An Investigation

of the

Rocky Ford Water Power.

by

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Contents.

Introduction.

The rapids known as Rocky Ford are situated on the Big Blue River, four miles, north of Manhattan. A portion of the power had, before the advent of railroads, been used to run a grist and saw-mill. The old mill-building still stands in good condition; but the dam, which was a frame structure, became dilapidated thru lack of attention, and was carried away by a freshet, several years since.

In an investigation of a water-power the first point to consider is the use to which the power is to be applied — in this case the requirements of a central power station. To furnish both light and power a twenty-four-hour plant would be necessary making a water storage impossible, and duplicate machinery a necessity. For light only the plant would need to be in operation but twelve or fifteen hours making a water storage possible.

In 1898, Mr. M. W. Sanderson, B. Sc. investigated this power with regard to irrigation; and having had no opportunity to consult his work, I do not know; but this may, in part, be a repetition.

A. Determination of Power.

1. Natural Fall.

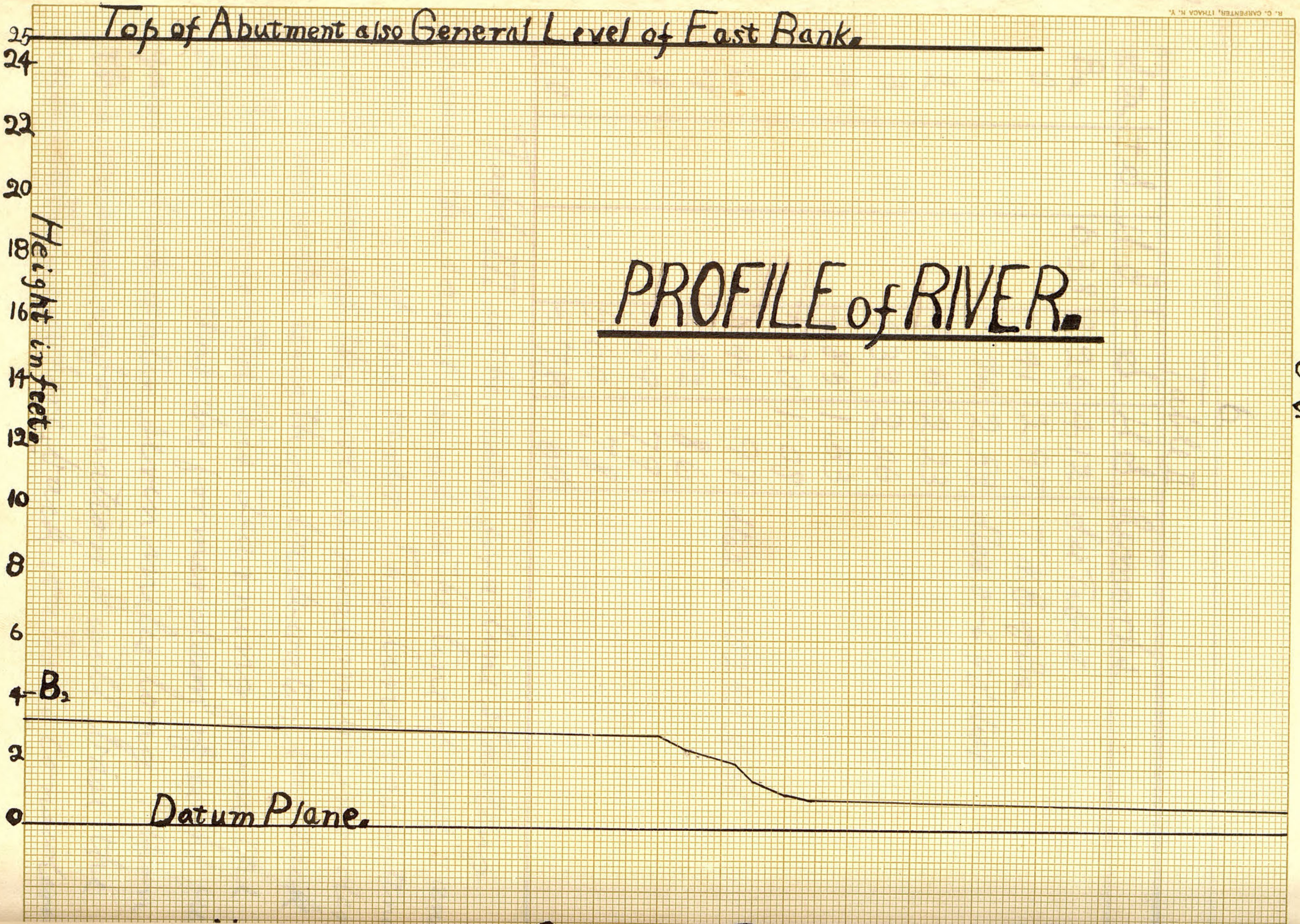
A line of levels was run along the East bank of the river, which at this point runs almost due North and South. The following field notes taken at the time and the accompanying field data plotted upon squared paper, which shows graphically the profile of the rapids, indicate a fall of two feet in three hundred — the total natural fall at the rapids.

Field Notes. Table I is the notes for a line of levels between bench on abutment and bench on portion of the old dam which is still in place at the East bank.

Table I

Sta.	+S.	H. I.	−S.	H. S.	Remarks.
B_1	1.995	26.995		25	X on S. stone, top course, W. abutment.
0			1.995	25	same as B.
1 t.p.	.846	15.904	11.937	15.058	
2 t.p.	2.411	6.379	11.936	3.968	
B_2			2.264	4.115	X at inter. of timbers W. end of old dam E. bank of river.

Table II is the notes for a line starting at the old dam and running down the river 1300 feet.


Top of Abutment also General Level of East Bank.
PROFILE of RIVER.
Height in feet.
25
24
22
20
18
16
14
12
10
8
6
4
2
0
B2
Datum Plane.

6a.

Table II

Sta.	+S.	H. I.	−S.	H. S.	Remarks
B_2		6.38	2.26	4.12	See Table I.
0			3.41	2.97	17' N.E. of B_2.
1			3.75	2.53	Stas. 0–6. 50' dist.
2			4.15	2.23	
3			4.32	2.06	
4			4.85	1.53	
5			5.30	1.08	
6			5.41	.97	Stas. 6–10 250' dist.
7			5.52	.86	
8			5.59	.79	
9			5.60	.78	
10			5.78	.60	

Table III is the notes for a line starting from the same point as the line of Table II and running up the river. This line was intended to run up the river several miles in order to obtain the length of back-water, but lack of time prevented this. Learning from the old miller that the former dam of eight feet gave a back-water seven miles long. Upon this meagre information I will base the calculations where back-water is considered.

Table III

Sta.	+S.	H. I.	−S.	H. S.	Remarks
B_2	4.066	8.181		4.115	Same as in Table II.
0			5.22	2.96	" " " " .
1			5.18	3.00	
2			5.14	3.04	
3			5.09	3.09	
4			4.99	3.19	
5			4.89	3.29	

2. Artificial Fall — Dam.

From the preceding a natural available fall of two feet is indicated. This of itself is of small value unless augmented by an artificial fall produced by a dam. This brings us to the style of dam suitable for this particular location. The bed of the river is an ideal one for a dam, being of solid rock. A masonry dam could be built cheaply, there being excellent stone-quarries conveniently located. Upon inquiry I found that at times of high water the river rose to within a foot or so of the top of the East bank shown on Profile Diagram. This being the case a stationary dam of sufficient height would be likely to inundate the surrounding country during a freshet. Hence the only solution would be a flash-board dam or better still one similar to the "Davis Island Dam" on the Ohio River, which is composed of wickets, hinged at the bottom, that can be lowered whenever a freshet occurs.

A dam of the latter type with a three foot foundation and twelve foot wickets operated either by hydraulic means or from an upstream pier or boat could be worked satisfactorily. The cost of such a dam is rather a matter of conjecture as there are few of this style built in the United States; but upon estimating roughly the cost of materials, I would say that the dam would not cost over five thousand dollars. It would ordinarily give an available head or fall of fifteen feet.

3. Minimum Flow.

All the data for this topic was obtained from the U.S. Geological Survey. A river station was established by the Survey at the county bridge about one-half mile below the rapids, April 12, 1895. Since then with a slight exception, continuous gage readings have been taken and also occasional discharge measurements have been made with a meter. From fifteen discharge measurements made in 1895 and 1896, a rating curve in terms of the gage height and the discharge in second-feet was established. A table made from it is found in Part IV of the Eighteenth Annual Report of the U.S. Geological Survey, on page 217. (See Table IV). The gage measurements are given in Water Supply and Irrigation Papers, Nos. Eleven and Sixteen; and in Bulletin, One Hundred Forty. The lowest gage reading given is two and three-tenths feet on September 13-14, 1897. Upon referring this to the rating table, a discharge of two hundred sixty-two cubic feet per second is indicated. This falling fifteen feet would give a total of four hundred fifty horse power, for a twenty-four-hour plant. For a lighting plant, running twelve hours twelve feet head could be used on the turbine and the remaining three feet as a reservoir to store water when the

Table IV.

Rating Table for the Blue River at Manhattan, Ks.

(From measurements between April 12, 1895 – Dec 31, 1896)

G. H. (Feet)	Dis. (Sec. ft.)	G. H.	Dis.	G. H.	Dis.	G. H.	Dis.	G. H.	Dis.
2.00	2.14	4.00	662	6.00	1508	8.00	26.98	10.00	4268
2.10	229	4.10	692	6.10	1561	8.10	27.67	10.10	4357
2.20	245	4.20	724	6.20	1615	8.20	2837	10.20	4447
2.30	262	4.30	758	6.30	1670	8.30	2908	10.30	4538
2.40	280	4.40	793	6.40	1725	8.40	2980	10.40	4630
2.50	299	4.50	830	6.50	1775	8.50	3053	10.50	4724
2.60	320	4.60	868	6.60	1825	8.60	3127	10.60	4820
2.70	341	4.70	907	6.70	1881	8.70	3202	10.70	4918
2.80	363	4.80	946	6.80	1938	8.80	3278	10.80	5019
2.90	385	4.90	986	6.90	1996	8.90	3355	10.90	5122
3.00	408	5.00	1028	7.00	2055	9.00	3433	10.00	5228
3.10	431	5.10	1071	7.10	2115	9.10	3512	11.10	5337
3.20	454	5.20	1115	7.20	2176	9.20	3592	11.20	5449
3.30	478	5.30	1161	7.30	2238	9.30	3673	11.30	5565
3.40	502	5.40	1208	7.40	2301	9.40	3755	11.40	5685
3.50	527	5.50	1255	7.50	2365	9.50	3838	11.50	5809
3.60	552	5.60	1303	7.60	2430	9.60	3922	11.60	5937
3.70	578	5.70	1353	7.70	2496	9.70	4007	11.70	6069
3.80	605	5.80	1404	7.80	2563	9.80	4093	11.80	6205
3.90	633	5.90	1456	7.90	2630	9.90	4180	11.90	6345
								12.00	6485

 728.

turbines are idle. The channel is two-hundred fifty feet or more wide and a back water of seven miles (probably too small), and three feet deep at the dam, would store considerably more than the amount required to furnish an additional two hundred sixty-two cubic feet per second. This would give at minimum flow and twelve feet head nearly seven hundred horse power.

4. The Amount Available for Consumption At Manhattan.

This depends upon the efficiency of the various means for transforming and transmitting the energy of the falling water. The first transforming is thru the turbine. Kent in his "Mechanical Engineers' Pocketbook" gives an average efficiency of seventy-five percent for turbines. For dynamos ninety five per cent is a common efficiency, and for wiring, transformers, etc about ninety per cent. Making a general efficiency of sixty-four per cent available at Manhattan. Making an output of three hundred horse power for a twenty-four hour plant, or four hundred fifty horse-power for a twelve hour plant.

B. Relative Economy as Compared with Similar Steam Plant.

1. Cost to Establish and Operate.

First cost, twenty-four hour water plant:

Dam	$5000
Enlarging and Repairing Race and Building.	2000
Four, 100 H. P. Turbines	4500
Four, 100 H. P. Dynamos	6000
Extra Wiring, Transformers, etc.	2500
Total for four hundred horse power	20,000

This gives a cost of $50 per horse power.

A steam-plant can be built for $40 per ~~horse~~ power.

The fixed charges or operative cost of the water plant, would be:

Depreciation, Interest, Repairs, etc @ 11%	$2200
Attendance (Five men at an average wage of $1.250 for 333 full 24-hour days)	4162
Total for an output of 300 H. P.	6362

or $21.21 per H. P. per year.

The fixed charges on a similar steam plant, would be:

Depreciation, Interest, etc. @ 14%	$2240
Coal at 3# per H.P. per hour, for 333 days of 24 hours each; 3500 short tons @ $2.75	9625
Attendance, seven @ $2.00, $14 per day, 333 ds.	4662
Total for output of 300 H.P.	$16527

or $55.09 per H.P. per year.

Twelve hour plant:—

First cost of water plant:—

Dam	$5000
Repairs on Race and Building	2500
Two, 250 H.P. Turbines	4000
Two 225 H.P. Dynamos	4000
Wiring, Transformers, etc.	2500
Total for 450 H.P.	$18000

This gives $40 per H.P.; same as for steam plant.

The fixed charges for water plant would be:—

Depreciation, etc. @ 11%	$1980
Attendance, four @ $2.50; 365 days	3650
Total for output of 450 H.P.	$5630

or $12.51 per H.P. per year.

The fixed charges for the steam plant would be:

Depreciation, etc. @ 13%	$2340
Coal, 3000 short tons @ $2.75	8250
Attendance 4 @ $2.00, 365 days.	2920
Total for 450 H.P.	$13510

or $30.02 per H.P. per year.

2. Relative Economy.

As is shown above the first cost to establish a water power upon the site of the old mill is practically the same as for an entire steam plant. However in the matter of operation there is a very wide margin in favor of the water power, but this could be reduced by the use of economizers, heaters stokers, etc.

So far there appears to be a considerable advantage in favor of the water power, but there are certain obstacles which for a central light and power station would be next to insurmountable.

In time of high water the back water in the tail race would occasion great inconvenience and reduce the available head.

And in cases of extreme high water a shut down would be necessary until the water subsided.

A minor disadvantage that might be mentioned which may in time disappear is the absence of any demand for the entire output, and the erection of a plant to supply the present demand — less than one hundred horse power — would be out of the question.

In the future, the development of this power may become practicable, when coal or other fuel becomes scarce enough to prohibit its use as a source of power, and when the demand for power and light becomes great enough to utilize the maximum output.

Finis.

Authorities.

The following are the works and references from which I have gathered information in writing this thesis:

Bulletin No. 140; U. S. Geological Survey.
Eighteenth Annual Report, Part IV; U. S. Geol. Sur.
Kent; Mechanical Engineers' Pocket-Book.
Scientific American Supplement, No , Vol. .
Transactions Am. Soc. Mech. Engs., Vols. 17 & 19.
Water Supply and Irrigation Papers
Nos. 1 & 16; U. S. Geol. Survey.