THE EFFECT OF THE COLombo FLOOD SCHEMES ON UNPROTECTED AREAS:

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1.—General.

As is well known, two large and valuable areas in Colombo North and Colombo South, have recently been protected from periodical floods by means of a bunding system, which prevents water from the Kelani River from entering the areas.

Previous to Mr. Harward’s Schemes a number of suggestions had been made, all with the object of protecting these low-lying areas from floods. Some of these schemes were sound in principle, but chiefly owing to the absence of a proper contour survey, the simple expedient of blocking the Kolonnawa and Dematagoda Gaps had not been discovered.

The blocking of these gaps, the provision of a lock at Dematagoda and the clearing of a canal between Kolonnawa and Dematagoda was the work Mr. Harward first carried out, and the Colombo South Scheme was thereby completed in May 1925. Subsequently work on the Colombo North Scheme was commenced. This consisted of blocking a few openings in the Railway Embankment which runs from the high ground near Wellampitiya to the ridge at Madampitiya, and, in order to improve the drainage of the Colombo North area, it was decided to drive a tunnel through the ridge between the Bloemendali Swamp and the Fishery Harbour. The tunnel has recently been completed, and owing to the action of self-closing gates at the outfall, it has been found possible to drain the out-time
Bloemendaal, 'swamp' to nearly one foot below mean sea level. This desirable result has only been obtainable because the tunnel outlet is situated in one of the few spots on the Ceylon Coast where a sandbar does not form. (See Diagrams, I and II Colonbo North and South Schemes).

The benefits of these two schemes have never been denied, and the fortunate landowners in the protected areas have had literally lakhs of rupees presented to them in the increased value of their lands. These benefits have been conferred entirely free of charge, possibly because Government felt the necessity of demonstrating the great advantages of flood protection, and it is quite understandable that landowners in the unprotected areas should feel somewhat aggrieved that they too cannot share in the bounty.

2. —Effects on Unprotected Areas.

When Mr. Harward was preparing his schemes he at once realised the possibility that by excluding Kelani water from the Colombo South and North areas, the conditions in the unprotected areas might be altered, and to the writer's personal knowledge Mr. Harward spent a great deal of time studying this question. As the result of his calculations Mr. Harward came to the conclusion that under the very worst conditions he could imagine the effect of the Colombo South Scheme would be to increase the depth of a maximum flood outside the protected area by one foot three inches. (vide Sessional Paper XVI—1923 page 6).

It must be clearly understood that this increased depth of one foot three inches would only apply to an abnormally severe flood such as that of 1913. In ordinary major and minor floods the effect would be less, and in certain circumstances (as Mr. Harward has pointed out in Sessional Paper XXIX—1923, para 3) it would have been possible for the flooding in unprotected areas to have been worse under Pre-Flood Scheme conditions than under the present conditions.

In spite of this warning, published in 1923, and available to everybody concerned, the Schemes were sanctioned, and carried out under Mr. Harward's personal supervision.
3. The Problem.

Since the completion of the Schemes several floods of considerable magnitude have occurred, and the question naturally arises as to whether it is not possible to ascertain from the records of these floods the actual effect of the Schemes on the height and duration of floods in the unprotected areas; and it is the purpose of these notes to throw as much light as possible on the problem.

In Sessional Paper XXX. of 1926 Mr. Hatward dealt fully with the limitations of the information obtainable by comparing Pre-Flood Scheme floods with recent floods, and in fact the only way in which a real comparison could be made would be to compare the average depths of floods over a period of, say, thirty years before the Schemes with the average depths of floods over a period of thirty years after the Schemes. Even that would not be conclusive, because no one could be certain that climatic conditions had not altered, that the run-off had not increased owing to jungle clearing in the catchment, and that changes had not taken place in the river bed. The occurrence of one, or even a series of high floods subsequent to the Schemes would be in itself no indication whatever that the Schemes were a contributory cause of the high floods, and we are compelled to fall back on calculation alone as being the only available means of arriving at a solution of the problem.

4. What the Problem Really Amounts to.

If the floods in the unprotected areas are deeper than they were before the Schemes were completed, it follows that more water must now be compelled to flow in the "flood channel" than would have flowed in an exactly similar flood under Pre-Flood Scheme conditions. If it is possible to find out how much more water has to flow through, say, Victoria Bridge, it can be estimated with fair c"
accuracy, how much deeper this, or that particular flood would be than Victoria Bridge. There is a definite relation between river height and discharge, this relation being shown by a discharge curve prepared by Robert Skelton, late Municipal Engineer of Colombo. How accurate this curve is the writer is not prepared to say, but it is certainly approximately correct. (Diagram III).

Having once ascertained by how much the level of floods has increased at Victoria Bridge, it will be shown later how it is possible to calculate with reasonable accuracy the increase in depth over the unprotected area for some distance up the river. The problem is therefore reduced to the question as to whether the discharge through Victoria Bridge, or more correctly, the discharge in that portion of the river "flood channel" from Kolonnawa to the sea has been increased, and if so by how much.

5.—What was the Flood Flow Under Pre-Flood Scheme Conditions?

A. It is not necessary to discuss the actual flow conditions, and their variations, which were rather complicated. All that is required is a clear grasp of the main sequence of events, which were as follows:

1. During the rising period of a Flood.—While the bulk of the water flowed in the river channel and over the Ambatalen fields to the river mouth, a certain portion flowed through the Kolonnawa Gap and Dematagoda Ela into the Colombo South and North reservoirs, where it remained stored. At the same time a certain quantity of this water escaped to the sea via the Kulutara Canal and the Wellawatte and Dehiwala outlets, this flow naturally increasing with the increasing depth of water in the Colombo South "reservoir."

2. During the falling period of a Flood.—As soon as the peak of the flood had passed, and the river level commenced to fall, the stored water in the Colombo North and South reservoirs began to flow back again into the river, this flow continuing till the flood had subsided altogether. At the same time water still flowed out to the sea via
the Kakul, the volume of the flow decreasing as the depth of water on the reservoirs decreased.

2. Two other Flows.—Two more conditions must be noticed, and these are as follows:

1. As soon as the Colombo South reservoir had a depth of about six feet, the flow entering this reservoir via the Dematagoda Gap reversed and therefore during the higher stages of a major flood a certain flow took place from the river through the Kolonnawa Gap, across the northern part of Colombo South, through the Dematagoda Gap, and across Colombo North to the river again just above Victoria Bridge.

2. Water also flowed through the Uragoda-Watte Bridge, across Colombo North, returning to the river above Victoria Bridge. (This bridge is marked B in Diagram II).

Recapitulating, the four main flows were:

(a) A flow into the reservoirs during the rising period of a flood and a flow out of the reservoirs during the fall of the flood.

(b) A continual flow to the sea via the Wellawatte and Dehiwala Outlets.

(c) During the higher stages of a flood a flow out of the river at Kolonnawa, and back to the river again just above Victoria Bridge.

(d) A continual flow through the Urugoda-Watte Bridge.

6.—What are the conditions of flow now?

Simply that the four separate flows a, b, c, and d of the preceding paragraph have been stopped; all the flood water now being confined to the main flood channel, and passing through the Victoria Bridge, (Note.—Bridge A has also been blocked, but it will be shown later that the flow through this bridge was negligible).
the Flows under Pre-Flood Scheme conditions be calculated?

Flow (a).—This can be done by means of a combined capacity curve of the Colombo North and South reservoirs. (Diagram IV). Suppose that on one day the level in the reservoir was +5.00. From the curve it is seen that at this level the capacity of the reservoir was 12,000 acre-feet. Assume that on the following day the level had risen to +6.00. The capacity at this level is 16,000 acre-feet. Hence the volume of water which flowed into the reservoir during the 24 hours is 4,000 acre-feet, which means an average flow of 2,000 cusecs (one cusec will fill 1 acre-foot in 24 hours).

Flow (b).—This necessitates the construction of a combined discharge curve (Diagram V) the discharge varying from nothing at about +2.00, below which sandbars form, to a maximum of about 7,000 cusecs at +13.50 in a flood such as that of 1913. (Mr. Harward said 8,000 cusecs).

Flows (c) & (d).—In para 9 of Sessional Paper XII of 1924, Mr. Harward describes what would have happened in the Colombo North area in the event of a big flood under Pre-Flood Scheme conditions, and he shows that the level of the water in this area would have continued to rise to such a level that the discharge through bridges C and D became equal to the flow into the area through bridges A and B, plus the Dematagoda flow.

It is possible to calculate with fair accuracy that the level in Colombo North during a flood similar to that of 1913 would have risen to 12' 3", at which level the flow through the Urugottawatte Bridge B would have been about 7,500 cusecs. Owing to the presence of the Railway Embankment opposite the Dematagoda Gap, and to the flow through the Gap, it can be shown that the level on either side of Bridge A would have been about 12' 6", and in consequence there would have been little or no flow through this bridge at all. The level in Colombo South being 13' 6", there might have been as much as one foot difference of head on either side of the 50' span bridge at Dematagoda, the calculated discharge for this head being 4,500 cusecs (Mr. Harward speaks of a "strong" flow in a northerly direction.).
In normal minor floods, that is to say floods which have not yet topped the lower Avisawella Road, flows (c) and (d) would have been negligible. The lower Avisawella Road begins to be topped when the level at Victoria Bridge is about six feet, and it is therefore possible to say that under normal conditions flow (c) would have varied from nothing, in a six-feet flood, to a maximum of about 4,500 cusecs, and flow (d) would have varied from nothing at six feet to a maximum of about 7,500 cusecs in a flood such as that of 1913. An approximate discharge curve for flow (c) is shown in Diagram VI.

3. Effects of the Schemes at Victoria Bridge.

Confining the investigation for the moment to the levels at Victoria Bridge, it is clear that although flows (c) and (d) left the river above the bridge, they both rejoined the river again above the bridge; therefore the diversion of these flows into the main flood channel can have had no effect at Victoria Bridge. Only flows (a) and (b) have to be taken into account.

Having ascertained the values of flows (a) and (b) on any particular day, the amount by which the flow through Victoria Bridge has been altered on that day can at once be calculated. (Table I). By doing this for every day of a flood it is possible to plot a curve which will indicate what this particular flood would have been under Pre-Flood Scheme conditions, and by comparing this curve with the actually recorded curve the effects of the Schemes are clearly demonstrated.

9.—Results of Calculations.

(a). Effect at Victoria Bridge.—The curves herewith (Diagrams VII and VIII) show the results of applying this method to Post-Flood Scheme floods of 1925-26 and 1927. One very interesting effect demonstrated by the curves is that with the elimination of the storage capacity the floods now tend to rise quite steadily, whereas a study of Pre-Flood Scheme Curves indicates that in most major floods there was a short pause, during the rising period, at about 4-00' above mean sea level. The fact that this pause is so clearly shown in the calculated curves is strong evidence in favour of the reliability of the method. Another
apparent effect of the elimination of storage is that the floods are slightly speeded up, both in rising and falling, under present conditions, but that the effect on the ultimate crest level of floods is negligible. From this it would appear that the 4,000 cusecs allowed by Mr. Harward as "Flood absorbing capacity" at the peak of a flood is excessive (vide Sessional Paper-XVI-1923, para 12). Assuming that 7,000 cusecs is the correct maximum discharge via the sea outlets, the greatest difference in level to be anticipated at Victoria Bridge appears to be about nine inches.

(b). Effect opposite Kolonnawa.—On the same principle it is possible to ascertain with reasonable accuracy what will be the increase in level in that portion of the flood channel opposite the Kolonnawa Gap. Having seen that the elimination of storage has little or no effect on the crest level of floods, all that need be considered is the increased flow in the flood channel, which in this case will be by flows (b) and (c) only. The first step is to obtain a discharge curve for this portion of the channel, and this can be done by tabulating the Kolonnawa gauge readings and discharge figures as shown in Table II herewith.

The curve produced by plotting discharge against the Kolonnawa readings is shown herewith (Diagram IX). It will be noticed that the readings are for a major flood only, the reason being that in a major flood the levels in the river opposite Kolonnawa will be practically the same as the levels at the Kolonnawa gauge. In a minor flood this will not be the case, as the river will not have topped the lower Avisawella Road.

It may be argued that Pre-Flood Scheme gauge readings should be used to produce the discharge curve, but it must be remembered that prior to 1925 the channel was not a confined one, but was subject to a fluctuating flow in and out of the Kolonnawa Gap. If the 1924 gauge readings are plotted it will be found that the points are very scattered, and no comparatively smooth curve such as that for 1927 can be obtained.

Table III is self-explanatory, and an attempt has been made to correct the error introduced by the fact that the Pre-Flood Scheme Levels in Colombo South would have been lower than
the Post-Flood Scheme Kolonnawa Levels. The figures indicate that the level in the Flood Channel would be increased rather more opposite Kolonnawa than at Victoria Bridge. The rate of increase appears to be about one inch per foot rise of flood level, from which it may be deduced that the maximum increase in level in such a flood as that of 1917 could be about 10\(\text{ft}\) at Kolonnawa, whereas at Victoria Bridge it would be only nine inches.

(c) The effect above Kolonnawa.—Above Kolonnawa, what is known as a "Backwater curve" would be produced, which means that increased flow will be continued for some distance up the river, but always decreasing in value until the effect vanished altogether. Numerous formulae have been evolved for calculating this distance, which in this case, according to Buckley, would be about four miles.

(d) The effect of blocking the Urugodawatte Bridge.—It is impossible to construct a discharge curve for the flow through the Railway Bridge, for the reason that a very slight difference of head will cause a large difference in the discharge. It can be shown that an extra head of about one inch is required to increase the velocity through the bridge sufficient to pass the extra 7,500 cusecs which under Pre-Flood Scheme conditions used to flow through the Urugodawatte Bridge.

Much stress has been laid on the assertion that the flow through the Sedawatte culvert in the Kandy Railway Embankment is greater than it was previous to the completion of the Flood Schemes. It is perfectly true that this flow has increased, and the reason is obvious. Not only has the level on the upstream side been increased slightly by the extra head required at the Railway Bridge, but also by the fact that the lower Avisawella Road acts as a bund, and tends to pond up the water on the fields adjacent to and on the east side of the embankment. This can and will be remedied, and at the same time the drainage of the fields adjacent to and on the east side of the Railway embankment will be improved. The proposal is to cut a wide canal parallel to and on the east side of the embankment, and the provision of several automatic gates where the canal passes under the lower Avisawella Road.
Conclusion.

In submitting these notes, the writer wishes to emphasize that he does not by any means claim that the figures are incontrovertible, in fact they are admittedly only approximations. The problem is exceptionally difficult, as will be found by anyone who attacks it seriously, and all that can be stated quite definitely is that there is no reliable evidence in the recent floods to show that Mr. Harward has underestimated the effects of his scheme. It is quite possible that future study may show that there are small inaccuracies in the above methods of calculation, and if these can be pointed out the writer will readily acknowledge them. The fact however remains that the figures herewith represent entirely independent calculations arriving at more or less the same conclusions as those of Mr. Harward, who unfortunately left no notes on the subject other than the various Sessional Papers already published.

It will be observed that no allowance whatever has been made in these calculations for the compensating effect of the scour which doubtless takes place in the bed of the river during floods, and which in time may completely nullify the effect of the schemes. For this reason it is quite possible that the extra height of recent floods was not as much as these calculations tend to show, a surmise which is well-supported by a second independent investigation carried out by Mr. Bamford, Superintendent of the Colombo Observatory, the results of which were described in his paper read before this Association in 1928.

In conclusion, the writer would like to take this opportunity of issuing a word of warning, and that is that although Mr. Harward took the 1913 flood as his maximum, it is not by any means certain that even heavier floods will not occur. It is a well-known fact that the more the land is cleared of jungle and forest up-country, the greater the run off due to a given amount of rainfall. The 1913 flood was the highest flood of which we have reliable records, but it is not only possible, in fact extremely probable, that sooner or later such a flood will occur as will eclipse all previous records.
Thanks to Mr. Bamford, the authorities are now able to give warning in Colombo some three or four days before a flood is expected, and it is to be hoped that all those who dwell in those areas which cannot be protected will take heed of these warnings in time to remove themselves and their belongings to high ground and safety.

LIST OF DIAGRAMS.

I. Colombo South Scheme.
II. Colombo North Scheme.
III. Skelton's Discharge Curve.
IV. Capacity Curve, Colombo North and South.
V. Wellawatte and Dehiwala Discharge Curve.
VI. Assumed Discharge Curve at Damnagoda.
VII. Curves showing effect of Schemes at Victoria Bridge.
IX. Discharge Curve at Kolonnawa.

TABLES.

I. Calculations showing effect at Victoria Bridge of 1925, 1926 and 1927 Floods. (Extract only)
II. Gauge Readings and Corresponding Discharge opposite Kolonnawa.
II. Calculations for difference of level at Kolonnawa.
PLAN SHOWING FLOODED AREA IN COLOMBO NORTH.

Area within Catchment above Flood Level.
Area within Catchment below Flood Level.
Area less than 3 feet above Mean Sea Level.
Kelan River Discharge Curve
(near old Bridge of Gods)
from Shelton's Memorandum
in Kelani River Flood 1909
ASSUMED DISCHARGE CURVE
DEMATERIAL Gap
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<th>Average River at Colombo N. &amp; S.</th>
<th>Capacity Variation in 24 hours</th>
<th>Flow into Colombo N. &amp; S.</th>
<th>River Level at Negilagam Street</th>
<th>Average</th>
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<td>Discharge (Post-Flood Scheme) ( = D )</td>
<td>Flow to sea outlets (Pre-Flood Scheme) ( = B )</td>
<td>Assumed Flow through Dematagoda Gap ( = C )</td>
<td>Calculated Pre-Flood Scheme Discharge ( = D - (B + C) )</td>
<td>Pre-Flood Scheme Levels at Kolonnawa ( = B )</td>
<td>Assumed Flow to pre-flood scheme levels ( = B )</td>
<td>Dematagoda flow corrected to pre-flood scheme levels ( = B )</td>
<td>Flow ( B' + C' )</td>
<td>Total increased discharge ( = D + B' + C )</td>
<td>Levels at increased discharge</td>
<td>Difference in level</td>
</tr>
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</tr>
<tr>
<td>8'0&quot;</td>
<td>35,600</td>
<td>2,870</td>
<td>0</td>
<td>32.730</td>
<td>7'3&quot;</td>
<td>2,650</td>
<td>0</td>
<td>2,650</td>
<td>38,250</td>
<td>8'7½&quot;</td>
<td>7½&quot;</td>
</tr>
<tr>
<td>9'0&quot;</td>
<td>39,600</td>
<td>3,530</td>
<td>300</td>
<td>35.770</td>
<td>8'1&quot;</td>
<td>2,950</td>
<td>0</td>
<td>2,950</td>
<td>42,550</td>
<td>9'8&quot;</td>
<td>8&quot;</td>
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<tr>
<td>10'0&quot;</td>
<td>44,200</td>
<td>4,220</td>
<td>950</td>
<td>39.030</td>
<td>8'10&quot;</td>
<td>3,450</td>
<td>200</td>
<td>3,650</td>
<td>47,850</td>
<td>10'9&quot;</td>
<td>9&quot;</td>
</tr>
<tr>
<td>11'0&quot;</td>
<td>49,500</td>
<td>4,960</td>
<td>1,800</td>
<td>42.740</td>
<td>9'9&quot;</td>
<td>4,000</td>
<td>500</td>
<td>4,500</td>
<td>54,000</td>
<td>11'10&quot;</td>
<td>10&quot;</td>
</tr>
<tr>
<td>12'0&quot;</td>
<td>55,000</td>
<td>5,750</td>
<td>2,800</td>
<td>46.450</td>
<td>10'6&quot;</td>
<td>4,570</td>
<td>1,150</td>
<td>5,720</td>
<td>60,720</td>
<td>12'10½&quot;</td>
<td>10½&quot;</td>
</tr>
<tr>
<td>13'0&quot;</td>
<td>61,500</td>
<td>6,650</td>
<td>3,900</td>
<td>50.950</td>
<td>11'3&quot;</td>
<td>5,150</td>
<td>1,900</td>
<td>7,050</td>
<td>68,550</td>
<td>13'10&quot;</td>
<td>10&quot;</td>
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</table>
DISCUSSION.

Mr. E. C. Hillman read his paper entitled "The Effect of the Colombo Flood Schemes on Unprotected Areas."

THE PRESIDENT.—"Gentlemen, the Association has been much indebted in the past to members who have from time to time contributed interesting papers; not the least interesting of which I venture to suggest is the one that has just been contributed by Mr. Hillman. He has dealt mostly with the effect on maximum floods produced by the construction of the Colombo North and South Flood Protection Schemes. The effect on minor floods has turned out to be almost as important and as interesting a problem to those who have studied it. I would welcome observations from any member upon the points brought up by Mr. Hillman."

Col: T. G. JAYEWARDENÉ.—"Mr. Chairman and gentlemen, we are much indebted and greatly thankful to Mr. Hillman for the trouble he has taken in writing this important paper. I am sorry, however, I am unable to agree with him in some of his conclusions. The figures in column 1 of table III are post-Flood Scheme levels at Kolonnawa, and the figures in column 2 are figures of discharge of what the writer calls post-Flood Scheme, but they are really pre-Flood Scheme discharges, for they have been taken from the late Mr. Skelton’s Diagram of 1915 reproduced in the present paper as Diagram III. If you scale off from Mr. Skelton’s Diagram the height at Nagalagam Street corresponding to the discharges given in column 2 table III and compare them with the figures in column 6 you will at once see what the slope of the river was pre-Flood Scheme. Then again if you compare those heights at Nagalagam Street with the figures in column 1 which are post-Flood Scheme levels, you will see that the slope is greater than under pre-Flood Scheme conditions. Therefore, the figures given in column 2 as post-Flood Scheme
discharges, are, in my opinion incorrect, and it must naturally follow that the other figures in Table III are also incorrect. The same error appears in Tables I and II. The discharge figures cannot be taken as those based on the present slope of the river. They have been taken from Mr. Skelton's Diagram based on a different river slope and are pre-Flood Scheme discharges. If the discharge figures are incorrect, all the tables become valueless, and the final conclusion arrived at by the writer I am sorry to say cannot be accepted.

I wish I could have ended my remarks with the few observations I have just made but in justice to others who put forward flood protection schemes in the past I am sorry I cannot allow the statement made in the second para. of page 1 to go uncontradicted.

As far back as 1893 another Irrigation Engineer, by name Brunton, who had been working under the Provincial Irrigation Board, Western Province, in connection with a scheme for banking in the Kelani Ganga, and who had made a contour survey of the whole locality, had made the same discovery as Mr. Harward. His proposal which was submitted to Government by the Government Agent, Western Province, as Chairman of the then Provincial Irrigation Board was to block the Kalutara canal at Kittampahuwa (4 miles Colombo - Avisawella Road) just below Wellampitiya hill, instead of at Gobetuwana near Kolonnawa as proposed by Mr. Harward. The principle, however, was the same, i.e., to block the Kahtara canal by which the Kelani floods gained access to the Colombo South area. Under Brunton's scheme it was necessary to block the canal at Kittampahuwa instead of at the Kolonnawa gap as his proposal was to protect the whole of Colombo under one scheme, instead of under two separate schemes as done at present, and which only became possible after the construction of the Harbour to Kolonnawa Railway. The details of this proposal will be found in the paper I read before this Association in 1923.

Now the reason for the non-acceptance of this scheme by Government, which was practically
the same in principle as that of Mr. Harward for they both proposed the blocking of the Kalutara canal by which floods entered Colombo South. It was not because it was an expensive one, for the Government Agent said it could be carried out at a moderate cost, but because the two Engineers, Mr. Skelton, the Municipal Engineer, and Mr.Macbride, the E. P. W., to whom it was referred, condemned it.

This is what Mr. Skelton said.

In principle it is extremely dangerous to resort to embankments, for no matter what height is assumed to be ample under the condition of known floods, there is always the danger of exceptional floods occurring which would overtop or perhaps breach the bunds inundating an area which under years of security from floods may have in the interval become occupied by a considerable population.

THE PRESIDENT.—"I think Col. Jayewardene you are going beyond the paper. What you say has little to do with the matter under discussion. You are going to other schemes, and we have no time to discuss these at length, besides, Mr. Hillman has qualified his remarks with regard to these schemes."

Col. JAYEWARDENE.—"I will finish in two minutes. I will read what Mr. Macbride said.

'Mr. Elliot's Scheme though but partial in its effects appears feasible, but the damage to property where I have shaded the sketch map thus "/" (i.e. outside the protected area) would be considerable and heavy compensation would be the penalty.'

'I have seen all the very high floods since 1872. Increase the flood outlets so as to mitigate the duration of floods and leave the Kelani as it is, is my advice."

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Note.

I have assumed that the figures in column 1 are post-Flood Scheme levels only, but if the writer
contends that they are pre-Flood Scheme levels also, I would submit that they are incorrect in such. For to take only one example—the difference in height of the river in the 1913 flood between Kolonnawa and Nagalagam was only 2'-6" (13'-6"-11'-0"), whereas the difference in height of a 13 feet flood as given in the paper is 3'-1" (13'-0" at Kolonnawa and 9'-1" at Nagalagam Street). This could not happen, for conditions being unchanged the slope of a river would if anything be higher in a higher flood than in a lower one.

Mr. HILLMAN.—"Mr. Chairman and gentlemen, Col. Jayewardene has referred to my Table III, and in doing so assumes that the figures in column 2 are taken from Skelton’s Discharge Curve. They are not. They are taken from the Discharge Curve constructed, as I have explained in Table II, by comparing the Kolonnawa levels with the discharge at Victoria Bridge. This curve is plotted in diagram ix, and I am, therefore, afraid that Col. Jayewardene’s criticism on this point is based on a misunderstanding.

The Colonel mentions that it is quite wrong to use Skelton’s Discharge Curve now, as the river slope has probably been altered by the flood schemes. While reading my paper I was careful to qualify my results by stating that we now have certain information, obtained by comparing pre- and post—Flood Scheme gradients, which indicates that the slope has been very slightly increased in the neighbourhood of Victoria Bridge and decreased above Kolonnawa, and I stated that I consider the effect of this would be to slightly decrease the calculated difference of level at Victoria Bridge, and increase the difference opposite Kolonnawa, which would bring my figures even more into line with Mr. Harward’s prediction.

Col. Jayewardene’s next criticism was with reference to my calculations of the storage effect. He suggests that I have not taken into account the flow which escaped to the sea at Wellawatte and Dehiwala, whereas you will see in my paper that I have most certainly taken this flow into
account, but for purposes of calculation I have dealt with the storage effect and the effect of the Wellawatte and Dehiwela flow separately, combining the two effects to obtain the final result.

With reference to his remarks about paragraph 2 on page 1 of my paper, Col. Jayewardene claims that Mr. Harward's schemes were not original. Gentlemen, time after time, in his Sessional Papers and elsewhere, Mr. Harward has paid tribute to Col. Jayewardene for the interest which he has displayed in the various flood schemes, and I may be quite wrong in stating that the Kolonnawa had not been discovered.......

Col. Jayewardene—'I do not claim any credit for having discovered that. I said that another officer did that before.'

Mr. Hillman—'All I have to say, with reference to Mr. Brunton's scheme, which Col. Jayewardene mentions, is that this proposal was to raise certain roads near the river bank to form flood bunds. The result of doing this would have been to have pinched in the "flood channel" to such an extent that the increase in flood level over the unprotected areas would have been very much greater than the increase caused by Mr. Harward's schemes. Gentlemen, I submit that this was probably the real reason why Mr. Brunton's scheme was not adopted.'