Note on Medway Discharges
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Report on Examination of Medway Water, October, 1909—May, 1910.

By A. N. FITZGERALD.

The samples were taken by Mr. Randall Mercer's gardener at the boathouse above Allington lock by means of a long ladle dipped below the surface. As explained by Dr. Strahan (p. 311, March, 1908), observations on water-level and flow of stream are useless in the case of the canalized Medway, and are therefore omitted from the following table of results, which will have to be considered later in conjunction with Mr. Mackenzie's work on the 'Medway Discharges.'

Table of Results.

Date.	Time.	Remarks.	Solids in parts per 100,000.		
			Suspended.	Dissolved.	Total.
October 16, 1909	12.40 p.m.	—	3·5	26·9	30·4
„ 23, „	12.30 p.m.	—	5·3	26·35	31·65
„ 28, „	12 noon	Flood	5·65	20·9	26·55
November 13, „	12.15 p.m.	—	0·7	27·1	27·8
„ 27, „	11.50 a.m.	—	3·3	29·1	32·4
December 10, „	4 p.m.	—	1·0	25·7	26·7
„ 23, „	2.15 p.m.	Flood	13·02	21·73	34·75
January 8, 1910	12 noon.	—	0·4	27·5	27·9
„ 22, „	3.15 p.m.	—	0·9	21·9	22·8
February 5, „	12 noon	—	6·6	26·25	32·85
„ 19, „	12 noon	—	8·9	28·5	37·4
March 4, „	7.30 a.m.	—	0·7	22·6	23·3
„ 19, „	12.15 p.m.	—	3·1	26·1	29·2
April 16, „	12.15 p.m.	—	5·9	24·4	30·3
May 21, „	11 a.m.	—	14·1	19·3	33·4

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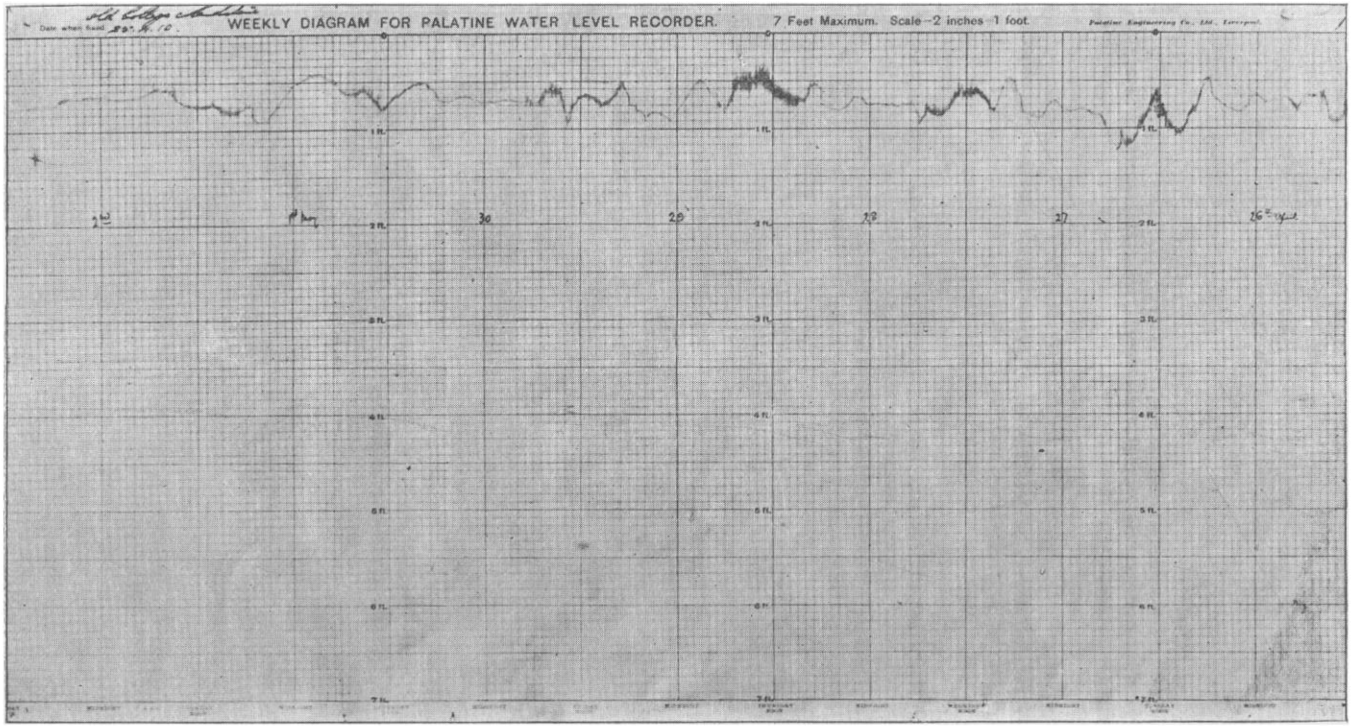
NOTE ON MEDWAY DISCHARGES.

By N. F. MACKENZIE.

In my last report I mentioned that the coefficient of rugosity for the Medway still remained to be determined; and in April last I measured the necessary discharges, accompanied by Dr. Owens. We were favoured with exceptionally calm weather. and were able to get satisfactory data during the two days we spent on the river. Working out the three discharges we measured, I find that the coefficient comes to 0·030 as closely as possible, so closely that a difference of $\frac{1}{60}$ inch in the surface slope would account for the difference between the measured discharges and those calculated with a coefficient of 0·030. This value of the coefficient is the one I mentioned in my last report as probably applicable to the Medway. Our discharges were measured with a low surface slope, and on examining some 2500 pairs of gauge readings I find that 75 per cent of the readings give surface slopes of less than 1 inch in 2 miles, and 4 per cent. only give slopes of 6 inches and over. Our discharges, therefore, were measured in what may be called the normal stage of the river.

Based on this coefficient I have worked out a table of final results for all gauges up to $4\frac{1}{4}$ feet advancing by inches, and for all slopes up to 4 feet advancing by

WATER LEVEL RECORD: OLD COLLEGE GAUGE. SCALE: $\frac{1}{4}$ FULL SIZE.



eighths of an inch, a somewhat extensive table containing about 17,000 discharges. From the table I have recorded in a book the daily discharge of the Medway for all periods during which we have gauge records, each daily discharge being the average of eight separate discharges at three-hour intervals. We have had many difficulties to contend with, and as there are gaps in the record, it is well to explain why these gaps occur.

The diagram is an original record of water-level taken from the self-recording gauge. The curve of the water surface is by no means a clean-cut line, at various points there are marked oscillations. The float which works the recording pencil is placed in a well 18 inches in diameter and the well is connected to the river by a 2-inch pipe,so that any surface wave action would be throttled and would not effect the water-level in the well. The cause of the oscillation on the record was one of the points noted for investigation by Dr. Owens and myself. We found that the period of surface wind waves in the river exactly synchronized with the oscillations in the well, and when the river was dead calm, the water-level curve was a clean-cut line. It appeared, therefore, that there must be an open communication between the river and the well, and on inquiry from the contractor who erected the gauge this opinion was confirmed. He was not aware that a tight joint between the well and the river was necessary, and the connecting pipe was laid in rammed earth which had been washed away. To check the conclusion we had come to, we made artificial waves in the river with a piece of planking, and found that these waves were immediately reproduced on the gauge record. We have no doubt that the oscillations on the gauge record are due to surface wind waves.

This conclusion would be merely interesting but for the fact that these wave oscillations affect our gauge readings. It not unfrequently happens that after correction for difference of level of gauge zeros, the downstream gauge reads higher than the upstream gauge, *i.e.* the river apparently flows upstream. An obvious explanation of this phenomenon at once suggests itself, viz. that there is a mistake in the levels of the gauge zeros. I had levelled the gauge zeros three times over last year with results which were practically identical, leaving a possible error of one-eighth inch in 2 miles. To check my levels I did the work a fourth time, and the result exactly confirmed my levels of last year. There is therefore no error in the levelling beyond the possible error of one-eighth inch, which cannot be eliminated.

This reverse surface slope appears under two different sets of conditions. When the river is low, very nearly a still water channel, the reverse slope is always accompanied by oscillations on the gauge record due to wind; and in these conditions the reverse slope occasionally lasts for many hours until the wind drops; on one occasion it lasted for twenty-four hours, but that was quite exceptional, and during the whole of the period the lower gauge record shows oscillations of about 3 inches, while the upper gauge was in shelter, and its record is a clean-cut line. The reverse slope appears very occasionally during moderate floods, and is not necessarily accompanied by oscillations on the records; it may and does occur during a dead calm. In such cases it never lasts any length of time, and is probably caused by the sudden closing of some of the sluices at Allington lock, which is some 3 furlongs below our downstream gauge.

The difficulty connected with these reverse slopes is in determining the discharge of the river when they occur. Notwithstanding the apparent upstream flow of the river, there must be some water passing downstream, and I confess I see no practical method of arriving at the discharge. In computing the discharge records, I have omitted the periods when the lower gauge read higher than the upstream gauge. In an extended series of gauge-readings, the upper gauge will sometimes read too high, though this cannot be proved from the records; and I fancy that in the long run the excess readings on the upper and on the lower gauges will balance each other. It will be possible to eliminate the wind action by making a very small connection between the river and the gauge well, and this will be done. I need not enter into details of the work.

From September, 1908, to August, 1909, the gauges worked very well, and, except for an occasional gap due to reverse slope, we have a continuous record of discharges, extending over one year. In September, 1909, the clocks began to give serious trouble, and one or other was continually breaking down. We have had a broken hairspring, a broken mainspring, a broken pivot in the reducing gear, numerous minor troubles, and finally a very high flood which submerged one of the clocks and rendered it useless until cleaned and repaired. An important defect in the self-recording gauges is that when the apparatus has to be dismantled for repairs, there is no means of resetting the pencil so that it records at the same level as before; the makers have recently introduced an improvement which gets over this difficulty. With our gauges it means that each time the apparatus is altered, its new zero has to be connected with the water surface by levelling from bench-marks close to the gauge sites. As a consequence of the various mishaps, we have no reliable records from September, 1909, to the beginning of April, 1910. From the latter date our record begins again.

The Medway, by reason of its small surface slope, is an exceedingly difficult river to measure with the methods of gauging at our disposal. These methods are expensive, and with all possible care, there remain so many indeterminate factors which affect the discharge that our results are subject to a considerable percentage of error. I think, therefore, we should in future avoid a canalized river, and that the next serious breakdown of the gauging apparatus would be a suitable time to close our observations on the Medway. This sounds rather like a confession of failure, but the methods of gauging the river are governed by financial considerations, and, with the funds at our disposal, we were tied down to the surface slope method, which, I admit, has not been so successful as I had hoped, though we have got a useful series of discharges.

The best way to gauge a canalized river is by calculating the discharge passing through the locks. Given the width of the sluices, the height to which they are opened, and the head, we can calculate the volume passing through the openings. On the Medway this would mean an establishment constantly on the spot to keep a continuous record of alterations in the area of the sluice-openings and of the level of the water upstream. I ascertained that this could not possibly be done by the existing lock establishment, and to employ the establishment necessary for such records was beyond our means. I mention this method as the one which should be adopted if we *must* deal with a canalized river in future.

THE SEVERN.

In the Report of last year reference is made to the gaugings of the Severn which were placed at the disposal of the Committee by the late Dr. G. F. Deacon. These have been copied in the form of discharge-curves, covering the period November, 1881, to December, 1889. Owing to the large scale used in the original, the length of the single curve for the period mentioned is 140 feet, and, in order to bring it within manageable limits the curve has been redrawn by Dr. Owens, with the horizontal scale reduced to one-fifth, and the vertical scale to one-half.

Dr. Owens proposes further to draw a synchronous rainfall-curve alongside