1920

Preliminary study of possible power development on the Gasconade River

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PRELIMINARY STUDY OF POSSIBLE POWER DEVELOPMENT ON THE GASCONADE RIVER.

BY

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A THESIS SUBMITTED TO THE FACULTY OF THE MISSOURI SCHOOL OF MINES AND METALLURGY, IN PARTIAL FULLFILLMENT OF THE WORK REQUIRED FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING.

Rolla, Missouri. 1920.

Approved by Elmo G. Harris
Professor of Civil Engineering.

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LIST OF CHARTS AND MAPS.

FOREWORD.

The location of a possible dam site on the Gasconade River as a thesis proved to be a very interesting subject. Our first trip pointed out to us that we had undertaken a large task. We also realized that our subject was too big to complete thouroughly in the time alloted ~~to us~~.

Due to this circumstance we tried to cover the essential facts and to eliminate as much of the detail work as possible. For instance, we made no attempt to make a complete survey of the basin, instead, we ran surveys for some distance up the river to give an idea of the nature of the country and a way of approximating the volume of the basin.

C.R.B.

R.B.W.

H.W.Z.

THE ARLINGTON-JEROME POWER SITE.

Early in January 1920 actual field work was started, but due to the weather conditions nothing definite was accomplished at that time. However, upon the conditions found then, a general idea of the problems to be solved, and the nature of the country was obtained.

The work was divided into three parts: Surveying, Water Gaging, and Power Estimate.

SURVEYING.

Accurate surveys were made of the section best suited for the dam. It was started at the St. Louis & San Francisco Railroad bridge, between Arlington and Jerome, and continued for a mile up the river. The work was done by triangulation and plane table. The base line for the triangulation was seven hundred sixty feet in length, and was laid out on a tangent of the railroad which crosses the bridge at this point. Triangulation points were set off from this ~~line at any~~ base to several convenient points; it being necessary to cross the river several times in order to get conditions suitable for plane table work. This method of surveying was used up the river ~~as far as~~ to the beginning of the ~~second~~ range of cliffs. At this point military mapping methods were substituted for the plane table. This was found to be much faster, and as accurate as necessary under the circumstances. No attempt was made to survey every draw encountered. About every half mile a check was made on the river to see that the elevations were correct. It was possible to make the checks because levels had previously been run up the river and several bench marks established. [1] These levels [1] gave the amount of fall in the river for any distance up from the bridge. There was no attempt made to run the contours to the top of all the hills, they were merely run high enough to be above the highth of any dam that would be likely to be built. The accompanying maps show the general layout of the land and the course of the river.

To determine the fall of the river, levels [1] were run from the bridge up the river for a distance of about two and one half miles. The B.M. for all elevations was taken on the top and at the center of the east cross girder of the bridge. This elevation was assumed as 100. While running the levels, the elevation of a B.M. at the gaging station, (which will be described later,)

1 No check was made on these levels.

was established. A B.M. of elevation 84.41 was set in a large elm tree at the head of the gravel bar opposite the lower end of the third island. It was found from the levels that the average fall in the river was about three feet per mile. From this it was estimated that since the dam was to be about eighty feet high, the basin would extend for twenty-five miles. By the use of the plannimeter an approximate volume of the part surveyed was obtained. Therefore, knowing this distance, and the distance that the water when dammed up would cover, some idea of the total volume of the basin was obtained.

The only cultivated land was found in the flats, as shown on the map. The hills are too steep for cultivation and were covered, as a rule, with post oak and underbrush. The map shows the area that must be purchased as valuable land, and that which is of low value.

It was at first thot that the valuable timber on the land would pay for the cutting of that of little or no value, but this idea was later decide to be of no importance.

Gravel in sufficient quantities to

construct any dam that might be built was located at two places above the bridge, and one place just below the bridge. This item will be discussed more fully later on under the head of Power Estimate.

WATER GAGING.

A site for a gaging station was ~~selected~~ tried about midway between the first and second islands. This was found to be impracticable due to the extreme width at this point, and also because of the variable currents encountered.

It was then decided to use the gaging station used by Collins and Hatch in 1915. (Thesis, "Gaging the Gasconade River".) This station is about a hundred yards above where the cut-off or "Slough" enters the river, and about three-quarters of a mile above the Frisco bridge. The exact location is at two large sycamore trees standing on the north (left, looking down stream) side of the river. The one tree has a peculiar heart-shaped blaze on the river side, with the heart blaze pointing up. The currents at this point are fairly uniform, the velocity being lowest near the north bank, and steadily increasing until within a few feet of the south bank, after which it again decreases.

The bottom of the river is also well suited for a gaging station, being made up mostly of gravel with large stones on the south side only

This station was used as an accurate means of determining the flow up to a river stage of about three feet. At this point the water would start to run thru the cut-off or slough, this causing the measurements to be inaccurate.

When theriver reached a stage higher than about three feet and it was impossible to use the gaging station, another means of determining the flow was resorted to as follows:

A fairly straight strech in the river was selected just below the first island, and along the bank a distance of five hundred feet was laid out. Floating objects would be sighted as they passed the upper mark on the distance laid out, and the time noted. They were also sighted as they passed the lower mark, and the length of time necessary for the object to travel the five hundred feet was tabulated. These velocities were taken near both banks and in the middle of the stream. Knowing the velocity and cross-section, the amount of flow was easily calculated. These readings are only approximate. Four such readings were taken, at stages of 6.5 feet, 10 feet, 11 feet, and 12 feet. These points were used in the curve plotted for flow of the river for any stage.

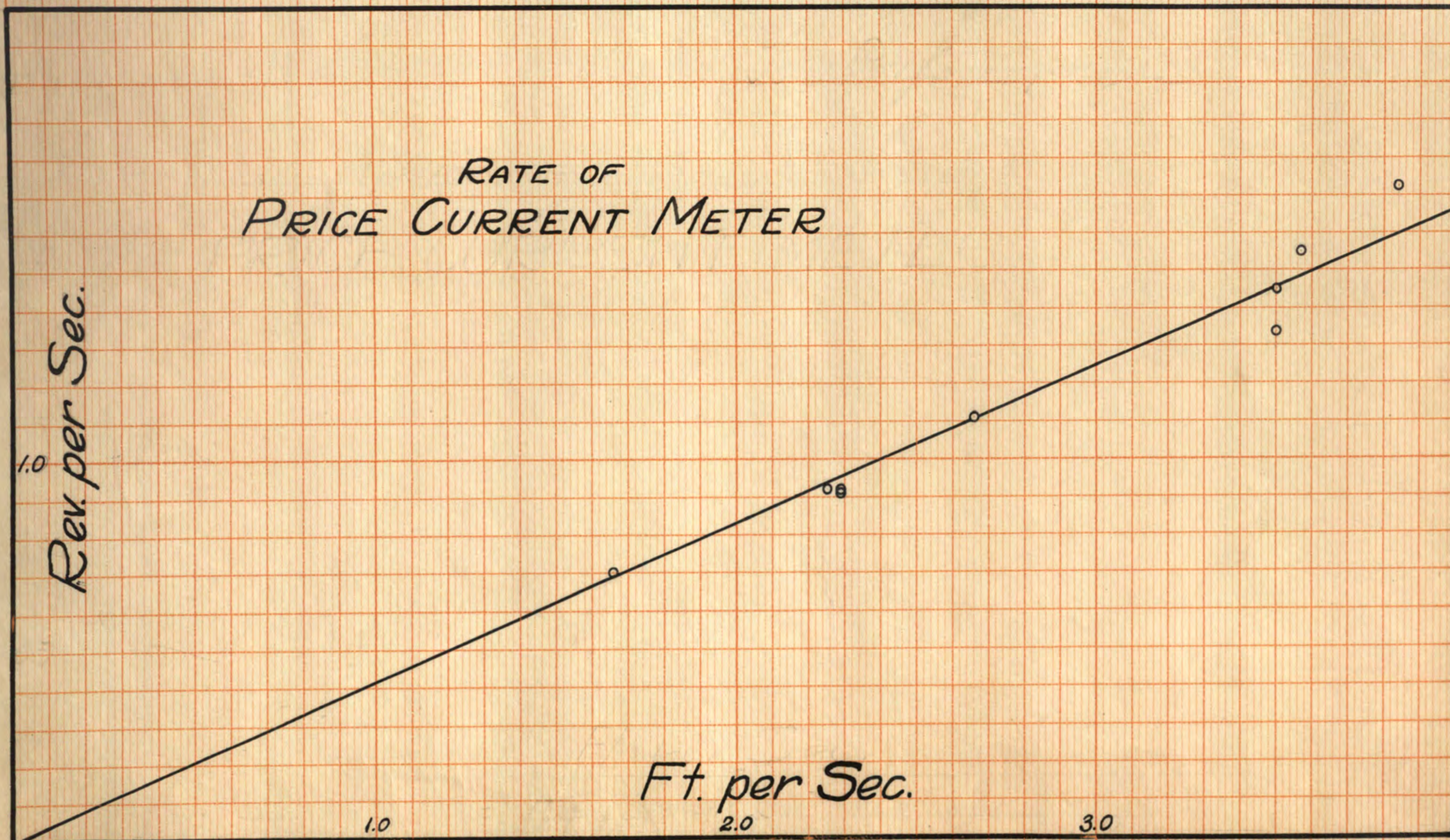
Water gagings at the regular station were taken with a Price Current Meter. Due to the fact that the meter had not been used for some time, it was necessary to rate it. This meter rating was done in the slough, or cut-off, which during low water has no current.

A distance of two hundred feet was measured along the bank of the slough. A boat was then rowed uniformily along this distance, care being taken that different velocities were obtained. ~~About~~ eight ~~such readings~~ were taken. By taking the time it took to travel the two hundred feet, the velocity in feet per second was found. At the same time ~~that these readings were taken~~, a man sitting in the front of the boat was rating the meter. This was done by holding the meter in the water and noting the number of revolutions made in a certain

RATING THE PRICE CURRENT METER.

Feb. 2, 1920.

ROWING BOAT.			RATE OF METER.		
Feet.	Time Sec.	Ft. per Sec.	Rev.	Time Sec.	Rev. per Sec.
200	56	3.57	70	45	1.55
200	75	2.66	80	72	1.11
200	87	2.29	60	65	0.91
200	87	2.29	60	64	0.92
200	120	1.66	100	138	0.70
200	57	3.50	90	62	1.45
200	89	2.25	90	97	0.92
200	57	3.50	90	67	1.34
200	52	3.84	90	52	1.73



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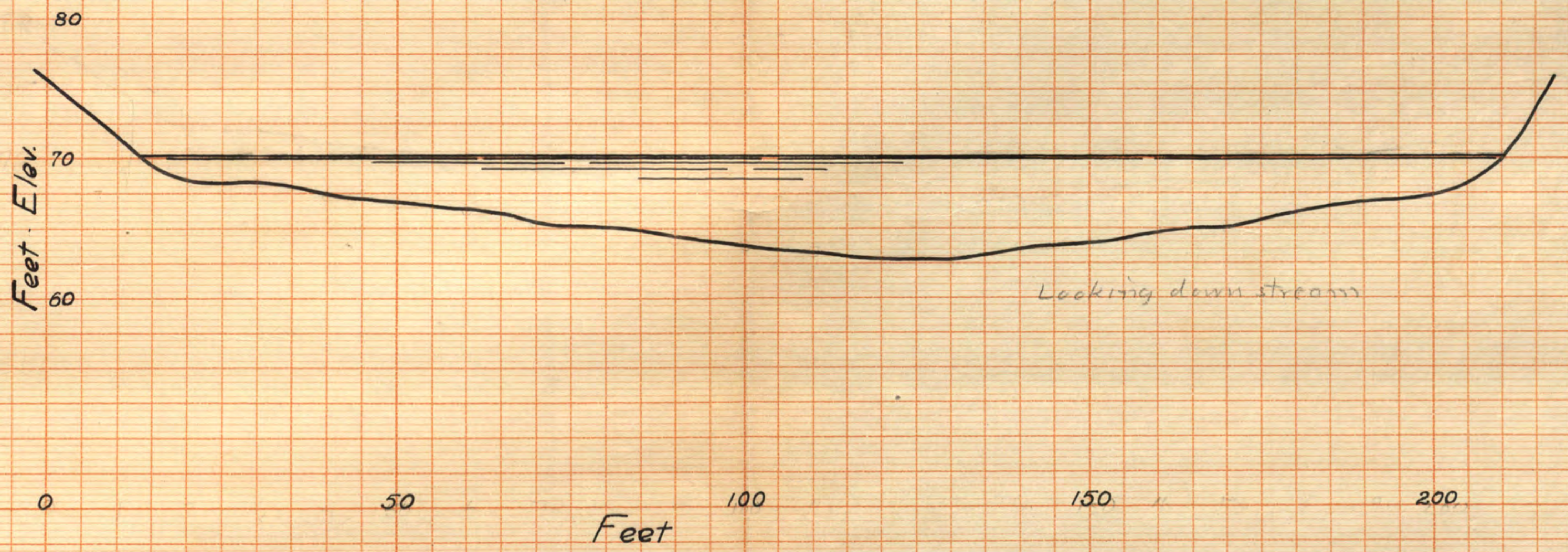
time. This work was done independently of the work of getting the velocity of the boat. From these results the velocity in feet per second was plotted as abscissae , and revolutions per second as ordinates, which gave a straight line curve. With this curve it is possible to compute the velocity in feet per second from the revolutions of the water meter.

In making the gagings a number nine wire was stretched across the river at the point taken as the gaging station. On this wire were tied strings at ten feet intervals. These were laid off from the north (left) bank, the blaze on the sycamore tree being used as zero , and the rest being laid off from there. To find the cross-section of the river bed, soundings were taken at the ten feet marks. These depths plotted gave an accurate profile of the river bed and area of the cross-section. This profile is shown as preface to page 12.

In using the Price Meter one man remained on the bank , tabulated the readings and kept the time. Two men were used in the boat, one handled the meter and the other took care of the boat to see that it kept straight with the current of the river.

Cross Section
PROFILE OF
GASCONADE RIVER GAGING STATION
FEB. 7, 1920.



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and by the aid of the oars relieved the other man from some of the strain of holding onto the wire, by rowing slowly upstream. The duties of the other man in the boat were to handle the meter and to hold to the wire. In making thegagings the meter was lowered into the water, and at a certain click which registers every ten revolutions, a signal was given to the man on the shore who started the stop-watch. Usually about five clicks were noted before the signal to stop the watch was given. The discharge sheets, pages 14 and 15 show how these results, along with the depths, were tabulated.

It was necessary to use some care in handling the meter so that the results would be accurate. The meter was placed into the water so that at the beginning of the time it was within about a foot of the surface. It was then lowered to within about a foot of the river bed, and raised again. This proved to be the easier of several methods of getting accurate results.

The result of these readings of the water meter gave revolutions of the wheel per second. To find the velocity of the stream the curve sheet was used, the given revolutions being found on the ordinates of the curve and the desired velocity of the stream on the abscissae.

Due to the fact that the time was so limited, and that the work was so varied, only two accurate river gagings were taken. These points are found on the discharge sheet. The quantities found for certain other stages of the river were taken from the thesis of Collins and Hatch to complete the curve.

This curve is plotted with the river gagings as ordinates, and volume as abscissae, so that it is possible to find the discharge of the Gasconade River for any stage.

Bridge, Stage -0.3 Feet. Feb. 7, 1920.

Sta.	Depth	Rev. of Meter	Time Sec.	Rev. per Sec.	Ft. per Sec.	Area	Vel.	Quan.
1+3.7	0.0	00	000	0.00	0.00			
						5.0	0.24	1.21
2	1.6	20	100	0.20	0.48			
						17.0	0.53	9.01
3	1.8	20	84	0.24	0.58			
						22.0	0.73	16.17
4	2.6	40	109	0.37	0.89			
						29.5	1.02	29.94
5	3.3	40	86	0.47	1.14			
						36.0	1.30	46.80
6	3.9	40	66	0.61	1.46			
						42.5	1.70	72.25
7	4.6	40	50	0.80	1.94			
						48.0	1.96	94.08
8	5.0	40	49	0.82	1.98			
						53.0	2.13	112.89
9	5.6	50	53	0.94	2.28			
						59.0	2.32	136.88
10	6.2	50	51	0.98	2.36			
						64.5	2.45	158.02
11	6.7	40	38	1.05	2.54			
						69.5	2.66	184.87
12	7.2	70	61	1.15	2.78			
						72.5	2.77	200.83
13	7.3	40	35	1.14	2.76			
						68.5	2.62	179.47
14	6.4	50	49	1.02	2.48			
						63.5	2.36	149.86
15	6.3	40	43	0.93	2.24			
						59.0	2.22	130.98
16	5.5	50	55	0.91	2.20			
						53.0	2.18	115.54
17	5.1	40	45	0.89	2.16			
						45.0	1.91	85.95
18	3.9	40	58	0.69	1.66			
						35.0	1.47	51.45
19	3.1	40	76	0.53	1.28			
						29.0	1.07	31.03
20	2.7	20	55	0.36	0.86			
						13.5	0.43	5.81
21	0.0	00	00	0.00	0.00			

Total cu. ft. per sec...... 1811.04

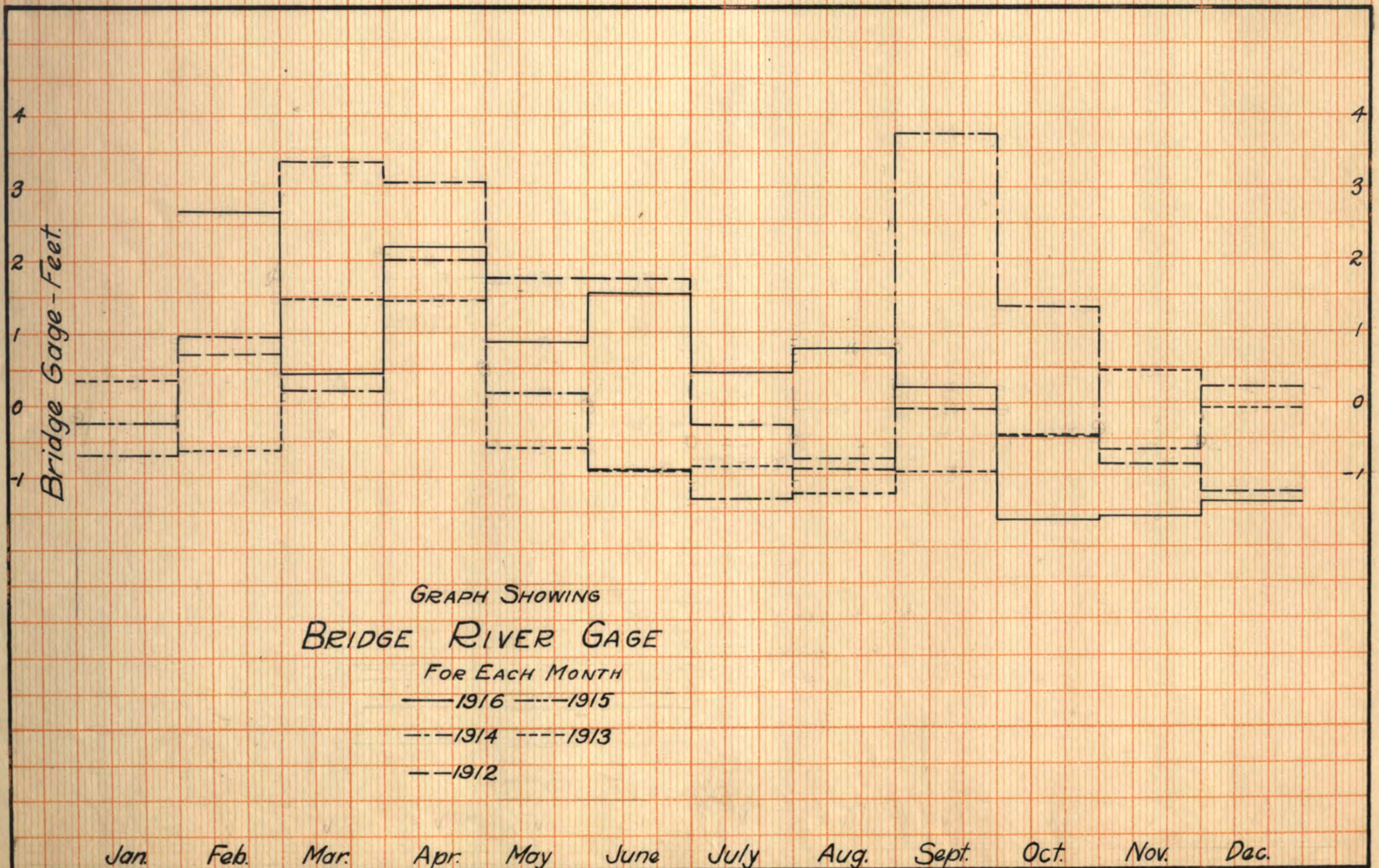
Bridge Stage 0.7 Feet. Feb. 23, 1920.

Sta.	Depth	Rev. of Meter	Time Sec.	Rev. per Sec.	Ft. per Sec.	Area	Vel.	Quan.
1+02	0.0	00	000	0.00	0.00			
						10.4	0.43	4.52
2	2.6	20	56	0.36	0.87			
						27.0	1.08	29.03
3	2.8	30	56	0.53	1.28			
						32.0	1.67	53.44
4	3.6	50	59	0.85	2.06			
						39.5	2.27	89.69
5	4.3	50	49	1.02	2.48			
						46.0	2.58	118.68
6	4.9	50	45	1.11	2.68			
						52.5	2.97	155.92
7	5.6	50	37	1.35	3.26			
						58.0	3.34	193.72
8	6.0	50	35	1.43	3.42			
						63.0	3.63	228.69
9	6.6	50	32	1.59	3.84			
						69.0	3.86	266.34
10	7.2	50	31	1.61	3.88			
						74.5	3.95	294.27
11	7.7	50	30	1.67	4.02			
						79.5	4.20	333.90
12	8.2	60	33	1.82	4.38			
						82.5	4.20	346.50
13	8.3	50	30	1.67	4.02			
						78.5	3.72	292.02
14	7.4	40	28	1.43	3.42			
						73.5	3.36	246.96
15	7.3	60	44	1.36	3.27			
						69.0	3.27	225.54
16	6.5	60	44	1.36	3.27			
						63.0	3.27	206.01
17	6.1	60	44	1.36	3.27			
						55.0	2.91	160.05
18	4.9	50	47	1.06	2.56			
						45.0	2.44	109.80
19	4.1	50	52	0.96	2.32			
						39.0	2.14	83.46
20	3.7	50	62	0.81	1.96			
						20.3	0.88	17.86
21+01	0.00	00	00	0.00	0.00			

Total cu. ft. per sec..... 3456.40

Average BRIDGE GAGE READINGS.

	1916	1914	1913	1912
JAN.		-0.70	0.37	
FEB.	2.66	0.95	-0.62	0.73
MAR.	0.44	0.24	1.45	3.39
APR.	2.20	2.00	1.43	3.09
MAY	0.86	0.17	-0.61	1.77
JUNE	1.52	-0.97	-0.97	1.77
JULY	0.41	-1.31	-0.86	-0.29
AUG.	0.75	-0.91	-1.26	-0.74
SEPT.	0.25	3.75	-0.97	-0.08
OCT.	-1.64	1.34	-0.47	-0.46
NOV.	-1.61	-0.63	0.46	-0.81
DEC.	-1.40	0.21	-0.07	-1.24



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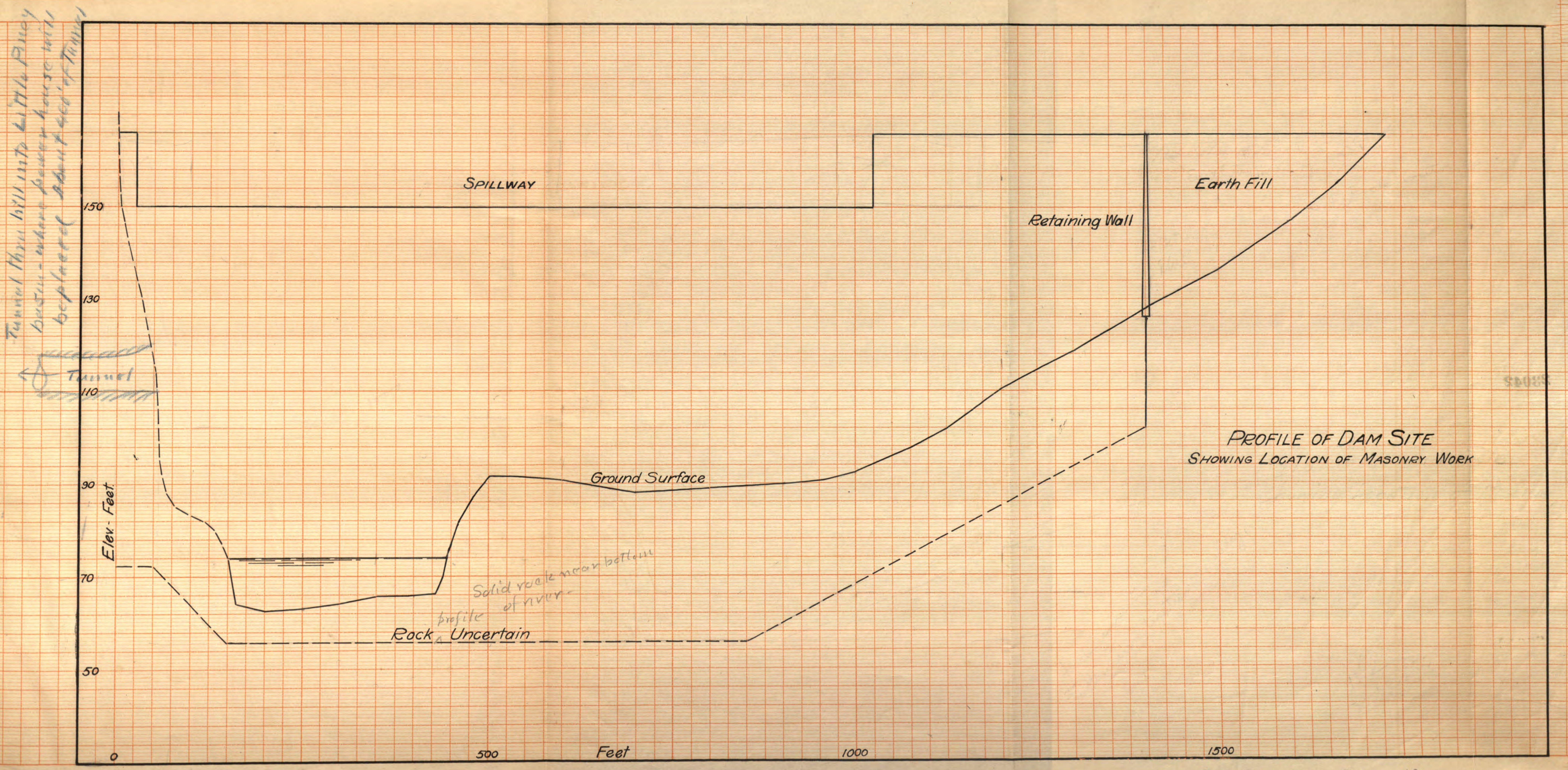
POWER ESTIMATE.

Construction of the Dam.

To find a location for a dam was not a hard proposition. The nature of the Gasconade River is such that a suitable location could be found in many places. The problem limited itself to the most economical location.

In locating the dam several things had to be kept in mind. Those were: A location such that as short a dam as possible could be obtained, that afforded the best foundation that could be had, that would allow the best methods of construction, and that would allow the most economy in obtaining material.

The site which seemed to best suit all t these needs was that just above the Frisco bridge. The exact location is shown on an enlarged map of that area. It is true that this site may not be as good as some other sites further up or down the river, but this fact is ofset by the nearness of this particular place to the Frisco R.R., which would be convenient in the shipment and handling of materials of construction.



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The subject of a foundation cannot be dismissed so easily. It is regretable to say that during the time that soundings were being taken, the river was at such a stage that it was impossible to reach solid rock by any means available. In going on with this work the assumption was made that rock could be found at a depth of ten feet below the river bed. This assumption is reasonable, because a few hundred feet below the site rock bottom is found only a few feet below the river bed.

The type of dam finally decided upon was that developed by the Wegman method. To be on the side of safety it was decided to use the Wegman gravity section built as an arch. The drawing shows two sectional views, one of a section thru the spillway, and the other of a section taken near the right end. The total length of the dam is seventeen hundred twenty-five feet. The two ends are built as abutments to the arch center. This method of construction was used in order to give a dam of as short a radius as practical. The spillway begins a few feet from the south end, or what is known as "Lover's Leap", and extends toward the north bank for a distance of one thousand feet. At this point the raised section begins and extends thru the earthen enbankment at the north end of the dam. The elevation of the crest of the spillway is one hundred fifty, the top of the raised section is sixteen feet higher. It was decided to use the ~~first~~ [top] fourty feet of the water for power development. Thisplaced the top of the tunnel at an elevation of one hundred ten. The entrance of the tunnel is to be protected with bars made into the shape of grating. Just inside this large grating is a finer one made of heavy wire with a fairly fine mesh. This arrangement is to keep any obsticals from entering the tunnel. Just below this grating, and a little to the left is a large sluice gate. This gate is six by eight feet. The gate itself is raised from above. The purpose of this sluice gate is to clean all the sand, gravel and other debris that may have settled at this point.

Tunnel thru "Lovers leap" point into Little Piney basin about ... to powerhouse

To protect the dam from water seaping underneath, a wall six feet wide and twelve feet deep ~~was constructed~~ [is designed] along the upper face of the dam. Further exploration of the foundation must be made before all the details can be recommended.

To protect the dam from suction during

overflow, water breaks ~~were~~ are to be built on the spillway at one hundred feet intervals. These water breaks reach to the same elevation as that of the raised section of the dam. They are two feet in width with a sharp edge facing upstream. The idea is that these obsticles break up the water so that is does not pass over the dam in one unbroken sheet. This relieves the suction caused by the vacuum formed by the water passing over the dam.

Method of Construction.

The exact time necessary to build the dam would depend upon the equipment used and the number of men at work. However the nature of the river is such that it is readily affected by rains. A general rain of very short duration over the water-shed will often cause the river to raise several feet. This means that extreme care should be taken to prevent disaster. The following is a suggestion for the best available method. The work would be started by building a coffer-dam out into the middle of the river, and inclosing the extreme south end of the dam. This would allow the water to flow between the coffer-dam and the north bank. The south end of the dam would then be but to above low water and the sluice gate set in. Work could also at this time be started on the north end. At a distance of about a hundred feet from the north band of the river earth excavation would be started and worked towards the north end. This would leave an earthen dam to protect the work from the river. The completion of this much of the work would leave a section of about three hundred feet unfinished. By opening the sluice gated the water of a slight raise could be taken care of. This would allow a coffer-dam to be built around the unfinished portion. The remaining earth could then be removed , and the construction work on the dam completed.

Materials of Construction.

Since the most important materials of construction are sand, gravel, and cement, they will be the only ones considered. To facilitate shipment of anything that may be needed on the job, an extention could be made to the spur track that is already in at Jerome. This would make it necessary to handle materials of construction only once, for they could be taken directly from the cars to the warehouse.

Cement would have to be shipped in, as well as most of the sand. It would be possible to ob tain some sand along the river but the expense ihcurred in digging and cleaning it would probably be more than would have to be paid for sand shipped in from outside.

Gravel can be obtained at several places along the river. A good gravel bar was found at the upper end of the second island, and further up at what is known as "Buzzard's Shoot". The bar at the second island is of such a nature that it would fill up as fast as it was used. The material obtained at this second island could be floated down tb the site in flat bottom scows or could be hauled to the site by wagon. That obtained at "Bussard's Shoot" could be brot down in boats, but could not be hauled. A few hundred feet below the bridge is a cable gravel digger used by the Frisco R.R. to get material for their roadbed. This could probably be used as another source .

Computations of Power Estimate.

In the following work several assumptions were made. For instance, it was decided to utilize only the top forty feet. The mean head was taken as sixty-five feet. This is fifteen feet below the level of the spillway. This assumption was made because at all but three or four months the water will be passing over the spillway making a head of eighty feet, so that it was reasonable to expect that the mean would be not below sixty-five feet. The price per K.W. hour was taken at one cent. This was used as a representive figure due to the fact that prices are continually fluctuating, and it was necessary to get some standard to work from.

From the sheet showing the Bridge Gage Readings for several years it was found that fifteen hundred cubic feet per second of water could be used. as a low water average

From the small contour map the volume of the basin from elevation 110 to 115, which takes in the top forty feet, was found to be five billion five hundred twenty million cubic feet. It would take approximately twenty-five hours to fill the dam with a flow of sixty thousand cubic feet per second, and at (fifteen hundred cubic feet per) not three-second discharge, it would take approximately thirty-five days to empty the basin, so that were the river to completely stop flowing, the plant could run for thirty-five days on the storage water.

Using the head as sixty-five feet, the amount of flow as fifteen hundred cubic feet per second, and the price per K.W. hour as one cent, it was found that eleven thousand one hundred H.P. could be developed. Changing the price into K.W., the yearly revenue was seven hundred twenty-five thousand dollars. This sum capitalized at 5% gave an amount of three million six hundred and twenty-five thousand dollars which would be justified in spending ~~on the construction of the dam.~~ to develop the power at 1c per KW

9000 HP @ 80% eff.
5,400 KW @ 87% eff
$475,000.00
cap @ 13% (old figures)

It was decided by rough estimate that one million five hundred thousand dollars would be necessary to purchase the land covered by the water, and that two million dollars would be necessary to construct the dam and power house and get everything in working order.

This figure falls below the capitalized amount, so the proposition would be profitable so far as the investment is concerned.

Altho the capitalized amount and the

construction expenses are nearly equal, it is not to be gathered that the project is a doubtful one. The fact that in all the computations one cent was used as the price per K.W. hour when it is actually selling for as much as fifteen cents per K.W. hour justifies the proposition.

The computations were also made on the development of only fifteen hundred cubic feet per second flow. As the dam would be overflowing most of the time, larger turbines could be installed so that during certain times much more water could be used. Contracts could be taken for the amount of K.W. developed by the fifteen hundred cubic feet per second flow at a set price, and all over that figure which could be developed, could be sold only when obtainable, and at a somewhat less price.

Another way in which to use the extra power which might be obtained at certain times would be to run some commercial plant in connection with the power development project. For instance, on some similiar projects operating under the same conditions, nitrate plants have been put in.

Auxiliary steam plants running about one month in twelve would insure much more continuous continuous power -- 1½ to 2 times as much

2304?