THESIS

A SANITARY SURVEY OF THE GRAND RIVER

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A Sanitary Survey of the Grand River

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By

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INTRODUCTION

The problem which confronts the sanitary engineers of today is the removal of the waste products which accompany all living processes, in order to guard against the spread of epidemics which always threaten crowded communities.

Questions of public health have appeared in such great number, of such manifold variety and dominant importance that State and Federal supervision have been found necessary, whence have arisen Dairy and Food commissions as well as Boards of Health.

The removal of a city's wastes is one of the most difficult problems which confronts a municipality of today. A river of waste material flows from every large city, which pollutes streams, harbors, and sea shores, damaging property and spoiling pleasure-spots, and also threatening human life and health.

The most common method of disposal is to discharge the sewage directly into some flowing stream, or other bodyof water. This is called "Disposal by Dilution," and is the cheapest method of disposal since it does not require the purchase of land and needs no care to regulate its working.

By this method the waste material will be carried away from the tributory area, but it may be deposited in proximity to some other community, on banks or shores, or may be retained by dams, thus creating a nuisance; may render unfit for drinking, household or manufacturing purposes,

water which otherwise could be so used.

There are some conditions under which disposal by dilution is much less objectionable than is generally the case. In nearly all cases the liquid wastes from our cities must be discharged, either in their crude condition or after treatment, into some body of water. The degree of treatment must be determined by the local conditions. In some cases no treatment may be necessary other than what is afforded by the natural purification agencies. Under what conditions and to what extent a water receiving sewage will purify itself is a question which has received less attention than have methods of treating sewage; although it is by far the most common method of disposal.

Many different opinions are expressed in discussing the problem of the pollution of water ways. Some speak of the absolute prevention of pollution as though it were possible, while it is held by others that the stream should receive the unrestricted discharge of sewage from urban communities. Between these two extremes lies the logical position held by students of the problem whose professional training and experience permits them to properly decide this question. This latter position consists in the control of pollution, using the streams wherever it is possible without danger to the public health.

Some states have laws controlling the pollution of its rivers, streams and lakes.

The Water and Sewage Law of the State of Michigan provides for the supervisory control over public water supplies and over the discharge of sewage into the waters of the State, by the State Board of Health. This law outlines the duties of both the Board and the Municipality. No power is granted in this act " to prevent any municipality now disposing of its sewage into any river, from continuing to do so ".

In this connection, the Michigan Supreme Court handed down a decision in the Grand Rapids stream pollution case, May 28th, 1913 as follows:

"This was a proceeding in equity to declare and to abate and restrain a public nuisance claimed to result from the discharge of sewage and night soil from the city of Grand Rapids into the Grand River. The decision declares that the acts complained of do create a nuisance below the city, and that the continuing or creating of that nuisance may properly be restrained by injunction, and that the Attorney General is a proper complainant".

"This decision is based upon the doctrine of riparian ownership, and not primarily upon consideration of public health such as form the broad foundation of sewage law. The right of the city, as the riparian proprietor, to make reasonable use of the water of the river for the purpose of carrying away the sewage in an unreasonable manner, or in such a way as to destroy the usefulness of the river to the lower riparian proprietors or to impair their rights or to unreasonably increase their burdens, is as clearly defined.

Thus the question of what reasonable or unreasonable use of a stream is a question of fact, to be determined as other facts are determined.

In order that these facts may be determined, it is necessary to make a thorough investigation and study of the stream in question. Such investigations and studies have been termed " Sanitary Surveys ".

The city of Jackson disposes of part of its sewage through a septic tank and cinder contact filters thence into the Grand River. However, this plant is inadequate, because of the rapid growth of the city, and the fact that the tank is situated so low that the river backs into the filters. As a result, part of the raw sewage is discharged into the GrandRiver without any treatment and the rest without sufficient treatment. With this idea in mind " A Sanitary Survey of the Grand River " was started to determine the effect or result of the disposal of these partially treated wastes by dilution into the river.

Surveys of this nature are carried on by certain of the State Boards of Health or by municipal boards of health, extending over long periods. This survey was carried on for three months, during which time normal and flood conditions were encountered but no low water was experienced during which time self purification is most active and also when there might be distinct nuisances caused by the insufficient dilution.

The writers wish to express their thanks for the valuable suggestions and co-operation given by Prof. E.D.Rich and Mr. J.W.Follin of the Michigan State Board of Health, Mr. A.H.Jewell of the University of Michigan, and Prof. H.K. Vedder of the Civil Engineering Department of the Michigan Agricultural College.

TREATMENT

The object of this survey is to determine as far as possible (1) whether or not there is a local nuisance treated, (2) what is the effect of this pollution on the stream, and to what extent does the stream purify itself.

All results depend upon the discharge of the stream, therefore gaugings were made at different periods. The discharge determined, the next problem is to make the necessary examinations. It is usual to make complete physical, chemical, microscopical, and bacteriological examinations, but as our means were limited only the following were considered. Under " chemical " it was decided that dissolved oxygen, oxygen consumed, and chlorine would probably be the best adapted to the problem under consideration. Under " bacteriological " it was decided that total counts on nutrient agar and presumptive tests for B.Coli would best show the condition of the stream and the self purification effect. Under " physical " only color and temperature tests were made.

With the above problem solved the next step would be to form a conclusion, considering these results and all available data, together with the necessary assumptions.

All work of taking samples was done with an automobile, covering the whole territory on the same day. Gaugings were made during the week ends that samples were not not taken, by means of a team hired at Rives Junction. One gauging trip required about one and one-half days.

DISCHARGE

In determining discharge it was necessary to obtain the cross section and velocity of the river at the gauging stations, which were chosen at various bridges on the river. On each gauging trip the depths of the water were measured by means of a graduated line and plumb bob at intervals of five feet along one truss of the bridge. Velocities were taken every ten feet with a small Price current meter at six tenths of the depth of the water below the surface. A fixed point was marked at each station from which measurements were taken to the water surface on each trip. Curves were plotted from this data which give the area, velocity, and discharge for any distance below the fixed point. A gauge rod was permanently set and tied into a city benchmark at the Jackson sewage disposal plant and was read daily.

CHEMICAL EXAMINATION

In the carbon, nitrogen, and sulphur cycles, "Destruction" is the part in which we are particularly interested. It is a process of oxidation or burning up, aided by bacterial action, or the changing of unstable, putrefying, organic matter to stable compounds. In order to do this the organic matter must have oxygen, which it takes out of the water. As long as there is sufficient dilution the required amount of oxygen can be furnished, but as soon as the available oxygen is exhausted, putrefaction will take place. In other words, it is simply a question of a balance between the available oxygen in the water and the oxygen which is required by the organic matter.

Thus the amount of the dissolved oxygen in a sample of water will give us a relative idea of the condition of the stream. It was decided to use the dissolved oxygen method used in the New York Harbor Method. (Modification of Levy method, see Mason page 110).

Solutions:

Standard $FeSO_4$ -- 144 grams (Kahlbaums crystallized sulphate) and 15 cc conc. H_2SO_4 all diluted to 3 liters.

Standard Na_2CO_3 -- 200 grams in 1 liter of water.

Standard H_2SO_4 -- dilution 1 part acid to 1 part water.

Standard Potassium Permanganate -- 25.4 grams in water diluting to 4.5 liters. Standardized against especially prepared Mohz's salt, 1 c.c. = 1 c.c. of oxygen.

Collection of the Sample:- The sample shall be collected with extreme care in order to avoid entrainment or absorption of any oxygen from the atmosphere. The sample bottle shall be a glass-stoppered bottle with a narrow neck and which holds at least 250 c.c. The exact capacity of the bottle shall be determined and etched on the glass. A two holed rubber stopper is inserted in the mouth of the bottle and in one hole is placed a brass tube which almost touches the bottom of the bottle. In the other hole is placed a short curved brass tube. In taking samples, two bottles with the above described stoppers were placed in a rack and lowered into the water below the surface. The water will run down the long brass tube and the air will be expelled from the bottle through the other tube. As soon as the bottles have been filled they are drawn up and the temporary stopper is removed and a permanent glass stopper is inserted using care not to entrain any air bubbles.

Procedure:- Remove the stopper from the bottle and add 6 c.c. of $FeSO_4$ to the bottom by means of a pipette, then 5 c.c. of Na_2CO_3 at the top. Replace the stopper and shake well. Then remove the stopper and add 10 c.c. of H_2SO_4 Sol. This sets a sample and dissolves the precipitate allowing the titration to proceed with potassium permanganate.

Run a blank using the same water and the same procedure only omitting the addition of Na_2CO_3 which gives an alkaline reaction, and allows the D. O. to work.

The number of c.c. of potassium permanganate used in this blank determination, minus the number used in the first or sample test, gives the number of c.c. of dissolved oxygen in the sample. Put the result in terms of oxygen per liter.

The oxygen consumed test gives us a knowledge of oxygen consuming power of the carbon compounds. An oxidizing agent, potassium permangabate, is added to a portion of the sample together with a quantity of sulphuric acid, and the whole is digested at boiling temperature for 30 minutes. The amount of permanganate used is determined from a titration. The procedure was made in conformity with the Standards of the American Public Health Association.

The chlorine determination gives us an index of the dilution afforded. If we know the normal chlorine value of the stream, we can make an estimate of the amount of water entering the river through the tributaries. The chlorine value is high at the city limits due to the presence of chlorine in the household wastes, and this value will become less as water enters from the tributaries of less chlorine content. This test was carried out in conformity with the specifications of the American Public Health Association.

BACTERIOLOGICAL EXAMINATION

The samples were examined as soon as possible after the time of collecting them. The tests decided upon included total count on nutrient agar, and presumptive tests for B.Coli using lactose bile. The preparation of media was according to the " Standard Methods of Water Analysis" of the A. P. H. A.

DISCUSSION

The determination of the effect of the discharge of the partially treated sewage from Jackson into the Grand River was made by means of physical, chemical, and bacteriological examinations such as have been outlined under the heading of treatment. The results of these tests are shown in Tables 1 - 3 together with the distances of the sampling points below the city. There is also denoted the points at which the two main tributaries join the river.

There are several factors which enter into the self purification of streams. The two physical factors, dilution and sedimentation play an important part while the real oxidation of the organic matter is carried on by a bacterial action which is supported by the abundant food material of the sewage laden water. The reduction in bacteria is accomplished through several agencies, Sedimentation and unfavorable environment constituting the chief factors.

A large majority of the bacteria are of intestinal origin, the optimum temperature of which is the body temperature. Naturally they would die in time in the changed conditions and grow scarce in the battle of the survival of the fittest with the more hardy water bacteria.

Sampling Trip March 25, 1916.

Weather- Fair with thaw. Temp. of air 58 - 64 deg. F.
Condition of stream - Flood.

The chlorine tests gave fairly uniform results and show a drop from 13 p.p.m. at station 1 to 7 p.p.m. at station 17. The values are shown graphically on the chart, together with a curve showing the flow in the river at the various stations, and the total bacterial count, As the discharge increases in amount the chlorine decreases in accordance with this dilution. The total bacterial count shows a decrease from 63,600 at station 1 to 13,200 at station 17, a reduction of about 80%. There are several irregularities in the curve which may be contributed to several facts, one of which is that it is difficult to obtain a correct estimate of the total bacteria where the number per c.c. is so high, unless several plates are made and in this case only one was made.

The estimated B.Coli content per 100c.c. as shown on the table gives a reduction from 10,000 at station 1 to 100 at station 17. This latter value shows the water to be of fair purity at this point. Unless a large number of

these tests were made covering a long period it would not be possible to show the progressivepurification.

In general the low temperature of the water at this time was unfavorable to the active operation of self purification processes, though there is a fair degree of bacterial removal shown.

Sampling trip April 22, 1916.

Weather - Rain. Temp. of air 42 - 47 deg. F.
Condition of stream - Normal.

The chlorine tests gave about the same results as in the previous trip showing a drop from 13.5 p.p.m. at station 1 to 7 p.p.m. at station 17. These values are also shown graphically on the chart together with the curve showing the flow in the river at the various stations, and the total bacterial count. The total bacterial count shows a decrease from 40,000 to 3600 a reduction of about 89%.

The estimated B.Coli content gives a reduction from 1,000 at station 1 to 100 at station 17. This latter value shows the water to be of fair purity at this point.

Sampling trip May 6, 1916.

Weather - Rain. Temp. of air 57 - 66 deg. F.
Condition of stream - Normal.

The chlorine tests gave uniform results down to station 14 and show a drop from 13 p.p.m. to 8 p.p.m. at station 14, but at station 17 the value ran up to 16 p.p.m. due to the confluence of the Sandstone creek. The total bacterial count

shows a decrease from 40,000 at station 1 to 9,000 at station 17, a reduction of about 78%. The estimated B.Coli content per 100 c.c. gives a reduction from more than 3,000 at station 1 to 100 at station 17. This latter value shows the water to be of fair purity at this point.

GENERAL CONCLUSIONS

All the work was done during high water or normal water conditions and,accordingly,it was not possible to determine the effect of this pollution during low water and warm temperatures when self purification would be most active and there would be more physical evidence in the stream itself. However, there was a marked change in the character of the water as shown by the chemical and bacterialogical tests. And during the 22.4 miles of flow the river changes markedly in physical appearance which is shown on the pictures at the end of the text.

Picture number 1 was taken at the sewer disposal works and shows the gauge located there. The river above this point has received some raw sewage and at this point is discharged the sewage filter effluents. There is a distinct evidence of sewage in the water both here and more distinctly at Point 1, 0.3 miles below. The water is turbid and laden with solids, and also carries some floating solids.

The river flows 4.4 miles from here to the confluence with Portage Creek where it receives a large flow, sometimes in excess of the main river discharge.

This furnishes a large dilution for the polluted water. The fall of the river from Point 1 to Portage Creek and below here is very small which affords excellent chance for the settling out of the sewage solids.,Pictures 2 and3 show the conditions of the river banks at Point 3, midway between Point 1 and Portage where large quantities of sludge have been deposited. Picture 4 shows Portage Creek at Station D, above the confluence, where samples were collected. The flat grade is apparent.

At Point 6, 2.6 miles below Portage, the river shows but little direct evidence of sewage pollution from its appearance alone, and the banks are fairly clean. This physical appearance improves all the way to Point 17. Just before Point 17 is reached, the river is augmented by the flow from Sandstone Creek which furnishes clear, but colored water of a fair degree of purity. Picture 5 shows Sandstone Creek at Tompkins Center above the confluence. The water is impounded here for use in a water wheel at the mill. It is seen here flowing through the wheel and spilling over the dam.

As a whole,the problem furnishes an excellent opportunity to study river conditions in general and self-purification processes in particular. The problem should not be considered as finished in the work covered in this thesis but to hold good opportunity for others to continue it in the future.

C. B. M.

C. E. T.

Picture 1

Picture 2

Picture 3

Picture 4

Picture 5

GRAND RIVER SANITARY SURVEY

March 25, 1916

Weather --- Fair with thaw. **Temperature of Air 58° 64°F**

Condition of Stream - Flood.

Sampling Sta. No.	Distance Below Jackson in Miles	Gauge Reading	Physical Examinations		Chemical Examinations	Bacteriological Examinations	
			Temp. of Water Deg. F.	Color of Water P. P. M.	Chlorine P. P. M.	Total Bacterial Count on Agar 24 hrs. at 37° C	B. Coli per 100 c.c. by Phelps' Method
1	.31		43	35	13.0	63,600	10000
3	2.3	4.11	43	35	14.0	48,000	1000
D	Joins River at 4.73		36	70	7.0	40,800	100
6	7.33	6.31	40	55	9.5	14,760	1000
9	10.6		40	50	10.5	26,400	1000
10	12.3		40	50	9.5	33,600	1000
11	13.4		40	55	11.0	24,000	1000
14	17.8	9.09	40	52	7.0	32,400	1000
E	Joins River at 21.8		38	35	4.5	19,200	1000
17	22.4	7.0	40	50	7.0	13,200	100

Daily Gaging Station Record

Sept. 27, 1910

Weather --- Fair with thun. Temperature of Air 71° F.

Condition of Stream - Good.

Day of Month	Discharge Feet per sec. in Miles	Gage Height	Temperature Morning 8		Turbidity Parts per Million	Total Material in Solution Parts per Million
			Temp. of Water Deg. F.	Color in M. K.	Chlorine in P. P. M.	Total Material in Solution Parts per 100 c.c. by Evaporation
1	.23		48	78	16.0	83,320
2	2.6	4.11	44	85	14.0	46,000
3	6.75		56	70	7.0	40,840
4	7.50	6.71	40	65	9.8	14,760
5	10.6		40	60	10.6	76,400
6	12.3		42	60	9.6	68,800
7	14.4		40	62	11.0	41,000
8	17.8	9.09	40	52	7.0	68,400
9	21.3		50	50	6.0	18,400
10	18.4	7.0	50	70	7.0	18,600

GRAND RIVER SANITARY SURVEY

April 22, 1916.

Weather --- Rain. Temperatures of air-42-47°F.

Condition of Stream - Normal

Sampling Sta. No.	Distance Below Jackson in Miles	Gauge Reading.	Physical Examinations: Temp. of Water Deg.F.	Physical Examinations: Color of Water P. P. M.	Chemical Examinations: Chlorine P.P.M.	Chemical Examinations: Oxygen Consumed 30 Min. P.P.M.	Bacteriological Examinations: Total Bacterial Count on Agar 24 hrs. at 37° C.	Bacteriological Examinations: B. Coli per 100 c.c. by Phelps' Method
1	.31	5.5	54	60	13.5	13.2	40,000	1000
2	1.19			45	13.0		22,000	1000
3	2.31	4.5	45	60	11.5	11.0	34,000	1000
4	3.68			45	11.5		24,000	1000
B	Joins River @ 4.73	4.2	45	60	3.5	14.1	5,400	Less than 100
6	7.33	6.0	45	65	7.0	13.0	5,000	1000
8	9.26			60	7.5		5,000	1000
9	10.6			55	7.5		17,000	1000
10	12.3	4.7	45	55	7.0	12.95	12,000	1000
11	13.4			60	8.5		5,000	1000
14	17.8	8.2	45	60	7.0		5,000	1000
E	Joins River at 21.8			60	5.5	12.1	6,000	Less than 100
17	22.4	6.2	45	65	7.0	13.3	3,600	100

Camp No.	Distance below Culbeaux in Miles	Gauge Reading Inches.	Irrigated Area Above Point Desired. Temp. of Water Deg. F.	Color of water P. P. M.	Chlorine P. P. M.	Irrigated Area Below Point Desired. Grass Burned Up to Date. Sq. Miles.	Acres Cultivated Below Point Desired. Sq. Miles. Acres.	Population Below Point Desired. Total Number. Increase Since 1900
1	21.	5.8	74	60		15.8	40,000	1000
2	1.19			45		16.0	42,000	1040
3	2.21	4.8	48	60		11.8	84,000	1200
4	3.68			45		11.8	84,000	1000
5	Volga River at 4.78	4.8	45	50	8.5	14.1	8,400	100 less than
6	7.23	6.0	46	65	7.0	13.0	8,000	1000
8	9.16			60	7.8		8,000	1000
9	10.6			58	7.5		17,000	1000
10	12.5	4.7	48	58	7.0	12.0	12,000	1000
11	16.4			60	7.8		8,000	1000
12	17.8	6.2	45	60	7.0		7,000	1000
13	Volga River at 21.3			60	7.0	12.1	8,000	100 less than
14	22.4	6.8	42	65	7.0	12.0	7,000	100

GRAND RIVER SANITARY SURVEY

May 6, 1916

Weather ---- Rain Temperatures of Air -57°-66° F.

Condition of Stream - Normal.

Sampling Sta. No.	Distance Below Jackson in Miles	Gauge Reading.	Chemical Examinations: Color of Water P.P.M.	Chlorine P. P. M.	Oxygen Consumed 30 Min P.P.M.	Dissolved Oxygen Per cent of Saturat'n	Bacteriological Examinations: Total Bacterial Count on Agar 24 hrs. at 37° C.	B. Coli per 100 c.c. by Phelps' Method
1	.31		40	13.0	14.6	69.5	40,000	Greater than 3000
2	1.19		160	16.0		65.5	20,000	3000
3	2.31	3.6	40	13.5	14.0	85.6	33,000	3000
D	Joins River at 4.73	4.8	80		16.6		5,000	100
6	7.33	5.8	60	11.0	15.6	69.0	6,000	1000
8	9.26		80	9.5			12,000	100
9	10.6		75	8.5			30,000	1000
10	12.3	4.9	80	9.5			24,000	100
14	17.8	8.6	80	8.0	16.2	92.0	6,000	100
E	Joins River at 21.8		65	6.5	16.1	59.0	3,000	100
17	22.4	6.8		16.0 ?	16.3	80.	9,000	100

NOTE;- Samples were taken up the river, from pt. 17 to pt. 2.

Temp. Ref. No.	Distance below Redwood in Miles	Gauge Reading in ft.	Color of Water in P.P.M.	Chemical Characteristics: Chlorine in P. P. M.	Turbidity in Parts per Million	Bacteria per c.c. Count on Agar Plate 24 hrs. at 37° C.	Bacteria per c.c. Count on Gelatine Plate 72 hrs. at 20° C.
1	.81		40	12.0	11.3	40,000	65.0
2	1.19		100	14.0		50,000	68.8
3	2.81	3.6	40	13.8	14.4	18,000	64.4
D	Water taken at 4.75	4.8	60	13.6		8,000	100
6	7.75	5.5	70	11.0	13.5	6,000	100.0
8	9.25		60	9.6		12,000	1.0
9	10.6		75	8.6		20,000	1000
10	12.8	4.9	60	7.8		22,000	100
14	17.8	8.5	50	6.0	13.2	6,000	100
B	Water taken at 21.8		65	6.6	13.1	8,000	100
17	22.4	6.8		10.0 ?	13.2	8,000	[illegible]

NOTE:- Samples were taken on Dec 17th, 1906 fr. 12 to 1 P. M.

GRAND RIVER SANITARY SURVEY
GAUGE READINGS AT SEWAGE DISPOSAL PLANT

Elevation of 5.0 foot mark on gauge is
73.934 Jackson datum
917,734 U.S.Geodetic Survey datum-
elevation above mean sea level

Date	Time	Reading	Weather	Date	Time	Reading	Weather
Mar.30	12 N.	4.7	Clear	May 15	7 AM	2.2	Rain
" 31	"	4.8		16		2.2	
Apr. 1		4.8		17		2.4	Cloudy
2		4.5	Cloudy	18		2.6	
3		4.4	Clear	19		3.2	Clear
4		4.1		20		3.0	
5		4.1		21		2.9	
6		3.8		22		2.8	Rain
7		3.3		23		2.8	Clear
22	9 AM	1.4	Cloudy	24		2.8	
23	7 AM	1.5		25		2.8	
24		1.5		26		2.6	
25		1.5		27		2.2	Cloudy
26		1.5	Clear	28		2.5	Clear
27		1.4		29		2.3	Cloudy
28		1.4		30		2.1	Clear
29		1.4		31		2.2	
30		1.4		June 1		2.8	
May 1		1.5	Cloudy	2		2.5	
2		1.7		3		2.4	Cloudy
3		1.4	Rain	4		2.1	"
4		2.3	Clear				
5		2.5					
6		2.4	Rain				
7		2.0	Clear				
8		2.0					
9		2.2					
10		1.9	Rain				
11		1.7	Clear				
12		0.9					
13		1.1					
14		2.3	Rain				

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes — Gauging No. 2

STATION 3

March 30, 1916 — Gauge Height 1.81

Dist. from Initial Point	Depth Ft.	Depth of Obser-vation	Time in Sec-onds	Revo-lu-tions	Mean Vel. in Secs	Mean Depth Ft.	Width Ft.	Area Sq. Ft.	Dis-charge Cu.Ft. Sec.
0	3.0								
5	4.5	2.7	120	27	0.51	4.16	10	41.6	21.2
10	5.0								
15	5.5	3.3	45	50	2.48	5.50	10	55.0	136.4
20	6.0								
25	6.0	3.6	52.5	50	2.13	5.87	10	58.7	124.8
30	5.5								
35	5.5	3.3	120	45	0.84	5.33	10	53.3	44.8
40	5.0								
45.	5.0	3.0	120	32	0.60	4.33	10	43.3	26.0
50	3.0								
							Totals	251.9	353.2

Mean Vel.:
1.40 Ft. per sec.-0.95 m. per hr.

Gauging No. 3

April 28, 1916. — Gauge Height 4.3

0	0.5								
5	3.1	1.8	120	38	0.61	2.27	10	22.7	13.9
10	3.2								
15	4.0	2.4	110	50	1.02	3.63	10	36.3	36.4
20	3.7								
25	3.5	2.1	110	50	1.02	3.43	10	34.3	34.4
30	3.1								
35	3.0	1.8	109	50	1.02	3.07	10	30.7	30.8
40	3.1								
45	3.5	2.1	120	29	0.56	2.70	10	27.0	15.3
50	0.5								
							Totals	150.5	130.7

Mean Vel. :- 88 ft. per sec.--
0.60 mi. per hr.

STATE PLANE COORDINATES

Stream Gauging Notes — Sheet No. 2

MARCH 3

March 20, 1910 — Gage Hgt. 1.0'

Point	Ft. from Initial	Vertical Depth of Observation	Velocity at 0.6 Depth	Time in Seconds	Revolutions	Corrected Velocity	Width Represented by Point	Area	Discharge
0	0.0								
	3.0								
5	4.5	3.7	120	17	0.61	4.16	10	41.6	21.0
10	6.0								
15	8.5	3.3	40	60	0.19	0.60	10	62.0	152.4
20	9.0								
25	9.0	3.6	56.5	60	0.13	0.07	10	68.7	104.0
30	9.0								
35	8.5								
40	8.0	3.3	120	40	0.64	2.02	10	53.5	41.8
45	8.0								
50	8.0	3.0	120	20	0.30	1.20	10	42.5	20.0

Mean Vel.: 1.40 Ft. per sec.-0.39 m. per hr.

Total = 452.8:320.8

April 22, 1911. — Gage Height 4.8

Sounding No. 3

0	0.5								
5	3.1	1.9	120	80	0.41	0.27	10	27.7	18.9
10	3.2								
15	4.0	2.4	110	80	1.08	3.03	10	36.5	68.4
20	5.7								
25	6.2	3.1	110	60	1.03	3.43	10	54.4	94.4
30	7.1								
35	7.8	1.8	120	60	1.08	3.00	10	69.7	62.4
40	8.0	3.1	120	18	0.58	2.10	10	67.0	18.0

Mean Vel. :- 0.0 ft. per sec.-

Total = 1.5:1.50.7

0.0 : 1. per hr.

GRAND RIVER SURVEY

Stream Gauging Notes — Gauging No. 4

STATION 3

May 20, 1916. — Gauge Height 3.0

OBSERVATIONS					COMPUTATIONS				
Dist. from Ini'l Point:	Depth: Ft.	Depth of Obser vation:	Time in Secs:	Revolution:	Mean Vel. in Secs:	Mean Depth: Ft.	Width: Ft.	Area Sq. Ft.	Discharge Cu. Ft. Secs.
0	2.0								
5	4.4	2.6	43	50	2.59	3.73	10	37.3	96.8
10	4.8								
15	5.0	3.0	64	50	1.75	4.87	10	48.7	85.2
20	4.8								
25	4.7	2.8	60	50	1.87	4.57	10	45.7	85.6
30	4.3								
35	4.3	2.5	54	50	2.07	4.40	10	44.0	90.8
40	4.8								
45	5.0	3.0	120	50	0.94	4.30	10	43.0	40.6
50	3.1								
					Totals			218.7	399.0

Mean Velocity:-
1.83 ft. per sec--
1.25 mi. per hr.

PLATE 3

Stream Cross Sections

May 20, 1911. Engineering Course

Point	Distance	Depth	Velocity	Area	Discharge	Remarks
	Ft.	Ft.	Ft. per sec.	Sq. Ft.	Cu. Ft. per sec.	
0	0.0					
5	4.4	3.0	15	33	494.5	
10	7.4					
15	8.0	8.0	64	80	1,512.7	
20	4.6					
25	4.7	3.5	33	33	1,274.1	
30	4.9					
35	4.1	1.5	14	30	634.0	
40	4.1					
45	0.0	3.0	100	30	1,284.0	
50	0.1					
			Total		5,818.7	5,818.7

Mean Velocity:-
1.15 ft. per sec.
1.15 ft. per sec.

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Gauging No. 2.

STATION D. PORTAGE CREEK.

March 30, 1916. Gauge Height 2.8

Dist. From Initial Point	OBSERVATIONS Depth Ft.	Depth of obser-vation	Time in Secs.	Revo-lu-tions	Mean Vel. in Secs.	COMPUTATIONS Mean Depth Ft.	Width Ft.	Area Sq.Ft.	Discharge Cu.Ft.Sec.
0	4								
5	6	3.6	68	50	1.64	6.33	10	63.3	103.8
10	9								
15	12	7.2	52	50	2.15	11.66	10	116.7	251.0
20	14								
25	14	8.4	105	50	1.07	13.5	10	135.0	144.0
30	12.4								
35	10.0	6.0	95	50	1.18	9.8	10	98.0	115.8
40	7.0								
45	5.0	3.0	120	31	.59	5.4	13	70.2	41.5
50	4.2								
53	3.2								
						Totals		483.2	656.1

Mean Vel. 1.15 ft. per sec. = .78 miles per hour.

Gauging No. 3.

April 28, 1916. Gauge Height 4.2

0	3.0								
5	4.2	2.4	91	50	1.227	5.2	10	52.0	64.0
10	8.4								
15	12.5	7.5	80	50	1.39	12.03	10	120.3	167.0
20	15.0								
25	14.5	9.7	120	45	0.838	13.83	10	138.3	113.2
30	12.0								
35	9.5	5.7	120	31	0.59	12.00	10	120.0	70.9
40	6.8								
45	4.1	2.5	120	6	0.013	3.98	13	51.8	0.675
50	2.9								
53	2.1								
						Total		482.4	415.775

Mean Vel.= 0.865 ft. per sec.= 0.59 miles per hour.

Stream Gauging Party. Observer No. 5.

STAGE DISCHARGE.

March 30, 1916. Gauge Height 5.0

Hour.	Time Interval	Gauge Height	Area of Section	Velocity	Discharge	Mean Velocity	Mean Discharge
		ft.	sq. ft.	ft. per sec.	cu. ft. per sec.	ft. per sec.	cu. ft. per sec.
0		4					
8		5	8.0	85	1.64	12	654.9
10		9					
15		13	7.2	92	2.15	14	1124.7
20		14					
25		14	6.4	108	1.67	16	1398.0
30		12.4					
35		10.0	8.0	96	1.15	10	960.0
40		7.0					
45		6.0	4.0	150	.70	8.4	784.6
50		4.8					
55		3.8					

Mean Vel. 1.12 ft. per sec. = .78 miles per hour. Totals 4783.2 8565.1

Gauging No. 3.

April 28, 1916. Gauge Height 4.8

0		5.0					
5		4.2	2.4	91	1.11	5.2	594.0
10		3.4					
15		12.8	7.8	80	1.39	12.0	1560.0
20		11.0					
25		14.5	9.7	120	2.84	13.8	1338.6
30		12.0					
35		9.8	5.7	140	0.79	18.0	1120.0
40		6.8					
45		4.1	2.8	120	0.312	3.12	874.8
50		2.0					
55		2.1					

Mean Vel.= 0.8[illegible] ft. per sec. [illegible] 4[illegible].4 4[illegible].778
0.55 miles per hour.

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Gauging No. 4.

STATION D, PORTAGE CREEK.

May 20, 1916. Gauge Height 4.0

	OBSERVATIONS					COMPUTATIONS				
Dist. From Initial Point	Depth Ft.	Depth of observation	Time in Secs.	Revolutions		Mean Vel. in Secs.	Mean Depth	Width Ft.	Area Sq.Ft.	Discharge Cu.Ft.Sec.
0	3.5									
5	5.5	3.3	114	50		0.98	6.23	10	62.3	61.2
10	9.7									
15	13.6	8.16	104	50		1.08	12.77	10	127.7	138.0
20	15.0									
25	14.0	8.4	120	38		0.71	13.83	10	138.3	98.4
30	12.5									
35	9.2	5.52	120	30		0.57	9.40	10	94.0	53.6
40	6.5									
45	4.0	2.4	120	18		0.35	4.03	13	52.4	18.3
50	3.0									
53	2.6									
								Total	474.7	369.5

Mean Vel. 0.78 ft.per sec.=
0.53 miles per hour.

Sheet No. 4.

Sheet No. 2.

Dated 30, 1916.

Dist. From Initial Point	Depth ft.	Velocity ft.	Time in Sec.	Hydro-static Head	Friction Head	Loss in Pipe	Total Head	Horse Power
0	5.5							
5	5.5	2.3	114	50	0.25	10	60.8	81.2
10	9.7							
15	13.6	8.15	104	60	0.47	10	117.7	157.0
20	18.0							
25	14.0	8.4	120	40	0.5	10	114.5	152.6
30	12.0							
35	9.3	6.75	120	30	0.39	10	94.0	125.3
40	6.5							
45	4.0	8.4	120	15	0.85	15	82.4	109.9
50	6.0							
55	5.5							

Mean Vel. 6.76 Ft.per sec.=
0.65 miles per hour.

Total 474.7 632.9

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Gauging No. 1

STATION # 6. STATLER BRIDGE

April 29, 1915. Gauge Height 7.4

Dist. From Initial Point	Depth Ft.	OBSERVATIONS: Depth of Observation	Time in Sec.	Revolutions in Secs	Mean Vel. in Secs	COMPUTATIONS: Mean Depth Ft.	Width Ft.	Area Sq.ft.	Discharge Cu.ft.sec.
0	0.1								
5	1.0								
10	2.5	1.8	258	.50	0.49	2.0	20	40.00	19.6
15	5.0								
20	5.0								
25	5.2								
30	5.5								
35	5.8								
40	3.9	2.3	187	50	0.65	3.72	35	130.5	84.8
45	4.0								
50	4.1								
55	4.2								
60	4.0								
65	4.1	2.5	131	50	0.91	3.71	29	107.5	97.8
70	4.1								
75	4.1								
80	3.0								
84	1.0								
Mean Vel:-						TOTALS --		278.0	202.2

.727 ft. per second=0.495 miles per hour

Gauging No. 2.

March 30, 1916. Gauge Height 4.0

0	3								
5	4	2.4	45	50	2.48	4.33	10	43.3	107.8
10	6								
15	6.5	3.9	42.5	50	2.62	6.33	10	63.3	166.0
20	6.5								
25	6.5	3.9	44	50	2.53	6.60	10	66.0	166.0
30	6.8								
35	7.0	4.2	37	50	3.00	6.93	10	69.3	207.9
40	7.0								
45	7.0	4.2	53	50	2.11	7.00	10	70.0	147.7
50	7.0								
55	7.0	4.2	31	50	3.59	6.83	10	68.3	245.2
60	6.5								
65	6.5	3.9	45	50	2.48	6.50	10	65.0	162.0
70	6.5								
75	6.0	3.6	124	50	0.90	5.40	17	91.8	82.6
80	6.0								
87	3.0								
Mean Vel:-2.36 ft.per sec.- 1.62 miles per hour.						TOTAL		537.0	1285.2

Stream Loading Data.

April 29, 1916.

Dist. From Initial Point	Depth Ft.	Velocity Ft. per Sec.	Discharge Sq. Ft.	Area Sq. Ft.	Mean Velocity Ft. per Sec.	Gage Height Ft.	Discharge Sec. Ft.
0	0.1						
5	1.0						
10	1.8	2.8	258	93	2.8	4.0	260.3
15	3.0						
20	4.0						
25	4.5						
30	4.8						
35	4.8						
40	4.8	3.3	187	56	3.3	3.8	184.4
45	4.8						
50	4.8						
55	4.8						
60	4.7						
65	4.4	3.8	144	38	3.8	3.6	137.9
70	4.1						
75	3.1						
80	3.0						
84	1.0						
Mean Vel.:-							
.727 Ft. per second=0.498 Miles per Hour							

Gage Height 4.0

March 29, 1916.

0	0.5						
5	4.5	3.4	45	13	4.22	3.4	1074.5
10	5.4						
15	6.5	3.9	42.5	11	3.82	3.4	1060.0
20	6.5						
25	6.5	3.9	44	11	3.93	3.4	1060.0
30	6.6						
35	7.0	4.2	47	1.50	3.00	3.4	1072.3
40	7.0						
45	7.0	4.2	43	10	3.8	3.4	1047.7
50	7.0						
55	7.0	4.2	41	10	3.8	3.4	1041.2
60	6.5						
65	6.5	3.9	42	10	3.8	3.4	1047.0
70	6.5						
75	6.0	3.6	1.14	10	3.4	3.4	1021.5
80	6.0						
87	5.0						
Mean Vel.:-							
1.08 Ft.							

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Gauging No. 3.

STATION NO.6 STATTLER BRIDGE.

April 28, 1916. Gauge Height 5.9

OBSERVATIONS					COMPUTATIONS				
Dist. From Initial Point	Depth Ft.	Depth of Observation	Time in Secs.	Revolutions	Mean Vel. in Secs.	Mean Depth Ft.	Width Ft.	Area	Discharge
0.	1.8								
5	2.4	1.4	120	46	0.857	2.70	10	27.0	23.2
10	3.9								
15	5.0	3.0	101	50	1.11	4.63	10	46.3	51.4
20	5.0								
25	5.0	3.0	102	50	1.11	5.03	10	50.3	56.0
30	5.1								
35	5.3	3.2	79	50	1.38	5.30	10	53.0	73.2
40	5.5								
45	5.8	3.5	113	50	0.98	5.70	10	57.0	55.9
50	5.8								
55	6.3	3.8	85	50	1.31	6.10	10	61.0	80.0
60	6.2								
65	6.0	3.6	72	50	1.56	6.00	10	60.0	93.9
70	5.8								
75	6.0	3.6	120	17	0.329	4.95	17	49.5	16.4
80	5.2								
87	2.8	1.7							
							Total	404.1	450.0

Mean Vel. = 1.12 ft. per sec. =
0.76 miles per hour.

Gauging No. 4.

May 20, 1916. Gauge Height 4.1

0	3.0								
5	3.5	2.1	104	50	1.08	4.0	10	40.0	43.2
10	5.5								
15	6.5	3.9	102	50	1.10	6.0	10	60.0	66.3
20	6.0								
25	6.5	3.9	86	50	1.28	6.33	10	63.3	82.1
30	6.5								
35	7.5	4.5	72	50	1.58	7.07	10	70.7	112.0
40	7.2								
45	7.5	4.5	78	50	1.12	7.40	10	74.0	83.0
50	7.5								
55	7.8	4.7	54	50	2.07	7.77	10	77.7	160.8
60	8.0								
65	7.5	4.5	52	50	2.15	7.67	10	76.7	164.8
70	7.5								
75	7.0	4.2	120	22	0.42	6.25	17	106.25	44.6
80	6.5								
87	4.0								
							Total	568.65	756.8

Mean Velocity = 1.34 ft. per sec. =
0.91 miles per hour.

April 28, 1916.

Dist. from Initial Point	Depth	Depth of Observation	Velocity	Area	Discharge	Time	Discharge
	Ft.			Sq. Ft.		Min.	
0	1.8						
5	2.4	1.4	120	48	0.84	10	12.6
10	2.2						
15	2.0	1.0	124	50	1.12	10	11.2
20	2.0						
25	2.0	1.0	118	50	1.12	10	11.2
30	1.8						
35	1.6	0.8	72	50	0.80	10	8.0
40	1.4						
45	1.2	0.6	113	50	0.84	10	8.4
50	1.0						
55	0.8	0.4	85	50	0.60	10	6.0
60	0.6						
65	0.4	0.2	72	50	0.40	10	4.0
70	0.2						
75	0.0	0.0	120	17	0.00	17	0.0
80	0.0						
87	0.0	0.0					

Mean Vel. = 1.12 ft. per sec.=
0.76 miles per hour.

Total 4.1 4.0

May 20, 1916.

Dist. from Initial Point	Depth	Depth of Observation	Velocity	Area	Discharge	Time	Discharge
	Ft.			Sq. Ft.		Min.	
0	0.0						
5	3.8	3.1	104	50	1.08	10	10.8
10	3.8						
15	3.8	3.9	124	50	1.10	10	11.0
20	3.8						
25	3.8	3.9	96	50	1.28	10	12.8
30	3.8						
35	3.8	4.5	124	50	1.52	10	15.2
40	3.8						
45	3.8	4.5	78	50	1.12	10	11.2
50	3.8						
55	3.8	4.7	84	50	1.32	10	13.2
60	3.8						
65	3.8	4.5	52	50	2.12	10	21.2
70	3.8						
75	3.8	4.5	120	25	0.42	17	4.2
80	3.8						
87	4.0						

Mean Velocity 2.5= [illegible]
0.91 miles [illegible]

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Gauging No. 2.

STATION 10

March 30, 1916. Gauge Height 2.5

Dist. From Initial Point	OBSERVATIONS: Depth Ft.	Depth of Obser-vation	Time in Secs.	Revo-lu-tions	COMPUTATIONS: Mean Vel. in Secs.	Mean Depth Ft.	Width Ft.	Area Sq.Ft.	Discharge Cu.Ft.Sec.
0	5.0								
5	7.0	4.2	120	31	0.59	6.83	10	68.3	40.4
10	8.5								
15	8.5	5.1	38.5	50	2.88	8.50	10	85.0	246.0
20	8.5								
25	8.7	5.2	40.	50	2.78	8.57	10	85.7	238.0
30	8.5								
35	8.0	4.8	38	50	2.90	8.00	10	80.0	232.0
40	7.5								
45	7.5	4.5	41	50	2.71	7.40	10	74.0	202.0
50	7.2								
55	7.0	4.2	46	50	2.43	7.00	10	70.0	170.1
60	6.8								
65	7.0	4.2	48.5	50	2.30	7.10	10	71.0	163.5
70	7.5								
75	7.5	4.5	48.5	50	2.30	6.75	15	101.2	233.0
80	7.2								
85	4.0								
						Total		635.2	1525.0

Mean Vel.= 2.44 ft.per sec. =
1.67 miles per hour.

Gauging No. 3.

April 28, 1916. Gauge Height 4.8

0	2.5								
5	4.5	2.7	120	10	0.20	4.33	10	43.3	8.66
10	6.0								
15	5.5	3.3	90	50	1.24	5.67	10	56.7	70.5
20	5.5								
25	6.0	3.6	105	50	1.07	5.83	10	58.3	62.4
30	6.0								
35	5.5	3.3	73	50	1.54	5.67	10	56.7	87.2
40	5.5								
45	5.2	3.1	82	50	1.35	5.27	10	52.7	71.2
50	5.0								
55	4.8	2.9	75	50	1.48	4.87	10	48.7	72.1
60	4.8								

Continued on next page.

Sounding No. 5.

April 28, 1916. Gauge Height 4.8

Dist. from Initial point	Depth Ft.	Description of Bottom	Velocity ft. per sec.	Discharge per sec. ft.	Area of Section sq. ft.	Mean Velocity ft. per sec.	Discharge per hour cu. ft.	Area of Section sq. ft.
0	4.8							
5	5.6							
10	6.0							
15	6.6							
20	6.8							
25	6.0							
30	6.0							
35	5.8							
40	5.6							
45	5.1	Sand	2.7	150	55	4.54	10	45.3
50	4.8	Sand	3.5	90	55	1.64	10	16.7
55	4.6	Sand	3.6	198	60	3.30	10	33.3
60	4.8	Sand	3.5	175	50	3.50	10	35.0
65	4.8	Sand	3.5	175	50	3.50	10	35.0
70	4.8	Sand	3.5	175	50	3.50	10	35.0
75	4.8	Sand	3.5	175	50	3.50	10	35.0
80	4.8	Sand	3.5	175	50	3.50	10	35.0
							Total	350.0

Mean Vel.= 3.5 ft.per sec. = 2.38 miles per hour.

Sounding No. 6.

April 28, 1916. Gauge Height 4.8

Dist. from Initial point	Depth Ft.	Description of Bottom	Velocity ft. per sec.	Discharge per sec. ft.	Area of Section sq. ft.	Mean Velocity ft. per sec.	Discharge per hour cu. ft.	Area of Section sq. ft.
0	4.8							
5	5.6							
10	6.0							
15	6.6							
20	6.8							
25	6.0							
30	6.0							
35	5.8							
40	5.6							
45	5.1	Sand	2.7	150	55	4.54	10	45.3
50	4.8	Sand	3.5	90	55	1.64	10	16.7
55	4.6	Sand	3.6	198	60	3.30	10	33.3
60	4.8	Sand	3.5	175	50	3.50	10	35.0
65	4.8	Sand	3.5	175	50	3.50	10	35.0
70	4.8	Sand	3.5	175	50	3.50	10	35.0
75	4.8	Sand	3.5	175	50	3.50	10	35.0
80	4.8	Sand	3.5	175	50	3.50	10	35.0
							Total	350.0

Mean Vel.= 3.44 ft.per sec. = 2.37 miles per hour.

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Gauging No.3 cont'd.

STATION 10

March 30, 1916. Gauge Height 2.5

Dist. From. Initial Point	Depth Ft.	Depth of Obser-vation	Time in Secs.	Revo-lu-tions	Mean Vel. in Secs	Mean Depth Ft.	Width Ft.	Area Sq.Ft.	Discharge Cu.Ft. Sec.
65	5.0	3.0	84	50	1.33	5.10	10	51.0	67.8
70	5.5								
75	5.5	3.3	120	36	0.63	4.20	15	63.0	39.7
80	4.0								
85	1.8								
Mean Vel.= 1.11 ft.per sec. = 0.76 miles per hour.						Total		430.4	479.56

Gauging No. 4.

May 20, 1916. Gauge Height 3.8

0	3.7								
5	5.8	3.48	120	22	0.42	5.67	10	56.7	23.8
10	7.5								
15	7.5	4.50	64	50	1.75	7.83	10	78.3	137.4
20	8.5								
25	7.0	4.20	84	50	1.33	7.67	10	76.7	102.0
30	7.5								
35	7.3	4.38	72	50	1.58	7.80	10	78.0	123.7
40	8.6								
45	7.0	4.20	70	50	1.60	7.27	10	72.7	116.5
50	6.2								
55	5.8	3.48	62	50	1.81	6.07	10	60.7	110.0
60	6.2								
65	6.3	3.78	74	50	1.51	6.33	10	63.3	95.8
70	6.5								
75	6.1	3.66	96	50	1.17	5.30	15	79.5	93.0
80	5.0								
85	3.6								
Mean Vel. = 1.90 ft. per sec. = 1.30 miles per hour.						Total		565.9	801.2

Sept. 20, 1916.

Gauging No. 10

Point.	Depth	Velocity	Diameter	Area	Discharge	Remarks
0	3.7					
5	5.8	3.48	120	22.0	56.7	123.3
10	7.5					
15	7.5	4.50	64	20.1	72.3	137.4
20	8.5					
25	7.0	4.20	84	20.1	76.7	103.0
30	7.5					
35	7.8	4.38	72	20.1	78.0	124.7
40	8.5					
45	7.0	4.20	72	20.1	78.7	118.5
50	6.2					
55	5.8	3.48	62	20.1	69.7	110.0
60	6.2					
65	6.5	3.70	74	20.1	83.3	92.8
70	6.8					
75	6.1	3.65	96	20.1	78.8	92.0
80	5.0					
85	3.6					

Mean Vel. = 1.90 ft. per sec. = 1.30 miles per hour.

Total 546.9 1013.3

Sept 20, 1916.

Gauging No. 4.

Point.	Depth	Velocity	Diameter	Area	Discharge	Remarks
5b	8.0	3.0	64	20	1.33	1.10	10	71.0	94.8
70	8.8								
75	8.5	3.3	120	20	0.66	1.10	10	66.0	87.7
80	4.0								
85	1.6								

Mean Vel.= 1.11 ft.per sec. = 0.76 miles per hour. Total 430.4 474.2

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes — Gauging No. 1

STATION 14

April 29, 1915. — Gauge Height 11.31

OBSERVATIONS						COMPUTATIONS			
Dist. from Init'l Point	Depth: Ft.	Depth of Obser-vation:	Time: in Secs:	Revo-lu-tions:	Mean Vel. in Secs	Mean Depth: Ft.	Width: Ft.:	Area: Sq. Ft.	Discharge Cu. Ft. Secs.
0	+1.0								
5	0.0								
10	0.8	1.5	156:	50	0.665		13	29.7	19.75
15	3.2								
20	4.2								
25	3.5	2.4	95:	50	1.25		20	75.75:	94.75
30	4.0								
35	3.1								
40	3.8								
45	3.8	2.3	140:	60	1.02		15	50.25:	51.25
50	3.8								
55	3.2								
60	2.0	1.2	230:	30	0.35		25	60.50:	21.20
65	3.0								
70	2.0								
75	0.0								
78	+1.0								
						Totals		216.2	186.95

Mean Velocity:- 0.865 Ft. per sec.--
0.61 Mi. per hr.

Gauging No. 2

March 31, 1916. — Gauge Height 6.2

0	3.6								
5	6.4	3.8	120:	19	0.38	6.1	10	61.0	23.2
10	8.3								
15	8.5	5.1	32:	50	3.35	8.43:	10	84.3	282.0
20	8.5								
25	9.0	5.4	32.5:	50	3.31	8.83:	10	88.3	292.0
30	9.0								
35	9.0	5.4	26	50	4.30	9.0	10	90.0	387.0
40	9.0								
45	9.0	5.4	27	50	4.14	8.83:	10	88.3	366.0
50	8.5								
55	8.5	5.1	28	50	3.98	8.33:	10	83.3	333.0
60	8.0								
65	8.0	4.8	33	50	3.27	7.5	10	75.0	245.1
70	6.5								
75	5.2	3.1	58	50	1.93	5.23:	9	47.1	90.8
79	4.0								
						Totals		617.3	2019.1

Mean Vel.:-- 3.88 ft. per sec.--
1.81 mi. per hr.

Grass seeding [illegible]

[illegible]

March 25, 1919.

[illegible]

Plot.	Rotation	Manure	Lime	Fertilizer	Yield of Grain	Yield of Straw	Yield of Chaff	Total Yield
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Mean Yield:- [illegible]

[illegible]

Cropping No. 2

Plot.	Rotation	Manure	Lime	Fertilizer	Yield of Grain	Yield of Straw	Yield of Chaff	Total Yield
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Mean Yield:-- [illegible]

GRAND RIVER SANITARY SURVEY

Steam Gauging Notes — Gauging No. 3

STATION 14

April 29, 1916. — Gauge Height 8.5

OBSERVATIONS					COMPUTATIONS				
Dist. from Init'l Point	Depth Ft.	Depth of Observation	Time in Secs	Revolutions	Mean vel. in Secs	Mean Depth: Ft.	Width: Ft.	Area Sq. Ft.	Discharge Cu. Ft. Secs.
0	2.8								
5	5.0	3.0	120	9	0.20	4.53	10	45.3	9.06
10	5.8								
15	6.8	4.08	70	50	1.60	6.47	10	64.7	103.9
20	6.8								
25	7.5	4.5	120	46	0.86	7.10	10	71.0	60.9
30	7.0								
35	7.0	4.2	78	50	1.45	7.0	10	70.0	101.9
40	7.0								
45	6.8	4.1	88	50	1.27	6.97	10	69.7	88.8
50	6.8								
55	6.0	3.6	75	50	1.54	6.30	10	63.0	95.7
60	5.6								
65	5.8	4.5	120	40	0.74	5.30	10	53.0	39.3
70	4.5								
75	3.3	1.98	110	50	1.02	3.27	9	29.4	29.9
79	2.0								
							Totals	465.1	601.0

Mean Vel.:- 1.29 ft. per sec.--
0.88 mi. per hr.

Gauging No. 4

May 20, 1916. — Gauge Height 7.7 ft.

0	2.2								
5	4.4	2.6	120	22	0.42	4.87	10	48.7	20.5
10	7.0								
15	8.2	4.9	96	50	1.17	8.17	10	81.7	95.8
20	8.3								
25	8.2	4.9	96	50	1.17	8.50	10	85.0	99.7
30	9.0								
35	7.8	4.5	66	50	1.69	8.13	10	81.3	137.8
40	7.6								
45	7.6	3.9	52	50	2.15	7.67	10	76.7	164.8
50	8.2								
55	8.8	5.3	74	50	1.51	7.60	10	76.0	115.0
60	5.8								
65	6.5	3.9	74	50	1.51	5.63	10	56.3	85.4
70	4.8								
75	4.5	2.7	94	50	1.19	4.30	9	38.7	51.2
79	3.6								
							Totals	544.4	780.2

Mean Vel.:- 1.44 ft. per sec.-
0.984 mi. per hr.

Current Gauging Notes

Gauging No. 3

April 29, 1911.

0	2.2									
5	2.0	3.0	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
10	[illegible]									
15	[illegible]	4.03	[illegible]	40	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
20	6.8									
25	[illegible]	4.3	[illegible]	40	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
30	7.0									
35	[illegible]	4.2	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
40	7.0									
45	[illegible]	4.1	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
50	[illegible]									
55	6.0	3.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60	[illegible]									
65	5.5	4.5	110	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]
70	[illegible]									
75	3.5	1.08	110	[illegible]	1.23	[illegible]	5	[illegible]	[illegible]	[illegible]
80	2.0									

Total [illegible]

Mean Vel.:- 1.26 ft. per sec.--

Gauging No. 4

May 20, 1911.

0	[illegible]									
5	4.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
10	7.0									
15	[illegible]	4.3	[illegible]	[illegible]	[illegible]	8.17	10	[illegible]	[illegible]	[illegible]
20	[illegible]									
25	8.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
30	[illegible]									
35	[illegible]	4.5	[illegible]	[illegible]	[illegible]	8.13	10	[illegible]	[illegible]	[illegible]
40	7.0									
45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
50	[illegible]									
55	[illegible]	[illegible]	74	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
60	[illegible]									
65	[illegible]	[illegible]	74	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]
70	4.2									
75	4.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	[illegible]									

Mean Vel.:- [illegible]

Stream Gauging Notes. Gauging No. 1.

Station No. 17 - Tompkins Bridge

April 29, 1916. Gauge Height 9.0

Dist. From Initial Point	Depth Ft.	OBSERVATIONS: Depth of Observation	Time in Sec.	Revolutions in Secs.	Mean Vel. in Secs.	COMPUTATIONS: Mean Depth Ft.	Width Ft.	Area Sq. Ft.	Discharge Cu.Ft.Sec.
0	0.0								
5	2.5								
10	4.5								
15	5.0	3.0	(No Current)	0					
		2.0	(	))					
20	4.5	0.5	95	20	0.53p		20	71.25	31.7
25	2.9								
30	3.0			1					
85	5.0								
40	5.8	3.5	162	50	0.74		30	136.50	101.0
45	5.5								
50	5.7								
55	4.5								
60	3.0	1.8	130	50	0.92		15	60.75	55.9
65	3.0								
70	3.2								
75	4.7								
80	5.0	3.0	195	50	0.62		30	115.5	71.6
85	4.1								
90	4.0								
95	3.2								
Mean Vel:- 0.92 ft. per sec. = 0.64 miles per hour.						Total --		284.0	260.2

GAUGING NO.2

March 31, 1916. Gauge Height 4.3

0	7.7								
5	8.6	5.16	54	50	2.07	8.53	10	85.3	177.0
10	9.3								
15	10.0	6.0	49	50	2.28	9.5	10	95.	218.0
20	9.2								
25	8.8	5.28	42	50	2.65	8.3	10	83	228.5
30	6.9								
35	6.2	3.72	37	50	3.01	7.37	10	73.7	222.0
40	9.0								
45	11.6	6.96	39	50	2.84	10.6	10	28.4	302.0
50	11.2								
55	10.6	6.36	36	50	3.10	10.93	10	31.0	338.8
60	11.0								
65	10.0	6.0	32.5	50	3.31	10	10	33.1	331.0
70	9.0								
75	10.4	6.24	37	50	3.01	9.9	10	30.1	298.0
80	10.3								
85	9.2	5.52	38	50	2.90	9.73	10	29.0	282.0
90	9.7								
95	6.8	4.08	43	50	2.59	9.25	5	46.25	120.0
Mean Vel:- 2.79 ft. per sec. = 1.9 miles per hour.						Total ----		895.5	2517.3

Stream Gauging Notes.

April 20, 1912.

Section No. IV - Bear Creek

Initial Point	Dist. from Init. Point	Depth of Observation	Time in sec.	Velocity in ft. per sec.	Area in sq. ft.	Mean Depth	Mean Velocity
0	0.0						
5	5.0						
10	10.0						
15	15.0	2.0					
		8.0					
		(No Current)					
20	20.0	0.8	52	20	0.859	20	41.7
25	25.0						
30	30.0						
35	35.0						
40	40.0	3.8	182	20	0.74	20	148.0
45	45.0						
50	50.0						
55	55.0						
60	60.0	1.8	120	10	0.92	10	92.0
65	65.0						
70	70.0						
75	75.0						
80	80.0	3.0	198	20	0.62	20	124.0
85	85.0						
90	90.0						
95	95.0						

Mean Vel.:- 0.82 ft. per sec. - Total -- 248.0

0.94 efficient not poor.

Area Velocity 2

March 21, 1912. Cross Section A.B.

0	7.7						
5	6.6	8.16	64	60	2.07	10	20.3
10	9.3						
15	10.0	6.0	49	60	2.68	10	26.
20	9.2						
25	8.8	8.26	48	60	2.82	10	28.
30	6.8						
35	6.2	8.72	87	60	3.01	10	30.7
40	9.0						
45	11.8	6.96	69	60	2.84	10	28.4
50	11.2						
55	10.0	6.86	86	60	3.10	10	31.
60	11.0						
65	10.0	6.0	74.5	60	3.21	10	32.1
70	9.0						
75	10.4	6.2	97	60	3.01	10	30.1
80	10.2						
85	9.0						
90	9.7						
95	6.8	4.08	45	10	1.23	10	12.3

Mean Vel.:- 2.74 ft. per sec. -

1.9 miles per hour.

GRAND RIVER SANITARY SURVEY

Stream Gauging Notes. Station No.17 - Tompkins Bridge Gauging No. 3.

April 29, 1916. Gauge Height 6.5.

Dist. From Initial Point	Depth Ft.	Depth of Observation	Time in Sec.	Revolutions in Secs.	Mean Vel. in Secs.	Mean Depth Ft.	Width Ft.	Area Sq.Ft.	Discharge Cu.Ft.Sec.
0	5.2								
5	5.8	3.5	120	34	0.64	5.73	10	57.3	36.8
10	6.2								
15	7.0	4.2	120	50	0.94	6.73	10	67.3	63.5
20	7.0								
25	5.5	3.3	76	50	1.45	6.00	10	60.0	87.0
30	5.5								
35	4.7	2.8	88	50	1.14	6.07	10	60.7	69.3
40	8.0								
45	9.0	5.4	98	50	1.14	8.50	10	85.0	97.0
50	8.5								
55	8.0	4.8	82	50	1.36	8.17	10	81.7	117.0
60	8.0								
65	7.3	4.4	74	50	1.51	6.77	10	67.7	102.0
70	5.0								
75	6.7	4.0	100	50	1.12	6.33	10	63.3	71.2
80	6.5								
85	6.5	3.9	96	50	1.17	5.75	15	86.3	101.0
90	5.5								
95	4.5	2.7							
Mean Vel:- 1.19 ft. per sec. - 0.81 miles per hour.						Total ---		629.3	744.8

Gauging No. 4.

May 20, 1916. Gauge Height 5.7

0	6.6								
5	7.3	4.4	120	44	0.82	7.07	10	70.7	58.2
10	7.3								
15	8.0	4.8	68	50	1.64	7.77	10	77.7	127.5
20	8.0								
25	6.4	3.8	66	50	1.69	6.93	10	69.3	117.3
30	6.4								
35	5.7	3.4	58	50	1.93	6.97	10	69.7	134.8
40	8.8								
45	9.8	5.9	54	50	2.07	9.30	10	93.0	192.4
50	9.2								
55	9.0	5.4	58	50	1.93	9.33	10	93.3	180.1
60	8.8								
65	8.1	4.9	52	50	2.15	7.57	10	75.7	163.0
70	5.8								
75	7.5	4.5	62	50	1.81	6.87	10	68.7	124.3
80	7.3								
85	7.2	4.3	80	50	1.39	6.63	15	99.5	138.8
90	6.5								
95	5.5	3.3							
Mean Vel:- 1.72 ft. per sec. - 1.18 miles per hour.						Total --		717.6	1236.4

Stream Gauging Notes.

April 29, 1916.

Gauge Reading Zero.

Dist. from Initial Point	OBSERVATIONS: Depth Ft.	Depth of Observ. Vertical	Time in Seconds.	Rev. in Seconds.	Mean Vel. in Ft. per Sec.	Mean Depth Ft.	Area Sq. Ft.	COMPUTATIONS: Discharge Cu. Ft. per Sec.
0	6.2							
5	5.8	3.8	120	84	0.64	5.75	10	36.8
10	6.2							
15	7.0	4.2	120	80	0.74	6.75	10	47.3
20	7.0							
25	5.5	3.3	70	80	1.42	6.00	10	40.0
30	5.5							
35	4.7	2.8	68	80	1.14	6.07	10	30.7
40	8.0							
45	9.0	5.4	98	80	1.14	6.50	10	32.0
50	6.5							
55	8.0	4.8	82	80	1.36	6.17	10	31.7
60	8.0							
65	7.3	4.4	74	80	1.31	6.77	10	33.7
70	5.0							
75	8.7	4.0	100	80	1.12	6.88	10	38.8
80	6.5							
85	6.5	3.9	96	80	1.17	6.75	10	31.3
90	5.5							
95	4.5	2.7						
Mean Vel.- 1.19 ft. per sec. - 0.81 miles per hour.					Total ---		629.3	744.8

Gauging No. 4.

May 20, 1916.

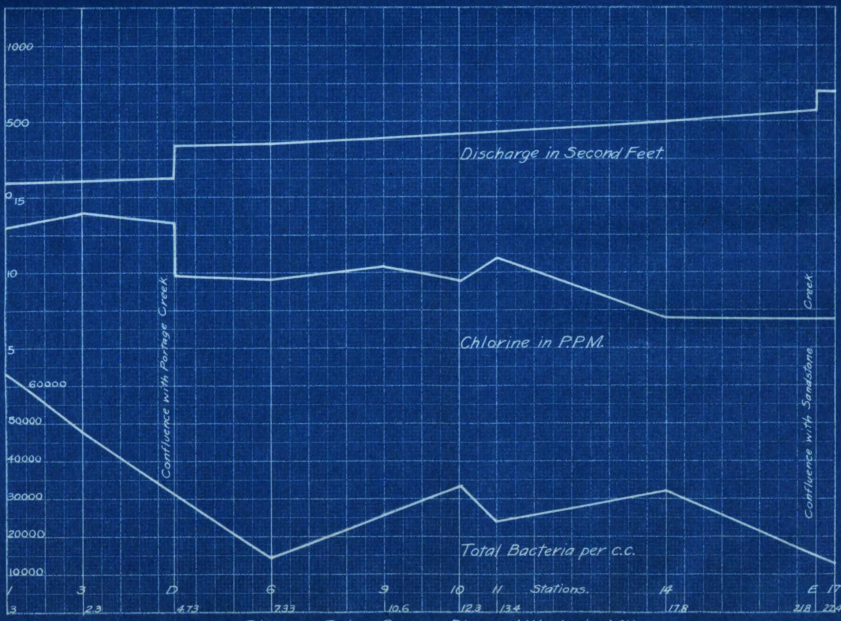
Gauge Reading 5.7

0	6.6							
5	7.3	4.4	120	44	0.82	7.07	10	70.7
10	7.3							
15	8.0	4.8	66	80	1.64	7.77	10	77.7
20	8.0							
25	6.4	3.8	66	80	1.69	6.93	10	69.3
30	6.4							
35	5.7	3.4	58	80	1.92	6.97	10	69.7
40	8.8							
45	9.8	5.9	64	80	2.07	9.30	10	93.0
50	9.5							
55	9.0	5.4	88	80	1.52	9.88	10	98.8
60	8.8							
65	8.1	4.9	82	80	2.16	7.67	10	76.7
70	5.8							
75	7.5	4.6	62	80	1.81	6.87	10	68.7
80	7.5							
85	7.2	4.2	60	80	1.60	6.62	10	66.2
90	6.5							
95	5.5							
Mean Vel.- 1.15 ft. per sec. - 1.15 [illegible]					Total ---		[illegible]	[illegible]


Station 13
Station 14
Station 12
Station 11
Station 10
Station 17
Station 15
Station 16
Rives Junction
Station E'
Station 8
Tompkins
Station 7
Station 6
CENTRAL R.R.
Grand River
Station 5
Station 4
G.T.R.R.
MICHIGAN
Station 3
Station 2
Station 1
Sewage Disposal
JACKSON
Station A
GRAND RIVER SANITARY SURVEY
MAP
SHOWING
DRAINAGE BASIN,
ROADS and SAMPLE POINTS
Scale 3/4" = 1 mile.

GRAND RIVER SANITARY SURVEY

SAMPLING MARCH 25, 1916.



Distance Below Sewage Disposal Works in Miles.
1 Inch = 2.5 Miles

GRAND RIVER SANITARY SURVEY

SAMPLING APRIL 22,1916.

GRAND RIVER SANITARY SURVEY

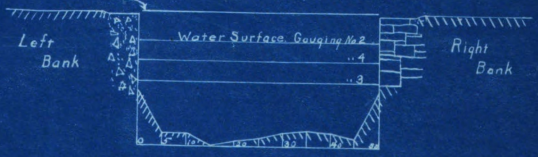
SAMPLING MAY 6, 1916.

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO.3.

S15 T2S R1W

VIEW FROM DOWNSTREAM.



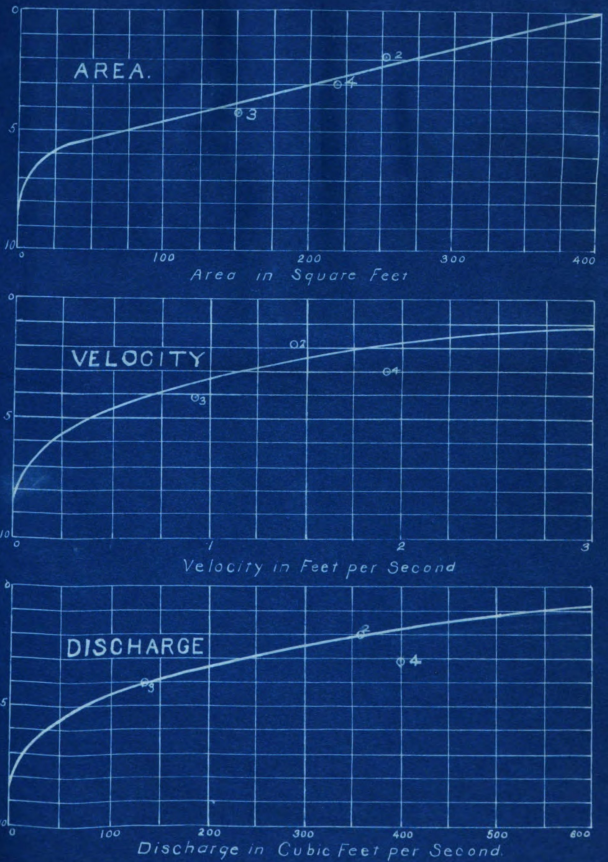
GROSS SECTION - UPSTREAM

Scales :- Vert. 1" = 6'-0".
Horiz. 1" = 20'-0".

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 3

S15 T2S R1W

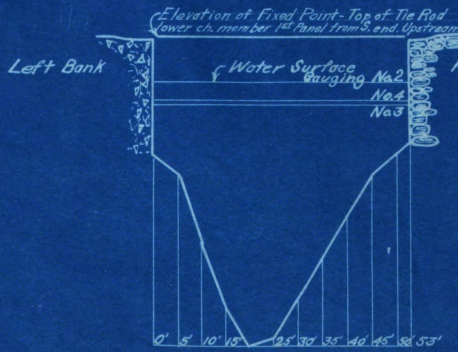


GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 'D'

Puddleford Bridge - S11-T2S-R1W.

VIEW FROM DOWNSTREAM



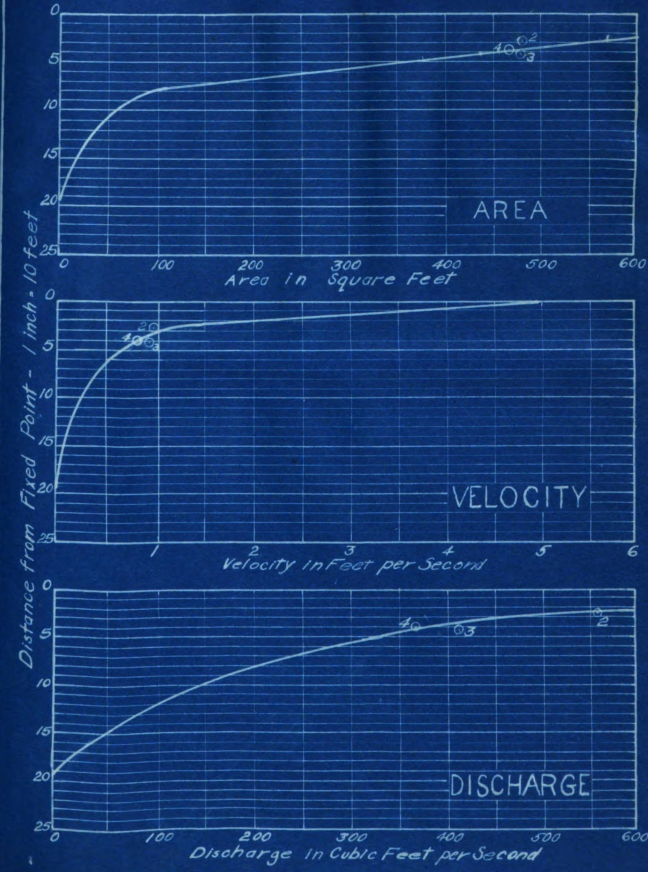
CROSS SECTION - UPSTREAM

Scales:- Vert. - 1" = 6'0"
Hor. - 1" = 20'0"

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 'D'.

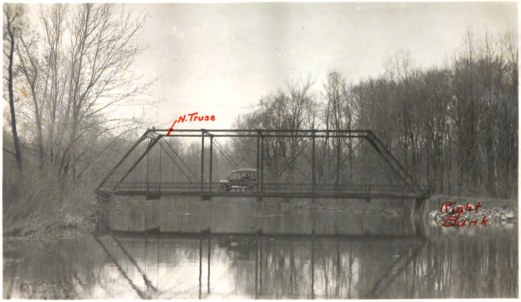
Puddleford Bridge



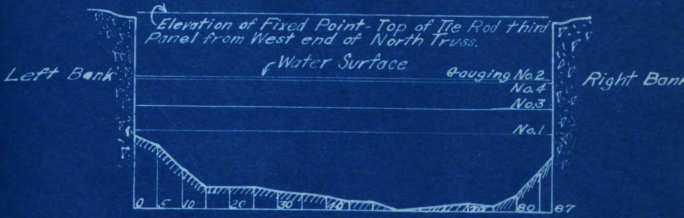
GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 6.

Stattler Bridge S35 T1S- R1W.



VIEW FROM UPSTREAM



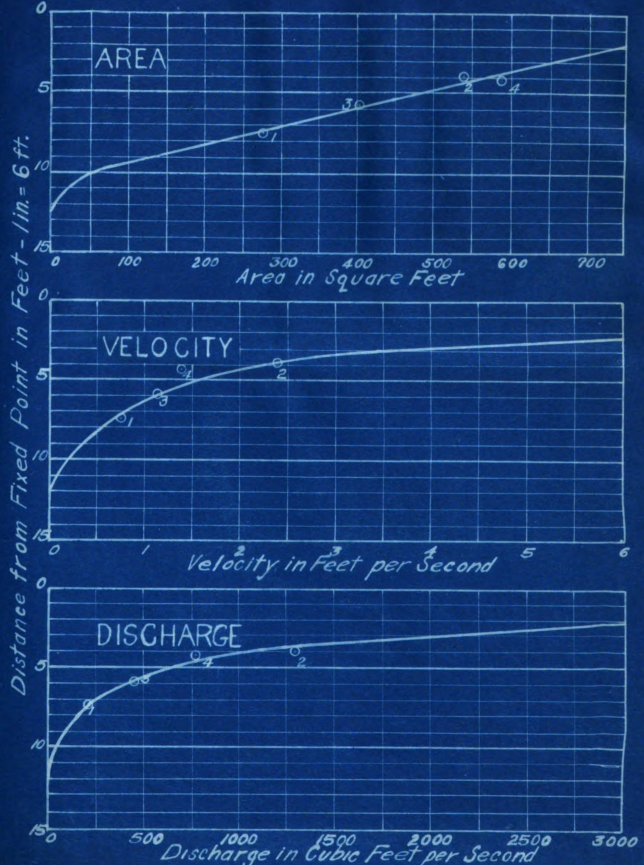
CROSS SECTION-DOWNSTREAM

Scales:- Hor. -1"= 20'0"
Vert. -1"= 6'0"

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 6.

Stattler Bridge - S35-T1S-R1W.

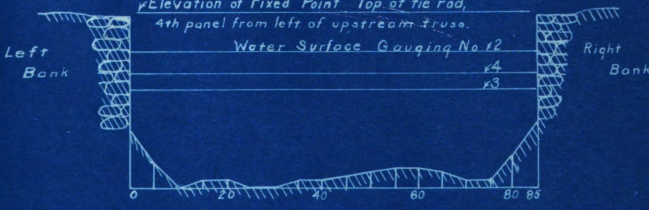


GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 10.

Northrop Bridge. S10-T1S-R1W

VIEW FROM DOWNSTREAM



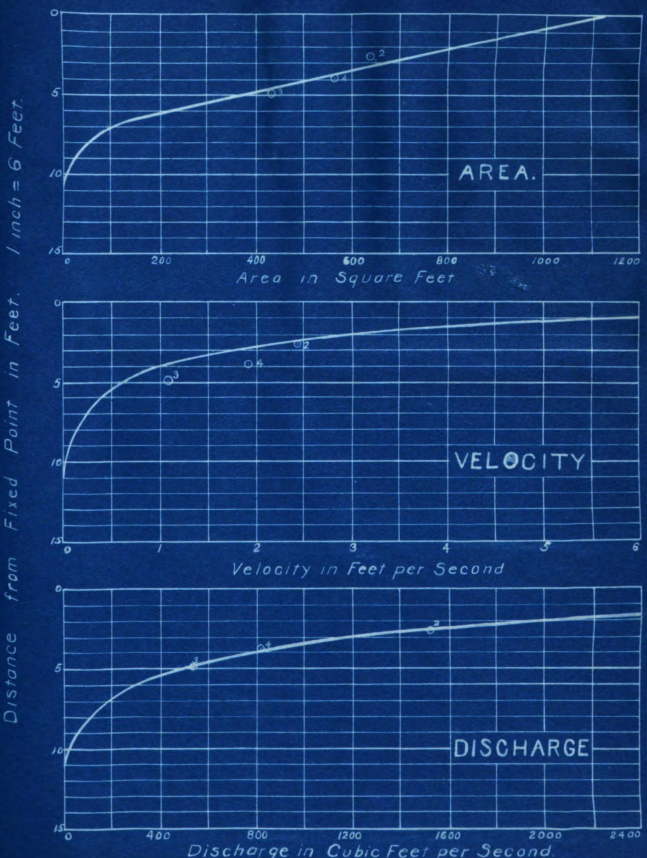
CROSS SECTION — UPSTREAM

Scales :- Vert. 1" = 6'-0"
Horiz. 1" = 20'-0"

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 10

Northrop Bridge. S 10 - T 1 S - R 1 W.

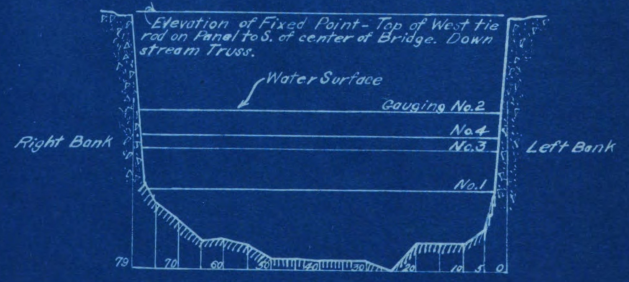


GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 14.

Berryville Bridge-S 12 -T1S-R2W

VIEW FROM DOWNSTREAM



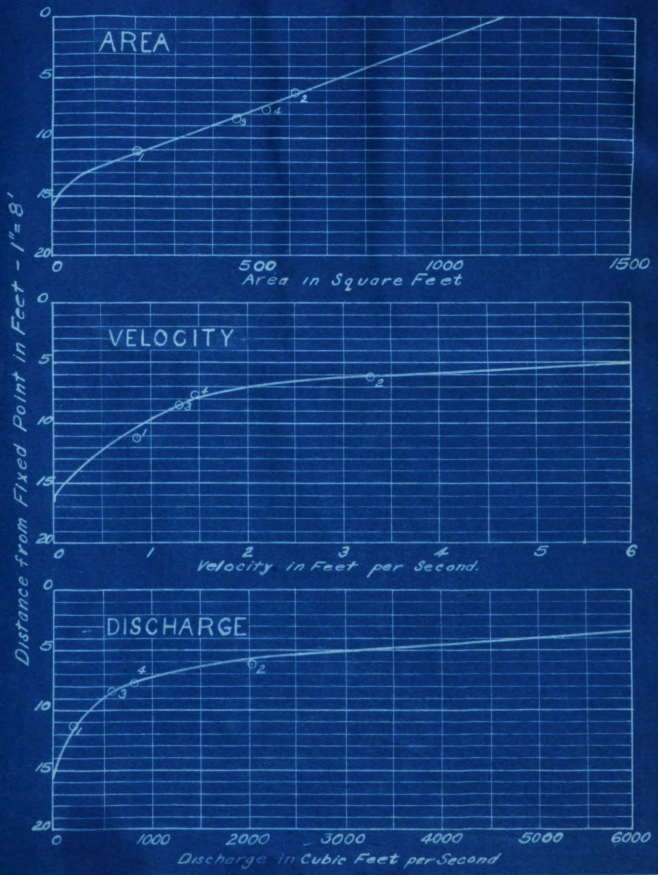
CROSS SECTION-DOWNSTREAM

Scales:- Hor.-1"=20'
Vert.-1"=6'

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO.14

Berryville Bridge S12-T1S-R2W

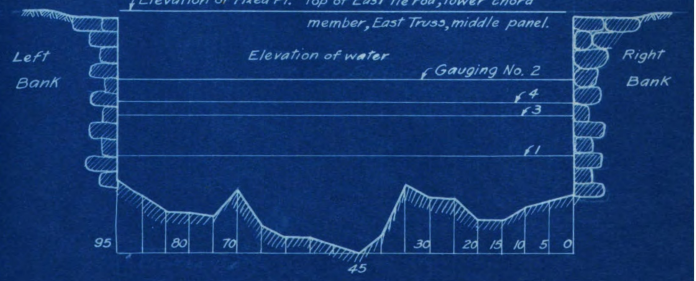


GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 17

Tompkins Bridge S15 T1S R2W

VIEW FROM UPSTREAM



CROSS SECTION — UPSTREAM

Scales:— Vert. 1" = 6'-0"
Horz. 1" = 20'-0"

GRAND RIVER SANITARY SURVEY

GAUGING STATION NO. 17

Tompkins Bridge S15 T1S R2W