PART II.

RIVER SYSTEMS OF INDIANA.

THE WHITEWATER SYSTEM.

The Whitewater River is located in southeastern Indiana. It rises by two main branches in southern Randolph and Wayne counties. The West Fork flows in a general southerly direction past Cambridge City and Connersville. Between Laurel and Metamora, in Franklin County, it bends toward the east and flows in that direction for eleven miles to Brookville, where it is joined by the East Fork. The main stream bends immediately to the southeast and flows in that direction to its mouth at Valley Junction, Ohio, where it empties into the Big Miami River. The East Fork flows in a general southerly direction from Richmond to Brookville, where it joins the West Fork. It is parallel to the West Fork and about ten miles to the east of it.

Whitewater valley is situated in the rocks of the Cincinnati series. The west bluff of the West Fork, throughout its course above Metamora, is capped by a considerable thickness of limestone of the Silurian age (Clinton and Niagara). The Niagara forms a distinct divide parallel to and just west of the West Fork, along its upper course. The crest of this divide forms the western edge of the Whitewater basin. This condition causes the western tributaries to the West Fork to be very short and very swift streams.

The Whitewater basin lies entirely within the area covered by the Illinois glacier. The Wisconsin glacial boundary makes a great bend northward in this vicinity. It crosses the West Fork near Alpine and the East Fork near Fairfield, in Franklin County. All the larger tributaries have their sources in the Wisconsin glacial area. The main parts of the trunk streams, however, lie outside of this area. A great valley train, which fills the valley to a depth of approximately a hundred feet, extends throughout its course south of the Wisconsin glacial line. This valley train is composed of sand and gravel. The head waters of both forks are in the deep glacial deposits of the Wisconsin area. These conditions make the discharge from the stream fairly constant.

The drainage basin of the Whitewater River in Indiana occupies practically four counties—Wayne, Fayette, Union and Franklin. Small portions of these counties drain to other streams and small portions of other counties drain into Whitewater. The approximate drainage area of Whitewater in Indiana is 1,300 square miles. The United States Weather Bureau has five observation stations in and near this basin, and the record of these stations will be used in computing the amount of water furnished to the basin. The stations are at Richmond and Cambridge City, Wayne Co.; Connersville, Fayette Co.; Mauzy, Rush Co., and Greensburg, Decatur Co. The following table shows the mean annual precipitation in inches at these stations for the years 1900 to 1909, inclusive:

	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Richmond	40.59	26.97	37.56	34.08	35.65	41.72	31.71	48.78	33.64	48.38
Cambridge City	39.65	31.55	40.25	41.69	40.39	*	34.21	46.54	32.57	48.99
Connersville	40.26	26.13	38.75	36.09	37.61	46.96	40.93	43.80	37.32	43.73
Mauzy	39.17	31.11	43.23	40.11	40.26	48.94	41.20	47.08	33.96	45.70
Greensburg	*	*	44.59	42.29	41.66	43.88	37.88	43.09	32.61	*
Mean	39.92	28.94	40.88	38.85	39.11	45.37	37.19	45.86	34.02	46.45
Average mean annual for ten years										39.66

*Report missing.

The rainfall of this basin, as shown by this record, is slightly more than the average rainfall of the State during the same period If all this water were carried away it would represent a discharge of 4,557.8 cubic feet per second for the ten years. The runoff of any region in Indiana is from 30 to 35 per cent. of the precipitation. This would give an average runoff of about 1,500 cubic feet per second. The rest is lost by evaporation, etc. By evaporation is meant the direct evaporation into the air and also that taken up by plants and animals. Another source of loss is by seepage through the underlying strata. The conditions for such loss in this valley are good in one respect, i. e., the dip of the underlying strata is about thirty-five feet per mile toward the west and this basin skirts the edge of a thickness of three to four hundred feet of these strata. On the other hand, the underlying strata are composed of shale and limestone which are almost impervious to water. Hence it is probable that there is little loss from this cause. A greater source of loss in this valley is from the underflow which penetrates the valley train, to which reference has already been made. The loss from this cause is great, for the sand and gravel is extremely pervious. This loss could be overcome by constructing a dam to the solid rock beneath the valley train. This would entail heavy expense and will not be done while the demand for power is no greater than at present.

The water power now used on Whitewater River is a very small per cent. of the available power. The East Fork and main stream have no developed power. The West Fork has two systems developed. One is at Connersville and the other at Metamora and Brookville. Both are of the feeder dam type. In the early part of last century a commercial canal was built by the government along the main stream and the West Fork. It extended from the Ohio River up the Whitewater River and northward. In the latter part of last century this canal was abandoned for commercial purposes. Hydraulic companies have taken advantage of this abandoned canal for the construction of power systems. Seven miles north of Connersville a dam has been constructed across the West Fork and the water turned into the canal. The canal conducts the water to Connersville, where it is used for power. The total fall in the canal from the crest of the dam to the tail-race at Uhl and Snider's mill is eighty feet. Of this fall, fifty-three feet are used. Five plants use power from this system. The water is first divided between the Connersville Waterworks Co. and the Connersville Furniture Co. The Waterworks Co. employs a thirty-six inch wheel on eighteen feet fall and receives eighty horse-power. The Furniture company employs a thirty-inch wheel on the same fall and receives fifty horse-power. The water then unites and is used by the McCann Milling Co. They employ a thirty-five inch wheel on nine feet fall and receive fifty to sixty horse-power. The water is then divided between the P. H. and F. M. Roots Manufacturing Co. and the Uhl and Snider Flour Mill. The Roots Manufacturing Co. employs a twenty-one inch wheel on twenty-three feet fall and receives ninety horse-power. The Uhl and Snider mill employs a twenty-one inch wheel on twenty-six feet fall and receives one hundred and eight horse-power.

Table showing power used on this system:

Plant.	Head.	Water.	Wheel.	Power.
Connersville Furniture Co.	18 ft.	Portion	30 inch	50 H. P.
Connersville Waterworks Co.	18 ft.	Portion	35 inch	80 H. P.
McCann Milling Co.	9 ft.	All	35 inch	50-60 H. P.
P. H. & F. M. Roots Mfg. Co.	23 ft.	Portion	21 inch	90 H. P.
Uhl & Snider Flour Mill	26 ft.	Portion	21 inch	108 H. P.
Total				388 H. P.

On Oct. 30, 1909, a current reading on this canal between the Waterworks and the McCann mill showed a discharge of 86.02 cubic feet per second. The formula for reducing this to horse-power is $\frac{\text{discharge} \times \text{feet fall}}{11}$ = horse-power (practical) or eighty per cent. of the absolute power. The entire fall employed on this system is fifty-three feet. An application of the above formula shows a practical power of 414.46 H. P. with the water as per current reading and the fall of fifty-three feet. This shows a loss of but 26.46 H. P. on the fall employed. According to these figures the wheels on this system are very efficient. However, one current reading does not give sufficient data from which to generalize, and since the year 1909 had a precipitation above the average and since the months of September and October were above the average for these months in the last ten years, it is not safe to make a definite conclusion regarding this system.

If we consider that six inches per mile is sufficient fall for a hydraulic canal, we find that the available head is 76.5 feet. This gives us a practical power of 598.23 H. P. All this power could be produced at small expense. Therefore there is a loss of 210.23 H. P. on this system with the amount of water that was flowing on October 30, 1909.

This system is owned and controlled by the Connersville Hydraulic Co., of which Mr. E. D. Johnson is manager.

One mile below Laurel in Franklin County is another feeder dam which turns the water from the river into the canal again. The canal conducts the water sixteen miles to Brookville, where it empties into the river. The total fall from the crest of the dam to the tail-race at Brookville is eighty-five feet. Of this fall twenty-eight feet are used. At Metamora, five miles below the dam, the Metamora Flour Mill employs a fifty-inch wheel on eight feet fall and receives thirty horse power. At Brookville, sixteen miles below the dam, the Thompson and Norris paper mill employs two twenty-nine inch wheels on twenty feet fall and receive two hundred and seventy-five horse-power.

Table showing power used on this system:

Plant.	Head.	Wheel.	Power.
Metamora Flour Mill	8 feet	50 inch	30 H. P.
Thompson & Norris Paper Mill	20 feet	(2) 29 inch	275 H. P.
Total			305 H. P.

On October 30, 1909, two current readings were taken on the canal of this system. One was taken at the source of the canal and showed a discharge of 117.43 cubic feet per second. The other was taken near the C., C., C. & St. L. depot at Brookville and showed a discharge of 159.34 cubic feet per second. These readings show that the canal is replenished by ground water along its course, for there was no surface water entering it when the readings were taken. Small springs are common along the foot of the bluffs in this locality. If the smaller amount of water is considered available at Metamora, the practical power on eight feet fall is 85.4 horse-power. Thus there is a loss of 55.4 horse-power at the Metamora site. This is not due to inefficiency of the wheel, but to the fact that only part of the water is used. At least half of the water does not go through the wheel at this place. Considering the larger amount available at Brookville, the practical power on twenty feet fall is 289.7 horse-power. This gives a loss of only 14.7 horse-power, and indicates a high efficiency of the Brookville plant. If the average of the two readings be taken for the whole canal, the discharge would be 138.38 cubic feet per second. The entire fall on the system is eighty-five feet, and if six inches per mile be deducted for flow there is a fall of seventy-seven and one-half feet on the system. This gives the practical power of the system as 968.66 horse-power. Thus the loss of power on this system is 663.66 horse-power. Much of this is lost in abrupt falls in the old canal locks. It could all be employed at very small expense. This system is owned by the Brookville-Metamora Hydraulic Company, of which Mr. W. D. Bradt of Brookville is president.

The single current readings on these canals do not give adequate knowledge of the available power, but the estimates are very approximate, and there is no doubt that the power estimated above could be produced constantly except in very long drouths. A considerable amount of water was leaking through the dam at Laurel on the day the readings were taken. None was passing over it. The dam is of wood and cannot be made entirely tight. However, if it were replaced by concrete the entire volume of the stream could be turned into the canal during low water. This dam is located on a solid rock bottom. The river has abandoned its preglacial valley at this point and has made a cut across a point of rock, leaving an isolated mound standing in the valley. The dam is located in this cut. It is the best dam site on Whitewater River.

No power is used between Connersville and Laurel. The fall between these points is not known, but it is at least as much as the fall between Laurel and Brookville. The old commercial canal in this portion of the valley is in bad repair where the tributaries cross it, but in other parts is in good condition. This canal could be repaired at a very reasonable cost, and the power developed as it is above and below. The loss of power in this part of the stream is estimated at from 900 to 1,000 H. P.

On the main stream below Brookville the fall is heavy and the volume of water much greater. The East Fork is not as large as the West Fork, but there is little difference in the volume of the two streams. Thus the volume is practically doubled at the junction. The distance from Brookville to the state line at Harrison is fifteen miles. The estimated fall is 115 feet.

A gage was established at New Trenton, Franklin County, on August 12, 1910, and current readings taken at the same time, with the following result:

Date.	Cross Section.	Gage Height.	Discharge.
August 12, 1910	268.9 sq. ft.	3.45 ft.	266.98 cu. ft.

The discharge of 266.98 cu. ft. per second gives a practical power of 24.27 H. P. per foot fall. On a fall of 115 ft. the power would be 2,791 H. P. When the above current reading was taken the river was very low, but since no gage readings had been taken prior to that time it is not known that the stage was extreme low water. It is probable that a power of 2,000 H. P. could be produced constantly on this part of the river. The development of this power would be greatly reduced in cost and labor by the presence of the old commercial canal, which is in fair repair.

No investigation of the power on the East Fork has been made. It is not as large as the West Fork. Its drainage basin is practically half that of the West Fork. There has been no commercial canal along it, and for this reason the installment of power systems would be more expensive. However, the same sort of gravel terraces are found here that are found on the West Fork, and these make the construction of power canals much more simple than on streams where they do not occur. The conditions for the full development of the power on both forks of Whitewater are very good.

The gage, which was installed at New Trenton August 12, 1910, is being read daily by Alfred Brown, and if the investigation of water power is continued definite data can be obtained from this station.

BLUE RIVER SYSTEM.

The main stream of Blue River forms the boundary between Harrison and Crawford Counties. It rises in central Washington County and drains the southern half of the county. It drains the eastern half of Crawford County, and the western part of Harrison County. The basin contains approximately 450 square miles. The drainage area is uncertain, because the system lies entirely within the Mitchell limestone belt, in which a large portion of the drainage is subterranean. Thus a river may drain more or less than its apparent basin. Large springs are common along the stream and each comes from an underground cavern. The extent of the caverns is unknown. The whole system lies within the unglaciated region. The topography is very rough, a typical mature region. The hills are approximately 300 feet high above the river near its mouth and gradually diminish in height toward the source.

The gradient of the stream is very steep. The average fall from Milltown to the mouth is 5.34 feet per mile. Although the drainage area is small, the underground drainage causes the flow to be more constant than on other streams of the same size. The U. S. Weather Bureau has four observation stations in or near this basin. They are located at Jeffersonville, Floyd County; Marengo, Crawford County; Salem, Washington County, and Paoli, Orange County. The following table shows the mean annual precipitation at these places for the last ten years, in inches:

	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Jeffersonville	37.11	31.17	41.91	35.78	55.10	49.65	43.67	46.28	37.62	37.48
Marengo	44.85	32.37	51.18	37.88	53.20	62.27	42.53	57.97	34.24	*
Salem	37.03	32.09	46.15	38.63	53.60	42.25	36.44	58.04	34.09	57.24
Paoli	43.01	29.12	49.43	35.18	52.90	*	45.25	55.86	33.01	49.25
Mean	40.50	31.20	47.04	36.87	53.70	51.39	41.97	54.54	34.74	49.99
Average mean annual for ten years	......	......	......	......	......	......	......	......	......	44.19

*Report missing.

The average is 4.69 inches higher than the average precipitation for the State during the same period. If all this water were carried away by the river it would represent a discharge of 1,464.9 cu. ft. per second for the ten years. The loss by evaporation, which is unknown, must be deducted from this. It seems that the subterranean drainage reduces the evaporation. Another source of loss of water from this stream is by underground drainage. How extensive this loss is, is unknown, but the probability is that the gain through the same agency is as great or greater than the loss. The apparent basin is probably very near the same as the real basin.

The investigation of Blue River has been carried on only from Milltown to the mouth. Throughout the whole of this course the valley is narrow and bounded by steep bluffs of Mitchell limestone. The valley contains little bottom land. The river bed is rocky. The river consists of long reaches and abrupt rocky ripples. Favorable dam sites are very common, and the Mitchell limestone is a convenient and excellent material for the construction of dams of either concrete or masonry. The inaccessibility of this region makes the demand for power very small. However, this small stream has abundant power which can be developed easily and at small expense.

Three powers are now being used on this stream, and one on a tributary from Wilson's Spring. The three powers are at Milltown, Rothrock's Mill and White Cloud. The mill on Wilson's Spring branch is known as Le May's mill.

The Milltown mill is located at Milltown, four hundred feet below the Southern Railroad bridge. The dam is of wood and affords a head of seven feet five inches. The government permit on this dam is for eight feet. The mill in which this power is used is located on the west end of the dam. It was built in 1872 and employs three wheels each forty-eight inches in diameter. The total power received is about forty horse-power. This power is constant except in times of extreme drouth. It was employed every day during the year 1908, which was an exceptionally dry year. The Milltown Milling Company owns and employs this power.

Rothrock's mill is located in Sec. 11, T. 3 S., R. 2 E. The dam is of stone except the middle section, which is of wood. This section will be replaced by stone. The dam is one hundred and fifty feet in length and affords a head of 5.15 feet. There is no government ruling on this dam. The mill is located on the east end of the dam. A single thirty-six inch wheel is used which furnishes twenty horse-power. The power is used for sawing and planing. This mill was built about 1840. It is owned and run by Rothrock Brothers.

White Cloud mill is located at White Cloud, in Sec. 30, T. 3 S., R. 3 E. The dam is 210 feet long and affords a head of five feet. It is constructed of stone and cement. A canal five hundred feet long increases the head to 8.25 feet. The mill is located 500 feet below the dam. Two forty-eight inch wheels and one forty-inch wheel are used on this fall, and about fifty horse-power is received. The mill was originally a flour mill, but is now used as a saw and feed mill. The present mill was built in 1880 and is owned and operated by Wm. Rothrock.

Le May's mill is located one mile north of White Cloud, in Sec. 19, T. 3 S., R. 3 E. It is located at the mouth of a tributary to Blue River from Wilson's Spring. This tributary is about one mile long and receives its entire volume of water from Wilson's spring, except in rainy weather. This spring is probably the largest in the State. The dam is one hundred feet from the mouth of the tributary. It is built of wood and is fifty-five feet long. It affords a head of eight feet. The mill is located on the north end of the dam and employs two thirty inch wheels. Thirty horse-power is produced. It is used in making implement handles. This mill is owned and operated by Mr. Le May. The first mill on this site was built by Hon. William Henry Harrison in the early part of the last century.

Table showing power used on Blue River:

PLANT.	Head.	Wheels.		Power.
		Number.	Size.	
Milltown Mill	7.4 feet	3	48 inches	40 H. P.
Rothrock's Mill	5.15 feet	1	36 inches	20 H. P.
White Cloud Mill	8.25 feet	3	48 & 40 inches	50 H. P.
Le May's Mill	8.0 feet	2	30 inches	30 H. P.

Seven small power stations could be operated to an advantage between Milltown and the mouth of Blue River. The fall in this distance is 155 feet from the crest of the Milltown dam to low water mark on the Ohio River. All of this fall is available and practicable for power, except near the mouth where the back water from the Ohio River would interfere with it. The seven stations are located as follows: Milltown at present site; the Narrows, Sec. 22, T. 2 S., R. 2 E.; farm of John Hannell, Sec. 34, T. 2 S., R. 2 E.; Babcock's mill site, Sec. 36, T. 2 S., R. 2 E.; Rothrock's mill at present site; at extreme end of large bend below Sharp's mill, Sec. 13, T. 3 S., R. 2 E.; Wiseman Ripple, Sec. 35, T. 3 S., R. 2 E.

Table showing estimated distances, by stream, and fall between these stations:

Station.	Distance.		Fall.	
	From Milltown.	From Previous Site.	From Milltown.	From Former Site.
Milltown	00.0 miles	00.0 miles	7.5 feet	7.5 feet
Narrows	2.5 miles	2.5 miles	22.5 feet	15.0 feet
Hannell's	5.0 miles	2.5 miles	32.5 feet	10.0 feet
Babcock's	8.0 miles	3.0 miles	48.5 feet	16.0 feet
Rothrock's	11.0 miles	3.0 miles	64.5 feet	16.0 feet
Sharp's	15.0 miles	4.0 miles	79.5 feet	15.0 feet
Le May's (Loss)	17.0 miles	2.0 miles	82.5 feet	3.0 feet
Wiseman's	25.0 miles	8.0 miles	135.5 feet	53.0 feet
Mouth (Lost)	29.0 miles	4.0 miles	155.0 feet	19.5 feet

The distances given above are to the end of each proposed tail race. Only two absolute elevations are known on Blue River. The crest of the Milltown dam is 516.8 feet above sea level, and low water of the Ohio at the mouth of Blue River is 359.8 feet above sea level. The other elevations are approximate. The only measured fall is the one over the Wiseman Ripple site from the crest of the White Cloud mill dam to the Congressional Township line. The measured fall there was 53.2 feet. This fall was measured and checked by Mr. Coleman, a civil engineer of New Albany, and again checked by the writer. The approximations cannot be very far from correct.

The Milltown dam could be raised to ten feet without damage to property above. This power could be applied at night for the lighting of Milltown. At present it is not used at night.

The Narrows is a narrow ridge within an incised meander of the river. The fall from the tail race at Milltown to the upper side of the Narrows is approximately 9.5 feet, and the fall on the meander is 5.5 feet. The ridge within the meander is very narrow at one place. It is composed of Mitchell limestone and is 100 feet high. The distance through the ridge at the narrowest place is approximately 400 feet. The distance around the meander at the narrowest place is 1.5 miles. A dam 8.5 feet high at the upper side of the Narrows and a short tunnel would give a fall of 14 feet, 5.5 feet of which would be permanent. The dam would be 250 feet long.

On the Hannell farm the bluffs rise abruptly on each side of the river. The east bluff is terraced, making an excellent location for a power house. The terrace is about fifty feet above the river. The west bluff rises abruptly 150 feet above the river. A ten foot dam could be constructed here without injury to property.

At Babcock's mill site is the remains of an old dam. The power has not been used for about twenty years. The abrupt fall at this point is 6.9 feet. A dam 14.5 feet high could be constructed here without injury to land above. The dam would be 250 feet long.

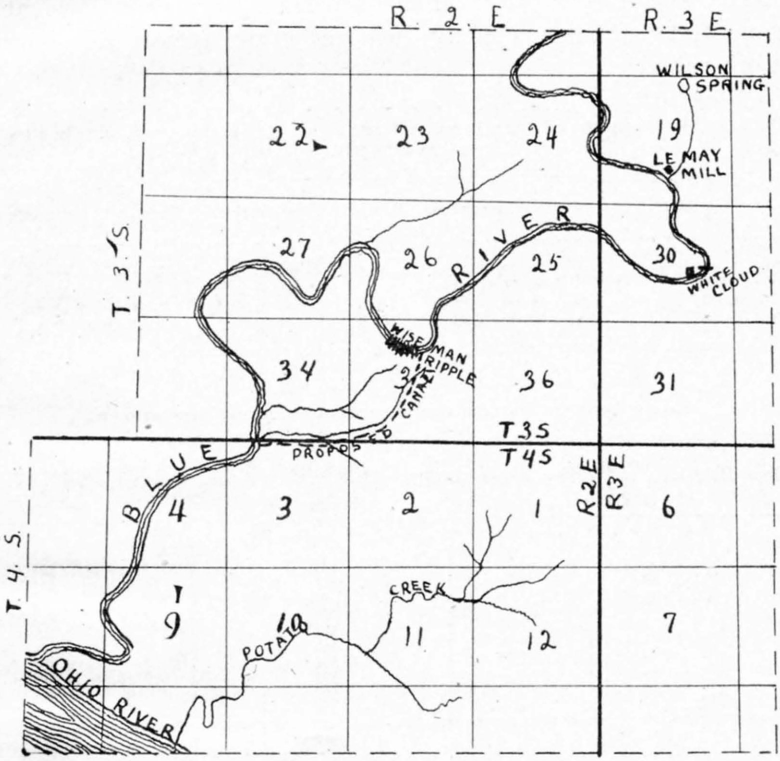
The dam at Rothrock's mill could be increased to 14.5 feet with injury to one small bottom field that can be bought for $300.

A seven foot dam on the extreme end of the bend below the old Sharp's mill site, and a canal along the west bluff for three-fourths of a mile would produce a fall of fourteen feet, of which seven would be permanent. This dam would not interfere with the power at Rothrock's mill and would injure no property. The cost of constructing the canal would be small, for a gradual hill, uncut by ravines, makes it unnecessary to cut or fill extensively. A wide bottom field occurs between the river and the proposed canal at this place.

Between the tail-race at this place and Le May's mill would be a loss of three feet fall. The cost of constructing any of the proposed powers would be small. The foundation of all dams are in solid rock. There is an abundance of Mitchell limestone at any site. The valley is narrow and the bluffs high.

The drainage from Wilson's spring increases the volume of Blue River considerably. During extreme drought the volume from the spring is almost equal to that of the river above the junction. The spring is more constant than the river, and at ordinary stages furnishes but a small part of the volume. The site at Wiseman's Ripple is below the junction of Wilson's spring branch. In approaching Wiseman's Ripple the river makes a great bend toward the south. Then it makes a great double bend northward and westward below the ripple, and swings far back toward the east at the Congressional Township line between T. 3 S. and T. 4 S., Fig. 3. At this point a small tributary joins the river from the east. The valley of this tributary extends directly across to Wiseman's Ripple. It reduces the south bluff of the river at Wiseman's Ripple to seventy feet. The fall from the crest of the dam at White Cloud to the head of Wiseman's Ripple is 26 feet. The fall from the head of Wiseman's Ripple to the Congressional Township line is 27 feet. A twenty-six foot dam at the head of Wiseman's Ripple with a tunnel one-eighth of a mile long, and a canal one mile long, would produce a fall of fifty-three feet. Twenty-seven feet of this fall would be permanent. Back water from the Ohio occasionally rises on this site. However, whenever this backwater occurs Blue River is also flooded. Reserve wheels could be installed and the loss by backwater overcome by the use of more water.

A gaging station was established one mile above White Cloud near the home of Julius Rothrock on August 18, 1909. The gage is constructed of heavy oak planks securely spiked to a large oak stump, and to the roots of a large sycamore tree. The plank is



MAP OF LOWER BLUE RIVER
SHOWING WISEMAN RIPPLE SITE.
FIG. 3.

placed with the slant of the river bank, which is about thirty degrees. The center is securely supported by heavy oak posts set in the bank. The scale is made of brass headed tacks on the upstream side of the gage. The base of this gage is three feet below a nail in the root of the sycamore tree, to which it is attached, and

23.7 feet below a nail in the corner of a barn which stands fifty feet south of the gage.

The gage has been read every day during the year by Victor Rothrock. Four current readings have been taken at this point within the last year. These current readings give a good definition of the flow of the stream between the limits at which they were taken. A rating table has been formulated from these readings. This rating table can be depended on between two and four feet. Further readings will make the rating table much more valuable.

DISCHARGE MEASUREMENTS ON BLUE RIVER AT WHITE CLOUD DURING THE YEAR AUG. 18, 1909, TO AUG. 18, 1910.

DATE.	Hydrographer.	Width.	Cross Section.	Gage.	Discharge.
Aug. 18, 1909	W. M. Tucker	153 ft.	333 sq. ft.	2.05 ft.	183 cu. ft.
July 27,1910	W. M. Tucker	157 ft.	416 sq. ft.	2.5 ft.	350 cu. ft.
July 28, 1910	W. M. Tucker	159 ft.	583 sq. ft.	3.55 ft.	1,109 cu. ft.
July 28, 1910	W. M. Tucker	162 ft.	651 sq. ft.	4.0 ft.	1,498 cu. ft.

RATING TABLE CONSTRUCTED FROM FOREGOING DISCHARGE MEASUREMENTS.

Gage Height, Feet.	Discharge, Cu. Ft. Per Sec.	Gage Height, Feet.	Discharge, Cu. Ft. Per Sec.	Gage Height, Feet.	Discharge, Cu. Ft. Per. Sec.
		2.1	197	3.1	744
		2.2	227	3.2	823
		2.3	263	3.3	904
		2.4	304	3.4	986
1.5	63	2.5	350	3.5	1,069
1.6	79	2.6	401	3.6	1.153
1.7	95	2.7	458	3.7	1,238
1.8	113	2.8	522	3.8	1,324
1.9	134	2.9	592	3.9	1,411
2.0	162	3.0	667	4.0	1,498

Above four feet a tangent is used, adding 88 cu. ft. for each .1 foot rise on the gage. This underrates the flow at high gage readings.

GAGE READINGS ON BLUE RIVER AT WHITE CLOUD, AUG. 18, 1909, TO AUG. 15, 1910.

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
1	......	1.65	1.60	1.70	1.80	1.85	2.70	7.00	2.00	2.70	2.60	2.30	3.10
2	......	1.65	1.55	1.70	1.90	2.25	2.65	6.20	2.00	2.60	2.60	2.05	2.80
3	......	1.65	1.55	1.70	2.20	3.05	2.60	4.40	2.05	2.55	2.50	2.15	2.70
4	......	1.65	1.55	1.70	2.20	2.70	2.60	4.00	2.00	4.00	2.40	2.05	2.40
5	......	1.60	1.55	1.65	2.20	2.50	2.60	3.70	2.00	3.10	2.70	2.25	2.45
6	......	1.65	1.50	1.65	2.10	3.20	2.60	3.50	2.05	2.85	2.50	2.90	2.35
7	......	1.60	1.55	1.60	2.15	2.75	2.50	3.30	2.00	2.80	2.50	7.00	2.30
8	......	1.65	1.55	1.70	2.30	2.30	2.40	3.15	2.00	5.70	2.35	4.20	2.20
9	......	1.60	1.60	1.70	2.45	2.30	2.40	3.00	2.00	5.20	2.30	3.40	2.20
10	......	1.65	1.60	1.80	2.25	2.20	2.40	2.95	2.00	5.00	2.15	3.60	2.15
11	......	2.40	1.70	1.80	2.25	2.20	2.40	2.80	1.95	3.55	2.30	3.50	2.10
12	......	2.00	1.70	1.70	3.50	2.30	2.35	2.75	2.00	3.60	2.20	3.70	2.05
13	......	2.00	1.80	1.75	4.30	2.50	3.30	2.70	3.10	3.95	2.80	4.30	2.00
14	......	1.80	1.75	1.75	4.80	9.60	2.20	2.65	3.20	3.40	2.60	4.70	2.00
15	......	1.70	1.70	1.75	3.75	5.20	2.25	2.55	2.80	3.10	2.50	3.65	1.95
16	......	1.70	1.75	1.70	3.30	4.00	2.30	2.50	2.80	2.95	2.40	3.80	......
17	......	1.75	1.70	1.80	3.00	3.55	3.00	2.45	4.90	2.80	2.35	9.00	......
18	2.05	1.75	2.00	1.80	2.80	4.85	3.10	2.40	4.90	2.90	2.30	5.30	......
19	1.95	1.75	2.05	1.80	2.60	7.10	2.90	2.35	4.50	2.95	2.25	4.30	......
20	1.90	1.70	2.10	1.80	2.30	4.55	3.00	2.30	4.80	2.80	2.20	3.60	......
21	1.60	1.60	2.40	1.95	2.25	4.00	3.30	2.30	4.40	5.10	2.00	3.30	......
22	1.75	1.65	2.25	1.80	2.25	3.80	5.20	2.30	3.80	3.85	2.05	3.00	......
23	1.70	1.70	2.25	2.25	2.20	3.60	5.40	2.30	3.50	3.50	2.05	2.85	......
24	1.70	1.60	2.55	2.25	2.10	3.45	4.60	2.25	3.30	3.30	2.10	2.75	......
25	1.70	1.60	2.55	2.30	2.10	3.30	3.80	2.20	3.10	4.40	2.00	2.70	......
26	1.65	1.60	2.20	2.15	2.05	3.10	3.40	2.15	2.95	3.85	2.00	2.80	......
27	1.65	1.60	2.05	2.00	1.95	3.10	7.10	2.10	2.90	3.40	2.05	2.55	......
28	1.65	1.55	1.90	2.00	1.90	3.05	12.15	2.10	2.90	3.10	3.25	2.45	......
29	1.65	1.60	1.90	1.95	2.00	3.00		2.10	2.90	2.90	3.70	3.20	......
30	1.65	1.55	1.80	1.95	1.90	2.90		2.05	2.80	2.80	2.55	5.15	......
31	1.70		1.70		1.85	2.80		2.05		2.80		3.60	......

These gage readings show from the rating table that the minimum discharge during the year was 63 cu. ft. per second. This discharge occurred on October 6. From the time the record was begun until December, the discharge varied from a minimum of 63 cu. ft. per second to a maximum of 304 cu. ft. per second. The average for this time was about 100 cu. ft. per second. For the other eight and a half months the minimum is 113 cu. ft. per second, with only six days that it was below 160 cu. ft. per second. These figures show that for eight months of the year, with a discharge of 160 cu. ft. per second, and a fall of 53 feet, which could be developed on Wiseman's Ripple, a minimum of 771 H. P. (practical) could be produced. For the other four months the minimum would be 303 H. P.

When the gage shows a stage of 2.0 to 2.5 feet the discharge of Wilson's Spring is estimated to be .25 of the entire discharge at this point. This would indicate a minimum discharge of 120 cubic feet per second for the sites above White Cloud for eight months of the year. This discharge at the proposed sites would yield the following minimum power for eight months of the year:

STATION.	Fall.	Discharge.	Power.
Milltown	10 feet	120 cu. ft.	109 H. P.
Narrows	14 feet	120 cu. ft.	152 H. P.
Hannels	10 feet	120 cu. ft.	109 H. P.
Babcock's	14.5 feet	120 cu. ft.	158 H. P.
Rothrock's	14.5 feet	120 cu. ft.	158 H. P.
Sharp's	14 feet	120 cu. ft.	152 H. P.
Le May's	8 feet	40 cu. ft.	29 H. P.
Wiseman's	53 feet	160 cu. ft.	771 H. P.
Total	....	....	1,638 H. P.

WHITE RIVER SYSTEM.

White River drains the south central portion of Indiana. Its basin comprises more than a third of the area of the State. It rises in central and southeastern Indiana by numerous branches which unite to form two main branches. The general direction of the drainage is toward the southwest. The east and west forks unite at the southwest corner of Daviess County. The main stream flows from this point to the Wabash River at Mt. Carmel, Illinois. The drainage area of the whole system is approximately 11,300 sq. mi. The drainage areas of the east and the west forks are approximately equal, each 5,550 sq. mi. Tributaries to the main stream below the junction drain approximately 200 sq. mi.

The East Fork of White River rises along the crest of the Niagara escarpment in Henry, Fayette, Rush, Decatur, Ripley and Jefferson Counties. The tributaries from this escarpment are long streams with slight fall. The largest tributary is known as Blue River, in Henry, Rush and Shelby Counties. It rises in the Wisconsin glacial area, which it leaves in Bartholomew County. It then flows for a short distance in the Illinois glacial area and enters the unglaciated region in Jackson County. It flows directly across the unglaciated region and re-enters the Illinois glacial area, in Daviess County, in which it continues to its mouth. The Wisconsin glacial deposits at the source of this stream tend to regulate the flow so that it never ceases, even in northern Rush County, where the stream is very small. A long valley train of glacial material occurs in Bartholomew and Jackson Counties, diminishing in Lawrence and Martin Counties. This valley train covers the underlying strata and leaves few bed rock dam sites. This stream flows across every rock formation of the State except the Ordovician, but only occasionally is bed rock exposed in the river bed. These exposures occur where the stream meanders into one of its bluffs.

The valley of the East Fork of White River is everywhere broad and level. It is an excellent farming region. Frequent floods occur which cover the lowland for great distances. During these floods the river often makes radical changes in its course. The loose sand and gravel of which the bed of the stream is composed is easily shifted by the flood water. Gradual changes are constantly going on whereby the stream in time entirely changes its course. These conditions hinder the installation of water power stations.

The rainfall in White River basin is very near the average of the State. Several observation stations are located in the basin, and the mean average of these stations for the last ten years shows slightly more than 39.5 inches. If this were all carried away by the river the continuous discharge of each fork would the 16,150 cu. ft. per second. These figures mean nothing as they stand, but if the actual discharge during the ten years could be known the difference between rainfall and runoff in the valley could be determined. In 1904 the U. S. G. S. took daily gage readings and careful current readings at Shoals. The mean discharge in second-feet for that year is given in Water Supply and Irrigation Paper No. 128, page 95, as 4,640 cu. ft. The mean annual rainfall in the East Fork of White River basin for that year was 39 inches. The drainage area above Shoals is 4,900 sq. mi. If all this water were carried away it would represent a discharge of 14,078 cu. ft. per second. Since the actual discharge was only 4,640 second feet, we find that the discharge is 32.96 per cent. of the rainfall. One year is not sufficient to make a definite determination of this relation. The government records have not been kept at Shoals for any full year except 1904 and 1905. The government statistics will be given here verbatim.

WHITE RIVER (EAST BRANCH), AT SHOALS, IND.[6]

This station was established June 25, 1903, by A. C. Lootz. It is located at the highway bridge, in the village of Shoals, Ind., 400 feet above the Baltimore and Ohio Southwestern Railroad bridge. There are rapids just below this station and also about 5½ miles below. The gage is read once each day by O. H. Greist. The standard chain gage is fastened to the railing and metal posts of the downstream side of the first span on the left end of the highway bridge. The length of the chain from the end of the weight to the marker is 46.41 feet. This gage was established to take the

[6] Water Supply and Irrigation Paper, No. 98, pp. 216–218.

place of the original vertical gage, which was fastened to one of the piers. Discharge measurements are made from the 3-span highway bridge to which the gage is attached. The initial point for soundings is the face of the left abutment. The channel is straight above and below the station and the current is swift. The right bank is a high rocky road embankment, and never overflows; the left bank is a steep rocky bluff and does not overflow. The bed of the stream is rocky, and the channel is divided into three parts by the bridge piers. Bench mark No. 1 is the stone cap on the downstream end of the first pier from the left bank. Its elevation is 100 feet above gage datum.

The observations of this station during 1903 have been made under the direction of E. Johnson, jr., district hydrographer.

DISCHARGE MEASUREMENTS OF WHITE RIVER (EAST BRANCH) AT SHOALS, INDIANA IN 1903.

DATE.	Hydrographer.	Gage Height. Feet.	Discharge. Second-feet.
une 22	A. C. Lootz	....	*2,000
Augus: 4	L. R. Stockman	65.07	3,392
September 4	L. R. Stockman	63.40	511

*Float measurements.

MEAN DAILY GAGE HEIGHT, IN FEET, OF WHITE RIVER (EAST BRANCH) AT SHOALS, INDIANA, FOR 1903.

DAY.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	64.50	63.60	63.50	63.40	63.50	63.70
2	....	64.40	64.70	63.50	63.40	63.50	63.70
3	....	64.30	64.80	63.50	63.40	63.50	63.70
4	....	64.10	65.30	63.50	63.50	63.50	63.60
5	....	64.00	66.10	63.50	63.50	63.50	63.60
6	....	64.20	66.90	63.50	63.50	63.50	63.50
7	....	64.20	66.80	63.50	63.60	63.50	63.50
8	....	64.10	66.00	63.50	63.70	63.50	63.50
9	....	64.10	65.50	63.50	63.80	63.50	63.60
10	....	64.10	65.10	63.50	63.90	63.50	63.60
11	....	64.00	64.90	63.50	63.90	63.50	63.50
12	....	64.00	64.60	63.50	63.90	63.50	63.50
13	....	63.90	64.40	63.50	64.00	63.50	63.50
14	....	63.90	64.10	63.50	64.00	63.50	63.50
15	....	63.80	64.10	63.50	63.90	63.50	63.50
16	....	63.80	64.00	63.40	63.90	63.50	63.50
17	....	63.80	64.00	63.40	63.80	63.50	63.50
18	....	63.90	64.00	63.40	63.70	63.70	63.50
19	....	63.80	63.90	63.40	63.70	63.70	63.50
20	....	63.70	63.90	63.40	63.60	63.70	63.60
21	....	63.70	63.90	63.40	63.60	63.80	64.10
22	....	63.50	63.80	63.40	63.50	63.90	64.20
23	....	63.50	63.80	63.40	63.50	64.00	64.20
24	....	63.50	63.70	63.40	63.50	63.90	64.50
25	....	63.50	63.70	63.40	63.50	63.80	64.60
26	....	63.50	63.70	63.40	63.50	63.70	64.90
27	64.30	63.50	63.60	63.40	63.50	63.70	65.20
28	64.30	63.60	63.60	63.40	63.50	63.60	65.00
29	64.40	63.60	63.60	63.40	63.50	63.60	65.00
30	64.50	63.60	63.50	63.40	63.50	63.70	64.80
31		63.60	63.50		63.50		64.60

WHITE RIVER (EAST BRANCH) AT SHOALS, INDIANA, FROM JUNE 22 TO DECEMBER 31, 1903.

Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.
63.4	510	64.7	2,600	67.0	6,970	69.6	11,910
63.5	640	64.8	2,790	67.2	7,350	69.8	12,290
63.6	770	64.9	2,980	67.4	7,730	70.0	12,670
63.7	910	65.0	3,170	67.6	8,110	70.5	13,620
63.8	1,050	65.2	3,550	67.8	8,490	71.0	14,570
63.9	1,200	65.4	3,930	68.0	8,870	71.5	15,520
64.0	1,350	65.6	4,310	68.2	9,250	72.0	16,470
64.1	1,510	65.8	4,690	68.4	9,630	72.5	17,420
64.2	1,680	66.0	5,070	68.6	10,010	73.0	18,370
64.3	1,860	66.2	5,450	68.8	10,390	73.5	19,320
64.4	2,045	66.4	5,730	69.0	10,770	74.0	20,270
64.5	2,230	66.6	6,210	69.2	11,150		
64.6	2,415	66.8	6,590	69.4	11,530		

Table made from measurements of August 4 and September 24, 1903, and January 24, 1904. Table should be accurate to limiting height in 1903.

DISCHARGE MEASUREMENTS OF WHITE RIVER (EAST BRANCH) AT SHOALS, IND., IN 1904.[7]

Date.	Hydrographer.	Width, Feet.	Area of Section, Sq. Ft.	Mean Vol., Ft. per Sec.	Gage Height, Ft.	Discharge, Sec. Ft.
January 24	F. W. Hanna		4,105	4.61	73.47	19,010
March 5	F. W. Hanna	375	2,321	4.99	68.64	11,590
March 30	F. W. Hanna	427	13,410	6.00	95.20	79,820
May 5	F. W. Hanna and Johnson	356	1,124	3.72	65.43	4,180
June 16	F. W. Hanna	349	789	2.30	64.53	1,812
July 28	F. W. Hanna	307	515	1.60	63.88	823
August 24	F. W. Hanna	295	379	1.28	63.32	484
September 15	F. W. Hanna	295	373	1.06	63.24	397
October 20	F. W. Hanna	295	371	1.07	63.23	396
November 3	F. W. Hanna	288	324	.99	63.17	320

[7] Water Supply and Irrigation Paper, No. 128, pp. 93-95.

Day.	Jan.*	Feb.*	Mar.*	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.†
1	64.6	66.2	67.6	91.0	67.0	64.8	65.3	63.8	63.3	63.5	63.2	63.2
2	64.5	65.5	68.1	88.8	66.5	65.6	65.1	63.7	63.3	63.5	63.2	63.2
3	64.3	65.2	68.2	87.2	65.9	66.0	65.0	63.7	63.3	63.5	63.2	63.2
4	64.2	64.9	68.7	85.6	65.6	66.0	64.8	63.7	63.3	63.4	63.2	63.2
5	64.1	64.8	68.6	84.4	65.4	65.6	64.7	63.7	63.3	63.4	63.2	63.2
6	64.1	68.5	69.1	83.4	65.3	65.4	64.5	63.7	63.2	63.3	63.2	63.2
7	64.1	71.5	72.3	80.2	65.1	65.0	64.4	63.7	63.2	63.3	63.2	63.2
8	64.0	72.8	72.9	73.2	65.0	64.9	64.3	63.7	63.2	63.3	63.2	63.2
9	64.0	74.3	71.5	68.4	64.9	64.7	64.3	63.7	63.2	63.3	63.2	63.2
10	64.0	76.1	70.3	67.7	64.8	64.6	64.3	63.6	63.3	63.3	63.2	63.2
11	64.0	77.0	70.5	67.5	64.7	64.5	64.4	63.6	63.3	63.3	63.2	63.2
12	64.0	76.0	69.8	67.3	64.7	64.4	64.5	63.6	63.3	63.3	63.2	63.2
13	64.0	72.5	69.1	67.0	64.7	64.4	64.5	63.5	63.3	63.3	63.2	63.2
14	64.0	68.5	68.9	66.8	64.6	64.3	64.5	63.5	63.3	63.3	63.2	63.2
15	64.0	66.5	68.7	66.5	64.6	64.4	64.4	63.5	63.3	63.3	63.2	63.0
16	64.0	66.0	68.0	66.2	64.5	64.3	64.5	63.5	63.2	63.3	63.2	63.0
17	64.0	65.9	67.6	66.0	64.5	64.5	64.3	63.5	63.2	63.3	63.2	63.1
18	64.0	65.6	67.5	65.8	66.5	64.6	64.2	63.5	63.4	63.3	63.2	63.1
19	64.1	65.4	67.6	65.6	66.5	64.7	64.2	63.5	63.7	63.3	63.2	63.2
20	64.1	65.2	67.7	65.4	64.5	64.9	64.2	63.5	63.6	63.3	63.2	63.2
21	64.6	65.1	67.7	65.3	64.5	64.9	64 2	63.6	63.5	63.3	63.2	63.2
22	69.4	67.3	68.0	65.2	64.5	64.9	64.2	63.6	63.5	63.2	63.2	63.2
23	73.3	68.3	74.4	65.1	64.6	64.8	64.2	63.6	63.4	63.2	63.2	63.2
24	73.5	69.6	75.2	65.1	64.7	64.8	64.1	63.5	63.4	63.2	63.2	63.3
25	74.2	70.9	78.4	65.2	64.6	64.8	64.1	63.4	63.4	63.2	63.2	63.4
26	74.5	70.6	87.1	66.5	64.6	64.8	64.0	63.4	63.7	63.2	63.2	63.9
27	74.8	69.4	87.7	67.5	64.8	64.8	64.0	63.3	63.8	63.2	63.2	64.5
28	75.0	68.0	92.8	68.6	64.6	65.2	63.9	63.3	63.8	63.2	63.2	65.2
29	72.2	67.3	95.0	68.4	64.6	64.8	63.9	63.3	63.7	63.2	63.2	66.0
30	67.8		94.9	67.8	64.6	65.4	63.8	63.3	63.5	63.2	63.2	66.3
31	66.5		93.4		64.7		63.8	63.3		63.2		66.0

*Ice conditions January, February and March uncertain.

†Frozen December 15 to 31.

RATING TABLE FOR WHITE RIVER (EAST BRANCH) AT SHOALS, IND., FROM JANUARY 1 TO DECEMBER 31, 1904.

Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.
63.0	215	64.7	2,000	67.4	8,110	76.0	30,030
63.1	286	64.8	2,150	67.6	8,610	77.0	32,630
63.2	360	64.9	2,310	67.8	9,110	80.0	40,430
63.3	440	65.0	2,470	68.0	9,610	83.0	48,230
63.4	520	65.1	2,640	68.5	10,860	84.0	50,830
63.5	605	65.2	2,820	69.0	12,110	85.0	53,430
63.6	695	65.3	3,010	69.5	13,360	87.0	58,630
63 7	790	65.4	3,210	70.0	14,610	88.0	61,230
63.8	890	65.6	3,640	70.5	15,860	90.0	66,430
63.9	990	65.8	4,110	71.0	17,110	91.0	69,030
64.0	1,100	66.0	4,610	71.5	18,360	92.0	71,630
64.1	1,210	66.2	5,110	72.0	19,630	93.0	74,230
64.2	1,330	66.4	5,610	72.5	20,930	94.0	76,830
64.3	1,450	66.6	6,110	73.0	22,230	95.0	79,430
64.4	1,580	66.8	6,610	73.5	23,530		
64.5	1,710	67.0	7,110	74.0	24,830		
64.6	1,850	67.2	7,610	75.0	27,430		

The above table is applicable only for open-channel conditions. It is based upon 13 discharge measurements made during 1903 and 1904. It is well defined between gage heights 63.2 and 65.4 feet.

Above gage heights 72 feet the rating curve is a tangent, the difference being 260 per tenth. Two flood measurements above 65.4 feet gage height define the tangent. The table has been extended beyond these limits.

DISCHARGE MEASUREMENTS OF EAST BRANCH OF WHITE RIVER AT SHOALS, IND., 1905.[8]

DATE.	Hydrographer.	Width, Feet.	Area of Section, Square Feet.	Mean Velocity, Feet per Second.	Gage Height, Feet.	Discharge, Second-Feet.
March 16	S. K. Clapp	355	1,421	4.28	66.00	6,090
May 15	M. S. Brennan	406	4,248	4.26	73.58	18,120
June 15	S. K. Clapp	330	744	2.47	64.40	1,838
October 16	M. S. Brennan	313	564	1.74	63.80	982

DAILY GAGE HEIGHT, IN FEET, OF EAST BRANCH OF WHITE RIVER AT SHOALS, IND., FOR 1905.

DAY.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	65.5	63.9	66.4	66.0	67.0	66.4	64.3	63.8	65.1	63.9	65.6	66.3
2	65.0	64.0	68.4	66.0	67.2	66.8	64.2	63.8	65.6	64.0	65.4	69.0
3	64.7	63.8	67.9	65.9	67.5	66.4	64.1	63.8	65.0	64.0	65.3	70.0
4	64.5	63.8	68.0	65.6	67.0	65.8	64.1	63.7	64.7	64.1	65.2	71.0
5	64.3	63.7	68.1	65.3	65.8	65.4	64.0	63.6	64.3	64.1	66.0	70.8
6	64.3	63.7	67.1	65.0	66.1	65.2	64.0	63.6	64.2	64.3	66.5	69.3
7	64.1	63.7	66.7	64.9	67.0	65.9	64.0	63.5	64.2	64.5	66.5	68.4
8	63.9	63.7	67.1	64.8	67.3	64.9	64.0	63.6	64.0	64.6	66.8	67.0
9	63.7	63.7	70.6	64.7	67.5	64.9	63.9	63.7	64.0	64.6	67.0	66.5
10	63.6	63.8	71.5	64.5	68.0	65.0	63.9	63.7	64.0	64.4	66.7	65.6
11	63.6	63.9	71.7	65.1	68.8	64.9	64.0	63.8	64.2	64.2	66.2	65.4
12	65.5	64.0	70.0	65.3	69.6	64.8	64.2	64.0	64.2	64.1	65.8	65.2
13	65.5	64.2	68.9	65.4	71.6	64.6	64.3	64.1	64.1	64.0	65.5	65.2
14	66.4	64.4	67.2	65.4	72.8	64.5	64.3	64.8	64.1	63.9	65.2	65.1
15	66.0	64.5	66.4	65.2	74.0	64.4	64.2	66.2	64.2	63.8	65.2	65.0
16	65.7	64.6	66.0	65.0	75.2	64.3	64.2	65.7	64.2	63.8	65.0	64.9
17	66.8	64.4	65.8	64.8	76.2	64.3	64.2	66.1	64.2	64.0	64.9	64.8
18	67.2	64.2	65.5	64.6	75.3	64.3	64.1	66.1	64.1	65.3	64.8	64.7
19	65.8	64.0	65.4	64.5	72.3	64.3	64.0	66.0	64.0	69.1	64.8	64.8
20	65.2	63.9	65.2	64.4	69.7	64.8	64.0	66.7	64.0	71.1	64.8	65.0
21	64.7	64.2	65.2	64.6	67.4	65.0	63.9	66.1	64.2	69.4	64.9	65.8
22	64.5	65.0	65.1	66.6	66.4	65.4	63.9	65.9	64.3	69.8	65.0	67.0
23	64.4	65.2	65.0	67.7	66.0	65.6	64.0	65.8	64.3	68.7	64.9	68.2
24	63.8	66.0	65.0	68.7	65.6	65.8	64.4	66.0	64.1	67.3	64.8	68.4
25	63.8	67.1	65.0	67.5	65.4	65.4	64.4	66.0	64.0	67.0	64.7	68.5
26	63.8	70.3	65.0	67.0	65.2	65.1	64.3	65.9	63.9	68.0	64.7	67.9
27	63.9	71.6	65.0	66.9	65.1	64.9	64.3	65.7	63.8	67.9	64.7	66.9
28	64.0	68.2	65.7	66.4	65.0	64.7	64.2	65.4	63.8	68.0	64.9	66.5
29	64.0		65.2	66.2	64.9	64.6	64.0	65.3	63.8	67.3	65.1	66.0
30	64.0		65.6	66.4	65.0	64.4	63.9	65.2	63.8	66.6	65.8	65.9
31	63.9		66.0		65.0		63.8	64.9		66.0		65.8

[8] Water Supply and Irrigation Paper, No. 169, pp. 87-88.

STATION RATING TABLE FOR EAST BRANCH OF WHITE RIVER AT SHOALS, IND., FROM JANUARY 1 TO DECEMBER 31, 1905.

Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.
63.50	570	65.40	4,041	67.30	8,390	70.40	15,520
63.60	670	65.50	4,266	67.40	8,620	70.60	15,980
63.70	790	65.60	4,492	67.50	8,850	70.80	16,440
63.80	918	65.70	4,718	67.60	9,080	71.00	16,900
63.90	1,050	65.80	4,945	67.70	9,310	71.20	17,360
64.00	1,190	65.90	5,172	67.80	9,540	71.40	17,820
64.10	1,338	66.00	5,400	67.90	9,770	71.60	18,280
64.20	1,500	66.10	5,630	68.00	10,000	71.80	18,740
64.30	1,673	66.20	5,860	68.20	10,460	72.00	19,200
64.40	1,856	66.30	6,090	68.40	10,920	72.50	20,350
64.50	2,051	66.40	6,320	68.60	11,380	73.00	21,500
64.60	2,259	66.50	6,550	68.80	11,840	73.50	22,700
64.70	2,479	66.60	6,780	69.00	12,300	74.00	23,900
64.80	2,700	66.70	7,010	69.20	12,760	74.50	25,100
64.90	2,922	66.80	7,240	69.40	13,220	75.00	26,300
65.00	3,145	66.90	7,470	69.60	13,680	75.50	27,500
65.10	3,365	67.00	7,700	69.80	14,140	76.00	28,700
65.20	3,592	67.10	7,930	70.00	14,600	76.50	29,900
65.30	3,816	67.20	8,160	70.20	15,060		

NOTE.—The above table is applicable only for open channel conditions. It is based on 14 discharge measurements made during 1903–1905. It is fairly well defined between gage heights 63.2 feet, and 69 feet. The table has been extended beyond these limits, being based on one measurement at 95.2 feet. This measurement may be considerably in error owing to backwater.

DISCHARGE MEASUREMENTS OF EAST BRANCH OF WHITE RIVER AT SHOALS, IND., IN 1906.[9]

Date.	Hydrographer.	Width, Feet.	Area of Section, Sq. Ft.	Gage Height, Feet.	Discharge, Sec. Ft.
February 15*	Brennan & Kriegsman	341	943	64.90	2,550
March 1	E. F. Kriegsman	331	967	65.08	3,200
March 29	E. F. Kriegsman	406	4,390	74.01	20,000
April 2	E. F. Kriegsman	430	9,400	85.62	37,800
April 15	E. F. Kriegsman	353	2,510	69.30	12,400

*Thin ice running.

DAILY GAGE HEIGHT, IN FEET, OF EAST BRANCH OF WHITE RIVER AT SHOALS, IND., FOR 1906.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	Day.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	65.8	65.5	65.2	84.5	65.0	64.3	17	70.0	64.7	67.1	69.3	64.4	64.0
2	66.2	65.4	65.1	86.0	65.0	64.3	18	69.8	64.7	66.7	68.8	64.4	63.9
3	67.8	65.3	67.1	87.4	65.0	64.2	19	69.5	64.7	66.7	67.8	64.3	63.9
4	76.4	65.2	69.0	88.0	64.9	64.2	20	69.2	64.6	67.0	67.0	64.3	63.9
5	75.0	65.0	70.8	87.5	64.9	65.1	21	68.0	64.7	68.1	66.7	64.3	63.8
6	73.5	64.8	70.2	85.7	65.0	64.8	22	67.6	64.9	69.7	66.4	64.3	63.8
7	73.0	64.6	68.8	82.8	65.1	64.7	23	67.9	65.5	69.8	66.0	64.3	63.9
8	72.5	64.3	67.4	77.0	65.0	64.5	24	67.7	65.9	69.7	65.8	64.3	63.8
9	71.3	64.3	66.3	73.2	64.8	64.5	25	67.5	65.8	69.7	65.7	64.2	63.8
10	69.5	64.4	66.6	72.0	64.7	64.7	26	67.1	65.5	70.0	65.6	64.2	63.8
11	67.8	64.5	66.6	71.0	64.6	64.6	27	66.7	65.3	70.7	65.4	64.2	63.8
12	66.6	64.7	66.6	70.5	64.4	64.4	28	66.3	65.2	73.7	65.3	64.2	63.8
13	66.4	64.7	66.6	70.0	64.5	64.3	29	66.0		74.4	65.2	64.1	63.8
14	66.2	64.7	66.7	69.8	64.5	64.2	30	65.8		78.2	65.1	64.1	63.8
15	67.5	64.7	66.9	69.5	64.5	64.1	31	65.6		82.5		64.1	
16	69.1	64.8	67.0	69.2	64.4	64.0							

NOTE.—Slight ice conditions during part of February, but flow was not probably much affected thereby.

[9] Water Supply and Irrigation Paper, No. 205, p. 69.

RATING TABLE FOR EAST BRANCH OF WHITE RIVER AT SHOALS, IND., FOR 1905 AND 1906.

Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.
63.80	880	65.00	2,920	66.20	6,360	67.80	9,700
63.90	1,000	65.10	3,180	66.30	6,580	68.00	10,080
64.00	1,130	65.20	3,460	66.40	6,800	68.20	10,400
64.10	1,270	65.30	3,750	66.50	7,020	68.40	10,840
64.20	1,410	65.40	4,050	66.60	7,240	68.60	11,220
64.30	1,560	65.50	4,360	66.70	7,460	68.80	11,590
64.40	1,720	65.60	4,670	66.80	7,680	69.00	11,950
64.50	1,890	65.70	4,980	66.90	7,900	70.00	13,750
64.60	2,070	65.80	5,280	67.00	8,100	71.00	15,400
64.70	2,260	65.90	5,580	67.20	8,500	72.00	17,000
64.80	2,460	66.00	5,860	67.40	8,900	73.00	18,500
64.90	2,680	66.10	6,120	67.60	9,300	74.00	20,000

NOTE.—The above table applicable only for open channel conditions. It is based on discharge measurements made during 1903 to 1906. It is well defined between gage heights 63.2 feet and 65 4 feet. Above gage height 72.0 feet the rating curve is tangent, the difference being 150 per tenth.

The following measurement was made October 12, 1908:[10] Width, 275 feet; area, 331 sq. ft.; gage height, 63.2 feet; discharge, 345 second-feet.

DAILY GAGE HEIGHT, IN FEET, OF EAST BRANCH OF WHITE RIVER AT SHOALS, IND., FOR 1908.

DAY.	May.	June.	Aug.	Oct.	Nov.	Dec.	DAY.	May.	June.	Aug.	Oct.	Nov.	Dec.
1......	......	65.5	......	......	63.2	63.4	17......	69.7	64.5	......	63.2	63.2	63.3
2......	67.4	65.5	......	......	63.2	63.4	18......	67.4	64.4	......	63.2	63.2	63.3
3......	67.8	65.4	......	......	63.2	63.4	19......	66.7	64.4	......	63.2	63.2	63.3
4......	68.0	65.3	......	......	63.2	63.4	20......	66.5	64.3	......	63.2	63.2	63.3
5......	77.5	65.2	......	......	63.2	63.3	21......	66.3	64.3	......	63.2	63.2	63.3
6......	81.8	65.0	......	......	63.2	63.3	22......	66.2	64.2	......	63.2	63.2	63.3
7......	83.8	64.9	......	......	63.2	63.3	23......	66.0	64.2	......	63.2	63.2	63.3
8......	85.6	64.8	......	......	63.2	63.3	24......	66.0	64.2	......	63.2	63.3	63.3
9......	87.1	64.9	......	......	63.2	63.3	25......	65.7	64.6	......	63.2	63.2	63.3
10......	87.9	64.8	......	......	63.2	63.3	26......	65.5	64.6	......	63.2	63.3	63.3
11......	88.2	64.7	......	......	63.2	63.3	27......	65.4	64.4	......	63.2	63.4	63.3
12......	88.2	64.7	......	63.2	63.2	63.3	28......	65.3	64.3	......	63.2	63.5	63.3
13......	87.5	64.7	64.8	63.2	63.2	63.3	29......	65.4	64.2	......	63.2	63.4	63.3
14......	85.9	64.6	......	63.2	63.2	63.3	30......	65.4	64.1	......	63.2	63.4	63.3
15......	82.6	64.6	......	63.2	63.2	63.3	31......	65.5			63.2		63.3
16......	76.6	64.5	......	63.2	63.2	63.3							

RATING TABLE FOR EAST BRANCH OF WHITE RIVER AT SHOALS, IND., FOR 1906 to 1908.

Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.
63.20	340	65.00	2,920	66.20	6,360	67.80	9,700
63.30	410	65.10	3,180	66.30	6,580	68.00	10,080
63.40	490	65.20	3,460	66.40	6,800	68.20	10,400
63.50	580	65.30	3,750	66.50	7,020	68.40	10,840
63.60	670	65.40	4,050	66.60	7,240	68,60	11,220
63.70	770	65.50	4,360	66.70	7,460	68.80	11,590
64.40	1,720	65.60	4,670	66.80	7,680	69.00	11,950
64.50	1,890	65.70	4,980	66.90	7,900	70.00	13,750
64.60	2,070	65.80	5,280	67.00	8,100	71.00	15,400
64.70	2,260	65.90	5,580	67.20	8,500	72.00	17,000
64.80	2,460	66.00	5,860	67.40	8,900	73.00	18,500
64.90	2,680	66.10	6,120	67.60	9,300	74.00	20,000

[10] Water Supply and Irrigation Paper, No. 243, p. 102.

During the time for which these statistics have been kept, the smallest discharge occurred on December 15 and 16, 1904. At this time the gage registered 63 feet, and the discharge was 215 cu. ft. per second. This period was the result of the drouth, which occurred in October, November and December of that year. The rainfall preceding this low discharge had been less than three inches in two and one-half months. It is unfortunate that the gage was not read during the months of July, August and September, 1908, which were unusually dry months. However, such periods are of rare occurrence, and a larger discharge than 215 cu. ft. per second can be relied upon for eleven and a half months of the dryest years at Shoals. During the time that the gage has been kept, there have been but six days on which the discharge was less than 340 cu. ft. per second. These days were December 15, 16, 17, 18, 1904, and October 12 and 23, 1908.

Another gage has been in operation at Tannehill bridge for the year December 7, 1909, to December 6, 1910. Tannehill bridge is situated on Blue River, one mile west of Taylorville, in Bartholomew County. The gage is located on the downstream face of the east abutment of the bridge. The base of the gage is mean low water mark. This gage was installed by R. T. Cooke, who owned the power site, and was kept by Mr. Jay, who lives near the bridge. The current readings were made by Mr. Cooke. The writer made two current readings with Mr. Cooke, and finds by the rating curve that Mr. Cooke's readings are accurate in every respect.

Discharge Measurements on East Fork of White River at Tannehill Bridge, 1910.

Date.	Hydrographer.	Gage Height.	Discharge.
March 27	R. T. Cooke	.8[illegible] feet	575 cu. ft.
March 31	Cooke & Tucker	.7 feet	532.42 cu. ft.
April 13	R. T. Cooke	.5 feet	453.09 cu. ft.
May 19	R. T. Cooke	.275 feet	307.09 cu. ft.
May 29	R. T. Cooke	.825 feet	674.42 cu. ft.
June 2	R. T. Cooke	.525 feet	491.94 cu. ft.
June 7	R. T. Cooke	.425 feet	390.90 cu. ft.
June 12*	R. T. Cooke	.45 feet	421.83 cu. ft.
June 12	R. T. Cooke	.45 feet	416.37 cu. ft.
June 14	R. T. Cooke	.4 feet	363.11 cu. ft.
June 26	R. T. Cooke	.175 feet	223.01 cu. ft.
July 26	R. T. Cooke	1.05 feet	836.19 cu. ft.
July 29	Cooke & Tucker	.825 feet	638.63 cu. ft.

*This measurement was made by float system.

GAGE READINGS ON EAST FORK OF WHITE RIVER AT TANNEHILL BRIDGE, FROM DECEMBER 7, 1909, TO DECEMBER 6, 1910, INCLUSIVE.

DAY.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	.7	1.3	10.5	.6	.6	.6	.65	.6	.35	.2	.55	1.1
2	......	.8	1.2	13.5	.6	.55	.6	.5	.7	.3	.15	.5	1.05
3	......	1.1	1.0	10.5	.55	.85	.55	.4	.5	.2	.1	.65	.9
4	......	2.0	1.1	7.9	.7	2.45	.5	.35	.45	.15	.1	.6	.75
5	......	1.7	1.2	6.1	.7	2.3	.5	.4	.4	.1	2.5	.55	.7
6	......	1.9	1.3	4.9	.7	1.6	.5	1.0	.35	.3	8.2	.55	.65
7	.5	2.0	1.1	4.1	.7	1.2	.5	.9	.35	1.1	10.9	.55	......
8	.8	2.0	.9	3.4	.7	1.2	.5	.8	.3	.85	12.0	.5	......
9	.9	1.9	.8	2.8	.65	1.1	.45	.7	.3	.6	8.9	.5	......
10	.6	1.2	.8	2.4	.6	1.0	.45	.6	.25	.5	5.7	.5	......
11	1.1	1.0	.7	2.2	.6	.85	.4	.6	.2	.35	3.8	.5	......
12	7.0	.8	.6	1.8	.55	.95	.45	.65	.2	.25	2.9	.5	......
13	5.7	2.1	.6	1.7	.5	1.1	.45	.8	.15	.2	2.3	.45	......
14	7.1	8.0	.5	1.6	.5	1.05	.4	1.2	.15	.15	1.9	.45	......
15	7.1	9.8	.5	1.4	.5	.9	.35	1.6	.15	.15	1.6	.45	......
16	5.5	8.4	.6	1.2	.6	.9	.35	2.1	.12	.15	1.45	.45	......
17	3.4	5.1	1.1	1.1	.6	.75	.4	7.3	.05	.1	1.3	.45	......
18	1.5	7.6	2.8	.95	.7	.7	.2	10.4	.05	.05	1.1	.4	......
19	1.8	9.5	1.8	1.05	.8	.75	.25	7.4	.05	.1	1.0	.4	......
20	1.3	8.6	1.7	1.2	.95	.7	.25	4.7	.05	.25	.95	.4	......
21	1.1	7.6	1.6	1.1	1.1	.75	.45	2.9	.05	.5	.95	.4	......
22	1.0	5.7	1.9	1.15	1.1	1.9	.25	2.1	.02	.45	.85	.4	......
23	.9	4.0	2.6	1.0	1.05	2.25	.22	51.7	.0	.35	.85	.35	......
24	.9	2.9	3.2	1.0	.85	1.95	.22	51.45	.1	.3	.8	.35	......
25	.8	2.5	2.4	.9	.8	1.6	.2	1.4	.4	.25	.85	.35	......
26	.7	2.2	2.1	.85	.7	1.3	.3	1.2	.3	.25	.85	.35	......
27	.7	2.0	1.9	.9	.7	1.0	.27	1.0	.37	.25	.75	.4	......
28	.8	1.8	4.2	.8	.7	.85	.25	1.0	.4	.2	.65	.75	......
29	.8	2.4		.7	.65	.7	1.85	1.0	.4	.25	.65	1.2	......
30	.7	1.9		.75	.6	.7	.9	.7	.4	.2	.55	1.3	......
31	.6	1.5		.6		*		.7	.45		.55		......

*No record.

STATION RATING TABLE FOR EAST FORK OF WHITE RIVER AT TANNEHILL BRIDGE FOR DECEMBER 7, 1909 TO DECEMBER 6, 1910.

Gage Height, Feet.	Discharge, Cu. Ft.	Gage Height, Feet.	Discharge, Cu. Ft.	Gage Height, Feet.	Discharge, Cu. Ft.
0.0	130	0.5	436	1.0	772
0.1	185	0.6	480	1.1	886
0.2	243	0.7	522	1.2	1,000
0.3	305	0.8	580	1.3	1,114
0.4	372	0.9	660		

During the year for which these gage readings have been kept the smallest discharge occurred on August 23, 1910; the discharge at this time was 130 cu. ft. per second. On sixty-two days during the year the discharge was below 372 cu. ft. per second. During these days the gage registered less than .4 of a foot.

PROFILE OF EAST FORK OF WHITE RIVER.

Station.	Distance Apart, Miles.	Distance from Morristown, Miles.	Elevation, Feet.
Morristown	0	0	815
Edinburg	50	50	652
Columbus	21	71	602
Rockford	25	96	556
Medora	30	126	505
Rivervale	40	166	479
Shoals	50	216	450
Junction, W. Fork	58	274	400
Mouth, White River	50	324	376

POWER SITES ON EAST FORK OF WHITE RIVER.

The writer traversed the East Fork of White. River from Columbus to the junction with the West Fork, and the Muscatatuck branch from Vernon to its junction with the main branch near Medora, in Jackson County. On this branch there is no power worthy of note. In the upper course above the junction with the Graham fork there is an insufficient flow to warrant development. Below the junction the stream bed is deeply filled with alluvium and the fall is exceedingly slight. The flow on this branch is very irregular. This is due to the lack of forest or glacial deposits at the head waters of the tributaries. The tributaries rise on the Niagara limestone and have bed rock beds. The whole Muscatatuck basin is approaching maturity in the cycle of erosion, and hence drains quickly into the streams. Thus heavy floods occur in rainy weather, and during dry seasons the streams practically cease to flow. An interesting old mill site occurs on this stream at Vernon. It was known as the Old Tunnel mill. A tunnel was constructed in the early part of the last century through the limestone and shale, at the neck of the large incised meander west of Vernon. This tunnel is about 200 feet long. The meander of the stream from the upper to the lower end of the tunnel is 2.5 miles. A small dam below the upper end of the tunnel turned the water through the tunnel, and twenty-six feet fall was produced. This was used on a large undershot wheel. The power was used for grinding flour until 1896. The flood in November of that year backed water into the lower story of the stone mill and the south wall fell out and crushed the wheel. The mill was never rebuilt. This power was supplemented by steam power which it was necessary to employ during dry seasons.

MAIN BRANCH OF EAST FORK.

This stream has not been thoroughly investigated above Columbus, but several powers on this part of the stream have been visited.

CARTHAGE, RUSH COUNTY.

A small power plant is in operation at Carthage in northwest Rush County. Blue River is dammed at a point 300 feet above the Big Four railroad bridge. The dam is built of timber five feet high. It is built on a foundation of sand and gravel. Glacial boulders have been placed below the dam to break the force of the overflow. A canal leads from the south end of the dam to the power plant one mile down the valley. The canal skirts the bluff on the southeast side of the stream, while the river makes a wide detour along the west bluff. The plant is thus located a quarter of a mile from the river. It is also situated twenty feet above low water mark on the river. Extreme high water floods the basement of the plant, but does not get above the first floor. Thus the canal serves the double purpose of removing the plant from the immediate vicinity of the river, and of making it possible to locate the plant above flood stage. However, little advantage is taken of the increased head of water. The fall on the wheel is but six feet. This could be increased to fifteen or eighteen feet by deepening the tail race to the river. This would yield about 100 horse-power.

One thirty-seven inch wheel is used which produces forty horse-power. During dry seasons the supply of water is insufficient for continuous use. During ordinary stage of water the power is used day and night. It is employed by the Cox & Cox Milling Company during the day and by the Carthage Light Company during the night. This power is owned by Cox & Cox Milling Company, Carthage, Indiana.

MORRISTOWN, SHELBY COUNTY.

Two miles north of Morristown, on the farm of O. W. Righter, is the site of a water power which was formerly used by a flour mill. The mill is now gone and only the remnants of the dam and race remain. The dam was constructed of wood and glacial boulders. The canal is similar to the one at Carthage. It skirts the east bluff of the river for half a mile, but the mill was located on the river bank below. This power could be restored with a fall of nine feet. On this fall a power of sixty horse-power could be produced, except in dry weather. This power is owned by O. W. Righter, of Carthage, Indiana.

FREEPORT, SHELBY COUNTY.

A well improved small power plant is in operation at Freeport. An excellent stone dam 5.5 feet high has recently been erected. The dam is 250 feet long. The power is used for grinding purposes. The mill is located on the west end of the dam. Three wheels are in operation. A thirty-six inch wheel is employed, which produces ten horse-power. This is used for shelling and grinding corn. A forty-eight inch wheel produces fifteen horse-power, which is used for crushing corn. A fifty-inch wheel produces twenty horse-power, which is used to run the flour mill. These wheels are not all employed at the same time. The power referred to each of these wheels is the amount used. None of them are used to their full capacity. Each wheel is capable of producing about twice the power employed. This power is owned and employed by H. Balting, Freeport, Indiana.

EDINBURG, INDIANA.

One of the best dams in the state is located at Edinburg. It is a stone and cement dam, and was built in 1884 by John Thompson, who then owned the site. The power was used in Mr. Thompson's large flour mill. It has not been in use for several years.

The dam is 225 feet long and seven feet high. A short race increased the head to eight feet. Both race and dam are in good repair. The flow here is approximately half the flow at Tannehill bridge, which is eight miles down the river. According to the data taken within the past year, the discharge at this point would be 65 cu. ft. per second at a minimum, and of 186 feet per second for nine months in the year. This discharge on the eight foot fall would yield 135 horse-power (practical), which is 80 per cent. of the absolute power.

TANNEHILL BRIDGE.

This power site is located one mile west of Taylorville, Bartholomew County. The power has been used in former times and the mill, dam and race are still in fair repair. The dam is constructed of brush and poles. It is 5.5 feet high. The race is one-fourth mile long and the fall at the wheel was 8 1-3 feet. From the year's data at this point the minimum discharge is 185 cu. ft. per second. For only 62 days during the year did the discharge fall below 340 cu. ft. This would produce a minimum of 140 horse-power on the 8 1-3 feet fall, or 257.5 horse-power, when the discharge was 340 cu. ft. per second.

For four miles from Tannehill to Lowell the fall in the river is heavy. From the crest of the dam at Tannehill bridge to the foot of the ripple at Lowell is a fall of 19.2 feet. The conditions for building a canal along the east bluff of the river between these two points are ideal. The soil is a clay and the bluff is very little dissected by valley tributaries to the river. A dam twenty feet high could be constructed at the point where the present dam stands. The river at this point is 140 feet wide, and the dam would be 400 feet long. The canal could be extended along the east bluff to Lowell, and there a fall of 33.7 feet would be realized. If two feet were deducted from this for canal flow, the actual fall would be 31.7 feet. The minimum flow of 185 cu. ft. per second on 31.7 feet fall would produce a practical power of 533 H. P., and with a discharge of 340 cu. ft. a power of 979.8 H. P. would be produced. The Indianapolis, Columbus and Southern Traction Company have control of this power site.

Below Columbus there is no developed power. The fall in this part of the river is very slight. No abrupt fall occurs, except in the vicinity of Shoals. However, several small power stations could be installed in this part of the river. There is an occasional exposure of rock in the bed of the river, which would form an excellent foundation for a dam.

Such an exposure occurs under the Pennsylvania Railroad bridge at Rockford, three miles north of Seymour, in Jackson County, section 31, T. 7 N., R. 6 E. This exposure is at the base of the knobstone. The stone is Rockford goniatite limestone. It is but two feet thick, and is of little use for dam construction. However, the bed rock forms an excellent site for a dam. The river is 200 feet wide. The east bank is near the bluff, which rises gradually to the upland. The west bank is about thirty feet in height, and the wide valley occurs beyond it. A head of 15 feet could be procured at this point.

Another outcrop of rock occurs about four hundred feet below the mouth of Muscatatuck in Washington County, section 22, T. 4 N., R. 2 E. The river sweeps into the south bluff exposing the knobstone shale. This shale forms the bottom of the river at this point. The south bank is the river bluff, which rises 200 feet or more above the river. It is composed entirely of soft, thin bedded knobstone shale. The north bank is about twenty-five feet in height, and beyond it is the broad valley. The river makes an abrupt bend on this exposure and is 200 feet wide. A head of 15 feet could be procured at this point.

At Lawrenceport, in Lawrence County, section 27, T. 4 N., R. 1 E., is an old dam site. A dam was first built here in 1850, and the present dam was abandoned in 1890. The head used was 6 feet. The south end of the dam is in an exposure of Harrodsburg limestone. The dam still remains except near the center, where it was blown out by government employes. The river is here 200 feet wide. Good exposures of Harrodsburg and Salem limestone occur here, which are excellent concrete and building stone. A head of 10 feet could be produced at this point.

WILLIAMS, INDIANA.

A power site is now being developed at Williams in western Lawrence County. At this point the river bed is in river deposit. The work of construction has begun since this part of the river was investigated by the writer. Hence, it is not known whether excavation to bed rock was possible at this point or not. The river here flows near the north bluff. The banks are about forty feet high above low water. The dam under construction is to give a head of seventeen feet. This will produce some storage in the channel, because the fall in the river above this point is very small. The back water will probably reach sixteen or seventeen miles. This site is about twenty-three miles above Shoals, and if the discharge be considered the same as at Shoals the minimum power for the time records have been kept at Shoals can be computed. The minimum discharge at Shoals during this time was 215 cu. ft. per second on December 15 and 16, 1904. On a head of seventeen feet this discharge would produce 332 horse-power. However, if 340 cu. ft. per second be considered available, 525 horse-power can be produced regularly. High stages of the water will interfere with this power by lowering the head. A twenty foot stage of the river will practically eliminate the head. The particular advantage of this site is in the height of the river banks. They will retain a twenty foot stage above the dam in the immediate vicinity of the dam.

The power from this point will be used at Bedford and in the quarry district about Bedford.

SHOALS, INDIANA.

The most favorable power site on the East Fork of White River is at Shoals, Martin County, Sec. 30, T. 3 N., R. 1 W., where the river flows over an exposure of Mansfield sandstone. This stone forms the bed of the river for several hundred feet above and below the B. & O. bridge. The river is very rapid at this point. It is 375 feet in width. A fall of approximately 6 feet occurs within the mile on the great bend at Shoals.

A line of levels from near the point where the B. & O. R. R. begins to parallel the river west of West Shoals, and a point near the Pinnacle showed a fall of 5.86 feet, when the river was 4.1 feet above low water mark. The fall would be increased if the river were nearer the low water mark. This fall has been measured by other parties, one of which found it to be 7.92. The fall in ordinary stage of water is approximately 6 feet. The river bed between the Pinnacle and the B. & O. R. R. bridge is of Mansfield sandstone, and forms an excellent foundation for a dam.

Two plans for developing this power have been suggested upon careful investigation of the topography of the region. It is found that the height of the dam at the point indicated on the map, Fig. 4, should not exceed ten feet because of injury by overflow to low lying lands above. Such a dam could be cheaply and easily built at this point. It is then necessary to conduct the water across the meander to a point at the foot of the fall where an abrupt fall of 16 feet would be obtained. Two routes for this channel are indicated on map, Fig. 4. A canal along route A would be easily constructed. The excavation would be entirely in alluvium and the depth would nowhere be great, as shown by the map. This route, however, presents certain difficulties, which are overcome in route B. The whole system, except a short distance near the middle, would be below flood stage of the river. This would increase the cost of maintaining a canal. The power house must also be in low land, which would increase the cost of constructing it. This canal would be about one mile in length.

A canal along route B would penetrate the hill at a point above the Pinnacle, where two small tributaries to the river have well begun the work. One of these tributaries has cut a gorge on the west side of the hill, while the other has cut a gorge on the east side directly opposite. The entire canal would be excavated in Mansfield sandstone, except a short distance at each end. About 650 feet would have to be tunneled. The cost of constructing this canal would be much greater than that of constructing the other, but the cost of maintenance would be greatly lessened. The power house could be located on the high ground near the west end of the tunnel.

With a head of sixteen feet and a discharge of 215 cu. ft. per second, 313 horse-power would be produced. A discharge of 340 cu. ft. per second would produce 495 horse-power.

HINDOSTAN FALLS.

Eighteen miles by river below Shoals occurs the Hindostan Falls, where another fall of approximately six feet occurs. This fall is abrupt, over an exposure of Mansfield sandstone. The bed of the stream both below and above the fall is of Mansfield sandstone. This makes an excellent foundation for a dam. At the time of investigating this site, the river was high and the fall was largely distributed. A line of levels for one-eighth of a mile above and an equal distance below the fall showed only 3.7 feet fall. However, the actual fall at low water is approximately 6 feet. A fifteen foot dam constructed at the crest of this fall would pond the water almost to the foot of the Shoals fall. Such a dam would injure some low lying land above. However, it would produce an abrupt fall of 21 feet. The discharge at this point can be considered the same as that of Shoals. With a discharge of 215 cu. ft. per second, and the fall of 21 feet, 410 horse-power will be produced. A discharge of 340 cu. ft. per second will produce 649 horse-power. This power would be interfered with by a high stage of the river. A stage of 20 feet would practically eliminate the fall.

It has been proposed to combine the Shoals and Hindostan falls. This could be done by constructing a fifteen-foot dam at the mouth of Beaver Creek (Fig. 4), and a canal from that point across the country to Hindostan. This canal would be about four and a half miles long. The writer has not investigated the country for a canal route. However, if such a canal could be built, a fall of about 37 feet could be obtained. Fifteen feet of this fall would be on the dam, eighteen feet from the dam to the crest of Hindostan falls, and six feet on Hindostan falls. Two feet must be deducted for canal flow. With a discharge of 215 cu. ft. per second, 723 horse-power could be produced on this fall, and with 340 cu. ft. per second, 1,144 horse-power could be produced.

The fall on the river from Hindostan Falls to the junction of the west fork is very slight. No power could be developed in this part of the river.

West Fork of White River.

The West Fork of White River is very similar to the East Fork. It rises by many tributaries on the Niagara escarpment in Randolph, Delaware, Madison and Tipton counties. Its source is within the Wisconsin glacial area. It flows in a general southwesterly direction throughout its course, and unites with the East Fork at the southwest corner of Daviess County. Its entire course lies within the glaciated areas. It leaves the Wisconsin glacial area near Martinsville, and flows in the Illinois glacial area from there to its junction with the East Fork. Below Martinsville is a great valley train from the Wisconsin glacier. Because of the glacial drift above, and the valley train below, rock exposures are rare. These occur where the river meanders into one of its bluffs. The river crosses all the rock formations of the State, except the Ordovician, and in the Knobstone, Mitchell and Mansfield plateaus, bluffs of solid rock are seen continually from the river, yet the river seldom cuts into one of them.

The valley is broad and flat. The banks of the river range from ten to fifty feet in height. These banks are usually composed of clay, sand and gravel. The bottom land is very valuable farm land, although much of it is subject to overflow. As before stated, these conditions hinder the full development of water power.

Statistics from the United States Weather Bureau show the average rainfall for the basin of the West Fork of White River to be about 39.5 inches per annum, for the past ten years. The United States Geological Survey maintained a river gaging station at Indianapolis on the main branch of the West Fork during part of 1904, 1905, and part of 1906; and at Cataract, on Eel River, a tributary to the West Fork of White River, during part of 1903, 1904, 1905 and part of 1906. The writer continued the observations at Cataract from June, 1909, until the present time. He also established a gage at Maysville, three miles and a half west of Washington, in August of 1909. Daily gage readings were taken at this point until December 18, 1909. The result of these observations follow:

WHITE RIVER (WEST BRANCH), AT INDIANAPOLIS, IND.[11]

This station was established May 6, 1904, by E. Johnson, Jr., assisted by F. W. Hanna. It is located in the central portion of the city on the bridge of the Cleveland, Cincinnati, Chicago and St. Louis Railway. A standard chain gage is attached to the down stream side of the bridge, the scale being graduated to feet and tenths on the down stream side of the binding tie. The length of the chain from the end of the weight to the marker, which is outside the ring, is 37.10 feet: The gage is read twice each day by J. D. Burk. The chain and weight are kept at the water softening plant of the Kingan Packing Company, located one hundred feet down stream from the right abutment of the bridge. Discharge measurements are made from the down stream side of the through Pratt truss bridge of three spans, to which the gage is attached. The initial point for sounding is the down stream inner face of the right abutment. The channel is straight for about 500 feet above and for 1,000 feet below the station. The current is direct, but sluggish in low stages. The right bank is moderately high and seldom overflows. The left bank is high, covered by buildings, and never overflows. All the water passes between the abutments of the bridge. The bed of the stream is composed of gravel and sand, and is fairly permanent. There are three channels at all stages. At low water the current is too sluggish to permit of very accurate measurement. Bench mark No. 1 is the south capstone of the ballast wall of the right abutment. Its elevation is 36.51 feet above the datum of the gage. Bench mark No. 2 is the down stream top edge of the fifth cross-girder from the right abutment of the bridge. Its elevation is 36.54 feet above the datum of the gage.

The observations at this station during 1904 have been made under the direction of E. Johnson, Jr., District Hydrographer.

DISCHARGE MEASUREMENTS OF WHITE RIVER (WEST BRANCH) AT INDIANAPOLIS, IND., IN 1904.

DATE.	Hydrographer.	Width, Feet.	Area of Section, Sq. Feet.	Mean Velocity, Ft. per Sec.	Gage Height, Feet.	Discharge, Sec.-Ft.
May 6	Johnson & Hanna	265	1,423	0.81	8.80	1,147
June 17	F. W. Hanna	256	1,324	.65	8.45	866
July 29	F. W. Hanna	222	1,129	.34	7.53	380
August 23	F. W. Hanna	233	1,210	.41	7.85	495
September 14	F. W. Hanna	223	1,042	.23	7.20	240
October 21*	F. W. Hanna	68	150	1.43	7.30	216
November 4*	F. W. Hanna	68	131	1.49	7.20	195

*Measurement made from boat and cable one mile below station.

[11] Water Supply and Irrigation Paper, No. 128, pp. 89-90.

Mean Daily Gage Height, in Feet, of White River (West Branch) at Indianapolis, Ind., in 1904.

Day.	Mar.*	Apr.*	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		18.85		8.90	8.30	7.50	7.30	7.40	7.20	7.10
2		21.66		9.50	8.45	7.45	7.30	7.10	7.20	7.10
3		20.90		9.20	8.35	7.40	7.30	7.30	7.20	7.10
4		14.71		9.10	8.25	7.40	7.20	7.30	7.20	7.10
5				9.10	8.20	7.40	7.20	7.30	7.20	7.10
6			8.80	8.75	8.20	7.35	7.25	7.25	7.20	7.10
7			8.75	8.60	9.10	7.35	7.30	7.25	7.20	7.10
8			8.70	8.40	9.50	7.35	7.30	7.20	7.20	6.75
9			8.70	8.30	9.45	7.30	7.25	7.20	7.30	6.70
10			8.70	8.30	9.20	7.30	7.20	7.20	7.25	7.10
11			8.60	8.20	8.90	7.40	7.20	7.50	7.20	7.10
12			8.50	8.20	8.70	7.30	7.20	7.50	7.20	7.10
13			8.50	8.10	8.50	7.25	7.20	7.40	7.20	7.10
14			8.40	8.10	8.40	7.20	7.25	7.40	7.10	6.90
15			8.40	8.00	8.20	7.15	7.20	7.30	7.20	6.95
16			8.40	8.10	8.10	7.20	7.20	7.30	7.20	7.00
17			8.40	8.50	8.00	7.20	7.20	7.30	7.20	7.15
18			8.50	8.50	8.00	7.10	7.25	7.30	7.20	7.15
19			8.70	8.70	7.90	7.20	7.30	7.30	7.20	7.10
20			8.90	9.10	7.90	7.50	7.55	7.30	7.20	7.10
21			9.10	9.60	7.85	7.80	7.35	7.30	7.20	7.10
22			9.10	9.60	8.00	8.20	7.30	7.30	7.20	7.10
23			8.80	9.00	8.00	8.00	7.30	7.30	7.20	7.20
24			8.70	8.90	7.85	7.65	7.30	7.30	7.20	7.50
25			8.70	8.55	7.80	7.60	7.40	7.25	7.20	7.60
26	21.42		8.60	8.45	7.70	7.40	7.70	7.25	7.20	7.70
27	24.74		8.70	8.40	7.65	7.35	7.60	7.25	7.20	9.20
28	21.21		8.70	8.30	7.60	7.30	7.60	7.20	7.10	9.70
29	13.79		8.80	8.30	7.55	7.30	7.60	7.10	7.10	8.75
30	12.15		8.80	8.30	7.50	7.25	7.60	7.15	7.10	8.45
31	13.26		8.90		7.50	7.30		7.15		8.50

*Readings March 26 to April 4 reduced from readings of Kingan gage.

Rating Table for White River (West Branch) at Indianapolis, Ind., from May 6 to December 31, 1904.

Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.
7.0	184	7.7	425	8.4	840
7.1	211	7.8	475	8.5	910
7.2	240	7.8	525	8.6	990
7.3	271	8.0	580	8.7	1,070
7.4	304	8.1	640	8.8	1,150
7.5	340	8.2	700	8.9	1,240
7.6	380	8.3	770	9.0	1,330

The above table is applicable only for open channel conditions. It is based upon seven discharge measurements made during 1904. It is well defined between gage heights 7.2 feet and 8.8 feet. The table has been extended beyond these limits.

Discharge Measurements of the West Branch of White River at Indianapolis, Ind., in 1905.[12]

Date.	Hydrographer.	Width Feet.	Area of Section Sq. Ft.	Mean Velocity, Ft. per Sec.	Gage Height, Feet.	Discharge, Sec.-Ft.
March 15	S. K. Clapp	250	1,415	1.00	8.80	1,408
May 13	M. S. Brennan	328	2,836	3.04	13.30	8,626
June 14	S. K. Clapp	243	1,277	.57	8.05	730
September 11	M. S. Brennan	272	1,452	.98	8.98	1,427
October 18	M. S. Brennan	239	1,234	.50	7.94	621

[12] Water Supply and Irrigation Paper, No. 169, pp. 83–84.

Daily Gage Height, in Feet, of West Branch of White River at Indianapolis, Ind., for 1905.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.5	7.3	11.8	10.6	10.4	11.0	7.6	7.3	7.8	7.7	7.75	8.3
2	8.3	7.2	12.1	9.8	9.4	9.8	7.6	7.3	7.7	8.35	7.7	8.4
3	8.15	7.1	11.2	9.3	9.0	9.3	7.65	7.35	7.6	10.3	7.7	8.8
4	7.65	7.1	10.8	8.9	8.75	8.8	7.65	7.3	7.7	10.7	7.65	9.9
5	7.85	7.15	10.1	8.75	8.6	8.5	7.6	7.3	7.8	9.6	7.9	8.2
6	7.85	7.15	9.6	8.5	8.65	8.7	7.6	7.3	7.75	9.0	8.4	8.4
7	7.8	7.1	9.4	8.4	9.0	8.8	7.6	7.75	7.65	8.6	9.7	8.6
8	7.55	7.1	9.6	8.2	9.2	8.9	7.6	7.65	7.6	8.3	9.35	8.3
9	7.4	7.2	10.2	8.15	8.95	8.5	7.8	7.6	7.5	8.2	8.9	8.15
10	7.35	7.15	10.7	8.1	8.7	8.3	8.0	7.6	7.6	8.15	8.5	8.1
11	7.5	7.15	9.8	10.3	8.9	8.2	7.85	7.5	7.85	8.0	8.3	8.0
12	8.1	7.15	9.5	10.2	13.2	8.2	7.8	7.5	11.1	7.95	8.15	7.95
13	8.8	7.1	9.1	10.0	13.3	8.2	8.2	7.65	11.5	8.0	8.1	7.9
14	8.9	6.95	8.9	9.3	12.5	7.95	8.2	7.85	9.8	7.9	8.0	7.85
15	8.7	7.0	8.75	8.85	11.1	8.0	8.0	8.2	9.0	7.85	7.95	7.7
16	8.25	7.0	8.9	8.6	10.4	7.9	7.85	8.65	9.1	7.8	7.85	7.65
17	8.2	7.1	8.6	8.4	10.0	7.95	7.7	8.8	11.7	7.7	7.8	7.65
18	8.2	7.1	8.75	8.3	9.8	7.9	7.7	8.6	12.0	7.9	7.8	7.6
19	8.1	7.2	8.8	8.2	9.5	7.9	7.6	8.5	10.8	8.25	7.75	7.6
20	8.0	7.2	8.9	8.3	9.2	7.95	7.55	8.3	9.6	9.15	7.7	7.65
21	7.95	7.25	8.95	10.1	9.0	8.2	7.55	8.3	9.3	9.1	7.6	7.75
22	7.9	7.35	8.8	11.9	8.7	8.4	7.5	8.9	8.8	8.85	7.6	9.9
23	7.75	7.55	8.65	11.8	8.5	8.3	7.55	8.5	8.5	8.6	7.55	10.5
24	7.7	8.0	8.6	10.4	8.35	8.1	7.55	8.2	8.3	8.3	7.5	10.1
25	7.3	9.7	9.1	9.6	8.2	8.0	7.5	8.6	8.2	8.15	7.5	9.5
26	7.2	10.9	9.1	9.3	8.15	7.9	7.5	9.9	8.0	8.0	7.5	8.95
27	7.4	11.7	8.8	9.2	8.1	7.65	7.45	9.6	7.9	8.0	7.5	8.6
28	7.5	11.4	8.55	9.2	8.0	7.6	7.35	8.9	7.85	7.9	7.65	8.4
29	7.35		8.5	9.4	8.3	7.6	7.3	8.5	7.85	7.8	7.7	8.35
30	7.3		9.5	10.4	12.4	7.6	7.3	8.15	7.75	7.75	7.9	8.5
31	7.35		11.0		12.2		7.3	7.9		7.8		8.6

Note.—Ice conditions unknown: discharge applied as for open channel.

Station Rating Table for West Branch of White River at Indianapolis, Ind., from January 1 to December 31, 1905.

Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.
6.9	125	8.2	800	9.4	1,895	11.2	4,315
7.0	150	8.3	880	9.5	2,005	11.4	4,655
7.1	180	8.4	960	9.6	2,115	11.6	5,005
7.2	215	8.5	1,045	9.7	2,225	11.8	5,375
7.3	255	8.6	1,130	9.8	2,345	12.0	5,765
7.4	300	8.7	1,215	9.9	2,465	12.2	6,165
7.5	350	8.8	1,305	10.0	2,585	12.4	6,585
7.6	400	8.9	1,395	10.2	2,845	12.6	7,015
7.7	455	9.0	1,490	10.4	3,125	12.8	7,455
7.8	515	9.1	1,585	10.6	3,405	13.0	7,905
7.9	580	9.2	1,685	10.8	3,695	13.5	9,055
8.0	650	9.3	1,785	11.0	3,995	14.0	10,210
8.1	725						

Note.—The above table is applicable only for open channel conditions. It is based on 10 discharge measurements made during 1904–5. It is well defined between gage heights 7.2 feet and 9 feet. The table has been extended beyond these limits, being based on one measurement at 13.3 feet.

DISCHARGE MEASUREMENTS OF WEST BRANCH OF WHITE RIVER AT INDIANAPOLIS, IND., IN 1906.[13]

DATE.	Hydrographer.	Width, Feet.	Area of Section, Sq. Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.
February 14	Brennan & Kriegsman	227	1,160	7.80	765
February 28	E. F. Kriegsman	221	1,200	8.00	1,000
March 30	E. F. Kriegsman	331	3,050	13.64	10,500
March 31	E. F. Kriegsman	331	3,700	16.00	18,000
June 9	E. F. Kriegsman	226	1,110	7.78	643

DAILY GAGE HEIGHT, IN FEET, OF WEST BRANCH OF WHITE RIVER AT INDIANAPOLIS, IND., FOR 1906.

DAY	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1	8.45	8.5	7.95	16.45	7.85	8.75	7.1
2	8.25	8.3	8.3	14.55	7.8	8.6	7.1
3	8.5	7.9	8.8	12.4	7.8	8.4	7.1
4	10.6	7.85	9.3	11.15	7.75	7.9	7.4
5	11.85	7.7	9.45	10.7	7.8	8.2	7.15
6	10.85	7.55	9.0	10.35	7.7	8.0	7.25
7	9.7	7.6	8.55	10.0	7.65	8.0	7.2
8	8.2	7.5	8.5	9.9	7.6	7.85	7.15
9	8.3	7.6	8.6	12.5	7.55	7.8	7.1
10	8.2	7.55	8.8	13.0	7.55	7.7	7.1
11	8.3	7.55	8.95	12.0	7.6	7.65	7.15
12	8.5	7.6	9.2	11.0	7.55	7.5	7.4
13	8.4	7.6	9.45	10.4	7.55	7.45	7.15
14	8.25	7.65	9.4	10.75	7.5	7.45	7.05
15	8.35	7.75	9.35	11.55	7.45	7.4	7.05
16	9.5	7.85	9.1	11.35	7.3	7.35	7.1
17	10.1	7.6	9.3	10.4	7.3	7.3	7.05
18	9.9	7.6	9.45	9.8	7.35	7.3	7.05
19	9.4	7.65	9.5	9.4	7.5	7.25	7.05
20	9.1	7.7	9.2	9.1	7.4	7.25	7.05
21	8.8	7.8	8.9	8.9	7.4	7.25	6.95
22	11.1	7.9	8.8	8.75	7.35	7.35	....
23	12.0	7.95	8.65	8.55	7.4	7.3	....
24	11.35	8.0	8.5	8.45	7.4	7.3	....
25	10.5	8.2	8.45	8.3	7.4	7.25	....
26	9.7	8.4	8.35	8.2	7.35	7.15	....
27	9.3	8.35	14.7	8.15	7.35	7.15	....
28	9.0	8.0	15.45	8.0	7.5	7.1	....
29	8.9		15.6	7.95	7.4	7.1	....
30	8.8		13.6	7.9	7.35	7.2	....
31	8.6		16.25		7.65		....

NOTE.—Discharge probably unaffected by ice conditions.

[13] Water Supply and Irrigation Paper, No. 205, pp. 66-67.

RATING TABLE FOR WEST BRANCH OF WHITE RIVER AT INDIANAPOLIS, IND., FOR 1906.

Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.	Gage Height, Feet.	Dis-charge, Sec.-Ft.
6.9	240	8.2	1,080	9.5	2,420	11.6	5,820
7.0	280	8.3	1,170	9.6	2,540	11.8	6,230
7.1	325	8.4	1,260	9.7	2,670	12.0	6,650
7.2	375	8.5	1,350	9.8	2,800	12.2	7,090
7.3	430	8.6	1,450	9.9	2,930	12.4	7,540
7.4	490	8.7	1,550	10.0	3,070	12.6	8,000
7.5	550	8.8	1,650	10.2	3,350	12.8	8,470
7.6	615	8.9	1,750	10.4	3,650	13.0	8,950
7.7	680	9.0	1,850	10.6	3,970	14.0	11,570
7.8	750	9.1	1,960	10.8	4,310	15.0	14,570
7.9	830	9.2	2,070	11.0	4,670	16.0	18,000
8.0	910	9.3	2,180	11.2	5,040	16.5	19,830
8.1	990	9.4	2,300	11.4	5,420		

NOTE.—The above table is applicable only for open channel conditions. It is based on five discharge measurements made during 1906 and on the form of the 1905 rating curve. It is not very well defined.

During the time the records have been kept at this station, the lowest discharge of 1904 occurred on December 8, 9, 14 and 15. The gage at this time registered less than 7.0 feet, and the discharge was less than 184 cu. ft. per second. An equally low stage of the river occurred in February, 1905, when for twenty days the discharge was 180 cu. ft. per second or less. The lowest stage in 1906 occurred on the last day of which the record was taken. At that time the discharge was 260 cu. ft. per second.

LOWER EEL RIVER AT CATARACT, INDIANA.[14]

This station was established August 6, 1903, by E. Johnson, Jr., assisted by L. R. Stockman. It is located six miles from Cloverdale, Ind., and one-half mile southwest of Cataract, Ind. It is 300 feet above a dam, below which there is a fall of 35 feet The gage is a 3 by 6 inch oak timber, securely fastened to the west abutment on the down stream face. It is marked by brass-headed nails and reads from zero to 10 feet. The gage is read once each day by Joe Steiner. Discharge measurements are made from the upstream side of the single-span, covered highway bridge, which has a length between abutments of 128 feet. The initial point for soundings is the face of the left or west abutment at the coping on the upstream side. Distances are marked by wire nails and painted figures on the guard rail on the upstream side of the bridge. The channel is straight for about 500 feet above and 300 feet below the bridge. The current varies from swift to rather sluggish. Both banks are high and rocky and will not overflow.

[14] Water Supply and Irrigation Paper, No. 98, pp. 218–219.

The bed of the stream is a smooth rock ledge, nearly level between the bridge abutments.

Bench mark No. 1 is a wire nail in the root of a small elm tree on the north side of the road approaching the bridge on the west side of the river about 50 feet from the bridge. Its elevation above the zero of the gage is 12.60 feet. Bench mark No. 2 is a wire nail in the root of a large oak tree in the pasture on the west of the river 300 feet from the bridge and 20 feet from the fence which bounds the south side of the road approaching the bridge. The elevation of this bench mark is 27.20 feet above the zero of the gage.

The observations at this station during 1903 have been made under the direction of E. Johnson, Jr., district hydrographer.

DISCHARGE MEASUREMENT OF LOWER EEL RIVER AT CATARACT IN 1903.

DATE.	Hydrographer.	Gage Height, Feet.	Discharge, Sec.-Ft.
August 6	E. Johnson, Jr	2.60	1,479
August 12	E. Johnson, Jr	1.30	127
September 25	L. R. Stockman	1.04	14
March 24, 1910	W. M. Tucker	1.25	50.25*

*This discharge measurement was made as a check on the measurements made in 1903 and was found to fit the curve very closely. A rating table was then formulated from these four measurements. This rating table follows the 1909-10 gage readings. It is not very well defined, but should be accurate up to 2.6 feet.

MEAN DAILY GAGE HEIGHT, IN FEET, OF LOWER EEL RIVER AT CATARACT, IND., FOR 1903.

DAY.	Aug.	Sept.	Oct.	Nov.	Dec.	DAY.	Aug.	Sept.	Oct.	Nov.	Dec.
1	....	1.20	1.10	1.20	1.30	17	1.15	1.35	1.20	1.30	1.30
2	....	1.15	1.10	1.20	1.25	18	1.20	1.30	1.20	1.30	1.30
3	....	1.15	1.10	1.20	1.30	19	1.10	1.30	1.15	1.30	1.40
4	....	1.20	1.30	1.20	1.30	20	1.10	1.15	1.20	1.30	1.60
5	....	1.15	1.20	1.20	1.30	21	1.10	1.15	1.30	1.30	1.60
6	2.60	1.00	1.30	1.20	1.30	22	1.10	1.25	1.20	1.20	1.60
7	2.00	1.00	2.50	1.20	1.35	23	1.10	1.20	1.20	1.25	1.60
8	1.55	1.00	2.70	1.20	1.35	24	1.10	1.20	1.20	1.20	1.60
9	1.50	1.00	2.20	1.00	1.35	25	1.10	1.15	1.20	1.30	1.60
10	1.40	1.00	2.10	1.20	1.35	26	1.10	1.15	1.20	1.30	1.60
11	1.35	1.00	1.20	1.20	1.40	27	1.10	1.10	1.20	1.25	1.40
12	1.30	1.00	1.15	1.30	1.40	28	1.05	1.15	1.20	1.20	1.40
13	1.20	1.10	1.15	1.40	1.30	29	1.20	1.10	1.15	1.30	1.40
14	1.20	1.10	1.15	1.30	1.30	30	1.15	1.05	1.20	1.30	1.40
15	1.20	1.15	1.60	1.30	1.30	31	1.20		1.20		1.40
16	1.15	1.30	1.30	1.30	1.30						

One measurement was made on May 4, 1904; gage height, 1.28 feet; discharge, 140 sec. ft.[15]

[15] Water Supply and Irrigation Paper, No. 128, pp. 91-92.

MEAN DAILY GAGE HEIGHT, IN FEET, OF LOWER EEL RIVER NEAR CATARACT, IND., FOR 1904.

DAY.	Jan.*	Feb.*	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	1.60	2.40	3.50	4.80	2.00	1.40	1.40	0.90	1.10	1.40	0.80	†
2....	1.60	2.40	3.60	4.90	2.10	1.30	1.30	.90	1.20	1.40	.80	†
3....	1.50	2.40	3.70	4.80	2.10	1.30	1.30	.90	1.20	1.30	.70	†
4....	1.50	2.40	3.70	4.80	2.20	1.30	1.30	.90	1.10	1.30	.70	†
5....	1.50	2.40	3.60	4.60	2.20	1.20	1.20	.90	1.10	1.20	.70	†
6....	1.50	2.60	2.70	3.60	2.20	1.20	1.20	.90	1.00	1.10	.80	†
7....	1.50	4.00	2.90	3.00	2.20	1.30	1.20	.80	1.00	1.10	.90	†
8....	1.50	4.00	2.90	2.50	2.10	1.40	1.20	.80	.90	1.10	1.00	†
9....	1.50	4.00	2.60	2.20	2.10	1.40	1.20	.80	.80	1.20	1.00	†
10....	1.50	4.00	2.60	2.10	2.20	1.40	1.10	.80	.60	1.20	1.00	†
11....	1.50	3.90	2.70	2.10	2.20	1.30	1.10	.80	.70	1.30	1.00	†
12....	1.50	3.70	2.60	2.10	2.30	1.30	1.10	.80	.70	1.20	1.00	†
13....	1.50	3.40	2.30	2.00	2.30	1.40	1.10	.80	.70	1.10	1.10	†
14....	1.50	3.20	2.25	2.00	2.20	1.40	1.10	.90	.80	1.00	1.10	†
15....	1.50	3.20	2.30	2.00	2.20	1.40	1.10	.90	.90	1.00	1.10	†
16....	1.50	3.10	2.40	2.00	2.20	1.40	1.10	.90	1.00	1.00	1.00	†
17....	1.60	3.00	2.50	2.10	2.10	1.40	1.05	.90	1.00	1.00	1.00	†
18....	1.70	2.90	2.60	2.10	2.10	1.40	1.05	.90	1.00	1.10	1.10	†
19....	1.90	2.90	2.70	2.00	2.10	1.40	1.05	.90	1.10	1.10	1.00	†
20....	2.50	2.90	2.80	2.00	2.00	1.50	1.10	1.00	1.10	1.10	1.00	†
21....	2.70	2.90	2.90	2.00	2.00	1.50	1.00	1.00	1.20	1.10	1.00	†
22....	4.10	2.90	3.00	2.00	2.00	1.50	1.00	1.00	1.10	1.00	1.00	0.50
23....	4.10	3.00	3.40	2.00	2.00	1.50	1.00	1.00	1.00	1.00	1.00	.80
24....	4.00	3.00	3.50	2.20	2.00	1.50	1.00	1.10	1.00	1.00	1.00	1.30
25....	3.90	3.00	4.70	2.20	1.80	1.60	1.00	1.20	1.20	1.10	1.00	1.40
26....	3.60	3.00	6.60	2.10	1.80	1.60	.90	1.20	1.40	1.00	1.00	1.70
27....	3.40	3.00	6.60	2.10	1.70	1.50	.90	1.20	1.45	1.00	.80	2.00
28....	3.00	3.20	6.30	2.10	1.60	1.50	.90	1.10	1.55	1.00	.70	2.30
29....	2.70	3.40	5.20	2.10	1.50	1.40	.90	1.10	1.50	.90	.50	2.70
30....	2.60		4.00	2.00	1.50	1.40	.90	1.10	1.40	.90	.40	3.00
31....	2.40		3.90		1.40		.90	1.00		.90		3.30

*Ice condition January and February. †Below gage.

NOTE.—The zero of the gage is 0.96 feet below the crest of the dam; therefore when the gage is below 0.96 all the water flows through a small flume.

DAILY GAGE HEIGHT, IN FEET, OF LOWER EEL RIVER AT CATARACT, IND., FOR 1905.[16]

DAY.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1....	3.3	2.1	3.3	2.4	3.9	2.0	2.0	1.1	1.6	1.6	1.8	2.4
2....	3.2	2.1	3.4	2.3	3.8	2.0	1.9	1.1	1.5	1.4	1.8	2.5
3....	3.1	2.1	3.5	2.2	3.8	2.0	1.8	1.0	1.6	1.3	1.9	2.4
4....	3.0	2.0	3.6	2.1	3.7	2.0	1.7	1.0	1.8	1.2	1.9	2.3
5....	2.9	2.0	3.6	2.1	3.5	2.1	1.6	1.0	1.9	1.2	2.0	2.2
6....	2.8	1.6	3.5	2.0	3.4	2.1	1.7	1.0	1.9	1.1	2.0	2.2
7....	2.7	1.6	3.4	2.0	3.3	2.0	1.8	1.1	1.8	1.1	2.1	2.3
8....	2.8	1.6	3.2	2.0	3.2	2.0	2.0	1.1	1.8	1.2	2.0	2.3
9....	2.8	1.6	3.0	1.9	3.5	2.1	2.0	1.2	1.8	1.2	2.0	2.4
10....	2.9	1.6	2.9	1.8	3.6	2.0	2.0	1.2	1.7	1.3	1.9	2.4
11 ...	2.9	1.6	2.8	1.8	3.6	2.1	1.9	1.3	1.7	1.3	1.9	2.4
12....	3.0	1.6	2.8	1.7	3.5	2.1	1.9	1.2	1.6	1.4	2.0	2.3
13....	3.0	1.6	2.7	1.6	3.5	2.0	1.8	1.3	1.5	1.5	2.0	2.3
14....	3.0	1.6	2.7	1.6	3.4	2.1	1.9	1.4	1.4	1.6	2.1	2.2
15....	2.9	1.7	2.7	1.6	3.2	2.2	2.0	1.6	1.3	1.6	2.1	2.1
16....	2.9	1.8	2.6	1.6	3.1	2.3	2.0	1.7	1.2	1.7	2.0	2.0
17....	2.8	1.8	2.5	1.6	3.0	2.4	1.9	1.9	1.2	1.8	1.9	2.0
18....	2.8	1.8	2.5	1.7	2.9	2.5	1.8	2.0	1.1	1.9	1.9	2.1
19....	2.7	2.0	2.4	1.7	2.8	2.6	1.7	2.5	1.1	2.0	1.8	2.2
20....	2.6	2.2	2.4	1.9	2.7	2.7	1.6	2.4	1.0	2.1	1.7	2.3
21....	2.6	2.3	2.3	1.9	2.6	2.8	1.5	2.4	1.0	2.3	1.6	2.4
22....	2.6	2.5	2.2	2.0	2.6	2.9	1.4	2.3	1.0	2.3	1.5	2.4
23....	2.6	2.8	2.2	2.0	2.5	2.8	1.3	2.2	1.0	2.3	1.5	2.3
24....	2.6	3.0	2.1	2.0	2.4	2.7	1.2	2.1	1.1	2.2	1.4	2.4
25....	2.6	3.0	2.0	2.2	2.3	2.6	1.2	2.0	1.2	2.1	1.5	2.5
26....	2.6	3.0	2.0	2.3	2.3	2.5	1.3	2.0	1.4	2.1	1.6	2.6
27....	2.6	3.1	2.0	2.5	2.2	2.4	1.3	2.0	1.5	2.0	1.7	2.6
28....	2.6	3.2	2.1	2.7	2.2	2.3	1.4	1.9	1.6	2.0	1.9	2.7
29....	2.5		2.2	4.0	2.1	2.2	1.4	1.9	1.6	2.0	2.0	2.8
30....	2.4		2.3	4.0	2.1	2.1	1.3	1.8	1.7	1.9	2.0	2.8
31....	2.3		2.3		2.1		1.2	1.7		1.8		2.7

NOTE.—Ice condition unknown.

[16] Water Supply and Irrigation Paper, No. 169, p. 86.

Daily Gage Height, in Feet, of Eel River at Cataract, Ind., for 1906.[17]

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1..........	2.8	2.9	3.2	17..........	4.0	2.9	2.8
2..........	3.0	2.7	3.0	18..........	4.1	2.8	2.7
3..........	3.2	2.6	3.4	19..........	4.2	2.7	2.7
4..........	3.4	....	3.3	20..........	4.2	2.7	2.6
5..........	3.6	....	3.3	21..........	4.1	2.6	2.6
6..........	3.7	....	3.2	22..........	4.0	2.8	2.5
7..........	3.7	....	3.2	23..........	4.0	2.9	2.5
8..........	3.7	....	3.1	24..........	3.9	3.0	2.6
9..........	3.6	....	3.0	25..........	3.9	2.9	2.7
10..........	3.6	2.7	3.0	26..........	3.8	2.9	3.3
11..........	3.6	2.7	3.1	27..........	3.7	2.9	4.1
12..........	3.6	2.7	3.1	28..........	3.6	3.0	4.4
13..........	3.6	2.6	3.0	29..........	3.4		4.4
14..........	3.7	2.6	3.0	30..........	3.2		4.6
15..........	3.8	2.8	2.9	31..........	3.0		4.9
16..........	3.9	2.9	2.9				

Note.—River frozen February 4th to 9th.

Daily Gage Height, in Feet, of Lower Eel River at Cataract, Ind., from June 18, 1909, to June 18, 1910.

Day.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
1..........	......	1.4	1.7	1.1	1.1	1.2	1.3	1.2	1.3	3.7	1.2	1.3	1.2
2..........	......	1.3	1.5	1.1	1.1	1.3	1.4	1.8	1.2	3.0	1.2	1.3	1.2
3..........	......	1.3	1.2	1.1	1.1	1.3	1.4	2.0	1.7	2.5	1.2	1.8	1.2
4..........	......	1.3	1.2	1.1	1.1	1.2	1.3	2.3	1.5	2.2	1.1	2.0	1.2
5..........	......	1.2	1.2	1.1	1.1	1.2	1.3	2.5	1.5	2.0	1.2	1.5	1.2
6..........	......	2.1	1.1	1.1	1.1	1.2	1.3	2.5	1.4	2.0	1.2	1.5	1.2
7..........	......	2.8	1.1	1.1	1.1	1.2	1.4	2.3	1.3	1.7	1.3	1.5	1.1
8..........	......	2.3	1.1	1.1	1.1	1.4	1.3	2.0	1.3	1.6	1.3	1.5	1.1
9..........	......	1.6	1.1	1.1	1.1	1.3	1.3	2.0	1.2	1.5	1.3	1.6	1.1
10..........	......	1.4	1.1	1.6	1.1	1.3	1.4	1.7	1.2	1.5	1.2	1.3	1.1
11..........	......	1.5	1.1	1.7	1.1	1.3	1.4	1.3	1.2	1.4	1.2	1.3	1.1
12..........	......	2.3	1.1	1.3	1.1	1.3	2.0	1.2	1.2	1.4	1.2	1.8	1.1
13..........	......	3.7	1.1	1.1	1.2	1.3	3.4	2.8	1.2	1.3	1.2	1.6	1.1
14..........	......	3.8	1.1	1.1	1.2	1.3	3.4	3.1	1.2	1.2	1.2	1.4	1.1
15..........	......	1.9	1.1	1.1	1.2	1.2	2.5	2.8	1.4	1.2	1.2	1.3	1.1
16..........	......	1.6	1.1	1.1	1.2	1.3	1.9	2.4	2.6	1.3	1.0	1.3	1.1
17..........	......	1.5	1.1	1.1	1.2	1.4	1.6	2.0	1.5	1.3	1.2	1.3	1.1
18..........	2.1	1.3	1.1	1.1	1.2	1.4	1.4	3.6	1.4	1.2	1.2	1.3	......
19..........	1.1	1.2	1.1	1.1	1.3	1.3	1.3	4.1	1.5	1.3	1.3	1.3	......
20..........	1.6	1.9	1.1	1.2	1.3	1.3	1.3	3.9	1.5	1.2	1.3	1.3	......
21..........	1.3	1.0	1.1	1.2	1.4	1.3	1.2	2.9	2.2	1.3	1.3	1.3	......
22..........	1.5	1.3	1.1	1.2	1.4	1.3	1.2	2.3	2.5	1.2	1.3	1.3	......
23..........	1.4	1.4	1.1	1.3	2.7	2.9	1.2	2.0	2.5	1.2	1.3	1.3	......
24..........	2.3	1.3	1.1	1.2	1.8	2.7	1.2	1.3	2.0	1.2	1.2	1.2	......
25..........	2.7	1.2	1.1	1.2	1.4	2.6	1.2	1.3	1.4	1.2	1.2	1.2	......
26..........	3.4	1.3	1.3	1.1	1.3	2.6	1.2	1.2	1.6	1.2	1.2	1.2	......
27..........	3.6	1.1	1.2	1.1	1.2	2.3	1.2	1.3	4.1	1.2	1.2	1.2	......
28..........	2.9	1.1	1.3	1.1	1.2	2.3	1.2	1.4	5.6	1.2	1.4	1.2	......
29..........	2.2	1.1	1.1	1.1	1.2	2.4	1.2	1.4		1.2	1.3	1.2	......
30..........	1.6	1.9	1.1	1.1	1.2	2.1	1.2	1.3		1.2	1.3	1.2	......
31..........	......	1.7	1.1		1.2		1.2	1.2		1.2		1.2	

[17] Water Supply and Irrigation Paper, No. 205, p. 68.

RATING TABLE FOR LOWER EEL RIVER AT CATARACT, IND., FOR 1903 TO 1910.

Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.	Gage Height, Feet.	Discharge, Sec.-Ft.
1.0	10	1.8	638	2.6	1,479	3.3	2,205
1.1	21	1.9	742	2.7	1,585	3.4	2,311
1.2	50	2.0	845	2.8	1,688	3.5	2,418
1.3	127	2.1	948	2.9	1,790	3.6	2,527
1.4	212	2.2	1,050	3.0	1,893	3.7	2,633
1.5	320	2.3	1,157	3.1	1,996	3.8	2,753
1.6	428	2.4	1,263	3.2	2,098	3.9	2,873
1.7	532	2.5	1,370				

NOTE.—This table is based upon five discharge measurements made during 1903, 1904 and 1910. It is fairly well defined between 1.0 foot and 2.6 feet. It has been extended beyond this limit. Beyond 3.9 feet the curve is considered a tangent with a difference of 120 per tenth.

During the time the records have been kept in this station, there have been periods when there was practically no discharge. These periods occurred when the gage registered less than 1.0 feet. Four such periods occurred in 1904, from July 26 to August 20; Sept. 8 to 16; Oct. 29 to Nov. 8; and Nov. 27 to Dec. 24. During 1905 and 1906 no such periods occurred. During the year June 18, 1909, to June 18, 1910, the gauge never registered less than one foot.

WEST FORK OF WHITE RIVER AT MAYSVILLE, INDIANA.

This station was established by W. M. Tucker, July 31st, 1909, at the Washington Waterworks plant at Maysville, Indiana. It was a chain gage and was attached to a cedar pole firmly braced and anchored on the east bank of the river near the waterworks engine room. The datum of this gage was 27.89 feet below the sill of the second door from the southwest corner along the west side of the Washington Waterworks plant. The river at this point has a straight channel for a half mile above and below the gage. The river bed is composed of sand and clay. The gage was read daily by Gus Gutch, chief engineer of the Washington Waterworks Company, from August 1st, 1909, until December 18th, 1909, when the gage was damaged by ice. The gage has not been re-established. The single current reading was taken from a boat and cable, directly across the river from the gage.

DISCHARGE MEASUREMENT ON WEST BRANCH OF WHITE RIVER AT MAYSVILLE, IND.

Date.	Hydrographer.	Width of River, Feet.	Gage Height, Feet.	Discharge, Sec.-Ft.
August 1, 1909	W. M. Tucker	230	10.0	1,636

DAILY GAGE HEIGHT, IN FEET, OF THE WEST FORK OF WHITE RIVER, AT MAYSVILLE, IND., FROM AUGUST 1 TO DECEMBER 18, 1909.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.5	8.4	7.5	9.2	12.3	17	8.7	7.5	7.0	8.5	18.8
2	12.0	8.4	7.3	9.0	11.9	18	8.6	7.4	7.2	8.9	19.3
3	11.5	8.5	7.3	9.1	11.2	19	8.7	7.4	7.3	9.2	....
4	10.8	8.3	7.2	8.8	11.0	20	8.5	7.3	7.3	9.9	....
5	10.3	8.1	7.2	8.8	11.0	21	8.6	7.1	7.8	9.9	....
6	10.2	8.8	7.2	8.6	10.8	22	8.6	6.9	8.1	9.8	....
7	9.8	8.0	7.0	8.9	10.8	23	8.4	7.3	8.4	9.9	....
8	9.5	7.7	7.0	8.3	11.6	24	8.2	7.3	8.6	1.09	....
9	9.2	7.7	7.0	8.3	11.5	25	8.1	7.3	10.0	13.3	....
10	9.0	7.7	6.8	8.2	11.0	26	8.0	7.4	11.1	15.0	....
11	8.8	7.8	6.6	8.2	*	27	8.0	7.5	11.2	15.7	....
12	8.7	7.1	6.6	8.4	12.4	28	8.0	7.7	11.1	16.2	....
13	8.6	8.2	6.8	8.4	15.0	29	8.5	7.7	10.6	15.0	....
14	8.5	8.1	6.9	8.3	17.3	30	8.4	7.6	10.1	13.6	....
15	8.4	7.9	6.8	8.2	18.6	31	8.3		9.6		....
16	8.6	7.7	6.9	8.1	18.7						

*No record.

The lowest discharge occurred at this station from October 10 to 16, but since an insufficient number of current readings were taken to determine a rating table, the discharge at this time cannot be determined. This data will be of interest if this gage is re-established and a rating table determined.

PROFILE OF WEST BRANCH OF WHITE RIVER.

Station.	Distance Apart, Miles.	Distance from Noblesville, Miles.	Elevation, Feet.
Noblesville	0	0	741
Indianapolis	34	34	675
Martinsville	43	77	600
Spencer	38	115	540
Worthington	32	147	506
Newberry	38	185	476
Edwardsport	29	214	445
Washington (B. & O. bridge)	25	239	419
Junction (E. Fork)	17	256	400
Mouth (White River)	50	306	376

Power Sites on the West Fork of White River.

The writer traversed the West Fork of White River from Noblesville to its junction with the East Fork. The fall in this part of the river is very uniform. The profile of the river shows the fall to average about two feet per mile near Noblesville, and about one foot per mile near the junction with the East Fork. There are no abrupt falls such as found at Tannehill Bridge and Shoals on the East Fork. The greatest abrupt fall is at Spencer, where there is 2.25 feet on one ripple. Eel River, which enters the main branch of the West Fork at Worthington, has an excellent power site at Cataract. No other power site occurs on this tributary

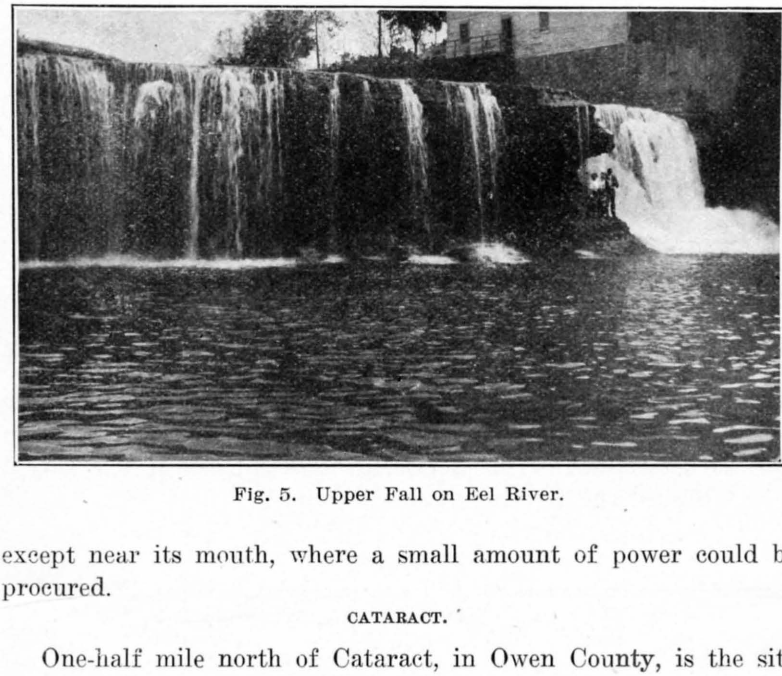


Fig. 5. Upper Fall on Eel River.

except near its mouth, where a small amount of power could be procured.

CATARACT.

One-half mile north of Cataract, in Owen County, is the site of an old power mill. The old mill stands on the west bank of Eel River at the crest of an abrupt fall twenty feet high, figure 5. Above the fall is a rapid which adds ten feet to the abrupt fall. At the head of the rapid, which is about fifty yards in length, is a concrete dam which adds four feet more to the fall. A concrete race leads the water from the pond above the dam to the mill, where a fall of thirty-four feet occurs. This is a splendid site for a power plant, but it is not employed at the present time, and the mill is rapidly decaying.

Another fall occurs one-half mile down stream, figure 6. This fall has approximately the same fall as the former. The entire fall from the crest of the dam above the upper fall to the pond below the lower fall is eighty feet. Between the falls the valley is broad and is extended by a tributary from the northeast. Both the falls occur in Mitchell limestone, which is well exposed at the falls and in the bluffs. The amount of water available at this point is too small to depend upon for continual power. However, the facilities for storage are good. A dam 45 feet high located above the lower fall, as indicated in the topographic map, figure 7, would pond the water to the crest of the present dam above

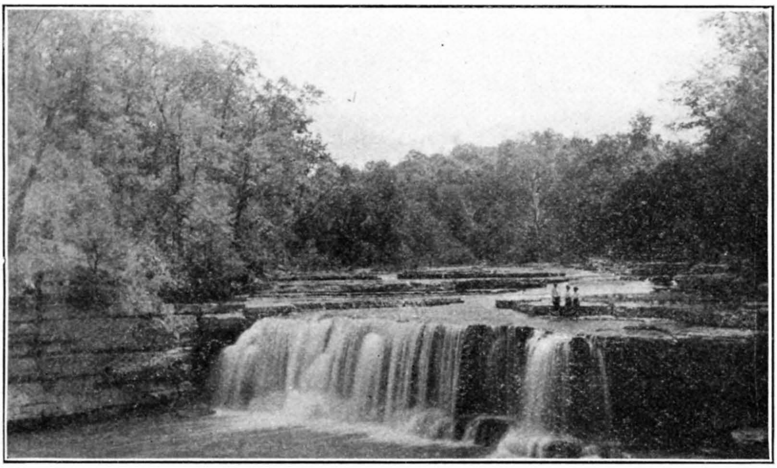


Fig. 6. Lower Fall on Eel River.

the upper fall. The edge of the pond would follow the eighty foot contour. It would cover .31 of a square mile, or 198.4 acres. The capacity of this pond would be 222,606,635 cu. ft.

Along the crest of the ridge south of the lower fall is a saddle which is so low that it would form a spillway if a pond were constructed as indicated above. The water would then escape through the valley which enters the main valley below the lower fall. This spillway could be dammed very easily. However, the storage basin could be enlarged by damming the tributary valley at the point indicated on the map. This dam would be 35 feet high. The pond formed by this dam would cover .131 of a square mile, or 83.84 acres. The capacity of this pond would be 54,560,455 cu. ft. The whole reservoir would cover .441 of a square mile, or

282.24 acres. The entire capacity of the reservoir would be 277,167,090 cu. ft.

From the gauge reading and rating table it is calculated that the entire runoff for the year 1904 was 22,351,690,000 cu. ft., or enough to fill the reservoir over eighty times. If this runoff could have been controlled and used regularly it would have produced over 5,000 horse power continually on eighty feet fall. However, it is evident from the gauge readings that the monthly discharge is very irregular. The following table shows the monthly discharge:

January	2,863,555,200 cu. ft.
February	5,053,708,800 cu. ft.
March	6,497,020,800 cu. ft.
April	3,936,988,800 cu. ft.
May	2,285,798,400 cu. ft.
June	580,089,600 cu. ft.
July	94,262,400 cu. ft.
August	24,537,600 cu. ft.
September	144,460,800 cu. ft.
October	111,801,600 cu. ft.
November	20,227,600 cu. ft.
December	739,238,400 cu. ft.
Total	22,351,690,000 cu. ft.

These figures show that no monthly discharge between June and December was sufficient to fill the reservoir. If this water be retained in the reservoir a reduction must be made for evaporation. In this latitude the evaporation from water surfaces is about forty inches per year. During the dry summer months the evaporation would be heavier than during the winter months. The evaporation during these months is about four and one-half inches per month. This depth over the surface of the reservoir (.441 sq. mi.) amounts to 4,610,390 cu. ft. Thus, this amount must be deducted from each month's discharge. The following table shows the reduced amounts from June to November, inclusive:

June	575,479,210 cu. ft.
July	89,652,010 cu. ft.
August	19,927,210 cu. ft.
September	139,850,410 cu. ft.
October	107,191,210 cu. ft.
November	15,617,210 cu. ft.

Since the month of November had the minimum discharge, the amount of power, which could be produced continually during the month on the eighty feet fall, will be considered. To reduce this discharge to a continual discharge per second during the month the total discharge is divided by 2,592,000, the number of seconds in a month of thirty days. Using this quotient in the formula $\frac{\text{discharge} \times \text{feet fall}}{11}$ = practical horse power, the power which could be produced is found to be 43.81 horse power.

In the above calculation the water stored in the reservoir is not considered to be used. The following calculation shows that almost 250 horse power could have been produced continually during the drouth of 1904. If the water from the reservoir be used the head will necessarily fall below eighty feet. Since considerably more than half the volume of the reservoir occurs within a depth of twenty feet from the surface, a head of sixty feet will give a conservative working basis. To produce 250 horse power on a sixty foot head, it is necessary to use 122,760,000 cu. ft. of water during a month of thirty-one days, and 118,800,000 cu. ft. during a month of thirty days. If the reservoir be full at the end of June and 250 horse power be produced regularly thereafter, the following reservoir conditions would exist:

	In Reservoir at Beginning of Month.		Runoff During Month.		Necessary to Produce 250 H. P. per Month.		In Reservoir at End of Month.
July	277,167,090	+	89,652,010	—	122,760,000	=	244,059,100
August	244,059,100	+	19,972,210	—	122,760,000	=	141,226,310
September	141,226,310	+	139,850,410	—	118,800,000	=	163,276,720
October	163,276,720	+	107,191,210	—	122,760,000	=	147,707,930
November	147,707,930	+	15,617,210	—	118,800,000	=	44,525,140
Dec. 1–24	44,525,140	+	0	—	91,080,000	=	—46,554,860

This calculation shows that there would have lacked 46,554,860 cu. ft. to have produced the 250 horse power. However, in calculating the monthly discharges, all discharge was neglected when the gage registered less than one foot. This occurred on seventy days during the drouth. During this time there was a small discharge. Since the evaporation correction was considered high, head of water low, and no discharge for the seventy days, it is probable that the 250 horse power could have been continually produced.

During the year 1905 no drouth occurred. The gage readings show the smallest monthly discharge to have been in September. The discharge during that month was 823,910,400 cu. ft., which would produce 2,311 horse power for one month. The gage readings for the year do not seem to be accurate, however, for the total discharge for the year is entirely too high.

The gage records for 1909-1910 are accurate. The lowest discharge occurred in August and September, 1909. During these months 500 horse power could have been produced continually.

The general conclusion concerning this site is that from 1,000 to 2,000 horse power could be produced during eight months of ordinary years and 500 to 1,000 horse power during the remaining four months. During exceptionally dry years the minimum would be about 250 horse power. The reservoir is too small to control the discharge.

MOUTH OF EEL RIVER AT WORTHINGTON, INDIANA.

On Eel River, 250 yards above the highway bridge at Worthington occurs an old dam site. The bank on the east side of the river is of Mansfield sandstone eighteen feet high above low water. This sandstone cliff forms an excellent abutment for a dam. The opposite bank is of river deposit, sand and loam, about fourteen feet high. Remains of the former dam make the river narrow and shallow at this point. The bed of the river is solid Mansfield sandstone. A ten foot dam at this point would not flood the low land above in ordinary stages of water. Such a dam would back the water about three miles in the channel, but would form practically no storage. The sandstone ledge on the east would form an excellent foundation for a power house, and a short race could also be cut into it.

The drainage basin of Eel River above this point is between five and six times as great as the drainage area above Cataract. If the discharge is correspondingly large, 1,000 horse power could be produced for eight months of the year with an average rainfall.

MAIN BRANCH OF WEST FORK.

NOBLESVILLE, IND.

During September, 1909, when this part of White River was investigated, The White River Light & Power Company of Noblesville was constructing a waterpower plant on White River two miles north of Noblesville, near the section line between sections 19 and 20, T. 19 N., R. 5 E. The river bed at this point is in glacial drift. The channel is 700 feet wide. The south bank is high and slopes gradually up to the south bluff. The north bank is about twenty feet high and slopes very gently upward up to the highway which parallels the river on the north. This highway is forty rods from the river at this point, and is about fifty feet above low water of the river.

The dam, when completed, is to be 594 feet in length and eighteen feet high. It is to be built entirely of concrete. The entire exposed works will be 692 feet, turbine house 96 feet, seven waste gates 112 feet, spillway 184 feet, distance in embankment 300 feet. The power house is on the north end of the dam. It will probably be necessary to construct a wing dam along the north bank. The backwater will reach five miles. All the land which will be injured has been purchased. Five pairs of horizontal, single discharge, twin turbines will be installed. Each will have a capacity of 330 horse power. The entire capacity will be 1,850 horse power.

The drainage area of the West Branch of White River above Noblesville is approximately 1,000 square miles. The average precipitation in this basin for the past ten years was about 39.5 inches per year. The run off in this state is about one-third of the total precipitation. Thus the runoff from this basin is approximately thirteen inches per year. This would give an average discharge of the river at Noblesville of 958 cu. ft. per second. If this could be controlled and used regularly it would produce continuously 1,567 horse power on eighteen feet fall. However, the storage facilities at Noblesville must necessarily be inadequate for storing the flood water, because the storage basin is all in the river channel. Thus during the flood seasons it will be possible to produce the 1,850 horse power, except when the river is so high that the head will be reduced by the overflow on the dam. During several months of the year, however, the power must be much less than the average 1,567 horse power. According to the data taken at Indianapolis during 1905, the discharge for the year represented a depth of 10.81 inches runoff from the drainage basin. The report of the United States Weather Bureau for the same year gives the precipitation as above the average. Hence the estimated depth of thirteen inches runoff is too high rather than too low. In the short discussion following the data taken at Indianapolis it is shown that there were several days in 1904 and again in 1905 when the discharge ran below 180 cu. ft. per second. The discharge at these times was smaller at Noblesville than at Indianapolis. However, if it be considered the same, the power at Noblesville during these periods would have been less than 294 horse power. The data from the Indianapolis station may not be entirely trustworthy, for reasons which will be given in a following paragraph. However, there can be no doubt that the power at Noblesville will run below three hundred horse power for long periods during years of average rainfall.

There is no developed power on the West Branch of White River below Noblesville. The fall on the river between the L. E. & W. Railroad bridge at Noblesville and the West Washington Street bridge at Indianapolis is 66 feet. Two dams occur on this part of the river. The Broad Ripple dam at Broad Ripple turns the water from the river into the canal of the Indianapolis Waterworks Company. This canal conducts the water to the Waterworks plant in Indianapolis. The Riverside dam at Riverside Park ponds the water for boating purposes in the park. Each of these dams is about twelve feet high. The fall on and between these two dams occupies about half of the fall from Noblesville to Indianapolis. This leaves thirty-three feet fall between Noblesville and Broad Ripple which is not used. The natural environment for developing this power is as favorable as that at Noblesville, Broad Ripple or Riverside. Good rock exposures occur in the bed of the river near the head of the back water from Broad Ripple dam. The best site for a dam in this part of the river has not been determined. However, the convenient market for power in Indianapolis and vicinity, should make its development in this part of the river very profitable. The great objection to this power, as is true of all the water power of the state, is its extreme irregularity.

When the Broad Ripple dam was visited on September 12, 1909, no water was passing. All the water passed into the Waterworks canal. The river bed below the dam was dry except for an occasional small pond. There was no running water in this part of the river. The river at this point flows on a deep deposit of glacial gravel in which the underflow is great. Two miles below the dam a small stream was flowing in the river bed. This stream was furnished by the underflow. At Riverside dam the discharge at this time was probably forty or fifty cu. ft. per second. At the mouth of Fall Creek this discharge was probably doubled, but the river did not resume its regular flow until the last sewer in the southern part of the city had been passed. Because the water is taken from the river at Broad Ripple and discharged into the river again by the sewers, etc., of the city, the volume of water in the river, anywhere between Broad Ripple and the last sewer of the city, is not normal. This deficiency gradually decreases down stream from the Broad Ripple dam. The per cent. of deficiency is greatest during low stages of the river.

The gaging station which the United States Geological Survey maintained at Indianapolis during 1904 to 1906 was located within the limits of the deficient flow. It was located below the mouth of Fall Creek but above the large sewers of the city. While the data from the station, no doubt, is accurate for the point where the station was located, yet it is evident that it does not represent the normal discharge for the West Fork of White River in this part of its course. If the station had been located three miles further down stream it would probably have shown a considerably greater discharge during low stages of the river.

Three miles by river below the Union Station at Indianapolis, between the mouth of Pleasant Run and Big Eagle Creek, is a half mile of the river in which the fall is greater than is usual in this part of the stream, and the current is correspondingly swifter. This is due to the recent cutting off of a large oxbow bend in the river. A fall of about two and one-half feet occurs on this ripple. The fall is entirely in glacial gravel, and for this reason is very temporary. It will soon be distributed by an adjustment of the gravel bed.

WAVERLY, IND.

Throughout the rest of Marion County and Johnson County the river is very sluggish. No development of power seems feasible in this part of the stream. An abrupt fall of one foot occurs at Waverly, in Morgan County, over the remains of an old mill dam. A woolen mill formerly used the power from the river at this point. The old timber dam is now in decay. By the construction of a new dam, a head of fifteen feet could be procured here. This river is narrow and the banks are comparatively high.

Throughout Morgan County the river is flowing on the Knobstone formation. Exposures of rock in the bed of the stream are numerous in the eastern and central parts of the county. These exposures make good foundations for dams, but the rock is of no use in dam construction. It is comparatively soft sandstone and shale.

HIGHROCK.

Highrock is located three miles northwest of Martinsville. An abrupt bluff of Knobstone sandstone forms the west bank of the river here. A carding mill formerly used power from the river at this point, and the remains of the old dam still cause an abrupt fall of 1.52 feet. The dam is on a foundation of Knobstone. This is an excellent location for a power site. At least fifteen feet head could be procured, and the bluff on the west makes an ideal location for a plant. The convenience of this site to Martinsville makes it an extremely desirable location. It is within three-fourths of a mile of the Martinsville Traction line.

SPENCER, INDIANA.

The West Fork of White River is very crooked and sluggish between Martinsville and Gosport. The development of any power in this part of the river does not seem feasible. After passing Gosport the river becomes swifter. An abrupt rocky ripple occurs one-fourth of a mile above the highway bridge at Spencer. This ripple is forty rods in length and in this distance has a fall of 2.25 feet. The entire bed of the stream is on Harrodsburg limestone, which also forms the south bank of the stream. The north bank is a deposit of alluvium. The river banks are high. Sixteen or seventeen feet head could be procured at this point. A dam of this height would injure but little land. The back water would extend about eleven miles. This is one of the best power sites on the West Fork of White River. Indianapolis is about fifty-five miles, Terre Haute about forty miles, and Brazil about thirty-five miles from this site. These are the most convenient markets for power.

This branch of the river is very sluggish and crooked after it leaves the Mitchell limestone, a short distance below Spencer. The banks are low and the valley wide. Few rock exposures occur and the conditions for water power development are very poor. The only point at which any development seems feasable is at Aprow.

APROW, INDIANA.

Aprow is the local name for a point on the West Fork of White River, four miles northeast of Wheatland, and four miles southeast of Bicknell. There is no town here, and the name will not appear on any map. At this point the river flows against the west bluff, and exposes shale and coal, which form the bed and west bank of the stream. On this exposure the fall is sharp and the stream rapid. The east bank is twelve feet high. A line of levels over the fall for half a mile showed 4.6 feet fall. The fall above and below this point is very slight, estimated at .66 foot per mile. The river valley is between a mile and a mile and a half wide on this part of the river. The land is very valuable farm land. Because of the low banks and the value of the land a head of ten feet is all that can be procured at this point. The discharge at Aprow is about equal to that of Shoals, on the East Fork, or probably somewhat greater. From 400 to 1,000 horse power could be procured at this point, except in the lowest and highest stages of the river. The cost of developing this power would not be great. The river is about 300 feet wide, the banks are abrupt and the bed rocky. Washington and Vincennes are convenient markets for this power.

Below Aprow the river again becomes sluggish and no power could be profitably developed between Aprow and the junction with the East Fork.

MAIN BRANCH OF WHITE RIVER.

The fall on the Main Branch of White River from the junction of the two forks to its mouth at Mt. Carmel, Illinois, is but 24 feet. The distance is approximately fifty miles by the river. An exposure of rock occurs in the river bed three miles above the mouth. This place is known as Kelley's Ripple. The fall on this ripple within .25 mile is 1.4 feet. The banks here are fourteen feet high. During flood periods the river overflows both banks. Both banks are alluvium. The valley is very wide. This is the only point on the Main Branch of White River where a development of power is feasible. If a head of ten or twelve feet could be procured at this point, the volume of water, as calculated from the Shoals data, is sufficient to produce a minimum of about 500 horse power. For the most of the year 2,000 to 3,000 horse power could be procured. Evansville and Vincennes are convenient markets for this power.

WABASH RIVER SYSTEM.

No investigation was made of the Wabash River System except of two small power sites on Sugar Creek. Sugar Creek is a small stream which rises in Clinton and Boone counties, flows in a general southwesterly direction through Montgomery and Parke counties and empties into the Wabash River, four miles southeast of Newport. This stream drains an area of about 1,000 square miles. It is a very rapid stream and abundant power is available when there is sufficient water. No investigation of the discharge of this stream has been made, except one current reading, which was made September 27, 1909. This reading was taken at Shades of Death, five miles northwest of Waveland, Montgomery County. The stream was not at low water mark. Discharge measurements: September

27, 1909, Hydrographer, W. M. Tucker; width, 74 feet; area of cross section, 105.9 sq. ft.; discharge, 273.5 cu. ft.

The valley of Sugar Creek is narrow and little bottom land occurs. At Pleasant View, which is three miles below Shades of Death, the river is only 500 feet wide. The bed of the stream is in the Knobstone formation and the bluffs are capped by Harrodsburg limestone. A dam could be constructed 20 feet high at this point. This would pond the water past the Shades of Death and would produce an excellent boating pond for the hundreds of people who visit the Shades every summer. It is probable that the discharge at Pleasant View seldom falls below 100 cu. ft. per second. This discharge on 20 feet fall would produce 182 horse power. The cost of developing this power would be small. The power could be used on the pleasure grounds at Shades of Death, and the convenience and amusement furnished thereby would greatly increase the number of visitors at this already popular pleasure resort.

The other site visited on this stream is the Narrows, on the farm of John Lusk, Sec. 26, T. 17 N, R. 7 W. A flour mill was formerly operated on this site. The river banks at this point are of solid Mansfield sandstone, twenty-five feet high. They are abrupt and but eighty feet apart. From the top of the banks the slopes rise abruptly to a height of 150 feet. This is an ideal site for a dam. A concrete dam properly constructed between the sandstone cliffs would be almost as solid as the cliffs themselves. The conditions for locating a power house are also ideal. It is probable that a minimum of 250 horse power could be produced at this point. The up-stream conditions are not known.

GAGES FROM WHICH NO DATA HAS BEEN RECEIVED.

During the summer of 1910, gages, of which the descriptions and locations follow, were established.

On July 6, 7 and 8 a direct reading gage was established on the Mississinnewa River at Peoria, five miles southeast of Peru, Indiana. This gage is made of heavy white oak bridge planks. It s securely spiked to the root of a small tree and to two white oak posts. The gage is placed with the slant of the river bank, which is about thirty degrees. The scale is made of brass headed tacks on the up-stream side of the gage. This gage is located two hundred yards down stream from the mill of H. F. Whisler. The gage is read each day by Mr. H. F. Whisler, Peru, Ind., R. F. D. No. 11.

On July 11 and 12 a chain gage was established on the St. Joseph River at South Bend, Ind. This gage is located on the up-stream handrail of the south span of the Leaper bridge which crosses the St. Joseph River on North Michigan Street. This gage was read daily by J. W. Fisher, 601 N. Cushing St., South Bend, Indiana. The chain of this gage was stolen late in October and has not been replaced.

On July 14 and 15 a chain gage was established on Eel River at Logansport, Indiana. The gage is located on the down-stream hand-rail of the south span of the Third Street bridge, which crosses Eel River on Third Street. This gage is read daily by Henry J. Kruck, Logansport, Indiana.

On July 16 and 18, a chain gage was established on the Wabash River at Logansport, Indiana. This gage is located on the down-stream handrail of the south span of the Cicott Street bridge, which crosses the Wabash River on Cicott Street. This gage is read daily by William Sehrt, Logansport, Indiana, R. F. D. No. 6.

On July 19, the Imler Bridge, which crosses the Tippecanoe River five miles west of Delphi, Indiana, was visited with the view of establishing a gage thereon. A gage which belongs to the United States Geological Survey was already located on this bridge. It is not now in use. If the work on water power is continued in Indiana arrangements can be made to continue this station by corresponding with District Engineer A. H. Horton, Federal Building, Newport, Kentucky.

On July 21 and 22, the Wabash River at Terre Haute was investigated with the view of establishing a gage at that point. It was found, however, that the Terre Haute Waterworks Company had maintained a gage on the river at this point since June 1, 1901. In case the work on waterpower were continued in the State the data would be of value. Mr. Taylor, Chief Engineer of the Terre Haute Waterworks Company, has kindly offered this data for the use of the State.

A current reading was taken at each of the above stations. The results of these readings are of no value in this report, because no gage readings have been received or rating tables made for these stations, but they will be of value if the problem is continued. The data can be found in the writer's field book in the office of the State Geologist, at Indianapolis.