1903

Methods of discharge measurements of streams

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Department: Civil, Architectural and Environmental Engineering

THESIS

FOR THE

Degree of Bachelor of Science

IN

CIVIL ENGINEERING.

SUBJECT:

"Methods of Discharge Measurements of Streams."

R. S. WEBSTER AND W. A. LUTHER.

CLASS OF 1903.

METHODS OF DISCHARGE MEASUREMENTS OF STREAMS.

I. The description of methods employed in gauging streams.

The method of determining the discharge of large streams is that in which the area of cross section is multiplied by the velocity per. sec. of the water passing through the section.

The velocity can be measured by the following methods:

1. By floats. 2. Current Meters. 3. Pitots tube. 4. Can be determined by use of Kutter's formula.

The method of using floats is not very accurate and is used only when circumstances do not permit the use of a current meter. This requires the sight to be on a straight reach from 100 ft. to 300 ft. long and to have a fairly uniform cross section. The flow of water should be regular and free from eddies and cross currents. The area of cross section of the upper and lower ends should be carefully determined by soundings taken at right angles to the axis of the stream. If the stream is not too wide the soundings in a crosssection can be taken most conveniently along a tagged rope or wire stretched across the channel from shore to shore. The soundings can be taken from a boat or other means. On very large rivers where tagged ropes cannot be used the boat from which the soundings are taken should be located by triangulation or stadia. The soundings should be taken at equal distances apart, which is generally 10 ft.

There are three kinds of floats used, surface floats, double floats, and rod floats.

Surface floats are small balls or pieces of wood so colored and weighted as to be readily seen, and still be little affected by the wind. These are allowed to float with the current in different parts of the width of the stream. The time of their passage over a given distance is determined by two observers at the ends of a base on shore by stop watches; or if one watch is used, the instant of passing each section being signalled to the time keeper.

Let V - velocity of float per.sec.

t - time in passage in sec.

l - length of the base,

Then $V - l/t$

Double floats consist of two floats. A small surface float, which is lighter than water, is connected by a fine wire or chain to a large float, which is weighted so as to remain submerged and to keep the chain taut. The surface float should be of such a form as to offer but little resistance to the motion, while the lower float is large, it being the object of the combination to determine the velocity of the lower float alone.

Let $v' =$ velocity of double float

$V_0 =$ mean surface velocity

$V =$ velocity of lower float.

Then $V = 2V' - V_0$

The rod float is a hollow cylindrical rod, of adjustable length, weighted to float upright with the top just visible. Its observed velocity is assumed to be an average of the velocities of all the filiments lying between the ends of the rod.

The method of using current meter is the most convenient and by far the most accurate method for determining the velocity of streams. The mean velocity can be determined in three ways:

1. By making point measurements at a depth corresponding to the approximate position of the thread of mean velocity.

2. By deducting the mean velocity from observations from other points made in the same vertical.

3. By integration method.

It has been determined by experiment that the position of the thread of mean velocity in a vertical section occurs at a depth varying from 6/10 to 2/3 of the total section measured, from the surface of the water down.

In multiple measurements the following methods are used:

1. Observation at top and bottom. 2. Observations at mid-depth.

3. Observations at various points in a vertical.

4. Observations of surface velocity.

In the first method the measurements are made in each vertical just below the surface, and as near the bottom of the stream as the meter will permit. The mean of these two are taken for the mean velocity. This method should only be used in streams that are shallow compared to their width.

The second method consists in making measurements at mean depth and the mean velocity is obtained by taking 95% of this. This method is not at all satisfactory as the velocity at mid-depth does not bear a constant relation to mean velocity.

The third method is to make measurements at regular intervals in a vertical, plotting the velocity on cross section paper. The mean velocity is determined by dividing the area, inclosed by the curve, by the total depth. This is the most accurate of the four methods.

In the fourth method the measurement of surface velocities is very often the only method that can be used, as in streams where the velocity is so very great that it is impossible to lower the current meter to maintain its position at the desired depth. The mean velocity is deducted from the surface velocity by multiplying it by a factor. When the surface velocity is the maximum velocity the factor should be 0.8. If the maximum velocity occurs lower down, a factor of 0.9 to 1.0 should be used to obtain the mean velocity.

Integration method is by moving the current meter uniformly in a vertical line from the surface of the water to the bottom, and vice-versa The velocity is integrated mechanically, and the mean velocity is computed by noting the time and the number of up and down movements made. The vertical motion of the meter must be slow enough and uniform to prevent the errors in the resultant velocities, due to the up and down motion of the meter.

Pitot's tube is an instrument for measuring the velocity of a current by the velocity head which it will produce. In its simplest form it consists of a bent glass tube, the mouth of which is submerged and is placed so as to face the current. The water then rises in the tube a distance "h" above the surface of the flowing stream, and the velocity is approximately equal to $\sqrt{2gh}$.

The advantage of this instrument is that no time observation is necessary. The chief disadvantage is that "h" is si small that errors are liable to be made in determining its value.

The velocity can also be computed by Kutter's formula, by measuring the slope of the surface, the cross section of the stream, and a knowledge of the roughness of the bottom and sides of the stream. The formula is as follows:

$$V = \left[\frac{41.6 + \frac{1.811}{n} + \frac{.00281}{s}}{1 + \left(41.6 + \frac{.00281}{S}\right) \frac{n}{\sqrt{R}}} \right] \sqrt{RS}$$

V - velocity in ft. per. sec.

S - surface slope - h/l; h - fall in dist.l.

R - hydraulic radius

R - F/W

F - Area of cross section

W - wetted perimeter

N - ratio whose value varies from 0.009 for well planed wooden channel to 0.035 for channel with rough bottom and sides. This formula will apply to streams of all sizes. The disadvantage of this method is that it is difficult to measure the surface slope very accurately.

The most convenient way of precise measuring the discharge of small streams is by means of a weir built for that purpose, or a good masonry dam. In this the conditions are rarely the same in any two cases and no fixed rule can be laid down for all cases, but must be governed by local conditions. In this method the discharge is computed by empirical formula which vary with the kind of dam or weir, by observing the head on the wier

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In the selecting of a site for a gauging station it is necessary to obtain a straight portion of the channel which has a narrow cross section and high banks on either side which are not likely to overflow and to be free from obstruction. It is desirable to place gauge low enough so there will be no minus readings. The gauge is read every day so as to get material for computing the discharge. The most common form of gauges consist of well seasoned timber, the usual size being about 4" x 2" and high enough so the top of gauge will not be submerged during high water. These gauges are either vertical or inclined along the bank. The rods are graduated to feet and tenths, the graduation being put on so it will not wash off. A good form is to use brass tacks, or paint the gauge. The gauge should be set near the bank for convenience of the reader and also so it can be securely fastened. The gauge should be referred to some permanent bench mark on shore.

Stream measurements can be made; (1) by means of a boat which is managed by a wire stretched from shore to shore. (2) They can be taken from a bridge. (3) By means of a wire cable from which is suspended a box, large enough for two men, which is run in either direction by means of pulley wheels.

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II. Accuracy of Stream Measurements.

The chief factors controlling the accuracy of stream measurements are: 1st. Errors in obtaining the cross section; 2nd. Errors in obtaining the velocity of the current; 3rd. Errors due to flunctuations of surface height during a gauging; 4th. Errors due to condition of instrument.

The errors in obtaining the cross section are not difficult to keep within limits of desirable accuracy. The chief error being in the taking of the soundings, and assuming that the bottom of the section is a straight line between points of soundings. The error in taking the distance between sounding points being extremely small where it is possible to stretch a wire or cable across the stream or where the measurements are taken from a bridge. When the cross section sounding are located by transit, sextant, or similar means, it is difficult to get all soundings in a line at right angles to the current, especially if the current is very swift, also the distance between soundings will be less accurate.

There are numerous conditions which tend to introduce errors into the determination of the velocity of the current. The current is found to vary at different depths, being slower under most circumstances , near the top and near the bottom, than at intermediate points. Likewise the velocity of the current is greater at the center than near the shore, except at bends.in the channel or where there is some obstruction in the channel to deflect it.

Aside from these variations of the current, there are observed to be vertical and cross currents, which give the water a kind of boiling effect; also causing small whirls and giving some water a relatively up stream motion, and under certain conditions, may give, near the shore, an absolute velocity up stream.

It is also found that the forward velocity at any point is not constant, but is constantly varying, there being a kind of pulsating effect, being at times a diminution of velocity, which is followed by an increase,etc. When the current becomes moderately swift, the effect of this pulsation and of the vertical and cross current becomes very evident to the eye.

The physical features of the bottom near the section where the observations are taken, has considerable to do with the accuracy of the measurements, as an uneven bottom will cause an increase in the magnitude of the vertical currents, and any bend in the channel will cause cross currents. It is therefore desirable to locate the gauging station on a straight stretch in the river, and where the bottom is comparatively even and free from boulders, snags, and other obstructions.

The scouring of the bottom and shifting of gravel and sand are liable to cause considerable change in shape and size of channel and consequently the relation of gauge reading to discharge will be changed.

If discharge measurements are taken at times when the stream is rising or falling rapidly, there will be a considerable variance in the velocity of the water, due to the change in sectional area.

Accuracy of different methods of determining velocity of current. The use of surface floats is not desirable except when it is impossible to use other methods, or as a rough check on some other measurements.

The difficulty with surface floats are that they are affected by the wind, and at best show only the surface velocity of the water upon which they float, this may be owing to the pulsation effect, considerably faster or slower than the average surface velocity.

Double floats are less affected by wind, and the velocity being a combination of that at the surface and at the lower float, which gives more nearly an average; like the surface float, this method is subject to errors due to pulsation.

Rod floats give more nearly an average of the velocities at all points in a vertical section, but this method is also subject to the same error as that of the double float.

There are numerous other methods for the measurements of current velocity, but all of them are subject to errors due to their manner of operation, and it has been found by experience that a current meter of revolving cups is the most convenient, and gives the most satisfactory results.

The advantages of the current meter over the other methods are very marked, not only does it give an average velocity, at a given point for a given time, thus eliminating the error that pulsation causes in other methods, but the velocity at any desired depth can be obtained; or an average for all depths may be obtained by slowly moving the meter from the top to the bottom and back a number of times. This mechanical integration may be carried still farther, by moving the meter slowly across stream while moving it up and down, so as to get the average of the whole stream. The most accurate method of making discharge measurements with meters is to take sounding at frequent intervals on the section, and at these points obtain the velocity by means of several meters, strung vertically one above another, at intervals of from 1 to 2 ft. using the average of the velocities thus obtained.

It has been found from numerous experiments that for ordinary conditions of stream bed,etc., that the average velocity is found at very close to the points of six-tenths and three tenths the depths. For measurements of streams of less than six feet in depth, it is found to be sufficiently accurate to call the six-tenths of depth as the point of average velocity, but for streams over six feet in depth it is best to take the average of the velocity at both the six-tenths and three-tenths points.

METHODS FOLLOWED IN MEASUREMENTS ON GASCONADE, BIG PINEY, LITTLE PINEY, MERAMAC, MERAMAC SPRINGS, and DRY FORK RIVERS.

The same method was followed in all of these streams, that of obtaining the velocity with a small Price current meter operated from a boat. Before locating a guaging station, the river in the vicinity of the desired location, was carefully gone over in search of the best place for this station. It being desired, if possible, to get a point where the stream would be confined to one comparatively narrow channel, at all stages of the water, and where there was sufficient current to operate the meter at the lowest stages. It is also desirable that the channel be straight for some distance above, and the bottom be fairly regular and free from boulders, snags, and other obstructions.

After a point for the station has been selected, a gauge is put in, in such a manner as to be able to measure the height of the surface of the water above some datum plane at all stages of the river. The gauge is then referenced to some permanent bench mark. Next a wire is stretched across the river and tagged every ten feet .

The gauge being located, there is left to take the daily gauge heights and frequent velocity measurements, getting the stream at nearly all its stages. When sufficient data is obtained, the discharge and guage heights are plotted, using the gauge heights as ordinates and the discharges as absissas. A curve is drawn through these points and the discharges for any gauge height is taken off the curve.

The form of notes kept, rating tables, and other notes and computations are attached.

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Form of Notes Used.

Gaging made May 9. 1903 by R. S. Webster / W. H. Lutchen Meter No. 365

Gage height: beginning 3.2 ft., ending 3.2 ft., mean 3.2 ft. River Sta.

Total area 253.3 sq. ft.
Mean Veloc 0.79
Discharge 200.1 sec. ft.

At Station: Arlington Mo. on Little Piney River

Soundings: Dist. from initial Point	Soundings: Depth	Observations: Depth of Observ.	Observations: Time in Sec.	Observations: Register Reading	Revol. Per Sec	Veloc. Per Sec		Section: Width	Section: Mean Depth	Section: Area	Discharge of Sec.	REMARKS
74	0.0											
80	1.8	1.1	60	10	.20	0.52				14.6	7.6	Wind Gentle across
90	2.0	1.2	62	14	.20	0.52				21.0	10.9	stream.
100	3.0	1.8	63	20	.30	0.77				28.9	22.3	
110	3.1	1.9	63	20	.30	0.77				31.4	24.2	Measurements made
120	3.5	2.1	61	25	.40	1.02				34.4	35.1	from boat, anchored
130	3.4	2.0	60	23	.40	1.02				33.5	34.2	by means of wire
140	2.9	1.7	61	21	.35	0.90				29.1	26.2	stretched across
150	2.5	1.5	62	18	.30	0.77				24.8	19.1	river
160	2.0	1.2	62	16	.25	0.65				20.0	13.0	
170	1.5	0.9	60	10	.20	0.52				15.6	8.1	Channel straight
180	0.0											for several hundred
												feet above and
												below.

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LIST OF DISCHARGE MEASUREMENTS

Of Big Piney River at Hooker Mo.

DATE.	HYDROGRAPHER.	Gage heig't (feet).	Discharge (sec. ft).	REMARKS.
Apr. 19	{R. S. Webster W. A. Luther	2.9	1151.0	
" 25	" "	2.3	632.5	wind up stream
May 8	" "	2.2	639.5	

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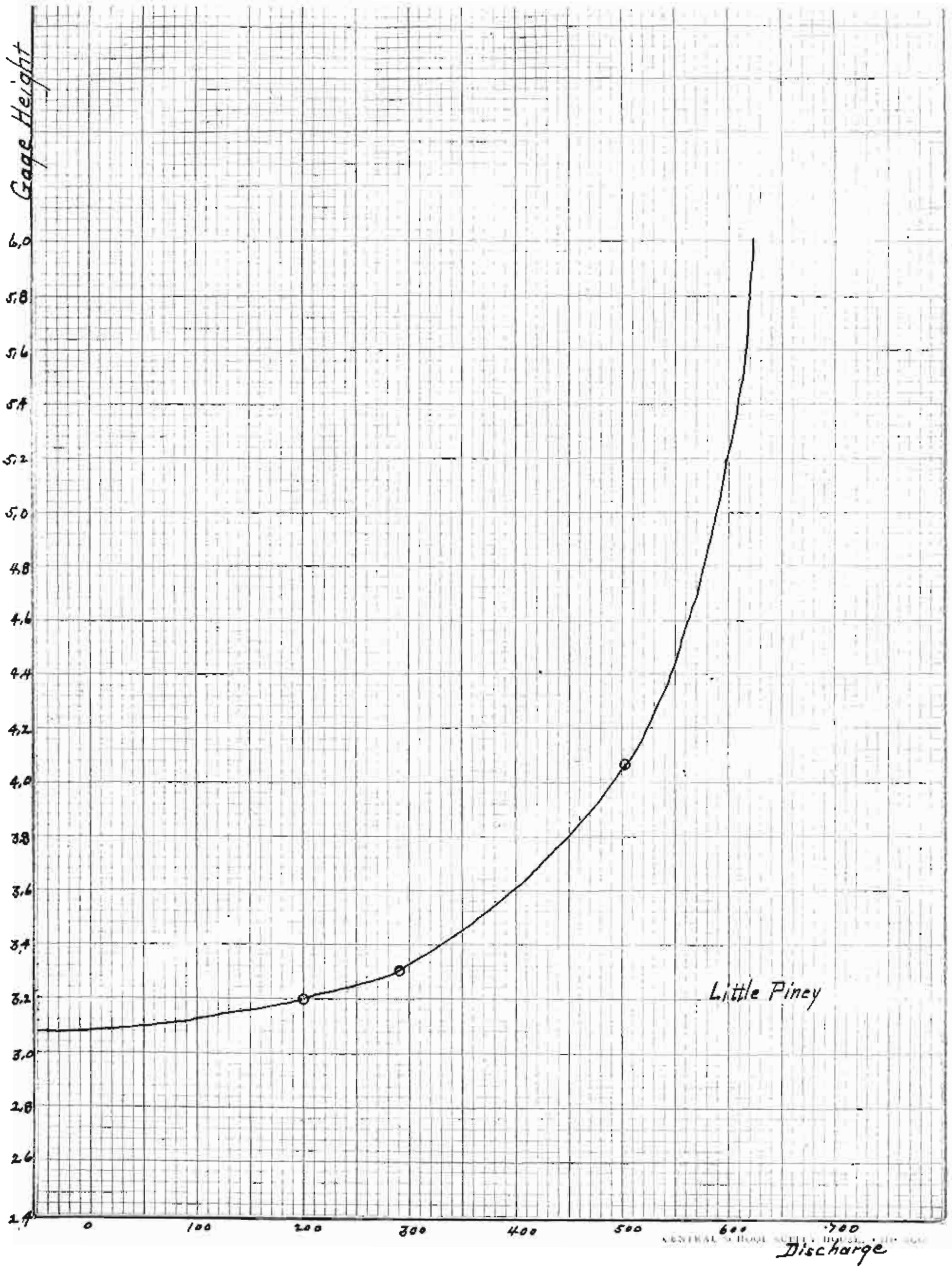
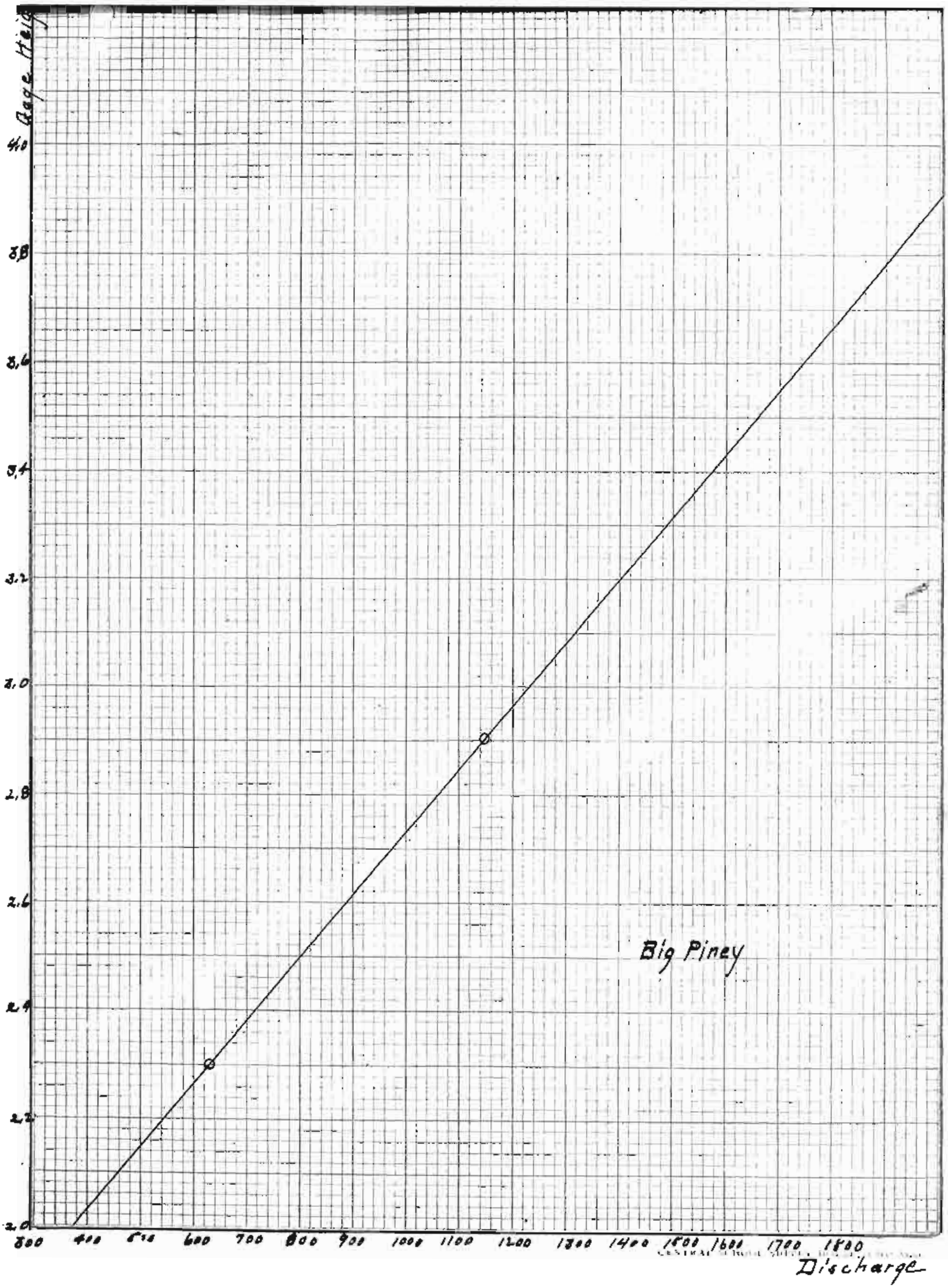
LIST OF DISCHARGE MEASUREMENTS

Of Little Piney River at Arlington Mo.

DATE.	HYDROGRAPHER.	Gage heig't (feet).	Discharge (sec. ft).	REMARKS.
Apr. 16	R. S. Webster W. A. Luther	4.05	504.2	
" 25	" "	3.5	289.1	
May 9	" "	3.2	200.1	


Gage Height
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
0
100
200
300
400
500
600
700
Discharge
Little Piney


Gage Heig
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
Big Piney
Discharge

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Daily mean gage height and discharge in second-feet of Big & Little Piney *River*s

at {Hooker / Arlington} Mo., *for* 1903. *Drainage area* {Big P. 740 / Little P 265} *sq. miles.*

Observer,

DAY.	Big Piney ~~JANUARY~~ April		~~FEBRUARY~~ May		~~MARCH~~ June		Little Piney APRIL		MAY		JUNE		DAY.
	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	
1			2.0	380					3.2	200			1
2			2.0	380					3.2	200			2
3			2.0	380					3.2	200			3
4			2.0	380					3.3	290			4
5			2.1	460					3.6	400			5
6			2.2	540					3.4	330			6
7			2.2	540					3.3	290			7
8			2.3	632					3.3	290			8
9			2.1	460					3.3	290			9
10			2.1	460					3.3	290			10
11			2.1	460					3.4	330			11
12	2.6	890	2.2	540			2.5		3.4	330			12
13	3.5	1660	2.2	540			5.9	620	3.6	400			13
14	4.3	2340	2.4	720			5.5	610	3.5	365			14
15	4.0	2080	3.1	1320			4.9	580	3.2	200			15
16	3.8	1920	3.3	1480			4.0	490	3.2	200			16
17	3.7	1825					3.8	450					17
18	3.2	1400					3.6	400					18
19	2.9	1151					3.6	400					19
20	3.0	1225					3.9	470					20
21	2.9	1151					3.5	365					21
22	2.9	1151					3.4	330					22
23	2.9	1151					3.4	330					23
24	2.6	890					3.4	330					24
25	2.5	800					3.4	330					25
26	2.4	720					3.4	330					26
27	2.3	632					3.4	330					27
28	2.3	632					3.4	330					28
29	2.3	632					3.3	290					29
30	2.2	540					3.3	290					30
31													31
Total,													
MEAN, - -													
RUN-OFF, per sq. mile,													
RUN-OFF, in inches,													

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RATING TABLE FOR STATION No.

for Little Piney *River at* Arlington Mo

Constructed by R. S. Webster / W. A. Lucher, *from discharge measurements number* — *to* —

as shown on accompanying blank form 9—207, and also from soundings made at intervening dates, as follows: Apr 16, Apr. 25, May 9th

This table is applicable only from Apr. 16, 1903, *to* —, 190—

Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.
3.00			4.00	492	8	.00			.00			.00			.00		
.05			.05	500	8	.05			.05			.05			.05		
.10			.10	510	10	.10			.10			.10			.10		
.15			.15	519	9	.15			.15			.15			.15		
.20	200		.20	525	6	.20			.20			.20			.20		
.25	250	50	.25	530	5	.25			.25			.25			.25		
.30	290	40	.30	535	5	.30			.30			.30			.30		
.35	310	20	.35	540	5	.35			.35			.35			.35		
.40	330	20	.40	545	5	.40			.40			.40			.40		
.45	350	20	.45	550	5	.45			.45			.45			.45		
.50	370	20	.50	555	5	.50			.50			.50			.50		
.55	384	14	.55	559	4	.55			.55			.55			.55		
.60	397	13	.60	562	3	.60			.60			.60			.60		
.65	412	15	.65	566	4	.65			.65			.65			.65		
.70	425	13	.70	570	4	.70			.70			.70			.70		
.75	438	13	.75	574	4	.75			.75			.75			.75		
.80	450	12	.80	578	4	.80			.80			.80			.80		
.85	462	12	.85	581	3	.85			.85			.85			.85		
.90	474	12	.90	584	3	.90			.90			.90			.90		
.95	484	10	.95	586	2	.95			.95			.95			.95		

REMARKS: Should have more points on curve for higher gage readings.

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RATING TABLE FOR STATION No.

for Big Piney *River at* Hooker Mo

Constructed by R. S. Webster / W. A. Luther, *from discharge measurements number* — *to* —

as shown on accompanying blank form 9—207, and also from soundings made at intervening dates, as follows: Apr. 19. Apr. 25, May 8.

This table is applicable only from Apr. , 1903, *to* , 190—

Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.
2 .00	372		.00			.00			.00			.00			.00		
.05	420	48	.05			.05			.05			.05			.05		
.10	460	40	.10			.10			.10			.10			.10		
.15	500	40	.15			.15			.15			.15			.15		
.20	542	42	.20			.20			.20			.20			.20		
.25	588	46	.25			.25			.25			.25			.25		
.30			.30			.30			.30			.30			.30		
.35			.35			.35			.35			.35			.35		
.40			.40			.40			.40			.40			.40		
.45			.45			.45			.45			.45			.45		
.50			.50			.50			.50			.50			.50		
.55			.55			.55			.55			.55			.55		
.60			.60			.60			.60			.60			.60		
.65			.65			.65			.65			.65			.65		
.70			.70			.70			.70			.70			.70		
.75			.75			.75			.75			.75			.75		
.80			.80			.80			.80			.80			.80		
.85			.85			.85			.85			.85			.85		
.90			.90			.90			.90			.90			.90		
.95			.95			.95			.95			.95			.95		

REMARKS:

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List of Discharge Measurements

Of Meramec River at Meramec Mo.

DATE.	HYDROGRAPHER.	Gage heig't (feet).	Discharge (sec. ft).	REMARKS.
Mar 3	T. N. McCormick	5.3	1345.8	Wind gently across.
" 28	" "	3.6	563.5	
Apr 24	" "	3.5	504.5	

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List of Discharge Measurements

Of Meramec River at Fenton Mo.

DATE.	HYDROGRAPHER.	Gage heig't (feet).	Discharge (sec. ft).	REMARKS.
Apr. 18	J.W. McConnell Mo. Leighton	15.1	5002.6	Wind strong up stream
May 9	J.W. McConnell	10.9	1608.9	

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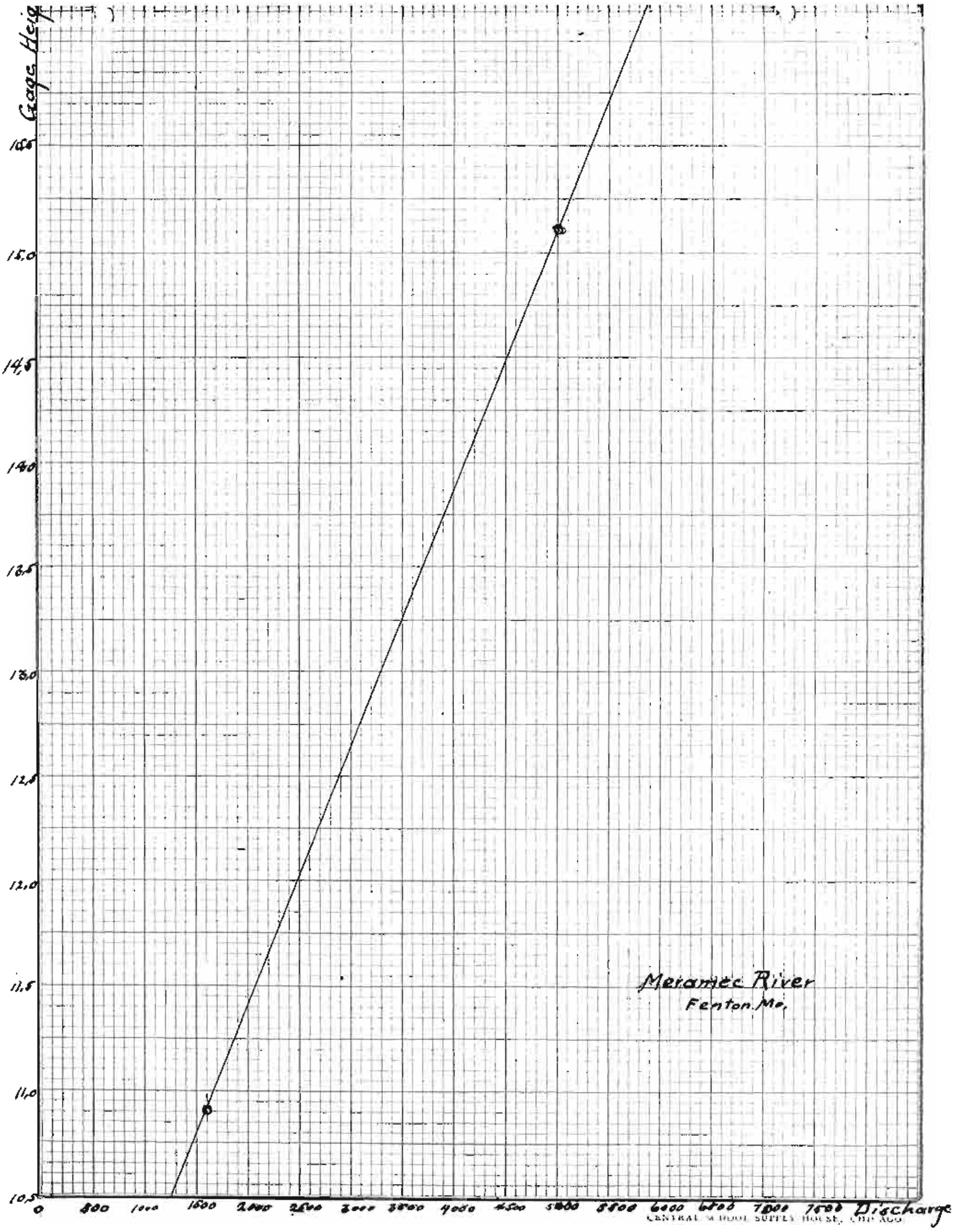
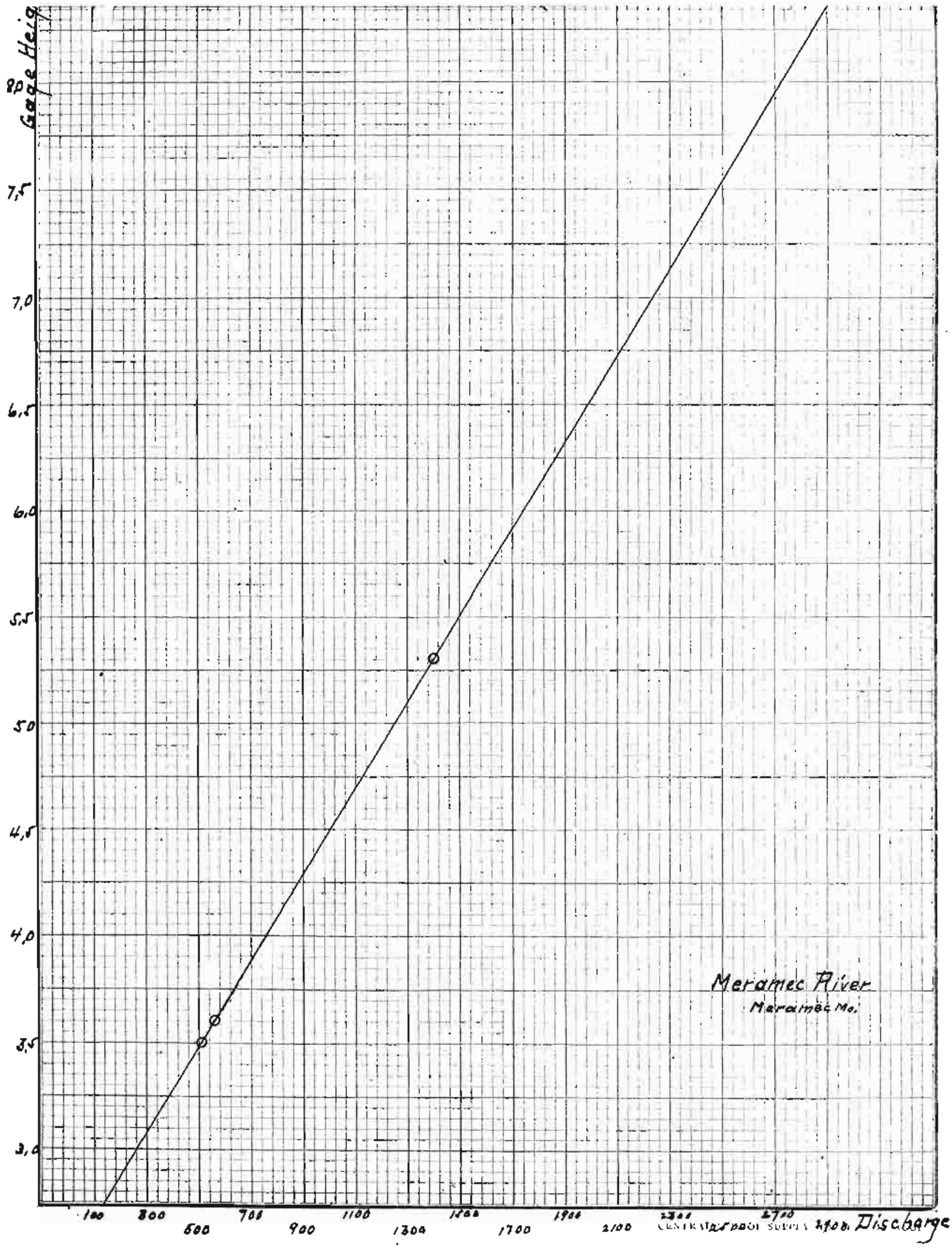

Gage Heig
15,5
15,0
14,5
14,0
13,5
13,0
12,5
12,0
11,5
11,0
10,5
Discharge
Meramec River
Fenton, Mo.
CENTRAL SCHOOL SUPPLY HOUSE, CHICAGO


Gage Heig
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
Meramec River
Meramec Mo.
800
500
700
900
1100
1300
1700
1900
2100
2700
Discharge

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RATING TABLE FOR STATION No.

for Meramec *River at* Meramec Mo

Constructed by R S Webster / W. A. Luther, *from discharge measurements number* — *to* —

as shown on accompanying blank form 9—207, and also from soundings made at intervening dates,

as follows: Mar 3. Mar 28, Apr. 24

This table is applicable only from , *190* , *to* , *190*

Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.
.00			.00			.00			.00			.00			.00		
.05			.05			.05			.05			.05			.05		
.10			.10			.10			.10			.10			.10		
.15			.15			.15			.15			.15			.15		
.20			.20			.20			.20			.20			.20		
.25			.25			.25			.25			.25			.25		
.30			.30			.30			.30			.30			.30		
.35			.35			.35			.35			.35			.35		
.40			.40			.40			.40			.40			.40		
.45			.45			.45			.45			.45			.45		
.50			.50			.50			.50			.50			.50		
.55			.55			.55			.55			.55			.55		
.60			.60			.60			.60			.60			.60		
.65			.65			.65			.65			.65			.65		
.70			.70			.70			.70			.70			.70		
.75			.75			.75			.75			.75			.75		
.80			.80			.80			.80			.80			.80		
.85			.85			.85			.85			.85			.85		
.90			.90			.90			.90			.90			.90		
.95			.95			.95			.95			.95			.95		

REMARKS:

2778b1m2–02

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

RATING TABLE FOR STATION No.____

for Meramec *River at* Fenton Mo

Constructed by R. S. Webster / W. A. Luther, *from discharge measurements number* — *to* —

as shown on accompanying blank form 9—207, and also from soundings made at intervening dates, as follows: Apr. 18, May 9.

This table is applicable only from Apr. , 1903, *to* ——, *190*__

Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.
.00			.00			.00			.00			.00			.00		
.05			.05			.05			.05			.05			.05		
.10			.10			.10			.10			.10			.10		
.15			.15			.15			.15			.15			.15		
.20			.20			.20			.20			.20			.20		
.25			.25			.25			.25			.25			.25		
.30			.30			.30			.30			.30			.30		
.35			.35			.35			.35			.35			.35		
.40			.40			.40			.40			.40			.40		
.45			.45			.45			.45			.45			.45		
.50			.50			.50			.50			.50			.50		
.55			.55			.55			.55			.55			.55		
.60			.60			.60			.60			.60			.60		
.65			.65			.65			.65			.65			.65		
.70			.70			.70			.70			.70			.70		
.75			.75			.75			.75			.75			.75		
.80			.80			.80			.80			.80			.80		
.85			.85			.85			.85			.85			.85		
.90			.90			.90			.90			.90			.90		
.95			.95			.95			.95			.95			.95		

REMARKS:

2778b1m2–02

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

Daily mean gage height and discharge in second-feet of Meramec River,

at Fenton Mo., for 1903 Drainage area, 3600 / 342 sq. miles.

& Meramec "

Observer,

DAY.	~~JANUARY~~ March (Meramec)		~~FEBRUARY~~ April (Meramec)		~~MARCH~~ May (Meramec)		APRIL (Fenton)		MAY (Fenton)		JUNE		DAY.
	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	
1	4.6	1020	3.4	460	3.1	300			11.0	1650			1
2	4.3	900	3.4	460	3.0	260			10.9	1600			2
3	4.2	860	3.4	460	3.0	260			10.8	1500			3
4	4.6	1020	3.3	420	2.9	220			10.7	1400			4
5	9.3	3340	3.2	360	2.9	220			10.6	1320			5
6	8.2	2820	3.2	360	3.0	260			10.5	1250			6
7	7.6	2540	3.2	360	3.1	300			10.5	1250			7
8	7.6	2540	3.4	460	3.1	300			10.5	1250			8
9	6.4	1940	3.3	420	3.0	260			10.6	1320			9
10	5.3	1395	3.3	420	3.0	260			10.8	1500			10
11	4.9	1200	3.3	420	2.9	220			10.8	1500			11
12	4.8	1150	3.3	420	2.8	160			10.8	1500			12
13	4.5	1000	6.1	1790	2.8	160			10.8	1500			13
14	4.3	900	5.7	1600	3.4	460			10.9	1600			14
15	4.1	800	4.8	1150	3.6	560			11.5	2070			15
16	3.9	700	4.5	1000	3.5	500			12.3	2720			16
17	3.8	650	4.0	760									17
18	3.7	590	3.9	700									18
19	3.7	590	3.7	590			14.6	4600					19
20	5.3	1395	5.7	1600			14.2	4220					20
21	5.9	1700	4.5	1000			14.1	4200					21
22	4.3	900	3.8	650			14.4	4420					22
23	4.3	900	3.7	590			13.9	4020					23
24	4.3	900	3.6	560			13.3	3550					24
25	4.2	860	3.4	460			12.6	2950					25
26	4.0	760	3.3	420			12.2	2650					26
27	3.8	650	3.3	420			12.0	2500					27
28	3.6	560	3.2	360			11.5	2070					28
29	3.5	500	3.1	300			11.5	2070					29
30	3.5	500	3.1	300			11.3	1900					30
31	3.4	460											31
Total,													
MEAN, - -													
RUN-OFF, per sq. mile,													
RUN-OFF, in inches,													

12351b2m11-99

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

LIST OF DISCHARGE MEASUREMENTS

Of Gasconade River at Arlington Mo

DATE.	HYDROGRAPHER.	Gage heig't (feet).	Discharge (sec. ft).	REMARKS.
Apr. 18	R. S. Webster Wm. Luther	6.1	4606.3	
May 9	" "	4.4	2459.7	

15062b2m 7-1900

DEPARTMENT OF THE INTERIOR

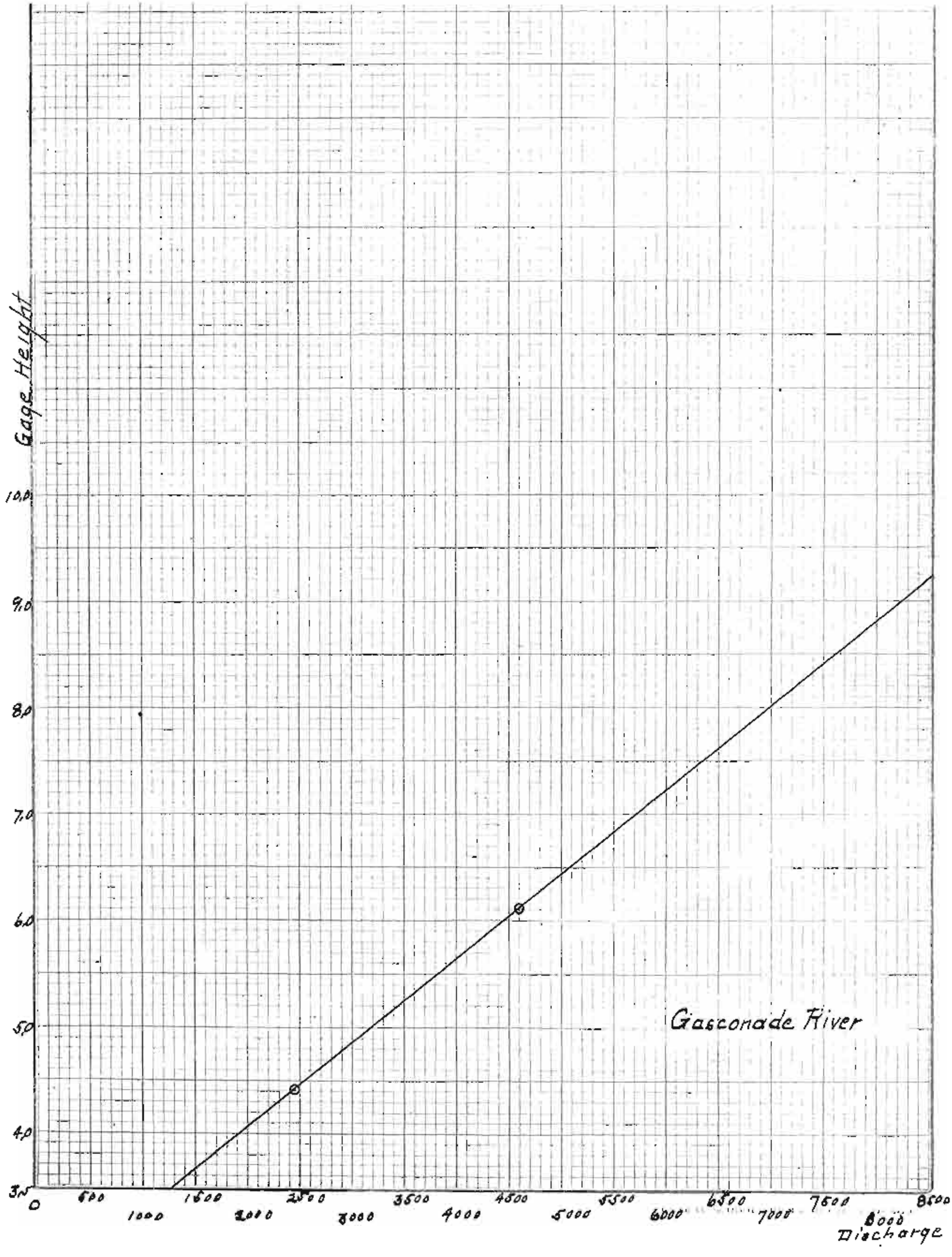
UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

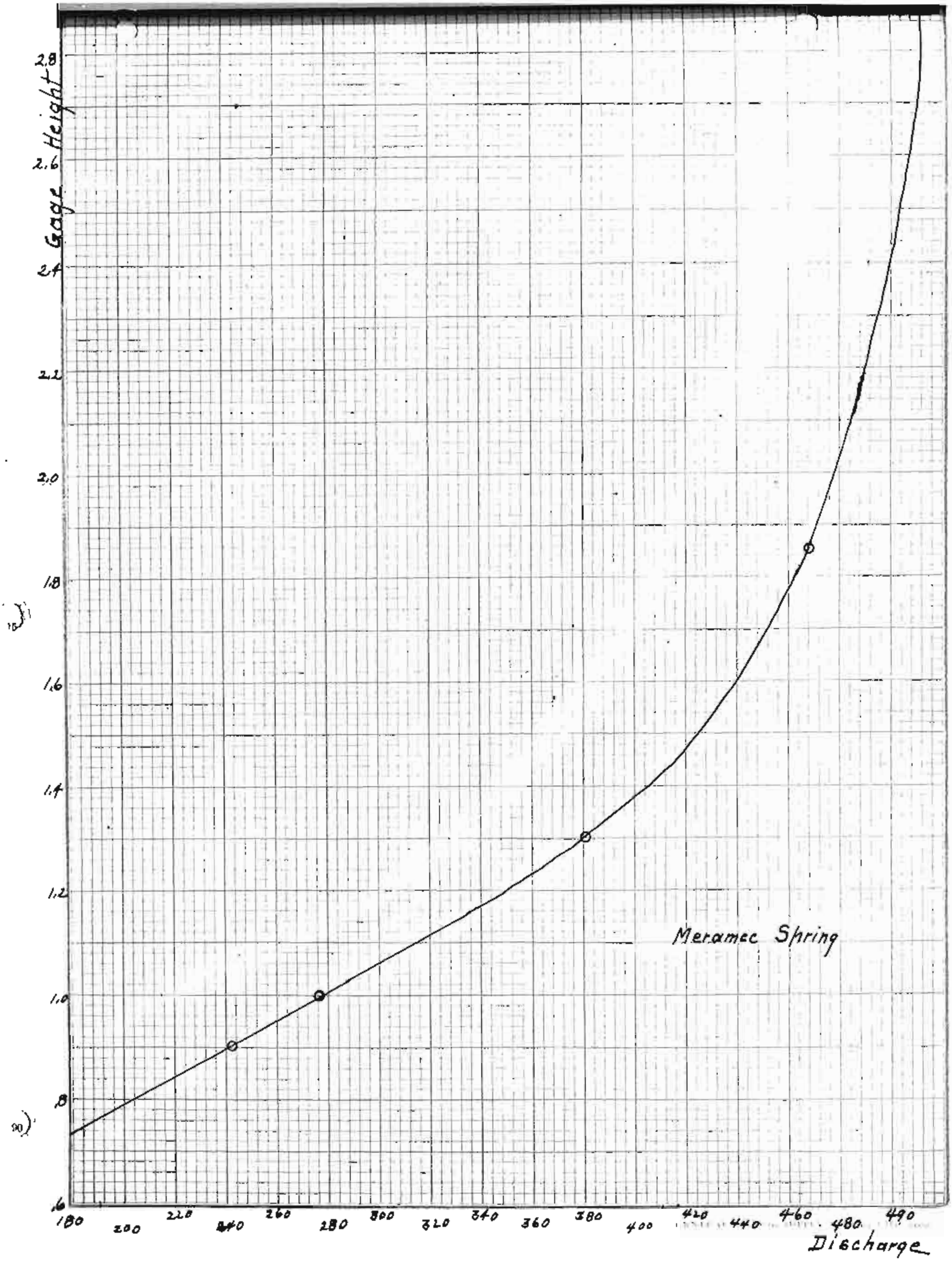
LIST OF DISCHARGE MEASUREMENTS

Of Meramec Spring ~~River~~ at Meramec Mo.

DATE.	HYDROGRAPHER.	Gage heig't (feet).	Discharge (sec. ft).	REMARKS.
Feb 28	J. W. McConnell	1.3	387.5	No wind
Mar 10	" "	1.85	467.46	Very little wind up stream.
" 27	" "	1.0	275.2	Gentle wind
Apr 24		0.9	242.88	" " down stream



Gage Height
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.5
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
Discharge
Gasconade River



Gage Height
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
490
Discharge
Meramec Spring

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

RATING TABLE FOR STATION No.

for Meramec Springs *River at* Meramec Mo

Constructed by [illegible] *, from discharge measurements number* — *to* —

as shown on accompanying blank form 9—207, and also from soundings made at intervening dates, as follows: Feb. 28, Mar. 10, Mar. 27, Apr. 24

This table is applicable only from Feb *, 190*3*, to* *, 190*

Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.
.00			.00			.00			.00			.00			.00		
.05			.05			.05			.05			.05			.05		
.10			.10			.10			.10			.10			.10		
.15			.15			.15			.15			.15			.15		
.20			.20			.20			.20			.20			.20		
.25			.25			.25			.25			.25			.25		
.30			.30			.30			.30			.30			.30		
.35			.35			.35			.35			.35			.35		
.40			.40			.40			.40			.40			.40		
.45			.45			.45			.45			.45			.45		
.50			.50			.50			.50			.50			.50		
.55			.55			.55			.55			.55			.55		
.60			.60			.60			.60			.60			.60		
.65			.65			.65			.65			.65			.65		
.70			.70			.70			.70			.70			.70		
.75			.75			.75			.75			.75			.75		
.80			.80			.80			.80			.80			.80		
.85			.85			.85			.85			.85			.85		
.90			.90			.90			.90			.90			.90		
.95			.95			.95			.95			.95			.95		

REMARKS:

2778b1m2–02

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

RATING TABLE FOR STATION No.

for Gasconade *River at* Arlington Mo

Constructed by R S Webster W A Keith*, from discharge measurements number* — *to* —

as shown on accompanying blank form 9—207, and also from soundings made at intervening dates, as follows: Apr. 18, May 9

This table is applicable only from Apr *, 1903, to* —— *, 190*

Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.	Gage height.	Discharge.	Difference.
.00			.00			.00			.00			.00			.00		
.05			.05			.05			.05			.05			.05		
.10			.10			.10			.10			.10			.10		
.15			.15			.15			.15			.15			.15		
.20			.20			.20			.20			.20			.20		
.25			.25			.25			.25			.25			.25		
.30			.30			.30			.30			.30			.30		
.35			.35			.35			.35			.35			.35		
.40			.40			.40			.40			.40			.40		
.45			.45			.45			.45			.45			.45		
.50			.50			.50			.50			.50			.50		
.55			.55			.55			.55			.55			.55		
.60			.60			.60			.60			.60			.60		
.65			.65			.65			.65			.65			.65		
.70			.70			.70			.70			.70			.70		
.75			.75			.75			.75			.75			.75		
.80			.80			.80			.80			.80			.80		
.85			.85			.85			.85			.85			.85		
.90			.90			.90			.90			.90			.90		
.95			.95			.95			.95			.95			.95		

REMARKS:

2778b1m2-02

9–192.

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

DIVISION OF HYDROGRAPHY

Meramec Spring

Daily mean gage height and discharge in second-feet of Gasconade *River,*

at Arlington Mo *, for 1903 Drainage area,* 2700 *sq. miles.*

Meramec "

Observer, Gasconade River

Meramec Spring

DAY.	~~JANUARY~~ March		~~FEBRUARY~~ April		~~MARCH~~ May		APRIL		MAY		JUNE		DAY.
	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	Gage Height	Discharge	
1	1.4	405	0.9	240	0.7	175			3.8	1700			1
2	1.3	387	0.9	240	0.7	175			3.7	1550			2
3	1.1	315	0.9	240	0.7	175			3.6	1430			3
4	1.6	440	0.9	240	0.7	175			3.5	1300			4
5	2.1	485	0.8	204	0.7	175			3.5	1300			5
6	2.1	485	0.8	204	0.8	204			3.8	17[illegible]0			6
7	2.4	490	0.8	204	0.8	204			3.9	1800			7
8	2.6	495	0.8	204	0.8	204			4.2	2200			8
9	2.4	490	0.9	240	0.8	204			4.4	2400			9
10	2.1	485	0.9	240	0.7	175			4.3	2300			10
11	2.0	475	0.9	240	0.7	175			4.2	2200			11
12	1.8	465	0.9	240	0.7	175	5.1	3300	4.0	1900			12
13	1.6	440	1.5	422	0.7	175	7.4	6200	4.0	1900			13
14	1.4	405	1.5	422	0.9	240	9.4	8800	4.1	2050			14
15	1.3	387	1.4	405	0.9	240	9.5	8900	4.6	2700			15
16	1.2	350	1.2	350	0.9	240	8.0	7000	6.9	5600			16
17	1.1	315	1.1	315			6.9	5600					17
18	1.1	315	1.1	315			6.2	4700					18
19	1.1	315	1.0	275			5.8	4200					19
20	1.7	350	1.1	315			5.9	4300					20
21	1.8	465	1.2	350			5.4	3700					21
22	1.7	350	1.1	315			5.1	3300					22
23	1.5	422	1.0	275			4.9	3050					23
24	1.4	405	0.9	240			4.7	2800					24
25	1.2	350	0.9	240			4.5	2550					25
26	1.2	350	0.9	240			4.3	2300					26
27	1.1	315	0.8	204			4.2	2200					27
28	0.9	240	0.8	204			4.1	2050					28
29	0.9	240	0.8	204			4.0	1900					29
30	0.9	240	0.8	204			3.9	1800					30
31	0.9	240											31
Total,													
MEAN, - -													
RUN-OFF, per sq. mile,													
RUN-OFF, in inches,													