5.40	......	4.10	......	1.60	1.30	......	1.60	......	2.30

GRAND VIEW STATION, ON BRUNEAU RIVER.

Observations and measurements of river height have been carried on at this point by Mr. Andrew J. Wiley, chief engineer of the Owyhee Land Irrigation Company. The point of observation is 10 miles east of Grandview, below the head of Bruneau ditch. The observer is Perry Shull, watchman at the canal. Observations are taken each morning. There are two gages, one on the north and one on the south side of the river, each at the same elevation. The channel is straight, both above and below the station, the banks high and rocky, and the bed changing little, if any, the section being a good one with the exception that the velocity is very slight at low water. A measurement on August 3, 1895, at a height of 1.33 feet, gave a discharge of 50 second-feet, and a second measurement on December 21 gave a discharge of 127 second-feet.

Daily gage height of the Bruneau River near Grand View, Idaho, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.52	1.55	1.70	2.20	2.83	2.65	2.00	1.35	1.30	1.40	1.50	1.75
2..	1.53	1.55	1.70	2.20	2.72	2.50	2.00	1.35	1.35	1.40	1.50	1.70
3..	1.63	1.60	1.72	2.20	2.80	2.45	1.95	1.30	1.30	1.40	1.50	1.70
4..	1.50	1.84	1.72	2.20	2.93	2.40	1.90	1.30	1.30	1.35	1.55	1.70
5..	1.40	1.55	1.71	2.20	3.00	2.40	1.90	1.30	1.35	1.35	1.55	1.70
6..	1.28	1.50	1.73	2.18	3.25	2.40	1.85	1.25	1.40	1.35	1.55	1.70
7..	1.16	1.60	1.73	2.18	3.25	2.45	1.80	1.25	1.40	1.35	1.55	1.70
8..	1.60	1.70	1.80	2.18	3.25	2.45	1.70	1.25	1.40	1.35	1.55	1.70
9..	1.40	1.60	1.82	2.20	3.25	2.40	1.75	1.25	1.35	1.35	1.55	1.70
10.	1.50	1.60	1.82	2.20	3.25	2.40	1.70	1.25	1.40	1.35	1.60	1.70
11.	1.60	1.40	1.82	2.20	3.15	2.40	1.70	1.20	1.40	1.35	1.60	1.70
12.	1.60	1.40	1.81	2.20	3.00	2.40	1.70	1.20	1.40	1.35	1.60	1.70
13.	1.65	1.50	1.84	2.20	3.00	2.40	1.65	1.20	1.40	1.35	1.65	1.70
14.	1.65	1.55	1.84	2.20	3.05	2.40	1.65	1.20	1.35	1.35	1.65	1.70
15.	1.65	1.53	1.85	2.20	3.15	2.40	1.60	1.20	1.35	1.35	1.65	1.70
16.	1.70	1.50	1.88	2.20	3.15	2.30	1.55	1.20	1.35	1.35	1.65	1.70
17.	1.72	1.55	1.88	2.20	3.15	2.30	1.45	1.20	1.35	1.40	1.65	1.70
18.	1.72	1.50	1.87	2.30	3.07	2.25	1.45	1.20	1.40	1.40	1.70	1.70
19.	1.62	1.50	1.88	2.32	3.07	2.15	1.50	1.20	1.40	1.40	1.70	1.75
20.	1.60	1.55	1.90	2.20	3.07	2.15	1.50	1.20	1.40	1.40	1.70	1.75
21.	1.65	1.60	1.90	2.30	3.07	2.10	1.50	1.20	1.40	1.40	1.70	1.70
22.	1.70	1.40	1.92	2.40	3.06	2.10	1.50	1.20	1.35	1.40	1.70	1.70
23.	1.70	1.30	1.93	2.45	2.95	2.10	1.40	1.15	1.35	1.45	1.70	1.70
24.	1.60	1.30	1.93	2.45	2.90	2.10	1.40	1.15	1.35	1.45	1.70	1.70
25.	1.70	1.30	1.98	2.45	2.95	2.10	1.40	1.20	1.35	1.45	1.70	1.65
26.	1.60	1.40	2.10	2.60	2.80	2.10	1.40	1.25	1.35	1.45	1.70	1.65
27.	1.60	1.60	2.08	2.70	2.80	2.00	1.40	1.25	1.40	1.45	1.70	1.65
28.	1.55	1.70	2.10	2.75	2.75	2.00	1.40	1.25	1.40	1.45	1.75	1.60
29.	1.55	......	2.10	2.80	2.75	2.00	1.35	1.20	1.40	1.45	1.75	1.60
30.	1.60	......	2.20	2.85	2.75	2.00	1.30	1.20	1.35	1.45	1.75	1.60
31.	1.55	......	2.20	......	2.75	2.00	1.30	1.30	......	1.45	......	1.60

Estimated discharge of Bruneau River near Grand View, Idaho.

Month.	Discharge in second-feet.			Total for month in acre-feet.
	Maximum.	Minimum.	Mean.	
1895.				
January	150	106	134	8,239
February	167	110	129	7,164
March	310	147	163	10,022
April	785	308	401	23,861
May	1,101	680	906	55,708
June	625	225	364	21,660
July	225	45	115	70,711
August	55	25	31	1,906
September	67	45	60	3,570
October	75	55	64	3,935
November	150	87	119	7,081
December	150	111	130	7,993
Per annum	1,101	25	218	221,850

An examination was made on August 2, 1895, of the Bruneau River and irrigation works in process of construction. These works consist of a diversion dam and canal designed to convey the waters of Bruneau River to the valley lands on the south side of Snake River at and near Grand View. The dam is of loose rock, surmounted by a timber crest, upon which can be placed flashboards to raise the water to the desired height in the canal. The dam is 176 feet long and 170 feet wide at base, and was constructed by blasting rock into the stream bed from the abutting ledges and filling in the crevices with earth and gravel. Water spills over the entire width of the dam, its lower slope being protected by timber.

The canal was nearly finished when seen. The abundance of rock and the great cost of lumber have caused the constructors to use masonry wherever possible, construction being of the best character. The result is that the work appears to be one of the most thorough of its class. Most of the side drainage is taken through culverts under the canal. Waste gates are provided wherever repairs are anticipated.

MONTGOMERY STATION, ON SNAKE RIVER.

An examination was made by Mr. Arthur P. Davis of localities along Snake River, in the vicinity of Minnedoka, for the purpose of ascertaining whether it would be possible to make a series of measurements of the discharge of this stream. This examination was in accordance with desires expressed by citizens of Idaho, as it is proposed to construct a canal system to reclaim lands under the provision of the so-called Carey law. At Shoshone the water was found to be too sluggish for accurate measurement, there being no perceptible motion excepting near the center of the stream. It is reported to be over 200 feet in depth. At the ferry, 12 miles from Minnedoka, the most favorable section was found, the stream being about 800 feet wide, and from 3 to 6 feet deep, and with a hard, gravel bottom. Measurements were made from the ferryboat, but considerable difficulty was found in holding this at the desired spot in the section. The gage at this point is inclined and is fastened to posts set in the ground. The observer is George Montgomery, the ferryman. The first measurement, that on August 9, 1895, gave for a height of 2.80 feet a discharge of 5,413 second-feet. The second measurement, on October 3, when the water stood 2.28, gave a discharge of 4,592 second-feet.

Daily gage height of the Snake River at Montgomery ferry, Idaho, for 1895, in feet.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	2.20	2.30	2.40	2.60	17	2.40	2.30	2.30	2.60	2.45
2	......	2.20	2.20	2.40	2.60	18	2.40	2.30	2.30	2.60	3.10
3	......	2.20	2.30	2.40	2.60	19	2.40	2.10	2.30	2.60	3.50
4	......	2.20	2.30	2.40	2.70	20	2.40	2.10	2.30	2.60	2.95
5	3.00	2.20	2.20	2.50	2.65	21	2.35	2.20	2.30	2.60	2.60
6	2.90	2.20	2.20	2.50	2.55	22	2.30	2.20	2.30	2.60	(a)
7	2.85	2.20	2.30	2.50	2.45	23	2.30	2.30	2.30	2.60	(a)
8	2.90	2.20	2.30	2.50	2.30	24	2.30	2.30	2.30	2.60	(a)
9	2.80	2.20	2.20	2.50	2.30	25	2.20	2.30	2.30	2.60	(a)
10	2.80	2.20	2.30	2.50	2.30	26	2.20	2.30	2.30	2.50	(a)
11	2.80	2.10	2.25	2.50	2.30	27	2.20	2.30	2.30	2.40	(a)
12	2.70	2.10	2.20	2.50	2.30	28	2.20	2.30	2.30	2.45	(a)
13	2.65	2.10	2.30	2.60	2.40	29	2.20	2.30	2.30	2.50	(a)
14	2.60	2.10	2.30	2.60	2.50	30	2.20	2.30	2.40	2.60	(a)
15	2.50	2.10	2.30	2.60	2.50	31	2.20	......	2.40	......	(a)
16	2.50	2.30	2.30	2.60	2.40						

a River frozen from December 22 to 31, inclusive.

NYSSA STATION, ON OWYHEE RIVER.

This station is described in Bulletin No. 131, page 66. Observations of height have been continued throughout the year, and a number of discharge measurements were made. The first, on May 25, 1895, gave for a height of 2.40 feet a discharge of 773 second-feet; the second, on June 30, when the water stood at 1.30 feet, gave a discharge of 213 second-feet; the third, on July 20, when the water was at a height of 1 foot, gave a discharge of 64 second-feet. The observations at this point during 1895 are not considered wholly reliable. A large ditch is taking water out above the station, so that the river measurements do not give the total discharge of the river during the irrigating season.

Daily gage height of Owyhee River at Nyssa, Oreg., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.60	2.20	3.90	2.70	4.90	2.00	1.20	0.90	1.00	1.20	1.20	1.30
2..	1.60	2.20	2.90	3.30	4.90	1.80	1.20	0.90	1.00	1.20	1.20	1.30
3..	1.60	2.30	2.55	4.10	5.05	1.80	1.20	0.90	1.00	1.20	1.20	1.30
4..	1.70	2.20	2.40	4.40	5.25	1.70	1.20	1.00	1.00	1.20	1.20	1.30
5..	1.70	2.10	2.30	4.10	5.25	1.70	1.20	1.00	1.00	1.20	1.20	1.30
6..	1.80	2.10	2.20	3.35	5.20	1.70	1.20	1.00	1.00	1.20	1.20	1.30
7..	1.80	1.90	2.20	3.80	5.20	1.70	1.10	1.10	1.00	1.20	1.20	1.30
8..	1.90	1.90	2.10	3.90	5.15	1.60	1.10	1.10	1.10	1.20	1.20	1.30
9..	1.90	1.90	2.10	3.90	5.05	1.60	1.10	1.10	1.10	1.10	1.20	1.30
10.	1.90	1.90	2.00	4.00	4.95	1.60	1.10	1.10	1.10	1.10	1.20	1.30
11.	1.90	1.85	2.00	4.00	4.80	1.60	1.10	1.10	1.10	1.10	1.20	1.30
12.	2.00	1.80	2.00	4.10	4.70	1.60	1.10	1.10	1.10	1.10	1.20	1.30
13.	2.45	1.85	1.80	4.20	4.40	1.50	1.10	1.10	1.10	1.10	1.20	1.30
14.	2.70	1.90	1.80	4.30	4.00	1.50	1.20	1.00	1.10	1.10	1.20	1.30
15.	2.95	1.90	1.80	4.45	3.85	1.50	1.20	1.00	1.00	1.10	1.20	1.30
16.	3.00	1.90	2.05	4.65	3.80	1.40	1.20	1.00	1.00	1.10	1.20	1.30
17.	3.15	2.00	2.25	4.80	3.75	1.40	1.10	1.00	1.00	1.10	......	1.30
18.	3.00	2.05	2.40	4.90	3.65	1.40	1.10	1.00	1.00	1.10	......	1.30
19.	2.25	2.15	2.60	5.05	3.35	1.40	1.10	1.00	1.00	1.10	......	1.30
20.	......	2.20	2.65	5.20	3.15	1.40	1.10	1.00	1.00	1.20	......	1.30
21.	2.10	2.30	2.70	5.15	3.00	1.40	1.00	1.00	1.00	1.20	......	1.30
22.	2.05	2.30	2.65	5.05	2.75	1.40	1.00	1.00	1.10	1.20	......	1.40
23.	2.00	2.30	2.55	5.00	2.65	1.30	1.00	1.00	1.10	1.20	......	1.40
24.	1.95	2.65	2.40	4.95	2.50	1.30	1.00	1.00	1.10	1.20	1.20	1.40
25.	1.90	2.85	2.40	4.70	2.40	1.30	1.00	0.90	1.10	1.20	1.20	1.40
26.	1.90	3.15	2.30	4.60	2.40	1.30	1.00	0.90	1.10	1.20	1.20	1.40
27.	1.90	3.65	2.25	4.45	2.30	1.30	1.00	0.90	1.10	1.20	1.30	1.40
28.	2.00	3.80	2.15	4.65	2.30	1.30	0.90	0.90	1.10	1.20	1.30	1.40
29.	2.00	......	2.05	4.70	2.20	1.30	0.90	0.90	1.20	1.20	1.30	1.30
30.	2.10	......	1.90	4.80	2.15	1.20	0.90	0.90	1.20	1.20	1.30	1.30
31.	2.10	......	2.20	......	2.05	......	0.90	0.90	......	1.20	......	1.30

VALE STATION, ON MALHEUR RIVER.

This station has been described in Bulletin No. 131, on page 68. It is located at a bridge about one-fourth of a mile from Vale. Measurements made at this point are shown in the following table:

List of discharge measurements made on Malheur River at Vale, Oreg.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.					
1	Apr. 26	V. C. Tompkins	26	3.00	0.74	521
2	May 24	.....do	26	2.10	0.70	261
3	June 29	.....do	23	0.80	0.63	28
4	July 21	G. F. Sherman	23	0.58	0.97	9

Daily gage height of Malheur River at Vale, Oreg., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	1.95	1.50	2.40	3.05	2.85	2.00	0.80	0.58	0.61	1.40	1.50	1.70
2..	2.00	1.95	2.35	3.25	2.80	2.00	0.85	0.59	0.61	1.40	1.50	1.70
3..	2.05	2.05	2.30	3.60	2.75	2.05	0.70	0.60	0.61	1.40	1.50	1.60
4..	2.10	2.05	2.25	3.45	2.70	2.00	0.70	0.60	0.61	1.40	1.50	1.60
5..	2.15	2.15	2.25	3.25	2.70	1.90	0.65	0.60	0.61	1.40	1.50	1.65
6..	2.30	2.15	2.25	3.25	2.75	1.80	0.60	0.59	0.62	1.40	1.50	1.70
7..	2.30	2.10	2.25	3.00	2.85	1.80	0.70	0.58	0.62	1.40	1.50	1.70
8..	2.30	2.15	2.30	2.85	2.90	1.75	0.70	0.58	0.62	1.50	1.50	1.60
9..	2.20	2.15	2.15	2.85	2.75	1.70	0.70	0.60	0.62	1.45	1.50	1.60
10.	2.15	2.15	2.40	3.05	2.70	1.65	0.70	0.60	1.00	1.40	1.60	1.70
11.	2.15	2.15	2.60	3.25	2.65	1.60	0.70	0.60	1.10	1.40	1.60	1.70
12.	2.20	2.00	2.90	3.30	2.55	1.60	0.70	0.60	1.10	1.40	1.60	1.70
13.	2.20	2.10	2.95	3.35	2.40	1.60	0.70	0.60	1.20	1.40	1.60	1.70
14.	2.15	2 15	2.70	3.25	2.35	1.60	0.60	0.59	1.35	1.40	1.60	1.70
15.	2.25	2.15	2.40	3.30	2.40	1.60	0.60	0.58	1.40	1.40	1.60	1.70
16.	2.25	2.15	2.05	3.25	2.25	1.60	0.60	0.60	1.55	1.50	1.60	1.60
17.	2.25	2.10	2.35	3.25	2.20	1.50	0.60	0.60	1.55	1.45	1.60	1.60
18.	2.15	2.15	2.25	3.25	2.20	1.45	0.60	0.60	1.50	1.40	1.60	1.60
19.	2.15	2.20	2.35	3.40	2.20	1.35	0.50	0.59	1.50	1.40	1.60	1.70
20.	2.10	2.15	2.25	3.30	2.10	1.25	0.50	0.58	1.45	1.45	1.60	1.80
21.	2.15	2.20	2.35	3.20	2.10	1.15	0.50	0.60	1.40	1.50	1.75	1.70
22.	2.15	2.60	2.35	3.25	2.15	1.10	0.58	0.60	1.40	1.50	1.90	1.70
23.	2.10	3.15	2.35	3.25	2.10	1.05	0.58	0.60	1.40	1.50	1.85	1.65
24.	2.10	3.20	2.35	3.30	2.10	1.00	0.58	0.60	1.50	1.50	1.85	1.70
25.	2.25	3.25	2.55	3.05	2.00	1.00	0.58	0.60	1.50	1.50	1.70	1.70
26.	2.10	3.00	3.15	3.00	2.00	1.00	0.58	0.60	1.40	1.50	1.60	1.70
27.	1.90	2.60	3.60	3.00	1.95	1.00	0.58	0.60	1.50	1.50	1.65	1.75
28.	1.95	2.60	4.10	3.00	1.90	0.95	0.59	0.60	1.50	1.50	1.70	1.90
29.	1.95	......	4.25	2.95	2.10	0.90	0.60	0.61	1.50	1.50	1.70	1.90
30.	1.95	......	4.40	2.90	2.15	0.80	0.58	0.61	1.45	1.50	1.70	1.80
31.	1.95	......	3.15	......	2.00	......	0.58	0.61	......	1.50	......	1.70

Below this point on Snake River the Weather Bureau has two points of observation in Idaho, the first being at Weiser, below Montgomery ferry, and the second at Lewiston, farther downstream, this town being near the boundary between Idaho and Washington. These gages were established for the purpose of giving warnings for flood, and daily readings are not taken. When the rivers are at or near the danger line observations are made and the results are telegraphed to the Portland, Oreg., office.

The gage on the Snake River at Weiser was erected in December, 1894. It consists of an incline 45 feet long, graduated to give a vertical record of 28 feet. It is located on the bank of the Weiser River where it empties into the Snake. The bench mark is the railroad track in front of the depot, the elevation above sea level being 2,123 feet. The elevation of the zero of the gage is 2,095 feet. The danger line is at a reading of 10 feet.

The gage on the Snake River at Lewiston was erected in January, 1895, and consists of a vertical scale attached to a pile of a wheat warehouse and having a total length above zero of 28 feet. The bench mark, elevation 750 feet above sea level, is the base stone of the Masonic Building. The elevation of the zero of the gage is 722 feet. The danger line is at a reading of 24 feet on this gage.

YAKIMA RIVER.

This stream is of first importance in the irrigation of the arid portions of the State of Washington. As described in the Fourteenth Annual Report United States Geological Survey, Part II, page 132, it rises in the Cascade Range, receiving waters from numerous small lakes scattered among high peaks. The numerous tributary streams flow in a general southeasterly course, uniting to form the main stream, which passes in a southerly direction through numerous valleys. About a mile above the town of North Yakima the Naches River, one of the largest tributaries, comes in from the west. A river station has been established, as noted below, near the mouth of this stream, giving thus the total outflow from its catchment basin. The total area drained, as measured from the land-office map of Washington, is 1,000 square miles, of which 300 square miles are within the catchment area of Tiaton River, its principal tributary.

After passing along the west side of Moxee Valley, Yakima River flows out through Union Gap, this point being 7 miles below the mouth of Naches River, and 6 miles below the town of North Yakima. Before passing through the gap the river receives Atanum Creek. A measurement of this stream was made near its mouth on August 18, 1895, showing that the discharge at that time was 19 second-feet. The total drainage area above this point, as measured from the land-office map, is 3,300 square miles. A river station, described below, has been established on the Yakima River at Union Gap.

Passing through Union Gap, the river enters the broad Yakima Valley, in which it receives a number of tributaries from the west. The principal of these are Topinish and States creeks, the drainage areas of both of these streams being included within the Yakima Indian Reservation. These streams have been measured at the railroad crossings near their mouths.

There are a large number of irrigating ditches taking water from the Yakima River and its tributaries, both above and below the river stations mentioned. Most of the smaller ditches are in the Kittitas Valley, or in the vicinity of the town of North Yakima. The largest irrigating enterprises are below this point, taking water out upon the broad valley to the east of the Indian reservation, or farther down the river near Prosser and Kiona. The largest canal in operation is known as the Sunnyside, which has its head a few miles below the river station at Union Gap. The company owning this canal has maintained readings of the height of the river at the head works since April 5, 1894. On July 25, 1894, a wing dam was constructed just below the river rod, so that it no longer gave the true height of the stream. The total outflow of the river is measured at the river station near Kiona, this being below the heads of all large irrigating canals.

NORTH YAKIMA STATION, ON NACHES RIVER.

This station, as mentioned on page 73 of Bulletin No. 131, was established August 14, 1893, the gage being located at a point a few yards above the mouth of the river and near the bridge of the Northern Pacific Railroad. Owing to the difficulty of securing accurate measurements the readings were discontinued on September 20, 1894, and not resumed until August 19, 1895. The observer during 1895 has been the section foreman on the railroad. Discharge measurements were made from the railroad bridge at times of flood, and by wading the stream at low water. The bed of the stream is rocky, fairly permanent, and straight for about 50 feet above and below the bridge.

List of discharge measurements made on Naches River above North Yakima, Wash.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1893.						
1	Aug. 14	F. H. Newell......	24	1.00	322	3.70	1,193
	1894.						
2	Nov. 21	A. P. Davis........	24	2.50	490	2.44	*a* 1,196
	1895.						
3	Aug. 16	.....do............	55	1.62	289	1.61	466
4	Dec. 2	S. Storrow........	55	....	243	1.44	349

a Measurement made at Nelson's bridge, 4 miles above mouth of river.

Daily gage height of Naches River above North Yakima, Wash., for 1895, in feet.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	......	1.60	1.20	......	17	......	1.60	1.40	......	1.90
2	......	1.60	1.60	1.20	1.10	18	......	1.60	1.40	1.70	1.70
3	......	1.60	1.60	......	1.10	19	1.60	1.60	1.30	1.70	1.70
4	......	1.60	1.60	1.20	1.10	20	1.60	1.60	......	1.60	1.70
5	......	1.60	1.60	1.20	1.10	21	1.60	1.60	1.20	1.40	1.70
6	......	1.60	......	1.20	1.10	22	1.60	......	1.20	1.20	......
7	......	1.60	1.60	1.20	1.10	23	1.60	1.60	1.20	1.20	1.60
8	......	......	1.60	1.20	......	24	1.60	1.60	1.20	......	1.70
9	......	1.60	1.60	1.20	1.40	25	......	1.60	1.20	1.20	1.70
10	......	1.60	1.60	......	1.80	26	1.60	1.60	1.20	1.20	1.80
11	......	1.60	1.60	1.40	2.00	27	1.60	1.60	......	1.20	1.80
12	......	1.60	1.60	1.40	2.30	28	1.60	1.60	1.20	1.20	1.80
13	......	1.60	......	1.60	2.60	29	1.60	......	1.20	1.20	......
14	......	1.60	1.60	1.70	2.40	30	1.60	1.60	1.20	1.20	1.80
15	......	......	1.60	1.70	......	31	1.60	......	1.20	......	1.70
16	......	1.60	1.40	1.80	2.10						

UNION GAP STATION, ON YAKIMA RIVER.

Union Gap is the name applied to the deep gorge which the Yakima has cut in the ridge south of the valley in which the town of North Yakima is located. This section of country has been described by Mr. I. C. Russell in Bulletin No. 108 of this Survey, to which reference should be made for the geologic details. The first measurement of the river was made at this point on August 14, 1893. At that time there was an old vertical river rod attached to the central pier of the bridge. As the foot of this at low water was covered by rock and could not be read, a new inclined gage was put in position at the west end of the county bridge. This consisted of two pieces of timber having a total length of 24 feet. These were firmly secured to timbers, bedded, and loaded with rock. The gage rod was painted white and lettered in vertical feet and tenths of a foot. After this new gage was located, it was ascertained that the readings on the old gage would be 1.13 feet higher than on the new. The zero of this new gage was 19.02 feet below the top of the rail of the Northern Pacific Railroad immediately west of the west end of the bridge, which was about 40 feet from the gage. The high-water mark at that time showed that a flood had risen to 8.80 feet on the old gage. Readings at this point were begun on October 2, 1893, and continued during the following winter and spring until May 19, 1894. Owing to the destruction of the gage by floods the station was for a time abandoned.

On September 26, 1893, Mr. Samuel Storrow, assisted by Mr. J. B. Rogers, acting chief engineer of the Northern Pacific, Yakima and Kittitas Irrigating Company, measured the stream at a point about 200 yards above the bridge. The height of water was 0.25 foot below zero of the gage. On November 25, 1894, Mr. Arthur P. Davis visited the locality and made a measurement, the water at that time being 21.9 feet below the hand rail of the bridge. The width of the stream was 258 feet, the mean depth 3.14 feet, the maximum depth 8.10 feet, the mean velocity 5.74 feet per second, and the maximum velocity 6.91 feet per second. At this point the cross section is broken by two bridge piers, causing cross currents, but the results are considered to be fairly accurate.

During August, 1895, Mr. Arthur P. Davis revisited the locality and found that the bridge at the spot had been restored, but that the section was not favorable for making discharge measurements. He accordingly selected a place about 1,000 yards farther down the stream and stretched a cable. Measurements are to be made from a car suspended on this cable. He also established an inclined gage, following the slope of the bank, the distance between the vertical footmarks being 1.95 feet. This is attached to a willow stump and to posts set into the ground, and is loaded with rock. The gage is referenced to a mark, this being a stone marked B. M., 39 feet west of the gage and 8.5 feet east of the railroad track. It is 18.85 feet above the 11-foot mark. The initial point for soundings is at the tree which serves as a support for the cable on the left bank. The channel is straight for about 600 feet above the station and for about 300 feet below, the water having moderate velocity. During floods a part of the water passes through a depression on the left bank, and this must be measured from the bridge. The right bank is high and not liable to overflow.

List of discharge measurements made on Yakima River at Union Gap, Washington.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1893.						
1	Aug. 14	F. H. Newell	24	0.90	960	3.09	2,963
2	Sept. 26	Samuel Storrow	27	−0.25	453	2.62	1,186
	1894.						
3	Nov. 25	A. P. Davis	24		875	5.74	5,026
	1895.						
4	Aug. 19	do	55	4.10	949	1.13	1,070
	Nov. 18	Samuel Storrow		4.66		1.63	1,889

Daily gage height of Yakima River at Union Gap, below North Yakima, Wash., for 1893 and 1894, in feet.

Day.	1893.			1894.				
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
1	....	0.60	1.00	1.40	1.20	1.40	....	6.00
2	....	0.60	1.00	1.30	1.20	1.20	3.40	5.50
3	0.30	0.60	....	1.20	1.20	1.00	4.20	4.50
4	0.30	0.70	1.10	1.20	....	....	4.20	4.50
5	0.30	....	1.60	1.20	1.20	0.80	4.10	4.50
6	0.30	2.20	2.00	1.20	1.10	0.80	3.80	....
7	0.80	3.30	1.80	....	1.00	0.70	4.00	5.20
8	....	5.80	1.60	1.20	1.00	0.70	....	5.00
9	0.80	6.30	1.60	1.20	1.00	0.70	3.30	4.40
10	1.30	5.40	....	1.20	1.00	0.70	3.90	4.20
11	1.80	4.60	6.00	....	....	....	4.50	4.20
12	1.40	....	5.50	1.20	1.20	0.50	5.00	4.30
13	1.40	3.20	5.00	2.20	1.10	0.60	4.50	....
14	1.20	2.80	4.60	....	1.10	0.70	4.40	4.40
15	1.10	2.50	4.30	5.60	1.00	0.70	....	4.20
16	1.10	2.30	4.00	5.20	1.00	0.70	3.90	4.20
17	1.10	2.20	....	4.80	1.00	0.70	3.60	4.20
18	0.80	2.10	4.00	4.20	....	....	3.40	4.40
19	0.80	....	4.00	3.80	0.80	0.70	3.50	5.00
20	0.80	1.60	3.80	3.20	0.80	0.70	3.90	....
21	....	1.20	4.60	....	0.80	0.70	4.90	....
22	....	1.10	4.80	2.20	0.80	0.70	....	....
23	0.60	1.10	4.60	2.20	0.80	0.70	4.00	....
24	0.60	1.10	....	2.20	0.80	0.70	4.20	....
25	0.50	1.10	2.20	2.00	....	....	4.30	....
26	0.50	....	1.90	2.00	0.80	1.70	0.80	....
27	0.50	1.20	1.80	2.00	0.80	2.20	5.60	....
28	0.50	1.10	1.60	....	1.20	3.70	6.30	....
29	....	1.00	1.60	2.40	....	4.20	....	....
30	0.60	1.00	1.60	2.10	....	3.80	6.50	....
31	0.60	....	....	....	....	2.70	....	....

Daily gage height of Yakima River below North Yakima, Wash., for 1895, in feet.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	......	4.10	3.90	....	17	......	4.20	......	......	5.10
2	......	4.00	4.10	3.90	4.40	18	......	4.20	......	4.60	5.00
3	......	4.00	4.10	......	4.40	19	4.00	4.20	......	4.50	5.00
4	......	4.00	4.10	3.90	4.35	20	4.00	4.10	......	4.40	4.90
5	......	4.00	4.10	3.90	4.35	21	4.00	4.10	4.00	4.35	4.80
6	......	4.00	......	3.90	4.30	22	4.00	......	4.00	4.30	....
7	......	4.00	......	3.90	4.30	23	4.00	4.10	4.00	4.30	4.80
8	......	......	......	3.90	....	24	4.00	4.10	4.00	......	4.80
9	......	4.00	......	3.90	4.60	25	......	4.20	4.00	4.45	4.85
10	......	4.00	......	......	4.90	26	4.00	4.20	4.00	4.45	4.85
11	......	4.00	......	4.10	5.20	27	4.00	4.20	......	4.40	4.90
12	......	4.10	......	4.20	5.30	28	4.00	4.20	3.90	4.40	4.90
13	......	4.30	......	4.30	5.40	29	4.00	......	3.90	4.40	....
14	......	4.30	......	4.35	5.50	30	4.00	4.10	3.90	4.40	....
15	......	......	......	4.40	....	31	4.00	......	3.90	......	....
16	......	4.30	......	4.45	5.20						

Daily gage height of Yakima River at head of Sunnyside Canal, 1894, in feet.

Day.	April.	May.	June.	July.	Day.	April.	May.	June.	July.
1	....	6.1	8.4	4.5	17	4.8	5.00	5.0	3.8
2	....	5.5	8.7	4.5	18	4.7	4.85	5.7	3.8
3	....	5.35	8.8	4.6	19	4.7	5.00	6.2	3.7
4	....	5.35	9.7	4.8	20	4.7	6.05	6.3	3.6
5	4.3	5.35	9.8	4.9	21	5.1	6.8	6.0	3.5
6	4.3	5.6	8.7	5.1	22	5.5	7.1	5.7	3.3
7	4.4	5.8	7.8	5.2	23	5.8	7.3	5.4	3.2
8	4.5	5.5	7.4	5.1	24	5.8	8.1	5.2	3.1
9	4.5	5.3	6.9	4.8	25	6.0	9.1	5.2	(a)
10	4.7	5.1	6.5	4.5	26	6.2	9.8	5.0	....
11	5.2	5.1	5.9	4.2	27	8.1	10.35	4.9	....
12	5.5	5.05	5.3	4.0	28	7.8	10.10	4.75	....
13	5.35	5.15	5.0	3.7	29	7.2	9.5	4.6	....
14	5.25	5.15	4.8	3.3	30	5.7	8.7	4.5	....
15	5.1	5.15	4.6	3.7	31	....	8.3	....	....
16	4.8	5.10	4.6	3.8					

a Wing dam erected.

TOPINISH STATION, ON TOPINISH CREEK.

The work at this point has been described on page 74 of Bulletin No. 131. Occasional observations of river height have been maintained, but owing to failure to make discharge measurements material has not been obtained for interpreting these into discharges.

Daily gage height of Topinish River at Topinish, Wash., for 1895, in feet.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	......	2.90	......	......	17	3.00	......	......	3.30
2	......	2.90	3.10	3.20	18	3.00	2.90	3.20	3.20
3	......	......	3.20	3.20	19	......	2.90	3.20	......
4	......	2.90	3.20	2.20	20	2.90	......	3.20	3.10
5	......	......	3.20	3.20	21	2.90	3.00	3.20	3.10
6	......	......	3.20	3.20	22	......	3.00	3.20	......
7	......	2.90	3.20	3.20	23	2.90	3.00	3.20	......
8	......	......	3.20	......	24	......	3.00	......	......
9	2.80	2.90	3.20	3.30	25	2.90	3.00	3.20	......
10	......	......	......	3.30	26	......	3.00	3.20	......
11	2.80	2.90	3.20	3.30	27	2.90	......	3.20	......
12	2.90	2.90	3.20	3.30	28	2.90	3.00	3.20	......
13	3.00	......	3.20	3.30	29	......	3.00	3.20	......
14	3.00	2.90	3.20	3.30	30	2.90	......	3.20	3.40
15	3.00	......	3.20	......	31	......	3.00	......	3.40
16	3.00	2.90	3.20	3.30					

SATAS STATION, ON SATAS RIVER.

Observations at this point have been maintained as described on page 75 of Bulletin No. 131. No measurements, however, have been made by Mr. Storrow, and as yet it has not been found practicable to attempt computation of probable discharge through the various bridge openings.

KIONA STATION, ON YAKIMA RIVER.

This, the lowest point at which measurements have been made on Yakima River, is located at the wagon bridge, about a quarter of a mile north of the railroad station at Kiona. The river rod was established on August 20, 1895, the observer being W. A. Kelso, postmaster at Kiona. Measurements are made from the bridge. The gage consists of two parts, one being vertical, the other inclined at an angle of 30°. It is spiked to the east end of the south pier, and anchored by means of rocks. The initial point for soundings is on the right-hand side at the end of the bridge. The channel for about 200 feet both above and below the station is nearly straight and the water is quite swift. The right bank is low, and may overflow at time of great floods. The left bank, on the contrary, is high and rocky. The bed of the stream is of gravel, and affords an excellent locality for the river measurements. On August 20, 1895, measurement by means of a Price meter No. 55 gave an average velocity of 1.27 feet per second, a maximum velocity of 2.10 feet per second, a total area of 753 square feet, and a total discharge 954 second-feet.

Daily gage height of Yakima River at Kiona, Wash., for 1895, in feet.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	2.90	......	......	4.60	17	......	3.65	3.20	3.80	7.20
2	......	2.90	3.80	3.20	4.60	18	......	3.60	3.20	......	6.80
3	......	2.85	......	3.20	4.50	19	......	3.75	3.20	4.70	......
4	......	2.80	3.80	3.20	4.50	20	3.30	3.30	3.20	......	6.00
5	......	2.80	3.70	3.20	4.50	21	3.30	3.40	3.10	5.30	(a)
6	......	2.90	3.60	3.20	4.40	22	3.25	3.50	3.10	5.20	......
7	......	3.05	3.60	3.20	......	23	3.15	3.50	3.10	5.00	5.50
8	......	3.10	3.60	3.20	......	24	3.12	......	3.10	5.00	6.20
9	......	3.00	......	3.25	......	25	3.10	......	3.10	4.65	6.20
10	......	3.00	......	3.23	4.10	26	3.05	......	3.00	4.50	5.70
11	......	3.05	3.40	3.20	4.15	27	3.05	......	3.00	4.50	6.10
12	......	3.25	3.35	3.20	4.90	28	2.95	......	3.00	4.30	5.50
13	......	3.40	3.30	3.20	5.75	29	2.90	......	......	4.40	6.00
14	......	3.60	3.30	3.20	6.50	30	2.85	......	......	4.50	6.20
15	......	3.70	3.30	......	7.20	31	2.90	......	......	......	6.05
16	......	3.70	3.25	......	7.45						

a Water frozen on gage.

SACRAMENTO BASIN.

SACRAMENTO RIVER.

A brief description of the work along this river has been given in Bulletin No. 131, on page 75. As there stated, observations of river height have been made at two points not far apart, the first at Redbluff and the second at Tehama, about 12 miles by rail below. The observations of river height at Redbluff have been made by the Weather Bureau, and those at Tehama by the Central Pacific Railroad Company, at its bridge. The record of river height at Tehama was begun in May, 1877, and is continuous from that time. It thus affords one of the longest series of observations concerning the fluctuations of river height that have been made in the West. On the 1st of August, 1886, there is an abrupt change in the reading, apparently 9 feet having been arbitrarily added to the rod, so that the reading of July 31, 1886, of 12.50 feet is succeeded on August 1 by 21.60. Another arbitrary change apparently takes place on June 30, 1870, as the reading of that date, 22.83 feet, is followed on July 1 by a reading of 16 feet. This change in reading is explained by the statement that a new bridge watchman, finding the depth different from that which his predecessor had reported, and believing that the depth of water was wanted, changed the reading. This change having been made, instructions were issued to continue, and to avoid confusion, not to go back to the old datum.

A statement is made that in August, 1886, the river was sounded 14 feet east of the draw pier, and a depth of 21.17 feet was found, this depth being caused by the obstruction offered by the pier. The following river soundings were taken 500 feet above the bridge, commencing at the western bank, the river being 493 feet in width.

Soundings of Sacramento River.

Distance from bank.	Depth of river.
Feet.	*Feet.*
100	9.50
150	8.83
200	8.17
250	7.67
300	6.50
350	5.33
400	4.17
450	3.00
490	0.50

At that time the river was reported to be 2 feet above low-water mark. The velocity at a point 150 feet from the western bank was 1 mile in 1,900 seconds, or 3.51 feet per second; at 150 feet from the eastern bank the velocity was 1 mile in 2,100 seconds, or 3.98 feet per second.

On August 6, 1890, it is reported that the river was sounded by J. K. Birdsall and R. Gard, bridge keepers, who state that at that time the deepest hole was 14.75 feet. At the other places the depth was from 8 to 11 feet.

A general description of the Sacramento River and Valley has been given in the report of the examining commission on rivers and harbors to the governor of California, prepared by C. F. Reed, C. E. Grunsky, and J. J. Crawford, commissioners, 1890; also in the report of the commissioner of public works to the governor of California, by A. H. Rose, commissioner, Marsden Manson and C. E. Grunsky, consulting engineers, Sacramento, 1895.

REDBLUFF STATION, ON SACRAMENTO RIVER.

As stated in Bulletin No. 131, page 76, the conditions at the station at Redbluff are not favorable for accurate discharge measurements, the bridge being oblique to the current and its piers disturbing the uniform flow. A better locality has been found at Jelly's ferry, about 12 miles above Redbluff. There are a few short drainage channels coming into the river between these two points, the principal one of these being Paines Creek. The summer discharge of these streams is so small that it does not perceptibly increase the flow of the river. The discharge measurements made at Jelly's ferry can, therefore, be applied with reasonable accuracy to the rod readings at Redbluff. A river gage was established at Jelly's ferry by Mr. J. B. Lippincott, and readings were begun on April 29, 1895. The observer is Fred. Lemstrom, the ferryman at this place.

The gage consists of a vertical rod marked to tenths of a foot. It is made in three sections and nailed firmly to trees. The first section reads from 4 to 8 feet, and is located on the north bank, 30 feet above the cable; the second section reads from 8 to 20 feet, and is placed 20 feet below the cable; the third section reads from 20 to 40 feet, and is attached to a large sycamore tree at the north end of the cable. Beside the gage rod at this point, another rod is located 1,206 feet upstream from the gage and another 350 feet downstream, in order to determine the slope of the water surface. There are two bench marks. Bench mark No. 1 is on an oak tree on the left bank, 1,206 feet upstream from the ferry and 65 feet north of the upper rod; bench mark No. 2 is on an oak root on the left bank of the river 300 feet below the cable. Assuming the zero of the river gage at the ferry cable as the datum plane, bench mark No. 1 is at an elevation of 22.724 feet, and bench mark No. 2 is at an elevation of 22.429 feet. The zero of the upstream gage, 1,206 feet above the cable, is at a height of 5.106 feet, and the zero of the lowest rod, 350 feet below the cable, is at a height of 3.846 feet.

The channel for a thousand feet above and below the station is nearly straight, and the water during summer has a mean velocity of about 2.5 feet per second. The right bank is high, but the left bank is liable to be overflowed when the water rises above the 25-foot mark. The bed of the stream consists of gravel, and changes slightly.

The following list shows the measurements made at Redbluff and at Jelly's ferry. Those numbered from 1 to 3 are at the former place. The first measurement, that on December 20, 1894, was an approximation, as the water in a part of the channel was too swift to permit the use of the meter, necessitating an estimation of the higher velocities. The fourth measurement, that on April 30, was at Jelly's ferry, for the results previously obtained at Redbluff were not considered to have the desirable degree of accuracy. At that time, April 30, the equipment was not in position, and it was necessary to make measurements with such material as was at hand. A rowboat was swung from the cable of the ferry, and from this soundings and velocity were measured, the position of the boat being determined by stadia readings from a transit set on the south bank of the river. The greatest depth found was 19 feet and the maximum velocity was 6.80 feet per second. The depth and high velocity, together with the motion of the boat, interfered considerably with accurate measurements. The velocity of the river, on account of the uniform section and straight channel above and below the ferry, is quite regular.

On June 30, 1895, a second measurement was made at Jelly's ferry, the river having fallen from 12 feet to 6.75. The water at that time was clear, and was considered to be at its normal stage for this period of the year. More satisfactory soundings were obtained at this time than formerly, owing to the fact that a relatively light lead weight of about 5 pounds was used, this being held by a fine braided silk trout line.

The slope of the stream, as determined by the gage rods, was on August 25, 1895, 0.28 foot in 1,556 feet, or 0.00018. Assuming that

$n = 0.025$, the discharge, according to Kutter's formula, would be 6,288 second-feet, with $n = 0.0275$, the discharge would be 5,497 second-feet. The measured discharge was 5,452 second-feet. On October 5 the slope was 0.24 foot in 1,556 feet, or 0.00015 instead of 0.28 foot, as found on August 25. But little difference was found in the areas of cross section of these two measurements. There was a decided increase in the velocities throughout the stream. The measurements were made by the same meter.

A short distance below Jelly's ferry the river enters a narrow box canyon. In times of high water this canyon causes the river to pond, so that the rise and fall at Jelly's ferry is very great, a 40-foot rod being required at this point. This blocking of the river prevents the excessive velocities which occur at other places examined along the stream, and which are too great for accurate measurement with present instruments. The daily fluctuation of the river appears to be small, on account of the balancing influence of the numerous tributaries entering both from the Coast Range and from the Sierra Nevadas. The State engineers of California have made measurements of the Sacramento at Iron Canyon, as the section is uniform and the river is confined at all stages.

During 1895 the Army engineers made a survey of the stream from Redding to Redbluff, the present head of the river navigation, to determine the feasibility of making this portion of the stream navigable. It is reported that they have established a gage at Redding, and are also keeping readings at a point lower down on the river, but have made no measurements of discharge.

List of discharge measurements made on Sacramento River at Redbluff and Jelly's ferry, California.

No.	Date.	Hydrographer.	Meter number.	Gage height, Redbluff.	Gage height, Jelly's ferry.	Mean velocity (feet per second).	Discharge (second-feet).
	1894.						
b 1	Dec. 20	A. P. Davis......	24	10.70	....	8.60	*a* 45,000
	1895.				....		
b 2	Mar. 19	J. B. Lippincott .	24	4.80		....	15,461
b 3	Apr. 27	.....do..........	24	8.40	....	7.72	*a* 36,181
4	Apr. 30	.....do..........	24	....	12.00	5.96	33,457
5	June 30	.....do..........	24	2.70	6.75	3.31	8,456
6	Aug. 25	.....do..........	24	0.90	5.55	2.41	5,452
7	Aug. 26	.....do..........	....	0.80	....	....	*c* 5,500
8	Oct. 5	.....do..........	24	0.70	5.55	2.57	6,165

a Approximate.
b Measurements made at Redbluff, others at Jelly's ferry.
c River rising.

Rating table of Sacramento River at Redbluff, Cal., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*	*Feet.*	*Sec. feet.*
0.50	5,750	2.40	8,380	5.80	19,660	12.50	57,200
0.60	5,830	2.60	8,820	6.00	20,600	13.00	60,000
0.70	5,910	2.80	9,260	6.20	21,700	13.50	62,800
0.80	5,990	3.00	9,700	6.40	22,800	14.00	65,600
0.90	6,070	3.20	10,260	6.60	23,900	14.50	68,400
1.00	6,150	3.40	10,820	6.80	25,000	15.00	71,200
1.10	6,285	3.60	11,380	7.00	26,100	15.50	74,050
1.20	6,420	3.80	11,940	7.50	28,950	16.00	76,900
1.30	6,555	4.00	12,500	8.00	31,800	16.50	79,850
1.40	6,690	4.20	13,180	8.50	34,400	17.00	82,800
1.50	6,825	4.40	13,860	9.00	37,000	17.50	86,000
1.60	6,960	4.60	14,540	9.50	39,900	18.00	89,200
1.70	7,195	4.80	15,220	10.00	42,800	19.00	95,600
1.80	7,230	5.00	15,900	10.50	45,700	20.00	102.200
1.90	7,365	5.20	16,840	11.00	48,600	21.00	110,000
2.00	7,500	5.40	17,780	11.50	51,500	22.00	119,000
2.20	7,940	5.60	18,720	12.00	54,400	23.00	129,000

Daily gage height of Sacramento River at Redbluff, Cal., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct,	Nov.	Dec.
1...	6.8	4.8	9.8	8.2	7.3	5.6	2.7	1.0	0.7	0.7	0.8	1.6
2...	6.0	5.2	9.0	8.2	7.3	5.6	2.6	1.0	0.7	0.7	0.8	1.0
3...	5.8	5.2	9.0	8.0	8.1	5.5	2.5	1.0	0.6	0.7	1.0	1.6
4...	21.4	4.5	8.7	7.6	8.2	5.4	2.5	1.0	0.6	0.7	1.4	3.2
5...	15.6	4.4	8.6	7.1	8.4	5.4	2.4	0.9	.06	0.7	1.0	1.4
6...	10.5	4.4	8.8	7.5	10.5	5.2	2.3	0.9	0.6	0.7	1.0	1.2
7...	7.7	4.4	8.9	7.6	11.0	5.1	2.2	0.9	0.6	0.7	0.8	1.0
8...	9.3	4.6	7.4	7.6	10.5	4.8	2.2	0.9	0.6	0.7	0.7	2.5
9...	10.0	4.6	7.1	7.4	10.4	4.4	1.9	0.9	0.6	0.7	0.7	3.2
10..	7.9	4.6	7.1	7.4	10.0	4.0	1.8	0.9	0.8	0.8	0.7	3.9
11..	7.1	6.0	7.0	7.1	9.5	4.0	1.8	0.9	1.7	1.1	0.7	8.0
12..	7.8	9.2	6.8	7.1	8.2	4.0	1.8	0.9	2.4	0.8	0.7	5.4
13..	18.6	8.7	6.8	7.1	8.0	4.0	1.8	0.9	3.4	0.9	0.7	2.0
14..	14.6	8.2	6.8	7.6	8.0	3.9	1.8	0.9	2.0	0.8	0.7	1.0
15..	10.3	6.2	6.8	7.6	8.5	3.8	1.8	0.9	1.5	0.8	0.9	1.0
16..	10.8	5.7	6.0	7.4	7.5	3.8	1.7	0.9	1.2	0.8	0.8	1.0
17..	11.6	5.2	5.8	7.1	7.6	3.6	1.6	0.8	0.8	0.7	1.0	1.4
18..	13.5	5.4	5.8	7.1	7.3	3.5	1.5	0.8	0.8	0.7	1.3	1.3
19..	10.9	7.4	5.6	7.1	7.2	3.5	1.4	0.8	0.8	0.7	1.0	3.0
20..	9.5	6.8	6.4	7.1	6.8	3.5	1.4	0.8	0.8	0.7	1.0	2.0
21..	14.0	6.6	6.8	7.4	6.2	3.5	1.4	0.8	0.8	0.7	0.8	1.4
22..	22.0	8.2	9.7	7.6	5.9	3.4	1.4	0.9	0.8	0.7	0.8	1.0
23..	20.0	13.4	8.4	7.6	5.6	3.4	1.4	1.0	0.8	0.7	0.7	1.0
24..	12.6	14.0	6.8	7.8	5.4	3.1	1.3	0.9	0.8	0.7	0.7	3.8
25..	9.8	11.6	6.8	8.3	5.2	3.0	1.3	0.9	0.8	0.7	0.7	3.4
26..	7.7	9.6	7.6	8.4	6.6	3.0	1.3	0.8	0.8	1.0	0.7	9.2
27..	6.4	8.4	8.2	8.4	8.4	2.9	1.3	0.8	0.8	0.8	0.7	6.2
28..	5.7	8.6	17.4	8.2	7.3	2.8	1.3	0.8	0.8	0.9	0.7	2.6
29..	5.5	......	14.0	8.1	6.8	2.8	1.2	0.8	0.8	0.8	0.8	1.4
30..	5.1	......	11.6	7.7	5.9	2.7	1.1	0.8	0.8	0.8	1.2	1.0
31..	4.8	......	8.4	......	5.8	......	1.0	0.9	......	0.8	.....	1.0

Discharge of Sacramento River at Redbluff Bridge.

[Drainage area, 9,356 square miles.[1]]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1895.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Inches.*	*Sec. feet.*
January	123,000	15,220	47,267	2,906,320	5.824	5.052
February	65,600	13,860	26,792	1,487,940	2.982	2.864
March	85,360	15,220	32,517	1,999,418	4.007	3.475
April	33,880	26,670	29,566	1,759,300	3.526	3.160
May	48,600	16,840	30,238	1,859,250	3.726	3.232
June	18,600	9,040	12,764	759,510	1.522	1.717
July	9,040	6,150	7,235	444,863	.892	1.364
August	6,150	5,990	6,057	372,436	.746	.647
September ...	10,820	5,830	6,321	376,106	.754	.676
October	6,285	5,910	5,989	368,261	.738	.640
November ...	6,690	5,910	6,046	359,792	.711	.646
December	36,880	6,150	10,095	620,760	1.244	1.079
Per annum.	123,000	5,830	18,390	13,313,956	26.672	1.9656

[1] Drainage areas were measured from maps of United States Geological Survey.

Daily gage height of Sacramento River at Jelly's ferry, California, for 1895, in feet.

Day.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	11.65	9.30	6.70	5.80	5.50	5.60	5.60	5.95
2	....	12.25	9.00	6.70	5.80	5.50	5.60	5.60	5.90
3	....	12.10	8.90	6.70	5.80	5.50	5.60	5.60	5.80
4	....	13.00	8.90	6.70	5.80	5.50	5.50	5.60	5.80
5	....	14.20	9.00	7.05	5.80	5.50	5.50	5.60	5.90
6	....	15.30	9.00	6.40	5.80	5.50	5.50	5.60	7.30
7	....	15.20	8.80	6.65	5.70	5.50	5.60	5.60	6.50
8	....	14.20	8.60	6.60	5.70	5.50	5.60	5.60	6.15
9	....	13.35	8.45	6.50	5.70	5.50	5.50	5.60	6.00
10	....	12.60	8.30	6.50	5.70	5.50	5.50	5.60	5.90
11	....	12.05	8.20	6.40	5.70	6.05	5.50	5.60	5.80
12	....	12.05	8.15	6.40	5.70	7.75	5.50	5.60	5.80
13	....	12.25	8.10	6.40	5.70	7.30	5.50	5.60	5.80
14	....	12.50	7.95	6.35	5.70	6.30	5.50	5.60	5.80
15	....	12.50	7.75	6.30	5.60	6.05	5.50	5.65	6.15
16	....	12.45	7.55	6.30	5.60	5.90	5.50	5.70	6.00
17	....	12.35	7.40	6.20	5.60	5.90	5.50	5.70	5.90
18	....	11.95	7.30	6.15	5.60	5.90	5.50	5.70	5.85
19	....	11.45	7.25	6.10	5.60	5.80	5.50	5.70	5.90
20	....	10.95	7.25	6.10	5.60	5.80	5.50	5.70	12.75
21	....	10.40	7.25	6.05	5.60	5.80	5.60	5.70	7.50
22	....	9.95	7.25	6.00	5.60	5.70	5.60	5.70	6.50
23	....	9.60	7.25	6.00	5.60	5.70	5.60	5.70	6.40
24	....	9.40	7.20	6.00	5.60	5.70	5.60	5.70	6.20
25	....	9.40	7.10	6.00	5.55	5.70	5.60	5.70	6.00
26	....	11.90	7.00	5.95	5.50	5.70	5.60	5.70	5.90
27	....	13.45	6.95	5.90	5.50	5.70	5.60	5.70	5.80
28	....	11.25	6.90	5.90	5.50	5.70	5.60	5.70	5.80
29	12.00	10.35	6.80	5.90	5.50	5.65	5.60	6.10	5.80
30	11.75	9.85	6.70	5.90	5.50	5.60	5.60	5.80	5.70
31	....	9.50	....	5.85	5.50	....	5.20	....	5.70

Daily gage height of Sacramento River at Tehama Bridge, California, for 1891, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	12.83	12.50	20.50	14.50	14.00	13.67	12.00	12.17	11.67	11.67	10.83	13.00
2	13.00	12.50	19.00	14.50	14.00	13.67	12.83	12.17	11.67	11.67	11.83	13.00
3	13.50	12.50	19.00	14.50	14.00	13.67	12.83	12.17	11.67	11.67	11.00	13.00
4	13.67	12.50	18.00	14.75	14.00	13.67	12.83	11.83	11.67	11.67	12.00	13.00
5	15.67	12.50	17.00	14.00	14.00	13.33	12.83	11.83	11.67	11.67	12.83	13.00
6	13.00	12.50	16.00	14.00	14.50	13.33	12.83	11.83	11.67	11.67	13.50	13.00
7	13.00	12.50	15.00	15.00	16.00	13.33	12.50	11.83	11.67	11.67	13.33	13.00
8	13.50	12.50	15.00	15.00	15.00	13.33	12.50	11.83	11.67	11.67	12.17	13.00
9	13.50	12.33	14.50	14.50	14.50	13.33	12.50	11.83	11.67	11.67	12.17	13.00
10	13.17	12.33	14.50	14.50	14.33	13.00	12.50	11.83	11.67	11.67	12.00	13.00
11	12.00	12.33	15.00	18.00	14.00	13.00	12.50	11.83	11.67	11.67	12.00	13.00
12	12.00	12.33	15.00	16.00	13.83	14.00	12.67	11.83	11.67	11.67	12.00	13.00
13	12.00	12.33	15.50	15.50	13.83	14.00	12.50	11.83	11.67	11.67	12.83	13.00
14	12.00	16.00	15.00	15.50	13.50	14.00	12.50	11.83	11.67	11.67	12.83	13.00
15	12.00	25.00	15.60	15.50	13.50	13.00	12.50	11.83	11.83	11.67	12.83	13.00
16	12.00	18.00	15.00	15.00	13.33	13.00	12.50	11.83	11.83	11.67	12.83	13.00
17	12.67	18.00	15.50	16.00	13.00	13.00	12.50	11.67	11.83	11.67	12.83	13.00
18	12.67	14.00	15.50	16.00	13.00	13.67	12.50	11.67	11.83	11.67	12.83	13.00
19	12.67	13.50	15.50	15.00	13.00	13.67	12.50	11.67	11.83	11.67	12.83	13.00
20	12.67	13.50	15.50	15.00	13.00	13.00	12.50	11.67	11.83	11.67	12.83	13.00
21	12.67	14.00	15.50	15.00	12.00	13.00	12.50	11.67	11.83	11.67	12.83	13.00
22	12.67	19.00	15.00	15.00	12.00	13.67	12.50	11.67	11.83	11.67	12.83	13.00
23	12.50	24.00	15.00	15.00	12.00	13.67	12.50	11.67	11.83	11.67	12.83	13.00
24	12.50	18.00	15.00	15.00	12.00	13.33	12.50	11.67	11.83	11.00	12.83	12.67
25	12.50	16.00	14.50	15.00	12.00	13.33	12.33	11.67	11.83	11.00	12.83	12.67
26	12.50	15.00	14.50	14.50	12.00	13.33	12.33	11.67	11.83	11.83	12.83	12.67
27	12.50	16.00	17.50	14.50	12.00	13.33	12.33	11.67	11.83	11.83	12.83	13.50
28	12.50	22.00	15.50	14.50	12.83	13.33	12.33	11.67	11.83	11.83	12.83	13.50
29	12.50	....	15.50	14.17	12.00	12.00	12.33	11.67	11.67	11.83	12.83	14.83
30	12.50	....	15.00	14.33	12.00	12.00	12.33	11.67	11.67	11.83	12.83	14.00
31	12.50	....	15.00	....	13.00	....	12.17	11.67	....	11.83	....	13.00

Daily gage height of Sacramento River at Tehama Bridge, California, for 1892,[1] in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	13.00	13.00	14.00	15.00	15.00	13.83	12.00	11.50	11.50	11.83	12.00	19.00
2..	13.00	13.00	14.00	17.00	16.00	13.67	12.83	11.50	11.50	11.83	12.00	18.50
3..	14.00	13.00	13.50	16.00	16.00	13.67	11.83	11.50	11.50	11.83	12.00	24.25
4..	14.00	13.00	13.50	16.00	16.00	13.50	11.83	11.50	11.50	11.83	12.00	20.00
5..	13.00	13.00	13.50	14.00	16.50	13.50	11.83	11.50	11.50	11.83	12.00	17.50
6..	13.00	19.00	13.50	13.50	17.00	13.50	11.83	11.50	11.50	11.83	12.00	16.25
7..	14.00	19.00	13.50	13.50	17.00	13.50	11.83	11.50	11.50	11.83	12.00	15.25
8..	14.00	13.50	13.50	13.50	16.50	13.50	11.83	11.50	11.50	12.00	12.00	14.50
9..	15.00	13.50	13.50	13.50	16.00	13.17	11.83	11.50	11.50	12.00	12.00	14.50
10.	13.50	13.50	13.50	13.50	16.00	13.17	11.83	11.50	11.50	13.00	12.00	14.25
11.	13.00	13.00	13.00	13.50	16.50	13.17	11.67	11.50	11.50	12.50	12.00	14.00
12.	13.00	13.00	13.00	13.50	16.50	13.17	11.67	11.50	11.50	12.50	12.00	13.75
13.	12.50	13.00	13.00	13.50	16.50	13.17	11.67	11.50	11.50	12.67	12.00	13.75
14.	12.50	13.00	13.00	14.00	15.00	13.17	11.67	11.50	11.50	12.67	12.00	13.50
15.	12.00	13.00	13.00	20.00	17.00	12.83	11.67	11.50	11.50	12.67	12.00	13.25
16.	12.00	13.00	13.00	17.00	17.50	12.83	11.67	11.50	11.50	12.67	12.00	13.25
17.	12.00	13.00	13.00	17.00	17.00	12.83	11.67	11.50	11.50	12.67	12.00	13.00
18.	12.00	13.50	14.00	16.00	16.00	12.83	11.67	11.50	11.50	12.00	12.00	13.00
19.	12.00	15.50	14.00	15.00	15.00	12.83	11.67	11.50	11.50	12.00	12.00	13.00
20.	12 00	18.00	15.00	15.00	14.00	12.67	11.67	11.50	11.50	12.00	12.00	13.00
21.	12.00	18.50	14.00	15.00	15.00	12.50	11.67	11.50	11.83	12.00	12.00	13.00
22.	12.00	19.00	13.50	15.00	15.00	12.50	11.67	11.50	11.83	12.00	12.00	14.50
23.	12.00	16.00	13.50	15.00	14.50	12.50	11.67	11.50	11.83	12.00	12.00	24.25
24.	12.00	15.00	13.00	14.67	15.50	12.50	11.67	11.50	11.83	12.00	12.25	27.00
25.	12.00	14.50	13.00	14.67	15.00	12.50	11.67	11.50	11.83	12.00	12.33	31.50
26.	13.00	14.50	13.00	14.50	15.00	12.33	11.67	11.50	11.83	12.00	12.50	31.50
27.	13.00	14.00	13.00	14.50	15.00	12.33	11.50	11.50	11.83	12.00	13.75	31.00
28.	13.00	14.00	13.00	14.50	14.67	12.33	11.50	11.50	11.83	12.00	18.50	28.00
29.	13.00	14.00	13.00	14.50	14.50	12.33	11.50	11.50	11.83	12.00	21.75	25.00
30.	13.00	....	17.00	15.00	14.33	12.00	11.50	11.50	11.83	12.00	24.50	23.00
31.	13.00	....	15.00	....	14.33	....	11.50	11.50	....	12.00	....	21.50

[1] The daily gage heights of Sacramento River at Tehama Bridge for 1893 and 1894 are given in Bulletin 131, pages 77-78.

Daily gage height of Sacramento River at Tehama Bridge, California, for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	4.75	3.75	6.17	6.67	6.00	3.83	1.83	0.75	0.67	0.67	0.67	0.83
2..	4.08	3.58	6.25	6.50	5.00	3.67	1.75	0.92	0.67	0.67	0.67	0.83
3..	3.75	3.58	6.17	6.17	5.83	3.50	1.67	0.83	0.67	0.67	0.67	0.83
4..	*a*15.08	3.50	6.00	6.17	6.08	3.50	1.67	0.75	0.67	0.67	0.67	0.83
5..	11.58	3.58	5.67	5.75	7.25	3.67	1.92	0.75	0.67	0.67	0.67	0.92
6..	7.50	3.50	4.92	5.33	7.75	3.67	1.83	0.75	0.67	0.75	0.67	2.50
7..	5.75	3.42	5.33	5.08	7.83	3.50	1.75	0.75	0.67	0.67	0.67	1.67
8..	7.50	3.42	5.08	5.08	7.75	3.42	1.75	0.75	0.67	0.67	0.67	1.25
9..	7.25	3.50	5.08	5.17	6.75	3.25	1.58	0.75	0.67	0.67	0.67	1.00
10.	5.83	3.50	5.08	5.33	6.17	3.17	1.50	0.75	0.67	0.67	0.67	1.00
11.	4.17	3.67	5.08	5.33	5.83	3.08	1.42	0.75	1.00	0.67	0.67	0.92
12.	4.92	6.75	4.92	5.17	5.75	3.00	1.42	0.75	2.58	0.67	0.67	0.83
13.	13.17	6.42	4.92	5.17	6.00	2.00	1.33	0.75	2.75	0.67	0.67	0.83
14.	10.08	5.75	5.08	5.25	6.00	2.00	1.33	0.75	1.50	0.67	0.67	0.83
15.	7.50	5.25	4.67	5.17	6.08	2.75	1.25	0.75	1.08	0.67	0.67	1.17
16.	8.58	4.83	4.33	5.00	6.17	2.58	1.25	0.67	1.00	0.67	0.67	1.08
17.	7.67	4.58	4.00	5.50	6.00	2.42	1.25	0.67	1.00	0.67	0.67	1.00
18.	7.83	4.58	3.83	5.50	5.83	2.33	1.17	0.67	1.00	0.67	0.67	0.92
19.	8.50	4.58	3.67	5.50	5.50	2.17	1.17	0.67	1.00	0.67	0.67	0.92
20.	6.25	4.83	4.42	5.50	5.42	2.17	1.17	0.67	1.00	0.67	0.67	*a*7.58
21.	9.92	5.08	5.42	5.58	4.92	2.08	1.17	0.67	0.75	0.67	0.58	2.92
22.	11.83	5.58	7.08	5.50	4.50	2.25	1.17	0.67	0.75	0.67	0.58	1.92
23.	15.50	8.17	5.00	5.58	4.25	2.17	1.17	0.67	0.75	0.67	0.58	1.33
24.	9.08	10.00	5.08	5.50	4.00	2.17	1.08	0.67	0.75	0.67	0.67	1.17
25.	7.50	8.08	5.33	5.92	4.00	2.25	1.08	0.67	0.75	0.67	0.67	1.08
26.	6.50	7.00	5.33	6.00	4.00	2.17	1.00	0.67	0.75	0.67	0.67	0.92
27.	5.25	6.42	5.58	6.08	7.58	2.08	1.00	0.67	0.75	0.67	0.67	0.83
28.	4.67	6.17	11.83	6.50	5.50	2.00	0.92	0.67	0.75	0.67	0.67	0.83
29.	4.33	....	9.83	5.83	5.00	2.00	0.92	0.67	0.75	0.67	0.83	0.83
30.	4.08	....	8.08	5.58	4.42	2.00	0.92	0.67	0.67	0.67	0.92	0.83
31.	3.83	....	7.25	....	4.17	....	0.83	0.67	....	0.58	....	0.75

a Rain.

SAN JOAQUIN BASIN.

By J. B. LIPPINCOTT.

A reconnoissance of the streams of the San Joaquin Valley was made during the latter part of 1895. This examination began at old Fort Tejon, on the Canyada de Los Uvas, or Fort Tejon Creek, in the extreme western limits of the valley, and included all of the streams on the south and east side as far north as the Stanislaus at Oakdale. The description in general is given in geographic order down the valley from south to north.

FORT TEJON CREEK.

This is one of the many singular streams of the State. It rises in the Ventura highlands at a maximum elevation of 8,000 feet, the upper part being known as Cuddy Creek and the lower as Fort Tejon Creek. The old stage line between northern and southern California, through Fort Tejon Pass, follows this stream down from Castac Lake, which has an elevation of 3,500 feet, to Rose Station, where the elevation is 1,300 feet. The total drainage area, including Cuddy Creek and Castac Lake, is 93 square miles. The formation of the upper portion of the basin on the south and west is largely granitic. It is soft, however, and has become to a large extent disintegrated on the surface, being washed down as a coarse sand into the valleys or canyons. On the northern side of the upper basin, however, the formation is largely limestone, much of it being in the nature of very beautiful white and gray marbles. The area of this upper basin is 56 square miles. A stream of 1 or 2 second-feet, known as Cuddy Creek, flows from this basin during the summer season. During the winter this is largely augmented by rains and melting snows. The minimum measured discharge of this stream is 0.4 second-foot, and sections have been measured while still wet that indicate a flood discharge of 30 second-feet. This is at a point on the drainage line of the stream 5 miles southwest of Castac Lake, near Menzies's house. Below this point the stream rapidly sinks and is soon lost in the sands. A well-marked drainage line in a broad canyon extends to Castac Lake, but the stream has seldom, even in flood, been seen to flow into the lake. The waters of the stream are fresh and sweet, while those of the lake are salty. Wells sunk along this dry sandy wash find no water. While this lake lies in the direct drainage line of this stream, it is not subject to violent rise or fall, for it seldom runs over the divide, which is only 12 feet above its ordinary level. The stream approaches the lake from the west, while a well-defined drainage line and a large canyon lead from the lake toward the northwest. The angle between the approaching and departing lines is less than 45°, the latter being much lower in elevation. The stream sinks into the sands at an elevation of over 4,000 feet. The elevation of the lake is 3,500 feet, and 9 miles below the lake the elevation of the plain is 1,300 feet. A mile below the lake strong springs, or cienegas, occur in large numbers, there being one alone that constantly flows over 1 second-foot. These springs, which are of sweet and soft water, are the source of Fort Tejon Creek. The ridge which lies between the cienegas and the point where Cuddy Creek disappears is of limestone or marble. The difference in elevation (1,000 feet) is such that, all things being considered, it is fair to assume that some of the waters of Cuddy Creek pass under the mountain, reappearing in the springs to swell Fort Tejon Creek.

The character of the soil of the Fort Tejon Creek basin proper is of clay, favorable to run-off. The rocks are usually near the surface, and are either of hard granite or marble. Both basins are covered with scattered trees of oak and pine, with much brush on the northern slopes.

Mr. Cuddy, who lives in the upper basin at an elevation of 5,278 feet, says that he has kept a rainfall record for a period of ten years at his house, which shows an average precipitation of 30 inches. Unfortunately this record, after having been preserved for many years, was destroyed. At Fort Tejon (elevation 3,245 feet) a very fragmentary record was kept from 1855 to 1864 by the United States Army. The Weather Bureau averages the record at 15.35 inches, while the California State engineer, with probably greater attention to details, gives 23.45 as the mean. The practice of the Weather Bureau of dividing the year at the 1st of January does not give correct ideas of the maximum and minimum seasonal rain on the Pacific Coast, and is often misleading in other ways in the determination of averages. The rainfall on the plains at Rose Station is probably between 10 and 12 inches. The average rainfall of the basin can be taken as 20 inches.

The seasonal rainfall at Fort Tejon, as reported by the United States War Department, is—

	Inches.
1855-56	32.97
1856-57	11.97
1857-58	25.40
Mean	23.45

The seasonal rainfall at the Tejon ranch house, as kept by Mr. R. N. Pogson, is—

	Inches.
1879-80	19.22
1880-81	9.58
1881-82	9.98
1882-83	9.10
1883-84	18.27
1884-85	7.95
1885-86	13.50

	Inches.
1886–87	11.67
1887–88	11.09
1888–89	9.40
1889–90	14.14
1890–91	11.20
1891–92	16.22
1892–93	10.30
1893–94	12.28
1894–95	12.97
Mean	11.52

The following is a list of the measurements of Fort Tejon Creek, taken at a point two miles south of Rose Station, at the foot of the road grade near a lone tree, and above where the creek debouches onto the plain. All measurements were made with floats, and the mean velocity taken as from 70 to 80 per cent of the surface velocity according as little or much water was in the stream.

Measurements of Fort Tejon Creek.

Date.	Second-feet.	Date.	Second-feet.
1894.			
January 10	40.0	December 31	5.6
March 2	60.0	1895.	
March 7	40.0	January 1	4.0
March 22	8.0	February 1	5.0
June 3	3.2	March 7	4.8
July 1	2.4	May 23	1.7
September 5	0.7	September 5	1.5
December 8	61.5	November 13	2.6

A feature of this stream is that it holds its own through the summer better than most of its neighbors, presumably because it is reservoired through the hills, as above stated. None of its waters are used for irrigation.

SALT AND SAN EMIDIO CREEKS.

Salt Creek lies next west of the Fort Tejon Creek. The drainage basin is similar to that of the others of this group. In area it covers 35 square miles, as indicated by the Wheeler map. The discharge has not been measured, but it is small and spasmodic. To the west of this stream, and also in the extreme southern limits of this valley, is the San Emidio Creek, which flows from the same group of mountains. Its usual summer discharge is reported on good authority to be about 3 second-feet. A flume has been placed in the bed of the creek and rated by the Kern County Land Company. A few orange groves are irrigated from this source. The area drained is estimated to be 54 square miles.

PASTORIA CREEK.

Next east of the Fort Tejon Creek is Pastoria Creek. The drainage basin of this stream is mostly of a granite formation with an overlying soil of clay. The country has been extensively pastured to sheep, and the effect is seen in the facts that the hard ground quickly sheds the water that falls thereon and the stream is very spasmodic. In connection with this it is interesting to note that intelligent observers state that pasturing sheep for three years on a drainage basin produces visible effect on the stream. The area of this basin as determined from the Wheeler map is 43 square miles, and its elevation ranges from 1,200 feet up to 5,500 feet. The country is sparsely timbered with a growth of oaks, and the northern slopes are usually covered with a dense growth of brush.

The basin lies between Fort Tejon, elevation, 3,245 feet, whose rainfall may be fairly taken as 23 inches, and Tejon ranch house, elevation 1,300 feet, but whose mean rainfall is 11.52 inches, with a probable average elevation of 2,600 feet and a rainfall of 20 inches. An interesting feature of the rainfall of this basin, as well as of that of the Fort Tejon Creek, Tunis Creek, and House Creek, is that it enjoys the benefit of two distinct types of rain storms. These basins lie at the junction of the Coast Range with the Tehachapi Mountains, which latter are the southern limit of the Sierra Nevadas and form a connection with the Coast Range. Many northern storms which are driven into the San Joaquin Valley from the west and southwest are deflected by the Sierras and forced south through this valley. Having reached the southern limit of the San Joaquin they are forced to ascend the Tehachapi slopes to an elevation of 5,000 feet, and often much of their moisture is condensed at this point. The rain storms of southern California usually approach from the south or southwest, having absorbed their humidity in their journey over the Pacific, and being chilled in their ascent over the Coast Range they give off their moisture. This is true of the storms which visit this basin from the south. Thus these districts get their storms from both north and south, while either to the north or south of them, storms as a rule only approach from one way.

The following are the gagings made of Pastoria Creek at the mouth of the canyon, at a red, rocky point:

Discharge measurements made on Pastoria Creek.

Date.	Second-feet.
1894.	
March 24	14.3
June 12	3.7
July 1	2.5
September 5	0.0
November 1	0.0
December 8	26.0
1895.	
January 1	0.8
February 1	2.8
November 13	0.4
September 1	0.0

TUNIS CREEK.

Next east of the Pastoria is Tunis Creek. The basin of this stream is very broken and with little soil on the sides of the mountains, the rocks being mainly granite. The area is about 20 square miles, as shown by the Wheeler map, but small, detailed areas of this sort can not be taken with accuracy from a map of so small a scale (4 miles to the inch). The rainfall is probably about that of the Pastoria drainage basin. The stream has seldom been measured, but apparently it discharges as much water as the Pastoria, except in flood, and holds its own rather better in midsummer. As in the case of the Fort Tejon and Pastoria creeks, the waters of this stream are not as yet used for irrigation. Large herds of cattle graze these plains and are watered from these streams.

TEJON HOUSE CREEK.

Tejon House Creek lies next north and east of Tunis Creek, and its basin, like that of the latter, is greatly broken with granite rocks, covered as a rule with clay, and with steep hillsides. The northern slopes are covered with a dense growth of high brush, and the valleys and hillsides generally are sparsely covered with oak of a quality too poor for any use except for firewood. The area, as shown by the Wheeler map, is 17 square miles, but the basin appears on inspection to be larger. This stream rises from the highest peaks of this vicinity, namely, Tehachapi, 8,056 feet, and Double Peak, 8,263 feet. This is the largest and most important stream from this range. The winter floods are large, and the summer flow is well sustained.

The rainfall in the basin of this stream is similar to that of others before mentioned. It has been measured for a period of sixteen consecutive years (1879–1895) at the Tejon ranch house and has a seasonal maximum of 19.23 inches, minimum 7.45 inches, and mean 11.52 inches. It may be safely taken at 25 inches for the average of the basin.

During 1894 the stream was occasionally measured. My measurements were all made at the Tejon ranch house, which is 2 miles below the foothills of the mountains. The bed of the stream between the foothills and the ranch house is in rocks and red clay. The channel of the creek at the point of measurement is covered with gravel of sizes ranging from 1 to 6 inches in diameter. The grade of the creek is steep. The average velocity of various floats in different parts of the stream was observed, and from 70 to 80 per cent used as the mean velocity, depending somewhat on the depth of water in the bed, a higher average velocity being taken when the water was deeper.

Discharge measurements of Tejon House Creek.

Date.	Second-feet.
1879.	
March 3 (*a*)	7.5
1894.	
January 10	60.0
January 21	66.1
March 1	80.0
March 24	60.0
June 24	6.5
September 5	0.9
December 4	1.0
December 6	3.0

a Made by J. D. Schuyler.

TEJON HOUSE STATION, ON TEJON HOUSE CREEK.

On January 1, 1895, a gaging station was established on the Tejon House Creek at a small footbridge near and just north of the ranch house. At this point a section of the creek bed was measured at intervals of time as frequent as was convenient. It was found that a heavy flood in January had filled up the channel of the creek 2 feet, as is shown by the sections of January 1 and February 1, and that simple rod readings of height of water thereon would not convey any true idea of discharge. It was therefore determined to measure the depth of water in the center of the creek with a hand rod at the 5-foot mark on the bridge. The observer standing at the 5-foot mark on the bridge measured the distance from bridge to bed and from bridge to water.

The channel of the creek was cleared of all brush and débris for a distance of 20 feet above and below the bridge. In this portion of the channel the creek is nearly straight and the flow fairly uniform. Velocities were measured by floats, which were dropped into the water in different parts of the channel and timed through a distance of at least 20 feet. In this case, as before, the mean velocity was taken as 70 or 80 per cent of the surface velocity, depending on the depth of water. On November 13 the velocities were taken with a Haskell meter, and the mean velocity was then found to be 88 per cent of the surface velocity. Mr. R. N. Pogson, a voluntary observer, measured the depth of the stream about once a week, and also whenever there was a decided change in the volume of discharge. After the bed of the creek is again filled, following the erosion by floods, it remains quite constant in section. It was found that with depths of water as ordinates and the amount discharged as abscissa, a uniform curve could be drawn, and the values thus obtained were accepted in the computation of the discharge on dates when the rods only were read.

Estimated discharge of Tejon House Creek at Tejon ranch house, California.[1]

[Drainage area, 17 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1895.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Inches.*	*Sec. feet.*
January	93.0	5.0	13.6	835	0.77	0.80
February	44.0	7.0	26.1	1,453	1.33	1.53
March	33.0	11.0	19.0	1,169	1.07	1.11
April	49.0	16.3	24.7	1,473	1.35	1.45
May	34.0	9.0	18.3	1,127	1.04	1.08
June	8.0	3.1	5.2	312	0.29	0.30
July	3.0	1.2	2.0	126	0.11	0.12
August	1.5	1.2	1.3	77	0.07	0.08
September	1.6	1.6	1.6	95	0.09	0.09
October	4.0	2.0	2.7	163	0.15	0.16

[1] Rod observations by R. N. Pogson. Observations were made about once a week, or when a large change occurred in volume of water. The discharge for intermediate dates is estimated. Change of channel in November prevents application of old rating curve to November and December.

All the water of this stream is now used during the summer for the irrigation of about 200 acres of orchards around the Tejon ranch house and for domestic purposes. The orchards are largely citrus fruits. Twenty years of growth has demonstrated that this class of fruit is well adapted to this soil and climate. On account of the greater summer heat, the fruit ripens from thirty to sixty days in advance of that of the southern coast counties.

RANCHERIA CREEK.

North and east of the Tejon House Creek is the Rancheria or Tejon Creek. This stream flows from the north side of the high mountains from the south side of which the Tejon House Creek flows. At its head is the original Tejon Pass, through which the early emigrants passed by trail into central California. This basin may be divided into two parts; the one, the Rancheria proper, has an extent of 51 square miles, and the other, the Comanche, including Cummins Valley, has an area of 48 square miles; in all 99 square miles. The former flows from mountains of the same class as the Tejon House Creek—steep, rocky, and high—while the latter flows from hills that, although high, are not so broken, and have slopes that are less steep and a soil that has more sand. Cummins Valley, near the head of this stream, is a large agricultural plain with several thousand acres under cultivation to wheat.

The rainfall in this basin is not so great as that in the ones before mentioned. The southern storms are largely robbed of their moisture in passing over the Coast Range before reaching so far inland as this, and the basin is supplied mainly from the northern storms. At the Tejon ranch house, 5 miles to the south of the mouth of this canyon, the rainfall, as stated, is 11.52 inches, and to the east of the basin the mean annual precipitation, as measured by the Southern Pacific Railroad, from 1876 to 1884, at Caliente (elevation 1,290 feet), is 11.27, and at Tehachapi for the same period (elevation 4,025 feet), the annual rainfall is only 12.44 inches. While the rain in the southern half of the basin may not be nearly so great as that in the Tejon House Creek basin, the precipitation in the north half is probably less by nearly one-half. This is unfortunate, as an excellent reservoir site exists in Cummins Valley, but without the water to fill it.

There is no available record of the discharge of this stream, but in a general way it might be stated that in flood it is much more than that of the Tejon House Creek, that the winter discharge is probably on the average larger, but that during summer the flow it is greatly reduced, and if any difference exists it is in favor of Tejon House Creek. A small amount of desultory irrigation is practiced on this stream, principally by the Indians.

The streams above described form a class by themselves. They are all situated in Kern County, and drain toward Buena Vista Lake. The next creek to the north and east, Caliente, presently to be described, differs from these, although the northern half of the Rancheria Creek basin resembles that of Caliente Creek, the soil being largely sandy, the mountains less steep, and the run-off consequently far less than in the case of the streams previously mentioned. For comparison, the areas of these drainage basins are herewith given in geographic order from west to east.

Drainage area of creeks.

	Sq. miles.
San Emidio	54
Salt Creek	35
Fort Tejon (total)	93
Pastoria	43
Tunis	20
House Creek	17
Rancheria	99

The topography of the country is unfavorable for irrigation development in that these streams flow in narrow canyons with steep grades, rendering it apparently impossible to find sites suitable for reservoirs. Castac Lake is the principal exception, being a most excellent reservoir site, but the elevation of 3,500 feet is such that a comparatively small drainage area lies above it. The great value of water storage on this group of streams can be readily appreciated when it is known that fully 85 per cent of the water passes off during the rainy nonirrigating and nongrowing season, while during the period when water is needed for plant life the creeks discharge only about 15 per cent of the average for the year. The winter waters are lost, while the summer flow is in most cases already fully used. Thus the only substantial extension of irrigation will be by means of storage. The annual rainfall, however, furnishing water for possible reservoirs, varies greatly, the minimum falling as low as 33 per cent of the mean, and the maximum rising as high as 200 per cent. The ratio of run-off increases rapidly with greater rainfall, resulting in a still greater variation in amount of water available. Thus the seasonal run-off may fall below 20 per cent of the annual average in years of drought or of well distributed gentle rains. These estimates, being based upon comparatively few measurements, can not be said to be final; but they emphasize the great importance of storage, not only of the winter storm waters but also of the excess supply of years of rainfall above the mean.

CALIENTE CREEK.

This stream, flowing from the southern end of the Sierras, comes from a watershed of type different from that of the creeks before described. It can best be considered as made up of three sections: First, of Tehachapi Creek, with a drainage area of 108 square miles; second, of Caliente Creek proper, with a drainage area of 219 square miles; and third, of Basin Creek, with a drainage area of 96 square miles; or in all, 423 square miles. All the branches of this stream are in Kern County. Its catchment area joins on its southern border the Rancheria and the Tejon House Creek basins, and, like the streams coming from these, the drainage is toward the Buena Vista Lake.

Tehachapi Creek is the southern fork of the Caliente Creek and is the drainage line along which the Southern Pacific Railroad follows down from the Tehachapi Pass into the San Joaquin Valley. The character of the mountains is that of detached hills rather than continuous ranges. The formation, though granitic, disintegrates and forms sandy soil, little disposed to yield a large per cent of run-off. The canyons are narrow, but the slopes are not very steep. The hills are covered with a scant growth of oak and with some brush. The area of this creek, as stated, is about 108 square miles.

The rainfall of this basin has been measured at frequent intervals by the Southern Pacific Railroad. Mr. William Hood, the chief engineer of this road, has done much in assisting the State and the General Government in the compilation of physical data along its lines. He has gone to much trouble and expense in this matter in many cases. The following is the average monthly and annual precipitation in inches at these stations in the basin of the Tehachapi for the years 1876 to 1884:

Rainfall in basin of Caliente Creek, California, in inches.

Station.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
Sumner......	0.00	0.11	0.43	0.47	0.97	0.98	0.68	0.88	0.40	0.10	0.00	0.00
Caliente.....	0.03	0.58	0.48	1.29	1.59	2.30	1.70	2.12	0.96	0.23	0.00	0.00
Keen........	0.08	0.48	0.51	1.75	1.91	3.67	2.20	2.22	0.69	0.27	0.00	0.00
Tehachapi...	0.04	0.45	0.36	1.60	1.53	3.39	1.74	1.52	0.45	0.18	0.00	0.00

This creek has not been gaged, but the normal summer flow is known to be very small, usually not more than a mere thread. The discharge will be discussed with that of the entire creek.

The drainage basin of Caliente Creek proper is decidedly sandy, the slopes are less steep, and the canyons, though frequently narrow, are as a rule broad and flat, offering large areas of absorbent material to take up any water that may start down their courses. The rainfall is probably about that of the Tehachapi basin. The town of Caliente is at the junction of this stream with the Tehachapi, and, as previously stated, the average seasonal precipitation at this point between the years 1876-77 and 1883-84, was 11.27 inches. The average rainfall for this basin is probably not far from 12 inches. The flow of this basin will be taken up with that of the other two tributaries.

Basin Creek, if it can be honored with such a name, flows from the Pah-Ute Mountain and Mount Breckenridge, its catchment area joining the basin of the Kern on its northern border. The peculiar feature of this basin is a high mountain valley known as Walkers basin. Below this point the canyon narrows and falls rapidly to the plain. The rainfall at Walkers basin, elevation 3,200 feet, is said to be 15 inches. This would indicate that the average rainfall of the basin is about 12 inches. The drainage line of this stream joins that of the Caliente Creek at a point called Pampa.

The discharge of Caliente Creek, like that of others of this district, varies widely at different points. These streams begin to sink as soon as they leave the box canyons in the mountains, where bed rock is near the surface. The coarse sand and bowlders, in which the voids amount to 33 per cent, are washed down from the hills and are deposited as soon as the lessened grades cause slower velocities. In consequence of this action of erosion and deposition delta formations with shifting channels usually occur at the mouths of the canyons, and bed rock is found only near the surface several miles above. These sands drain off during the summer and fall, and the water is also drawn to the surface by capillarity and lost by evaporation. The surface water of the stream during the late summer does not reach far into the plains to renew this loss. When the period of high water comes the first duty the new supply has to perform is to fill these voids. The progress of water as it follows down the old dry bed is slow. Mr. Dixon, an engineer for the Kern County Land Company, makes the following statement, which bears on the subject:

After the waters of the Kern River have been diverted into canals at the "first point of measurement" for some time, and are then turned back again into their old bed, it takes them about six days to get down to the second point of measurement, which is 16 miles below the first. With ordinary uninterrupted velocities, they ought to travel this distance in about twelve hours. The estimated loss in the flow of the Kern River during the summer between the junction of the two main forks of the river and the first point of measurement, only about 6 miles of which is through open country, is estimated to be 200 second-feet, and it should be remembered that the flow at the lower point is in low stages about 200 second-feet.

From the above it may be seen that the point of measurement has much to do with the results obtained for each river, and that the farther down in the valley the measurement is made the smaller the quantity will be. For this reason great care should be taken in the selection of gaging stations on all these streams. Such station should be taken as would get the maximum discharge of the stream without encroaching so far on the drainage basin as to cut off any large portion of the storm waters. This upper point should be chosen rather than a point at the head of present diversion, as ultimately all water will be saved that is possible. Unfortunately those places are so remote as to make access to them expensive.

Mr. Hall, in his report on Caliente Creek, designates as the point of measurement the place where the drainage line passes the western line of the Tejon Ranch, at the foothills near Pampa. He gives an area above this point of 423 square miles, which is closely checked by the area shown by the Wheeler map. He says:[1]

> This is a stream of which no actual measurement of discharge was had as a basis of calculation. Furthermore, the exposure of its basin is different, and other causes combine to make the application of the data of drainage per square mile of area, obtained on similar streams farther north, not strictly applicable. Hence, the results shown in the table are among the least reliable.

My observations give results which fall below the statements of discharge of this basin, as shown on page 474 of his report. During the past two years, 1893–94, 1894–95, this stream has been visited at intervals of two or three months. The year 1893–94 was generally considered one of the driest of which there is a record in this State. During this year the rainfall in the Tehachapi Range was of a higher per cent than in other localities. The rainfall station Keen is the most nearly representative in the basin. The average precipitation at this point during the period covered by the discharge table, from November 1, 1878, to October 31, 1884, as given by the Weather Bureau, was 13.79 inches. The record of rain for the year 1893–94 was 8.33 inches and for the year 1894–95 it was 19.63 inches. It will be seen that the first year mentioned was below the average and the second year above it. The rain fell during the latter year in heavy storms, favorable to a high per cent of run-off.

During a period of the two years' observation the stream has not been seen to flow over 2 or 3 second-feet at any point, but it was not visited during the periods of flood in the season 1894–95. Residents of this locality who have known it for many years agree that it is normally very small. It is apparently a stream of a very flashy nature, and during the winter storms the floods are so large as to do considerable damage. Persons have on several occasions been drowned in this creek. The stream was visited in order to establish a gaging station, but because of the shifting nature of the bed, and the small discharge, rendering estimates inexact, a station was not established.

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[1] Physical data and statistics of California. Tables and memoranda of data collected and compiled by the State Engineering Department of California. Wm. Ham. Hall, State Engineer, Sacramento, 1886, pages 410, 474 and 475.

No reservoir sites of value have been seen on the Tehachapi branch of the stream, and only ones of doubtful value on the main stream. In Walker basin, on Basin Creek, there is a most excellent reservoir site, but it has only a few square miles of drainage tributary to it. The waters of Caliente Creek are not used except for the watering of stock. The foothill lands, if irrigated, would be of value for the growing of citrus fruits. The lands below are suited for grains, grasses, and deciduous fruits. All these waters drain toward the Kern and Buena Vista lakes, but they are lost in the sands long before they reach them. The old Kern Lake bed is now dry and is being farmed.

The bottom lands of the San Joaquin Valley are almost flat, being only 415 feet above sea level and 240 miles from their drainage outlet. They are largely of adobe and alkali soil, which, when pierced, furnishes artesian water. The artesian supply of this valley, as well as of many other districts of the States, has been investigated with much thoroughness by the State, and the results are published in the Physicial Data and Statistics of California, pages 481–587. Generally speaking, artesian water can be found in large quantities in the lower levels of this great valley, west of the main line of the Southern Pacific Railroad, from Bakersfield to Sacramento and east of the thalweg of the valley. The depths of these wells are from 200 to 1,000 feet, but the majority of them are less than 500 feet deep.

KERN RIVER.

The next large stream to the north is the Kern River. This has the largest drainage basin of all the streams that flow into the San Joaquin Valley from the Sierras, but according to the State engineer's report it is only the eighth in average discharge. The North Fork of this stream rises among lofty mountains and flows south between high ranges for a distance of 75 miles before discharging on the plains. The drainage basin of the South Fork in its lower valleys is not so favorable to a high per cent of run-off as that of the North Fork, but farther up the mountains the catchment areas are of the same class as those of the North Fork. This basin is reported to be steep and exceedingly rough in the higher portions. The formation is largely granite. Its southern exposure offers an opportunity for a high rate of evaporation and accounts in a measure for the low per cent of water discharged.

The mountains at the head of these two branches of the river are above the timber line, are covered with little if any soil, and are exceedingly rough. The basin near the junction is rocky, largely favorable to run off, but the immediate valley of the South Fork above the junction is quite broad and sandy. The main canyon through which the river discharges into the San Joaquin Valley is narrow, deep, and has a very heavy grade. Above an elevation of 4,000 feet, and below the timber line, the basin is said to be covered with a dense growth of pine and redwood.

There are no observations of rainfall in the drainage basin of the Kern River, and the precipitation is difficult to estimate, as the basin is in several ways different from any others of the State. It has been found in California, as a rule, that the rainfall increases with the elevation. When the precipitation is known at the base of the mountains and on the side from which the storms approach, and when the rise in elevation is given, the precipitation for points above may be computed by assuming an increase of 0.6 inch with each rise in elevation of 100 feet if the higher mountains do not intervene. An exception is found in the series of gages along the Southern Pacific Railroad from Bakersfield or Sumner to Tehachapi. In this case it might be held that the moisture from the southern storms is all condensed in passing over the Coast Range, which intervenes between them and the sea, and that the basin is not freely exposed to the northern storms at anything like right angles to the direction of their approach. The Kern basin is also deprived of much moisture in the same way. In the rainfall map of California[1] Mr. Hall has included the Kern Basin between the 10 and 20 inch rain curves. Mr. Henry Gannett includes this basin between the 10 and 70 inch curves. The rainfall at Bakersfield, at the mouth of the canyon, is 5.14 inches, and at Tehachapi, at an elevation of 4,025 feet, it is 11.73 inches. To the north the Southern Pacific, on the line passing over the Sierras, has a series of gages in elevation ranging from 35 feet to 7,017 feet above sea level, and they show an increase up to a limit of about 6,000 feet in elevation, when the amount of precipitation, as in other known cases, begins to decrease. It would seem that the average rainfall would be between that given by Mr. Hall and that estimated by Mr. Gannett, and that considerable weight should be given to the records of the basin adjoining the Kern to the south. The United States Geological Survey established a rain gage in 1895 at the Mountain Home sawmill, at an elevation of 6,000 feet above sea level, on the range that divides the drainage of the Kern and the Tule and back of Porterville.

Data concerning the discharge of Kern River have been given in the report of the State engineering department of California[2] and in the reports of the United States Geological Survey.[3] The observations of river height made by the State engineering department were at the mouth of the canyon of Kern River at Rio Bravo Ranch, in sec. 6, T. 29 S., R. 30 E. In the report concerning this work the following statement is made, on page 410:

This stream has been gaged chiefly at the Rio Bravo Ranch station, a point just below the debouchment from the mountain canyon, and above all canals of diversion

[1] Rainfall distribution map to accompany report on irrigation and water supply in California. William Ham. Hall, State engineer, 1888.

[2] Physical data and statistics of California, tables and memoranda of data, collected and compiled by the State engineering department of California, William Ham. Hall, State engineer, Sacramento, 1886, pages 410, 470-472.

[3] Twelfth Annual Report of the United States Geological Survey, Part II, Irrigation, page 319, Plate LXXX. Daily discharge of Kern at Rio Bravo Ranch, California, 1879-1882. Also Bulletin No. 131, United States Geological Survey, page 79.

in the valley. A continuous gage-rod record was kept at this station from 1878 to 1883. These data formed the basis for making, by the method of scale of discharge for the channel, a calculation for the three years named, and then by method of drainage per square mile as compared to rainfall. The results given were estimated for the remainder of the period covered by the table.

The Kern County Land Company, as a result of the litigation over the waters of the Kern River, began on September 29, 1893, an accurate and systematic series of measurements on this stream, which has been extended to the present time. Mr. A. K. Warren has had charge of this work, under the direction of Mr. Walter James, chief engineer. The following is quoted from the second annual report of the gagings or measurement of water in the Kern River and canals, in Kern County, Cal., for 1894, to Walter James, chief engineer Kern County Land Company, by Albert K. Warren, engineer in charge.

A footway was constructed at a point in section 2, township 29 south, range 25 east, known as the "first point of measurement." Two boards, 2 by 12 inches, were placed side by side, making the top of the footway 24 inches wide. The bents are about 16 feet apart and are constructed by driving two 2 by 6 inch pieces perpendicularly 24 inches apart on the inside. Near the top of the upright pieces, for the boards to rest on, two pieces, 2 by 6 inches, are nailed, one on each side. The boards are cut and joined at the ends. The upright pieces extend to the top of the boards on each side. The bents of the footways are parallel with the flow of the water, the upright having the edge of the timber to the current. The cross sections and velocities of the water as here given were taken at the upper side of the footways before the water had reached the bents, so that practically the water was undisturbed at the points where the measurements were made.

All observations during the year 1894 to determine the velocity of the flow of the water were made with a Haskell current meter, the low velocity wheel being used at all times. This was rated in the following manner at what is known as the Power Canal, which carries water for the Kern Island Canal to what is known as the Mill Ditch. At the point where the water is emptied into the Mill Ditch is a drop where the water is used for power purposes. The drop being closed tight, a body of perfectly still water is formed in the Power Canal, which is 3 to 4 feet deep, about 35 feet wide and about 160 feet long from the drop to a wagon bridge across the canal. At this point the observations were made as given below:

A smooth and straight No. 8 wire was drawn as taut as it would bear from the drop to the bridge, the wire being almost free from sag and almost parallel with the center of the canal and surface of the water. An accurately measured course 100 feet in length was laid out and marked with straight perpendicular sticks on each bank of the canal, the first stake being about 15 feet from the bridge and the second stake being about 100 feet from the first. At a point about 8 feet from the second stake a support was placed under the wire so that the bearings would be as near together as possible to prevent sag of the wire.

At the ends and top of a frame about 4 by 6 feet were pivoted grooved wheels to rest and roll on the wire. To the back of the frame the meter rod was fastened at right angles to the surface of the water, the rod being fastened to the frame so that the meter could turn freely and be adjusted to the direction in which it was drawn through the water, the bottom of the frame being about 6 inches above the surface of the water, and the meter being submerged to a depth of about 18 inches.

Near the drop was constructed, above the water and below the wire, a platform on which was placed a drum. By turning the drum the meter was drawn through the water. To obtain a uniform velocity of the meter through the water, a plumb-bob was suspended and caused to swing as a pendulum, the operator turning the drum with the swing of the plumb-bob. By using two sizes of drums, about 6 by 24 inches in diameter, and shortening the plumb cord, observations of velocity from about 0.30 foot to 6 feet per second could be easily and accurately made. To the drum and frame and meter rod was attached a small copper wire. Electric connections were made with the copper wire from the meter rod through the axis of the drum to the battery and register and from the register to the No. 8 wire, and by a copper drag wire from the No. 8 wire to the insulated wire of the meter.

Commencing above the first stakes, the meter is drawn fast for a few feet so that it will adjust to the direction, then it is brought to the uniform velocity before reaching the stakes. Just as the front end of the frame reaches the first stake the watch is started and the circuit to the register is made, stopping the watch and breaking the circuit just as the front end of the frame reaches the second stake. The time required for the meter to pass over the course of 100 feet and the number of revolutions made by the meter wheel are obtained, from which the velocity of the meter in feet per second and the number of revolutions made by the meter wheel are computed. From these the number of revolutions of the meter wheel per second for each foot traveled is deduced.

Observations for the rating of the meter were later made in the same place and in the same manner as given above, excepting that a No. 6 wire for the wheels of the meter to rest and roll on was used instead of a No. 8. An additional copper wire was attached to the back end of the meter frame and passed around a pulley at the bridge and thence to the drum, making two wires attached to the drum, one on each side, one winding up as the other unwound. By this method the meter frame could be drawn in either direction by turning the drum. Electric connection from the No. 6 wire to the insulated wire of the meter frame was made through the grooved wheels of the meter instead of a drag wire. Calculations were made of the different lengths of the plumb cord or pendulum, so that the difference in time would make about 0.05 of a foot per second velocity. The cord or rod was made of small wire, the links having open eyes at the ends and being in lengths to make the difference in velocity as above. In this manner observations could be made each at the rate of 0.05 of a foot per second difference in velocity, making a uniform increase from the lowest to the highest velocity.

In taking cross sections of the stream a wye level and a self-reading rod with a large shoe or plate at the bottom, to prevent the rod sinking in the soft sand and sediment, are used. The areas of the cross section of the water are subject to correction. From time to time, as cross sections are taken, it will be found that the area may increase or decrease for the same height of water; that is, it will be found that the channel is subject to changes by filling or washing out. Calculations of the amount of change are determined and corrections made, assuming that the area increases or diminishes according to the time. Mean velocities for each section of the stream are obtained by slowly lifting and lowering the meter in the horizontal center of the section during a period of fifty seconds.

The total discharge is found by adding the discharge for each section of the stream and the mean velocity by dividing the area into the discharge. Gage rods are made of galvanized iron 6 inches wide, and graduated by sawing the edge of the rod. The 0.1 graduations were cut about one-half inch deep, and the 0.05 about one-fourth inch. The 0.5 points were marked by filing out a V-notch on the edge, and the foot points were indicated by holes punched to show the number of feet. The iron gages were usually put up at a point just above the footway and drawn taut and fastened at each end to cross pieces from a bent of the footway. Gages were put up at the first point of measurement on Kern River, March 24, 1894, all heights of the water prior to this time being taken with the level and rod at each 20 feet.

Mr. Warren has adopted a method of measurement of considerable refinement. The Kern River, like many other streams, has its channel washed out in the floods and filled in low water. There is a general lifting of the bed of the stream, as is the case in the delta formations. The "first point of measurement" is 5 miles from the mouth of the canyon. It may be seen that a rod reading in 1893 of, say, 5 feet, would mean more than one of 5 feet in 1895. For this reason the discharge is referred to areas of river sections and not to heights. A large number of measurements have established this relation of velocity and area, and intermediate velocities are interpolated when not measured. Assume, for example, that when the river is measured on January 1, the rod reading is 5 feet. On January 8 it is again gaged with a rod reading of 4 feet, daily rod readings being also taken between the 1st and the 8th. The soundings will show some change in the bottom. Suppose the bed shows a rise during the week corresponding to 7 square feet. The sections of both the 1st and the 8th are taken as exact. The river rises and falls between these dates. With the area of the 1st as the basis and with known rise and fall in the surface of the river, a preliminary set of areas is computed. They would reach the 8th, and the soundings of that date would show in the computation an error of + 7 square feet; this error would then be distributed over the areas for the previous six days. With these final areas the theoretical velocities are taken from the rating table. These theoretical velocities will be found to differ slightly with the mean measured velocity of January 1 and January 8. The error is determined and adjusted as in case of the cross section. The following is the result of the computation by Mr. Warren:

Estimated discharge of Kern River at first point of measurement.

[Drainage area, 2,345 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1893.	*Second-feet.*	*Second-feet.*	*Second-feet*	*Acre-feet.*	*Inches.*	*Second-feet*
October	554	517	534	32,861	0.26	0.23
November	559	467	518	30,827	.24	.22
December	590	430	516	31,757	.25	.22
					.75	
1894.						
January	741	562	661	40,644	.32	.28
February	1,114	604	717	39,817	.32	.30
March	1,443	762	1,001	61,541	.65	.43
April	1,892	1,209	1,495	88,952	.71	.64
May	2,208	1,228	1,607	98,798	.79	.69
June	1,719	871	1,085	64,557	.51	.46
July	1,051	400	700	43,036	.34	.30
August	549	256	335	20,565	.16	.14
September	382	172	248	14,756	.12	.11
October	363	224	279	17,178	.14	.12
November	268	230	244	14,500	.11	.10
December	805	234	470	28,908	.23	.20
Per annum	2,208	172	737	533,252	4.40	.31
1895.						
January	1,616	473	809	49,762	.40	.34
February	4,762	675	1,252	69,536	.55	.53
March	3,004	987	1,374	84,437	.67	.59
April	3,897	1,911	2,724	162,076	1.29	1.16
May	5,384	3,100	4,369	268,608	2.14	1.86
June	3,721	2,174	2,906	172,265	1.37	1.24
July	2,063	867	1,482	91,113	.73	.63
August	1,073	354	629	38,665	.31	.27

The year 1894 is generally considered one of very low stage of the river. It will be noted that Mr. Warren shows a recorded minimum of 172 second-feet, this being on September 28. This is considered by those in best positinon to judge as the lowest stage of the river known. The State engineer for October, 1878, shows a minimum of 145 second-feet at the Rio Bravo Ranch. The year 1895 is said to be near the average.

The following facts have been taken from a statement prepared by Mr. H. Hawgood, of Los Angeles, Cal., member Institute Civil Engineers, in reference to the run-off of the Kern River basin. He has made a careful study of this basin, and his conclusions are regarded as consevative.

The discharge of the Kern River was measured by the State engineering department from 1878–1882, and estimated by them from comparison of rainfall for 1882–1884. The point of observation was in section 11, T. 29 S., R. 29 E. The drainage area above this point is as follows:

	Sq. miles.
North Fork basin	1,115
South Fork basin	1,050
Lower basin	180
Total	2,345

Since September, 1893, the Kern County Land Company has taken careful daily measurements of the flow, at a point in section 2, T. 29 S., R. 28 E., this point of observation being about 8¼ miles down the stream from the point used by the State. It is estimated by Mr. James that in this intervening distance 50 second-feet may be lost in the porous bed of the river during the dry season. In times of high water a much larger area is covered, and consequently a much larger quantity is lost. A conservative estimate would be 75 second-feet as a mean for the entire year. This quantity is to be added to the Kern County Land Company's measurements to give the probable surface flow past the State measuring point, 8¼ miles up the stream.

Mean discharge of Kern River from 1878 to 1884, and for 1894.

Year.	Mean discharge.
	Sec. feet.
1878-79	*a* 514
1879-80	*a* 1,169
1880-81	*a* 1,263
1881-82	*a* 655
1882-83	*b* 638
1883-84	*b* 2,422
1894	*c* 812
Mean for 7 years	1,067

a State engineer's report, measured.
b State engineer's report, estimated.
c Kern County Land Company's measurement + 75 second-feet.

Measurements taken at a point 500 feet above the confluence of the North and South forks, compared with measurements taken by the land company, show a very large decrease of the surface flow in the 40 miles of river lying between the two points of measurement. The discharge on November 17, 1894, is reported to be the lowest water known.

			Second-feet.	Second-feet.
1894:				
Nov.	17.	Flow of the North Fork	363.78	
Nov.	17–18.	Mean of flow in section 2, T. 29 S., R. 28 E	236.02 loss	127.76
1895:				
Nov.	9.	Flow of the North Fork	460.28	
Nov.	7.	Flow in section 2, T. 29 S., R. 28 E	317.35 loss	142.93
Nov.	11.	Flow in section 2, T. 29 S., R. 28 E	372.80 loss	87.48
Dec.	3.	Flow of the North Fork	514.00	
Dec.	3–4.	Mean of flow in section 2, T. 29 S., R. 28E	395.44 loss	118.56

Unfortunately, no measurement was taken at the lower station on November 9 or November 10. The loss, evidently, is between 87.48 and 142.93 second-feet. Rain having fallen between the two stations on November 10, the reading on that day, if one had been taken, would have been nearer 317 than 372. It is assumed at 331 second-feet, making a loss of 129.28 second-feet. The mean of the three sets of observations is 125.2 second-feet. Taking from this the 50 second-feet estimated to be lost between section 11 and section 2, leaves 75.2 second-feet as the loss between the point at which the State made its measurements and the confluence of the North and South forks, exclusive of the flow of the South Fork and the several small streams which enter between the two measuring stations. Taking these into account a reasonable estimate would place the total loss from all causes at not less than 200 second-feet between the points in question during low water. This would be largely increased during the period of high water, raising the average for the year to, perhaps, from 250 and 300 feet, assumed for the purposes of this investigation at 275 feet.

Mr. Hawgood's investigation being particularly directed to the run-off of the upper basins, he found it essential to take into consideration these underground losses in the lower river in order to render the continuous observations of the lower river applicable to computations regarding the upper portions, where only a few observations have been made. Going back to the mean flow of 1,067.6 second-feet at section 11, and adding thereto the foregoing estimate of 275 second-feet gives 1,342.6 second-feet as the united mean drainage into the river channel from the North Fork, the South Fork, and the lower basins. This is equivalent to a mean run-off of 7.8 inches for the entire catchment basin of 2,345 square miles, 76 per cent of this being in visible surface flow past section 11, T. 29 S., R. 29 E., and 74 per cent past section 2, T. 29 S., R. 28 E.

For the purposes above noted it was necessary to segregate the drainage of each basin. After careful consideration of all available data as to areas, rainfall, topography, etc., and from a personal knowledge of a portion of the territory under consideration, Mr. Hawgood drew a small map of mean annual rainfall. Concerning this he states that if the lines of equal precipitation on the State engineering department's map are examined it will be seen that these show equal precipitation on Mount Whitney, 16,000 feet high, and at valley points 14,000 feet lower in elevation. If the map prepared by Mr. Henry Gannett is examined it will be found that he errs in the other direction, including places of known record within zones of greater rainfall than the records show. By making a new map and using the values given for the relation of run-off to rainfall for the mountainous areas, as shown on the diagram figure 24, page 151, of the Fourteenth Annual Report of the United States Geological Survey, the run-off from the North Fork would be 13.2 inches, from the South Fork 4.2 inches, and from the lower basin 1.35 inches.

Combining these run-offs with the area of each basin, it appears that the North Fork contributes 76 per cent of the drainage, the South Fork 25.5 per cent, and the lower basin 1.5 per cent. Applying these percentages to the previously determined run-off of the 1,342.6 second-feet, 1,010 second-feet would be ascribed to the North Fork, which is equivalent to a run-off of 12.3 inches. This is a satisfactory agreement with the 13.2 inches, being 93 per cent of it. The other basins show the same proportion.

The curves above mentioned are put forward not as an absolutely correct delineation of their true position, but as an arrangement, and a very probable one, that fulfills the requirements of the facts so far as they are known.

It is estimated that 100,000 acres are irrigated in the San Joaquin Valley (sometimes known as the Kern Valley) from this river. The winter floods are stored in Buena Vista Lake for irrigation below. The water is all diverted, but a great deal might be saved (and it doubtless will be some time) that is now lost in the sandy soils of the stream bed and in the beds of unlined canals. The crops are grains, grasses, and deciduous fruits. The water power of this river will be soon used for commerce and manufacturing. At the present time one plant is being constructed at the mouth of the canyon for furnishing power to Bakersfield, and another is seriously contemplated to bring power from the junction of the North and South forks of the river to Los Angeles, a distance of 108 miles.

POSO CREEK.

The next basin to the north is Poso Creek. This stream belongs to a class entirely different from that of Kern River. The latter flows from the higher basins, where the moisture precipitated in the winter is held in snow banks on the high peaks of the Sierras as if in reservoirs. As summer advances, the snow melts, sustaining the flow of the river. On the other hand, the streams of the second class, of which Poso Creek is an example, coming from the lower levels, where the precipitation occurs in the form of rain, flow mainly during winter storms, and the water passes off during the nongrowing season, when it is not needed. It is sometimes a question whether the evaporation from the extensive snow area is not so great as to render this form of precipitation less useful than in cases where the rainstorms are stored in reservoirs.

The following is quoted from a report by Virgil G. Bogue, formerly the chief engineer of the Union Pacific Railway, on the water supply of Poso Creek:

This stream has its principal source in the Greenhorn range of mountains, which is a spur of 4,500 feet to 8,000 feet in elevation, uniting with the Sierra Nevada at or near Mount Whitney. It is covered with snow above an elevation of 4,500 feet from January 1 to June 1 of each year. In all its lower portions it has a growth of oak trees, while its higher reaches abound in oak and several species of pine.

The formation is wholly of granite. The soil is a mixture of vegetable mold and disintegrated granite, through which the rock protrudes wherever the eye may rest. It contains a few farms, but generally the business of its scant population is that of sheep raising. The water flows all the year in the streams, but near where it debouches upon the plains it is lost in the sands of its bed, except during floods or high water, when it flows on, eventually reaching Tulare Lake.

The area of the watershed is estimated in the report of the State engineer mentioned as 289 square miles. In my opinion, the available watershed areas—that is, the portion above the Granite Dam—is about 250 square miles, from which a supply of water at least 7 inches deep can be depended on each year for irrigation. This would produce sufficient water to cover the entire area of the Poso district to a depth of 26.5 inches, which, with the rainfall, would make a depth of 35.5 inches.

As the water is accumulated upon a granite watershed, it is naturally of pure quality.

This estimate of run-off appears to be too large. From conversation with those acquainted with the basins of both the Caliente and Poso Creek it is learned that the character of the Poso basin is a good deal like that of the Caliente. From a basin of this nature, in order to get a run-off of 7 inches, there would probably have to be a rainfall of at least 25 inches. With peaks, as stated, that rise to elevations of from 4,500 to 8,000 feet, and with a base elevation at Poso of 350 feet, it is fair to assume that the average elevation in this basin is not over 2,500 feet, and the rainfall at Delano being 6.32 inches, the average rainfall for the basin is probably less than 20 inches. No rain gages are located in this basin. Mr. H. Hawgood estimates the mean run-off from the lower basin of the Kern as 1.3 inches. This joins Poso Creek on the south.

At the time this stream was visited, November 16, 1895, at Poso it was altogether dry, but the Southern Pacific Railroad has a bridge opening at this point of 1,570 square feet. A recent water line at this point was measured that showed a section of 117 square feet. Mr. J. D. Brown, the engineer of the Poso irrigation district, says that no measurements have been made of the discharge of the creek, and that there is now no water below the proposed point of diversion, where a dam 25 miles south of Delano is being built. The irrigation district is now building a canal and flume in a very rough mountain district with a capacity of 150 second-feet, and is also constructing a reservoir on the stream. A statement of the engineering features of the project is contained in the report of Mr. Bogue, which has been printed by this district.

Mr. Hall says[1] in reference to the Deer, White, and Poso creeks: "The estimate of the flow of these creeks is based on a number of special observations, general information from the residents near them, and the method of discharge per square mile of drainage area." This authority gives average monthly discharge tables on these streams from November 1, 1887, to October 31, 1884, which shows an average discharge of 145 second-feet, or a run off of 6.8 inches in depth. The quantities given by both Mr. Bogue and the State engineer are estimates. No systematic records of rainfall or of stream gaging have ever been kept on this stream. The lands of the district are excellent in quality, being largely a disintegrated granite loam. The present method of dry farming, forced on the people by the lack of water, has proved to be unprofitable with the usual rainfall of about 6 inches.

WHITE AND DEER CREEKS.

White and Deer creeks are of the same class as Poso Creek—that is, they are foothill streams. The valleys of both branches of the Kern lie between their basins and the crest of the Sierras. White Creek has a drainage basin of 90 square miles, and Deer Creek one of 110 square miles. No rain gages have been established in the basin of these streams, and the rainfall is not known. The streams were both dry near the foothills on November 17, 1895. White Creek did not have even a well-defined drainage line at the point where it was visited, that is on the road from Delano to Porterville. Deer Creek at a point 6 miles south of Porterville at the crossing at the railroad has a broad, sandy bed 200 feet wide, and shows evidence of large floods. The run-off from these two basins, as well as that of Poso Creek, is estimated by Mr. Hall as given on page 312. This estimate is based on an assumed rainfall and run-off per square mile.

TULE RIVER.

This stream heads well in toward the heart of the Sierras, though it does not reach the highest peaks. The greatest elevations in the basin are at Mount Moses and Mount Maggie, which are said to be 11,000 and 11,500 feet, respectively. The average elevation of the basin is probably between 4,000 and 5,000 feet. The formation is largely granitic. The lower hills are well covered with soil. As the higher points are reached the topography is much broken. The lower hills have a large growth of brush, and the mountains above an elevation of 4,000 feet are covered

[1] Physical Data and Statistics, page 410.

with timber. This timber is often very dense and large. Much redwood is found under the elevation of 7,000 feet, and several sawmills are busy cutting it off. The area of this basin, as given by the State engineer, above sec. 31, T. 21 S., R. 28 E., above Porterville, is 437 square miles.

There is no record of rainfall in this basin above the town of Porterville, where the mean is 9 inches. The precipitation on the higher ranges back of the valley must be very heavy. As previously stated, a rain gage was located during 1895 at an elevation of 6,000 feet at the Mountain Home Mill. It may be supposed that there is an increase of precipitation with the rise in elevation at this point as in other points of the State.

The flow of this river has been measured and estimated by the State engineer between the years 1878–79 and 1883–84, as given on page 312. On page 410 of Physical Data and Statistics the following statement is made:

This stream is of the character of the Kaweah in the matter of watershed, but somewhat lower in the scale. The observations were made at a point several miles above Porterville, but below the head of the Pioneer Canal. A number of gagings, an imperfect rod record, and other occasional observations formed the basis of calculating the flow past the station. Results thus obtained, and expanded by the method of drainage per square mile and corrected by the approximately known amounts of intake of the canal, give the data of the delivery of the river into the valley, as presented in the table, upon a footing considered to average well with all others taken together.

The above authority gives a minimum discharge in August and September, 1879, of 26 second-feet.

Mr. E. Newman, of Porterville, who is a civil engineer and the president of the Pioneer Ditch Company, says that his minimum recorded discharge of the main Tule, excluding the South Fork, occurred on August 8, 1889, as measured at the head of the Pioneer Canal, and was 18.55 second-feet. He estimates that at this time there was being used above this point in Pleasant Valley for irrigation, from several small ditches, 14 second-feet. This, then, would give his minimum recorded discharge of the main Tule as 32.55 second-feet. The discharge of the South Fork is not known for this date. Mr. Newman states that the lowest stage of this river is in August, and that the time of highest water is as a rule in February. He also states that on August 6, 1892, there was near the head of the Pioneer ditch, below the canal, 18 second-feet; in the canal, 30; total, 48. This includes the South Fork.

The South Fork of the Tule, on August 6, 1892, near the Pioneer Canal head works, was flowing 6 second-feet, and it is estimated that above this point there was being used for irrigation 9 second-feet more, or 15 second-feet in all in the South Fork. The following figures are given on the authority of Mr. E. Newman.

1894—	Second-feet.
July 12, Pioneer ditch	28
July 12, Campbell & Moreland ditch	7
July 12, in river below canals	7
July 12, above Pioneer ditch	14
Total in Tule River	56

	Second-feet.
August 16, Pleasant Valley ditch	5
August 16, Mount Whitney ditch	1
August 16, Wilcox ditch	2
August 16, Pioneer ditch	11
August 16, Campbell & Moreland ditch	6
August 16, sundry small ditches	5
Total	30

A measurement was made on November 18, 1895, at the head-works of the Pioneer Canal, giving the amount of water in the canal and also at a point a short distance below the mouth of the South Fork on the Tule River, this point being about 5 miles east of Porterville. The discharge in the Pioneer ditch was found to be approximately 32 second-feet and in Tule River below the head gates 28 second-feet, giving a total for the river, including the South Fork, of 60 second-feet.

All the water of this stream is now appropriated and little opportunity for storage exists. The water is carried in open sandy ditches with great loss. In one instance there is a known loss in the Pioneer Canal, whose capacity is 72 second-feet, of 25 per cent in 6 miles. The increase in irrigated area from this stream will probably come from the introduction of lined canals and pipes as well as from more careful division of the water. The great variety of opinion generally expressed as to the duty of water is largely due to difference in care of handling. Where water is valuable and scarce it is handled with more care, divided with precision, and the soil is well cultivated. Where there is an abundance of water such conditions as the above exist. The amount of water entering at the main head works being known in a general way, and also the extent of area irrigated, a deduction is reached that does not compare with the careful handling of water in other districts.

Generally speaking, the amount of water used in irrigation per acre is growing less with increased experience, especially in southern California. It is found that less water and more cultivation give a better result. The season of 1894 was very dry in this southern area and the water supply was in most instances greatly reduced, in some cases as much as one-half. With the assistance of the increased cultivation that followed, it was found that the crop of that year was the equal of any that had been produced. This was especially true under the Sweetwater system. But it should be remembered that this was in a district where the duty of water is already as great as 500 acres of orchard to the second-foot. It is safe to predict that the present area of 10,000 acres that is now irrigated from the Tule will ultimately be doubled. A feature of the Porterville district is that it has recently been shown that a high grade of orange can be grown here which will mature very early for California. About 1,000 acres are under cultivation to this fruit near Porterville. The soil is largely a red and black adobe.

The method of water supply for Lindsay, Cal., about 6 miles north of Porterville, is of especial interest. The following facts are given on the authority of J. C. Hutchinson, of that place: The Lindsay Land Company intended to get its water supply from the Kaweah River, but complications as to right of way prevented. An investigation of the underground water supply revealed the fact that under a thick layer of tough red clay and a thin layer of blue clay at a depth of about 65 feet from the surface of the ground a stratum of very fine white sand is found which varies from 2.5 feet to 6 feet in thickness. This sand at first does not show much water, but when it is cleaned out a little it carries enough water to be pumped with strong centrifugal pumps. A large quantity of this material may be taken out and then a good water supply may be had. There are two wells of this nature at the point above mentioned, each 72 feet deep. Two engines of 35 horse-power are used driving San Francisco Tool Company centrifugal pumps, one at each well, with a capacity of 140,000 gallons per day. The lift from water to pump is 27 feet (which is to be lessened); from pump to surface 29 feet, and the water is then forced 1.5 miles in a 15-inch pipe to a rise of 18 feet. The friction is equivalent to a rise of 8 feet, giving a maximum duty of 82 feet lift.

The total amount irrigated from plant No. 1 in 1894 was 630 acres during 156 days. The orchards are 2-year-old orange trees. The area of the water supply is not known. The cost of irrigation is from $2.50 to $6 per acre per annum.

Mr. Seybolt, of Lindsay, in 1895 bought in San Francisco 15 drums of Peruvian crude oil of 105 gallons each, 1,575 gallons in all, at a cost of $113.82. He used this in a vapor engine and had a residue of 350 gallons of thick lubricating oil which he sold for $70, leaving a net cost of fuel of $63.82. With this plant he irrigated from four wells of the same class as those above described, the lift being 70 feet, 115 acres of citrus fruit five times and 25 acres of peaches three times between May 1 and October 15. As the engine was automatic, he considers this the total cost of his irrigation. This is at the rate of 46 cents per acre.

KAWEAH RIVER.

This stream combines the characteristics of both the foothill streams and those from the high mountains. Its headwaters come from the region of Mount Whitney, and it has many branches in the lower mountains. The maximum flow usually occurs in May, but flood stages extend from the 1st of April to the end of June. Its period of high water is from thirty to sixty days earlier than that of Kings and Kern rivers, which flow from the higher portions of the same district. As these floods come from the melting of the snows which fell in midwinter, and as snow melts first from the lower and warmer levels, the inference would be, in the absence of other observations, that the average elevation of this basin is relatively lower than that of the Kern and Kings.

The heart of the Sierras south of the Yosemite is little known. The heads of great rivers and the names of great peaks are still in dispute. The California State engineer gives the area of the Kaweah above a point in section 3, T. 18 S., R. 27 E., as 619 square miles.

The rainfall on the plains at Visalia is 8.84 inches, the elevation being 348 feet. The precipitation at Tuohy's Ranch, in Lewis Valley, which is in the foothills, is 12.39 inches. No rain gages have been established in the mountains of this basin so far as can be ascertained. The average precipitation in the basin would be probably between 30 and 35 inches. The basin has an exposure favorable for a large rainfall. The State engineer makes the following statements:[1]

> This is an important stream, but its watershed is much less elevated and snow covered than that of the Kings River, and its flow far less steady. It receives several tributaries below the point of opening of its canyon, itself divides into several channels, widely separated soon after entering upon the plain, and is tapped by a number of irrigation ditches. Several gaging stations were established on the Kaweah River. Reliable records were made, however, only at the station near Three Rivers. This point is above Lime Kiln and Horse creeks—tributaries of importance at some seasons. The gaging and rod-record data afford a basis for an estimate of flow for all ordinary stages, which could be applied as for Watchumna Point, and this was corrected for additional drainage area tributary below, and for higher stages by the method of estimated discharges per square mile. The data of the table is presented therefore as a fair approximation to the actual water quantities entering the valley by this river and the creeks which enter its system in the plains.

This point of gaging, the Three Rivers, is well up in the mountains and is a good location for a gaging station. It will be seen that there is a minimum average monthly discharge given for the month of August, 1879, of 31 second-feet. In this connection it will be well to remember the statement given by this authority on page 406 of Physical Data and Statistics (previously quoted), that "where only average volumes are given the records have not been full, or the mean flow has simply been estimated." This is the case with all the data given in the tables for this river.

Mr. A. G. Wishon, the superintendent of the Kaweah Irrigation and Power Company, states that the Kaweah has been gaged by this company at a point 100 feet above their head works, which is about 5 miles

[1] Physical Data and Statistics of California. Tables and memoranda of data. Collected and compiled by the State Engineering Department of California. Wm. Ham. Hall, State Engineer, Sacramento, 1886, p. 410.

above the Lime Kiln post-office, at a place where the bed rock comes near the surface of the ground and just above where the stream spreads over a sandy bar, as follows:

1894—	Second-feet.
May	476
June	423
July	375
August	190
September	93

The method of gaging, presumably, was that generally practiced when meters are not at hand. In such cases surface floats are used and two sections laid off, one at the upper end and one at the lower end of the place where the measurements were made. At this point their are a good many large bowlders in the bed of the stream, and during the lower stages of the river the velocity is very slow. For these reasons it is difficult, if not impossible, to estimate the relation of the surface to the mean velocity, as has been done in gagings made with floats even if submerged. The results, therefore, though approximate, are not absolute. Probably only one or two gagings were made each month, and no rod readings were kept. The year 1894 is taken by many engineers as a minimum for the San Joaquin Valley.

On September 6, 1895, during the low stage of the river, two measurements were made, by Mr. Narboe and Mr. William A. Burr, to determine the loss of water between the head works mentioned above and the Iron Bridge, where are located the head works of lower canals, and where the Power Company will return the water to the river after it has passed through their water wheels. The measurement was first made at the upper head works. Six floats were timed with a stop watch, one-half of them being submerged. The average velocity was found to be 1.12 feet per second and the area 100.2 square feet. This would give 112 second-feet, but the engineers above mentioned made a deduction of 20 per cent to get a mean velocity which would give a discharge of 90 second-feet for the upper head works. At a point 2,000 feet above the Iron Bridge, at the Lime Kiln, the river was again gaged on the same day by the same engineers. Floats were used as before, and a surface velocity of 0.455 foot per second was obtained, which was reduced 20 per cent, thus making 0.364 foot per second as the mean. The area was 169.3 square feet and the discharge 61.6 second-feet, indicating a loss of 28.4 second-feet.

These two points were visited on November 20, 1895, when the river was still low, and gaged at both places. The measurement at the head-works was very unsatisfactory. The stream, out of a total width of 60 feet, was practically still water for 15 feet. On the south bank and in many other places the velocity was so slow, especially on the bottom, where there were many large bowlders, as to make the work of the meter very unsatisfactory, and the result is not considered of value. It is hard to see how surface floats could be accurate under conditions of this nature. The volume at the head-works, as measured, was 69.82 second-feet. If the river is to be measured above the head-works, a more suitable place must be selected for low stages of water in the river. On the other hand, the measurement at the lower point of the iron bridge was very satisfactory. The velocities were strong and quite uniform and the section, also, was of a favorable nature. At this point the discharge was found to be 78.53 second-feet. The river was stated to be very low at that time. The discharge of the river from 1879 to 1882 is given on Plate LXXXI of the Twelfth Annual Report of the United States Geological Survey, Part II, Irrigation.

The waters of this stream are all appropriated, and there is much discussion of the necessity of storage. Good sites are said to exist in the upper parts of the basin. There is one at Watchumna Hill, where an earthen dam with a maximum height of 56 feet, and estimated as containing 932,000 cubic yards of earth on slopes of 2 to 1 inside and 3 to 1 outside, top width 16 feet, would have a storage capacity of 14,585 acre-feet of water.

Mr. P. J. Flynn reported on an irrigation proposition for the Tulare irrigation district, and states that there are twenty canals taking water from this river, with a total capacity of 774 feet, which is generally in excess of the low stages of the river. Fortunately the high stages of the river occur when the principal irrigation is needed for the grains and early fruits. It must also be remembered that canal owners, when asked for the capacities of their canals, seldom underestimate them. It is interesting to note that the Tulare irrigation district, which has the Kaweah for the source of its supply, has finished its works and has now been operating under the Wright law successfully for a number of years, and is one of the few districts that have been able to finish their works. Along the foothills there is a strip of land about a mile wide, measured from the mountain, where the citrus fruits are grown with success.

The following statement was received from Mr. H. White, secretary of the St. Johns River Association:

The ditches named below are all taken from the St. Johns River, an outlet of the Kaweah.

Name of ditch.	Capacity.	Acres irrigated.
	Second-feet.	
Lakeside	301	5,000
C. F. Buckley	77	2,500
Tulare irrigation district	500	8,000
Mathews	17	600
Jennings	39	1,400
Modock	67	3,000
Uphill	30	2,000
Riparian owners	50	4,000
Others not named	40	2,500

The capacity of ditches is correct. The number of acres irrigated is estimated, but is about what has actually been irrigated. The ditches are capable of irrigating much more than this when there is plenty of water.

KINGS RIVER.

Kings River is one of the greater streams of the State, and draws its source from the highest Sierras. The area of its drainage basin is 1,742 square miles. It ranges in elevation from 300 feet at Kingsburg to 15,000 feet on Mount Whitney. The topography is said to be rough and the canyon of this river is one of the grandest in all the Sierras. There is much large timber at an elevation of from 4,000 to 5,000 feet, which is being rapidly taken off; the lower portions of the basin have a scattered growth of brush and oak trees. So far as known the watershed is well adapted to deliver a high per cent of run-off. The slope of the river is said to be very gradual at the mouth of the canyon. As is the case with other streams of this region, no record of rainfall has been kept in its basin. The rainfall of the plains is less than 10 inches. The Sanger Lumber Company is willing to keep the record of precipitation at one of their sawmills, at an elevation of over 5,000 feet. The waters of this stream, as well as those of the others to the south of this point, are used in irrigation.

The following is a list of the canals taken from Kings River for the purposes of irrigation, as given by Mr. John McMullin, president of the Fresno National Bank, the figures being approximate only, but practically correct:

	Capacity in second-feet.
In Fresno County:	
Enterprise Canal	100
Kings River and Fresno Canal	200
Fresno Canal and Irrigation Company	1,000
Kingsburg and Centerville Canal Company	400
Fowler Switch	500
Emigrant Ditch Company	200
Liberty Canal Company	100
Crescent Canal Company	60
Stimson Canal Company	40
In Tulare County:	
76 Canal Company, now Alta irrigation district	600
In Kings County:	
People's Ditch	300
Last Chance Ditch Company	200
Lower Kings River Ditch Company	250
Miscellaneous and unincorporated companies in Fresno County on the Laguna de Tache	200
Total	4,150

It will be noted that the figures differ somewhat from those given on page 80 of Bulletin No. 131, which figures were given by the secretary of one of the companies named therein. The actual discharge of these canals is not known, and it changes from year to year. Most of them are taken out above the Southern Pacific Railroad crossing of the river near Kingsburg. The State engineer makes the following statement as to the measurement of Kings River on page 409 of Physical Data and Statistics:

This is one of the most important irrigation feeders in the State, having a high watershed of the best character for plentiful and well-delivered supply, largely within the snow line. Many gagings have been made of Kings River at a number of points between Slate Point, at its debouchment from the mountains, 5 miles above Centerville, and Tulare Lake, its outfall basin, about 65 miles below. The character of the channel of this stream at all available locations near the mountains, or in the canyon, has not admitted of a first-class series of observations being made there, without the construction of a gaging section, at an expense which the known resources of the Department have at no time justified. Thus at Slate Point, the upper station, where measurements were made and a gage rod was established, the flow was influenced in varying amounts by the alternate formation and washing away of cobblestone and gravel bars immediately below.

At the railroad bridge crossing, south of Kingsburg, a good gage-rod record has been kept for the entire period, and its results, with those of the gagings, have afforded the data for what is believed to be a fair approximation to the actual water quantities which passed that point. But between that station and the mountains a number of canals take water from the stream in volumes which at ordinary stages together constitute a large part of the flow. These canals have been repeatedly gaged and records kept, or observations made of their flow during one or more seasons, so that the amounts of their abstraction from the river are approximately known and have been applied to the data of flow at the Kingsburg Bridge in preparing the table of water quantities delivered by the river into the valley. The methods employed throughout have been similar to those for the San Joaquin.

KINGSBURG STATION, ON KINGS RIVER.

The United States Geological Survey made three measurements of this river at the Kingsburg Bridge during 1895, and it was found that the stream was so influenced by the canals above and the section so poor that the work here was abandoned. The late summer flow of the river is only 500 second-feet, and the combined capacities of the canals, many of which are above the bridge, is 4,150 second-feet. This condition, together with the facts that the channel of the river is badly broken by numerous piers and that the current is both slow and oblique, was a determining factor in the abandonment of the station. The railroad company has kept a long series of rod readings at their bridge, the observers being careful, regular, and punctual in their observations. The Southern Pacific Company has freely given the United States Geological Survey all this information, and has thus made this station, as well as their other bridge stations, desirable to rate.

Daily gage height of Kings River at railroad bridge, Kingsburg, Cal., for 1891, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	3.50	2.20	10.50	3.90	8.65	7.10	9.50	5.10	3.00	3.00	2.80	2.70
2..	3.50	2.20	9.40	4.00	9.20	6.80	9.40	5.00	3.00	3.00	2.80	2.60
3..	3.20	2.20	7.10	4.20	9.10	7.20	9.10	5.00	3.00	3.00	2.80	2.60
4..	3.20	2.20	6.80	4.30	9.40	8.00	8.90	4.80	3.00	3.00	2.80	2.60
5..	3.10	2.10	5.20	4.50	9.80	9.30	8.20	4.70	3.00	3.00	2.80	2.50
6..	3.30	2.10	4.70	4.60	10.00	10.30	7.90	4.30	3.00	3.30	2.80	2.50
7..	3.30	2.10	3.80	4.80	9.70	10.50	7.90	4.10	3.00	3.30	2.80	2.40
8..	3.20	2.10	3.20	5.00	9.70	10.20	7.00	4.00	3.00	3.20	2.80	2.40
9..	3.10	2.00	3.00	7.60	8.80	10.00	6.60	3.90	3.00	3.20	2.80	2.50
10.	3.00	2.00	2.90	4.40	9.50	10.00	6.70	3.80	3.00	3.10	2.80	2.50
11.	2.80	2.00	2.80	4.40	9.30	9.70	6.50	3.80	3.00	3.10	2.80	2.60
12.	2.70	2.00	3.00	4.60	9.40	9.00	6.30	3.60	3.00	3.00	2.80	2.60
13.	2.50	2.00	3.00	4.50	9.40	8.00	6.30	3.60	3.00	3.00	2.80	2.60
14.	2.50	2.00	3.00	4.40	9.10	7.90	6.20	3.40	3.00	3.20	2.80	2.60
15.	2.60	2.00	3.10	4.40	8.10	10.00	6.10	3.40	3.00	3.20	2.80	2.80
16.	2.60	2.90	3.10	4.40	7.70	9.80	6.50	3.30	3.00	3.20	2.80	2.80
17.	2.60	4.70	3.10	5.10	8.10	10.10	6.60	3.40	3.00	3.20	2.80	2.70
18.	2.60	3.90	3.00	5.50	9.30	10.00	6.20	3.50	3.00	3.20	2.80	2.70
19.	2.60	3.20	3.10	5.00	9.00	9.60	6.20	3.50	3.00	3.20	2.80	2.60
20.	2.50	2.90	3.00	5.00	9.00	9.70	6.10	3.40	3.00	3.10	2.70	2.60
21.	5.40	2.70	3.20	5.00	9.70	9.80	6.10	3.20	3.00	3.10	2.70	2.60
22.	2.30	2.90	3.80	5.50	9.50	9.80	5.60	3.20	3.00	3.00	2.70	2.60
23.	2.30	10.20	4.10	5.20	7.50	9.30	5.50	3.10	3.00	3.00	2.70	2.60
24	2.30	7.20	3.80	7.20	7.00	9.30	5.40	3.10	3.00	3.00	2.70	2.50
25.	2.30	6.60	3.80	6.80	7.80	9.10	5.40	3.00	3.30	3.00	2.70	2.50
26.	2.20	5.20	3.70	6.50	8.00	9.30	5.40	3.00	3.30	3.00	2.70	2.50
27.	2.20	4.70	4.00	6.80	8.85	9.70	5.60	3.10	3.20	2.90	2.70	2.50
28.	2.20	5.00	4.60	7.35	9.10	10.10	5.60	3.00	3.10	2.90	2.70	2.70
29.	2.20	....	4.40	7.80	9.10	9.80	5.60	3.10	3.00	2.80	2.70	2.80
30.	2.20	....	4.10	8.30	8.30	9.50	5.30	3.30	3.00	2.80	2.70	4.10
31.	2.20	....	4.00	....	8.10	....	5.20	3.20	....	2.80	....	8.60

Daily gage height of Kings River at railroad bridge, Kingsburg, Cal., for 1892, in feet.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	5.20	3.00	2.50	4.20	5.40	9.60	6.00	1.11	2.60	2.70	2.40	3.80
2..	4.20	2.50	2.90	4.50	4.70	9.60	5.20	2.00	2.60	2.70	2.50	4.10
3..	3.90	2.20	3.40	4.20	4.70	9.10	4.80	2.00	2.60	2.70	2.50	3.90
4..	3.70	2.20	3.50	4.60	4.70	7.80	4.40	2.00	2.60	2.70	2.50	3.70
5..	3.50	2.30	3.20	4.10	4.20	7.70	4.30	2.00	2.70	2.70	2.50	4.00
6..	3.50	2.50	3.10	3.80	4.00	7.50	4.10	2.00	2.60	2.60	2.40	3.30
7..	4.30	2.50	3.00	3.80	4.00	7.20	3.60	1.11	2.60	2.50	2.40	2.10
8..	4.20	2.50	3.10	4.50	3.70	6.60	3.30	1.11	2.60	2.50	2.40	2.80
9..	4.20	2.20	3.10	5.40	3.60	6.10	3.10	1.11	2.50	2.50	2.40	2.70
10.	3.30	2.20	3.30	5.60	4.20	5.80	2.90	1.11	2.50	2.70	2.40	2.60
11.	3.10	2.10	3.70	5.70	5.20	5.50	2.80	1.11	2.50	2.70	2.40	2.60
12.	3.00	2.10	3.90	5.60	5.40	5.10	2.70	1.11	2.50	2.70	2.40	2.60
13.	3.00	2.10	3.90	5.30	5.40	4.80	2.40	1.11	2.50	2.60	2.40	2.50
14.	3.00	2.40	3.80	5.10	4.90	4.70	2.30	1.11	2.50	2.50	2.40	2.50
15.	2.70	2.40	3.90	5.10	5.30	4.80	2.20	1.11	2.50	2.50	2.40	2.40
16.	2.70	2.40	4.10	5.10	6.60	4.50	2.10	1.11	2.50	2.50	2.40	2.40
17.	2.70	2.30	3.80	5.20	6.00	5.60	2.10	1.11	2.50	2.40	2.40	3.40
18.	2.60	2.30	3.50	4.80	6.70	6.70	2.10	1.11	2.50	2.50	2.40	2.40
19.	2.60	2.30	3.30	4.20	8.10	7.20	2.00	1.11	2.50	2.50	2.40	2.30
20.	2.60	2.40	3.70	4.00	8.90	7.50	1.90	1.11	2.50	2.60	2.40	2.30
21.	2.60	2.70	3.30	3.80	9.50	7.60	1.90	1.11	2.50	2.60	2.40	2.30
22.	2.60	2.80	3.00	3.90	9.80	7.20	1.90	1.11	2.50	2.60	2.40	2.30
23.	2.60	2.60	2.90	3.90	9.20	6.60	1.90	1.11	2.40	2.50	2.40	2.30
24.	2.60	2.50	3.00	4.60	9.30	6.20	1.90	2.20	2.40	2.50	2.40	2.30
25.	2.60	2.45	2.80	4.50	9.00	5.60	1.90	2.20	2.40	2.50	2.40	11.90
26.	2.60	2.30	2.70	4.40	8.60	5.60	1.80	2.20	2.30	2.50	2.40	8.00
27	2.60	2.25	2.80	4.50	8.50	5.50	2.60	2.20	2.40	2.20	2.50	6.70
28.	2.60	2.30	2.70	4.30	8.70	6.20	2.70	2.10	2.40	2.30	2.50	5.90
29.	2.60	2.40	2.70	4.50	9.30	6.80	2.60	2.10	2.60	2.30	2.60	5.40
30.	2.80	....	2.80	4.80	9.30	6.80	2.60	2.10	2.70	2.40	4.30	5.00
31.	2.90	....	5.70	....	9.30	....	2.10	2.35	....	2.40	....	4.80

[1] The daily gage heights of Kings River at Kingsburg for 1893 and 1894 are given in Bulletin No. 131, page 81.

Daily gage height of Kings River at Kingsburg, Cal., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	5.08	5.25	5.58	5.58	6.33	7.17	7.25	4.08	3.00	3.17	3.83	3.58
2..	5.00	5.25	5.58	5.58	8.50	6.83	7.08	4.00	3.00	3.08	3.83	3.33
3..	4.75	5.25	5.67	5.75	7.83	7.17	7.08	4.00	3.00	3.08	3.75	3.25
4 .	4.67	5.25	5.50	5.75	7.08	8.25	6.75	4.00	3.00	3.58	3.83	3.33
5..	10.33	5.17	5.42	5.75	7.42	9.17	6.42	4.17	2.92	3.67	3.92	3.42
6..	6.50	5.17	5.33	5.50	8.25	9.75	6.33	4.00	2.92	3.67	3.92	3.42
7..	6.00	5.08	5.25	5.42	8.83	10.00	6.33	4.00	2.92	3.67	3.83	3.33
8..	5.75	5.08	5.25	5.67	9.33	10.00	6.33	3.92	2.83	3.42	3.83	3.33
9..	5.92	5.08	5.33	5.83	9.75	9.67	6.50	3.83	2.83	3.42	3.83	3.25
10.	5.83	5.50	5.25	5.75	9.75	9.58	6.50	3.67	2.83	3.42	3.83	3.25
11.	5.50	5.25	5.25	5.83	9.75	9.58	6.33	3.50	2.75	3.50	3.75	3.25
12.	5.33	7.00	5.17	5.75	10.25	9.58	5.92	3.17	2.83	3.50	3.67	3.17
13.	5.33	9.17	5.00	5.83	10.50	9.75	5.83	3.08	2.83	3.75	3.33	3.17
14.	5.50	7.00	5.42	6.00	10.92	9.25	5.75	3.42	7.17	3.83	3.25	3.17
15.	6.00	6.50	5.08	5.75	11.25	8.75	5.50	3.33	5.50	3.83	3.25	3.25
16.	5.83	6.17	4.92	5.50	11.42	8.33	5.50	3.25	4.83	3.92	3.25	3.25
17.	6.50	6.08	4.83	5.75	11.25	7.83	5.50	3.33	4.33	3.83	3.17	3.25
18.	7.00	6.00	4.92	6.25	11.00	8.00	5.50	3.50	4.17	3.92	3.17	3.08
19.	7.50	5.92	4.50	6.83	10.50	8.08	5.58	3.50	3.75	3.92	3.17	3.00
20.	6.67	6.00	4.25	7.25	10.25	8.75	5.50	3.50	3.67	4.00	3.17	3.17
21.	6.25	5.92	4.75	7.50	10.00	8.58	5.17	3.42	3.50	4.17	3.17	3.25
22.	6.17	5.83	4.25	7.25	9.83	8.33	5.00	3.42	3.33	4.17	3.17	3.25
23.	6.17	6.17	4.25	7.25	9.75	8.50	4.92	3.33	3.25	4.25	3.08	2.83
24.	6.25	5.92	4.08	7.17	9.58	8.75	4.83	3.25	3.25	4.25	3.08	2.50
25.	6.00	6.17	4.25	7.00	9.75	8.83	4.83	3.25	3.17	4.17	3.08	2.50
26.	5.83	5.83	4.50	7.25	9.83	8.75	4.83	3.17	3.17	4.08	3.00	2.67
27.	5.75	5.75	4.50	7.08	9.00	8.83	4.83	3.17	3.08	4.08	3.08	2.50
28.	5.58	5.58	7.25	7.00	8.33	7.92	4.75	3.08	3.08	4.00	3.17	2.42
29.	5.50	....	7.83	7.00	7.75	7.50	4.50	3.08	3.00	3.92	3.17	2.42
30.	5.33	....	6.33	6.33	7.25	7.50	4.25	3.08	3.00	3.92	3.25	2.42
31.	....	....	5.92	....	7.50	....	4.17	....	....	3.83	....	2.33

SUSPENSION BRIDGE AND RED MOUNTAIN STATIONS, ON KINGS RIVER.

An effort was made to establish a station on this river higher up in the foothills, most of the other bridges in the valley being like the one at Kingsburg. Two trips were made to Suspension Bridge, about 30 miles above Sanger, where the flume of the Sanger Lumber Company crosses the river. At this point the conditions were hardly better than at Kingsburg, for while the river was comparatively confined and there were no canals taken out above it, in times of high water the velocities were so high that it was difficult to handle the meter in the water, and the channel was badly broken with large bowlders. The bed of the stream was found to be shifting very rapidly also. The station was abandoned on September 30, 1895, in favor of the cable station at Red Mountain.

Daily gage height of Kings River at Suspension Bridge, California, in feet.

Day.	June.	July.	Aug.	Sept.	Day.	June.	July.	Aug.	Sept.
1	......	12.8	10.5	9.4	17	......	11.0	10.0	10.0
2	......	12.8	10.3	9.4	18	......	11.0	10.0	10.0
3	......	12.6	10.5	9.4	19	......	11.0	10.0	9.8
4	......	......	......	9.4	20	......	11.0	10.0	9.7
5	......	12.2	10.5	9.3	21	......	10.8	9.9	9.6
6	......	11.6	10.6	9.3	22	......	10.8	9.9	......
7	......	12.1	10.6	9.3	23	......	10.8	9.9	9.5
8	......	12.2	10.3	......	24	......	10.8	9.8	9.4
9	......	12.3	10.1	9.2	25	13.2	11.0	......	9.4
10	......	12.2	10.1	9.2	26	13.9	......	9.6	9.3
11	......	11.8	......	9.3	27	13.9	10.8	9.6	9.3
12	......	11.7	10.0	9.4	28	12.9	10.7	9.5	9.3
13	......	11.6	10.0	13.4	29	13.0	10.6	9.5	......
14	......	11.5	10.0	12.7	30	......	10.5	9.5	9.2
15	......	11.5	10.0	11.7	31	......	10.5	9.4	......
16	......	11.4	10.0	10.1					

As this river is so important, it was decided to establish a cable station at a more favorable gaging point and one that would be more accessible to the railroad. The station called Red Mountain, on the lower flume, section No. 9, was established. A half-inch cable was stretched across the river and an inclined gage rod was placed in position. The rod was made of two 4-inch by 8-inch timbers 20 and 14 feet long. This was placed on the north bank of the stream at a point about 300 feet above the cable and just below a small shanty which is on the flume. This is 15 miles from Sanger and can be reached from either side of the river. The station is 3 miles below Jarretts, 1,000 feet below a point where the lumber flume hugs a rocky cliff, and is to the southwest of a hill which is well named Red Mountain. This gage rod is bolted to a tree and to crosspieces loaded with rocks: the lower end is placed under a large bowlder.

A bench mark 18.045 feet above datum, 11 feet northwest of a sycamore tree at the upper end of the rod, is marked with a cross on the rock. The cable was fastened to an oak tree on the north bank and to a "dead man" on the south bank. It was found that by fastening a block and tackle to the top of an upright set on the south bank 50 feet from the dead man and next to the cable, notching it on the upstream side, and then pulling from the ground, the cable could be made as tight as desired. The bed of the stream is covered with bowlders ranging from 6 inches to 2 feet in diameter, with little sand at the surface. A tag wire with markers is stretched across the river just above the cable.

This station at Red Mountain has not as yet stood the test of high-water gaging. Two gagings have been made here. Sufficient data are not yet obtained to form a rating table for this station at Red Mountain, but the station will be maintained and rated. A diagram of gage heights from 1880 to 1891, and also a statement in reference to this river, may be found on Pl. LXXXII and on page 320 of the Twelfth Annual Report of the United States Geological Survey.

Daily gage height of Kings River at Red Mountain, California, in feet.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	......	4.2	4.1	4.0	17	5.4	4.1	4.0	3.8
2	......	4.2	4.1	4.0	18	......	4.1	4.0	4.0
3	4.3	4.2	4.1	4.1	19	4.9	4.3	3.9	3.9
4	4.3	4.1	4.1	4.1	20	4.8	4.4	3.9	4.0
5	4.3	4.1	4.1	4.1	21	4.7	4.5	3.9	4.5
6	4.2	4.1	6.4	4.0	22	4.6	4.5	4.0	......
7	4.2	4.1	4.1	4.0	23	4.1	4.5	3.9	......
8	4.2	4.1	4.1	4.0	24	4.5	4.4	3.8	......
9	4.2	4.0	4.1	4.0	25	4.4	4.3	3.8	......
10	4.1	4.0	4.1	......	26	4.4	4.3	3.9	......
11	4.1	4.0	4.0	4.0	27	4.3	4.2	3.9	......
12	4.2	4.0	4.0	4.0	28	......	4.2	3.9	......
13	6.6	4.0	4.0	4.0	29	4.2	4.1	4.0	......
14	8.0	4.0	4.0	4.0	30	4.2	4.1	4.3	......
15	6.4	4.0	4.0	4.0	31	......	4.1	......	......
16	5.8	4.0	4.0	4.0					

List of discharge measurements made on Kings River at Kingsburg and at Suspension Bridge, Cal.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Jan. 10	A. P. Davis	24	6.00	1,985	0.92	*a* 1,830
2	Mar. 23	J. B. Lippincott	24	4.10	1,273	0.39	*a* 500
3	June 25	.....do	24	13.20	1,914	5.38	*b* 10,300
4	Sept. 2	.....do	24	*c* 9.50	223	2.50	*b* 524
5	Nov. 24	.....do	24	3.80	350	0.93	248
6	Dec. 2	.....do	Floats.	3.25	529	0.69	*a* 356

a Measurements made at Kingsburg railroad bridge.
b Measurements made at Suspension Bridge.
c Height at Red Mountain, 4.32 feet.

The problem of daily variation in the streams of the San Joaquin Valley, no matter where they are measured, is a difficult one. Beginning early in the spring, the snow melts first on the lower foothills, the greatest melting, of course, being about midday. This snow, which is the first melted, being low on the foothills and near the plains, will reach a given point in the valley in a much shorter time than that which later in the season is melted from a greater elevation and at points which are more distant, consequently a given point may show a maximum height of river elevation in March at one time of the day, but in June the maximum elevation will occur at a very much later time of the day. Again, an unusually warm day, or a warm period of days, may occur at any time during the season, which will produce conditions of river height and variation that it is impossible to foretell, or warm rains in the mountains will exaggerate these conditions. Again, a river which is rising will have a higher velocity than one that is falling, but if stations are selected well back in the foothills, where the natural grades of the river are steep, this trouble with velocities will produce less effect than where stations are on the plains and the grades are perhaps 0.2 or 0.3 foot per mile. Observers in all cases have been instructed to watch the daily variation of the rivers and endeavor to read the rod at the time of mean daily height.

SAN JOAQUIN RIVER.

The area of the drainage basin of the San Joaquin River above Hamptonville is given by the State engineer, whose figures as to areas of drainage basins have in most instances been checked by planimeter measurements, as 1,627 square miles. The elevation map of the United States Geological Survey shows this basin as ranging from below 500 feet to above 11,000 feet above the sea. Judging from the bulletins of the Sierra Club of San Francisco, the drainage basins of the tributaries of the Upper San Joaquin are all rugged and precipitous, favorable alike in geological formation and exposures to a large per cent of run-off. The topographic features, however, have not as yet been mapped south of Yosemite Park. The great heights are indicated by the fact that Mount Lyell, which is at the head of this basin, is given as 13,042 feet in elevation. A small canal of an unknown capacity has been constructed well up in the mountains from the North Fork of the San Joaquin to the Fresno River, which changes the natural discharge of the stream to some extent.

No rain gages are to be found in the higher portions of this basin. One at Buchanan in the foothills shows a precipitation of 18.78 inches for the seasons 1881–82 to 1883–84. As showing the relation of rainfall to increased elevation the following list of observations of stations on the Southern Pacific Railroad up the Sierras from Sacramento to Summit, about 150 miles north of this basin but with the same general exposures, is given. This data will also be of interest in the case of other basins of this same class.

Station.	Elevation.	Average annual precipitation.
	Feet.	*Inches.*
Sacramento	30	19.80
Folsom	182	23.33
Auburn	1,360	32.55
Colfax	2,421	44.01
Alta	3,612	42.13
Emigrant Camp	5,230	50.77
Cisco	5,939	57.41
Summit	7,017	47.93

It will be noted that there is a uniform increase of rainfall with the rise in elevation until 5,000 feet is reached, when there is a slight decrease. The same conditions have been found elsewhere, especially in the Himalayas, namely, that there is a limit to the increase of precipitation due to elevation, and that above certain elevations the fall is less. The records as given above may follow this law. The snowfall is on the average 29.6 feet at Cisco and 31.3 feet at Summit, and it may be that there is an unavoidable error in its measurement which would explain the decrease, especially if the snowfall was accompanied by high winds. If Alta was taken as the average for the group in elevation this would call for a mean precipitation of over 42.13 inches.

There is a general increase of rainfall as latitude increases, as has been clearly shown by Captain Glassford.[1] Mr. Gannett, in his precipitation map of the United States, shows as great a rainfall here as in any other basin in the State.

This river has been gaged by the State engineers between the seasons of 1878–79 and 1883–84, and the locality where work was carried on was pronounced among their best stations. As the maximum and minimum monthly discharges of the river are given for each month except for the last two years, the daily discharge of the river has been evidently noted for that period.

[1] Irrigation and water storage in the arid regions, Fifty-first Congress, second session, House of Representatives, Ex. Doc. No. 287, page 339.

This river is of the first class in the group, having an elevated watershed in large part within the snow line. The points of observation have been at Hamptonville (formerly Jones's store), at the edge of the valley, and the railroad crossing near Sycamore. Gagings and special examinations were made many times during the period from 1878 to 1884 at both of these places. A good record of water elevations was kept at the railroad bridge from 1879 to 1882, inclusive, and a similar record at Hamptonville for one season. For the period covered by the table practically no water was diverted from the stream above the lower station. The results of the data of that point admitted of direct application to the upper station, no account being had of loss or gain in the river channel, which is known not to be large. The results were worked out by the method of the scale of discharge, and supplemented by that of drainage per square mile, as already explained, and are presented as worthy of full reliance for all purposes of water-supply study for the period covered.[1]

The United States Geological Survey has gaged this stream at Herndon, 12 miles from Fresno, on the railroad, at what is known as the Upper Crossing. The station has proven to be one of the most favorable in the State. The observer, Mr. G. G. Nelson, is interested, capable, and exact. The section of the stream bed has been reasonably permanent, and not subject to erratic change. The velocities have been fairly moderate, and the channel is well confined. There is no substantial irrigation from this river above the point of measurement, and the bridge from which the gagings are made is without piers in the channel.

HERNDON STATION, ON SAN JOAQUIN RIVER.

Observations of river height at this point were begun on May 1, 1877, and have been conducted continuously since that time by the Southern Pacific Company. The station is described in Bulletin 131, page 81.[2] This river, as reported by the observer, has a daily variation in the spring and early summer, due to the melting snow. The low stage is about 9 a. m., and the high about 9 p. m. The reading made at 3 p. m. is considered to be the average height for the day.

The station is about three-quarters of a mile north of Herndon and 10½ miles from Fresno. The measurements of discharge are made from the wagon bridge, 1,200 feet upstream from the railroad bridge, to which the gage is attached. This gage is vertical, marked at intervals of 1 foot. It is nailed to the center pier, the rod being on the upstream face, where the water is backed up or broken into small waves. The initial point for soundings is on the right, or south, bank. The channel is straight for about 900 feet above the station and is of uniform cross section. It is also straight for 3,000 feet below the station, the water being somewhat swift. The right, or south, bank is high, with gravel slope. At an elevation equivalent to 13 feet on the rod this bank is liable to overflow into a back channel. The left, or north, bank is high

[1] Physical Data and Statistics of California, collected and compiled by the State engineering department of California, Sacramento, 1886, p. 409.

[2] Physical Data and Statistics of California, pp. 409, 449-451. Twelfth Annual Report of the United States Geological Survey, Part II, Irrigation, p. 321, Pl. LXXXIV. Gage height of the San Joaquin River at Herndon, Cal., 1880-81.

and can not be overflowed until the water stands at 38 feet on the rod. The bed of the stream is of small gravel and sand and varies according to the stage of the water.

The bench mark is on the south end of the wooden trestle of the wagon bridge, on the west side. It consists of a cut in the post and a nail 0.2 foot above ground. The elevation is 24.12 feet above datum.

A graduation has been painted on the southwest iron pier of the wagon bridge, at a point 930 feet above the railroad bridge, to show the slope of the river. The water does not stand at this gage in low stages of the river.

The velocities of the stream were taken with a Haskell electrical meter, at top and bottom, and soundings were made at least every 20 feet, and as often as every 5 feet, depending on the roughness of the bottom. When velocities were below 0.5 foot per second, as was the case in some places in the river during extreme low water, the current was measured with floats, and the mean velocities for these points were determined with the assistance of previous records at these points during higher stages of the river. The stream was gaged at this point seven times by the United States Geological Survey during 1895.

List of discharge measurements made on San Joaquin River at Herndon, Cal.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Jan. 9	A. P. Davis	24	4.00	1,198	1.67	1,995
2	Mar. 22	J. B. Lippincott	24	3.85	1,273	1.60	1,938
3	May 5	do	24	6.65	2,262	3.28	7,419
4	June 23	do	24	8.00	2,769	4.05	11,225
5	Aug. 31	do	24	3.00	1,005	0.68	677
6	Oct. 11	do	Float.	2.60	29	0.45	332
7	Nov. 25	do	Float.	2.55	703	0.38	270

Estimated discharge of San Joaquin River at Herndon, Cal.

[Drainage area above Hamptonville, 1,637 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1895.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Inches.*	*Sec. feet.*
January	11,225	1,260	2,881	177,102	2.029	1.760
February	8,500	909	2,568	142,590	1.634	1.569
March	9,318	1,554	2,779	170,840	1.957	1.697
April	9,863	3,354	5,834	316,600	3.626	3.564
May	19,960	5,100	13,124	807,000	9.243	8.017
June	14,565	7,250	10,674	599,404	6.866	6.520
July	8,000	2,148	4,528	278,410	3.189	2.766
August	2,301	793	1,417	87,104	.997	.866
September	8,500	260	1,085	64,567	.740	.663
October	1,260	260	420	25,846	.296	.257
November	426	260	362	25,562	.247	.221
December	677	260	373	22,905	.262	.228
Per annum.	19,960	260	3,791	2,717,930	31.086	2.344

Rating table of San Joaquin River at Herndon, Cal., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.50	260	3.70	1,554	5.80	5,550
2.60	343	3.80	1,701	6.00	6,000
2.70	426	3.90	1,848	6.50	7,250
2.80	509	4.00	1,995	7.00	8,500
2.90	592	4.20	2,301	7.50	9,863
3.00	677	4.40	2,607	8.00	11,225
3.10	793	4.60	2,958	8.50	12,738
3.20	909	4.80	3,354	9.00	14,250
3.30	1,025	5.00	3,750	9.50	15,825
3.40	1,141	5.20	4,200	10.00	17,400
3.50	1,260	5.40	4,650	10.50	19,000
3.60	1,407	5.60	5,100	11.00	20,600

Daily gage height of San Joaquin River at Upper Crossing railroad bridge, Herndon, Cal., for 1891, in feet.

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.33	1.75	3.00	3.17	6.50	5.25	6.75	3.58	2.33	1.25	1.00	0.75
2..	2.33	1.75	7.00	3.17	7.00	5.00	6.50	3.33	2.33	1.25	0.92	0.75
3..	2.25	1.75	3.33	3.17	7.00	5.08	6.33	3.25	2.17	1.25	0.92	0.75
4..	2.25	1.75	4.00	3.33	7.25	5.50	6.00	3.42	2.17	1.25	0.92	0.92
5..	2.25	1.75	3.33	3.67	7.25	5.67	5.50	3.25	2.08	1.17	0.92	0.92
6..	2.17	1.75	3.33	3.92	7.25	5.92	5.00	3.08	2.08	1.17	0.92	0.92
7..	2.17	1.67	3.33	4.00	7.33	7.50	5.00	2.83	2.08	1.17	0.92	0.92
8..	2.17	1.67	3.25	4.00	7.00	8.00	4.75	2.75	2.08	1.17	0.92	0.83
9..	2.08	1.67	3.25	4.00	7.00	7.75	4.50	2.75	2.08	1.17	0.92	0.83
10.	2.08	1.67	3.17	4.00	6.33	7.17	4.50	2.67	2.08	1.08	0.92	1.17
11.	2.00	1.67	3.17	4.00	6.67	7.25	4.42	2.67	2.00	1.08	0.83	1.25
12.	2.00	1.67	3.17	3.92	6.50	7.08	4.42	2.58	2.00	1.08	0.83	1.25
13.	2.00	1.67	3.42	3.83	6.33	6.83	4.25	2.58	2.00	1.08	0.83	1.33
14.	2.00	1.67	3.67	3.67	6.17	6.50	4.25	2.83	1.92	1.08	0.83	1.33
15.	2.00	1.92	3.50	3.58	6.08	6.00	4.25	2.83	1.92	1.08	0.83	1.33
16.	2.00	3.50	3.50	3.50	6.08	5.67	4.25	2.75	1.83	1.08	0.83	1.33
17.	2.00	3.00	3.75	4.50	6.33	5.33	4.33	2.67	1.83	1.08	0.83	1.33
18.	2.00	2.33	3.75	4.00	6.25	5.75	4.42	2.67	1.75	1.08	0.83	1.33
19.	2.00	2.08	3.75	4.00	6.25	7.17	4.25	2.58	1.75	1.08	0.83	1.25
20.	2.00	2.00	3.75	3.83	6.17	6.50	4.17	2.58	1.67	1.08	0.75	1.33
21.	1.92	2.00	3.75	4.83	6.17	6.00	4.08	2.50	1.67	1.00	0.75	1.42
22.	1.92	3.00	3.75	4.58	6.00	6.17	4.00	2.50	1.67	1.00	0.75	1.42
23.	1.92	8.00	3.67	5.50	5.83	6.25	3.83	2.50	1.58	1.00	0.75	1.33
24.	1.92	6.00	3.58	5.50	5.50	6.42	3.83	2.33	1.50	1.00	0.75	1.25
25.	1.83	4.00	3.50	5.33	5.42	6.50	3.92	2.42	1.50	1.00	0.75	1.17
26.	1.83	3.17	3.42	5.42	5.50	6.33	3.92	2.42	1.50	1.00	0.75	1.17
27.	1.83	3.08	3.42	5.50	5.58	6.75	3.92	2.42	1.42	1.00	0.75	1.17
28.	1.83	3.00	3.42	6.00	5.58	6.75	4.00	2.50	1.42	1.00	0.75	1.17
29.	1.83	......	3.33	6.42	5.50	7.00	4.17	2.50	1.33	1.00	0.75	2.25
30.	1.83	......	3.25	6.50	5.50	6.75	4.25	2.50	1.25	1.00	0.75	2.75
31.	1.83	......	3.25	......	5.42	......	3.83	2.50	......	1.00	......	3.17

Daily gage height of San Joaquin River at Upper Crossing railroad bridge, Herndon, Cal., for 1892, in feet.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	3.00	1.50	2.00	3.08	3.67	7.00	5.00	2.25	1.25	0.83	0.92	5.33
2..	2.50	1.50	2.08	3.00	3.75	8.00	5.08	2.17	1.17	0.83	0.92	4.00
3..	2.17	1.42	2.67	3.00	3.92	7.83	4.83	2.17	1.17	0.83	0.83	3.75
4..	2.17	1.42	2.42	3.00	3.92	7.00	4.75	2.17	1.17	0.83	0.83	4.25
7..	2.08	1.42	2.50	2.83	3.75	6.00	4.50	2.08	1.17	0.83	0.83	3.25
5..	2.08	1.42	2.33	2.67	3.33	6.00	4.33	2.08	1.17	0.83	0.83	2.83
6..	2.17	1.42	2.17	2.75	3.17	5.50	3.75	2.08	1.17	0.83	0.83	2.17
8..	2.33	1.33	2.00	3.83	3.08	5.00	3.50	2.08	1.08	0.83	0.83	2.08
9..	2.33	1.33	2.00	4.00	3.08	5.00	3.67	2.08	1.08	0.83	0.83	2.00
10.	2.25	1.33	2.17	4.25	3.75	4.83	3.50	2.00	1.08	1.25	0.83	1.83
11.	2.17	1.33	2.33	4.08	3.50	4.67	3.42	2.00	1.08	1.08	0.83	1.75
12.	2.00	1.33	2.75	3.75	3.67	4.50	3.25	2.00	1.00	1.00	0.83	1.75
13.	1.83	1.33	2.83	3.42	3.17	4.17	3.17	2.00	1.00	1.00	0.75	1.67
14.	1.75	1.42	2.83	3.33	3.42	4.33	2.92	1.83	1.00	1.00	0.75	1.67
15.	1.67	1.42	2.92	3.42	3.50	4.25	2.75	1.67	1.00	1.00	0.75	1.67
16.	1.67	1.42	3.08	3.75	5.00	4.00	2.67	1.58	1.00	0.92	0.75	1.67
17.	1.67	1.33	3.08	3.67	4.50	5.00	2.67	1.58	1.00	0.92	0.75	1.58
18.	1.67	1.33	3.00	3.50	5.33	5.33	2.50	1.58	1.00	0.92	0.75	1.50
19.	1.58	1.42	2.75	3.17	6.00	6.17	2.75	1.50	0.92	0.92	0.75	1.50
20.	1.58	2.67	3.17	3.00	6.50	6.33	2.83	1.50	0.92	0.92	0.75	1.42
21.	1.50	2.75	3.08	2.83	7.00	6.17	2.83	1.50	0.92	0.92	0.67	1.42
22.	1.50	2.67	2.83	3.00	7.67	5.83	2.75	1.42	0.92	0.83	0.67	1.42
23.	1.50	2.67	2.67	3.08	7.00	5.25	2.67	1.42	0.92	0.83	0.67	6.00
24.	1.42	2.58	2.58	3.17	7.50	5.08	2.67	1.42	0.92	0.83	0.67	7.00
25.	1.42	2.42	2.33	3.17	7.58	4.83	2.58	1.42	0.92	0.83	0.67	14.00
26.	1.42	2.33	2.25	3.42	7.00	4.50	2.58	1.33	0.92	0.83	0.92	7.00
27.	1.42	2.08	2.08	3.33	6.83	4.33	2.50	1.33	0.83	0.83	1.00	6.50
28.	1.42	2.00	2.08	3.33	6.50	5.50	2.50	1.33	0.83	0.83	1.00	5.00
29.	1.42	2.00	2.00	3.50	7.00	5.33	2.33	1.33	0.83	0.92	1.00	5.00
30.	1.42	....	2.75	3.58	7.83	5.17	2.33	1.25	0.83	0.92	3.50	4.33
31.	1.42	....	3.50	....	7.50	....	2.33	1.25	....	0.92	....	4.00

[1] The daily gage height of San Joaquin River at Upper Crossing, Herndon, for 1893 and 1894 has been published in Bulletin No. 131, page 82.

Daily gage height of San Joaquin River at Upper Crossing railroad bridge, Herndon, Cal., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	3.83	4.33	4.17	4.92	5.67	6.50	6.83	4.17	3.00	2.50	2.50	2.83
2..	3.67	3.83	4.25	4.92	8.00	6.50	6.50	3.92	3.08	2.50	2.50	2.83
3..	3.50	3.67	4.25	4.83	7.25	6.67	6.50	3.92	3.08	2.50	2.50	2.67
4..	3.50	3.50	4.17	5.00	6.75	7.33	6.42	3.83	3.08	2.50	2.50	2.58
5..	8.00	3.42	4.33	5.00	6.83	8.25	5.92	4.25	3.00	2.50	2.67	2.58
6..	5.00	3.25	4.25	4.83	7.00	8.67	5.67	4.25	3.00	2.58	2.67	2.58
7..	4.08	3.50	4.33	4.92	8.00	9.08	5.83	4.08	2.83	2.58	2.58	2.50
8..	3.75	3.67	4.33	5.17	8.50	9.00	6.00	4.08	2.75	2.58	2.58	2.50
9..	4.33	3.67	4.50	5.33	9.00	8.50	6.00	4.00	2.67	2.58	2.58	2.50
10.	4.17	3.75	4.42	5.08	9.00	8.50	6.17	3.92	2.50	2.58	2.67	2.50
11.	4.00	3.75	4.42	5.42	8.83	8.50	6.00	3.75	2.50	2.58	2.75	2.50
12.	4.00	6.00	4.33	5.33	9.33	8.50	5.67	3.58	2.50	2.58	2.75	2.50
13.	3.92	7.00	4.50	5.50	9.50	8.75	5.25	3.83	2.83	2.58	2.75	2.50
14.	3.83	5.00	4.50	5.83	9.67	8.75	5.25	3.67	7.00	2.50	2.75	2.50
15.	4.50	4.75	4.17	5.67	10.33	8.00	5.17	3.42	4.83	2.50	2.67	2.50
16.	4.67	4.75	4.00	5.33	10.83	7.50	5.17	3.58	4.00	2.50	2.67	2.50
17.	4.92	4.42	4.00	5.50	10.33	7.25	5.25	3.50	4.00	2.50	2.67	2.50
18.	7.00	4.33	4.08	6.08	10.17	7.00	5.17	3.42	3.75	2.50	2.67	2.50
19.	5.50	4.00	4.17	6.42	10.00	7.17	4.92	3.33	3.58	2.50	2.58	2.50
20.	4.50	4.17	3.83	7.00	9.75	7.25	4.83	3.25	3.50	2.67	2.58	2.50
21.	4.42	4.25	4.00	7.50	9.17	7.42	5.00	3.33	3.33	3.00	2.58	2.75
22.	4.17	4.25	3.92	7.33	9.00	7.42	4.83	3.17	3.25	3.50	2.58	3.00
23.	4.75	5.00	3.83	7.00	9.00	7.75	4.75	3.33	3.00	3.42	2.58	2.92
24.	4.50	4.50	3.83	7.00	8.83	8.00	4.67	3.25	2.83	3.33	2.58	2.83
25.	4.50	4.67	3.75	6.75	9.00	7.50	4.58	3.33	2.75	3.33	2.50	2.83
26.	4.33	4.42	4.17	7.00	9.00	7.58	4.50	3.17	2.75	3.17	2.50	2.75
27.	4.25	4.25	4.33	6.83	8.33	8.00	4.50	3.25	2.67	2.83	2.50	2.75
28.	4.00	4.17	7.33	6.67	7.83	7.67	4.42	3.17	2.58	2.67	2.67	2.75
29.	3.83	....	6.75	6.58	7.17	7.17	4.42	3.25	2.58	2.67	2.67	2.67
30.	3.58	....	5.25	6.00	7.00	6.92	4.25	3.25	2.50	2.58	2.67	2.67
31.	4.83	....	5.00	....	6.92	....	4.08	3.08	....	2.50	....	2.58

No extensive irrigation is dependent on this river. Works have been built, but have been washed out, and have not yet been reestablished. An extensive power plant is now well under construction on the upper waters of the stream. It includes a plan for the storage of flood waters. This power will be largely taken to Fresno.

FRESNO RIVER.

This stream is one of those that may be classed between those that flow from the high mountains with their perpetual snow and those of the foothills, whose periods of flood depend upon the rain alone. The area of the basin is 272 square miles. On November 6, 1895, when the stream was visited, at a point about 2 miles above Madera, at the head-works of the Crocker-Huffman Canal, it was practically dry. It is usual for the stream to dry up at this point in June and remain dry until the fall rains. This is the place where it was gaged by the State engineer. There is about 10 miles of sandy bed between this point and the place where the river leaves bed rock in the canyon.

The Madera Canal and Irrigation Company makes a diversion from the river at Dennis, where the bed rock is near the surface. This canal returns water into the old slough, and thence it is brought to a second point of diversion, to the point mentioned above, 2 miles from Madera. Attempts were made to divert the river entirely at first, in new canals, but the ground was so sandy and porous that they would not carry the water, and use had to be made of one of the old delta channels which had become silted up and which were, as is often the case, on the higher ground. A canal well up in the mountains is taken from one of the tributaries of the Merced River called Big Creek and another from the North Fork of the San Joaquin, both of which are perennial streams, and they discharge continually into the Fresno River. This, of course, increases the flow of the river to the extent of the delivery by the canals.

The State engineers gaged this stream at the second diversion point, which is 2 miles above Madera. This point in winter would probably show fair results, but it would not do so in summer. The following is taken from Physical Data and Statistics, page 409:

This stream is one of the largest creeks or smallest rivers whose flow has been observed. Its drainage basin is similar to those of the three creeks mentioned last above (Bear, Mariposa, and Chowchilla creeks), whose watersheds do not extend back to the region of perennial snows. The point of observation was at the head of the Fresno River Canal and Irrigation Company's canal, about 3 miles above the railroad crossing near Minturn. The actual record of water fluctuations was for one season only. The figures in the table are, hence, largely estimated discharges from the drainage area, based on the results of one year's observations and checked by occasional observations through the remainder of the period. The results apply to the stream as it enters the valley part of its course.

Between 10,000 and 15,000 acres are under irrigation from this river. This area is largely in fruits and vines. A storage system is in contemplation for this stream, which will greatly add to its utility as an irrigation supply.

CHOWCHILLA CREEK.

This stream may well be classed in the same group as Fresno Creek. Its area above section 1, T. 9 S., R. 18 E., as given by the State engineer, is 268 miles. The rainfall at Buchanan, where the creek leaves the mountains, and where the stream was gaged by the State engineer for the seasons 1878–79 to 1881–82, was 18.78 inches. These years were rather above the average of precipitation at the other stations. There are no rain gages located in the higher portions of the basin. The creek is one of the winter storm-class. The period of flow begins with the storms and ends with the early summer.

Rod readings were kept by the State engineer for two years, and the estimates for the flow for four more were kept. The observer, Mr. L. O. Sharp, of Madera, says that the engineers visited this station three times in the two years, and that he, the observer, kept a record of gage heights, as well as one of velocities. The following statement is made by the State engineer as to the discharge of this stream:

> The station of observation was at a point near Buchanan, where a rod record was kept for portions of the period. The flow of this stream was especially characterized by sudden short freshets, of which not nearly all have been reported. A scale of discharge was estimated from the channel dimensions and slopes, which, with the data above named, forms the basis of the tabulated results.

At present one ditch is taken out of this stream at Buchanan and one at Minturn. Large storage works are in contemplation.

MARIPOSA AND OTHER CREEKS.

A number of small foothill streams intervene between the Fresno and Merced rivers. They are all subject to sudden floods after rains, and their discharge does not extend well into the summer. They are Mariposa Creek, drainage area 122 square miles; Owens Creek, area 30 square miles; and Bear Creek, area 166 square miles. When visited in November, 1895, at the crossing of the Millerton road Owens Creek was flowing about 1 second-foot and Bear Creek had some water standing in holes, but little, if any, flowing; Mariposa Creek was dry.

The California State engineer, in Physical Data and Statistics, makes the following statements in reference to Mariposa Creek and Bear Creek:

> These are small streams whose watersheds do not extend back to the regions of perennial snows. Their flow is characterized by sudden rises after heavy rains, and periods of low flow intervening. Scales of discharges for these streams were based on cross-sectional dimensions and slopes of channel ways. For several seasons gage-rod records afforded definite data of water stages in them. Actual discharges per square mile of drainage area, calculated from these data, together with ratios

obtained by comparison of such results with those similar for other adjacent streams, form the basis for approximations of water quantities during the time when gage records were not kept.

MERCED RIVER.

This stream extends well into the Sierras, though not having as high an average elevation as some others. It flows from the famous Yosemite Valley. The topographic maps show the basin to be rough, especially in the canyon portions. The area of the basin above Merced Falls is 1,076 square miles. The exposure of the basin is favorable to a high per cent of rainfall and run-off. This stream has been gaged at Merced Falls and at Livingston.

This river has not been rated during the year 1895 by the United States Geological Survey. It was visited and gaged at Merced Falls on November 27, 1895. The bed of the stream at this point is largely small gravel, with some shifting sand. The channel is well confined, but broken by the central pier of the bridge. The river was at the low summer stage when it was visited and the velocity at the bridge was too slow for the meter.

The mean velocity where measured, 16 miles from Merced and at the point where rods had been read for several years, was 3.02 feet per second; maximum velocity, 3.74 feet per second; total area, 41 square feet, and discharge, 125 second-feet.

A dam three-fourths of a mile below the bridge and about 8 feet high has a number of gates in it which check the velocity at the bridge when the gates were closed, but not when they were open. This would prevent the establishment of a rod at the bridge, as different volumes might be passing for the same height of rod. Suitable stations could probably be established a short distance above. No substantial diversion occurs above this point. The Crocker-Huffman Canal diverts water from the Merced River about 3 miles below the falls. It was stated by the Crocker-Huffman Company that there are 40,000 acres subject to irrigation from their system in the immediate neighborhood of Merced. On November 27, 1895, at a point 100 yards above the bridge there was flowing 125 second-feet, and the river was said to be then at the low summer stage.

The State engineer makes the following report in reference to this river:

This is a river having a high mountain watershed, but not so great in proportion to its whole basin as have the Tuolumne and San Joaquin. The results in the table apply to the station at Merced Falls, a point in the valley but above all diversions by irrigation canals. Gagings have been made at this station and also at McSwain's Ferry and the railroad bridge near Livingston (Cressy). Rod records were kept for part of the periods at McSwain's Ferry and at the railroad bridge, and occasional observations were made at other times. From these data actual water quantities were calculated for much of the period, and such results have been supplemented by the method of drainage per square mile per area of basin, as elsewhere explained. These results have been corrected for quantities diverted by canals, and so the tabulated data relate to the amount of water brought into the valley.

Construction is now in progress on an electric-power plant at Merced Falls. The diversion dam at this point is a wooden apron set on an inclination of about 1½ to 1, and supported by posts which are merely set on the bed of the stream. This dam has stood for a number of years. The structure winds about to get on the most favorable bottom possible.

TUOLUMNE RIVER.

This is one of the most important streams in the valley. It flows from the crest of the Sierras, Castle Peak being 12,500 feet high. Above a point called Roberts Ferry the drainage area is 1,501 square miles, and above Modesto the area is 1,635 square miles. The basin is extremely rough, and the formation is to a large extent granite. Mr. R. M. Price, in the Sierra Club Bulletin, describes a trip through the Tuolumne Canyon, from which the following extracts are made:

> Almost immediately below where Conness Creek enters the Tuolumne River are the White Cascades, marvels of beauty, where the river spreads out over a large surface of glacier-polished rock, inclined at an angle of 25°. Opposite these cascades there is on the north wall a dome of great height; below there is a small meadow and a grove of aspens and tamarack pines. From Conness Creek to Return Creek, a distance of 4 or 5 miles, the river drops very rapidly, and the scenery becomes more rugged and inspiring in the magnificent cascades and in the lofty cliffs and domes. The walls and domes here are at least 2,000 feet high, and one dome in particular, a grand structure on the north wall, can not be less than 2,500 feet above the river. This dome has a noticeable scar on its southern face, where a huge block of granite has been shaken from place by some post-Glacial earthquake. Near here, on the south wall, there are three domes so like one another in appearance that they might be called the Three Brothers. From this point a magnificent and imposing view of the cascade is obtained. The water dashes 600 or 700 feet down a surface inclined at an angle of 50° or 55°, a mass of foam and spray. At intervals the formation of the bed rock is such that the water is thrown out in columns 15 to 20 feet high, and in huge water-wheels of fantastic forms. Words utterly fail to describe the sublimity of this part of the canyon. Looking east from a point beyond the gorge there is a perfect amphitheater, through whose perpendicular walls there appears no way for the river to enter. On the sides the walls rise to such heights that the walls of the Yosemite seem low in comparison. The tall conifers on the summits are scarcely noticeable.

No rain gages have been observed on in the upper portions of this basin, but the records and the accompanying data, given previously, of the precipitation along the railroad line over the Sierras east of Sacramento will also apply here. The mean rainfall, as determined by fifteen years' record at Lagrange, 1869–1884, is 15.68 inches, and at Modesto, for the same period, it is 9.58 inches.

The State engineering department devoted considerable time to this stream at the Southern Pacific Railroad crossing near Modesto between the seasons 1878–79 and 1883–84. Monthly maximum, minimum, and mean discharge is given by this authority for all these years, save the last two, which indicates that the observations were made daily and account taken of the flow.

MODESTO STATION, ON TUOLUMNE RIVER.

As in the case of Kings River, three gaging stations have been tried by the United States Geological Survey on this river in an effort to obtain a station without serious defect. The first point to attract attention was at the Southern Pacific Railroad bridge, south of Modesto. This station was easily accessible, convenient, and had a long record of rod readings. It was found that the velocity at this point was influenced by the height of the San Joaquin, into which the Tuolumne flows at a point 12 miles below. The normal elevation of the surface of the San Joaquin is said to be only 2 feet less than the elevation of the Tuolumne at Modesto. When local storms occur, therefore, in the basin of the Tuolumne, and not in that of the San Joaquin, a discharge will occur in excess of the normal indications of the rating curve, due to the increased slope of the river.

On May 1, 1895, the river was gaged, the rod reading 10.25, the discharge being 6,078 second-feet. On May 2 the river was again gaged at this same station with the water at 12.9 on the rod, and the discharge was found to be 13,546 second-feet. On May 1 and 2 there were local storms east of Modesto which produced these results.

The gage rod at the railroad bridge is set on the central pier and is referenced to the railroad track immediately above it, the distance from 0.0 of the rod to the top of the rail being 46.05 feet. The observer, Mr. J. T. Reed (post-office, Modesto), lives at this bridge. His observations are taken daily at 3 p. m. at approximately the time of mean height. This river has a daily variation due to the fact that more snow is melted during the day than during the night. The channel of the river at this point is uniform for a considerable distance above and below the bridge. The section and velocity are measured at the wagon bridge west of the railroad bridge. Levels were taken showing the section for a rise of about 24 feet on the present rod.

Rating table for Tuolumne River at Modesto, Cal., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
3.00	170	9.00	4,500
3.50	225	9.50	5,120
4.00	300	10.00	5,740
4.50	550	10.50	6,335
5.00	850	11.00	6,930
5.50	1,170	12.00	8,125
6.00	1,550	13.00	9,375
6.50	1,950	14.00	10,650
7.00	2,400	15.00	12,000
7.50	2,875	16.00	13,350
8.00	3,350	17.00	14,700
8.50	3,925	18.00	16,000

Daily gage height of Tuolumne River at Modesto, Cal., for 1891, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	5.25	4.17	17.75	6.75	12.00	9.58	13.83	5.67	2.58	2.17	1.92	2.42
2..	4.75	4.25	22.25	6.42	12.17	9.50	14.08	5.42	2.67	2.17	1.92	2.67
3..	4.67	4.17	20.50	6.75	13.83	9.50	12.67	5.25	2.58	2.17	1.92	2.50
4..	4.92	4.17	16.17	6.92	11.92	9.17	12.33	5.08	2.50	2.08	1.92	2.42
5..	4.83	4.17	10.50	7.83	14.08	10.00	11.33	4.83	2.42	2.17	1.92	2.42
6..	6.58	4.25	8.75	7.67	14.17	11.83	10.67	4.75	2.33	2.08	1.92	2.33
7..	5.75	4.33	8.00	8.33	14.23	13.42	9.83	4.67	2.33	2.08	1.92	2.33
8..	4.92	4.17	7.42	8.00	14.58	15.83	9.67	4.50	2.25	2.08	1.92	2.67
9..	4.67	4.08	7.17	7.50	13.17	15.50	8.92	4.33	2.33	2.08	1.92	2.67
10.	4.50	4.08	6.67	7.42	12.67	14.42	8.33	4.17	2.33	2.08	1.92	2.67
11.	4.50	4.08	8.00	7.50	11.75	14.00	8.17	4.08	2.25	2.08	1.92	2.42
12.	4.42	4.08	8.08	7.58	12.17	14.00	7.92	4.00	2.25	2.08	1.92	2.42
13.	4.42	4.00	8.25	7.25	13.42	12.83	7.75	3.92	2.33	2.00	1.92	2.67
14.	4.42	4.00	8.17	7.42	13.50	11.33	7.92	3.83	2.42	2.00	1.92	2.50
15.	4.25	4.00	8.00	7.67	12.50	10.50	7.83	3.75	2.42	2.00	1.92	2.42
16.	4.25	6.58	8.08	7.25	11.33	11.33	8.08	3.67	2.33	2.00	1.92	2.42
17.	4.17	8.17	8.00	9.50	12.25	11.58	8.42	3.50	2.33	2.00	1.92	2.42
18.	4.17	5.50	7.83	8.00	14.08	13.17	8.25	3.42	2.25	2.00	1.92	2.50
19.	4.17	5.08	7.67	8.33	13.50	14.08	7.83	3.25	2.33	2.00	1.92	2.50
20.	4.17	4.92	7.25	8.83	13.17	13.33	7.58	3.08	2.33	1.92	1.92	2.67
21.	4.17	4.83	7.17	8.75	14.58	12.08	7.42	3.25	2.25	1.92	1.92	2.67
22.	4.17	5.42	7.67	9.17	12.75	11.33	6.92	3.08	2.33	1.92	1.92	2.67
23.	4.17	*a*18.25	8.17	9.50	11.67	11.75	6.83	2.92	2.33	1.92	1.92	2.67
24.	4.33	13.50	7.58	10.92	11.33	11.33	6.67	2.83	2.33	1.92	1.92	2.67
25.	4.25	9.83	7.42	11.17	11.17	11.50	6.58	2.75	2.25	1.92	2.00	2.67
26.	4.25	7.92	7.50	10.08	11.75	12.33	6.67	2.75	2.25	1.92	2.00	3.50
27.	4.25	7.00	7.42	9.33	13.50	11.75	6.58	2.83	2.25	1.92	2.00	3.50
28.	4.25	8.00	7.83	10.33	13.00	11.58	6.42	2.75	2.25	1.92	2.00	4.50
29.	4.17	....	7.42	10.92	12.08	12.08	6.33	2.67	2.25	1.92	2.00	5.50
30.	4.08	....	6.92	11.75	11.58	13.58	6.25	2.58	2.17	1.92	2.00	9.00
31.	4.08	....	6.83	....	10.58	....	5.92	2.67	....	1.92	....	5.00

a Fourteen hours' rain.

Daily gage height of Tuolumne River at Modesto, Cal., for 1892, in feet.[1]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	5.50	4.50	5.33	7.50	9.50	16.58	12.33	5.00	1.83	1.42	1.67	18.58
2..	5.00	4.50	5.92	7.67	8.33	17.08	11.50	4.67	1.83	1.42	1.67	10.50
3..	4.67	4.42	5.58	9.75	8.42	16.67	10.25	4.58	1.83	1.42	1.75	7.67
4..	4.33	4.17	5.50	7.67	8.58	15.75	10.08	4.42	1.75	1.42	1.75	12.42
5..	4.17	4.75	5.33	7.00	8.33	14.08	10.08	4.42	1.75	1.42	1.75	8.17
6..	4.08	5.00	5.50	6.50	7.58	13.00	9.67	4.42	1.75	1.42	1.67	7.25
7..	4.50	4.50	5.42	6.58	11.17	13.50	9.17	4.33	1.75	1.42	1.58	6.17
8..	4.67	4.42	4.92	6.67	8.58	12.33	8.83	4.08	1.75	1.42	1.58	5.42
9..	4.67	4.17	5.33	6.67	7.75	11.33	8.50	4.00	1.67	1.42	1.50	5.08
10.	4.58	4.17	5.83	8.25	8.33	10.42	8.25	3.83	1.67	1.42	1.50	4.83
11.	4.50	4.08	6.08	9.17	12.67	9.58	7.83	3.67	1.67	1.42	1.42	4.25
12.	4.33	4.00	6.33	8.50	12.83	9.17	7.50	3.42	1.67	1.50	1.42	4.08
13.	4.08	4.33	6.42	7.83	10.67	9.25	7.25	3.25	1.67	1.58	1.42	3.92
14.	3.92	4.42	6.67	7.17	9.17	10.00	6.83	3.08	1.67	1.67	1.42	3.75
15.	3.83	4.42	6.75	7.25	9.00	9.33	6.50	3.00	1.58	1.58	1.42	3.67
16.	3.83	4.58	8.08	8.83	12.50	9.58	6.33	3.00	1.58	1.58	1.33	3.58
17.	3.75	4.67	6.67	9.00	10.42	11.17	6.17	2.92	1.58	1.58	1.33	3.50
18.	3.75	4.83	6.50	7.33	11.00	13.17	5.92	3.00	1.58	1.58	1.33	3.33
19.	3.67	4.92	8.58	7.00	13.50	14.50	6.00	3.08	1.58	1.50	1.50	3.33
20.	3.58	9.00	9.92	6.67	14.50	15.75	5.58	3.25	1.50	1.50	1.42	3.08
21.	3.50	7.58	6.75	6.58	16.08	15.83	5.33	2.92	1.50	1.50	1.42	3.25
22.	3.50	6.67	6.83	6.75	17.58	15.92	5.50	2.50	1.50	1.50	1.42	3.17
23.	3.42	5.92	6.33	7.08	16.33	14.83	5.25	2.33	1.50	1.50	1.42	3.25
24.	3.33	5.58	6.17	7.00	16.83	13.25	5.17	2.17	1.50	1.50	1.58	11.75
25.	3.33	5.42	5.50	7.33	16.17	12.33	5.25	2.00	1.50	1.50	1.67	24.83
26.	3.25	5.58	6.42	7.83	16.25	11.83	5.42	2.00	1.50	1.50	1.67	19.50
27.	4.75	5.67	6.00	7.17	15.92	11.67	5.00	1.92	1.50	1.50	1.75	16.58
28.	4.42	5.50	6.50	7.08	17.58	11.75	4.75	1.92	1.42	1.50	1.83	13.67
29.	4.25	5.58	6.67	7.33	16.50	13.50	4.50	1.92	1.42	1.50	3.50	10.92
30.	4.17	....	10.33	7.25	17.25	13.50	4.25	1.83	1.42	1.58	11.83	9.50
31.	4.08	....	11.50	....	17.08	....	3.92	1.83	....	1.58	....	8.75

[1] The daily gage heights of Tuolumne River at Modesto for 1893 and 1894 have been printed in Bulletin No. 131, page 85.

Daily gage height of Tuolumne River at Modesto, Cal., for 1895, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	6.17	5.67	7.50	8.33	10.33	10.50	10.83	6.00	*a* 3.83	*a* 3.33	*a* 3.17	3.50
2..	5.92	5.75	7.75	8.08	15.00	9.92	10.50	5.92	3.83	3.25	3.50	3.67
3..	5.92	5.75	7.83	9.17	13.17	10.08	10.50	5.75	3.75	3.25	3.42	3.67
4..	5.83	5.75	7.50	8.67	11.50	11.58	10.33	5.58	3.67	3.17	3.42	3.50
5..	18.92	5.83	7.33	8.42	11.08	13.33	9.67	5.50	3.67	3.17	3.42	3.58
6..	12.75	5.75	7.50	8.00	13.33	14.08	9.33	5.50	3.58	3.17	3.50	3.67
7..	8.67	5.67	7.67	7.92	14.83	15.08	9.33	5.50	3.58	3.17	3.50	3.58
8..	7.50	5.67	7.58	8.50	15.08	15.42	9.50	5.42	3.50	3.17	3.58	3.58
9..	10.08	5.92	7.75	8.00	15.83	14.50	9.83	5.42	3.42	3.17	3.58	3.50
10.	8.83	6.00	7.83	8.42	15.17	13.83	9.92	5.33	3.33	2.17	3.58	3.58
11.	7.75	6.17	8.00	8.58	14.50	13.17	9.33	5.33	3.33	2.17	3.67	3.50
12.	7.42	18.42	7.83	8.83	15.08	13.83	9.08	5.25	3.50	2.17	3.67	3.42
13.	6.92	20.75	7.50	9.00	16.75	14.75	8.67	5.25	9.92	2.17	3.58	3.42
14.	9.08	13.42	7.33	10.08	17.33	14.50	8.58	5.17	6.58	2.17	3.58	3.25
15.	8.17	9.33	7.00	9.50	17.42	13.42	8.42	5.08	6.17	2.17	3.42	3.08
16.	10.50	8.50	6.50	8.67	17.83	12.33	8.42	4.92	5.50	2.17	3.50	3.67
17.	13.58	8.00	6.50	9.50	17.92	11.50	8.33	4.92	5.33	2.17	3.42	3.75
18.	16.50	7.50	6.25	10.17	18.00	10.83	8.17	4.83	4.92	2.17	3.42	3.75
19.	15.33	7.25	6.17	10.75	17.75	11.25	7.67	4.83	4.42	2.17	3.42	3.75
20.	10.75	7.33	6.25	11.50	17.58	11.58	7.33	4.75	4.08	2.17	3.50	3.83
21.	8.67	7.58	6.33	12.08	16.17	12.17	7.33	4.75	3.92	2.17	3.42	3.92
22.	8.50	7.67	6.17	12.50	15.33	13.25	7.42	4.67	3.83	2.17	3.33	4.75
23.	12.58	8.75	6.83	12.17	14.42	12.83	7.17	4.58	3.75	2.17	3.33	4.33
24.	8.75	8.50	6.67	12.25	13.75	14.17	7.08	4.50	3.67	2.17	3.33	4.17
25.	7.67	8.67	6.75	11.67	13.83	13.83	6.83	4.42	3.58	2.17	3.25	4.00
26.	6.92	8.33	6.92	12.17	14.08	13.42	6.67	4.33	3.50	2.17	3.25	3.92
27.	6.92	7.67	7.33	12.08	16.50	12.75	6.58	4.25	3.50	2.17	3.33	4.08
28.	6.50	7.42	12.17	13.50	14.83	12.67	6.33	4.08	3.42	2.17	3.33	4.17
29.	6.25	....	14.08	12.42	12.50	12.17	6.25	4.00	3.42	2.17	3.50	3.92
30.	6.00	....	10.67	10.33	11.50	11.67	6.08	3.92	3.33	2.17	3.67	3.83
31.	5.83	....	8.33	....	10.83	....	6.00	3.92	....	2.17	....	3.75

a Heights for September, October, and November of doubtful value, as the water fell below bottom of rod.

Some confusion has arisen in the reading of the gages at the Modesto railroad bridge, owing to the fact that the new gage, established in 1889, read 1 foot higher than the rod previously used. This matter is referred to in Bulletin No. 131, page 84. The new gage does not extend below 4 feet, but where the old gage stood there are marks by which readings have been made by the observer acquainted with these. The old gage extends down to a platform, the first figure on the gage being 3 feet. Readings below 4 feet on the new gage and 3 feet on the old were made by going in a boat under the bridge and observing the old marks, measuring up from the surface of the water to the top of the platform to obtain the reading according to the old gage and adding 1 foot to correspond with the new; all reports since 1890 referring to the new gage.

The bridge at this point was built in 1869, this being believed to be the driest season known. The piles were sawed off at the surface of the water, and the river when at its lowest was 14 inches below the top of these, or 3 feet 2 inches below the top of the platform. Two years later the water fell to a point 3 feet below the platform. About three years after the bridge was built a standard gage was placed on the bridge, sawed off at the bottom of the figure 3. The lower portion, from 0 to 3 feet, was placed on the pile cap, and the upper portion, reading from 3 to 30 feet, was placed on the pier. From 1873 to 1889 all rod readings were made from this gage. After the bridge was renewed the new gage was erected. The highest water known stood 29.13 feet on the old gage, and the next highest water, that of December 25, 1892, read 24.83 feet on the new gage.

List of discharge measurements made on Tuolumne River at Modesto and Lagrange, Cal.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Jan. 8	A. P. Davis	24	7.70	1,435	2.10	3,003
2	Mar. 21	J. B. Lippincott	24	6.90	1,378	1.76	2,429
3	May 1	do	24	10.25	2,395	2.55	6,078
4	May 2	do	24	12.90	3,148	4.37	13,546
5	June 27	do	24	13.00	3,090	3.01	9,308
6	Aug. 27	do	Floats.	4.00	719	0.41	294
7	Aug. 29	do	24	4.40	93		*a* 299
8	Sept. 14	do	24	5.80	757	2.41	*a* 1,824
9	Oct. 8	do	*c*	4.05			110
10	Nov. 28	do	24	4.20	191	*b* 0.68	129
11	Nov. 30	do	Float.	3.42	497	*b* 0.39	213

a Measurements at Lagrange bridge.
b Velocities too low to obtain accurate results.
c Computation based on length of time required to fill reservoir.

Estimated discharge of Tuolumne River at Modesto, Cal.

[Drainage area, 1,501 square miles at foothills.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1895.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Inches.*	*Sec. feet.*
January	16,130	1,398	4,828	296,900	3.700	3.220
February	19,650	1,322	3,915	217,430	2.720	2.610
March	10,785	1,710	3,165	194,610	2.430	2.110
April	10,012	3,255	5,824	346,570	4.330	3.880
May	16,000	6,097	11,798	725,400	9.065	7.870
June	12,530	5,616	9,163	545,110	6.815	6.110
July	6,692	1,550	3,831	235,540	2.944	2.554
August	1,550	285	848	52,125	.652	.565
September *a*	5,616	200	615	36,600	.457	.410
October *a*	200	120	152	9,346	.117	.101
November *a*	500	210	255	14,985	.187	.170
December	730	180	283	17,405	.217	.189
Per annum	19,650	120	3,719	2,692,021	33.634	2.45

a Water below bottom of rod. Quantities are approximated.

LAGRANGE STATION, ON TUOLUMNE RIVER.

Because of the variation at Modesto a new station was established at the Lagrange bridge. The river at this point is fairly uniform in section and the channel is straight for a considerable distance. The rod is set on the north side of the river, between two iron piers, and so placed as to be read from the central portions of the bridge. The bench mark is on the fifth bent, south of the south iron pier, on the west side, on a nail, and is marked M by a cut in the post. It is 15.31 feet above the zero of the rod. It is found that the channel of the river at this point is influenced by the sediment from extensive river mining which is practiced just above.

Rating table of Tuolumne River at Lagrange bridge, Cal., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*
3.80	61	5.00	800
4.00	95	5.50	1,310
4.20	129	6.00	1,910
4.40	299	6.50	2,590
4.60	439	7.00	3,280
4.80	606		

Daily gage height of Tuolumne River at Lagrange bridge, Cal., for 1895, in feet.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	4.40	4.10	4.10	4.30	17	......	5.30	3.90	4.10	4.20
2	......	4.40	4.10	4.10	4.30	18	......	5.00	3.90	4.10	4.20
3	......	4.30	4.10	4.10	4.30	19	......	4.80	3.90	4.10	4.30
4	......	4.30	4.10	4.10	4.20	20	......	4.70	4.10	4.10	4.50
5	......	4.30	4.10	4.10	4.20	21	......	4.40	4.30	4.10	5.20
6	......	4.30	4.00	4.10	4.20	22	......	4.20	4.40	4.10	4.80
7	......	4.20	3.80	4.10	4.20	23	......	4.00	4.30	4.10	4.70
8	......	4.20	(*a*)	4.10	4.20	24	......	3.90	4.30	4.10	4.60
9	......	4.20	......	4.10	4.20	25	......	4.00	4.30	4.10	4.50
10	......	4.20	......	4.10	4.20	26	......	4.40	4.30	4.10	4.50
11	......	4.00	......	4.10	4.20	27	......	4.30	4.30	4.10	4.50
12	......	4.90	......	4.10	4.20	28	......	4.20	4.20	4.10	4.50
13	......	6.20	......	4.10	4.20	29	......	4.20	4.20	4.20	4.50
14	......	5.80	......	4.10	4.20	30	4.50	4.20	4.20	4.10	4.50
15	......	6.60	......	4.10	4.30	31	4.50	......	4.10	......	4.50
16	......	5.50	......	......	4.30						

a Opening in dam closed; no water at gage.

Discharge of Tuolumne River, Lagrange bridge, California.

[Drainage area, 1,501 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1895.	*Sec.feet.*	*Sec.feet.*	*Sec.feet.*	*Acre-feet.*	*Inches.*	*Sec.feet.*
September	2,182	78	263	15,635	0.195	0.175
October	299	78	134	8,231	.103	.089
November	129	112	113	6,698	.084	.075
December	1,004	129	270	16,614	.208	.180

The mining canal takes out approximately 35 second-feet of water above this point of measurement and returns it to the river a short distance below. This amount is not herein accounted for.

At the time this station was established there was an opening in the Lagrange dam, which is 1½ miles above the bridge. It was the intention then to establish a gaging station at the dam or diversion weir, as soon as this opening was closed, for here a section could be had with no change in profile. This station has since been established. On December 1, 1895, a timber rod was bolted to the granite cliff near the north end of the dam and referenced to the levels of the Modesto Canal. There is a bench mark in the first gulch west of the dam on the north side of the river, 300 feet from the head gates and 20 feet to the right or north of line on a five-eighths-inch iron bolt, 14 inches long, driven into the ground. The elevation is 291.49 feet above the Modesto datum.

The holes in the dam were closed on October 8, and all of the water was held back. In exactly seven days, or one hundred and sixty-eight hours, the water rose to the sand gates, 16 feet below the top of the dam. The daily record was begun on December 1, the height of water being noted and also the arrangement of the gates as to whether any or all were opened or closed. The elevation of the sand gates, as given by H. S. Crowe, engineer for the Modesto irrigation district, are, on the upper side, 283.20 feet and on the lower side 282.30, showing a fall of 0.90 feet in 28 feet in length. It will be necessary to have several rating curves to provide for the various combinations of openings that may occur, but when once these curves are determined there will be no variation. When the river is carefully measured on some given day, the openings may then be closed and opened in such manner as is likely to occur again, and the height of the water on the rod noted. In this way one measurement may be made to apply to several discharge curves. It has been deemed advisable to continue the record at the bridge for a month or so until the river is rated at the dam.

SURVEY OF LAGRANGE RESERVOIR SITE.

In order to obtain figures upon the rate at which sediment is brought down by mountain streams, it was deemed advisable to make a survey of the Lagrange reservoir site before the dam was finally completed and closed, with the intention of making another survey at some time in the future, and by comparison bring out the amount of silting. Accordingly an accurate survey and map were made. The methods pursued and the results accomplished are shown by the following description. The map resulting from this survey has not as yet been published, but is held for comparison with future surveys.

The reservoir site was visited by Messrs. Davis and Lippincott on August 29, 1895, and found to be empty. The Lagrange dam had been built some years before, and in the construction an opening had been left in the bottom 4 feet wide by 5 feet high, through which the waters of the Tuolumne passed out without interfering with the work. The sides of this opening were of rubble masonry. On August 29 the water of the river was down to the level of the top of this opening on the inside of the dam. The river was discharging through the opening at the rate of 299 second-feet. On September 15 Mr. Lippincott returned and found that, owing to severe storms in the meantime, the river was discharging at the rate of 1,824 second-feet. The reservoir was full and the water was running through all of the openings of the dam and 1 foot in depth over the crest. As soon as the river began to fall below the 300-foot level work was begun on the upper end of the reservoir site, and the water line was followed down as it fell, the survey progressing toward the dam. At the time the work was completed the water stood only 3 feet above the inner top of the hole left in the dam, this being at 222.6 feet. During the storm the water rose to a point 1 foot above the top of the dam, or to the 300-foot level, leaving a well-defined wet line used as the datum of the survey. Vertical angles were employed to determine other elevations. A base was carefully measured by stadia and work was expanded from this, in part by graphic triangulation and in part by stadia measurement. A plane table with a telescopic alidade with vertical arc reading to single minutes and with stadia hairs set to read the interval of 1 foot for each 100 feet distant from instrument was used. Many points in the canyon at the upper end of the reservoir site were not accessible and it was necessary to sketch some portions. The survey was begun on September 14 and completed on September 21, 1895.

The elevation of the top of the dam referred to the Modesto levels is 299 feet. Besides the hole temporarily left in the bottom of the dam, two other openings were provided, these being about 15 feet below the top. In size they are 4 feet by 5 feet, and are intended to act as sand sluices, preventing the blocking of the intakes of the canals with silt.

It was noticed that when the reservoir was filled the velocity of the stream was checked as soon as it reached the 300-foot level, the water going over the dam one foot deep, and that the silt was at once deposited. Subsequently, as the water in the reservoir fell, the swift stream extended into the reservoir, washing out the silt in the bottom of the canyon, leaving a portion in the form of benches or shelves on the sides. This material took a slope of about 3 to 1. Little or no silt is carried through the lower opening until the river is at a low stage and the water in the reservoir falls to an elevation of about 230 feet. It is thought that the reservoir will fill with silt in about three years. An accurate record will be kept of the discharge of the river, and when the reservoir has filled with silt it will be possible to ascertain how much water has passed through, and thus establish the relation between the amount of water and the amount of solid material transported. The areas upon the map resulting from this survey were computed by means of measurements with a planimeter. The following table gives for each contour the area inclosed, in acres, and the total capacity of the reservoir in acre-feet:

Area and capacity of the Lagrange reservoir at various depths.

Elevation.	Area.	Capacity.	Elevation.	Area.	Capacity.
Feet.	*Acres.*	*Acre-feet.*	*Feet.*	*Acres.*	*Acre-feet.*
300	56.12	2,332.3	250	21.45	553.1
290	48.90	2,060.8	240	16.67	338.6
280	42.07	1,571.8	230	9.55	171.9
270	33.83	1,151.1	220	6.66	76.4
260	25.97	812.8	210	.41	9.8

STANISLAUS RIVER.

The watershed of this stream is immediately north of that of the Tuolumne River and is similar to it in many respects. Observations of river height were begun at Oakdale and carried on by the Southern

Pacific Railroad Company at their bridge at intervals since 1879. This river has above Oakdale a drainage area of 1,051 square miles, mainly of a high and rough mountainous character. No records of rainfall have been kept, but the remarks on the Tuolumne and Merced rivers will apply to this basin. This stream has been gaged at Oakdale by the State engineer, who makes the following statement:

> The character of the watershed of this river is similar to that of the Tuolumne. The discharge is given for the river at Oakdale. The stage of the river was regularly recorded for only a small portion of the period covered by the table, and hence the results given are largely based upon estimates made by the method of drainage areas, as above explained. No allowance is made for water diverted from this stream above Oakdale.

Only fractional portions of the three seasons (1878–79, 1879–80, and 1880–81) have actual records of river heights.

OAKDALE STATION, ON STANISLAUS RIVER.

This river was examined on May 3, 1895. The old gage rod for the State engineering department was set on the central railroad pier. The new rod for the United States Geological Survey was set between the south piers of the wagon bridge and can be read from that bridge. The zero of the rod is 27.92 feet below the top of the southeast iron pier and 5.92 feet above the east end of the cap on the piles on the south main pier of the Southern Pacific Railroad bridge, to which the lower rod is spiked. It was found that a special rod had to be set for the lowest readings of the river at the wagon bridge. One was made and driven several feet into the bed of the river and the top nailed to a willow tree 125 feet below the wagon bridge, on the south side of the river and 25 feet above a cattle chute. On July 31, 1895, this rod was torn down by some unknown parties, but it was reset October 10, 1895. On the same date a new rod was set on the same datum inside of the Southern Pacific Railroad bridge, to be used in connection with the upper rod in determining the grade of the river. A crib pier extends well down into the water and the rod is spiked firmly to it. It is free from drift and easily read from the sides of the pier. The two main rods are 1,071 feet apart, and as they are on the same datum they show the slope of the river. Mr. E. A. H. Meyer, of Oakdale, observed on the upper rod from June 1 to July 1, but as he could not read it regularly Mr. Frank Templin, a carpenter, who lives at the first house below the the railroad bridge, was engaged to take the observations on the lower rod, which was the nearer for him. As during the lower stages when the river has been gaged there was only about 0.01 foot difference in the two rods, no appreciable error would result from this change. The initial point of measurement for the section is 100 feet south of the center of the south iron pier of the wagon bridge, the velocities and the soundings being always taken from this bridge. The channel at this point is fairly uniform, straight, and not obstructed.

In the case of this river, as in that of other important streams in the San Joaquin Valley, the daily variation of river height is an important matter. Early in the spring the snow melts on the lower foothills, the greatest amount of melting being about midday. The water resulting from this reaches points in the valley in a comparatively short time, while that melted later in the year from higher locations takes a greater number of hours to reach the same place. As a result for any given locality the maximum height may occur in March at one time of the day and in June at a different hour. An unusually warm day, or a number of such days in succession, may occur at any time during the season, producing variations, and warm rains add to the complexity. In the case of a rising river the velocity with which the diurnal wave travels may be greater than in the case of a stream which is falling. From all these causes it is difficult to ascertain with any considerable degree of accuracy the hour at which readings of river height will represent the average condition of the stream. Probably the only feasible way by which reliable results can be obtained without a self-recording instrument is by having the observer note hourly readings of the rod during one or two days a month. In order to ascertain this daily fluctuation, readings were made for an interval of three days at Oakdale, as shown in the following table. At that time the snow had disappeared from the foothills and the water was coming largely from melting ice among the higher banks. The weather was cool during the days on which these observations were made, and undoubtedly during warmer weather there is a larger variation. From the time of mean height in June on this table it is decided that the reading at about 4 p. m. would be in the main representative.

Diurnal variations of river height at Oakdale, Cal.

July 1 and 2.		July 3.			July 4.		
Time.	Rod reading.	Time.	Temperature.	Rod reading.	Time.	Temperature.	Rod reading.
	Feet.		*Deg. F.*	*Feet.*		*Deg. F.*	*Feet.*
5 p. m.	6.20	5.30 a. m.	56	5.60	5.30 a. m.	58	5.60
7 p. m.	6.15	6 a. m.	58	5.57	6.30 a. m.	60	5.57
8.40	5.60	7 a. m.	62	*a* 5.50	7.30 a. m.	64	5.50
9.20 a. m.	5.57	8 a. m.	66	5.57	8.30 a. m.	68	5.47
10 a. m.	5.57	9.30 a. m.	72	5.55	9.30 a. m.	70	5.45
11 a. m.	*a* 5.50	10.30 a. m.	72	5.55	10.30 a. m.	74	*a* 5.40
1 p. m.	5.60	11 a. m.	74	5.60	11.30 a. m.	80	5.42
2 p. m.	5.80	1 p. m.	80	5.80	1 p. m.	80	5.45
3 p. m.	5.95	2 p. m.	80	5.90	2 p. m.	82	5.47
4 p. m.	6.05	3 p. m.	81	6.05	3 p. m.	82	5.52
5 p. m.	6.10	4 p. m.	80	6.10	4 p. m.	78	5.60
6 p. m.	6.15	5 p. m.	78	6.12	5 p. m.	74	5.62
7 p. m.	6.17	6 p. m.	74	6.15	6 p. m.	72	5.65
		7 p. m.	72	6.15	7 p. m.	70	5.67
Mean time	5 p. m.	Mean time		1 p. m.	Mean time		4.30 p. m.
Maximum time	11 p. m.	Maximum time		7 p. m.	Maximum time		10.30 p. m.
Minimum time	11 a. m.	Minimum time		10.30 a. m.	Minimum time		10.30 a. m.

a Minimum reading for day.

At the time of the measurement, on August 28, the slope of the stream was found to be 0.0001, and n was assumed to be 0.025. On

October 10 the slope was less than 0.00005, being so gentle that it could not be satisfactorily determined.

List of discharge measurements made on Stanislaus River at Oakdale, Cal.

No.	Date.	Hydrographer.	Meter number.	Gage height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	May 3	J. B. Lippincott...	24	8.80	1,970	3.92	7,744
2	July 2	.....do.............	24	6.15	1,242	2.98	3,754
3	Aug. 28	.....do.............	24	2.40	200	1.39	279
4	Oct. 10	.....do.............	24	2.11	170	1.13	192
5	Nov. 29	.....do.............	Float.	2.12	149	0.99	147

Rating table of the Stanislaus River at Oakdale, Cal., for 1895.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
2.00	145	3.80	1,106	7.50	5,665
2.20	212	4.00	1,260	8.00	6,400
2.40	279	4.50	1,750	8.50	7,200
2.60	369	5.00	2,310	9.00	8,000
2.80	459	5.50	2,940	9.50	8,850
3.00	550	6.00	3,570	10.00	9,700
3.20	674	6.50	4,250	10.50	10,550
3.40	800	7.00	4,930	11.00	11,400
3.60	953				

Daily gage height of Stanislaus River at Oakdale, Cal., for 1895, in feet.

Day.	June.	July.	Oct.	Nov.	Dec.	Day.	June.	July.	Oct.	Nov.	Dec.
1...	6.20	6.20	......	2.10	2.20	17...	6.80	4.40	2.00	2.10	2.20
2...	6.60	6.00	......	2.10	2.10	18...	6.50	4.10	2.00	2.10	2.20
3...	7.00	6.10	......	2.10	2.10	19...	6.80	3.80	2.10	2.10	2.20
4...	7.80	5.60	......	2.10	2.10	20...	7.20	3.60	2.10	2.10	2.30
5...	9.30	5.50	......	2.10	2.10	21...	7.10	3.50	2.10	2.10	2.70
6...	9.10	5.40	......	2.10	2.00	22...	7.30	3.40	2.10	2.10	....
7...	9.00	5.30	......	2.10	2.00	23...	7.70	3.40	2.30	2.10	....
8...	8.25	5.20	......	2.10	2.10	24...	7.90	3.50	2.20	2.10	....
9...	8.00	5.00	......	2.10	2.10	25...	7.70	3.30	2.20	2.10	....
10..	7.90	4.90	2.10	2.10	2.00	26...	7.50	3.30	2.10	2.10	....
11..	8.20	5.30	2.10	2.10	2.00	27...	7.30	3.20	2.10	2.10	....
12..	7.80	4.70	2.10	2.10	2.00	28...	6.90	3.10	2.10	2.10	....
13..	7.60	5.10	2.10	2.10	2.00	29...	6.70	3.00	2.10	2.10	....
14..	7.40	4.80	2.10	2.10	2.00	30...	6.50	*a*3.00	2.10	2.10	....
15..	7.30	4.60	2.00	2.10	2.00	31...	......	......	2.10	......	....
16..	7.10	4.50	2.00	2.10	2.20						

a Rod stolen. No observations from July 30 to October 10, 1895. There was a summer freshet during this period—discharge estimated from that of the Tuolumne.

Estimated discharge of Stanislaus River at Oakdale, Cal.

[Drainage area, 1,051 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1895.	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*	*Acre-feet.*	*Inches.*	*Sec.-feet.*
June.........	8,510	3,842	5,686	338,340	6.038	5.410
July..........	3,842	550	1,778	109,330	1.950	1.692
August......	550	145	330	20,304	.362	.314
September...	3,161	145	638	37,970	.677	.607
October......	246	145	176	10,802	.193	.167
November...	179	179	179	10,651	.190	.170
December....	414	145	198	12,208	.218	.189

The Stanislaus and San Joaquin Water Company have about completed a canal and flume from a point about 5 miles above Knights Ferry, on this river. The present capacity of this flume will be 250 second-feet, but it is so constructed that it may be enlarged to a capacity of 900 second-feet. No water is as yet discharging into this canal, but it will probably be used in 1896. Mr. W. L. Rockwell, the engineer in charge, says that 15 second-feet were being diverted from this river through a small canal during the month of October; in November, 30 second-feet, and in December, 13 second-feet were being diverted in the same channel. As this diversion occurs above the point of measurement at Oakdale, the discharge of the river as shown above is too small by that amount.

MOKELUMNE RIVER.

LODI STATION, ON MOKELUMNE RIVER.

This station is described in Bulletin No. 131, page 86. Observations of river heights were begun by the Southern Pacific Company in 1879, and they have been made at intervals since that time. Computations of discharge based upon these and upon measurements made by the State engineer have been previously referred to.[1]

The results obtained at this station during 1895 were so unsatisfactory that it did not seem desirable to continue work at this locality, and therefore measurements were discontinued. The Woodbridge Dam, 2 miles below the railroad bridge, influences the relation of gage height to discharge. The gates of this dam were opened on July 20 that the reservoir might be cleaned. On July 22 and 23 the gates were closed. The dam broke shortly after. During August the dam was being repaired. The influence upon the reading of river height can be noticed in the interval from July 15 to July 25.

List of discharge measurements made on Mokelumne River at Lodi, Cal.

Date.	Hydrographer.	Meter number.	Gage height (feet).	Mean velocity (feet per second).	Discharge (second-feet).
1895.					
Jan. 6	A. P. Davis	24	12.25	1.04	1,063
Mar. 20	J. B. Lippincott	24	8.00	....	1,068
Aug. 27	.....do	24	1.33	0.78	91

[1] Physical Data and Statistics of California, collected and compiled by the State Engineering Department of California, Sacramento, 1886, p. 407, 422-424. Twelfth Annual Report of the United States Geological Survey, Part II. Irrigation, p. 323, Pl. LXXXVII.

Daily gage height of Mokelumne River at Lodi, Cal., for 1891, in feet.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	2.75	1.67	12.50	6.50	14.00	10.00	9.50	1.25	0.25	0.25	4.83	4.83
2..	2.25	1.75	17.50	6.50	14.50	9.75	8.92	1.17	0.25	0.25	4.83	4.83
3..	2.25	1.83	15.50	6.75	15.00	9.50	8.33	1.08	0.25	0.25	5.00	5.50
4..	2.33	1.75	13.50	7.00	15.50	10.50	7.83	1.00	0.25	0.25	5.17	6.00
5..	2.83	1.67	11.25	7.50	15.00	11.75	7.00	1.00	0.25	0.25	5.17	6.00
6..	2.50	1.67	9.67	8.00	15.00	13.50	6.33	0.92	0.25	0.25	5.17	5.33
7..	2.33	1.67	8.25	9.50	15.50	14.25	5.83	0.83	0.25	0.25	5.25	5.00
8..	2.17	1.67	7.33	10.00	15.75	15.00	5.50	0.75	0.25	0.25	5.25	5.00
9..	2.00	1.67	6.83	7.83	15.00	14.50	5.33	0.67	0.25	0.25	5.17	4.92
10.	1.92	1.67	6.75	7.50	14.50	14.00	5.00	0.58	0.25	0.25	5.00	5.00
11.	1.83	1.58	8.83	8.50	14.33	13.50	4.83	0.58	0.25	0.25	5.83	5.17
12.	1.83	1.67	8.17	7.83	14.50	14.50	4.50	0.58	0.25	0.25	5.83	5.00
13.	1.92	1.67	8.08	7.75	14.58	15.50	4.25	0.50	0.25	0.25	6.17	4.83
14.	1.92	1.67	8.00	8.25	14.33	14.08	4.00	0.50	0.25	0.25	5.00	4.83
15.	1.92	1.67	7.92	7.50	14.00	12.50	3.75	0.42	0.25	0.25	5.17	4.83
16.	1.83	3.58	8.25	7.33	13.33	12.50	3.50	0.42	0.25	0.25	5.17	4.83
17.	1.83	6.00	8.08	8.25	14.00	13.75	3.25	0.33	0.25	1.17	5.00	4.83
18.	1.75	3.83	8.00	8.25	14.92	14.00	3.08	0.33	0.25	2.00	4.83	4.83
19.	1.75	3.08	7.83	8.17	15.00	14.00	3.00	0.25	0.25	2.83	4.83	4.83
20.	1.75	2.75	7.50	8.67	15.50	13.00	2.92	0.25	0.25	3.50	4.83	4.83
21.	1.75	2.75	7.25	9.50	15.75	11.50	2.75	0.25	0.25	4.00	4.83	4.83
22.	1.83	2.67	7.75	10.50	15.00	11.50	2.67	0.25	0.25	4.50	4.83	4.83
23.	1.92	8.75	8.25	11.00	14.00	11.50	2.50	0.25	0.25	4.50	4.83	4.83
24.	1.92	12.00	8.00	12.00	13.50	10.17	2.25	0.25	0.25	4.50	4.83	4.83
25.	1.92	7.75	7.42	12.75	13.75	10.00	2.08	0.25	0.25	4.50	4.83	4.83
26.	1.83	6.08	7.17	12.58	14.17	10.00	2.00	0.25	0.25	4.50	4.83	4.83
27.	1.83	5.25	8.50	11.50	14.42	9.50	2.00	0.25	0.25	4.67	4.83	4.83
28.	1.83	5.83	9.00	12.33	14.33	9.75	1.92	0.25	0.25	4.67	4.83	7.00
29.	1.83	....	7.75	13.50	13.33	10.00	1.83	0.25	0.25	4.67	4.83	6.00
30.	1.83	....	7.50	13.75	12.33	10.50	1.75	0.25	0.25	4.67	4.83	9.00
31.	1.83	....	7.00	....	11.00	....	1.50	0.25	....	4.67	....	....

Daily gage height of Mokelumne River at Lodi, Cal., for 1892,[1] *in feet.*

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	6.50	5.25	6.50	8.50	9.50	15.00	11.50	9.00	9.00	7.00	5.50	14.50
2..	7.00	5.25	6.50	8.17	9.33	16.00	10.50	8.83	8.83	7.00	5.50	15.00
3..	6.00	5.25	6.33	8.67	10.00	16.33	10.00	8.67	8.67	8.00	5.50	13.00
4..	5.50	5.25	6.25	8.33	9.00	15.00	9.50	8.50	8.50	8.00	5.50	12.00
5..	5.50	5.25	6.25	7.50	10.00	15.00	9.50	8.33	8.33	8.00	5.50	12.00
6..	5.50	5.25	6.25	7.50	10.50	14.67	9.00	8.00	8.00	8.00	5.50	8.00
7..	5.50	5.50	6.25	7.50	11.00	14.50	8.50	8.00	8.00	8.00	5.50	8.00
8..	5.50	5.50	6.17	8.50	10.50	13.50	8.00	8.00	8.00	8.00	5.50	8.00
9..	5.50	5.50	6.33	9.00	10.00	13.00	8.00	8.17	8.00	8.17	5.50	7.00
10.	5.50	5.50	6.50	9.50	9.67	12.00	8.33	8.17	8.00	8.25	5.50	7.00
11.	5.50	5.50	6.67	10.50	12.67	12.00	8.00	8.00	8.00	8.50	5.50	7.00
12.	5.50	5.50	7.17	10.00	13.67	11.00	7.50	8.00	8.00	8.67	5.50	6.00
13.	5.50	5.50	7.33	9.50	12.83	10.00	8.00	8.00	8.00	8.33	5.50	6.00
14.	5.50	5.50	7.17	9.25	11.50	11.00	8.50	8.00	8.00	8.00	5.50	6.00
15.	5.50	5.50	7.50	9.17	11.83	11.00	8.33	8.00	8.00	8.00	5.50	6.00
16.	5.50	5.50	8.50	11.50	14.00	12.00	8.00	8.00	8.00	8.00	5.50	6.00
17.	5.50	5.50	8.00	10.50	13.67	11.83	8.17	8.00	8.00	8.00	5.50	6.00
18.	5.50	5.50	7.00	9.50	13.50	13.00	8.00	8.00	8.00	8.00	5.50	6.00
19.	5.50	5.50	8.50	9.00	14.33	14.00	8.00	8.00	8.00	8.33	5.50	6.00
20.	5.25	7.50	8.67	9.00	15.33	15.00	8.25	8.00	8.00	8.50	5.50	6.00
21.	5.25	9.50	8.33	9.00	16.00	15.00	8.50	8.00	8.00	5.50	5.50	6.00
22.	5.25	8.08	7.50	8.50	16.50	15.00	8.50	8.00	7.83	5.50	5.50	6.00
23.	5.25	7.33	7.33	8.50	17.00	14.00	8.33	8.00	7.67	5.50	5.50	6.00
24.	5.25	7.25	7.25	9.33	16.67	13.50	6.50	8.00	7.50	5.50	5.50	8.00
25.	5.25	7.00	7.25	10.50	17.00	11.50	8.58	8.00	7.50	5.50	5.50	19.00
26.	5.25	6.50	7.25	9.50	16.50	11.50	8.67	8.00	7.50	5.50	5.50	17.00
27.	5.25	6.33	7.17	9.00	16.00	12.00	8.50	8.00	7.50	5.50	6.00	18.00
28.	5.25	6.00	7.83	8.50	15.50	13.00	8.50	7.92	7.50	5.50	6.00	16.00
29.	5.25	6.00	8.00	9.00	16.67	12.50	8.67	7.83	7.50	5.50	7.00	15.00
30.	5.25	....	9.00	10.50	16.50	12.00	10.00	7.83	7.50	5.50	12.25	12.00
31.	5.25	....	9.00	....	15.50	....	9.00	7.83	....	5.50	....	11.00

[1] The daily gage heights of Mokelumne River at Lodi for 1893 and 1894 have been published in Bulletin 131, on pages 86-87.

Daily gage height of Mokelumne River at Lodi, Cal., for 1895.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1..	7.00	7.25	10.00	10.50	14.00	13.33	12.50	3.50	1.25	1.25	1.08	1.75
2..	6.50	7.25	10.00	10.67	14.83	13.50	11.83	3.33	1.25	1.25	1.17	1.50
3..	6.50	7.33	10.17	10.50	15.58	13.83	11.83	3.25	1.25	1.17	1.25	1.33
4..	6.50	7.42	10.25	10.33	14.50	14.17	11.75	3.25	1.25	1.17	1.25	1.33
5..	12.50	7.42	10.25	10.50	14.00	15.00	11.50	3.17	1.33	1.17	1.33	1.25
6..	13.00	7.42	10.17	10.25	15.50	15.50	11.00	3.17	1.33	1.17	1.33	1.25
7..	7.50	7.33	10.17	10.00	16.00	15.67	12.00	3.08	1.25	1.08	1.33	1.17
8..	8.00	7.17	10.00	10.00	16.50	15.50	12.00	3.00	1.25	1.08	1.33	1.17
9..	8.58	7.25	10.00	10.33	16.25	15.33	11.75	2.92	1.25	1.00	1.33	1.25
10.	8.75	7.25	10.00	10.50	16.33	15.17	11.33	2.75	1.25	1.00	1.33	1.42
11.	8.50	7.42	10.00	10.33	16.00	15.33	11.50	2.58	1.25	0.83	1.50	1.42
12.	8.00	10.50	9.83	11.00	15.83	15.25	11.17	2.42	2.50	0.92	1.50	1.33
13.	9.00	16.67	9.83	11.50	16.50	15.33	11.33	2.33	6.50	0.92	1.58	1.17
14.	10.75	14.83	9.75	12.33	16.67	15.00	11.00	2.25	4.00	0.92	1.50	1.25
15.	9.00	13.50	9.50	12.00	17.00	15.00	10.83	2.08	3.50	0.92	1.50	1.42
16.	12.17	11.00	9.00	11.83	16.50	14.50	10.67	2.08	3.00	0.92	1.58	1.58
17.	12.58	10.50	8.50	11.67	17.25	13.25	10.50	2.08	2.50	0.92	1.58	1.92
18.	13.83	9.50	8.50	11.75	17.42	13.42	10.50	2.00	2.50	1.00	1.50	1.83
19.	11.50	9.42	8.42	11.92	17.17	13.50	9.92	1.92	2.33	1.08	1.50	1.75
20.	10.33	9.50	8.50	12.50	16.50	13.42	10.00	1.67	2.17	1.17	1.42	2.00
21.	9.50	9.50	8.67	14.00	15.50	14.00	8.00	1.50	2.00	1.50	1.50	3.50
22.	9.50	9.67	8.50	14.50	15.33	14.42	8.00	1.50	1.92	1.75	1.33	2.50
23.	10.50	10.50	8.42	14.58	15.17	14.50	11.00	1.50	1.83	1.83	1.33	2.00
24.	9.25	11.67	8.33	14.50	15.00	14.58	5.42	1.50	1.67	1.83	1.17	2.00
25.	8.33	10.50	8.25	14.50	15.33	14.50	4.25	1.42	1.50	1.58	1.17	1.83
26.	8.33	11.00	8.25	15.00	16.00	14.17	4.00	1.33	1.42	1.92	1.00	1.67
27.	8.00	10.33	8.33	15.50	17.25	14.42	4.00	1.33	1.42	1.17	1.00	1.50
28.	8.17	10.00	10.50	15.67	16.00	14.33	3.83	1.25	1.50	1.08	1.00	1.50
29.	7.75	....	13.67	14.50	15.00	13.83	3.50	1.25	1.33	1.00	1.17	1.42
30.	7.50	....	13.00	13.83	13.83	13.17	3.50	1.25	1.33	1.00	1.50	1.33
31.	7.50	....	11.00	....	13.33	....	3.50	1.25	....	1.00	....	1.33

MEASUREMENTS BY CALIFORNIA STATE OFFICIALS.

In the foregoing description numerous references have been made to the work of the State engineering department of California, the results of whose investigations are shown largely in a volume entitled Physical Data and Statistics of California. This was printed in 1886, but it is not generally accessible. It may not, therefore, be out of place to quote somewhat fully from the statements relating to the method of measuring water supply and append to this a condensed table showing the result of this river work:[1]

TABLES OF AVERAGE FLOW OF CALIFORNIA RIVERS.

The rivers whose water qualities are presented in the following tables are now or will be notable irrigation feeders. The tables as printed do not include the data of nearly all the streams of the State important in this connection. They do contain all data sufficiently complete in the individual instances to justify arrangement in continuous tables of discharge, which has been collected by this department. The discharge of other streams is known generally for their low-water periods only, or for times scattered through spring, summer, and fall of various years, from 1879 forward.

The river observations of the department have been made in the streams of the Great Central Valley—Sacramento, San Joaquin, Tulare, and Kern valleys—of the State, and in Los Angeles, San Gabriel, and Santa Ana valleys in the southern part. The streams of the Sacramento Valley, and particularly the Sacramento River itself, have been more particularly the subjects of systematic flood-flow observations in connection with the arterial drainage questions. Those of San Joaquin, Tulare, and Kern valleys have been more closely observed throughout the years for purposes of the irrigation water supply study, and those of the southern valleys have been observed also for the latter purpose, but with far less precision and regularity.

[1] Physical data and statistics, p. 405, 406.

The gagings have been of many classes and grades, according to circumstances, purpose, and means available, ranging from those of most complete and accurate character, conducted at much expense, by large, fully equipped parties of observers on the greater streams, to simple rough measuring by a single observer on the smaller streams. Supplementing measurements of volume, the rise and fall of the water have been observed and recorded from gage rods on all the main streams at one or more stations, and on a number of the smaller ones daily for periods on the various streams ranging from one to seven years; and renewed sounding sections have been at times made to ascertain the extent of change in bottom elevations and sectional dimensions of the waterways. Data thus obtained form the basis of the following tables. Their character, extent, degree of fullness, and value, together with the methods of observation and the results, will be given due attention in a future publication of the Department, where, also, will appear all that should be said as to the embarrassing circumstances under which the work has been carried forward, and the disastrous effect which such influence necessarily has upon investigations of this class.

Certain of the streams were chosen for the more extended and systematic observations in a manner to well duplicate the locations geographically and hydrograpically throughout the valley. Less careful and extended observations were made on the intermediate streams. The actual data of observation were thus much fuller for some streams than for others. The missing data were supplied to make the tables full for average discharges by estimating the probable output of the streams upon the basis of their drainage areas, knowing from observations on them or on similarly situated streams of the same character the discharges which they would probably have per square mile of drainage area in years of known amount of rainfall.

The tables are thus filled out for all the streams for a period of six years, and the results for the Sacramento River, which is observed daily by this office, are estimated to October, 1885. Full sets of observations for any month enabled the greatest, least, and average rates of discharge to be given for that time. Where only average volumes are given, the records have not been full, or the mean flow has simply been estimated as above explained. Wherever the discharges per square mile have been thus approximated, they are marked with an asterisk.

The arrangement of the tables as to grouping of months follows the division of the year—from low-water season to low-water season—from November to October, inclusive; and each such exhibit for the twelve months is followed by a trimonthly seasonal grouping of the same data.

Average flow of streams for six years, November 1, 1878, to October 31, 1884.

Name of stream.	Average of mean monthly discharge (cubic feet per second).					
	November.	December.	January.	February.	March.	April.
Sacramento River	8,700	15,067	30,500	38,167	60,833	93,833
Cosumnes River	81	244	527	1,214	1,547	3,074
Dry Creek	24	115	276	613	667	830
Mokelumne River	123	292	469	1,261	1,607	3,226
Calaveras Creek	29	135	492	1,172	1,344	1,832
Stanislaus River	146	535	688	2,044	2,645	4,236
Tuolumne River	215	556	909	1,801	2,754	5,338
Merced River	183	456	590	1,587	1,784	3,264
Bear Creek	4	25	46	171	219	212
Mariposa Creek	3	20	36	129	162	122
Chowchilla Creek	9	45	78	359	535	466
Fresno Creek	0	64	123	392	568	475
San Joaquin River	387	792	1,054	1,945	2,133	4,252
Kings River	313	510	515	1,290	1,817	4,090
Kaweah River	113	208	263	662	810	1,396
Tule River	88	136	215	585	605	702
Deer Creek	13	26	49	124	143	131
White Creek	11	20	38	101	119	16
Poso Creek	34	64	126	325	384	345
Kern River	374	433	443	658	792	1,489
Caliente Creek	50	100	180	475	562	504

Average flow of streams for six years, November 1, 1878, to October 31, 1884—Cont'd.

Name of stream.	Average of mean monthly discharge (cubic feet per second).					
	May.	June.	July.	August.	September.	October.
Sacramento River	93,833	62,667	23,833	10,250	7,083	7,917
Cosumne River	3,722	3,055	1,159	324	66	83
Dry Creek	250	83	5	1	2	12
Mokelumne River	3,911	3,296	1,252	269	74	113
Calaveras River	961	217	49	2	0	12
Stanislaus River	5,290	4,929	2,158	449	127	162
Tuolumne River	7,622	8,188	3,752	751	196	266
Merced River	4,528	4,340	1,973	504	188	210
Bear Creek	67	28	11	0	0	3
Mariposa Creek	50	22	8	0	0	0
Chowchilla Creek	172	136	45	3	0	0
Fresno Creek	194	143	45	5	0	0
San Joaquin River	8,663	10,156	5,144	1,355	555	495
Kings River	7,588	8,180	4,655	1,162	455	447
Kaweah River	1,816	1,939	980	271	139	97
Tule River	1,138	1,017	669	230	106	75
Deer Creek	75	29	1	0	0	4
White Creek	61	23	1	0	0	3
Poso Creek	198	75	2	0	0	5
Kern River	2,481	3,006	1,897	851	467	392
Caliente Creek	287	110	3	0	0	0

Average flow of streams for six years, November 1, 1878, to October 31, 1884.

Name of stream.	Locality.	Average mean yearly discharge (cubic feet per second).	Area drainage basin (square miles).
Sacramento River	Collinsville	37,632	26,187
Cosumne River	Live Oak Street Bridge	1,234	580
Dry Creek	At base foothills	237	283
Mokelumne River	Lone Star Mill	1,321	657
Calaveras River	Bellota	520	491
Stanislaus River	Oakdale	1,958	1,051
Tuolumne River	Modesto	2,685	1,501
Merced River	Merced Falls	1,631	1,076
Bear Creek	At base foothills	65	166
Mariposa Creek	do	46	122
Chowchilla Creek	do	152	268
Fresno Creek	do	167	272
San Joaquin River	Hamptonville	3,074	1,637
Kings River	Slate Point	2,584	1,742
Kaweah River	Wachumna Hill	723	619
Tule River	Porterville	451	437
Deer Creek	At base foothills	49	110
White Creek	do	40	90
Poso Creek	do	145	289
Kern River	Rio Bravo ranch	1,110	2,345
Caliente Creek	At base foothills	191	423

METHODS OF MEASUREMENT.

The following is the method of gaging and computation of stream flow practiced by the California State engineers from 1878 to 1884:

On the streams near the foothills three wire markers were stretched across the stream at intervals of from 50 to 100 feet. In the large streams a boat was used from which to drop floats. Observers were stationed at each wire, which was hung so low as to permit the ready location of the float. The observer in the boat properly placed the float and gave a signal at the time of the crossing of the first wire. The crossing of the other lines was also signaled as to time and position. These floats were dropped into the water at intervals of 10 and 20 feet, and the observation was repeated three times. The floats were surface floats. No efforts were made to obtain bottom velocities in the streams near the foothills.

The velocities were averaged for each part of the stream from the three observations above referred to and applied to the area of the section, which was determined as described below. To the mean surface velocities so determined a coefficient was applied to determine a mean velocity for the mean area of the three sections, the coefficient varying, according to the judgment of the observer, from 75 to 85 per cent.

Soundings were taken every 20 feet in the large streams and every 5 or 10 feet in the smaller ones, and areas were computed for each of the sections where the wire was suspended. The areas were averaged. A small canvas boat, that could be easily folded and carried, was used on this work. Gagings were made of all the streams at convenient intervals at stations where gage rods were erected, attempts being made to catch them at flood intervals as well as at low water, and from these gagings a scale of discharge was made up to correspond with the gage readings at each station. From these tables and the records of rod readings, which later were taken daily, and in many cases for a period of years, it was possible to plot out curves of discharge for each stream for the entire period covered by the published data. To be sure, there were necessarily many interpolations, and some tables were made up on the minor streams with very few points in the curve located by actual observation, but for the larger streams the data given are fairly reliable and trustworthy. Mr. J. D. Schuyler, consulting engineer, had personal charge of the stream gaging in the San Joaquin Valley, and Mr. Edward Yorke in the Sacramento. Mr. C. E. Grunsky was in charge of the work of computation in the office at Sacramento.

In the large trunk streams in the lower valleys, such as the Sacramento, elaborate experiments were made. An exhaustive report, by C. E. Grunsky and Marsden Manson, consulting engineers, illustrated and accompanied with numerous diagrams, has been published by the commissioners of public works of California (1894), treating of this work on the Sacramento River.[1]

SURVEYS BY COMMISSIONER OF PUBLIC WORKS.

The California State commissioner of public works has taken up a certain amount of hydrographic work during 1895, consisting mainly of the measurement of San Joaquin River during flood periods. This work was carried on during May and June at a station located above and near what is known as the San Joaquin bridge. Careful cross sections and observations on the velocity of the stream, both in the main river and in Paradise Cut, were taken, surface and double floats being used.

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[1] Report of the Commissioner of Public Works to the Governor of California. A. H. Rose, commissioner; Marsden Manson, C. E. Grunsky, consulting engineers. Sacramento, Cal., 1894.

This is at a point where the flood waters of the San Joaquin River concentrate. The observations were made during the stages of water reported to be the highest ever known on the river. Gage readings with accurate tidal connections for elevation are now recorded at these points by the Southern Pacific agent and by direction of the Army Engineers. A line of check levels has been completed from New York Landing and Antioch to the San Joaquin bridge, Paradise Cut, Stockton, Ishton, and Rio Vista, together with transit and level lines connecting with the work.

It is proposed to have rods at the following places and to have a record kept during the high-water season:

At the San Joaquin bridge, in San Joaquin County, and near Stockton, in the same county; at Bouldin, on Bouldin Island; at Ishton, on the Sacramento River; at Rio Vista, also on Sacramento River, near Tolands Landing, and on Cache Slough, above the mouth. Cross sections of the streams will be taken at some of these stations, but not at all, the object being to determine the flow of flood waters in particular.

The San Joaquin River divides its waters at what is known as Paradise Cut, where a portion of the waters leave the old channel of the river and, taking a northwesterly course, pass over Paradise Cut Dam, and empty into Old River at a point northeast of the town of Bethany, in San Joaquin County. It has been found by inspection that it would be necessary to gage the river below Paradise Cut and some minor sloughs. The gagings of the river below Paradise Cut were made by a system of double floats. The gaging of the waters of this cut was made by measurement of the amount running over the dam, as well as by a check measurement in the Paradise Cut channel, which agreed very closely. The gaging of the sloughs was necessarily rough, but gives a close approximation, probably in excess of the actual flow.

The results of this work may be summarized as follows, the river being within 5 inches of the highest water ever known in the San Joaquin:

	Second-feet.
Flow of the San Joaquin June 10, 1895, below Paradise Cut	18,260
Flow through Paradise Cut	10,000
Flow through minor sloughs	6,818
Total flow (cubic feet per second)	35,078

These observations were made when the gage at the San Joaquin River Bridge registered 17 feet 3 inches, being the highest record given.

SOUTHERN CALIFORNIA STREAMS.

SAN GABRIEL RIVER.

The San Gabriel River rises in the Sierra Madre Mountains, in Los Angeles County, and flows southwesterly with steep descent into the broad San Gabriel Valley lying northeast of the city of Los Angeles. Its drainage basin is small, being estimated to be about 220 square miles. It is, however, favorably situated for a very large run-off, as the rocks are granitic and the slopes steep. The eastern branch of the stream rises on the west slope of the San Antonio peak, whose elevation is 10,117 feet, and the western branch on the eastern slope of San Gabriel peak, whose elevation is 6,232 feet. The altitude at the mouth of the canyon, where the water is diverted, is about 700 feet. The river and its drainage basin are described at length in the report upon Irrigation in Southern California, by William Ham. Hall.[1]

The rainfall on this drainage basin is reported to range from 18 to 75 inches per year, the amount being dependent largely upon the altitude and the steepness of the slope. The catchment basins on the other side of the mountains draining into the Mohave Desert have less rainfall and run off, but it is still a matter of interest to ascertain what becomes of the water flowing away.

In the case of San Gabriel River, the water coming out of the canyon is used to considerable extent for irrigation only in summer, and, owing to the precipitous character of the drainage basin, it has not yet been found possible to store the surplus water of winter and early spring. The ordinary summer flow is diverted at the mouth of the canyon into cement-lined channels and is there carefully divided, three-tenths going to Duarte and seven-tenths to Azusa. During the summer of 1894 the water in all the streams of this part of the country was extraordinarily low, and a flume about 1,000 feet long was built up the canyon to prevent loss of water, and a tunnel about 2,000 feet in length was driven under a ridge of the hill, cutting off the flow of the water through three miles of the creek bed. By these means it is reported that the available flow of the river at the point of division of the water was increased about 20 per cent. The minimum discharge was 9 second-feet. At the same time it is stated that the effect was to cut off the water available at a point farther down, resulting in disputes with other water claimants.

During 1894 Mr. H. F. Parkinson made measurements of the daily discharge of San Gabriel River applicable to a point 2 miles north of the town of Azusa. This was termed a dry year, and all of the water was used for irrigation. In this year the flume was built, cutting off

[1] Irrigation in California (southern); the field, water supply and works; organization and operation in San Diego, San Bernardino, and Los Angeles counties. The second part of the report of the State engineer in California on irrigation and the irrigation question, William Ham. Hall, C. E., State engineer, Sacramento, 1888, pp. 373–376. Azusa and Duarte ditches, pp. 426–456.

nearly 3 miles of the river bed, thus saving a considerable amount of water otherwise lost in the thick bed of coarse gravel. The following table gives the quantity of water in second-feet as ascertained by Mr. Parkinson:

Daily discharge of the San Gabriel River for 1894, in second-feet.

Day.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
1	34	27	17	11	23	16	14
2	35	27	17	11	21	15	14
3	35	26	15	11	18	14	13
4	35	26	15	10	18	14	13
5	34	25	15	11	18	13	13
6	34	26	16	13	17	13	13
7	33	26	15	14	17	14	13
8	33	26	14	15	15	14	13
9	32	22	14	15	15	13	13
10	31	23	14	15	15	14	13
11	30	22	14	14	14	14	13
12	30	23	14	15	15	14	13
13	30	24	14	14	15	13	13
14	31	24	13	14	15	13	13
15	50	22	13	14	14	13	13
16	45	22	13	13	14	13	....
17	38	24	13	13	14	13	....
18	34	24	11	11	13	13	....
19	32	24	11	14	13	13	....
20	33	24	9	13	13	13	....
21	32	21	9	13	13	13	....
22	32	21	9	13	13	14	....
23	30	21	9	13	13	14	....
24	28	21	10	13	13	14	....
25	27	19	10	14	13	14	....
26	27	19	10	17	13	14	....
27	27	18	9	15	13	14	....
28	27	18	9	15	13	14	....
29	27	18	9	27	14	14	....
30	27	17	10	21	16	14	....
31	27	....	11	22	....	14	....

Daily discharge of San Gabriel River for 1895, in second-feet.

Day.	Aug.	Sept.	Oct.	Nov.	Day.	Aug.	Sept.	Oct.	Nov.
1	....	39	29	29	17	42	31	30	....
2	....	38	28	29	18	41	31	30	....
3	....	36	28	29	19	40	31	31	....
4	....	36	29	50	20	40	31	31	....
5	....	36	29	....	21	39	31	32	....
6	....	36	29	....	22	39	31	32	....
7	....	36	29	....	23	39	30	32	....
8	47	35	29	....	24	39	29	31	....
9	47	34	28	....	25	38	29	30	....
10	47	34	28	....	26	38	29	30	....
11	46	33	28	....	27	39	29	30	....
12	46	32	28	....	28	39	29	30	....
13	46	32	27	....	29	40	29	30	....
14	45	32	27	....	30	40	29	30	....
15	44	32	29	....	31	40	....	29	....
16	43	32	30	....					

Daily discharge of San Gabriel River at mouth of canyon.

[Drainage area, 222 square miles.]

Month.	Discharge.			Total for month.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth.	Per square mile.
1894.	*Sec. feet.*	*Sec. feet.*	*Sec. feet.*	*Acre-feet.*	*Inches.*	*Sec. feet.*
May	50	27	32.2	1,981	0.17	0.14
June	27	17	22.7	1,349	0.11	0.10
July	17	9	12.3	758	0.06	0.05
August	27	10	14.3	875	0.07	0.06
September	23	13	15.0	894	0.08	0.07
October	16	13	13.7	843	0.07	0.06
November *a*	14	13	13.1	390	0.03	0.06
1895.						
August *b*	47	38	41.8	1,991	0.17	0.19
September	39	29	32.4	1,928	0.16	0.14
October	32	27	29.4	1,811	0.16	0.13
November	50	29	40.2	2,392	0.20	0.18
December	54	37	41.7	2,561	0.22	0.19

a Observations November 1-15, inclusive, only.
b Observations August 8-31, inclusive, only.

On September 10, 1895, two measurements of the stream were made, one in the flume above the division box and the second at the division weir. At this weir the water was contracted at the ends and had a velocity of approach of 2 feet per second. Below the division box is the ice house weir, over which the seven-tenths of the water going to Azusa is measured. Basing a computation of discharge of the whole stream on this lower weir, three results are obtained, that in the flume giving 39.93 second-feet, that at the division box 37.76 second-feet, and that at the ice house a little less.

AZUSA STATION, ON SAN GABRIEL RIVER.

The flow of the river during the summer can be obtained with a sufficient degree of accuracy from measurements at the ice house, but to obtain the discharge during the winter, when the water is not used, is a matter of considerable difficulty and expense. It was decided to place a rod in the river to be used after the summer weir measurements were dropped; accordingly, a station was established at the head of the lower tunnel leading to the Azusa ditch. This was equipped with cable, car, and guy wire. The gage consists of a 4-inch by 6-inch post planted 5 feet deep in the bowlders; on this a painted rod is fastened. The bench mark is on the sill at the upper portal of the lower tunnel. The initial point for soundings is at the vertical granite wall. The channel both above and below the station is straight for about 200 feet. The bed is rocky and apparently permanent. Arrangements have been made for having this gage read during the winter whenever the observer passes up or down the canyon, the trip being made usually three times a week. In case of flood, other readings will be made by Mr. H. F. Parkinson.

On November 5, 1895, Mr. Lippincott made measurements, the water at this time standing at a height of 1.50 feet on the rod. The quantity at the rod was found to be approximately 13 second-feet, at the waste pipe below 3 second-feet, and at the weir in canal a little less than 30 second-feet, in all about 46 second-feet.

MOHAVE RIVER.

Measurements of Mohave River were made by F. W. Skinner at the upper narrows at the proposed dam site of the Victor Reservoir Company, in sec. 10, T. 5 N., R. 4 W. Mr. Skinner states that the measurements were made at frequent intervals between January 1 and August 1, 1893. The maximum discharge was 8,500 second-feet and the minimum 38 second-feet. Surface velocity measurements only were made, these being obtained by means of floats. From the estimates thus prepared the average flow from August 1, 1892, to August 1, 1893, was calculated to have been 825 second-feet. The appearance of the drift along the banks and the statements of residents of Victor show that the water during the winter lacked several feet of reaching the high-water marks of previous years.

WHITEWATER RIVER.

On January 16, 1895, Mr. Arthur P. Davis made an estimate of the discharge of Whitewater River, in southern California. At the time of examination the discharge was approximately 4,800 second-feet. The river was in flood, and had been much higher the day before.

SANTA ANA RIVER.

This river is the most important source of water for the San Bernardino Valley, supplying the region in the vicinity of Redlands, a portion of its waters being taken over into the San Jacinto basin. The irrigation systems depending upon this river are described by William Ham. Hall, in his report upon Irrigation in Southern California.[1]

Estimates of the amount of water available from this river have been made by the Bear Valley Company. The Santa Ana Canal, designed to carry the winter storm waters to San Jacinto Lake as well as the summer flow and stored water from Bear Valley reservoir, has a capacity of 240 second-feet. The following list gives the dates upon which measurements were made and the quantity of water in cubic feet per second. The third column in the table gives the estimated average discharge for the month named.

[1] Irrigation in California (southern), the field, water supply and works, organization, and operation in San Diego, San Bernardino, and Los Angeles counties. The second part of the report of the State engineer of California on irrigation and the irrigation question, William Ham. Hall, C. E., State engineer. Sacramento, 1888, pp. 119-120, 177.

Estimated discharge of Santa Ana River at mouth of canyon.

Date.	Estimated discharge.	Average for month.	Date.	Estimated discharge.	Average for month.
1881.	*Second-feet.*	*Second-feet.*	1882.	*Second-feet.*	*Second-feet.*
January		*a* 24.0	July 29	13.4	
February		*a* 24.0	July 31	14.7	16.9
March		*a* 24.0	August 5	11.6	
April		*a* 24.0	August 11	*b* 17.7	
May		*a* 24 0	August 12	24.0	
June 20	23.4		August 17	24.8	19.8
June 29	14.8	22.0	September 1	20.0	
July 4	13.6	12.0	September 15	18.0	18.8
August 23	14.0	14.0	October		*a* 20.0
September 7	17.1		November	22.5	21.7
September 12	14.0		December		*a* 22.1
September 15	15.5		1883.		
September 20	12.2		January		*a* 24.0
September 22	18.2		February		*a* 24.0
September 23	18.2		March		*a* 24.0
September 24	18.0		April		*a* 24.0
September 30	20.2	16.3	May		*a* 24.0
October 1	17.6		June		22.8
October 7	18.4		July 26	16.4	
October 10	20.4		July 30	14.4	18.0
October 19	20.7		August 2	15.4	
October 24	21.2		August 8	11.8	
October 28	24.0	20.5	August 9	11.8	
November 3	22.4		August 10	11.6	
November 8	22.7		August 13	11.4	
November 28	21.4	22.1	August 15	12.6	
December 15	22.2		August 16	12.2	
December 21	22.4		August 17	12.3	
December 23	24.4	22.6	August 21	13.4	
1882.			August 23	13.0	
January		*a* 24.0	August 25	11.7	
February		*a* 24.0	August 29	13.2	
March		*a* 24.0	August 30	13.6	12.8
April		*a* 24.0	September 14	12.3	
May		*a* 24.0	September 20	14.2	
June		21.6	September 23	12.8	12.9
July 1	19.6		October		*c* 16.8
July 19	16.7		November 24	27.6	
July 22	17.6		November 29	21.0	21.4
July 25	13.8		December		*c* 21.8

a During the first five months of each year, from January to May, inclusive, there was found to be a surplus over the demands made upon the river. The estimated discharge has been placed at 24 second-feet plus, evidently indicating that more than this amount was discharged by the stream. As to how much more the records do not indicate.

b On August 11, 1882, there was a heavy shower in the mountains and a "cloud-burst" in Mill Creek Canyon about 1 p. m. It is reported that for over two hours a flood of about 1,500 second-feet ran down Mill Creek wash. This is said to have come in a wall. The discharge fell off rapidly in volume after two hours.

c Approximate discharge; obtained by comparison.

The average discharge of Santa Ana River by months is given in the following tables for the years 1881 to 1885, inclusive. These figures have been taken from records of the engineers of the Bear Valley Company. It is evident from estimates of the discharge during the first five months of the year, as given in the preceding table and in the following figures, that the engineer merely wished to show that there was more than 24 second-feet flowing during the winter, and did not try to ascertain the exact amount. It is obvious that a stream which averaged 14 second-feet in August or September would discharge ordinarily much more than 24 second-feet in January or February. The record for the year 1884 has doubtful value, although in view of the heavy rainfall it may be reasonable. The estimates for 1885 have also been called in question. The figures for 1884 have been estimated from measurements and observations made in Bear Valley Divide, at the mouth of Santa Ana Canyon. About one-half of the total amount is reported to have come from Bear Valley.

Estimated monthly discharge of Santa Ana River in second-feet.

Month.	1881.	1882.	1883.	1881–1883 (average).	1884. *a*	1885.
January	+24.0	+24.0	+24.0	24.0	700.0	48.0
February	+24.0	+24.0	+24.0	24.0	1,000.0	50.0
March	+24.0	+24.0	+24.0	24.0	1,200.0	48.0
April	+24.0	+24.0	+24.0	24.0	1,200.0	56.0
May	+24.0	+24.0	+24.0	24.0	960.0	44.7
June	22.0	21.6	22.8	22.1	370.0	36.0
July	12.0	16.9	18.0	15.6	62.0	27.3
August	14.0	19.8	12.8	15.5	46.0	24.0
September	16.3	18.8	12.9	16.0	36.0	21.6
October	20.5	20.0	16.8	19.1	56.0	22.5
November	22.1	21.7	21.4	21.7	40.0	....
December	22.6	22.1	21.8	22.2	44.0	....

a The record for this year has doubtful value.

A series of measurements were made on September 12, 13, 14, and 15, 1883, showing for each hour in the day the temperature of the air and the amount of water in the stream. This quantity is the average at the point known as Divide, lying between the North Fork and South Fork ditches in the mouth of Santa Ana Canyon. The elevation at this point, as obtained by engineer's level on June 30, 1895, is 1,916 feet. Measurements were taken simultaneously at several points on the river and averaged. The temperature in the following table is given in degrees Fahrenheit and also in the percentage or ratio which it bears at a given hour to the average throughout the given time. The quantity of water is given in second-feet and also in percentages which this bears to the average for the period under consideration.

Average daily temperature and discharge of Santa Ana River, September 12, 13, 14, and 15, 1883.

Time.	Temperature.		Discharge.	
	Average air.	Ratio to mean.	Average.	Ratio to mean.
	Deg. F.		*Sec. feet.*	
1 a.m	56	.840	11.9	.968
2 a.m	54.3	.815	12.0	.978
3 a.m	54.3	.815	12.2	.999
4 a.m	53.7	.805	12.5	1.019
5 a.m	53.3	.800	12.7	1.039
6 a.m	57.3	.860	13.0	1.062
7 a.m	59.3	.890	13.2	1.080
8 a.m	62.7	.940	13.2	1.080
9 a.m	70	1.050	13.2	1.080
10 a.m	74	1.110	13.4	1.090
11 a.m	77.3	1.160	13.2	1.080
12 noon	81.3	1.220	13.2	1.080
1 p.m	83.3	1.250	12.9	1.050
2 p.m	84	1.260	12.6	1.029
3 p.m	83.7	1.255	12.1	.989
4 p.m	82.3	1.235	11.6	.964
5 p.m	79.7	1.120	11.3	.923
6 p.m	74	1.110	11.1	.908
7 p.m	66	.991	11.1	.903
8 p.m	62.7	.940	11.1	.903
9 p.m	60.7	.910	11.3	.923
10 p.m	57.7	.865	11.5	.938
11 p.m	56	.840	11.8	.962
12 midnight	56	.840	11.9	.973

The drainage basin of the Santa Ana River is in San Bernardino County, Cal., and includes the northern slopes of the Grizzly and San Bernardino mountains, 11,725 and 10,100 feet in elevation, respectively. These are the highest mountains in southern California. At most points they are very steep; the summits are snow-capped until May and June. The rocks are largely granitic and have been cut into deep, narrow canyons, which are filled with bowlders. The elevation of the mouth of the Santa Ana Canyon is estimated to be 1,800 feet. The whole character of the basin is favorable to a large run-off. Records of precipitation upon this basin have been kept at a point near the present Bear Valley Dam. As this locality is in a depression or canyon, it is thought that the observed results are probably in excess of the average rainfall for the basin above the dam. The assumed elevation of the rain gage is 6,500 feet. The record as given below is stated to show the largest precipitation shown for any point in southern California, and engineers have considered it excessive. The measurements made, however, on the head-waters of Mohave River by the Arrowhead Company appear to confirm these figures. The following table gives the depth of the annual rainfall in inches, the year being taken from September 1 to August 31. The average for ten years given is 57.46 inches. The precipitation of a maximum year is 165 per cent of this average and of a minimum year 42 per cent.

Table of annual precipitation at Bear Valley Dam.

Year—	Inches.
1883–84	94.60
1884–85	28.06
1885–86	65.51
1886–87	24.00
1887–88	62.30
1888–89	46.03
1889–90	93.40
1890–91	78.40
1891–92	38.00
1892–93	44.32
Average	57.46

SAN LUIS REY RIVER.

The following computations of discharge were made by Mr. E. F. Tabor, of San Jacinto, Cal. The first, that of May, 1894, is a flood discharge as shown by high-water marks. The other figures are based upon measurements, excepting that of January 15, 1895, which is an estimate in round numbers.

Date.	Discharge.
1894.	Second-feet.
May	6,716
October	4
December 8	10
December 20	240
1895.	Second-feet.
January 15	5,000
March 8	152
April 11	100
April 17	72
May 10	39
May 19	19

SWEETWATER RIVER.

The drainage basin of Sweetwater River is in the extreme southwestern corner of the United States, being in San Diego County, Cal., adjacent to the Republic of Mexico. The river flows from the western slope of the Cuyamaca Mountain, which rises to an elevation of 6,000 feet. The city of San Diego, on the coast, is about 33 miles west and 12 miles south of this peak. The drainage basin is 34 miles in length by about 5 miles in width, its total area above the reservoir being 186 square miles, as determined in part from survey and in part from the county maps. This area is classified by Mr. Lippincott, as follows:

	Sq. miles.
Steep and rocky mountains favorable to large run-off	
Lower rolling mountains, usually covered with brush	99
Rolling hills, covered with soil and disintegrated granite	30
Agricultural lands (17 per cent) and river bottom	31
Total	186

The most noticeable topographic feature of this basin influencing the run-off is the abrupt flattening of the slopes at the base of the mountains into agricultural fields. The drainage lines deeply cut into the steep hillsides are quickly lost or are poorly defined in crossing the flat alluvial cones or partly filled valleys on the low grounds. In turn, the nearly level fields or parks drain into deep canyons. The occasional flood caused by a heavy rain rushing down the mountain side spreads out over the flat lands, much of it disappearing before it can reach the lower canyon. The steady percolation which might be expected at points below is to a large extent cut off by the high rate of evaporation, and thus the percentage of run-off, taking the basin as a whole, is small. A more detailed description of this river is given in William Ham. Hall's report on irrigation in southern California.

The figures relating to the amount of water draining from this basin and also the other details given in the following table have been compiled by Mr. J. B. Lippincott from data obtained by Mr. H. N. Savage, chief engineer, and Mr. James D. Schuyler, consulting engineer, of the San Diego Land and Town Company. The first column in the table gives the evaporation from the surface of the Sweetwater reservoir in inches in depth per month. This was measured from a metallic pan exposed to the direct rays of the sun at a point near the dam, this being continued in use until May, 1893. Subsequently observations were made by means of a Piche evaporometer.[1] This was placed in an instrument shelter of the ordinary type used by the Weather Bureau. This shelter is 15 feet above the ground and about 40 feet above the evel of the lake, being located 500 feet northeast from the gate tower. It has been noted that the records from the Piche evaporometer which

[1] Described by Prof. Thomas Russell in the Monthly Weather Review for September, 1888, in connection with a report upon the depth of evaporation in the United States.

cover the same months as those from the pan are in the ratio of 48 to 57. It is believed that the exposed pan gives more nearly the evaporation from the water surface than the Piche evaporometer. If the evaporation were annually 5 feet in depth from the surface of the reservoir—that is, from the 70-foot level down to the 65-foot level—the loss would amount to 24 per cent of the total amount stored. The area of the reservoir at the 70-foot level is 721.86 acres.

The average wind velocity given in miles per hour is that noted at the city of San Diego, 12 miles from the reservoir, and under similar conditions. In this connection it may be well to note the results obtained by Prof. Thomas Russell as to the effect of velocity upon evaporation obtained by whirling the Piche evaporometer at varying rates.

> Experiments were made which show that the effect of the wind on the evaporation from a vessel exposed in the open air is very great. Two Piche instruments were taken, one suspended in quiet air and the other fixed rigidly on the end of the 28-foot arm of the whirling machine set up in the inclosure of the Pension Office building. The whirling machine was the one used in standardizing anemometers.
>
> The instruments, filled with water, were first weighed on a fine balance to the hundredth of a gram. The whirling arm was then turned so that the Piche on its end moved with a velocity of five miles an hour. The motion was continued for half an hour, and at the end of the time both Piches were again weighed. Then the Piche that had been suspended in quiet air was put on the arm, and the one that had been on the arm was put in its place. The whirling was then started again at the same velocity, and continued for another half hour. At the end of the time the Piches were again weighed. While this was being done the humidity of the air was determined from time to time by means of whirled wet and dry bulb thermometers.
>
> Observations were also made in the same way with the Piche moving at velocities of 10, 15, 20, 25, and 30 miles per hour. At a velocity of 5 miles an hour the evaporation from a Piche was 2.2 times that from one in quiet air; at 10 miles, 3.8 times; at 15 miles, 4.9 times; at 20 miles, 5.7 times; at 25 miles, 6.1 times; and at 30 miles, 6.3 times. During the time the observations were made, June 25 and 26, 1888, the average temperature of the air was 83.7 and the relative humidity 50 per cent.

Measurements were made of the relative humidity at the reservoir during 1893 and 1894. When not obtained at this point they are given from the Weather Bureau figures at San Diego. The temperature of the air is taken as the average of the maximum and minimum daily readings. The temperature of the water in the lake and also in the pan was taken daily. That in the pan was observed at about 2 p. m., thus giving a reading slightly higher than that of the lake, as the pan under the hot sun caused the water to warm slightly. If two readings had been taken each day at intervals of twelve hours the average would probably have been very nearly that of the lake. It is noted that the water in the lake was usually a few degrees warmer than the atmosphere.

RAINFALL IN SWEETWATER BASIN.

The rainfall has been measured at two rain gages, one at the reservoir and one at Descanso, 25 miles east of the reservoir and at an elevation of 3,500 feet. The Descanso gage is 3 miles to the east of the summit of a ridge which may act in such a manner as to cut off the precipitation, thus reducing it below a theoretical amount for this position. In addition to the two rain gages within the drainage basin, the record from a third—that at the Cuyamaca reservoir—is given. This is at an elevation of 4,800 feet, and is only 3 miles distant from the divide between the drainage of Sweetwater and of San Diego River. The gage here is in a narrow valley or canyon, and the results obtained, being probably influenced by local topography, are regarded as excessive for this altitude and the locality.

The total amount of precipitation, as obtained at the reservoir and as Descanso, is not considered as showing the rainfall upon the drainage basin as a whole. One of the gages is located too high and the other too low to fairly represent the average conditions. In order, therefore, to obtain approximately the total amount of water falling upon the basin, certain assumptions are made and corrections are applied to the recorded precipitation. It is assumed that there is a regular increase in the rate of precipitation with altitude, and that this is at the rate of 0.6 inches of rain for each 100 feet increase in elevation. It is also assumed that the mean elevation of the whole basin is approximately 2,200 feet. Taking San Diego, which is nearly at sea level, as the base station, this, under the assumptions just given, would indicate that the rainfall on the basin should average 13.2 inches greater than that at San Diego. As the average rainfall at San Diego is 9.92 inches, the rainfall on the Sweetwater catchment area should be 9.92 plus 13.2 inches, or 23.12 inches.

In the same way the average rainfall is deduced from the measurements at the points within the basin. At Descanso the average rainfall is 26.38 inches. This point, having an altitude of 3,500 feet, is 1,300 feet above the assumed altitude of Sweetwater basin. Deducting, therefore, 7.8 inches leaves 18.58 inches as the average rainfall. Again, taking the results obtained at the rain gage at the Sweetwater reservoir, 12.01 inches, at an elevation of 250 feet, and adding to this the theoretical increase due to altitude of 11.70 inches, the sum 23.71 can be applied to the basin. The average of these two computations, based on the observations at Descanso and at the reservoir, is 21.14 inches for the basin. This method has been used in the following table, p. 325, in determining the average rainfall throughout the 186 square miles in the catchment basin for each year, additions being made to the rainfall recorded at the reservoir, and subtractions from that at Descanso, the average of the two results thus obtained being given in the table.

RUN-OFF FROM SWEETWATER BASIN.

The run-off shown in the table on page 326 has been computed by Mr. H. N. Savage. The stream usually ceased flowing about the 1st of June and remained dry throughout the summer, water flowing again in the fall or early winter after the rains began. At this latter time the reservoir is at a low stage, the water having been used for irrigation during the hot season. The flow into the reservoir, being wholly held, is therefore computed from the increase of height shown by the readings on the gage rod in the reservoir, due allowance being made for evaporation and the amount withdrawn. Later, when the reservoir is full and some of the water overflows, an additional amount must be added. To obtain this amount is a somewhat difficult matter, as the water flows out through a gate valve, over the waste weir, and also occasionally, during floods, over the top of the dam.

Evaporation, temperature, and rainfall at Sweetwater reservoir, San Diego County, Cal.

Month.	Evaporation.	Wind (miles per hour).	Humidity.	Temperature.		Rainfall.		
				Air, degrees Fahrenheit.	Water, degrees Fahrenheit.	At reservoir.	At Descanso.	At Cuyamaca.
1888.	*Inches.*		*Per cent.*			*Inches.*	*Inches.*	*Inches.*
September	....	....	....	70	....	0.00	....	0.21
October	....	....	....	65	....	0.36	....	3.82
November	....	....	....	60	....	2.81	....	8.33
December	....	....	....	58	....	3.20	....	13.30
1889.								
January	1.990	4.8	80	57	....	1.56	....	2.99
February	3.336	5.7	74	56	....	0.82	....	4.70
March	3.380	5.4	80	59	....	3.87	....	12.85
April	4.961	5.6	79	61	....	0.36	....	3.34
May	5.822	5.9	75	61	....	0.21	....	2.21
June	6.806	5.5	81	64	....	0.33	....	0.00
July	7.898	5.1	79	67	....	0.01	....	0.00
August	8.253	5.0	69	73	....	0.00	....	1.71
September	7.360	5.1	....	71	....	0.00	....	0.03
October	2.998	4.7	....	65	....	2.22	....	2.82
November	4.800	4.4	....	60	....	1.08	....	1.64
December	0.246	4.7	....	56	....	7.07	....	21.00
1890.								
January	1.588	5.0	....	48	....	2.20	....	11.02
February	2.214	5.2	....	52	....	2.07	....	16.36
March	3.280	4.9	....	55	....	1.30	....	4.00
April	4.141	5.1	....	58	....	0.10	....	0.97
May	6.140	4.6	....	60	....	0.41	....	0.00
June	7.302	5.4	....	65	....	0.00	....	0.00
July	7.380	4.7	....	70	....	0.00	....	0.09
August	9.020	4.6	....	71	....	0.07	....	0.90
September	6.482	4.3	69	72	....	0.42	....	1.40
October	4.920	4.0	79	66	....	0.45	....	0.58
November	5.535	4.3	59	65	....	0.93	....	3.62
December	1.845	4.5	83	62	....	2.29	....	12.13
1891.								
January	3.608	4.4	58	55	....	0.83	....	0.00
February	1.353	5.8	73	52	....	5.28	....	34.70
March	3.075	5.3	74	57	....	0.23	....	3.17
April	3.707	4.9	76	58	70	1.27	....	3.50
May	5.599	5.4	75	61	69	0.83	....	3.69
June	6.027	4.6	74	65	78	0.09	....	0.00
July	6.501	4.0	78	71	80	0.00	....	0.04
August	8.890	3.8	77	73	82	0.03	....	0.30
September	6.150	4.7	76	73	76	0.00	....	2.67
October	6.314	3.8	79	66	72	0.00	....	0.00
November	4.100	3.8	74	60	•64	0.13	....	0.45
December	2.752	5.4	65	52	54	0.90	....	6.75
1892.								
January	2.542	3.7	58	55	54	2.42	....	7.23
February	1.394	4.7	75	54	63	3.47	....	6.47
March	3.075	4.8	73	56	66	0.55	....	7.76
April	5.822	5.5	82	57	70	0.93	....	3.35
May	4.674	5.7	68	61	71	1.39	....	5.90
June	6.478	5.6	69	63	74	0.07	....	0.67
July	8.808	5.0	73	67	78	0.00	....	0.00
August	6.540	4.9	74	68	78	0.02	....	0.00
September	6.273	4.8	74	68	76	0.00	0.00	0.00
October	6.560	4.2	65	64	*a* 68	0.15	0.00	0.30
November	4.766	3.7	50	62	60	0.04	1.50	2.87
December	2.614	4.3	66	53	56	2.12	2.00	3.76

a End of measurements from pan and beginning of observations on Piche evaporometer.

Evaporation, temperature, and rainfall at Sweetwater reservoir, San Diego County, Cal.—Continued.

Month.	Evaporation.	Wind (miles per hour).	Humidity.	Temperature.		Rainfall.		
				Air, degrees Fahrenheit.	Water, degrees Fahrenheit.	At reservoir.	At Descanso.	At Cuyamaca.
1893.	*Inches.*		*Per cent*			*Inches.*	*Inches.*	*Inches.*
January	2.768	4.0	51	57	58	0.22	3.01	5.55
February	2.214	5.1	67	54	59	1.96	2.64	9.13
March	1.076	6.2	76	51	60	6.50	14.07	15.60
April	5.002	5.3	73	58	64	0.27	0.50	1.00
May	4.902	5.8	72	61	68	0.20	0.00	1.00
June	3.411	4.9	77	65	76	0.00	0.00	0.00
July	5.318	5.1	77	69	81	0.16	0.75	1.20
August	4.693	5.0	75	72	80	0.00	0.00	0.30
September	4.864	5.1	75	66	77	0.00	0.25	0.00
October	4.586	4.6	67	65	70	0.33	1.25	1.90
November	4.513	4.5	65	58	60	0.84	3.15	3.30
December	6.283	4.5	60	58	58	2.08	4.38	6.05
1894.								
January	3.897	5.0	68	50	52	0.36	2.10	2.05
February	3.533	5.2	67	50	56	0.71	3.40	2.05
March	3.008	5.8	73	56	59	1.69	3.63	3.00
April	3.634	5.4	70	59	65	0.04	0.13	0.00
May	3.451	5.7	74	59	68	0.15	0.50	1.00
June	4.683	5.6	72	62	76	0.00	0.38	0.50
July	3.161	5.2	75	67	80	0.00	0.12	0.00
August	3.066	4.8	77	68	82	0.00	0.13	1.50
September	4.637	5.1	76	69	75	0.00	0.00	0.40
October	3.232	3.8	72	64	70	0.04	0.00	0.00
November	3.347	3.9	76	59	64	0.00	0.00	0.00
December	2.344	4.3	73	54	59	3.03	7.62	12.76
1895.								
January	2.357	6.0	74	53	....	9.63	19.52	28.43
February	2.850	5.0	....	54	....	1.52	2.76	6.05
March	3.121	5.3	....	56	....	1.18	3.13	5.52
April	3.939	5.2	....	58	....	0.44	0.64	1.20
May	4.119	5.8	77	63	....	0.35	0.63	0.16
June	3.188	....	....	66	....	0.00	0.00	0.00
July	....	....	....	69	....	0.00	0.00	0.00
August	....	....	....	71	....	0.00	0.00	0.00

The following table gives, for the period from 1888 to 1895, the estimated precipitation upon the catchment basin, obtained as stated on p. 324, also the depth of run-off in inches and the relation which this bears to the depth of rainfall, by years. The years chosen are not calendar years, but extend from September to August, inclusive, as this division is more in accordance with the distribution of rainfall and the discharge of the streams.

Estimated rainfall upon the Sweetwater catchment basin, also depth and percentage of run-off.

Year.	Rain.	Run-off.	Per cent.
	Inches.	*Inches.*	
1888-89	21.00	2.54	12
1889-90	25.71	3.71	14
1890-91	23.40	2.07	9
1891-92	17.14	0.62	4
1892-93	20.00	1.61	8
1893-94	14.76	0.14	1
1894-95	27.14	7.12	26
Total	149.15	17.81	12

The figures concerning the amount of evaporation, wind movement, humidity, temperature, rainfall, and run-off are brought together for comparison by years in the following table. In this case, as stated above, the years extend from September to August, inclusive, as this most nearly agrees with the natural division.

Annual evaporation, temperature, rainfall, run-off, etc., in Sweetwater basin.

Period.	Evaporation.	Wind (mile per hour).	Humidity.	Temperature.		Rainfall.				Run-off.	
				Air.	Water.	Reservoir.	Descanso.	Cuyamaca.	Estimated on basin.		
	Inches.		*Per ct.*	*Deg. F.*	*Deg. F.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Per ct.*
1888-89						13.53		53.46	21.00	2.54	12
1889-90	56.47	4.9				16.52	31.30	58.83	25.71	3.71	14
1890-91	57.54	4.6				12.65	30.25	63.13	23.40	2.07	9
1891-92	58.65	4.8	72	61	68	9.88	20.50	41.75	17.14	0.62	4
1892-93	49.60	4.9	68	61	67	11.62	24.47	40.21	20.00	1.61	8
1893-94	48.68	5.1	70	60	67	6.20	19.42	21.35	14.76	0.14	1
1894-95						16.19	34.30	54.12	27.14	7.12	26

FLOODS IN THE RIVER.

The Sweetwater, like the other rivers of southern California, is liable at times to extraordinary floods, due to heavy precipitation upon the catchment basin. In 1893 two floods furnished 70 per cent of the annual discharge of the river for that year. For the 24 hours ending March 24, 1893, the river discharged 3,069 acre-feet. For the seven days ending March 27, the total amount discharged was 7,980 acre-feet. In January, 1895, a flood was carefully watched and the flow computed at short intervals, as shown in the following table. The total run-off from 5 p. m. on January 14 to noon on January 22 was equivalent to a trifle over 4.70 inches over the whole drainage basin, or in all 46,670 acre-feet. This same storm gave a maximum discharge from Cedar, Boulder, and Colman creeks, aggregating 100 square miles within the drainage basin of San Diego River, of 13,000 second-feet.

Rate of flow during flood of January, 1895, in Sweetwater River.

Time.	Second-feet.	Time.	Second-feet.	Time.	Second-feet.
January 14.		2.30 p. m	15,148	11.30 a. m	3,470
5 p. m	0	3.30 p. m	18,148	1.30 p. m	3,364
January 15.		4 p. m	14,034	3 p. m	3,968
7 a. m	84	4.30 p. m	14,490	3.30 p. m	4,692
12 m	1,855	5.30 p. m	7,227	4 p. m	3,224
3 p. m	6,410	6.30 p. m	9,420	4.30 p. m	3,230
4 p. m	5,214	7.30 p. m	8,310	9 p. m	3,176
5 p. m	5,262	8 p. m	6,930	January 20.	
6 p. m	4,152	January 17.		7 a. m	3,314
7 p. m	6,135	5 a. m	5,302	9 a. m	2,805
9 p. m	5,567	6 a. m	3,545	10 a. m	2,674
10 p. m	5,080	8 a. m	3,954	11 a. m	2,484
January 16.		3 p. m	4,416	1 p. m	2,500
5 a. m	3,297	January 18.		2 p. m	2,136
6 a. m	4,720	8 a. m	3,331	January 21.	
7 a. m	3,585	9 a. m	2,090	7 a. m	1,880
8.30 a. m	5,316	10 a. m	2,048	10 a. m	820
9.30 a. m	5,370	7 p. m	2,466	12 m	750
10.30 a. m	6,602	January 19.		5.30 p. m	800
11.30 a. m	8,713	5 a. m	1,532	January 22.	
12.30 p. m	8,713	8.30 a. m	2,944	7 a. m	810
1.30 p. m	13,684	9.30 a. m	2,888	12 m	530
2 p. m	13,000	10.30 a. m	3,068		

INCREASE OF PRECIPITATION WITH ALTITUDE.

In connection with the above data concerning the rainfall and run-off on the Sweetwater drainage basin, Mr. J. B. Lippincott has given a discussion of the precipitation in southern California, and has brought together figures showing the increase of rainfall with altitude. The following statement is taken from his report:

The warm, moisture-laden winds from the sea on their inland journey are driven up the slopes in the Coast Range. As they rise in elevation they expand under the lighter atmospheric pressure, become chilled, and are deprived of all moisture in excess of the point of saturation at that temperature and pressure. This lowering of temperature in their ascent is more pronounced in winter than in summer, and, coupled with the fact that a high barometer is normal off the coast of southern California during the summer season, the winds yield much less rain.

The year in California is naturally divided into a wet and a dry season, the dry season beginning about the 1st of May, with little rain falling, except in thunderstorms in the high mountains, before the 1st of October. The rains then gradually increase, reaching their maximum in January. The records of the United States Signal Service and the Weather Bureau begin the year with the 1st of January. This is not a proper division in this region, as it will not show either the maximum or minimum years of rainfall. Engineers divide the year either with the 1st of July or the 1st of September.

The effect of topography on rainfall is given in a report by Prof. G. E. Curtis[1] in the following words:

"In general the amount of rain increases with the elevation above sea level up to a maximum plane, after which a decrease takes place. S. A. Hill has shown that in the northwest Himalayas, where the rainfall is most remarkable in amount and rate of variation, the observations can be represented by the following empirical formula: $R=1+1.92h-0.40h^2+0.02h^3$, in which R represents the amount of rain and h the relative height in units of 1,000 feet above the assumed plane, which is itself 1,000 feet above sea level. From this formula the height of maximum rainfall is computed to be 3,160 feet above the plane, or 4,160 feet above sea level. It is further shown that this elevation is that at which, according to the observed law of decrease of temperature, the southwest monsoon is cooled just below its dew-point. This point will be that at which in the mean we should expect the maximum precipitation to take place. * * * A very rapid diminution takes place on the leeward side, where the stations record only about half the amount of rainfall given by stations of equal elevation on the windward side."

Similar conditions prevail in California. In illustration the following table (p. 329) is given, in which the results obtained at a base station are compared with those from other stations in the vicinity and on that parallel. The base station in each case is one whose record is of long standing. In the table the second column gives the period during which the record has been kept. The third shows the elevation of the station above sea. The fourth gives the annual average recorded rain at that station. The fifth gives the relation of the rainfall at the base station, during the years that rainfalls were actually recorded at the station under consideration, to the total average rainfall recorded at the base station during its entire period of observation. The record at the second station is then adjusted by this ratio and a probable average rainfall is determined for the station considered and entered in the sixth column under the head "Probable mean rain."[2] For example, take the station Poway. The

[1] Signal Service Notes, No. XVI. The effect of wind currents on rainfall, by G. E. Curtis, Washington, 1884, pamphlet, 11 pp., pp. 6–7.

[2] See statement of Arthur Jacobs, late executive engineer for irrigation, Her Majesty's Bombay Service, in Van Nostrand's Science Series, No. VI, p. 11.

record at this point is for ten years, while the record at the base station, San Diego, has been kept for a period of forty-five years. Now, the average annual rain for a period of forty-five years is probably nearer the actual average than that given by a record extending over a much less period. The two stations, being so near together and subject to the same general climatic conditions, have probably a close relation. If during the time that the record has been kept at Poway the rain at San Diego is found to be 117 per cent of the average of forty-five years, then the recorded rain at Poway is assumed to be 117 per cent of the average there.

By examining the data available, it has been found that the increase in precipitation due to elevation is approximately at the rate of 0.6 of an inch of rain for each 100 feet rise in elevation on the western slope of the Coast Range and of the Sierra Nevadas in California. There is also an increase due to elevation on the eastern slope, but this is very much less in amount. The figures in the seventh column in the table below have been obtained by adding the computed increase due to elevation above the base station to the recorded rain at the base station. By comparing these figures in the seventh column, showing theoretical rainfall, with the recorded mean rainfall and the probable mean rainfall given in the fourth and sixth columns, the applicability of this deduced rate of increase of precipitation with altitude is shown.

Table showing the relation of rainfall to elevation in California.

Station.	Period.	Elevation.	Rainfall.			
			Recorded.	Per cent.	Probable mean.	Theoretical.
First group.		*Feet.*	*Inches.*		*Inches.*	*Inches.*
San Diego *a*	1850-95	0	9.92			
Sweetwater, reservoir	1888-95	250	12.37	103	12.01	11.42
Poway	1878-89	460	13.38	117	11.43	12.68
Descanso	1889-95	3,500	26.65	101	26.38	30.92
Julian	1879-84	4,500	37.75	130	29.04	36.92
Cuyamaca	1887-95	4,800	44.66	102	43.79	38.72
Second group.						
Los Angeles *a*	1871-94	330	16.96			
Bear Valley, reservoir	1883-94	6,000	54.03	110	49.09	50.92
Third group.						
Sacramento *a*	1849-89	31	19.90			
Auburn	1870-84	1,360	32.72	102	32.08	27.78
Colfax	1870-84	2,422	44.81	102	43.93	34.20
Cisco	1870-84	5,934	57.41	102	56.28	55.20
Summit	1870-84	7,017	47.93	102	46.99	61.80
Fourth group.						
Truckee	1870-84	5,919	29.53	102	28.95	54.60
Reno	1870-91	4,497	5.17	102	5.07	46.56
Wadsworth	1870-91	4,085	3.83	102	3.75	44.28

a Base stations.

The stations of the first and second groups are located in San Diego County, and are all on the western slope of the Coast Range. Bear Valley is 80 miles east of Los Angeles on the same slope. The third group comprises the stations along the Central Pacific from Sacramento east to the summit, and the fourth those along the same line of road on the eastern slope 14, 49, and 83 miles by rail beyond the summit. This fourth group is given to show that wholly different conditions prevail on the eastern and on the western slopes of the mountain.

All these records are seasonal, the year being divided at the 1st of September when possible. Data are given from Signal Service and Weather Bureau reports, and from those of the California State engineer, the former being accepted in cases of differences. Excepting the fourth or last group, which is given simply to show that the conditions prevailing on the eastern slope are different from those of the western, it may be seen that the theoretical rain is very nearly the same as the probable mean rain. The instances where the widest variations exist usually can be explained.

In regard to the value of the theoretical rainfall, reference may again be made to the paper by Professor Curtis. He states (p. 8) that the Signal Service, in an investigation of the rainfall on the summit of Mount Washington to determine the local distribution and the average rainfall for the station, placed five gages on the summit of the mountain, one in the center and four to the four points of the compass 75 feet distant from it. It has been known for a long time that a gage placed at an elevation above ground usually recorded less than one placed on the ground below, this difference being caused by wind currents. The increased velocities of the wind around the corners and over the tops of the buildings, hills, or even the gage tend to increase the slant of the falling rain at those points, and when just past the obstruction, the velocity of the wind being again reduced, a heavier fall of rain will be deposited. In this experiment on Mount Washington observations were made from September 1, 1882, to October 1, 1883. As the measurement of snow was reported as altogether unreliable, it was excluded. In the following table it is shown that the windward gages had received during this period 24.64 inches of rain and the leeward ones 28.43 inches, single storms showing greater variation. The conclusion reached is that precipitation varies materially within distances of only 100 or 200 feet.

The most remarkable feature of the experiment is the different results obtained from gages with 3-inch and 8-inch catchment cups. The gages that were set to the four points of the compass had 3-inch cups and the regular station gage had one 8-inch cup. For the period in question the four exterior gages recorded 45.82, 51.19, 45.40, and 42.63 inches, respectively, while the regular station gage recorded 58.70 inches of rain.

Comparative reading of 8-inch and 3-inch gages in wind.

	Wind velocity in miles per hour.							
	15		40		60		75	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Diameter of gage	3	8	3	8	3	8	3	8
Amount of rain	1.75	1.84	2.77	3.37	1.60	2.44	1.87	3.49
Per cent	100	105	100	122	100	152	100	186

In view of these records, which are taken with experimental care, the statement would be justified that the "Probable rainfall," as shown in the table on page 329, agrees with the "Theoretical rainfall" as closely as it can be measured, the gages being of different makes and sizes.

The recorded rainfall of the Cuyamaca gage is probably in excess of the average rain for this elevation and the locality, and it is so considered by engineers in San Diego. The gage is in a narrow valley or canyon, and is probably affected by the winds and the topography.

It will be seen that Cisco, with an elevation of 5,934 feet, has a rainfall of 56.28 inches, while Summit, 13 miles beyond, with an elevation of 7,017, has only 46.99 inches of rain. It may be that this variation is due to the wind action, especially on the snow, which averages each year 31 feet in depth, or to the fact that Summit is above the plane of maximum rainfall, as mentioned on page 328.

RATING STATIONS.

DENVER RATING STATION.

The Denver rating station is located at the reservoir of the Denver Union Water Company's pumping works, two blocks west of Lincoln Park, in the city of Denver. This reservoir is covered by a platform or flat roof, supported on vertical timbers, whose lower ends are immersed in the water. The flooring consists of inch boards supported on horizontal joists at an elevation a few feet below the top of the reservoir bank. Permission was obtained from the water company to cut a slot 16 inches wide and 200 feet long in this platform or roof. On each side of this slot is laid a 9-pound T-rail, forming a tramway, having a gage of 18 inches. On these rails runs a car similar to those used in mines. On this car are mounted suitable devices for holding, vertically, an iron rod, to the lower end of which the current meter can be attached. This projects down through the slot into the water, so that the meter can be held at any desired depth.

The car is pushed by hand backward and forward, the meter being turned, or, when upon a swivel, taking its own position parallel with the slot. Distances of 10 feet are laid off along the rails, and the speed of the car can be regulated by observing the number of seconds required in passing over each 10 feet. Usually the length of course chosen for rating the meter is 100 feet, as it has been found that this is sufficient length for all practical purposes. When the meter is run at high velocities it is sometimes advantageous to run it for 150 feet, using the surplus 25 feet at each end for the purpose of starting and stopping the car.

As originally constructed the car was moved by means of a light cable, which could be wound round a drum turned by hand. It has been found, however, that the car can be pushed by hand at a nearly uniform speed, and that it is not necessary to employ extra assistance required to wind and unwind the cable and to regulate its speed.

KENSINGTON RATING STATION.

This station for rating meters in the vicinity of the city of Washington is located in Maryland, on the south side of a small pond constructed by the Chevy Chase Land Company near the power house at the junction of the Chevy Chase and Kensington electric railroads. The equipment consists of a wharf 165 feet long and 5 feet 4 inches wide. This extends easterly and westerly across a small indentation of the shore and connects the outer ends of two rough piers. The water is from about 4 feet deep on the east to 12 feet deep on the west. The wharf is built of Georgia and Virginia pine, and has upon it near the outside edge an 18-inch track 150 feet long made of T-rails weighing 8 pounds to the yard. A small car having wheels flanged on the inside runs along this track supporting, by suitable devices, a vertical iron rod which is thus made to move forward and backward, clearing the outer edge of the wharf by about 8 inches. The car can be moved at any desired speed, and the weight, about 125 pounds, is such that the motion is at a nearly constant rate. A measured course of 100 feet is laid off, leaving 25 feet of track at each end for the purpose of starting and stopping the car. A slight easterly current is perceptible in the water, due to the flow toward the outlet of the pond.

LAWRENCE RATING STATION.

The rating station at Lawrence, Mass., was used for Eastern meters before the Kensington station was constructed. This station was originally devised by the engineers of the Essex Company, and is located at the lower end of their canal at Lawrence. A wharf at that point has been built in the middle of the canal for a length of about 200 feet, and having a crosspiece at the upper end. These two wharves are planked to the bottom of the canal, thus preventing currents in the portion cut off. The measured course is 100 feet long, with 25 feet at each end for starting and stopping the car. The track is of wood, with a strip of iron attached, projecting about one-half inch above the outside rail. The car or truck is small, weighing only about 30 pounds. The outside wheels are grooved and run upon the projecting strip of iron, while the inside wheels are flat and bear directly upon the wooden rail. This, like the trucks at the other stations, is moved forward and backward over the course by hand.[1]

METER RATING TABLES.

The following tables give the ratings of the various current meters used by this Survey, arranged in concise form for convenience of reference by the hydrographers. There is also given a brief memorandum as to the amount of use or the individual peculiarities of each instrument, as it has been found that there is a noticeable difference in the operation of machines made from the same patterns and at the same time. The meters are rated as nearly as possible under the same conditions and theoretically should give the same results, but in practice it has been found that there are slight discrepancies due to peculiarities the origin of which can not always be definitely ascertained.

In these tables the ratings of similar instruments have been placed opposite each other for comparison, having been reduced to a common system. It has been found most convenient to express these meter ratings not in the coefficient of relation of revolutions of meter to velocity, but in the actual velocities corresponding to certain fractional revolutions.

[1]See also description of the rating station of the Kern County Land Company at Bakersfield, Cal., on page 269.

METHODS OF RATING THE METERS.

The current meters in use by the Survey are rated at the stations described on page 331, not only when first put in use, but at various times, whenever it is thought that the rating may have been altered by accident or by wear. After constant use in streams carrying more or less sediment, the bearings become worn and the friction is increased, or sometimes reduced. Accidents to the meters occasionally result in bending the blades or cups slightly, or in distorting the bearings by an amount too small to necessitate repairs but sufficient to materially alter the relation of revolution of the meter wheel to the velocity of the water. With meters in constant use, therefore, it is essential to have check ratings made from time to time. The instruments are sent in from the field to the rating stations, in the case of the larger instruments merely the revolving head and spindles being sent by mail.

At the station the meter is attached to the lower end of the vertical rod and immersed in the water at a depth of from 1 to 2 feet, the water usually being clear, so that the instrument can be plainly seen. The car to which the rod is attached is then pushed over the measured course at a uniform velocity and the number of revolutions of the meter noted, as well as the time in seconds. The car is run first in one direction and then in the other, so that the effect of currents which may be set up in the water by the motion of the meter is to a large extent eliminated. From twenty to forty observations are made at various velocities. These range from a rate of less than 0.5 foot per second up to 8 or 10 feet per second, or even more. It is usually found, however, that above very low velocities the rating table follows the equation of a straight line. From twenty to forty observations are usually taken, depending upon the smoothness and regularity with which the meter revolves.

The notes of the hydrographer rating the meter (entered on blank form 9-205) show the date, the locality, the motion of the water, whether drifting slightly or not, the wind velocity, as this may account for irregularities, and similar details as to the physical conditions at the time. The operator also notes when the meter was last rated, by whom it has been used, and ascertains whether the instrument has been recently injured or repaired. Before rating it is customary to cause the wheel of the meter to revolve by hand, counting the number of revolutions or the number of seconds during which it will revolve, in this way ascertaining in a general way the condition of the meter as regards friction. It is at all times kept well oiled, so that the friction may be as uniform as possible.

The facts concerning the condition of the meter having been noted, the person making the rating enters in the proper column and in regular order the direction in which the meter has been run for each observation, whether across the pond or back to the point of beginning, indicating this by the letter *a* or *b*. Next to this in the provided blanks is given the length of the run in feet, usually 100, and the time in seconds. Against this is placed the number of revolutions of the meter, or, when an electric meter with register is used, the readings of the register at the beginning and at the end are noted and the difference is placed in the proper column. A suitable number of observations agreeing among themselves having been made, the hydrographer can then compute the rating at his leisure.

The process of computing the rating table or coefficient is as follows: The number of seconds for each observation is divided by the number of feet, giving the velocity in feet per second, and the number of revolutions is divided by the number of seconds, giving the revolutions per second. For each observation, then, there is given the velocity and rate of revolution. If the former is divided by the latter, there will be obtained what is known as the coefficient for the meter, or the number of feet of water passed through for each revolution. If the friction of the meter were the same for all velocities, this coefficient would be a constant, and a few observations at any velocity would be sufficient for the rating of the meter, but as a matter of fact this coefficient, or relation between the number of turns of the wheel and the speed of the meter, varies, especially at low velocities. It is necessary, therefore, to determine the coefficient for various speeds.

Instead of computing the coefficient of the meter by dividing the speed in feet per second by the number of revolutions per second, it has been found best in practice to first express this relation graphically in order that anomalies or errors may be clearly seen. The values are platted upon rectangularly ruled paper by coordinates, in which the vertical distances y represents the revolutions per second, and the horizontal distances x the feet per second for each observation. The points thus obtained are found to lie approximately in the path of a straight line, except near the origin of coordinates. If a straight line is sketched through these points, its equation will be that of the rating of the meter. For example, the rating of meter 110 is given as $y = 3.67x + 0.65$. This indicates, obviously, that the straight line cuts the axis of y at a point above the origin, or, in other words, the meter does not revolve at very low velocities. As a matter of fact, however, as this line approaches the origin it changes to a curve, but as the equation of a curve is not convenient in practical use it has been assumed that this line is broken, and that the rating for low velocities follows a second straight line slightly inclined to the first. The equation above given is therefore modified by the statement that below 1.35 revolutions per second the equation $y = 4.15x$ is to be used.

The algebraic expression given above is not convenient for rapid use in the field, and therefore it is usually transformed into numerical values. This can be done in two ways. The first of these is by computing the coefficient for each revolution and one-tenth of revolution. This, however, involves the necessity of multiplying the observed speed of the meter each time when in use. To obviate this, a still further or second step is taken. Tables are constructed for each meter, giving directly the speed per second of the water in terms of the revolutions of the wheel. This latter, if carried out sufficiently far, does away with all multiplication in the field notes, the values being picked out directly from the tables.

Rating tables for large Haskell meters.

[Velocities in feet per second.]

Revolutions per second.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 17	No. 12 (*a*)	No. 13 (*a*)
0.00	0.30	0.30	0.23	0.30	0.28	0.30	0.30	0.30	0.24	0.22	0.35	0.30	0.16	0.30
0.10	0.36	0.37	0.30	0.35	0.34	0.35	0.35	0.34	0.30	0.28	0.41	0.35	0.27	0.37
0.20	0.44	0.44	0.37	0.41	0.40	0.41	0.41	0.38	0.37	0.36	0.48	0.41	0.38	0.45
0.30	0.51	0.51	0.45	0.47	0.47	0.48	0.48	0.42	0.44	0.44	0.55	0.48	0.49	0.53
0.40	0.59	0.58	0.54	0.54	0.54	0.55	0.56	0.47	0.51	0.52	0.62	0.55	0.60	0.61
0.50	0.68	0.66	0.64	0.62	0.62	0.63	0.65	0.54	0.58	0.60	0.70	0.63	0.71	0.70
0.60	0.78	0.75	0.74	0.70	0.70	0.72	0.73	0.63	0.66	0.68	0.78	0.71	0.82	0.80
0.70	0.88	0.85	0.85	0.80	0.78	0.82	0.81	0.73	0.75	0.78	0.86	0.81	0.93	0.90
0.80	0.99	0.94	0.96	0.90	0.86	0.92	0.89	0.83	0.84	0.88	0.95	0.92	1.05	1.00
0.90	1.09	1.03	1.07	1.00	0.95	1.03	1.00	0.93	0.93	0.98	1.04	1.03	1.17	1.12
1.00	1.20	1.12	1.17	1.10	1.05	1.14	1.13	1.03	1.02	1.08	1.15	1.16	1.28	1.25
1.10	1.30	1.20	1.28	1.20	1.15	1.24	1.23	1.13	1.11	1.18	1.25	1.26	1.39	1.37
1.20	1.40	1.30	1.39	1.30	1.26	1.34	1.34	1.23	1.20	1.28	1.35	1.37	1.50	1.49
1.30	1.51	1.40	1.49	1.40	1.36	1.45	1.45	1.33	1.30	1.38	1.46	1.48	1.61	1.61
1.40	1.62	1.50	1.60	1.50	1.47	1.55	1.56	1.43	1.40	1.48	1.56	1.58	1.73	1.73
1.50	1.73	1.60	1.71	1.60	1.57	1.65	1.66	1.53	1.50	1.58	1.66	1.69	1.84	1.85
1.60	1.84	1.70	1.82	1.70	1.68	1.76	1.77	1.63	1.60	1.68	1.77	1.80	1.96	1.97
1.70	1.95	1.80	1.93	1.80	1.78	1.86	1.87	1.73	1.70	1.78	1.87	1.90	2.08	2.09
1.80	2.06	1.90	2.04	1.90	1.89	1.96	1.98	1.83	1.80	1.88	1.97	2.01	2.20	2.21
1.90	2.17	2.00	2.15	2.00	1.99	2.07	2.08	1.93	1.90	1.98	2.07	2.12	2.31	2.33
2.00	2.28	2.10	2.26	2.10	2.10	2.17	2.19	2.03	2.01	2.08	2.18	2.22	2.43	2.45
2.10	2.38	2.20	2.37	2.20	2.20	2.27	2.30	2.13	2.11	2.18	2.28	2.32	2.55	2.57
2.20	2.49	2.30	2.48	2.31	2.31	2.38	2.40	2.23	2.21	2.28	2.38	2.42	2.67	2.69
2.30	2.60	2.40	2.59	2.41	2.41	2.49	2.50	2.33	2.31	2.38	2.49	2.53	2.79	2.81
2.40	2.71	2.50	2.70	2.51	2.52	2.60	2.61	2.43	2.41	2.49	2.59	2.64	2.90	2.93
2.50	2.82	2.60	2.82	2.62	2.62	2.71	2.72	2.53	2.51	2.59	2.69	2.74	3.01	3.05
2.60	2.93	2.70	2.93	2.73	2.73	2.82	2.82	2.63	2.61	2.69	2.80	2.85	3.12	3.17
2.70	3.04	2.80	3.04	2.83	2.83	2.92	2.93	2.73	2.71	2.79	2.91	2.96	3.24	3.29
2.80	3.15	2.90	3.15	2.94	2.94	3.03	3.04	2.83	2.81	2.90	3.01	3.07	3.36	3.41
2.90	3.26	3.00	3.27	3.04	3.04	3.13	3.14	2.93	2.91	3.00	3.11	3.18	3.48	3.53
3.00	3.36	3.12	3.39	3.15	3.15	3.23	3.25	3.03	3.02	3.10	3.21	3.30	3.60	3.65
3.10	3.47	3.22	3.50	3.25	3.25	3.33	3.35	3.13	3.12	3.20	3.31	3.40	3.72	3.77
3.20	3.58	3.32	3.61	3.36	3.36	3.44	3.46	3.23	3.22	3.31	3.41	3.46	3.84	3.89
3.30	3.69	3.43	3.72	3.46	3.46	3.54	3.56	3.33	3.32	3.41	3.52	3.57	3.96	4.01
3.40	3.80	3.53	3.83	3.56	3.57	3.65	3.66	3.43	3.42	3.51	3.62	3.68	4.08	4.13
3.50	3.91	3.64	3.95	3.67	3.67	3.76	3.77	3.53	3.52	3.61	3.72	3.79	4.21	4.25
3.60	4.02	3.74	4.06	3.77	3.78	3.86	3.87	3.63	3.62	3.72	3.83	3.90	4.33	4.37
3.70	4.13	3.85	4.17	3.88	3.88	3.97	3.98	3.73	3.72	3.82	3.93	4.02	4.46	4.49
3.80	4.25	3.95	4.28	3.98	3.99	4.08	4.09	3.83	3.82	3.92	4.03	4.13	4.59	4.61
3.90	4.36	4.05	4.40	4.09	4.09	4.18	4.20	3.93	3.92	4.03	4.13	4.25	4.72	4.73
4.00	4.46	4.16	4.52	4.20	4.20	4.30	4.31	4.03	4.03	4.13	4.24	4.38	4.84	4.85
4.10	4.57	4.26	4.63	4.30	4.30	4.41	4.41	4.13	4.13	4.23	4.34	4.49	4.96	4.97
4.20	4.68	4.37	4.74	4.41	4.41	4.52	4.51	4.23	4.23	4.34	4.44	4.60	5.09	5.09
4.30	4.79	4.47	4.86	4.51	4.51	4.63	4.62	4.33	4.33	4.44	4.55	4.71	5.21	5.21
4.40	4.90	4.57	4.97	4.62	4.62	4.74	4.72	4.43	4.43	4.54	4.65	4.83	5.34	5.33
4.50	5.01	4.67	5.08	4.72	4.72	4.85	4.82	4.53	4.53	4.65	4.75	4.94	5.47	5.45
4.60	5.12	4.77	5.20	4.82	4.83	4.96	4.93	4.63	4.63	4.75	4.86	5.05	5.60	5.57
4.70	5.23	4.88	5.31	4.93	4.93	5.07	5.04	4.73	4.73	4.85	4.96	5.16	5.72	5.69
4.80	5.35	4.98	5.42	5.04	5.04	5.18	5.14	4.83	4.83	4.96	5.06	5.26	5.85	5.81
4.90	5.46	5.09	5.53	5.14	5.14	5.29	5.26	4.93	4.93	5.06	5.16	5.36	5.98	5.93
5.00	5.56	5.20	5.65	5.25	5.25	5.40	5.37	5.03	5.04	5.16	5.27	5.46	6.10	6.05
5.10	5.67	5.30	5.76	5.35	5.35	5.51	5.47	5.13	5.14	5.26	5.37	5.57	6.23	6.17
5.20	5.78	5.40	5.87	5.46	5.46	5.62	5.57	5.23	5.24	5.37	5.47	5.68	6.35	6.29
5.60	5.89	5.51	5.99	5.56	5.56	5.73	5.67	5.33	5.34	5.47	5.58	5.78	6.48	6.41
5.40	6.00	5.62	6.10	5.67	5.67	5.84	5.78	5.43	5.44	5.57	5.68	5.89	6.60	6.53
5.50	6.11	5.72	6.21	5.77	5.77	5.94	5.88	5.53	5.54	5.67	5.78	6.00	6.73	6.65
5.60	6.22	5.82	6.33	5.88	5.88	6.05	5.98	5.63	5.64	5.77	5.89	6.10	6.86	6.77
5.70	6.33	5.92	6.44	5.98	5.98	6.16	6.09	5.73	5.74	5.88	5.99	6.21	6.99	6.89
5.80	6.45	6.03	6.55	6.09	6.09	6.27	6.20	5.83	5.84	5.98	6.09	6.32	7.11	7.01
5.90	6.56	6.13	6.66	6.20	6.19	6.38	6.32	5.93	5.94	6.09	6.19	6.43	7.24	7.13
6.00		6.23	6.78	6.30	6.30		6.43	6.03	6.05		6.30	6.54	7.37	7.25
6.50		6.74	7.34	6.82	6.82		6.93	6.53	6.55		6.81		8.00	7.85
7.00			7.91		7.55			7.03	7.06		7.35		8.64	8.45
7.50			8.47		7.87			7.53	7.56		7.93		9.27	9.05
8.00			9.04		8.40			8.03	8.07		8.51		9.90	9.65
8.50			9.60		8.92				8.57				10.53	10.25

a These meters have two wheels or heads. This table gives the rating for those of greater curvature for use in water having low velocity.

No. 1. Large Haskell meter, formerly known as 1 C, being one of the first two meters purchased. It was originally sent to Salt Lake City, Utah, and then to the station at Denver for rating, being used in May, 1890, by T. M. Bannon, in Utah. In 1891 it was returned to the Washington office, having been used only a few times. In June, 1895, it was sent to Arthur P. Davis and rated at the Denver station on July 6, finally being sent to Charles P. Ross, North Platte, Nebr., on October 31, 1895.

No. 2. Large Haskell meter, sent on July 26, 1889, to W. A. Farrish, Phœnix, Ariz., and on March 11, 1891, forwarded to Elwood Mead, Cheyenne, Wyo. From there returned to Denver, rated by A. P. Davis on May 24, 1895, and sent to L. G. Carpenter, Fort Collins, Colo.

No. 3. Large Haskell meter, originally sent from Washington to Frank Harrison at Santa Fe, N. Mex.; returned to Denver and sent to T. M. Bannon at Salt Lake City, Utah, stored there, and returned to Washington in 1891; has been used but a few times. Last rating is that of November 21, 1895, at the Kensington rating station.

No. 4. Large Haskell meter, originally sent to Denver, and forwarded, February 27, 1890, to F. M. Smith, Boise, Idaho. Used on the Idaho and Oregon rivers and later stored at Boise, Idaho. On May 26, 1895, rated at the Denver station by Arthur P. Davis and sent to Prof. O. P. Hood, Manhattan, Kans.

No. 5. Large Haskell meter, originally sent to Denver, Colo., and forwarded to T. M. Bannon, Salt Lake City, Utah; injured in service, repaired, and sent to J. B. Williams, Bozeman, Mont.; stored there and returned to Washington; has been used but little; rated by Cyrus C. Babb November 23, 1895, at the Kensington station.

No. 6. Large Haskell meter, originally sent to William Ham Hall, San Francisco, Cal., and used in the spring of 1890 by William P. Trowbridge, jr., in Nevada; later stored at Reno, forwarded to San Francisco in 1892, and returned to Washington in March, 1895; rated by Arthur P. Davis, July 6, 1895, at the Denver station; after having been altered for use from bridge, sent on July 15 to Prof. E. C. Murphy, Lawrence, Kans.; head lost while measuring the Neosho River at Iola, Kans., July 24, 1895, by driftwood catching upon it.

No. 7. Large Haskell meter, sent originally to J. B. Williams, Bozeman, Mont., the head lost in Gallatin River on May 26, 1890; new head made May, 1891, and later used in measurements of the Potomac at Chain Bridge, D. C.; rated on June 9, 1895, by Arthur P. Davis at the Denver station, fitted for use from bridge, and sent November 21, 1895, to Andrew J. Wiley, Grand View, Idaho.

No. 8. Large Haskell meter, retained at Washington and used during 1891 by Cyrus C. Babb in the Potomac measurements; the contact spring altered in 1891 so that direct connection was made with the wires; injury by use during the Potomac floods of June, 1894; rated on November 23, 1895, by Cyrus C. Babb at the Kensington station; issued December 14, 1895, to B. M. Hall, Atlanta, Ga.

No. 9. Large Haskell meter, sent originally to W. A. Farrish, Phœnix, Ariz., later stored there, and in 1891 returned to Washington; has been used but few times; rated last November 22, 1895, by Cyrus C. Babb, at the Kensington station.

No. 10. Large Haskell meter, sent originally to Denver, where it was rated and forwarded to L. D. Hopson, Eagle Rock, Idaho; later stored at Boise and sent to Denver, where it was altered for use from bridges; rated July 10, 1895, by Arthur P. Davis, at the Denver station and sent August 10, 1895, to Prof. E. C. Murphy, Lawrence, Kans.

No. 11. Large Haskell meter, formerly known as No. 1 A, being the first purchased by the United States Irrigation Survey. This was provided with heavy brass swivel and long tail. Originally sent to Embudo, N. Mex., and forwarded February 10, 1890, to W. A. Farrish, Phœnix, Ariz.; used there and later returned to Washington. In 1895, the meter was altered by the insertion of a small five-toothed wheel in front of the contact spring, so that the contact was made and broken for every five revolutions instead of for each revolution. This small wheel can be removed so that the meter records for single revolutions also. Rated on November 22, 1895, by Cyrus C. Babb, at the Kensington station. The rating with the five-spurred wheel inserted is a little less than five times that without the spur-wheel, being for 1 revolution per second, 5.07; 2 revolutions per second, 10.17; 3 revolutions per second, 15.27, and so on, 5.10 being added for each additional revolution per second.

No. 12. Large Haskell meter, with high and low velocity wheels. Originally purchased by Weather Bureau and loaned to this Survey June 14, 1895, marked 1 and 1a; rated August 20, 1895, by Cyrus C. Babb, at the Kensington station, and forwarded to Prof. D. C. Humphreys, Lexington, Va.

No. 13. Large Haskell meter, similar to No. 12. Loaned by Weather Bureau to this Survey June 14, 1895; rated August 21, 1895, by Cyrus C. Babb, at the Kensington station.

Rating table for high-pitch wheels[1] of small Haskell meters.

[Velocities in feet per second.]

Revolutions per second.	No. 14.	No. 15.	No. 20.	No. 21.	No. 22.	No. 23.	No. 24.	No. 25.	No. 26.	No. 27.	No. 28.	No. 29.
0.00	0.65	0.80	....	0.50	0.54	0.67	....	....	0.50	0.40	0.62	0.44
0.10	0.71	0.84	....	0.56	0.63	0.71	0.65	....	0.56	0.49	0.68	0.54
0.20	0.78	0.90	....	0.65	0.70	0.79	0.75	....	0.63	0.58	0.77	0.64
0.30	0.86	0.98	....	0.74	0.78	0.88	0.84	....	0.72	0.68	0.87	0.74
0.40	0.96	1.06	0.92	0.83	0.86	0.97	0.94	0.73	0.81	0.77	0.98	0.85
0.50	1.06	1.14	1.02	0.92	0.95	1.06	1.04	0.83	0.90	0.86	1.10	0.96
0.60	1.14	1.22	1.12	1.01	1.05	1.15	1.14	0.93	1.00	0.95	1.22	1.07
0.70	1.23	1.30	1.22	1.10	1.15	1.24	1.24	1.03	1.11	1.04	1.36	1.18
0.80	1.31	1.40	1.32	1.21	1.25	1.33	1.33	1.13	1.22	1.14	1.50	1.29
0.90	1.40	1.50	1.43	1.32	1.35	1.43	1.43	1.23	1.33	1.23	1.64	1.39
1.00	1.50	1.60	1.54	1.44	1.45	1.54	1.53	1.35	1.44	1.32	1.78	1.50
1.10	1.60	1.70	1.65	1.55	1.55	1.65	1.63	1.46	1.56	1.41	1.92	1.61
1.20	1.71	1.81	1.76	1.66	1.65	1.76	1.73	1.58	1.68	1.50	2.06	1.72
1.30	1.81	1.92	1.87	1.77	1.75	1.87	1.82	1.69	1.80	1.60	2.19	1.83
1.40	1.91	2.03	1.98	1.88	1.85	1.98	1.93	1.81	1.92	1.69	2.32	1.94
1.50	2.02	2.14	2.09	1.99	1.95	2.09	2.05	1.92	2.04	1.78	2.46	2.05
1.60	2.12	2.25	2.20	2.10	2.05	2.20	2.17	2.03	2.16	1.87	2.59	2.17
1.70	2.23	2.36	2.32	2.21	2.15	2.31	2.29	2.15	2.28	1.96	2.71	2.30
1.80	2.34	2.47	2.44	2.32	2.25	2.43	2.41	2.26	2.40	2.06	2.84	2.43
1.90	2.46	2.59	2.56	2.43	2.36	2.55	2.53	2.38	2.52	2.15	2.98	2.56
2.00	2.58	2.70	2.68	2.55	2.47	2.67	2.65	2.50	2.64	2.24	3.12	2.69
2.10	2.69	2.81	2.80	2.66	2.57	2.79	2.77	2.61	2.76	2.33	3.26	2.81
2.20	2.81	2.92	2.92	2.77	2.68	2.90	2.89	2.73	2.87	2.42	3.40	2.94
2.30	2.91	3.02	3.04	2.88	2.78	3.02	3.01	2.84	2.98	2.52	3.55	3.05
2.40	3.02	3.14	3.16	2.99	2.88	3.14	3.13	2.96	3.10	2.61	3.70	3.19
2.50	3.13	3.25	3.28	3.10	2.99	3.26	3.25	3.07	3.22	2.70	3.84	3.31
2.60	3.25	3.36	3.40	3.22	3.10	3.38	3.37	3.17	3.34	2.79	4.00	3.44
2.70	3.36	3.47	3.52	3.34	3.20	3.49	3.49	3.30	3.46	2.88	4.14	3.57
2.80	3.47	3.58	3.65	3.47	3.30	3.61	3.61	3.42	3.58	2.98	4.28	3.70
2.90	3.59	3.69	3.81	3.60	3.40	3.73	3.73	3.53	3.70	3.07	4.42	3.83
3.00	3.72	3.81	4.00	3.73	3.50	3.85	3.85	3.65	3.82	3.16	4.57	3.96
3.10	3.84	3.92	4.18	3.86	3.60	3.97	3.97	3.76	3.94	3.25	4.71	4.09
3.20	3.95	4.03	4.37	3.99	3.70	4.08	4.09	3.88	4.06	3.35	4.85	4.22
3.30	4.07	4.14	4.55	4.12	3.80	4.20	4.21	3.99	4.18	3.46	5.00	4.35
3.40	4.18	4.25	4.74	4.25	3.90	4.32	4.33	4.11	4.30	3.57	5.14	4.48
3.50	4.30	4.36	4.92	4.37	4.01	4.44	4.45	4.23	4.42	3.69	5.28	4.61
3.60	4.42	4.47	5.10	4.50	4.11	4.55	4.57	4.34	4.54	3.80	5.42	4.75
3.70	4.53	4.58	5.29	4.63	4.21	4.67	4.69	4.46	4.66	3.91	5.57	4.88
3.80	4.65	4.69	5.47	4.76	4.31	4.79	4.81	4.57	4.78	4.02	5.72	5.01
3.90	4.76	4.80	5.66	4.89	4.41	4.91	4.93	4.69	4.90	4.13	5.86	5.14
4.00	4.87	4.92	5.84	5.01	4.52	5.03	5.05	4.80	5.02	4.24	6.00	5.27
4.10	4.99	5.03	6.02	5.14	4.62	5.15	5.17	4.92	5.14	4.35	6.14	5.40
4.20	5.11	5.14	....	5.27	4.72	5.27	5.29	5.03	5.27	4.46	6.28	5.54
4.30	5.22	5.25	....	5.40	4.82	5.40	5.41	5.15	5.40	4.57	6.42	5.67
4.40	5.34	5.36	....	5.53	4.93	5.52	5.53	5.26	5.53	4.68	6.57	5.80
4.50	5.45	5.47	....	5.65	5.03	5.64	5.65	5.38	5.66	4.80	6.72	5.93
4.60	5.57	5.58	....	5.78	5.13	5.77	5.77	5.49	5.79	4.91	6.87	6.07
4.70	5.69	5.69	....	5.91	....	5.89	5.89	5.61	5.92	5.02	7.01	6.20
4.80	5.80	5.81	....	6.04	....	6.01	6.01	5.72	6.05	5.13	7.15	6.33
4.90	5.92	5.92	....	6.17	....	6.13	6.13	5.84	6.18	5.24	7.29	6.46
5.00	6.04	6.04	....	6.29	....	6.26	6.25	5.95	6.31	5.35	7.45	6.59
5.10	6.16	6.15	....	6.42	....	6.38	6.37	6.07	6.44	5.46	7.60	6.72
5.20	6.27	6.26	....	6.55	....	6.50	6.49	6.18	6.57	5.57	7.74	6.86
5.30	6.39	6.37	....	6.68	....	6.62	6.61	6.30	6.70	5.68	7.88	6.99
5.40	6.51	6.48	....	6.81	....	6.75	6.73	6.41	6.83	5.79	8.03	7.12
5.50	6.73	6.60	....	6.93	....	6.87	6.85	6.53	6.95	5.91	8.17	7.25
5.60	6.84	6.71	....	7.06	....	6.99	6.97	6.64	7.08	6.02	8.32	7.38
5.70	6.96	6.82	....	7.19	....	7.11	7.09	6.76	7.21	6.13	8.47	7.52
5.80	7.07	6.93	....	7.32	....	7.24	7.21	6.87	7.34	6.24	8.61	7.65
5.90	7.19	7.04	....	7.45	....	7.36	7.33	6.99	7.47	6.35	8.76	7.79

[1] For use in streams of slight or moderate velocity.

Rating tables for low-pitch wheel[1] *of small Haskell meters.*

[Velocities in feet per second.]

Revolutions per second.	No. 14	No. 15	No. 20	No. 21	No. 22	No. 23	No. 24	No. 25	No. 26	No. 27	No. 28	No. 29	No. 12 (*a*)	No. 13 (*a*)
0.9.....	0.90	0.90	......	0.73	0.84	0.90	......	......	0.90	0.40	0.70	0.75	0.35	0.40
0.10....	1.03	0.98	......	0.86	0.92	1.01	1.01	......	0.98	0.56	0.83	0.89	0.45	0.47
0.20....	1.17	1.08	......	1.00	1.05	1.15	1.17	......	1.08	0.72	0.97	1.03	0.59	0.60
0.30....	1.31	1.20	......	1.14	1.12	1.29	1.34	1.18	1.20	0.88	1.11	1.19	0.77	0.75
0.44....	1.45	1.32	1.32	1.28	1.25	1.43	1.50	1.33	1.33	1.04	1.25	1.35	0.98	0.90
0.50....	1.60	1.44	1.46	1.42	1.42	1.57	1.66	1.48	1.50	1.21	1.49	1.51	1.18	1.08
0.60....	1.75	1.57	1.60	1.55	1.58	1.71	1.82	1.64	1.66	1.37	1.65	1.68	1.39	1.29
0.70....	1.90	1.72	1.74	1.69	1.74	1.85	1.98	1.79	1.82	1.53	1.83	1.86	1.59	1.50
0.80....	2.05	1.87	1.89	1.83	1.90	2.01	2.14	1.94	2.00	1.69	2.00	2.06	1.80	1.71
0.90....	2.21	2.03	2.05	1.97	2.08	2.20	2.30	2.10	2.19	1.85	2.18	2.26	2.00	1.92
1.00....	2.37	2.20	2.21	2.11	2.26	2.39	2.47	2.25	2.38	2.01	2.35	2.46	2.21	2.13
1.10....	2.51	2.38	2.38	2.27	2.45	2.58	2.63	2.40	2.57	2.17	2.53	2.66	2.41	2.34
1.20....	2.67	2.56	2.55	2.44	2.62	2.77	2.79	2.56	2.76	2.33	2.71	2.86	2.62	2.55
1.30....	2.83	2.74	2.73	2.60	2.79	2.96	2.96	2.71	2.95	2.49	2.89	3.06	2.82	2.76
1.40....	2.99	2.92	2.91	2.77	2.95	3.15	3.12	2.86	3.14	2.65	3.07	3.26	3.03	2.97
1.50....	3.15	3.10	3.09	2.94	3.11	3.34	3.28	3.02	3.33	2.82	3.25	3.46	3.23	3.18
1.60....	3.32	3.28	3.26	3.10	3.28	3.53	3.44	3.17	3.52	2.98	3.43	3.66	3.44	3.39
1.70....	3.50	3.46	3.44	3.27	3.46	3.72	3.60	3.32	3.71	3.16	3.61	3.86	3.65	3.60
1.80....	3.68	3.64	3.61	3.43	3.64	3.91	3.77	3.51	3.91	3.33	3.80	4.07	3.85	3.81
1.90....	3.86	3.82	3.79	3.60	3.82	4.10	3.93	3.70	4.11	3.51	3.98	4.28	4.06	4.02
2.00....	4.05	4.00	3.97	3.77	4.00	4.29	4.09	3.89	4.31	3.68	4.17	4.50	4.26	4.23
2.10....	4.24	4.18	4.15	3.93	4.20	4.48	4.25	4.08	4.51	3.85	4.36	4.72	4.47	4.44
2.20....	4.44	4.37	4.32	4.10	4.40	4.67	4.44	4.27	4.71	4.03	4.56	4.94	4.67	4.65
2.30....	4.64	4.56	4.50	4.26	4.60	4.86	4.61	4.46	4.91	4.20	4.76	5.16	4.88	4.86
2.40....	4.84	4.75	4.67	4.42	4.80	5.05	4.81	4.65	5.11	4.38	4.96	5.38	5.09	5.07
2.50....	5.04	4.94	4.85	4.59	5.00	5.24	5.00	4.84	5.31	4.55	5.16	5.60	5.30	5.28
2.60....	5.24	5.13	5.02	4.77	5.20	5.44	5.19	5.03	5.51	4.72	5.35	5.82	5.50	5.49
2.70....	5.44	5.32	5.20	4.96	5.40	5.65	5.38	5.22	5.71	4.90	5.55	6.04	5.70	5.70
2.80....	5.64	5.51	5.37	5.14	5.61	5.86	5.56	5.41	5.91	5.07	5.75	6.26	5.91	5.91
2.90....	5.83	5.69	5.55	5.32	5.82	6.07	5.75	5.60	6.11	5.25	5.94	6.48	6.11	6.12
3.00....	6.03	5.88	5.73	5.50	6.03	6.27	5.95	5.78	6.30	5.42	6.14	6.70	6.31	6.33
3.10....	6.23	6.07	5.91	5.68	6.23	6.49	6.16	5.97	6.50	5.59	6.33	6.92	6.52	6.55
3.20....	6.43	6.27	6.10	5.86	6.44	6.70	6.36	6.16	6.71	5.77	6.53	7.14	6.72	6.77
3.30....	6.62	6.46	6.29	6.04	6.64	6.91	6.57	6.35	6.92	5.94	6.72	7.36	6.93	6.99
3.40....	6.82	6.65	6.48	6.22	6.85	7.12	6.77	6.54	7.13	6.12	6.92	7.58	7.13	7.21
3.50....	7.02	6.85	6.68	6.41	7.05	7.33	6.97	6.73	7.34	6.29	7.11	7.80	7.34	7.43
3.60....	7.21	7.05	6.88	6.59	7.25	7.55	7.18	6.92	7.54	6.46	7.31	8.02	7.55	7.65
3.70....	7.41	7.24	7.08	6.77	7.46	7.77	7.39	7.11	7.75	6.64	7.51	8.24	7.75	7.87
3.80....	7.61	7.44	7.28	6.95	7.66	7.98	7.59	7.30	7.96	6.81	7.70	8.46	7.96	8.09
3.90....	7.80	7.64	7.48	7.13	7.86	8.20	7.79	7.49	8.17	6.99	7.89	8.68	8.17	8.31
4.00....	8.00	7.84	7.68	7.32	......	8.41	8.00	7.67	8.38	7.16	8.10	8.90	8.37	8.53
4.10....	8.20	8.04	7.88	7.50	......	8.62	8.21	7.86	8.59	7.33	8.30	9.12	8.58	8.75
4.20....	8.40	8.23	8.08	7.68	......	8.84	8.41	8.05	8.80	7.51	8.50	9.34	8.78	8.97
4.30....	8.60	8.43	8.28	7.86	......	9.05	8.62	8.24	9.01	7.68	8.70	9.56	8.99	9.19
4.40....	8.80	8.62	8.48	8.04	......	9.27	8.82	8.43	9.22	7.86	8.90	9.78	9.19	9.41
4.50....	9.00	8.82	8.68	8.23	......	9.48	9.03	8.62	9.43	8.03	9.10	10.00	9.40	9.63
4.60....	9.20	9.02	8.88	8.41	......	9.69	9.23	8.81	9.64	8.20	9.30	10.22	9.60	9.85
4.70....	9.40	9.21	9.08	8.59	......	9.90	9.44	9.00	9.85	8.38	9.50	10.44	9.81	10.07
4.80....	9.60	9.41	9.28	8.77	......	10.11	9.64	9.19	10.06	8.55	9.70	10.66	10.02	10.29
4.90....	9.80	9.60	9.48	8.95	......	10.33	9.85	9.38	10.27	8.73	9.90	10.88	10.23	10.51
5.00....	10.00	9.80	9.68	9.14	......	10.54	10.05	9.56	10.48	8.90	10.10	11.10	10.44	10.73
5.10....	10.20	10.00	9.88	9.32	......	10.75	10.26	9.75	10.69	9.07	10.30	11.32	10.64	10.95
5.20....	10.40	10.20	10.08	9.50	......	10.97	10.46	9.94	10.90	9.25	10.50	11.54	10.85	11.17
5.30....	10.60	10.40	10.28	9.68	......	11.18	10.67	10.13	11.11	9.42	10.70	11.76	11.05	11.39
5.40....	10.80	10.60	10.48	9.86	......	11.40	10.88	10.32	11.32	9.60	10.90	11.98	11.26	11.61
5.50....	11.00	10.80	10.68	10.05	......	11.61	11.08	10.51	11.53	9.77	11.10	12.20	11.47	11.83
5.60....	11.20	11.00	10.88	10.23	......	11.83	11.28	10.70	11.74	9.94	11.30	12.42	11.67	12.05
5.70....	11.40	11.20	11.08	10.41	......	12.04	11.49	10.89	11.95	10.12	11.50	12.64	11.88	12.27
5.80....	11.60	11.40	11.28	10.59	......	12.25	11.69	11.08	12.16	10.29	11.70	12.86	12.09	12.49
5.90....	11.80	11.60	11.48	10.77	......	12.46	11.90	11.27	12.37	10.47	11.90	13.08	12.29	12.71

[1] For use in streams of great velocity.

a Rating for wheels of less curvature for use in water of greater velocity.

No. 14. Small Haskell meter, with high and low velocity wheels; originally No. 4 of Weather Bureau. Sent to Arthur P. Davis, at Denver, June, 1895; rated by him and issued to F. Cogswell, deputy State engineer.

No. 15. Small Haskell meter, similar to No. 14; originally No. 5 of Weather Bureau. Sent to Arthur P. Davis, June, 1895; rated at the Denver station and forwarded to G. F. Sherman, Boise, Idaho.

No. 16. Large Haskell meter used in Georgia, received from B. M. Hall, December 14, 1895, for repairs and rating.

No. 17. Large Haskell meter, formerly known as 1. D., originally sent to Denver; rated and forwarded to J. B. Williams, Bozeman, Mont., May 27, 1890; wheel lost in June and replaced in July; injured by use in Potomac, April 4, 1891, and sent to shop for repairs; exhibited at the World's Fair in 1893, and sent to A. P. Davis, Denver, Colo., in 1895; rated at Denver, and sent to E. C. Murphy, Lawrence, Kans., to replace lost meter No. 6.

No. 18. Small Price acoustic meter. Maker's No. 12. Purchased by Office of Indian Affairs; rated at Kensington station, November, 1895, and used in Arizona by Arthur P. Davis.

No. 19. Small Price acoustic meter. Maker's No. 3. Purchased in June, 1895, and issued to W. G. Russell, Russell, Kans., without rating. The rating formula obtained with the instrument was $V = 2.6$ R. Later the rating for meter of same make numbered 4, obtained from W. G. Price, was used in computations of discharge. This rating is given in the accompanying table under the head of No. 19. This formula, $V = 2.6$ R., was used for computations of discharge of Saline River, June 8; Smoky Hill River, June 5 and July 3; Arkansas River at Hutchinson, June 20; Medicine River, June 21; Cimarron River, June 24.

No. 20. Small Haskell meter, received April, 1892; rated June 3, 1892, by Cyrus C. Babb in the Aqueduct reservoir; issued August 20, 1892, to T. M. Bannon, and sent December, 1892, to Arthur P. Davis, Los Angeles, Cal.; rated at Lawrence, Mass., March 12, 1895, by Cyrus C. Babb, and mailed in April, 1895, to Prof. A. M. Ryon, Bozeman, Mont.

No. 21. Small Haskell meter, received April 4, 1892, from manufacturers; loaned to Prof. Thomas Russell, Weather Bureau, June 6, 1892; rated and used by him; later used by E. E. Haskell, in September, 1894; altered for use from bridge, extra tail added, and the whole nickel plated; used by F. H. Newell in October and November, 1894; rated November 21, 1895, by Cyrus C. Babb, at Kensington station.

No. 22. Small Haskell meter, received from shop March 29, 1892; rated June 6, 1892, by Cyrus C. Babb, in the Aqueduct reservoir; exhibited at the World's Fair in 1893; mailed to F. H. Newell at Denver November 1, 1894; altered for use from bridge, extra tail added, and nickel plated in September, 1894; October 29, 1894, issued to Prof. Samuel Fortier.

No. 23. Small Haskell meter, received from shop March 29, 1892; rated June 11, 1892, by Cyrus C. Babb in the Aqueduct reservoir; issued to Prof. C. N. Brown, Columbus, Ohio, February 10, 1893; returned December 13, 1893; sent to Charles P. Ross, North Platte, Nebr., September 15, 1894, and forwarded by him to V. C. Tompkins, June 12, 1895; November 20, 1895, rated by Cyrus C. Babb and returned to G. F. Sherman, Boise, Idaho.

No. 24. Small Haskell meter, received from shop March 29, 1892, rated by Cyrus C. Babb at the Aqueduct reservoir June 14, 1892; rated at Denver January 4, 1893; used by F. H. Newell in fall of 1893; altered for use from bridge; extra tail added and nickel plated at Denver, October, 1894; sent to J. B. Lippincott, Los Angeles, Cal., February 14, 1895.

No. 25. Small Haskell meter, received from shop March 29, 1892; rated by Cyrus C. Babb June 28, 1892, in Aqueduct reservoir; issued to Walter James, Bakersville, Cal., May 13, 1892; rated November 16, 1893; nickel plated and altered for use from bridge January, 1895; rated by Cyrus C. Babb March 19, 1895; issued to P. E. Harroun, Santa Fe, N. Mex., March, 1895.

No. 26. Small Haskell meter, received from shop March 29, 1892; rated by Cyrus C. Babb June 17, 1892, in Aqueduct reservoir; issued to William P. Trowbridge, jr., November, 1892, and stored at Boise, Idaho; used by V. C. Tompkins in 1895; lost in Payette River; recovered after several months; returned to Washington, and rated by Cyrus C. Babb November 20, 1895, at Kensington station; sent to P. E. Harroun, Santa Fe, N. Mex.

No. 27. Small Haskell meter, received from shop April 4, 1892; rated by Cyrus C. Babb, June 2, 1892, at Aqueduct reservoir; issued to Samuel Storrow, North Yakima, Wash., February 24, 1893; returned December 14, 1895, in bad order.

No. 28. Small Haskell meter, received from shop April 4, 1892; rated by Cyrus C. Babb June 20, 1892, at Aqueduct reservoir; issued to E. M. Douglas July 2, 1892; returned April 26, 1893; altered for use from bridge and nickel plated January, 1895; used by Arthur P. Davis and issued to W. G. Russell, Russell, Kans., July 15, 1895.

No. 29. Small Haskell meter, received from shop April 4, 1892; rated by Cyrus C. Babb June 1, 1892, at Aqueduct reservoir; rated again by Cyrus C. Babb at Denver, January 5, 1892; used by F. H. Newell, returned to Washington, sent to R. H. Chapman November, 1894; altered for use from bridge and nickel plated January, 1895; rated by Cyrus C. Babb at Lawrence, Mass., March 8, 1895, and used by Cyrus C. Babb.

Rating tables for Price and other meters.

[Velocities in feet per second.]

Revolutions per second.	No. 54.	No. 55.	No. 60.	No. 61.	No. 62.	No. 63.	No. 18.	No. 19.	No. 76.	No. 77.	No. 78.
0.00	0.14	0.20	0.15	0.20	0.20	0.20	0.10	0.03	0.15	0.17	....
0.10	0.46	0.48	0.45	0.49	0.49	0.50	0.33	0.27	0.52	0.36	....
0.20	0.77	0.75	0.76	0.80	0.78	0.79	0.56	0.52	0.88	0.56	0.88
0.30	1.08	1.05	1.08	1.10	1.07	1.09	0.79	0.77	1.25	0.76	1.17
0.40	1.40	1.36	1.40	1.40	1.36	1.39	1.02	1.00	1.61	0.96	1.47
0.50	1.71	1.67	1.72	1.72	1.65	1.68	1.25	1.25	1.98	1.16	1.76
0.60	2.02	1.98	2.03	2.03	1.94	1.98	1.48	1.48	2.34	1.36	2.06
0.70	2.33	2.29	2.35	2.43	2.23	2.28	1.71	1.72	2.71	1.56	2.35
0.80	2.64	2.60	2.67	2.74	2.52	2.57	1.94	1.96	3.07	1.76	2.65
0.90	2.95	2.90	2.99	3.06	2.81	2.87	2.17	2.20	3.44	1.96	2.94
1.00	3.25	3.20	3.31	3.38	3.10	3.17	2.40	2.44	3.80	2.16	3.24
1.10	3.55	3.50	3.62	3.70	3.39	3.47	2.63	2.69	4.17	2.35	3.53
1.20	3.85	3.81	3.94	4.02	3.68	3.76	2.86	2.93	4.53	2.55	3.82
1.30	4.15	4.11	4.26	4.34	3.97	4.06	3.09	3.17	4.90	2.75	4.12
1.40	4.44	4.42	4.58	4.67	4.26	4.36	3.32	3.41	5.26	2.95	4.41
1.50	4.74	4.73	4.90	5.00	4.55	4.65	3.55	3.64	5.63	3.15	4.71
1.60	5.03	5.04	5.22	5.33	4.84	4.95	3.78	3.88	5.99	3.35	5.00
1.70	5.32	5.34	5.54	5.66	5.13	5.25	4.01	4.12	6.36	3.55	5.30
1.80	5.61	5.64	5.86	5.98	5.42	5.54	4.24	4.36	6.72	3.75	5.59
1.90	5.89	5.95	6.18	6.30	5.71	5.84	4.47	4.59	7.09	3.95	....
2.00	6.18	6.25	6.50	6.64	6.00	6.14	4.70	4.83	7.45	4.15	....
2.10	6.47	6.55	6.82	6.98	6.29	6.44	4.93	5.07	7.82	4.34	....
2.20	6.75	6.85	7.14	7.31	6.58	6.73	5.16	5.30	8.18	4.54	....
2.30	7.03	7.16	7.46	7.65	6.87	7.03	5.39	5.54	8.55	4.74	....
2.40	7.31	7.46	7.78	7.98	7.16	7.33	5.62	5.78	8.91	4.94	....
2.50	7.59	7.77	8.10	8.32	7.45	7.62	5.85	6.01	9.28	5.14	....
2.60	7.87	8.08	8.42	8.66	7.74	7.92	6.08	6.25	9.64	5.34	....
2.70	8.15	8.38	8.74	8.99	8.03	8.22	6.31	6.49	10.01	5.5[illegible]	....
2.80	....	8.69	9.06	9.33	8.32	8.51	6.54	6.72	10.37	5.7[illegible]	....
2.90	....	9.00	9.38	9.67	8.61	8.81	6.77	6.96	10.74	5.94	....
3.00	....	9.30	9.70	10.00	8.90	9.11	7.00	7.19	11.10	....	....
3.10	....	9.60	10.02	10.34	9.19	9.41	7.23	7.43	11.47	....	....
3.20	....	9.90	10.34	10.67	9.48	9.70	7.46	7.67	11.83	....	....
3.30	....	10.21	10.66	11.01	9.77	10.00	7.69	7.90	12.20	....	....
3.40	....	10.52	10.98	11.35	10.06	10.30	7.92	8.14	12.56	....	....
3.50	....	10.83	11.30	11.69	10.35	10.59	8.15	8.38	12.93	....	....
3.60	....	11.13	11.62	12.02	10.64	10.89	8.38	8.62	13.29	....	....
3.70	....	11.43	11.94	12.39	10.93	11.19	8.61	8.85	13.66	....	....
3.80	....	11.74	12.26	12.69	11.22	11.48	8.84	9.09	14.02	....	....
3.90	....	12.04	12.58	13.03	11.51	11.78	9.07	9.32	14.39	....	....
4.00	....	12.35	12.90	13.36	11.80	12.08	9.30	9.56	14.75	....	....
4.10	....	12.65	13.22	....	12.09	12.38	9.53	9.80	15.12	....	....
4.20	....	12.95	13.54	....	12.38	12.67	9.76	10.03	15.48	....	....
4.30	....	13.26	13.86	....	12.67	12.97	9.99	10.26	15.85	....	....
4.40	....	13.57	14.18	....	12.96	13.27	10.22	10.49	16.21	....	....
4.50	....	13.88	14.50	....	13.25	13.56	10.45	10.73	16.58	....	....
4.60	....	14.18	14.82	....	13.54	13.86	10.68	10.97	16.94	....	....
4.70	....	14.48	15.14	....	13.83	14.16	10.91	11.20	17.31	....	....
4.80	....	14.79	15.46	....	14.12	14.45	11.14	11.44	17.67	....	....
4.90	....	15.09	15.78	....	14.41	14.75	11.37	11.67	18.04	....	....
5.00	....	15.40	16.10	....	14.70	15.05	11.60	11.91	18.40	....	....

No. 54. Rating card published by W. & L. E. Gurley as mean of several ratings of 6-inch wheel of Price meter.

No. 55. Large Price electric meter, from A. M. Ryon, Bozeman, Mont.; rated by Arthur P. Davis at Denver, May 27, 1895; used by him and issued to Samuel Storrow, North Yakima, Wash., August 20, 1895.

No. 60. Large Price electric meter, received June, 1895, and forwarded to Prof. A. M. Ryon, Bozeman, Mont.; rated October 27, 1895, by J. S. J. Lallie at Denver station and returned to Professor Ryon.

No. 61. Large Price electric meter, received in July, 1895, and issued to A. P. Davis in August, 1895.

No. 62. Large Price electric meter, received in July, 1895, and issued to Arthur P. Davis.

No. 63. Large Price electric meter, received December 18, 1895, rated by Cyrus C. Babb at the Kensington station, sent December 12, 1895, to J. B. Lippincott, Los Angeles, Cal.

No. 75. Old-style Colorado meter, manufactured by Scott, Denver, used largely in 1888, 1889, and 1890 until worn out.

No. 76. Buff & Berger meter, maker's No. 2154. A meter of this type is described and illustrated in Buff & Berger's catalogue for 1895, pages 135, 136, being style No. IV, used for measurements on the Connecticut River by General Ellis. This meter was received in July, 1895, and has been used in the measurements of Eastern rivers. Rated August 17, 1895, at Kensington station.

No. 77. English meter used by Prof. D. C. Humphreys.

No. 78. Large Price electric meter, property of department of civil engineering, University of Nebraska; used by O. V. P. Stout; rated April 27, 1895, at Lincoln Park, Lincoln, Nebr. Rating equation is $v = 2.945\, r + 0.29$.

Rating tables for self-recording or Lallie meters.

[Velocities in feet per second.]

Revolutions per second.	No. 100.	No. 102.	No. 103.	No. 104.	No. 106.	No. 108.	No. 109.	No. 110.
0.00	0.07	0.06	....	0.05	0.00	0.10	0.02	0.00
0.10	0.44	0.44	0.69	0.88	0.40	0.50	0.42	0.41
0.20	0.82	0.82	1.03	1.26	0.81	0.90	0.82	0.83
0.30	1.20	1.20	1.37	1.64	1.22	1.30	1.22	1.24
0.40	1.58	1.58	1.71	2.02	1.62	1.70	1.62	1.66
0.50	1.96	1.97	2.05	2.41	2.03	2.10	2.03	2.07
0.60	2.33	2.35	2.40	2.79	2.43	2.50	2.43	2.49
0.70	2.71	2.73	2.77	3.17	2.84	2.90	2.83	2.90
0.80	3.09	3.11	3.15	3.55	3.24	3.30	3.23	3.32
0.90	3.47	3.49	3.53	3.93	3.65	3.70	3.63	3.73
1.00	3.85	3.88	3.90	4.32	4.06	4.10	4.04	4.15
1.10	4.22	4.26	4.28	4.70	4.46	4.50	4.44	4.56
1.20	4.60	4.64	4.66	5.08	4.86	4.84	4.84	4.98
1.30	4.98	5.02	5.04	5.46	5.27	5.19	5.24	5.39
1.40	5.32	5.41	5.42	5.84	5.65	5.53	5.64	5.78
1.50	5.65	5.79	5.80	6.23	6.00	5.88	6.05	6.15
1.60	6.01	6.17	6.18	6.61	6.35	6.22	6.45	6.52
1.70	6.37	6.55	6.56	6.99	6.70	6.57	6.77	6.88
1.80	6.73	6.93	6.94	7.37	7.05	6.91	7.10	7.25
1.90	7.08	7.32	7.32	7.75	7.40	7.26	7.42	7.62
2.00	7.40	....	7.70	8.14	7.75	7.60	7.75	7.99
2.10	7.74	....	8.08	....	8.10	7.94	8.07	8.35
2.20	8.07	....	8.46	....	8.45	8.29	8.40	8.72
2.30	8.39	....	8.84	....	8.80	8.63	8.72	9.09
2.40	8.71	....	9.22	....	9.15	8.98	9.05	9.45
2.50	9.05	....	9.60	....	9.50	9.32	9.37	9.82

No. 100. Bailey meter, used by Robert Robertson in 1890, and then by W. A. Farish on Gila River; March 11, 1890, sent to Elwood Mead, Cheyenne, Wyo.; in October, 1894, repaired at Denver, rated and sent to L. H. Taylor, Reno, Nev.

No. 101. Bailey meter, used by W. A. Farish, Phœnix, Ariz., in 1891; returned to Washington in 1893; repaired at Denver; rated and sent to Prof. Samuel Fortier, Logan, Utah; returned to Denver, needing repairs, in 1895.

No. 102. Bailey meter, used in Idaho and stored at Boise City.

No. 103. Bailey meter, used by T. M. Bannon in 1891, sent to Washington in 1893, and later issued to Prof. Samuel Fortier, Logan, Utah.

No. 104. Bailey meter, used at El Paso, Tex., by H. M. Dyar, and later by W. B. Lane on the Rio Grande; loaned to E. C. Van Diest, San Luis, Colo., repaired at Denver in 1893, issued to Prof. Elwood Mead, Cheyenne, Wyo., and reported to be worn out.

No. 105. Bailey meter, used by Robert Robertson in 1890; stored at Denver, Colo.; sent to Washington in 1892; exhibited at the World's Fair, 1893; repaired in Denver, 1893; used in Wyoming; repaired again and later issued to Prof. O. V. P. Stout, Lincoln, Nebr.

No. 106. Bailey meter, used by T. M. Bannon; stored at Salt Lake City, Utah; returned to Washington in 1891; repaired and sent January 9, 1892, to Prof. S. Fortier, Ogden.

No. 108. Bailey meter, sent to William Ham Hall in 1889 and used by William P. Trowbridge, jr., on the Truckee River, Nevada; stored at Reno, Nev., 1891, at San Francisco, 1892; shipped to Washington in January, 1895; rated November 18, 1895, by Cyrus C. Babb at Kensington station.

No. 109. Bailey meter, used by W. A. Farish on the Gila River; repaired at Denver in 1891; returned to Farish; stored at Phœnix, Ariz.; sent to Washington, June 10, 1891; repaired by S. J. Kübel; used by F. H. Newell in 1892, also in 1893; repaired in October, 1894, at Denver; issued to P. E. Harroun in 1895; rated by J. S. J. Lallie, December 9, 1895, at the Denver station and returned to Harroun.

No. 110. Bailey meter, used in 1891 by T. M. Bannon and again in 1893; sent to Denver for repairs; rated January 16, 1892, by Cyrus C. Babb at the Denver station.

The meters from Nos. 100 to 110, inclusive, consist of a lot of ten, made by Lallie & Bailey, at Denver, Colo., being improvements on the old Colorado meter devised and used by E. S. Nettleton, State engineer.

DRAINAGE AREA MEASUREMENTS.[1]

		Sq. miles.
American Fork, near American Fork, Utah		66
Animas River at Durango, Colo		812
Arkansas River, East Fork, near Leadville, Colo		44
Arkansas River, Lake Fork, near Leadville, Colo		21
Arkansas River, Tennessee Fork		44
Arkansas River at Granite, Colo		425
Arkansas River at Salida (above South Fork)		1,160
Arkansas River at Canyon City, Colo		3,060
Arkansas River at Swallows, Colo		4,300
Arkansas River at Pueblo, Colo		4,600
Arkansas River at La Junta, Colo. (including Fountain Creek drainage, 1,011 square miles)		12,200
Arkansas River at railroad bridge above Holly, Colo. (including Animas River 7,3,33 square miles)		23,500
Arkansas River at Colorado-Kansas State line		24,600
Arkansas River at Hutchinson, Kans		34,000
Bear Creek at Morrison, Colo		170
Bear River at Battle Creek, Idaho		4,500
Bear River at Collinston, Utah		6,000
Boulder Creek, South, at South Boulder Canyon, near Marshall, Colo		125
Boulder Creek North at Boulder, Colo		179
Boulder Creek near Boulder, Colo		102
Blue River in Kansas	2,450	
Blue River in Nebraska	7,040	
		9,490
Cache la Poudre River above Fort Collins, Colo		1,060
Caliente Creek—		
Tehachapi Creek	108	
Caliente Creek proper	219	
Basin Creek	96	
		423
Canadian River in Kansas	5,110	
Canadian River in New Mexico	16,900	
Canadian River in Texas	18,620	
		40,630
Cape Fear River at Fayetteville, N. C		4,493
Carson River, east, at Rodenbahs, Nevada		414
Carson River, west, at Woodfords, Cal		70
Carson River near Empire, Nev		894
Catawba River at Fort Mill, S. C		2,987
Chama River at Abiquiu, N. Mex		2,300
Chattahoochee at Oakdale, Ga		1,560
Cheyenne River in Montana[2]	3,750	
Cheyenne River in Nebraska	17,910	
Cheyenne River in North Dakota	39,770	
Cheyenne River in South Dakota	40,840	
Cheyenne River in Wyoming	12,030	
		114,300
Chowchilla Creek above sec. 1, T. 9 S., R. 18 E		268
Cimarron at Arkalon, Kans		5,200

[1] A number of drainage areas not given in this table are to be found on pages 107 to 110 of the Eleventh Annual Report, Part II.

[2] Thirteenth Annual Report, Part III, page 33; area in square miles of principal drainage basins by States.

		Sq. miles.
Clear Creek near Granite, Colo		72
Colorado River in Arizona	56,182	
Colorado River in California	8,610	
Colorado River in Colorado	5,490	
Colorado River in Nevada	3,200	
Colorado River in New Mexico	19,000	
Colorado River in Utah	21,633	
		114,115
Colorado River at Yuma, Ariz		225,049
Columbia River in Oregon[1]		24,093
Columbia River in Idaho[1]	7,880	
Columbia River in Montana	25,000	
Columbia River in Washington	26,160	
		59,040
Connecticut River at Hartford, Conn		10,234
Cottonwood Creek, South Fork, near Buena Vista, Colo		28
Cottonwood Creek, Middle Fork, near Buena Vista, Colo		37
Dolores River at Dolores, Colo		562
Falls River, 5 miles above mouth, Idaho		594
Fort Tejon Creek, including Cuddy Creek and Castac Lake (upper basin, 56)		93
French Broad River at Asheville, N. C		987
Gallatin River at Logan, Mont		1,620
Gila River at Buttes, Ariz		13,750
Gila River, including small lost basins, in Arizona[1]	56,838	
Gila River, including small lost basins, in New Mexico	14,300	
		71,138
Grand River at Glenwood Springs, Colo		5,838
Grand River at Grand Junction, above Gunnison River, Colo		8,644
Grand River at Grand Junction, below Gunnison River (including, above Uncompahgre, 497 square miles, and Gunnison, at mouth, 7,935 square miles)		16,579
Grand River in Colorado[1]	22,294	
Grand River in Utah	3,873	
		26,167
Great Basin in California[1]	47,240	
Great Basin in Idaho	3,420	
Great Basin in Nevada	102,220	
Great Basin in Oregon	18,950	
Great Basin in Utah	43,548	
Great Basin in Wyoming	1,494	
		216,872
Green River in Colorado[1]	10,332	
Green River in Utah	15,916	
Green River in Wyoming	20,977	
		47,225
Gunnison River at Grand Junction, Colo		7,935
Henry Fork 1 mile above mouth Falls River, Idaho		931
Humboldt River at Elko, Nev		2,840
Humboldt River at Golconda, Nev		10,780
Jefferson River at Threeforks, Mont		9,400
Kansas River at Lawrence, Kans		59,841
Kansas River in Kansas	34,526	
Kansas River in Nebraska	17,455	
Kansas River in Colorado	9,459	
		61,440

[1] Thirteenth Annual Report, Part III, page 33; area in square miles of principal drainage basins by States.

		Sq. miles.
Kaweah River above section 3, T. 18 S., R. 27 E., Cal		619
Kern River at first point of measurement above Bakersfield, Cal., including—		
North Fork	1,115	
South Fork	1,050	
Lower Basin	180	
		2,345
Kings River		1,742
Laramie River above Woods Landing, Wyoming (in Colorado, 343)		435
Laramie River at Uva, Wyo. (including in Colorado 428)		3,179
Laramie River at mouth at Fort Laramie (not including 500 square miles of lost drainage to James Lake, Cooper Lake, etc.)		4,076
Loup River, Middle, at St. Paul, Nebr		6,849
Loup River, North, at St. Paul, Nebr		4,024
Loup River at Columbus, Nebr		13,542
Madison River at Redbluff, Mont		2,085
Madison River at Threeforks, Mont		2,402
Malheur River at Vale, Oreg		9,900
Medicine River at Kiowa, Kans		1,300
Merced River above Merced Falls		1,076
Middle Creek, near Bozeman, Mont		55
Missouri River at Canyon Ferry, Mont		15,036
Missouri River at Craig, Mont		17 615
Missouri River, above Yellowstone, in Montana[1]	81,018	
Missouri River, above Yellowstone, in Wyoming	760	
		81,778
Natches River at North Yakima, Wash		1,000
North Platte River, above Sweetwater (including, in Colorado, 1,696)		7,668
North Platte River above Douglas, Wyo		14,255
North Platte River above Orrin Junction, Wyo		14,828
North Platte River above Fort Laramie, Wyo		16,416
North Platte River below Laramie River, Wyo		20,492
North Platte River in Wyoming and Colorado		23,643
North Platte River to North Platte, Nebr		28,517
Ocmulgee River at Macon, Ga		2,425
Ogden River at Powder Mills, Utah		360
Owyhee River at Ontario, Oreg		9,875
Piedras River at Arboles, Colo		650
Platte River at North Platte:		
North Platte River	28,517	
South Platte River	23,294	
		51,811
Platte River at Columbus, Nebr		56,867
Platte River, north and south, in Colorado[1]	22,230	
Platte River in Nebraska	10,850	
Platte River in Wyoming	24,240	
		57,320
Potomac River, North Branch, above Bloomington, Md		293
Potomac River, North Branch, at Piedmont, W. Va. (including Savage Creek, 111)		409
Potomac River, North Branch, at Cumberland, Md. (including New Creek at mouth at Keyser, W. Va., 56)		891
Potomac River, North Branch, at junction with South Branch (including Patterson Creek at Burlington, below Mill Creek, 155, and at mouth, 279)		1,365

[1] Thirteenth Annual Report, Part III, page 33; area in square miles of principal drainage basins by States.

		Sq. miles.
Potomac River, South Branch, at junction with North Fork (including at Franklin, 188)		318
Potomac River, South Branch, including North Fork (including North Fork below Seneca Creek, 240, and at mouth, 322)		640
Potomac River, South Branch, at Moorefield, W. Va. (including Mill Creek at mouth, 101)		897
Potomac River, South Branch, below Moorefield (including South Fork at Fort Seybert, W. Va., 155, and at mouth at Moorefield, 301)		1,198
Potomac River, South Branch, at Romney, W. Va		1,407
Potomac River, South Branch, at United States Geological Survey station at railway bridge, between Romney and Springfield, W. Va		1,443
Potomac River, South Branch, at mouth		1,487
Potomac River at junction of North and South branches		2,852
Potomac River above Great Cacapon River (including Little Cacapon River, 117)		3,388
Potomac River below Great Cacapon River (including Great Cacapon above North River, 404, and at mouth, 671)		4,059
Potomac River at Hancock, W. Va		4,099
Potomac River at Williamsport, Md. (including Warm Spring Creek at mouth, 16; Conoloway Creek, 125; Sleepy Creek, 146; Licking Creek, 195; Back Creek, 288, and Conococheaque Creek, 579)		5,556
Potomac River at Harpers Ferry, W. Va. (including Opequon Creek, 335; Antietam Creek, 305)		6,354
Potomac River below Harpers Ferry, W. Va. (including Shenandoah River, 3,009)		9,363
Potomac River at Weverton, Md		9,397
Potomac River at Point of Rocks, Md		9,654
Potomac River at Edwards Ferry, below Goose Creek (including Monocacy River at mouth, 557, and Goose Creek, 384)		10,716
Potomac River at Great Falls, Md. (including Seneca Creek, 132)		11,043
Potomac River at Chain Bridge, District of Columbia		11,161
Prosser Creek at Boca, Cal		55
Provo River at Provo, Utah		640
Purgatoire Creek at Las Animas, Colo		3,040
Red Rock Creek at Redrock, Mont		1,330
Republican River in Colorado	7,926	
Republican River in Nebraska	10,415	
Republican River in Kansas	7,496	
		25,837
Rio Grande at Del Norte, Colo		1,400
Rio Grande at Embudo, N. Mex		7,000
Rio Grande at El Paso, Tex		30,000
Rio Grande in Colorado[1]	7,527	
Rio Grande in New Mexico (including Pecos River)	72,380	
Rio Grande in Texas	80,550	
		160,457
Sacramento River above Redbluff, Cal		9,356
Sacramento and San Joaquin in California	63,020	
Sacramento River	655	
		63,675
Salt River in canyon 20 miles above Verde		5,880
Salt River at Arizona Dam, Arizona		12,260
Saline River at Beverly, Kans		2,730

[1] Thirteenth Annual Report U. S. Geological Survey, Part II, p. 33; area in square miles of principal drainage basins by States.

		Sq. miles.
Saline River at mouth, Kansas		3,311
San Emidio Creek, California		54
San Gabriel River in canyon above Azusa, Cal		220
San Joaquin River above Hamptonville		1,637
San Juan River at Arboles, Colo		1,394
San Miguel River at Seymour, Colo		327
San Pedro River at Dudleyville, Ariz		2,870
Savannah River above Augusta, Ga		7,294
Sevier River at Leamington, Utah		5,595
Shenandoah River (North Fork) at Brocks Gap, Va		215
Shenandoah River (North Fork) at Mount Jackson, Va		511
Shenandoah River (North Fork) at Riverton, Va		1,037
Shenandoah River (South Fork) at Port Republic, Va. (including Middle River to junction with North River, 363; North River to junction with Middle River, 418; to junction with South River, 804; South River to junction with North River, 246)		1,050
Shenandoah River (South Fork) at Milnes, Va		1,288
Shenandoah River (South Fork) at Overall, Va		1,491
Shenandoah River (South Fork) at mouth at Riverton, Va		1,587
Shenandoah River at Riverton (including North Fork, 1,037, and South Fork, 1,587)		2,624
Shenandoah River at Millville, W. Va		2,995
Shenandoah River at mouth at Harpers Ferry, W. Va		3,009
Smoky Hill River at Ellsworth, Kans. (including in Colorado 1,533, in Kansas 6,447)		7,980
Smoky Hill River below Ellsworth, exclusive of Saline and Solomon rivers		2,255
Smoky Hill River at mouth at Junction City, Kans		20,428
Snake, North Fork, at Ferry, Idaho		931
Snake River at Idaho Falls, Idaho		10,100
Snake River in Idaho [1]	73,500	
Snake River in Nevada	5,280	
Snake River in Oregon	17,950	
Snake River in Washington	6,682	
Snake River in Wyoming	5,268	
		108,680
Solomon River at Beloit, Kans		5,539
Solomon River at mouth, Kansas		6,882
South River at Port Republic, Va		1,050
South Platte at Deansbury, Colo		2,600
South Platte at Denver, Colo. (including Bear Creek at Morrison, 170)		3,840
South Platte, at Greeley, Colo., above mouth of Cache la Poudre River		7,110
South Platte below Greeley, Colo		9,575
South Platte at Orchard, Colo		12,260
South Platte at mouth at North Platte, Nebr		23,294
Spanish Fork near Spanish Fork, Utah		670
St. Vrain Creek near Lyons, Colo		209
Stanislaus River at Oakdale, Cal		1,051
Sun River at Augusta, Mont		1,175
Sweetwater River (Wyoming) at mouth		2,929
Tejon House Creek at Tejon Ranch House, Kern County, Cal		17
Teton River at Wilford, Idaho		967
Thompson Creek near Loveland, Colo		305
Tongue River at Miles, Mont		3,875
Truckee Little River at Boca, Cal		186
Truckee River at Boca, Cal		887

		Sq. miles.
Truckee River at Tahoe, Cal		550
Truckee River near Essex, Nev		991
Truckee River near Laughtons, Nev		1,054
Truckee River near Vista, Nev		1,519
Tule River above Portersville, Cal		437
Tuolumne River above Roberts Ferry, Cal., at foothills		1,501
Tuolumne River at Modesto		1,635
Twin Lake Creek below Twinlakes, Colo		102
Uncompahgre River at Fort Crawford, Colo		497
Verde River 1 mile above Salt River		6,000
Weber River at Uinta, Utah		1,600
Weiser River at Weiser, Idaho		1,670
West Gallatin River above Salesville, Mont		860
White River at White River City, Colo		1,773
Wood River at Hailey, Idaho		906
Yadkin River at Holtsburg, S. C		3,399
Yakima River at Union Gap, Wash. (of this, Tiaton, 330)		3,300
Yellowstone River at Horr, Mont		2,700
Yellowstone River in Montana[1]	36,312	
Yellowstone River in North Dakota	250	
Yellowstone River in Wyoming	33,121	
		69,683

EVAPORATION AND SEEPAGE MEASUREMENTS.

SEEPAGE MEASUREMENTS ON FRENCHMAN RIVER.

On July 4, 5, and 6, 1895, an attempt was made by Prof. O. V. P. Stout to obtain some data as to the increase of flow in Frenchman River from underground sources. The following table gives a list of the observations made by him, showing the date, locality, and distance apart of the measurements and the total discharge as obtained by measurement, this latter being corrected by the addition of the quantity of water flowing in ditches diverted within this area:

Measurements of Frenchman River in the vicinity of Wauneta and Palisade, Nebr.

No.	Date.	Time of day.	Miles below No. 1.	Measured discharge.	Corrected discharge.	Increase.
	1895.			*Second-feet.*	*Second-feet.*	*Second-feet.*
1	July 5	4 p. m		47.45	47.45	
2	July 5	5.30 p. m	7	51.24	53.74	6.29
3	July 5	7.30 p. m	10	51.83	56.83	3.09
4	July 6	8 a. m	10	52.47	52.47	
5	July 6	8.45 a. m	10	54.59	54.59	
6	July 6	10 a. m	14	57.71	57.71	3.12
7	July 6	11.30 a. m	16	57.83	57.83	0.12
8	July 4	11 a. m	26	74.24	74.24	16.41

No. 1. Measurements made 300 yards upstream from the east line of sec. 4, T. 5 N., R. 37 W., this being in the northeast corner of sec. 5, T. 5 N., R. 37 W.

No. 2. Measurement made in the southeast quarter of sec. 5, T. 5 N., R. 36 W.

Nos. 3 and 4. Measurements made 50 feet above upper wagon bridge at Wauneta, Nebr.

No. 5. Measurement made at lower wagon bridge, Wauneta, Nebr.

No. 6. Measurement made 20 rods east of the middle point of the west line of sec. 16, T. 5 N., R. 35 W.

No. 7. Measurement made in northeast quarter of sec. 22, T. 5 N., R. 35 W.

No. 8. Measurement at established gaging station at Palisade, Nebr.

[1] Thirteenth Annual Report U. S. Geological Survey, Part II, p. 33; area in square miles of principal drainage basins by States.

Between measurements numbered 1 and 2 Munson's ditch was diverting an estimated amount of 2.5 second-feet. The current was too sluggish and the wind too strong for accurate measurement; hence great accuracy can not be claimed for this correction of 2.5. Between measurements 2 and 3 Dudek's ditch and the Fisher-Conway ditch were each diverting about 2.5 second-feet. The difficulties in the way of accurate measurement in the case of the latter were the same as those stated above.

Wauneta Falls are situated between the localities at which measurements 4 and 5 are taken. A mill is located by the side of the falls, and probably the shutting down of the wheel ponds some water, so that the early morning flow below the falls may be somewhat in excess of that later in the day. Measurements 1 to 3 may be considered as one series and numbers 5 to 8, inclusive, as a second.

Measurements made August 9 at about the location of No. 5 in the above table gave a discharge a trifle over 61 second-feet, and later gagings, on August 9 and 10, in the vicinity of section No. 8, gave a discharge of very nearly 71 second-feet. The stretch of river covered by these measurements receives no surface water except in time of floods, and, as before stated, due allowance has been made for water diverted by irrigating canals.

SEEPAGE MEASUREMENTS ON KEARNEY CANAL, NEBRASKA.

An attempt yielding negative results was made on July 10, 1895, by Prof. O. V. P. Stout, to measure the seepage from the Kearney Canal above Kearney, Nebr. An arrangement was made to have the water admitted to the canal at a uniform rate during the time at which measurements were made, but it appears from the following list that it is very doubtful whether the person to whom this was intrusted properly carried out the understanding. The wide fluctuation indicates, if anything, that the water could not have been entering the canal uniformly during the day, and emphasizes the necessity when such measurements are made of having the entire canal line under the direct control of the engineer carrying on the investigation.

Measurements of Kearney Canal, made on July 10, 1895, above Kearney, Nebr.

No.	Time of day.	Locality.	Miles below No. 1.	Discharge.
				Sec.-feet.
1	10.30 a. m	Below upper waste way	....	275.63
2	1.15 p. m	Cline's bridge	2.36	314.83
3	2.30 p. m	Odessa bridge	5.99	272.24
4	3.45 p. m	Barney's bridge	7.63	287.18
5	5 p. m	O'Day's bridge	9.03	307.06

The conditions of measurements at places Nos. 1, 2, and 3 were all favorable for accurate results. At No. 4 they were only slightly unfavorable, the channel being narrow and the velocity somewhat swift.

At No. 5 they were such as to make a high degree of accuracy impossible, owing to the swiftness of the current and the interference by driftwood. At a point immediately below measurement No. 5 it was noted that at 5.30 p. m. the surface water stood within one-quarter of an inch of its elevation at 8 a. m.

A measurement was made on July 9 immediately below the upper wasteway. The fall of the canal here is reported to be 2 feet to the mile. Comparing this measurement with No. 1, made at the same point on July 10, it is found that on July 9 the mean depth was 2.75 feet, the mean velocity 2.16 feet per second, and the discharge 254.87 second-feet; and on July 10 the mean depth was 2.95, the mean velocity 2.22 feet per second, and the discharge 275.63 second-feet. The mean velocities were found to vary as the square roots of the mean depths. Kutter's formula, with the value $n = 0.0265$, gives quantities which agree practically with those observed in both instances. The canal at this point is straight, and it was dredged and cleaned since construction.

EVAPORATION AND SEEPAGE FROM A SMALL LAKE.

A few observations were made under the direction of Prof. O. V. P. Stout upon a small lake on the grounds of the Nebraska State Industrial School, at Kearney, by Maj. H. C. McArthur, military instructor of this school. A hook gage was placed on August 12, 1895, this being fastened vertically and reading to one-hundredths of an inch. Daily observations and weekly reports were arranged for, together with statements of the estimated velocity of the wind and the occurrence of rain. This pond is 320 feet long in a north and south direction, and about 90 feet wide east and west. The mean depth when observations began varied from 3 to 3.5 feet. When full, the depth is nearly 7 feet, and usually it is from 5 to 5.5 feet. The water supply, with the exception of that which falls in the form of rain and snow upon the surface of the lake and the inner slopes of the embankments, was under complete control, being admitted from the Kearney Canal through a cast-iron pipe with a gate valve.

Losses by evaporation and seepage.

Date.	Height of water.	Loss in 24 hours.	Remarks.
1895.	*Inches.*	*Inches.*	
September 1	2.01	....	
September 2	3.34	1.33	
September 3	4.72	1.38	
September 4	6.26	1.54	
September 5	5.46	....	Filling pond.
September 6	2.57	....	Do.
September 7	2.55	....	Do.
September 8	3.30	....	
September 9	4.33	1.03	
September 10	5.79	1.46	
September 11	7.11	1.32	
September 12	8.56	1.45	
September 13	9.88	1.32	
September 14	11.23	1.35	

EVAPORATION AT GOODLAND, KANS.

A short series of observations of daily evaporation was made at Goodland, Sherman County, Kans., beginning September 26 and ending October 24, 1895, in all twenty-eight days. These were made by means of a galvanized iron evaporating pan 3 feet square, floated by means of hollow cylinders of the same material. It was placed in the reservoir of the well put down by the State board of irrigation. This reservoir was about 80 feet by 125 feet. The pan was placed near the center, and so arranged that it would rise and fall with the water. A platform was built out to it with the portion next to the bank removable, to prevent any molestation during the absence of the observer.

The water was pumped into this reservoir by means of a gasoline engine, from a well 6 inches in diameter and 166 feet deep. This well yielded at the rate of 3,783 gallons per hour for the entire time. The total amount evaporated in twenty-eight days was 5.05 inches, this being equivalent to 5.41 inches in thirty days. The temperature of the water as it came from the well was 56° Fahrenheit.

Summary of observations of evaporation at Goodland, Kans., from September 26 to October 24, 1895.

Date.	Period (in hours) over which the measured evaporation has continued.	Measured amount of evaporation.	Average water temperatures, degrees Fahrenheit.	
			In pan.	Outside pan.
1895.		Inches.		
September 26		0.0	56	58
September 27	24	0.15	62	64
September 28	24	0.20	54	55
September 30	48	0.30	54	56
October 1	24	0.25	57	56
October 2	24	0.25	62	60
October 3	24	0.20	58	58
October 4	24	0.20	58	59
October 5	24	0.05	56	55
October 7	48	0.25	57	56
October 8	26.5	0.20	56	56
October 9	21	0.15	60	58
October 10	24.8	0.20	57	56
October 11	23.5	0.20	56	54
October 12	23.8	0.20	57	56
October 14	48.3	0.40	56	55
October 15	24	0.20	57	56
October 16	24.3	0.20	56	54
October 18	48	0.40	52	53
October 19	24	0.20	48	49
October 21	48.2	0.35	51	50
October 22	23.7	0.20	48	48
October 23	24.3	0.15	45	46
October 24	24	0.15	47	46

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