

NOTE

ON THE

PRESENT STATE OF THE RIVER CHANNELS AND FLOOD EMBANKMENTS OF THE PURI DISTRICT.

WITH

PROPOSALS FOR THE CONSTRUCTION OF PERMANENT ESCAPES.

BY

W. A. INGLIS,

SUPFRINTENDING ENGINEER, ORISSA CIRCLE.



D26, 8.2541

D26, 8.2541
D2
071440

Calcutta:

BENGAL SECRETARIAT PRESS.

1962.

Not for sale.

Note on the present state of the river channels and flood embankments of the Puri district, with proposals for the construction of permanent outlets, from which so much of the flood, as is in excess of the capacity of the channels, may be allowed to escape.

1. *Objects of note.*—In Chapter XXVIII of the narrative, which I compiled of the principal events connected with the administration of the canals and embankments in Orissa during the last-half of the nineteenth century, I alluded to the fact that, as far as the Puri district is concerned, nothing had been done to provide any facilities for irrigation, or to relieve it from the liability to inundation which nature has imposed on it. It may be of some service to exhibit in greater detail the physical conditions of that part of the delta of the Mahanadi which is within the Puri district; to notice the schemes which have been suggested for dealing with the excessive volume of flood; to examine the extent to which the embankments, as they exist, are unable to resist the flood; to show the expenditure incurred in recent years in repairing the breaches; and to consider if any measures are practicable which may tend to economy in the maintenance of the flood banks, or may lessen the injury which is, to a certain extent, inevitable.

2. *General description of the river channels.*—The Puri district receives its share of the flood of the Mahanadi through the Kawakhai, which is an offshoot or spill channel of the Katjuri branch of the main river. The north-east corner of the district is affected by the flood in the Deb, which is the name given to the lower part of the Katjuri branch. The area so affected is, however, comparatively small, and it need not be further considered in this note. The bed of the Kawakhai at its offtake from the Katjuri is much obstructed by sand, and water does not flow down it freely until it has risen in the Katjuri to about 12 feet on the gauge at Bellevue on the Cuttack revetment.

The Kawakhai and its western branch, the Daya, skirt the high ground which forms the south-western limit of the delta and receive the drainage of a moderate area of country. The more important streams which fall into the Daya are the Gangua, which joins just above Kant, and the Moonagonee or Madagni, which is a hill stream of some size and which unites with the Daya a short distance from its end in the Chilka Lake. The Kawakhai divides into three branches—the Kushbhadra, the Bhargabi, and the Daya, which, after the custom of deltaic rivers, are of the nature of high level canals.

3. *Local drainages.*—The local drainage is provided for by the following streams:—The Nun and the Rathanchira drain the country between the Daya and the Bhargabi. These streams all unite close to the Chilka Lake. The Dhanua takes the drainage of the country between the Bhargabi and the Kushbhadra, and in times of flood it receives spill from both of these rivers. The Prachi drains a small area of country between the Kushbhadra and a ridge of high ground which runs along the boundary of the Cuttack and Puri districts. It is joined near the sea by the Kadua which drains part of the country on the left of the Kushbhadra. It seems probable that at some former time a large river may have flowed along the line of the Prachi, but it is at present of little importance. The Prachi receives some of the spill of the upper part of the Kushbhadra river, but the present channel is so restricted that at time of

Dhananjayaram Gadgil Library



GIPE-PUNE 071440

flood the water makes its way through gaps in the high ground on the left bank of the stream and joins in the spill of the Deb which is the main branch of the Katjuri.

The outline map attached shows the Kawakhai and its branches in blue and the local drainage channels in green. The Kushbhadra and the Daya keep to one channel, which in either case grows very small in the lower part of the delta. The Bhargabi towards the end of its course divides into several branches.

4. *Outlets to sea.*—The Kushbhadra, joined by the Dhanua, falls into the sea, about 15 miles east of Puri. The estuary passes through sand hills and is much choked by drift sand. The Bhargabi sends some of its water to the Sur Lake, and thence past the town of Puri parallel to the coast, and so eventually into the sea. The larger part of its flood discharge passes into the Chilka Lake in conjunction with the flood from the Daya and with the water coming down the Nun and Rathahira. At a time of high flood a large part of the Puri district becomes a lake. An early and not too prolonged inundation probably does good. On the other hand, if the flood comes late in the season and is at all prolonged, it causes much injury.

5. *Plan and sections prepared by Captain Harris.*—A section taken during the survey of the rivers in the Orissa delta by Captain Harris in 1857-58, which is reproduced,*

No. 2 and 3 of plans attached. will show the relative levels and sizes of the channels in the Puri district. The line along which this section was taken is shown on the plan which accompanies it.

6. *First enquiries.*—The question of the loss to the cultivators, and indirectly to the State, due to flood and drought, was first seriously considered in Orissa after the very high flood of 1855.

Captain Short reviewed the condition of the Puri district at some length in a note written in 1858, which will be found at page 52 of a collection of papers relating to Part II of reports by Captain Harris. Suggestions were made that the volume of the flood of the Mahanadi entering the Kawakhai should be reduced, a greater proportionate volume to be sent down the channels in the central part of the delta, i.e., in the Cuttack district. No detailed calculations or plans were prepared and no forecast was made of the effect on the flood level in the river channels in the Cuttack district which would be caused by the extra volume which it was proposed to send down them.

7. *Schemes of East India Irrigation and Canal Company.*—In 1861 the East India Irrigation and Canal Company was formed for the purpose of constructing canals for irrigation and navigation in Orissa and Bengal. The original scheme for Orissa provided for regulating the volume of water to be admitted to the Kawakhai and for using the channels of the Kushbhadra, Bhargabi, and Daya for navigation and irrigation with the aid of locks and weirs.

In a letter dated 15th September 1862, Colonel Rundall, R.E., at that time Chief Engineer of the Company, wrote that it was intended to limit the flood discharge of the Kawakhai to 150,000 cubic feet per second. The distribution proposed for this volume among the channels of the Puri district was as follows:—

			Cusecs*
The Prachi	to take	...	9,375
" Kushbhadra	"	...	9,375
" Daya	"	...	15,000
" Bhargabi	"	...	26,250
" Nun	"	...	22,500
" Dhanua	"	...	67,500
- Total			1,50,000

* Cusecs is short for cubic feet per second.

The Kushbhadra, Daya, and Bhargabi were to be in the position of high level canals, while the Prachi, Nun, and Dhanua were to act as escape channels at lower levels, to which the excess water was to be passed by weirs.

In the case of the Dhanua which unites with the lower part of the Kushbhadra, the construction of an additional outlet to the sea was contemplated.

In a memorandum dated 22nd April 1863, Colonel Rundall proposed to reduce the flood discharge of the Kawakhai to 75,000 cusecs, which was to be passed by the Kushbhadra, Bhargabi, and Daya, with escapes to the Prachi and Nun. He had abandoned the idea of using the Dhanua as an escape as he thought that this part of the district was too valuable. He contemplated reducing the maximum flood volume of the Mahanadi by means of storage reservoirs on the upper tributaries.

8. Mr. Levinge, who succeeded Colonel Rundall as Chief Engineer to the Company, in a note dated 3rd August 1863, proposed the following distribution of the flood of the Mahanadi. Taking the greatest volume of flood above Naraj as calculated by Major Harris to be 1,800,000 cusecs, Mr. Levinge proposed that 675,000 cusecs should be passed into the Katjuri and 1,125,000 cusecs sent down the main stream. This he proposed to effect by making the weir at Naraj across the head of the Katjuri 3,600 feet in length and with its crest at B. L. 78.00 above mean sea level. As built, the Naraj weir is of about this length, but the crest has only been raised to B. L. 73.50, so that the proportionate volume of flood which passes into the Katjuri is much larger than had been intended.

The head of the Kawakhai was to have been closed and sluices built to pass the 75,000 cusecs which was the volume of flood assigned to it.

Mr. Levinge in a note dated 10th March 1864 further proposed to distribute the volume of 75,000 cusecs as follows:—

The Kushbhadra to take 22,500, half of which would be escaped to the Prachi: the Bhargabi to take 37,500 cusecs, of which 30,000 was to be passed to the estuary of the Kushbhadra by means of an embanked escape following the course of the Dhanua: the Daya was to take the remaining 15,000. Mr. Levinge calculated that the Gangua Nala might bring to the Daya, after heavy local rain, a volume of 22,500 cusecs, and he proposed an escape from the Daya to the Nun to be made near Kanti just below the confluence with the Gangua to take 30,000 cusecs, so leaving 7,500 cusecs to pass down the lower part of the Daya.

9. *Commission of 1866.*—After the famine of 1865-1866 a Commission was appointed to enquire generally into the extent of the injury to crops caused by inundation in Orissa.

For the Puri district it was reported that the estimated loss due to the inundation of 1866 was 23,01,533 maunds of paddy. The conclusion arrived at by the Committee was that Government would be justified in spending for the Puri district a sum of 20 lakhs in preventing loss. This was on the basis that Government would save, as an average, Rs. 14,989 per annum, for which remissions of revenue had been allowed, and that the rent-payers should pay annually Rs. 1,85,000 to ensure the crops on the area liable to inundation. The Commissioners were further

*Paragraph 52 of the report.

of opinion,* on the supposition that the land liable to inundation should be fully protected and also provided with facilities for irrigation, that the increase in the yield of the crops on this area might be worth from 30 to 40 lakhs per annum. The flood of 1866 was not a particularly high one, but it was of longer duration than usual, and so caused exceptional injury to the crops submerged.

10. Rough calculations were made in the Chief Engineer's office of the cost of the embankments required throughout Orissa to give efficient protection, and are attached to a note by Colonel Rundall, who was then Chief

Engineer to the Government of Bengal, in which he reviewed the report of the Committee. According to the division of the flood volume proposed, the Kawakhai was to receive 130,000 cusecs. It was proposed to completely embank the Kushbhadra, Bhargabi, and Nun rivers, and to embank the Kawakhai and Daya on the left bank only, leaving the right open to flood throughout. The estimated cost of the embankments proposed for the Puri district amounted to Rs. 7,95,420. This, however, made no provision for the cost of the land or for the cost of the weir or sluices required to restrict the discharge entering the Kawakhai, or for the escape to the Nun. The project also involved expenditure in the Cuttack district in order to accommodate the increased flood volume which it would receive as a consequence of the restriction of the Kawakhai.

11. It was, however, decided* that it was not practicable

* Note by Colonel Haig, R.M., and to tax the landlords or memorandum by Sir George Campbell. occupiers of the land which would be protected and benefited, and no action was taken. It was hoped that the canal works which were in progress would do much to give protection from flood. At that time the extension of the canal scheme to the Puri district was still contemplated. The reasons for holding that it was not practicable to levy a special cess for protection from flood were not stated, and they are not quite apparent, but they were probably connected with the terms of the settlement of the land revenue.

12. *Value of protection from flood not yet determined.*—If the figures given by the Committee can be relied on, it would seem that the average gain to the cultivators from the protection which it was proposed to give would have been very considerable. There is, however, I think, even now little accurate information available as to what, on the average, the loss or gain to the cultivators in the Puri district from flood really is, and until this is ascertained, it is impossible to say what expenditure it might be prudent for Government to incur.

In the report by Mr. Maddox on the recent settlement of the land revenue, the question of the injury caused by inundation is discussed generally, but there were probably no data, or at all events not sufficient data, to allow of any exact estimate being formed. In one particular case

† Paragraph 90, page 61 of report. Mr. Maddox has stated his opinion† that an annual loss of revenue of Rs. 4,000 will be sustained in the Dhanua basin if the present policy with respect to the gap in the Bhargabi bank at Adlabad is maintained, while the loss to the zamindars and cultivators must be of course much greater.

In the resolution by the Bengal Government on the Settlement Report dated 4th October 1901, it is shown that as an average, the incidence of rent, or, as it is termed, of settled assets per acre, is as follows:—

	Rs.	A.	P.
Cuttack district	...	2	8 3
Balasore "	...	1	10 7
Puri "	...	1	11 7

In assessing the revenue payable, the proportion of the settled assets taken is—

	Rs.
Cuttack district	...
Balasore "	...
Puri "	...

This would seem to indicate that it is not considered by the Settlement Officers that the liability to inundation causes any material risk to the zamindar, though doubtless if the floods were better regulated the rates of rent would rise. Mr. Maddox shows that the incidence of the land revenue per acre is on the average Re. 1.09 in Puri as compared with Re. 1.35 in Cuttack (paragraph 556 of report). Assuming

that in either case the revenue bears a similar proportion to the value of the produce, this would indicate that the gain due to protection and to irrigation, both of which are given to a considerable extent in the Cuttaok district, is not so great as might have been anticipated.

13. *Investigation by Mr. Rhind after flood of 1872.*—After the high flood of 1872 an investigation was made by Mr. Rhind into the capacities of discharge of the various branches of the Mahanadi in the Cuttaok district. The investigation was made on the basis that it was desired to limit the discharge of the Kawakhai to 45,000 cusecs and to pass the rest of the flood to the sea by means of the channels in the Cuttaok district. No calculations were therefore made at this time as to the capacities of discharge of the channels in the Puri district. It was, however, necessary to determine the volume of flood which had passed into the Puri district, and Mr. Rhind calculated this at 334,483 cusecs for the flood of 1872. The conclusion he arrived at was that, by an expenditure of a little over 45 lakhs the discharge of the Kawakhai might be limited as proposed to 45,000 cusecs, and the channels in the Cuttaok district so embanked as to pass the rest of the flood volume to the sea. His estimate included the cost of the weirs or sluices required to adjust the discharges of the different branches of the rivers and of the earthwork in the embankments, but it made no provision for the cost of the land which would be required and which would be considerable. No orders of Government were recorded on Mr. Rhind's report and proposals, and the matter was allowed to drop.

14. *Decision not to extend the canal system to the Puri district.*—In 1876, when a modified scheme for the canals was sanctioned by the Secretary of State, it was definitely settled that the canal works should not be extended to the Puri district.

15. *Capacities of the Puri rivers investigated by Mr. Rhind.*—In 1882 complaints were made by the Officer in charge of the settlement of the Khurda Government Estate that serious injury was being caused by inundation to the lands in that estate on the right bank of the Daya river. These referred more particularly to injury which was said to be due to certain breaches having been left open at Teremole, which is about 22 miles below the offtake of the Daya. This led to a general enquiry being made into the capacities of discharge of the Puri rivers, viz., the Kawakhai, the Kushbhadra, the Bhargabi, and the Daya. The enquiry involved a large number of laborious calculations, and it

* Letter No. 2184, dated 29th April 1891, from Superintending Engineer, Orissa Circle, to Chief Engineer.

was not till April 1891 that a report* was submitted by Mr. Rhind, Superintending Engineer. Mr. Rhind calculated that under the conditions then obtaining, and which practically still obtain, the greatest probable volume of flood which might enter the Kawakhai may be reckoned at 277,180 cusecs as compared with 250,000 cusecs which entered in 1885 and with 334,483 cusecs which entered in 1872. He further calculated that in the flood of 1885 a volume of about 50,000 cusecs entered the Kushbhadra, while 74,000 cusecs entered the Bhargabi, leaving 126,000 cusecs as the volume which must have passed into the Daya at its head.

Mr. Rhind investigated the problem of how to pass such volumes, which are far greater than the natural channels can accommodate, between embankments, and gave certain figures showing the heights of the embankments required and the distances they would have to be retired from the channels. The method of disposing of the flood by escapes to the local drainage lines (Nun, Dhanua, and Rathan-chira), which had been originally proposed by Colonel Rundall and Mr. Levinge, does not appear to have been considered by Mr. Rhind. The report was reviewed by Mr. Odling, who was then Chief Engineer, in a note dated 5th June 1892, and the orders of Government are contained in Bengal Government letter No. 9621, dated 4th August 1892, to the Commissioner of Orissa. In this it was ruled

that "any extensive remodelling of the embankments in Orissa may be considered as beyond the range of practicable proposals." It was decided that the gaps at Teremole which had been open since 1879 should not be closed.

16. *Classification of embankments.*—In 1890 a question was raised concerning the upkeep of certain marginal embankments which had been superseded by new embankments constructed in connection with the canals. Orders of Government were issued in letter No. 1096I., dated 25th July 1890, that such marginal embankments as had been superseded should cease to be public embankments, and lists of such embankments were called for. Later in Bengal Government letter No. 522I., dated 25th April 1892, lists of all the embankments in the Orissa Circle were called for in which the embankments were to be classified, showing such as it was proposed to abandon. This was said to be required in connection with the resettlement of the land revenue then in progress.

The classification then made was approved by Government in letter No. 3486L.R., dated 14th July 1894, from the Revenue Department to the Board of Revenue. Under this classification the embankments scheduled in the Puri district were as follows:—

	Miles.	Feet.
Class II.—To be retained permanently ...	103	1,296
„ III.—To be retained for the present	105	915
„ IV.—To be abandoned at commencement of a new settlement	59	3,553
„ V.—Already abandoned ...	66	2,515

17. *Embankments on local drainage lines.*—The embankments scheduled in class V were mostly on the interior drainage lines, such as the Dhanua, Nun, and Rathanchira. They were of small importance and were in detached lengths and only come into action when breaches occur in the main banks. Should escapes be made in the main embankments regulating the flood discharge to the interior drainages, it may very possibly be a step forward, later on, to take up the original proposals of Colonel Rundall and Mr. Levinge, and to embank the channels in a manner suitable to the discharge to be passed.

18. *Revision of classification.*—After I had had an opportunity of going over the embankments in detail, it appeared to me that in a good many instances embankments had been scheduled in class IV which are of use and which in my opinion should be maintained. It is true that they do not give complete protection from high floods, but they protect sites of villages, and are of service in maintaining the régime of the river channels. The general ground I take is that the natural channels should be made to pass as much of the flood as is practicable and that the excess volume should be allowed to escape at fixed points. I therefore revised the classification of the embankments throughout the circle, doing away with the somewhat artificial distinction between class II and class III. Under my classification Government will maintain in the Puri district 250 miles 1,313 feet, while 23 miles 4,355 feet among those in class IV will be struck off our books. It is of course not intended that this is to be an absolute decision. Further causes may render it desirable to maintain other embankments, or to give up some of those now maintained. The new classification has been approved in Bengal Government letter No. 405I., dated 4th March 1902.

19. *Consideration of measures which may be practicable for fixing the distribution of flood.*—It may then, I think, be taken as established that the condition of the Puri district is not such as to demand any heroic measures, and that it is not practicable at any reasonable cost to materially reduce the volume of flood which it must receive through the Kawakhai. What has now to be considered is, whether it is desirable, and, if so, whether it is practicable to regulate better than is done at present the distribution of that part of the flood volume which cannot be passed to the sea

within the embanked channels. There can, in my opinion, be little, if any, doubt, but that in the interest of the land which is liable to inundation, taken as a whole, it would be better that the excess volume of flood should be passed out from the rivers at fixed places and in a more or less fixed proportion, rather than, as at present, it should pass through breaches, the position of which is uncertain, and which, once they have opened, can, as a rule, neither be controlled nor closed till the end of the flood season. The last point is of importance because it sometimes happens that a low flood late in the season finds breaches open which have been caused by an early high flood and does much damage. This was the case in 1866, when there was a low flood on the 25th September, which caused injury. (On page 33 of the Report of the Committee of 1866 it is shown that 12 breaches were re-opened in the Puri district by this low flood). With paved escapes of the nature proposed, at a comparatively high level, such a low flood would pass off within banks.

What has next to be considered is how the cost of such regulation of the spill may compare with the cost of making good the breaches under the present system.

The following notes of the floods of the 22 years, 1879 to 1900, which I have compiled from the records of this office, will show approximately what the cost of making good breaches has been under the existing system:—

1879.

** Nature and time of flood.*

High flood: Naraj gauge 91.00 on 13th August. At head of Kushbhadra 68.28. At head of Daya—Bhargabi 55.00. Stated in flood report that Kushbhadra breached in both banks near the head; that Daya breached at various points in left bank, and also Bhargabi.

Cost of making good breaches.

Estimates sanctioned for filling breaches in Kushbhadra Rs. 6,280 and Kawakhai Rs. 1,293. No entry in the register of estimates as regards Daya and Bhargabi.

1880.

Medium flood. 89.25 at Naraj on 3rd July. Breaches reported in Kushbhadra and Bhargabi.

Estimates sanctioned for closing breaches Rs. 2,957 on Kushbhadra and Rs. 11,368 in No. 5 Subdivision (Pipli or Puri district), which probably means chiefly Bhargabi and branches.

1881.

Medium flood. 89.25 at Naraj on 26th July; 58.97 at head of Daya. Kushbhadra breached heavily on right bank. Several breaches in Bhargabi. Apparently Daya not breached.

No entry in register of estimates for this year for either breach filling or retired lines. Apparently dealt with in the following year.

1882.

Low flood. 86.30 at Naraj on 24th July; 67.85 at head of Kushbhadra; 51.42 at head of Daya. No breaches recorded.

No specific estimates for breach filling or retired lines, but an estimate for annual repairs to embankments. No. 5 Subdivision (Pipli) for Rs. 41,609 probably includes breach filling on account of flood of 1881.

* Note.— High flood in the Mahanadi is when the gauge at Naraj reads over	...	...	90.00
Medium flood in the Mahanadi is when the gauge at Naraj reads over	...	...	87.00
Low flood in the Mahanadi is when the gauge at Naraj reads less than	...	...	87.00

All gauge readings are referred to the mean sea level datum in use in the Circle.

1883.

Nature and time of flood.

Low flood. 86·60 at Naraj in July. Breaches reported in Bhargabi and Sur Lake embankments.

Cost of making good breaches.

Estimate sanctioned for completing half finished works, retired lines, breach filling in No. 5 Subdivision, Rs. 10,701. Estimate sanctioned for filling breaches, Sur Lake, Rs. 2,801, and Kanchi Rs. 1,548. Estimates sanctioned for retired lines—

			Rs.
Kawakhai	...	...	5,159
Kushbhadra	...	...	753
Daya	...	...	2,664
Bhargabi	...	...	13,158
Kanchi	...	...	11,125
Sunamahi	...	...	1,567

1884.

Medium flood. 87·60 at Naraj on 26th July; 69·05 at head of Kushbhadra; 52·67 at head of Daya. No breaches in Kushbhadra and Daya, but one in Bhargabi and others in Kanchi and Sur Lake (the Kanchi is an offshoot of the Bhargabi and the Sur Lake receives flood from Bhargabi through the Kanchi).

Estimate sanctioned for filling breaches, Rs. 435 Kawakhai, Rs. 726 Kanchi. Estimates sanctioned for retired lines—

			Rs.
Kawakhai	...	...	1,777
Daya	...	...	4,985
Kushbhadra	...	...	1,520
Bhargabi	...	...	18,415

1885.

High flood. 90·75 at Naraj on 26th June; 71·90 at head of Kushbhadra; 54·67 at head of Daya.

On Kushbhadra only one breach reported on right near head and two breaches on left, which is remarkable considering the height of flood and that it had breached heavily on right in 1881 with lower flood. On the Daya there were three breaches on right bank and 24 breaches on left. On the Bhargabi there were three breaches on right and five on left.

Estimates were sanctioned for filling breaches—

			Rs.
Kawakhai	...	...	1,379
Kushbhadra	...	...	459
Daya	...	...	8,655
Bhargabi	...	...	4,229
Kanchi	...	...	4,283
Sur Lake	...	...	1,550
			<hr/> 10,062 <hr/>

1886.

Low flood. 82·50 at Naraj on 19th July. No breaches of any consequence.

Estimate sanctioned for filling breach Dhauriah Nala, Rs. 313. Retired line on Bhargabi sanctioned, Rs. 2,416.

1887.

Medium flood. 87·70 at Naraj on 26th August; 62·12 at head of Kushbhadra; and 52·67 at head of Daya. No breaches reported for Kushbhadra or Daya, but a number of breaches in Bhargabi.

Estimates sanctioned for filling breaches in Pipli Subdivision for Rs. 7,554. Details not specified, but probably mainly for Bhargabi and its branches. Retired lines sanctioned—

			Rs.
Kawakhai	...	...	1,164
Bhargabi	...	...	12,064

1888.

Low flood. 85·80 at Naraj on 11th August; only breaches reported were in the branches of lower part of Bhargabi and in Sur Lake.

Estimates sanctioned for filling breaches Pipli Subdivision, Rs. 935. Retired lines sanctioned—

			Rs.
Daya	...	...	4,325
Bhargabi	...	...	3,526

1889.

Medium flood. 87·00 at Naraj on 20th August. At head of Kushbhadra 68·20. At head of Daya 51·97. One small breach in Kushbhadra right bank. No breach in Daya; several breaches in the lower part of Bhargabi and Sur Lake.

No special estimates sanctioned for filling breaches. These were probably provided for in the general repair estimates.

1890.	<i>Nature and time of flood.</i>	<i>Cost of making good breaches.</i>																				
	Low flood. 85·90 at Naraj on 12th July. No breaches reported.	Nil.																				
1891.																						
	Medium flood. 87·90 at Naraj on 30th July. At head of Kushbhadra 68·35. At head of Daya 52·07. A few small breaches in Kushbhadra. None in Daya, but several in lower part of Bhargabi.	Estimates sanctioned for filling breaches— <table border="0" style="margin-left: 20px;"> <tr><td></td><td style="text-align: right;">Rs.</td></tr> <tr><td>Kushbhadra</td><td style="text-align: right;">22</td></tr> <tr><td>Bhargabi</td><td style="text-align: right;">1,316</td></tr> <tr><td>Kanchi</td><td style="text-align: right;">449</td></tr> <tr><td>Sur Lake</td><td style="text-align: right;">601</td></tr> <tr><td>Athara Nala</td><td style="text-align: right;">57</td></tr> <tr><td>Naya Nadi</td><td style="text-align: right;">66</td></tr> <tr><td>Retired line sanctioned—</td><td></td></tr> <tr><td> Bhargabi</td><td style="text-align: right;">5,279</td></tr> </table>		Rs.	Kushbhadra	22	Bhargabi	1,316	Kanchi	449	Sur Lake	601	Athara Nala	57	Naya Nadi	66	Retired line sanctioned—		Bhargabi	5,279		
	Rs.																					
Kushbhadra	22																					
Bhargabi	1,316																					
Kanchi	449																					
Sur Lake	601																					
Athara Nala	57																					
Naya Nadi	66																					
Retired line sanctioned—																						
Bhargabi	5,279																					
1892.																						
	High flood. 92·10 at Naraj on 26th July. At head of Kushbhadra 73·5. At head of Daya 55·67. Kushbhadra breached at 0½ mile right bank and several places left bank. Daya breached heavily 8½ mile and 10½ mile left bank and several other places lower down.	Estimates sanctioned for filling breaches— <table border="0" style="margin-left: 20px;"> <tr><td></td><td style="text-align: right;">Rs.</td></tr> <tr><td>Kawakhai</td><td style="text-align: right;">2,036</td></tr> <tr><td>Kushbhadra</td><td style="text-align: right;">3,249</td></tr> <tr><td>Daya</td><td style="text-align: right;">10,123</td></tr> <tr><td>Bhargabi</td><td style="text-align: right;">4,291</td></tr> </table>		Rs.	Kawakhai	2,036	Kushbhadra	3,249	Daya	10,123	Bhargabi	4,291										
	Rs.																					
Kawakhai	2,036																					
Kushbhadra	3,249																					
Daya	10,123																					
Bhargabi	4,291																					
	Bhargabi serious breaches at 6 miles and at 22½ mile, both on left bank and many other smaller ones.																					
1893.																						
	Medium flood. 87·75 on 26th September; 67·83 at head of Kushbhadra and 50·97 at head of Daya. Two breaches occurred in Bhargabi. Kushbhadra and Daya not breached.	No estimates sanctioned for filling breaches, but retired lines sanctioned— <table border="0" style="margin-left: 20px;"> <tr><td></td><td style="text-align: right;">Rs.</td></tr> <tr><td>Daya</td><td style="text-align: right;">5,005</td></tr> <tr><td>Bhargabi</td><td style="text-align: right;">3,153</td></tr> </table>		Rs.	Daya	5,005	Bhargabi	3,153														
	Rs.																					
Daya	5,005																					
Bhargabi	3,153																					
1894.																						
	Medium flood. 89·40 at Naraj on 28th July. At head of Kushbhadra 69·15. At head of Daya 52·07. Kushbhadra breached in 1st mile; Daya slight breach; several breaches in Bhargabi.	Estimates sanctioned for filling breaches— <table border="0" style="margin-left: 20px;"> <tr><td></td><td style="text-align: right;">Rs.</td></tr> <tr><td>Kushbhadra</td><td style="text-align: right;">1,921</td></tr> <tr><td>Daya</td><td style="text-align: right;">263</td></tr> <tr><td>Bhargabi</td><td style="text-align: right;">5,595</td></tr> <tr><td>Sur Lake</td><td style="text-align: right;">1,658</td></tr> <tr><td>Retired lines were sanctioned—</td><td></td></tr> <tr><td> Kawakhai</td><td style="text-align: right;">1,640</td></tr> <tr><td> Daya</td><td style="text-align: right;">998</td></tr> <tr><td> Bhargabi</td><td style="text-align: right;">5,683</td></tr> <tr><td> Dhauriah Nala</td><td style="text-align: right;">1,303</td></tr> </table>		Rs.	Kushbhadra	1,921	Daya	263	Bhargabi	5,595	Sur Lake	1,658	Retired lines were sanctioned—		Kawakhai	1,640	Daya	998	Bhargabi	5,683	Dhauriah Nala	1,303
	Rs.																					
Kushbhadra	1,921																					
Daya	263																					
Bhargabi	5,595																					
Sur Lake	1,658																					
Retired lines were sanctioned—																						
Kawakhai	1,640																					
Daya	998																					
Bhargabi	5,683																					
Dhauriah Nala	1,303																					
1895.																						
	High flood. 90·55 at Naraj on 1st July. At head of Kushbhadra 69·95. At head of Daya 52·47. Breach in 1st mile, Kushbhadra. Six breaches in Bhargabi. One breach in right of Daya. No breaches in Daya left.	Estimates sanctioned for filling breaches— <table border="0" style="margin-left: 20px;"> <tr><td></td><td style="text-align: right;">Rs.</td></tr> <tr><td>Kushbhadra</td><td style="text-align: right;">2,616</td></tr> <tr><td>Bhargabi</td><td style="text-align: right;">425</td></tr> </table> Breaches at Adlabad on Bhargabi and at Palaspur in right of Daya were left open.		Rs.	Kushbhadra	2,616	Bhargabi	425														
	Rs.																					
Kushbhadra	2,616																					
Bhargabi	425																					
1896.																						
	High flood. 92·10 at Naraj on 25th July; 71·35 at head of Kushbhadra; and 53·67 at head of Daya. Kushbhadra had a large breach in 1st mile, right. Daya large breach in 11th mile left and two breaches in left lower down. Some breaches in lower portion of Bhargabi and branches, but owing to breach at Adlabad having been open, this was of no great importance.	Estimates sanctioned for filling breaches— <table border="0" style="margin-left: 20px;"> <tr><td></td><td style="text-align: right;">Rs.</td></tr> <tr><td>Kushbhadra</td><td style="text-align: right;">6,584</td></tr> <tr><td>Daya</td><td style="text-align: right;">6,871</td></tr> <tr><td>Branches of Bhargabi</td><td style="text-align: right;">341</td></tr> <tr><td>Retired lines sanctioned—</td><td></td></tr> <tr><td> Daya</td><td style="text-align: right;">487</td></tr> <tr><td> Bhargabi</td><td style="text-align: right;">1,556</td></tr> </table>		Rs.	Kushbhadra	6,584	Daya	6,871	Branches of Bhargabi	341	Retired lines sanctioned—		Daya	487	Bhargabi	1,556						
	Rs.																					
Kushbhadra	6,584																					
Daya	6,871																					
Branches of Bhargabi	341																					
Retired lines sanctioned—																						
Daya	487																					
Bhargabi	1,556																					

1897.

*Nature and time of flood.**Cost of making good breaches.*

Low flood. 86·10 at Naraj on 14th August; 57·98 at head of Kushbhadra; and 46·97 at head of Daya. No breaches.

Nil

1898.

Low flood. 85·30 at Naraj on 15th August; 58·86 at head of Kushbhadra; and 49·93 at head of Daya. No breaches.

Nil

1899.

Very low flood, 82·10 at Naraj on 31st August; 54·28 at head of Kushbhadra; and 43·83 at head of Daya. This year marked by the extremely low state of the Mahanadi throughout the season, indicating very small rainfall in the Central Provinces.

Nil

1900.

Medium flood. 88·75 at Naraj on 21st September; 64·70 at head of Kushbhadra; 52·17 at head of Daya.

Estimates sanctioned for filling breaches—
Kushbhadra Rs. 552.

Breach in 4th mile Kushbhadra left. Small breach in 39th mile, Bhargabi, right.

The railway embankment on the right of the Kawakhai caused more water to pass down the Katjuri and less down the Kawakhai than would otherwise have been the case; but for this it is probable that there would have been a breach in the Kushbhadra right in the 1st mile.

20. During this period of 22 years there were high floods in the years 1879, 1885, 1892, 1895, and 1896, medium floods in 1880, 1881, 1884, 1887, 1889, 1891, 1893, 1894, 1900, and low floods in the remainder. It would therefore appear that as an average about once in five years there may be expected a high flood which will, under existing conditions, breach embankments on all the rivers, and that in 14 years out of 22, that is in two out of three, the flood is high enough to cause breaches on the Kushbhadra and Bhargabi, but not on the Daya left, the right bank of this river being open to flood. The Committee of 1866 arrived at a somewhat similar result. They found (paragraph 30) that in 24 out of the 36 years, 1831-1832 to 1866-1867, the Puri district suffered more or less from inundation. As regards the expenditure which has been incurred in making good the breaches exact figures cannot be given, because in some cases specific estimates were not sanctioned for breach repairs, and in others the gap was closed by making a retired line of embankment.

21. We may now consider each of the three branches of the Kawakhai separately, and see—*first*, what the share of the flood is which it has to receive; *second*, what its capacity of discharge is and what volume has to be escaped; *third*, what it might cost (approximately) to provide permanent escapes; *fourth*, what the average cost (approximately) is of escaping under the present system, viz., by breaches which after the flood are made good. The right bank of the Kawakhai is liable to be breached in very high floods, but for the present this need not be considered.

22. *Kushbhadra*.—Mr. Rhind calculated* that in the flood of 1885 the Kushbhadra received at its head a

volume of 50,425 cusecs, and that as a maximum its discharge might be taken at 54,006 cusecs. Mr. Rhind's sections and calculations show that the capacity of the river almost at once reduces to about 30,000 cusecs, or possibly it might carry

* Paragraph 53 of report.

35,000, and this accounts for the large breach in the right bank which occurred in 1892, 1894, 1895, and 1896 in the 1st mile. It is then clear that it is desirable to provide for an escape of 20,000 cusecs somewhere near this place. Flood escaping on the right bank has to pass away by the Dhanua, while if it is escaped on the left bank it will pass first into the Prachi and then into the Deb. Having regard to the fact that the Dhanua has also to receive flood from the Bhargabi, I would suggest that 10,000 cusecs should be escaped on either bank. The cross sections show that as far as section No. 6, which is a little below Balipatna inspection bungalow and about 10 miles from the head, the river can pass 30,000 to 35,000 cusecs. At section No. 7 there is a great reduction in the capacity of discharge of the river, but from about this point the left bank is not embanked, and the right bank is only partially embanked. The flood distributes itself over the banks without causing any particular injury, and I do not think that anything is required for the present.

23. *Cost of escapes.*—As regards the cost of making permanent escapes, this depends chiefly on the supply of rubble stone which is available. We are fortunate in Orissa in having such a supply at many points and usually within a moderate distance of the place where it is required. The type of escape which I would propose to use is as follows:—I would select a piece of the bank where the natural ground surface is about 5 feet below the maximum flood line. I would pave this at a level 5 to 6 feet below the high flood line with rubble stone for a width of 75 feet, of which 25 feet would be horizontal and 50 feet inclined at a slope of 1 in 10. The length would be in accordance with the volume to be escaped and the ends of the embankment would be revetted. The factor which has to be assumed is the velocity with which the water will pass through the escape. It is hardly possible to calculate this, as the depth over the country and consequent fall in flood line between river level and country level which a certain volume escaping would give cannot be ascertained with any accuracy. By waiting till breaches have occurred and then noting the level of the inundation and calculating the volume passing through the breach, a fair approximation could no doubt be got. For the present I would assume a velocity of 6 feet per second as likely to obtain. This for a depth of 6 feet gives a discharge of 36 cusecs per foot run, so that to pass 10,000 cusecs would require a length of weir of 277 feet. I attach a

* No. 4 of plans.

† Appendix L.

type plan* of an escape and a note† of the cost at which rubble stone could be laid down at each of the sites at which, I think, escape weirs are desirable.

24. *Cost in case of Kushbhadra.*—In the present case the probable cost of two weirs each of 280 feet in length required for the Kushbhadra would be Rs. 7,300. During the ten years, 1891 to 1900, breaches occurred in the Kushbhadra embankments in six, and the amounts sanctioned for filling up the breaches aggregated Rs. 14,944. This gives an annual average of Rs. 1,494. I consider that it may fairly be assumed that if the escapes are made the outlay in filling breaches will almost entirely cease, and that allowing for interest on the money sunk in the escapes and for their upkeep, it would be a measure of economy to spend on the escapes any sum within 12 times the average cost of filling the breaches. In the present case therefore the outlay which might be prudently incurred is Rs. 17,928 as compared with Rs. 7,300 which the escapes might cost.

25. *Escapes required for Bhargabi.*—The volume entering the Bhargabi in 1885 is given by Mr. Rhind as 73,582 cusecs (Table No. 1). We may take 75,000 cusecs as the maximum volume to be dealt with. The lower part of the Bhargabi with its branch, the Kanchi, can dispose of 40,000 to 45,000 cusecs, and it appears sufficient to provide for the escape of 30,000 cusecs. At present this is being effected by the gap in the left bank at Adlabad which has been open since 1895, and through

which about half the volume in the river passes out continuously over the country. Owing to the fact that the Bhargabi and its branches are almost completely embanked, breaches prior to 1895 were numerous. Taking breaches and retired lines jointly in the ten years, 1885 to 1894, the estimates sanctioned aggregated Rs. 57,832, giving as an average Rs. 5,783 a year.

In the six years, 1895 to 1900, the similar estimates sanctioned have aggregated only Rs. 2,322, equivalent to Rs. 387 a year. It is therefore apparent that the gap at Adlabad has meant a very considerable saving to Government so far as the expenditure on embankments is concerned. Against this we have the statement of the Settlement Officer, already noticed, that it means an annual loss to Government of Rs. 4,000 in land revenue, and of course a much greater loss to the country. It seems to me that the present policy with respect to the gap is wrong, and that undue injury to the land and crop in the Dhanua basin is being caused without any physical or economical necessity.

I have shown above that it is necessary to allow for the escape from the Bhargabi of about 30,000 cusecs at a time of very high flood, and I propose to provide for 15,000 cusecs being passed to the Dhanua and a similar volume to the Rathanchira.

Experience shews that as far as the 6th mile the Bhargabi can, as at present embanked, contain the full volume of flood, and I would close the existing gap and open an escape somewhere near this place. This would probably be cheaper than building a weir across the gap which was the plan of dealing with the case which first occurred to me. A few miles lower down I would open a similar escape on the right bank at or near the place indicated on the general plan. Before deciding on the site, the effect on communications (Cuttack-Puri Road and Railway) should be considered. It might be better to have two or more smaller escapes. The cost of these works might be as shown in the table attached (Rs. 14,550), while it might cost about Rs. 4,500 to close the existing gap by a strong dam. If, as I think would be the case, the loss of Rs. 4,000 a year in the land revenue would, by these works, be avoided, an outlay of Rs 50,000 would be quite justified.

26. *Escapes for the Daya.*—The total volume of flood to be dealt with being 277,000 cusecs while the Kusbhadra and Bhargabi account for 129,000 cusecs, it follows that 148,000 cusecs have to be passed down the Daya valley. In 1881 the flood reading on the guage at the bifurcation of the Daya and Bhargabi was 53·97 and the flood passed down the Daya and over the right bank without apparently breaching the left bank. In 1885 the flood at the head of the Daya rose to 54·67, and the left bank was breached. In 1892 the flood rose to 55·67 and the left bank was breached. In 1895 with the guage at 52·47, the left bank was not breached. In 1896 with the guage at 53·67, the left bank was breached. It seems probable either that some of the gauge readings are not accurate, or that the reading on the gauge does not indicate exactly the volume of the flood passing. The reading recorded for 1881 at this gauge appears to be too high, as at Naraj the flood that year only rose to 89·25, while in 1895 it rose there to 90·55 and in 1896 to 92·10. What, however, does seem to be fairly established is that the Daya left embankment can pass a flood which does not rise higher than about 90·00 at Naraj and that it is breached by a flood which rises much above this. For the 1885 flood it is computed that 126,000 cusecs must have passed down the Daya, and the left bank could not stand this volume. Without attempting to be precise, it would appear that for the present it is desirable to open escapes in the left bank by which 50,000 cusecs may pass out at time of very high flood. The water so escaping will pass off to the Chilka by the Nun. The left embankment of the Daya was breached in 1885, 1892 and 1896, the amount sanctioned for repairing breaches being Rs. 8,655, Rs. 10,123, and Rs. 6,870, respectively. If we assume that

floods high enough to cause similar breaches occur once in five years, the annual charge for repairing them may be taken at $\text{Rs. } 2,656 + \text{Rs. } 10,123 + \text{Rs. } 6,170 = \text{Rs. } 1,709$. This would give $\text{Rs. } 1,709 \times 12 = \text{Rs. } 20,508$ as the amount which might be spent on escapes having regard only to the cost of maintenance of the embankment and ignoring such value as there may be to the country in having the escapes.

Two escapes might be provided in the 6th and 11th mile, respectively. In either case stone is available within a moderate distance. The cost of the escapes might be as shown in the note attached Rs. 15,700.

27. *Escapes will be an economy.*—It would seem then that it is desirable, from a financial as well as from an engineering point of view, to provide for the escape of the surplus flood water in the manner suggested. This is more especially the case on the Bhargabi and Kushbhadra branches. The Daya might be left till some experience had been gained on the other rivers as to the thickness and length of the rubble packing necessary in the apron. It might also very probably be better when stone is fairly cheap to make the gaps longer with the paved apron at a higher level, so that only the top 5 feet or even 4 feet of the flood might pass out, and that thus the escapes should not come into action sooner than really necessary.

28. *Legal position and claims for compensation.*—As I have already said, it is, I think, undoubtedly in the interest of the district, and consequently of the cultivators, as a whole, that the flood should be passed out of the rivers at fixed places, instead of through breaches the exact position of which cannot be foretold. It has, however, to be considered whether any claims for compensation might have to be met from those having rights in the land near the escapes. The Embankment Act which has force in Orissa, No. XXXII of 1855 (India), has no specific provision for the regulation or distribution of the volume of flood, which is in excess of what can be passed along the natural channels. Section IV, clause 4, however, gives to the Superintendent of Embankments power to "do all acts necessary and proper for the maintenance" of a public embankment. It is, I think, fairly arguable that the provision of escapes, by means of which the embankment as a whole will be secured, is an act proper for its maintenance. Section VII, clause 1 of the Act, provides for the award of compensation on account of damages which may be attributable to certain specified acts on the part of the Superintendent of Embankments. The construction of an escape is not exactly specified, but any claims that might arise could probably be dealt with under this section. In most of the cases there is no probability of such claims, because the escapes would be at places, where, or near where, breaches are common, and there is no doubt that the water flowing out of the escape will cause less damage than the water from a breach which throws up sand over the land in the neighbourhood.

In the case of the escape proposed for the Bhargabi on the right bank near the head of the Rathanchira drainage, the conditions are rather different. Since the gap at Adlabad in the left bank has been open, the right bank has been intact, and even before that it would appear that the worst breaches usually occurred in the left bank. It is therefore possible that there may be some opposition to the escape proposed in the right bank, or that some claims for compensation may be made. How far any claims of this nature would be recognized in a civil court I cannot say; but if any material injury should be caused by flood passing out of the escape, it would only be fair that the parties injured should receive compensation in some form. It is desired in the interest of the Government revenue as well as in the interest of the cultivators to lessen the flood discharge on the left bank, and this can only be done by sending some of the water over the country on the right.

29. *Duration of flood.*—The following, without pretending to great accuracy, will give some idea of the number of

days in a season during which flood may pass out of such an escape as is proposed. A gauge is maintained at Sainso on the Bhargabi about 12 miles from the head, and not very far from the place where it is desirable to have an escape in the right bank. It would appear that if the flood is to be allowed to pass with a depth of 6 feet over the floor of the escape at times of very high flood, such an escape at the 12th mile should begin to act when the river at this point attains a level of about R. L. 30.00. Judging from the observations of 1891, when there was a moderate flood in the Mahanadi and the Bhargabi was not breached till below the 12th mile, such a level corresponded roughly with a reading of 18 on the Bellevue gauge at Cuttack.

Allowing for the presence of the escape which it is proposed to make in the left bank at Adlabad some miles above this point, it is probable that little water would pass out till the Bellevue gauge rises to 20. This has always been regarded as the flood-point for the Puri district, experience having shown that lower floods do no harm. I

* Appendix No. II.

append a statement* showing for the ten years, 1892-

1901, the dates on which the river stood above 20 on the Bellevue gauge with the height attained.

In one year, 1899, it did not rise to this height at all. In two years 1897 and 1898, it rose just above 20 on one day in each year. In 1901 it was above 20 for three days only. In 1892 when there was a very high flood, but of short duration; it was over 20 for six days. In 1873 there were two low floods in August and September, and it was above 20 for nine days in all. In 1894 there were two moderate floods, and it was above 20 for eight days of July and four days in August. In 1895 the river was above 20 for 11 days in all. In 1896 there was the most prolonged flood of which we have any record, and it was above 20 for 22 days in all. In 1900 it was above 20 for ten days in September and for two days in October. Speaking generally, an escape of the nature proposed would not usually be discharging for more than eight days at a time.

30. *Chilka Lake.*—One of the features of the Puri district is the Chilka Lake through which the flood of the greater part of the district has to pass to the sea. The question of the reclamation of the bed of the lake is one which will no doubt come to the front some day, but it is hardly one for present action. As time goes on and the northern part of the lake is filled up by the mud brought down in the flood water, it will probably be desirable to form a defined channel for the flood water and to encourage the growth of silt deposit on parts of the bed by a system of banks and sluices by which the flood water can be admitted, while after the flood season the salt water can be excluded and a crop grown in the cold weather in a manner somewhat similar to the basin system of irrigation in Egypt.

31. *Sur Lake.*—There are also near Puri two basins of some size known as the Sur Lake and the Samang Pât. These receive and retain flood water, and in the winter and spring the low land is cultivated with the dalwa rice. The Sur Lake is embanked and within the limits of the embankments it covers an area of about 19 square miles. The embankments have been rather neglected of late years, chiefly owing to the injury done to them by the uncontrolled flood escaping from the Adlabad breach which takes them in rear. In my opinion the Sur Lake forms a very useful compensation reservoir to the Bhargabi, and I think the embankment should be kept in good order.

32. *Co-operation with Agricultural Department required.*—In connection with the question of the value to the country and to Government of such regulation or distribution of the flood as may be found practicable, it would seem desirable to determine with which department the initiation and examination of such projects should rest. I venture to suggest that the Agricultural Department should take the initiative. The Public Works Department can furnish

(15)

information as to what may be practicable and as to what the probable cost of works proposed may be. It would then be for the Agricultural Department to show that the benefits to be gained by the works would be sufficient to justify the outlay, and it would be for that Department to obtain the administrative sanction of Government. In a wider field I think that the same procedure should obtain with respect to small irrigation works, and that generally while the Departments of Agriculture and Public Works should work in co-operation, the former Department should be responsible for forecasts of revenue or other benefits to be obtained, and the latter for the estimates of outlay on the construction and on the maintenance of the works. There might perhaps, be a Board or Committee at head-quarters on the lines of the Sanitary Board with local Committees of which the Collector of the district would be a member.

W. A. INGLIS,

The 1st May 1902.

Supdg. Engineer, Orissa Circle.

APPENDIX I.

Note as to the rates at which rubble stone packing could be done at the proposed sites for escapes from the rivers in the Puri district from information furnished by RAI, PROBANNO KUMAR PAL, SAHIB, Honorary Assistant Engineer.

Sites of proposed escapes.	Name of quarry from which stone to be had.	Distance.	Cost of carting per 100 cubic feet.	Cost of quarrying including Royalty) 100 cubic feet.	Loading, unloading and stacking.	Cost of packing 100 cubic feet.	Total cost per 100 cubic feet.
1	2	3	4	5	6	7	8
		Miles.	Rs. A.	Rs. A.	As.	Rs.	Rs. A.
A.—At Jogisahi, 1st mile, Kushbadra right.	Garh Jharpara.	4	2 4	1 12	8	1	5 8
B.—At 4th mile, Kushbadra left	Ditto	5	2 12	1 12	8	1	6 0
C.—At Adlabad, left bank of Bhargabi.	Dhowli Hill	6	3 4	1 12	8	1	6 8
D.—Bhargabi right opposite head of Ruthanchira.	Hurirajpur	13	6 12	1 12	8	1	10 0
E.—At 5½ mile, Daya left ...	Dhowli Hill	3	1 12	1 12	8	1	5 0
F.—At 11th mile, Daya left ...	Hurirajpur	4	2 4	1 12	8	1	5 8

NOTE—Rate for carting 1st mile 12 annas per 100 and 8 annas extra for every additional mile. Royalty annas 4 per 100.

Taking the rates as given in the above, the approximate cost of the escapes proposed may be taken as follows.

In the plan which accompanies, the quantity of rubble stone in the revetment is 3,789 cubic feet on each flank, which, to be on the safe side, may be taken as 4,000 cubic feet; while in the body the quantity is 175 cubic feet per foot run. The earthwork may be taken at 500 cubic feet per foot run—

Kushbadra, 1st mile, right bank. Length of escape required 280 feet—

	C. ft.
Rubble in flanks ...	8,000
„ „ body 280 x 175 = ...	49,000
Total ...	57,000

	Rs. A.
At Rs. 5-8 per 100 = ...	3,135 0
Earthwork 280 x 500 = 14,000 at Rs. 2-8 per 1,000 ...	350 0
Total ...	3,485 0
Say ...	3,500 0

Kushbadra, 4th mile, left. Length of escape required 280 feet—

	Rs. A.
Rubble as above, 57,000, at Rs. 6 per 100 = ...	3,420 0
Earthwork as above ...	350 0
Total ...	3,770 0
Say ...	3,800 0

Bhargabi left bank near Adlabad. Length of escape required 420 feet—

	C. ft.
Rubble in flanks ...	8,000
„ „ body $420 \times 125 =$...	73,500
	<hr/>
Total ...	81,500

	Rs.	A.
At Rs. 6-8 per 100 = ...	5,297	5
Earthwork $420 \times 500 = 210,000$, at Rs. 2-8 per 1,000 ...	425	0
	<hr/>	
Total ...	5,722	5
	<hr/>	
Say ...	5,850	0
	<hr/>	

Bhargabi at about 12th mile, right bank, near head of Rathanchira. Length required 420 feet—

	Rs.	A.
Rubble as above, 81,500, at Rs. 10 per 100 = ...	8,150	0
Earthwork as above ...	425	0
	<hr/>	
Total ...	8,575	0
	<hr/>	
Say ...	8,700	0
	<hr/>	

Daya in 6th mile, left bank. Length of escape required 700 feet—

	C. ft.
Rubble in flanks ...	8,000
„ „ body $700 \times 175 =$...	122,500
	<hr/>
Total ...	130,500

	Rs.	A.
At Rs. 5 per 100 = ...	6,525	0
Earthwork $700 \times 500 = 350,000$ at Rs. 2-8 per 1,000 = ...	875	0
	<hr/>	
Total ...	7,400	0
	<hr/>	
Say ...	7,500	0
	<hr/>	

Daya in 11th mile, left bank. Length of escape required 700 feet—

	Rs.	A.
Rubble as above, 130,500, at Rs. 5-8 per 100 ...	7,178	0
Earthwork as above ...	875	0
	<hr/>	
Total ...	8,053	0
	<hr/>	
Say ...	8,200	0
	<hr/>	

Some payments may have to be made in acquiring land. The amounts allowed above in excess of the estimated cost of rubble and earthwork should cover this.

— OUTLINE MAP OF THE PURI DISTRICT —

— SHOWING RIVER CHANNELS WITH EMBANKMENTS —

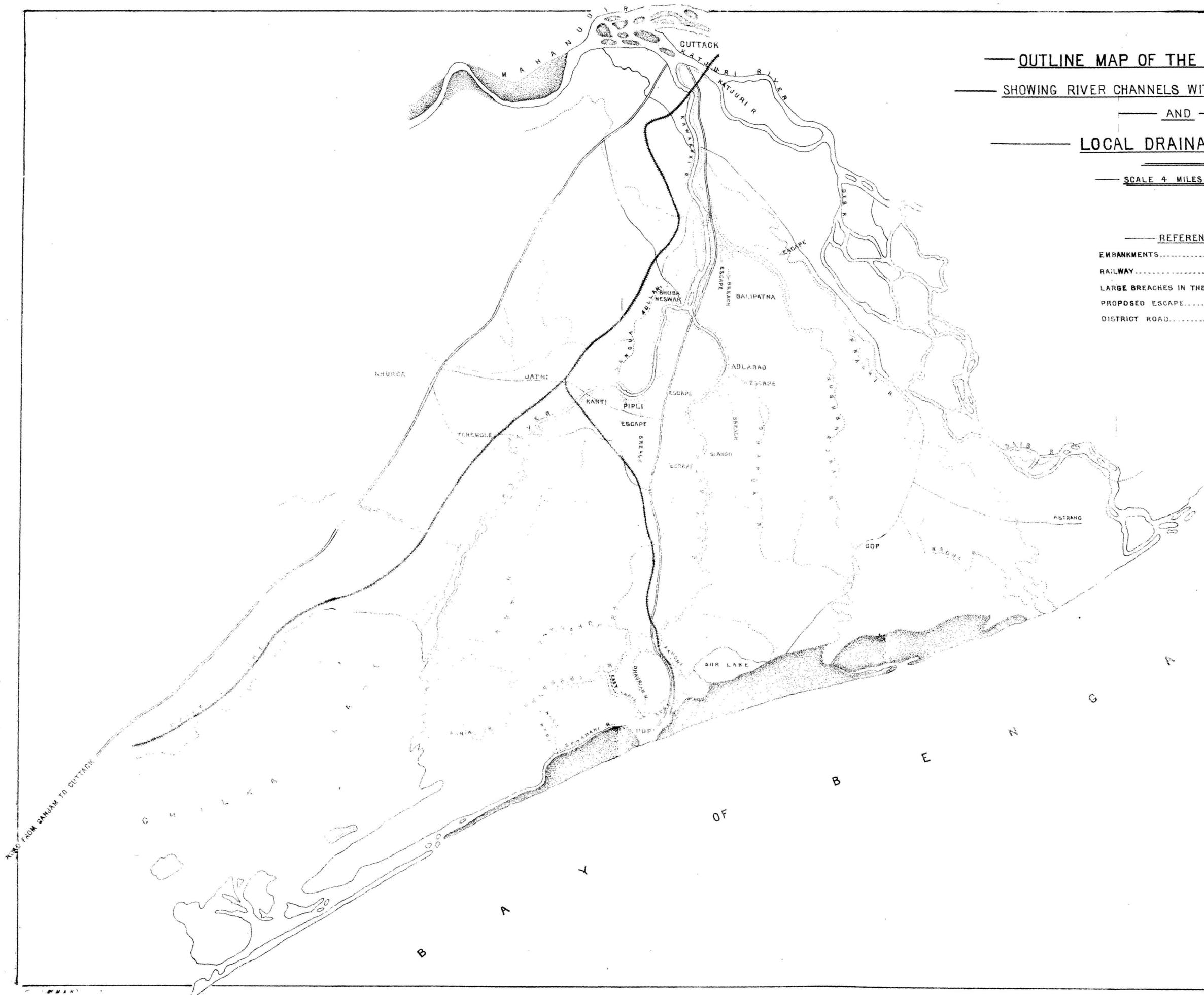
— AND —

— LOCAL DRAINAGE LINES —

— SCALE 4 MILES = 1 INCH —

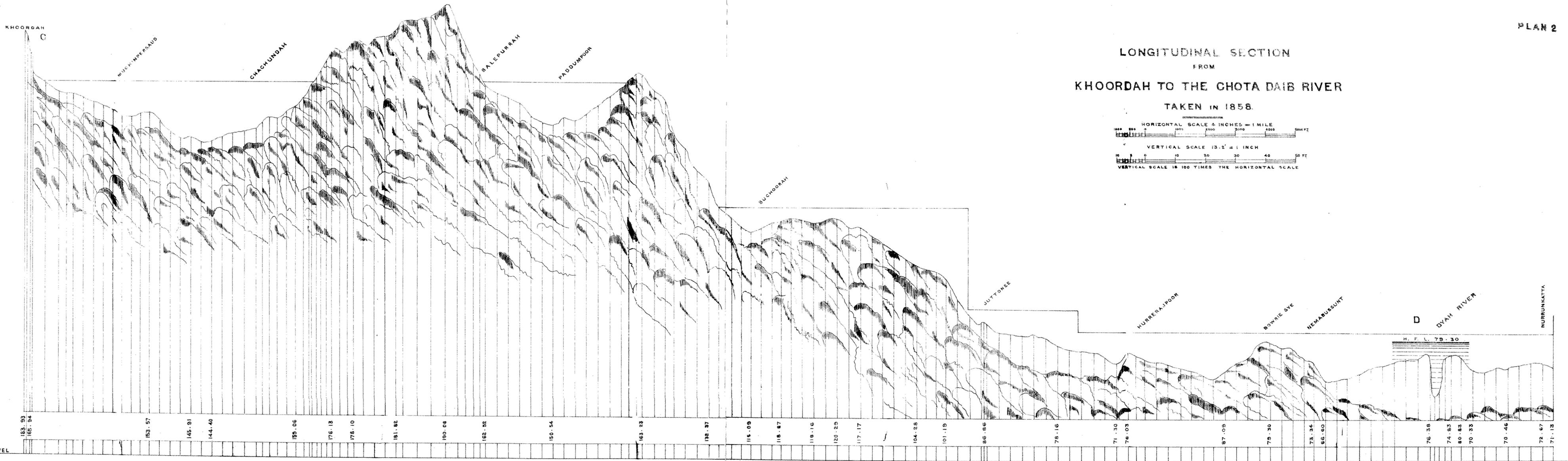
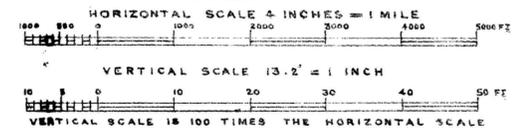
— REFERENCES —

- EMBANKMENTS.....
- RAILWAY.....
- LARGE BREACHES IN THE FLOOD OF 1896.....
- PROPOSED ESCAPE.....
- DISTRICT ROAD.....



ROAD FROM SANJUM TO CUTTACK

LONGITUDINAL SECTION
FROM
KHOORDAH TO THE CHOTA DAIB RIVER
TAKEN IN 1858.



(S^r) W. D. SHORT CAPTAIN
OFF^r SURVY EMBANKMENTS L.P.

(S^r) J. W. BEADLE
SURVY EMB^r
20.8.1858.

(S^r) JOHN HARRIS LIEN^r (S^r) W. A. ENGLIS.
IN CHARGE SURVY
CUTTACK RIVER.
SUPER^r ENGINEER
ORISSA CIRCLE
3.8.1902.



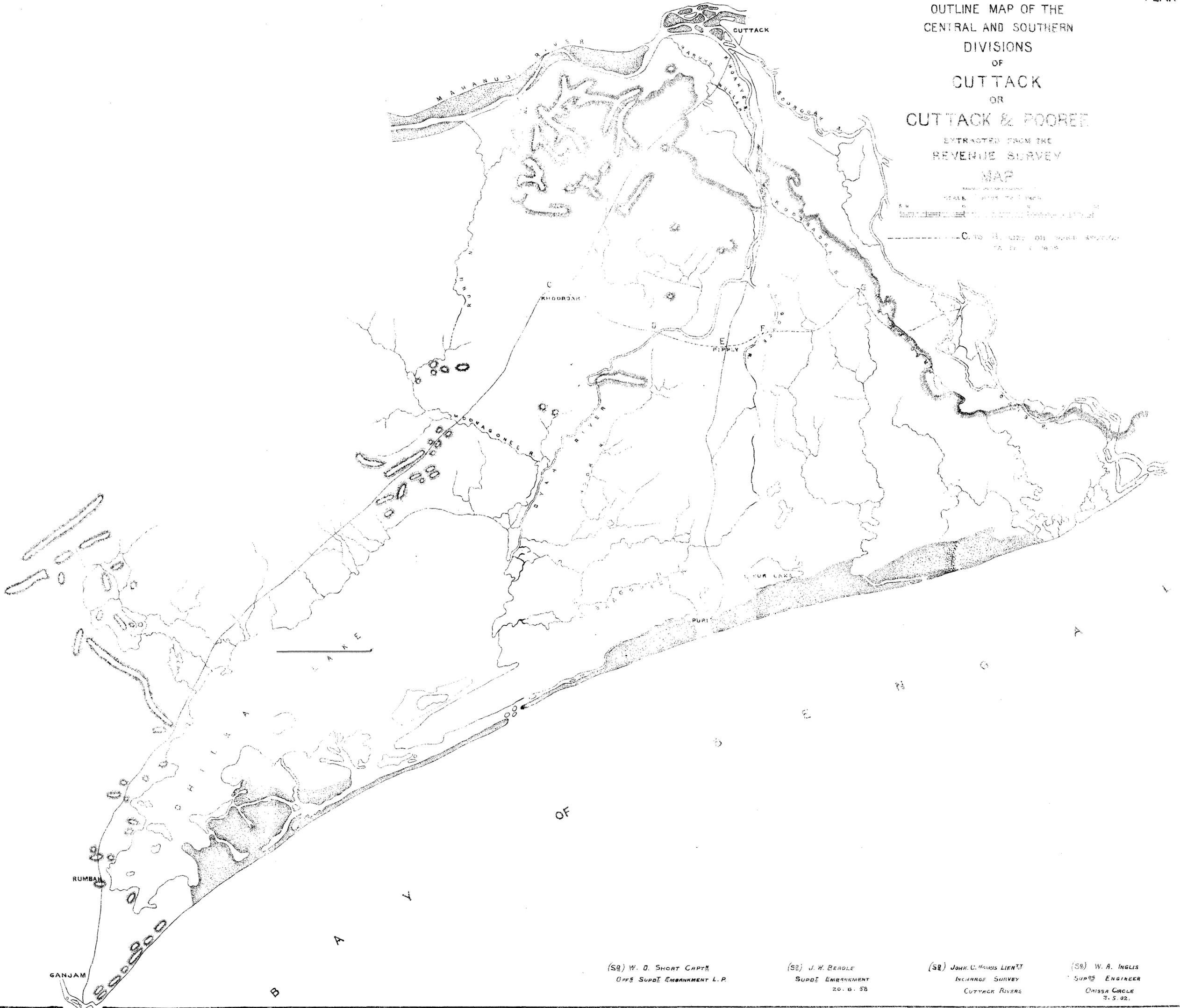
OUTLINE MAP OF THE
CENTRAL AND SOUTHERN
DIVISIONS
OF
CUTTACK
OR
CUTTACK & POOREE

EXTRACTED FROM THE
REVENUE SURVEY

MAP

SCALE 1 INCH TO 1 MILE
1:62,500

C. TO H. LINE ON ROAD SOUTH
TA 27 1 1905



(Sg) W. D. SHORT CAPT
OFFS SUPD EMBANKMENT L.P.

(Sg) J. W. BEADLE
SUPD EMBANKMENT
20. 8. 58

(Sg) JOHN C. HARRIS LIENT
INCHARGE SURVEY
CUTTACK RIVERS

(Sg) W. A. INGLIS
SUPD ENGINEER
ONISSA CIRCLE
3. 5. 02.

