

Govt. of 1874 Madras.
PUBLIC WORKS.

To Mr. Thornhill, Member
of the Board of Revenue

Dated

Recd.

Encl.

G. O. 29th Jan 1874, No. 215.

No. 426

Mr. Thornhill furnished
with an extract from the
Despatch from the Secy of
State for India exonerating
him from blame in
connection with the Madras
Water Works Project.

Proceedings of the Madras Government, Public Works Department,
30th January 1874.

No. 427. Read the following letter from J. W. RUNDALL, Esq., District Engineer, Tinnevely, to Colonel G. W. WALKER, R.E., Secretary to Government, Public Works Department, dated Palamcottah, 11th December 1873, No. 141:—

I HAVE the honour to request permission to demolish two of the out-houses attached to the late Artillery Barracks now occupied by the post-office.

2. The buildings in question were formerly used by the troops, one as a cook and the other as store room, and afterwards by the Department Public Works and are now unoccupied; I have lately inspected them, and am of opinion that the buildings should at once be removed; the buildings are in an unsafe condition and not worth repair.

3. Presuming that the buildings belong to the Military Department, I addressed the Commandant of the station to know if he objected to these being removed, but that officer states that the buildings are not included in his returns.

No. 428. ORDER THEREON, 30th January 1874, No. 216.

CIVIL WORKS, No. 29.

The demolition of the out-houses is sanctioned.

(True Extract.)

(Signed) G. W. WALKER, Colonel, R.E.,
Secretary to Government.

To the District Engineer, Tinnevely.

„ Officiating Controller of Public Works Accounts.

Exd. S. T. Austin.
Spare Copies

No. 41. District Engineer's Office Trinnevelly
Palanacottah 11th December 1873

I am,
J. W. Randall Esquire
District Engineer, Trinnevelly

To,
Colonel G. W. Walker R. G.
Secretary to Government P. W. D.

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to demolish two of the out houses attached to the
late Artillery Barracks now occupied by the
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Military Department, I addressed the Com-
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to these being removed, but that Officer states
that the buildings are not included within his return.

I have the honor to be

Sir,
Yours Most Obedt. Servt.
J. W. Randall

District Engineer

one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

50. Paragraph 70.—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

CHEPAUK,
10th April 1880.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

PUBLIC WORKS.

Colt. of 1874. 3000000.

The District Officer

Dated
Recd.
Encl.

G. O. 3000000 1874 216

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Building. The structure
of the two substances
attached to the lake
and the two small
buildings, the small
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Required for
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-ish line of the
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Barracks at the
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Leaked 11 3/4 hours
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Once: "

From the District Officer
to the District Officer
to the District Officer
to the District Officer

the demolition of the out-
houses

South India

to the District Officer
to the District Officer
to the District Officer
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R. H. SANKEY, Colonel, R.E.,
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to Mr. J. P. Smith
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OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. *Paragraph 3.*—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. *Paragraph 4.*—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. *Paragraph 5.*—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge ..	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge ..	43	10.00	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges south of Basin.					
0 0	Basin bridge	50-00	12-52	Masonry segmental arch		
0 4	Salt Cota bridge	29-66	8-64	Wooden bridge	12-17	11-94
0 6½	Elephant Gate bridge	49-00	10-94	Masonry segmental arch	8-64	8-64
0 7	Central Station Railway bridge	64-00	9-35	Iron girder bridge	10-52	10-28
1 4½	General Hospital bridge	49-00	11-04	Masonry segmental arch	9-35	9-35
1 6	Saint Mary's bridge	13-91	7-03	Wooden bridge	10-62	10-38
2 3	Government House bridge	29-00	11-49	Do. metalled	7-03	7-03
3 0	Marine Villa	32-00	10-40	Masonry segmental arch	11-49	11-49
3 2	Chepauk bridge	19-83	10-92	Iron piles rough stone abutments.	9-74	9-53
3 6	Pycroft's road bridge	19-62	10-92	Masonry segmental arch	10-92	10-92
3 7½	Soonkarammah Street bridge	19-62	11-29	Do. do.	9-92	9-17
4 2	Ice House road	20-17	11-52	Masonry and wooden platform.	10-29	9-54
4 6½	Elliott's road	19-83	11-68	Masonry segmental arch	11-52	11-52
5 0	Barber's bridge	20-17	11-77	Masonry semicircular arch	10-68	9-93
5 3½	Moondacunny Covil road bridge	27-33	9-71	Masonry and wooden platform.	10-44	9-35
5 6	Cutcherry road	20-00	13-22	Do. do.	9-71	9-71
5 6½	Brodie's road bridge	19-58	10-42	Masonry semicircular arch	13-22	13-22
6 3	Poonthotum aqueduct	20-17	10-89	Do. do.	9-09	8-00
6 3	Yellapatha Mauda Covil road	20-42	10-05	Masonry wooden platform	9-68	8-77
7 1½	Soolay Cauthoy Syphon	20-25	9-22	Do. do.	10-05	10-05
7 1½	Greenaway's bridge	21-83	10-00	Do. do.	9-22	9-22
8 0	Guindy bridge, span excluding tow paths.	21-00	13-03	Masonry segmental arch, skew	10-00	10-00
10 0	Lattice bridge do. do.	45-00	15-42	Masonry elliptical arch	12-03	11-03
42 0	Sadras bridge do. do.	43-00	12-14	Masonry abutments and wooden structure.	15-17	15-09
45 0	Ismalpett bridge do. do.	43-75	13-83	Masonry elliptical arch	12-14	12-14
		35-00	14-75	Masonry semicircular arch	13-58	13-50
					14-38	14-13

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.
6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.
7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.
8. Paragraph 9.—Agreed.
9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.
10. Paragraph 12.—New bridges should be provided for, but the removal of the present structures is not a matter of urgency.
11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to remove this lock and take a new isolated channel from 6 M. 6 F. through the ground to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.
12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep portion of canal between 17 M. and 19 M. might be included in this new line. Owing to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.
13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

18. Whether a flood-gate would be needed at the southern extremity near the Pulicat bar is not as yet clear.

19. Paragraph 22.—From Cusbah, 45 M., northwards a strong west bank, well above flood level, is essential, and the canal should be isolated up to 68 M., where a flood-gate may be placed. An interval will here have to be left for the passage of flood water, and the new cut to the west of the backwater, as suggested by Major Vibart, made up to Dugarápatnam, 69 M. This short portion will also need to be isolated by flood-gates at either end. The proposed basin at Dugarápatnam should, as elsewhere, consist of a simple widening of the channel.

20. Paragraph 24.—If on further inquiry the drainage which enters at 71 M. 5 F. cannot safely be barred from entering the canal, a flood-gate must be placed a little north. I do not consider a sluice weir, as proposed here, to be suitable. Another flood-gate will be needed a little south of the Swarnamukhi river. This reach of canal, 4 miles in length, will thus, with the embankments proposed, be thoroughly isolated in case of flood.

21. Paragraph 25.—The crossing of the Swarnamukhi river is a complicated matter, and calls for further examination. So far as can be judged, Major Vibart's proposed deviation from a point near the village of Govindapulli to Mullapulli, combined with training the river by means of embankments and strongly constructed cross bunds east and west, appears to hold out the best solution.

22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

23. Paragraph 30.—The Kistnapatam basin must be extended as proposed. A flood-gate will be required south of the basin, and as regards the canal to the north, the banks must be raised and the channel isolated.

24. Paragraph 31.—At Nellatoor it will be necessary to cut a fresh channel for nearly two miles (95 M. 4 F. to 97 M. 6 F.,) a little east of the present line in rather higher ground, thus leaving the present channel free for the passage of drainage.

25. *Paragraph 32.*—The whole of the drainage here must be collected and passed across the channel at one point.

26. *Paragraph 33.*—Here again, of the three openings the central one must be kept clear for the passage of the drainage, closing the others.

27. *Paragraph 34.*—The Pennér river (114 M. 3 F. to 116 M. 6 F.) crossing is probably the most difficult matter to deal with in the length of the canal. Some Rs. 11,000 were spent in taking the silt out of the cut here (115 M. 4 F. and 116 M. 3 F.) within the first year of opening the canal, and in both the cyclones of 1879 not only has the same cut again silted up to within 9 inches of L.W.L., but the several branches of the river, five in number, show such a tendency to change their course that it has become a serious matter for consideration as to how the canal can here be kept open for traffic. Even were steam-dredges available, the canal would still be closed after each ordinary fresh in the river to all but top-boats and others of very light draft taking advantage of high tide, and the stoppage would be absolute after a cyclone flood of any intensity. No mere palliatives will therefore answer here, and my conviction is that the best and, in the end, by far the most economical course will be to train the Pennér in such a way from the head of its delta that the discharge shall take place entirely through its southernmost channel, closing all the others. This can be done by training the river from a point near the village of Utakoor, about three miles west of the canal, on the left bank. At the same time, groynes should be so constructed on the right bank, a little north of Kuddipalem, that the present line of river bank and the flood embankment within it shall be preserved from invasion. The left embankment would probably extend from Utakoor to the destroyed village of Palipalem. By this means not only would a sufficiently deep channel be always preserved in the southern branch of the river, but by closing the canal ends north and south with flood-gates, these would be preserved from the silting which now causes the difficulty. I do not consider that there should be any serious difficulty in training the Pennér as proposed, but further careful study of all the features is necessary.

28. *Paragraphs 37 and 38.*—Banking across the Ramatheertham drainage is inadmissible; it will be essential to cut a new line, of about six furlongs in length, to the west of the present line, so as to avoid getting dangerously close to the bar.

29. *Paragraphs 39 and 40.*—As with the Ramatheertham so with the Pydaru (123 M. 6 F.) and the Eskapally (126 M.) drainages, free vent must be allowed across the line of canal, but a strong west bank to keep out floods should be constructed. Whether it will be necessary eventually to isolate each of these portions with flood-gates (that at 117 M. is essential) cannot however be decided with certainty.

30. *Paragraph 42.*—The plan suggested of training the river so as to occupy and deepen out its central channel, and further to make a new cut to the west, of about two miles long, through ground 3 or 4 feet above M.S.L., seem essential. Since the cyclone of May 1879 the existing channel through the backwater has changed no less than four times.

31. Flood-gates will be required, one north of the Chippelairoo, at probably 134 M. and another at the 148 M. 2 F.

32. *Paragraph 46.*—The Ramapatam drainage, which enters at 148 M. 3 F. might have its outlet to the sea barred permanently, and the drainage thus taken into the canal utilised with a view to bringing a beneficial scour to bear on the northern portion towards the Elikeru.

33. *Paragraph 47.*—As regards this drainage it will be best to embank across the northern outlet, placing a flood-gate at 151 M. leaving the present southern opening (150 M. 6 F. to 150 M. 7 F.) free to discharge by the open bar.

34. To prevent the silting of the channel south of the Manneru, a flood-gate will be necessary at about 160 M.

35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment, but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878 some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Palaru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing channel should be closed, cleared and deepened, opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalam, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened; and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The laterite bridge, which with its nine elliptical arches of 18 feet span carries off all the residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. *Paragraphs 59, 60, 61.*—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

45. *Paragraph 62.*—The crossing of the Gundlakamma river calls for no special remark.

46. *Paragraph 63.*—As regards the proposals in this paragraph I have seen reason for the present at least to prefer flood-gates nearly everywhere to locks, the grounds for which will be found elsewhere.

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one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

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CHEPAUK,
10th April 1880.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

Appendix to G.O., No. 284 W., of 6th February 1880.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. Paragraph 3.—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. Paragraph 4.—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. Paragraph 5.—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge ..	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge ..	43	10.00	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
Bridges south of Basin.						
0 0	Basin bridge	50-00	12-52	Masonry segmental arch ..	12-17	11-94
0 4	Salt Cotaar bridge	29-66	*8-64	Wooden bridge	8-64	8-64
0 6½	Elephant Gate bridge	49-00	10-94	Masonry segmental arch ..	10-52	10-28
0 7	Central Station Railway bridge ..	64-00	9-35	Iron girder bridge	9-35	9-35
1 4½	General Hospital bridge	49-00	11-04	Masonry segmental arch ..	10-62	10-38
1 4½	South Indian Railway bridge ..	13-91	7-03	Wooden bridge	7-03	7-03
1 6	Saint Mary's bridge	29-00	11-49	Do. metalled	11-49	11-49
2 3	Government House bridge	32-00	10-40	Masonry segmental arch ..	9-74	9-53
3 0	Marine Villa	19-83	10-92	Iron piles rough stone abutments.	10-92	10-92
3 2	Chepauk bridge	19-62	10-92	Masonry segmental arch ..	9-92	9-17
3 6	Pycroft's road bridge	19-62	11-29	Do. do.	10-29	9-54
3 7½	Soonkarammah Street bridge ..	20-17	11-52	Masonry and wooden platform.	11-52	11-52
4 2	Ice House road	19-83	11-68	Masonry segmental arch ..	10-68	9-93
4 6½	Elliott's road	20-17	11-77	Masonry semicircular arch ..	10-44	9-35
5 0	Barber's bridge	27-33	9-71	Masonry and wooden platform.	9-71	9-71
5 3½	Moondacunny Covil road bridge ..	20-00	13-22	Do. do.	13-22	13-22
5 6	Cutcherry road	19-58	10-42	Masonry semicircular arch ..	9-09	8-00
5 6½	Brodie's road bridge	20-17	10-89	Do. do.	9-68	8-77
6 3	Poonthotum aqueduct	20-42	10-05	Masonry wooden platform ..	10-05	10-05
6 3	Yellapatha Mauda Covil road ..	20-25	9-22	Do. do.	9-22	9-22
7 1½	Soolay Cauthoy Syphon	21-83	10-00	Do. do.	10-00	10-00
8 0	Greenaway's bridge	21-00	13-03	Masonry segmental arch, skew ..	12-03	11-03
8 0	Guindy bridge, span excluding tow paths.	45-00	15-42	Masonry elliptical arch ..	15-17	15-09
10 0	Lattice bridge do. do. ..	43-00	12-14	Masonry abutments and wooden structure.	12-14	12-14
42 0	Sadras bridge do. do. ..	43-75	13-83	Masonry elliptical arch ..	13-58	13-50
45 0	Isalpett bridge do. do. ..	35-00	14-75	Masonry semicircular arch ..	14-38	14-13

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.

6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.

7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.

8. Paragraph 9.—Agreed.

9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.

10. Paragraph 12.—New bridges should be provided for, but the removal of the present structures is not a matter of urgency.

11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to remove this lock and take a new isolated channel from 6 M. 6 F. through the ground to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.

12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.

13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

18. Whether a flood-gate would be needed at the southern extremity near the Pulicat bar is not as yet clear.

19. Paragraph 22.—From Cusbah, 45 M., northwards a strong west bank, well above flood level, is essential, and the canal should be isolated up to 63 M., where a flood-gate may be placed. An interval will here have to be left for the passage of flood water, and the new cut to the west of the backwater, as suggested by Major Vibart, made up to Dugarápatnam, 69 M. This short portion will also need to be isolated by flood-gates at either end. The proposed basin at Dugarápatnam should, as elsewhere, consist of a simple widening of the channel.

20. Paragraph 24.—If on further inquiry the drainage which enters at 71 M. 5 F. cannot safely be barred from entering the canal, a flood-gate must be placed a little north. I do not consider a sluice weir, as proposed here, to be suitable. Another flood-gate will be needed a little south of the Swarnamukhi river. This reach of canal, 4 miles in length, will thus, with the embankments proposed, be thoroughly isolated in case of flood.

21. Paragraph 25.—The crossing of the Swarnamukhi river is a complicated matter, and calls for further examination. So far as can be judged, Major Vibart's proposed deviation from a point near the village of Govindapulli to Mullapulli, combined with training the river by means of embankments and strongly constructed cross bunds east and west, appears to hold out the best solution.

22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

23. Paragraph 30.—The Kistnapatam basin must be extended as proposed. A flood-gate will be required south of the basin, and as regards the canal to the north, the banks must be raised and the channel isolated.

24. Paragraph 31.—At Nellatoor it will be necessary to cut a fresh channel for nearly two miles (95 M. 4 F. to 97 M. 6 F.,) a little east of the present line in rather higher ground, thus leaving the present channel free for the passage of drainage.

25. *Paragraph 32.*—The whole of the drainage here must be collected and passed across the channel at one point.

26. *Paragraph 33.*—Here again, of the three openings the central one must be kept clear for the passage of the drainage, closing the others.

27. *Paragraph 34.*—The Pennér river (114 M. 3 F. to 116 M. 6 F.) crossing is probably the most difficult matter to deal with in the length of the canal. Some Rs. 11,000 were spent in taking the silt out of the cut here (115 M. 4 F. and 116 M. 3 F.) within the first year of opening the canal, and in both the cyclones of 1879 not only has the same cut again silted up to within 9 inches of L.W.L., but the several branches of the river, five in number, show such a tendency to change their course that it has become a serious matter for consideration as to how the canal can here be kept open for traffic. Even were steam-dredges available, the canal would still be closed after each ordinary fresh in the river to all but top-boats and others of very light draft taking advantage of high tide, and the stoppage would be absolute after a cyclone flood of any intensity. No mere palliatives will therefore answer here, and my conviction is that the best and, in the end, by far the most economical course will be to train the Pennér in such a way from the head of its delta that the discharge shall be done by training the river from a point near the village of Utakoor, about three miles west of the canal, on the left bank. At the same time, groynes should be so constructed on the right bank, a little north of Kuddipalem, that the present line of river bank and the flood embankment within it shall be preserved from invasion. The left embankment would probably extend from Utakoor to the destroyed village of Palipalem. By this means not only would a sufficiently deep channel be always preserved in the southern branch of the river, but by closing the canal ends north and south with flood-gates, these would be preserved from the silting which now causes the difficulty. I do not consider that there should be any serious difficulty in training the Pennér as proposed, but further careful study of all the features is necessary.

28. *Paragraphs 37 and 38.*—Banking across the Ramatheertham drainage is inadmissible; it will be essential to cut a new line, of about six furlongs in length, to the west of the present line, so as to avoid getting dangerously close to the bar.

29. *Paragraphs 39 and 40.*—As with the Ramatheertham so with the Pydaru (123 M. 6 F.) and the Eskapally (126 M.) drainages, free vent must be allowed across the line of canal, but a strong west bank to keep out floods should be constructed. Whether it will be necessary eventually to isolate each of these portions with flood-gates (that at 117 M. is essential) cannot however be decided with certainty.

30. *Paragraph 42.*—The plan suggested of training the river so as to occupy and deepen out its central channel, and further to make a new cut to the west, of about two miles long, through ground 3 or 4 feet above M.S.L., seem essential. Since the cyclone of May 1879 the existing channel through the backwater has changed no less than four times.

31. Flood-gates will be required, one north of the Chippelairoo, at probably 134 M. and another at the 148 M. 2 F.

32. *Paragraph 46.*—The Ramapatam drainage, which enters at 148 M. 3 F. might have its outlet to the sea barred permanently, and the drainage thus taken into the canal utilised with a view to bringing a beneficial scour to bear on the northern portion towards the Elikeru.

33. *Paragraph 47.*—As regards this drainage it will be best to embank across the northern outlet, placing a flood-gate at 151 M. leaving the present southern opening (150 M. 6 F. to 150 M. 7 F.) free to discharge by the open bar.

34. To prevent the silting of the channel south of the Manneru, a flood-gate will be necessary at about 160 M.

35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment, but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878 some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Paleru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing channel closed by temporary banks and opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The laterite bridge, which with its nine elliptical arches of 18 feet span carries off all the residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. *Paragraphs 59, 60, 61.*—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

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48. *Paragraphs 66, 67, 68.*—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

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50. *Paragraph 70.*—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

CHEPAUK,
10th April 1880.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

Appendix to G.O., No. 281 W., of 6th February 1880.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER, 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. *Paragraph 3.*—For sanitary purposes it is most desirable that the level of the water in the Coom and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. *Paragraph 4.*—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. *Paragraph 5.*—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Coom when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge ..	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge ..	43	10.00	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
Bridges south of Basin.						
0 0	Basin bridge	50-00	12-52	Masonry segmental arch ..	12-17	11-94
0 4	Salt Cotaar bridge	29-66	8-64	Wooden bridge	8-64	8-64
0 6½	Elephant Gate bridge	49-00	10-94	Masonry segmental arch ..	10-52	10-28
0 7	Central Station Railway bridge ..	64-00	9-35	Iron girder bridge	9-35	9-35
1 4½	General Hospital bridge	49-00	11-04	Masonry segmental arch ..	10-62	10-38
1 6	South Indian Railway bridge ..	13-91	7-03	Wooden bridge	7-03	7-03
1 6	Saint Mary's bridge	29-00	11-49	Do. metalled	11-49	11-49
2 3	Government House bridge	32-00	10-40	Masonry segmental arch ..	9-74	9-53
3 0	Marine Villa	19-83	10-92	Iron piles rough stone abutments.	10-92	10-92
3 2	Chepauk bridge	19-62	10-92	Masonry segmental arch ..	9-92	9-17
3 6	Pycroft's road bridge	19-62	11-29	Do. do.	10-29	9-54
3 7½	Soonkarammah Street bridge ..	20-17	11-52	Masonry and wooden platform.	11-52	11-52
4 2	Ice House road	19-83	11-68	Masonry segmental arch ..	10-68	9-93
4 6½	Elliott's road	20-17	11-77	Masonry semicircular arch ..	10-44	9-35
5 0	Barber's bridge	27-33	9-71	Masonry and wooden platform.	9-71	9-71
5 3½	Moondacunny Covil road bridge ..	20-00	13-22	Do. do.	13-22	13-22
5 6	Cutcherry road	19-58	10-42	Masonry semicircular arch ..	9-09	8-00
5 6½	Brodie's road bridge	20-17	10-89	Do. do.	9-68	8-77
6 3	Poonthotum aqueduct	20-42	10-05	Masonry wooden platform ..	10-05	10-05
6 3	Yellapatha Mauda Covil road ..	20-25	9-22	Do. do.	9-22	9-22
7 1½	Soolay Cauthoy Syphon	21-83	10-00	Do. do.	10-00	10-00
8 0	Guindy bridge, span excluding tow paths.	21-00	13-03	Masonry segmental arch, skew ..	12-03	11-03
10 0	Lattice bridge do. do. ..	45-00	15-42	Masonry elliptical arch ..	15-17	15-09
42 0	Sadras bridge do. do. ..	43-00	12-14	Masonry abutments and wooden structure.	12-14	12-14
45 0	Ismalpett bridge do. do. ..	43-75	13-83	Masonry elliptical arch ..	13-58	13-50
		35-00	14-75	Masonry semicircular arch ..	14-38	14-13

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.

6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.

7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.

8. Paragraph 9.—Agreed.

9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.

10. Paragraph 12.—New bridges should be provided for, but the removal of the present structures is not a matter of urgency.

11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.

12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.

13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

18. Whether a flood-gate would be needed at the southern extremity near the Pulicat bar is not as yet clear.

19. Paragraph 22.—From Cusbah, 45 M., northwards a strong west bank, well above flood level, is essential, and the canal should be isolated up to 68 M., where a flood-gate may be placed. An interval will here have to be left for the passage of flood water, and the new cut to the west of the backwater, as suggested by Major Vibart, made up to Dugarápatnam, 69 M. This short portion will also need to be isolated by flood-gates at either end. The proposed basin at Dugarápatnam should, as elsewhere, consist of a simple widening of the channel.

20. Paragraph 24.—If on further inquiry the drainage which enters at 71 M. 5 F. cannot safely be barred from entering the canal, a flood-gate must be placed a little north. I do not consider a sluice weir, as proposed here, to be suitable. Another flood-gate will be needed a little south of the Swarnamukhi river. This reach of canal, 4 miles in length, will thus, with the embankments proposed, be thoroughly isolated in case of flood.

21. Paragraph 25.—The crossing of the Swarnamukhi river is a complicated matter, and calls for further examination. So far as can be judged, Major Vibart's proposed deviation from a point near the village of Govindapulli to Mullapulli, combined with training the river by means of embankments and strongly constructed cross bunds east and west, appears to hold out the best solution.

22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

23. Paragraph 30.—The Kistnapatnam basin must be extended as proposed. A flood-gate will be required south of the basin, and as regards the canal to the north, the banks must be raised and the channel isolated.

24. Paragraph 31.—At Nellatoor it will be necessary to cut a fresh channel for nearly two miles (95 M. 4 F. to 97 M. 6 F.) a little east of the present line in rather higher ground, thus leaving the present channel free for the passage of drainage.

25. *Paragraph 32.*—The whole of the drainage here must be collected and passed across the channel at one point.

26. *Paragraph 33.*—Here again, of the three openings the central one must be kept clear for the passage of the drainage, closing the others.

27. *Paragraph 34.*—The Pennér river (114 M. 3 F. to 116 M. 6 F.) crossing is probably the most difficult matter to deal with in the length of the canal. Some Rs. 11,000 were spent in taking the silt out of the cut here (115 M. 4 F. and 116 M. 3 F.) within the first year of opening the canal, and in both the cyclones of 1879 not only has the same cut again silted up to within 9 inches of L.W.L., but the several branches of the river, five in number, show such a tendency to change their course that it has become a serious matter for consideration as to how the canal can here be kept open for traffic. Even were steam-dredges available, the canal would still be closed after each ordinary fresh in the river to all but top-boats and others of very light draft taking advantage of high tide, and the stoppage would be absolute after a cyclone flood of any intensity. No mere palliatives will therefore answer here, and my conviction is that the best and, in the end, by far the most economical course will be to train the Pennér in such a way from the head of its delta that the discharge shall take place entirely through its southernmost channel, closing all the others. This can be done by training the river from a point near the village of Utakoor, about three miles west of the canal, on the left bank. At the same time, groynes should be so constructed on the right bank, a little north of Kuddipalem, that the present line of river bank and the flood embankment within it shall be preserved from invasion. The left embankment would probably extend from Utakoor to the destroyed village of Palipalem. By this means not only would a sufficiently deep channel be always preserved in the southern branch of the river, but by closing the canal ends north and south with flood-gates, these would be preserved from the silting which now causes the difficulty. I do not consider that there should be any serious difficulty in training the Pennér as proposed, but further careful study of all the features is necessary.

28. *Paragraphs 37 and 38.*—Banking across the Ramatheertham drainage is inadmissible; it will be essential to cut a new line, of about six furlongs in length, to the west of the present line, so as to avoid getting dangerously close to the bar.

29. *Paragraphs 39 and 40.*—As with the Ramatheertham so with the Pydaru (123 M. 6 F.) and the Eskapally (126 M.) drainages, free vent must be allowed across the line of canal, but a strong west bank to keep out floods should be constructed. Whether it will be necessary eventually to isolate each of these portions with flood-gates (that at 117 M. is essential) cannot however be decided with certainty.

30. *Paragraph 42.*—The plan suggested of training the river so as to occupy and deepen out its central channel, and further to make a new cut to the west, of about two miles long, through ground 3 or 4 feet above M.S.L., seem essential. Since the cyclone of May 1879 the existing channel through the backwater has changed no less than four times.

31. Flood-gates will be required, one north of the Chippelairoo, at probably 134 M. and another at the 148 M. 2 F.

32. *Paragraph 46.*—The Ramapatam drainage, which enters at 148 M. 3 F. might have its outlet to the sea barred permanently, and the drainage thus taken into the canal utilised with a view to bringing a beneficial scour to bear on the northern portion towards the Elikeru.

33. *Paragraph 47.*—As regards this drainage it will be best to embank across the northern outlet, placing a flood-gate at 151 M. leaving the present southern opening (150 M. 6 F. to 150 M. 7 F.) free to discharge by the open bar.

34. To prevent the silting of the channel south of the Manneru, a flood-gate will be necessary at about 160 M.

35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment, but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878, some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Paleru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing channel should be closed, cleared and deepened, opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The laterite bridge, which with its nine elliptical arches of 18 feet span carries off all the residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. Paragraphs 59, 60, 61.—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

45. Paragraph 62.—The crossing of the Gundlakamma river calls for no special remark.

46. Paragraph 63.—As regards the proposals in this paragraph I have seen reason for the present at least to prefer flood-gates nearly everywhere to locks, the grounds for which will be found elsewhere.

47. Paragraph 64.—For five miles north of the Gundlakamma river the canal is exposed to serious wash, particularly at two places where bars opened in the November cyclone, and which must therefore be left free of any obstruction. To all appearances, however, the spill water from the Gundlakamma might, as suggested by Sub-Engineer Ottmann, be effectually checked by constructing a strong training bank along the left bank of the river, two or three miles in length, and diverting the drainage from the Kanuparti swamp. The alternative to this plan would be to construct a strong west bank all along the canal. In addition to protection on the west, a well-planted east bank is also needed at two places, but only for short lengths. Major Vibart has suggested an entirely new channel between $199\frac{1}{2}$ and $191\frac{1}{2}$ M. but as the object here must be to get sufficiently inland from the Kanuparti bar, to which the present line is dangerously near, it will suffice to make the new cut to the westward of only three furlongs in length at a distance of 200 yards from the existing channel.

48. Paragraphs 66, 67, 68.—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

49. Paragraph 69.—The reasoning here employed by Major Vibart in favor of isolating the different reaches of the canal which intervene between drainages that cannot safely, particularly during flood, be barred in the passage to the sea, derives additional force from the effects of the November cyclone which followed on the

one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

50. Paragraph 70.—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

CHEPAUK,
10th April 1880.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

Appendix to G.O., No. 284 W., of 6th February 1880.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

Paragraph 3.—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

Paragraph 4.—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

Paragraph 5.—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
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M. P.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge ..	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge ..	43	10.00	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

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M. F.	Bridges south of Basin.					
0 0	Basin bridge ..	50-00	12-52	Masonry segmental arch ..	12-17	11-94
0 4	Salt Cotaar bridge ..	29-66	8-64	Wooden bridge ..	8-64	8-64
0 6½	Elephant Gate bridge ..	49-00	10-94	Masonry segmental arch ..	10-52	10-28
0 7	Central Station Railway bridge ..	64-00	9-35	Iron girder bridge ..	9-35	9-35
1 4½	General Hospital bridge ..	49-00	11-04	Masonry segmental arch ..	10-62	10-38
1 6	South Indian Railway bridge ..	43-91	7-03	Wooden bridge ..	7-03	7-03
2 3	Saint Mary's bridge ..	29-00	11-49	Do. metalled ..	11-49	11-49
3 0	Government House bridge ..	32-00	10-40	Masonry segmental arch ..	9-74	9-53
3 2	Marine Villa ..	19-83	10-92	Iron piles rough stone abutments.	10-92	10-92
3 6	Chepauk bridge ..	19-62	10-92	Masonry segmental arch ..	9-92	9-17
3 7½	Pycroft's road bridge ..	19-62	11-29	Do. do. ..	10-29	9-54
4 2	Soonkarammah Street bridge ..	20-17	11-52	Masonry and wooden platform.	11-52	11-52
4 6½	Ice House road ..	19-83	11-68	Masonry segmental arch ..	10-68	9-93
5 0	Elliot's road ..	20-17	11-77	Masonry semicircular arch ..	10-44	9-35
5 3½	Barber's bridge ..	27-33	9-71	Masonry and wooden platform.	9-71	9-71
5 5	Moondacunny Covil road bridge ..	20-00	13-22	Do. do. ..	13-22	13-22
5 5½	Cutcherry road ..	19-58	10-42	Masonry semicircular arch ..	9-09	8-00
6 3	Brodie's road bridge ..	20-17	10-89	Do. do. ..	9-68	8-77
6 3	Poonthotum aqueduct ..	20-42	10-05	Masonry wooden platform ..	10-05	10-05
7 1½	Yellapatha Mauda Covil road ..	20-25	9-22	Do. do. ..	9-22	9-22
7 1½	Soolay Cauthoy Syphon ..	21-83	10-06	Do. do. ..	10-00	10-00
8 0	Greenaway's bridge ..	21-00	13-03	Masonry segmental arch, skew ..	12-03	11-03
10 0	Guindy bridge, span excluding tow paths.	45-00	15-42	Masonry elliptical arch ..	15-17	15-09
10 0	Lattice bridge do. do.	43-00	12-14	Masonry abutments and wooden structure.	12-14	12-14
42 0	Sadras bridge do. do.	43-75	13-83	Masonry elliptical arch ..	13-58	13-50
45 0	Ismalpett bridge do. do.	35-00	14-75	Masonry semicircular arch ..	14-38	14-13

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.
6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.
7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.
8. Paragraph 9.—Agreed.
9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.
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11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to remove this lock and take a new isolated channel from 6 M. 6 F. through the ground to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.
12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep portion of canal between 17 M. and 19 M. might be included in this new line. Owing to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.
13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

18. Whether a flood-gate would be needed at the southern extremity near the Pulicat bar is not as yet clear.

19. Paragraph 22.—From Cusbah, 45 M., northwards a strong west bank, well above flood level, is essential, and the canal should be isolated up to 68 M., where a flood-gate may be placed. An interval will here have to be left for the passage of flood water, and the new cut to the west of the backwater, as suggested by Major Vibart, made up to Dugarápatnam, 69 M. This short portion will also need to be isolated by flood-gates at either end. The proposed basin at Dugarápatnam should, as elsewhere, consist of a simple widening of the channel.

20. Paragraph 24.—If on further inquiry the drainage which enters at 71 M. 5 F. cannot safely be barred from entering the canal, a flood-gate must be placed a little north. I do not consider a sluice weir, as proposed here, to be suitable. Another flood-gate will be needed a little south of the Swarnamukhi river. This reach of canal, 4 miles in length, will thus, with the embankments proposed, be thoroughly isolated in case of flood.

21. Paragraph 25.—The crossing of the Swarnamukhi river is a complicated matter, and calls for further examination. So far as can be judged, Major Vibart's proposed deviation from a point near the village of Govindapulli to Mullapulli, combined with training the river by means of embankments and strongly constructed cross bunds east and west, appears to hold out the best solution.

22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

23. Paragraph 30.—The Kistnapatam basin must be extended as proposed. A flood-gate will be required south of the basin, and as regards the canal to the north, the banks must be raised and the channel isolated.

24. Paragraph 31.—At Nellatoor it will be necessary to cut a fresh channel for nearly two miles (95 M. 4 F. to 97 M. 6 F.,) a little east of the present line in rather higher ground, thus leaving the present channel free for the passage of drainage.

25. *Paragraph 32.*—The whole of the drainage here must be collected and passed across the channel at one point.

26. *Paragraph 33.*—Here again, of the three openings the central one must be kept clear for the passage of the drainage, closing the others.

27. *Paragraph 34.*—The Pennér river (114 M. 3 F. to 116 M. 6 F.) crossing is probably the most difficult matter to deal with in the length of the canal. Some Rs. 11,000 were spent in taking the silt out of the cut here (115 M. 4 F. and 116 M. 3 F.) within the first year of opening the canal, and in both the cyclones of 1879 not only has the same cut again silted up to within 9 inches of L.W.L., but the several branches of the river, five in number, show such a tendency to change their course that it has become a serious matter for consideration as to how the canal can here be kept open for traffic. Even were steam-dredges available, the canal would still be closed after each ordinary fresh in the river to all but top-boats and others of very light draft taking advantage of high tide, and the stoppage would be absolute after a cyclone flood of any intensity. No mere palliatives will therefore answer here, and my conviction is that the best and, in the end, by far the most economical course will be to train the Pennér in such a way from the head of its delta that the discharge shall take place entirely through its southernmost channel, closing all the others. This can be done by training the river from a point near the village of Utakoor, about three miles west of the canal, on the left bank. At the same time, groynes should be so constructed on the right bank, a little north of Kuddipalem, that the present line of river bank and the flood embankment within it shall be preserved from invasion. The left embankment would probably extend from Utakoor to the destroyed village of Palipalem. By this means not only would a sufficiently deep channel be always preserved in the southern branch of the river, but by closing the canal ends north and south with flood-gates, these would be preserved from the silting which now causes the difficulty. I do not consider that there should be any serious difficulty in training the Pennér as proposed, but further careful study of all the features is necessary.

28. *Paragraphs 37 and 38.*—Banking across the Ramatheertham drainage is inadmissible; it will be essential to cut a new line, of about six furlongs in length, to the west of the present line, so as to avoid getting dangerously close to the bar.

29. *Paragraphs 39 and 40.*—As with the Ramatheertham so with the Pydaru (123 M. 6 F.) and the Eskapally (126 M.) drainages, free vent must be allowed across the line of canal, but a strong west bank to keep out floods should be constructed. Whether it will be necessary eventually to isolate each of these portions with flood-gates (that at 117 M. is essential) cannot however be decided with certainty.

30. *Paragraph 42.*—The plan suggested of training the river so as to occupy and deepen out its central channel, and further to make a new cut to the west, of about two miles long, through ground 3 or 4 feet above M.S.L., seem essential. Since the cyclone of May 1879 the existing channel through the backwater has changed no less than four times.

31. Flood-gates will be required, one north of the Chippelairoo, at probably 134 M. and another at the 148 M. 2 F.

32. *Paragraph 46.*—The Ramapatam drainage, which enters at 148 M. 3 F. might have its outlet to the sea barred permanently, and the drainage thus taken into the canal utilised with a view to bringing a beneficial scour to bear on the northern portion towards the Elikeru.

33. *Paragraph 47.*—As regards this drainage it will be best to embank across the northern outlet, placing a flood-gate at 151 M. leaving the present southern opening (150 M. 6 F. to 150 M. 7 F.) free to discharge by the open bar.

34. To prevent the silting of the channel south of the Manneru, a flood-gate will be necessary at about 160 M.

35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment, but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878 some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Paleru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. *Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1'9" have had to unload and have the goods carried by hand three-quarters of a mile.* For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing canal closed by temporary banks and opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear, on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The laterite bridge, which with its nine elliptical arches of 18 feet span carries off all the residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. *Paragraphs 59, 60, 61.*—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

45. *Paragraph 62.*—The crossing of the Gundlakamma river calls for no special remark.

46. *Paragraph 63.*—As regards the proposals in this paragraph I have seen reason for the present at least to prefer flood-gates nearly everywhere to locks, the grounds for which will be found elsewhere.

47. *Paragraph 64.*—For five miles north of the Gundlakamma river the canal is exposed to serious wash, particularly at two places where bars opened in the November cyclone, and which must therefore be left free of any obstruction. To all appearances, however, the spill water from the Gundlakamma might, as suggested by Sub-Engineer Ottmann, be effectually checked by constructing a strong training bank along the left bank of the river, two or three miles in length, and diverting the drainage from the Kanuparti swamp. The alternative to this plan would be to construct a strong west bank all along the canal. In addition to protection on the west, a well-planted east bank is also needed at two places, but only for short lengths. Major Vibart has suggested an entirely new channel between $199\frac{1}{2}$ and $191\frac{1}{2}$ M. but as the object here must be to get sufficiently inland from the Kanuparti bar, to which the present line is dangerously near, it will suffice to make the new cut to the westward of only three furlongs in length at a distance of 200 yards from the existing channel.

48. *Paragraphs 66, 67, 68.*—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

49. *Paragraph 69.*—The reasoning here employed by Major Vibart in favor of isolating the different reaches of the canal which intervene between drainages that cannot safely, particularly during flood, be barred in the passage to the sea, derives additional force from the effects of the November cyclone which followed on the

one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

50. *Paragraph 70.*—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

CHEPAUK,
10th April 1880.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. *Paragraph 3.*—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. *Paragraph 4.*—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. *Paragraph 5.*—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge ..	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge ..	43	10.00	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

		Name of Bridges.		Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
							With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges south of Basin.							
0 0	Basin bridge	..	..	50-00	12-52	Masonry segmental arch	12-17	11-94
0 4	Salt Cotaar bridge	..	..	29-66	*8-64	Wooden bridge	8-64	8-64
0 6½	Elephant Gate bridge	..	..	49-00	10-94	Masonry segmental arch	10-52	10-28
0 7	Central Station Railway bridge	..	..	64-00	9-35	Iron girder bridge	9-35	9-35
1 4½	General Hospital bridge	..	..	49-00	11-04	Masonry segmental arch	10-62	10-38
1 6	South Indian Railway bridge	..	..	29-00	7-03	Wooden bridge	7-03	7-03
2 3	Saint Mary's bridge	..	..	32-00	11-49	Do. metalled	11-49	11-49
3 0	Government House bridge	..	..	19-83	10-40	Masonry segmental arch	9-74	9-53
3 2	Marine Villa	..	..	19-62	10-92	Iron piles rough stone abutments.	10-92	10-92
3 6	Chepauk bridge	..	..	19-62	10-92	Masonry segmental arch	9-92	9-17
3 7½	Pycroft's road bridge	..	..	20-17	11-29	Do. do.	10-29	9-54
4 2	Soonkarammah Street bridge	..	..	20-17	11-52	Masonry and wooden platform.	11-52	11-52
4 6½	Ice House road	..	..	19-83	11-68	Masonry segmental arch	10-68	9-93
5 0	Elliott's road	..	..	20-17	11-77	Masonry semicircular arch	10-44	9-35
5 3½	Barber's bridge	..	..	27-33	9-71	Masonry and wooden platform.	9-71	9-71
5 5	Moondacunny Covil road bridge	..	..	20-00	13-22	Do. do.	13-22	13-22
5 5½	Cutcherry road	..	..	19-58	10-42	Masonry semicircular arch	9-09	8-00
6 3	Brodie's road bridge	..	..	20-17	10-89	Do. do.	9-68	8-77
6 3	Poonthotum aqueduct	..	..	20-42	10-05	Masonry wooden platform	10-05	10-05
7 1½	Yellapatha Mauda Covil road	..	..	20-25	9-22	Do. do.	9-22	9-22
7 1½	Soolay Cauthoy Syphon	..	..	21-83	10-00	Do. do.	10-00	10-00
8 0	Greenaway's bridge	..	..	21-00	13-03	Masonry segmental arch, skew	12-03	11-03
8 0	Guindy bridge, span excluding tow paths.	..	..	45-00	15-42	Masonry elliptical arch	15-17	15-09
10 0	Lattice bridge do. do.	..	..	43-00	12-14	Masonry abutments and wooden structure.	12-14	12-14
42 0	Sadras bridge do. do.	..	..	43-75	13-83	Masonry elliptical arch	13-58	13-50
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be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

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22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

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freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Paleru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing channel should be closed, cleared and deepened, opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. Paragraphs 59, 60, 61.—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

45. Paragraph 62.—The crossing of the Gundlakamma river calls for no special remark.

46. Paragraph 63.—As regards the proposals in this paragraph I have seen reason for the present at least to prefer flood-gates nearly everywhere to locks, the grounds for which will be found elsewhere.

47. Paragraph 64.—For five miles north of the Gundlakamma river the canal is exposed to serious wash, particularly at two places where bars opened in the November cyclone, and which must therefore be left free of any obstruction. To all appearances, however, the spill water from the Gundlakamma might, as suggested by Sub-Engineer Ottmann, be effectually checked by constructing a strong training bank along the left bank of the river, two or three miles in length, and diverting the drainage from the Kanuparti swamp. The alternative to this plan would be to construct a strong west bank all along the canal. In addition to protection on the west, a well-planted east bank is also needed at two places, but only for short lengths. Major Vibart has suggested an entirely new channel between $199\frac{1}{2}$ and $191\frac{1}{2}$ M. but as the object here must be to get sufficiently inland from the Kanuparti bar, to which the present line is dangerously near, it will suffice to make the new cut to the westward of only three furlongs in length at a distance of 200 yards from the existing channel.

48. Paragraphs 66, 67, 68.—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

49. Paragraph 69.—The reasoning here employed by Major Vibart in favor of isolating the different reaches of the canal which intervene between drainages that cannot safely, particularly during flood, be barred in the passage to the sea, derives additional force from the effects of the November cyclone which followed on the

Appendix to G.O., No. 251 W., of 6th February 1880.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. Paragraph 3.—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. Paragraph 4.—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. Paragraph 5.—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. Y.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge	43	10.09	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges south of Basin.					
0 0	Basin bridge	50-00	12-52	Masonry segmental arch		
0 4	Salt Cotaar bridge	29-66	8-64	Wooden bridge	12-17	11-94
0 6½	Elephant Gate bridge	49-00	10-94	Masonry segmental arch	8-64	8-64
0 7	Central Station Railway bridge	64-00	9-35	Iron girder bridge	10-52	10-28
1 4½	General Hospital bridge	49-00	11-04	Masonry segmental arch	9-35	9-35
1 6	South Indian Railway bridge	13-91	7-03	Wooden bridge	10-62	10-38
2 3	Saint Mary's bridge	29-00	11-49	Do. metalled	7-03	7-03
3 0	Government House bridge	32-00	10-40	Masonry segmental arch	11-49	11-49
3 2	Marine Villa	19-83	10-92	Iron piles rough stone abutments.	9-74	9-53
3 6	Chepauk bridge	19-62	10-92	Masonry segmental arch	10-92	10-92
3 7½	Pycroft's road bridge	19-62	11-29	Do. do.	9-92	9-17
4 2	Soankarammah Street bridge	20-17	11-52	Masonry and wooden platform.	10-29	9-64
4 6½	Ice House road	19-83	11-68	Masonry segmental arch	11-52	11-52
5 0	Elliott's road	20-17	11-77	Masonry semicircular arch	10-44	9-35
5 3½	Barber's bridge	27-33	9-71	Masonry and wooden platform.	9-71	9-71
5 6	Moondacunny Covil road bridge	20-00	13-22	Do. do.	13-22	13-22
5 5½	Cutcherry road	19-58	10-42	Masonry semicircular arch	9-09	8-00
6 3	Brodie's road bridge	20-17	10-89	Do. do.	9-68	8-77
6 3	Poonthotum aqueduct	20-42	10-05	Masonry wooden platform	10-05	10-05
7 1½	Yellapatha Mauda Covil road	20-25	9-22	Do. do.	9-22	9-22
7 1½	Soolay Cauthoy Syphon	21-83	10-00	Do. do.	10-00	10-00
8 0	Greenaway's bridge	21-00	13-03	Masonry segmental arch, skew	12-03	11-03
8 0	Guindy bridge, span excluding tow paths.	45-00	15-42	Masonry elliptical arch	15-17	15-09
10 0	Lattice bridge do. do.	43-00	12-14	Masonry abutments and wooden structure.	12-14	12-14
42 0	Sadras bridge do. do.	43-75	13-83	Masonry elliptical arch	13-58	13-50
45 0	Ismalpett bridge do. do.	35-00	14-75	Masonry semicircular arch	14-38	14-13

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.
6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.
7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.
8. Paragraph 9.—Agreed.
9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.
10. Paragraph 12.—New bridges should be provided for, but the removal of the present structures is not a matter of urgency.
11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to remove this lock and take a new isolated channel from 6 M. 6 F. through the ground to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.
12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep portion of canal between 17 M. and 19 M. might be included in this new line. Owing to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.
13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

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35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment, but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878 some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Palaru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing canal closed by temporary banks and opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The laterite bridge, which with its nine elliptical arches of 18 feet span carries off all the residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. *Paragraphs 59, 60, 61.*—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

45. *Paragraph 62.*—The crossing of the Gundlakamma river calls for no special remark.

46. *Paragraph 63.*—As regards the proposals in this paragraph I have seen reason for the present at least to prefer flood-gates nearly everywhere to locks, the grounds for which will be found elsewhere.

47. *Paragraph 64.*—For five miles north of the Gundlakamma river the canal is exposed to serious wash, particularly at two places where bars opened in the November cyclone, and which must therefore be left free of any obstruction. To all appearances, however, the spill water from the Gundlakamma might, as suggested by Sub-Engineer Ottmann, be effectually checked by constructing a strong training bank along the left bank of the river, two or three miles in length, and diverting the drainage from the Kanuparti swamp. The alternative to this plan would be to construct a strong west bank all along the canal. In addition to protection on the west, a well-planted east bank is also needed at two places, but only for short lengths. Major Vibart has suggested an entirely new channel between $199\frac{1}{2}$ -and- $191\frac{1}{2}$ M. but as the object here must be to get sufficiently inland from the Kanuparti bar, to which the present line is dangerously near, it will suffice to make the new cut to the westward of only three furlongs in length at a distance of 200 yards from the existing channel.

48. *Paragraphs 66, 67, 68.*—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

49. *Paragraph 69.*—The reasoning here employed by Major Vibart in favor of isolating the different reaches of the canal which intervene between drainages that cannot safely, particularly during flood, be barred in the passage to the sea, derives additional force from the effects of the November cyclone which followed on the

one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

50. *Paragraph 70.*—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

CHEPAUK,
10th April 1880.

Appendix to G.O., No. 284 W., of 6th February 1880.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. *Paragraph 3.*—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. *Paragraph 4.*—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. *Paragraph 5.*—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. P.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge ..	59	10.72	Iron girder bridge ..	10.72	10.72
1 4½	Washermanpettah bridge ..	43	10.00	Masonry segmental arch ..	9.60	9.40
3 6	Theroovattoor bridge ..	43	10.00	Do. do. ..	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges south of Basin.					
0 0	Basin bridge					
0 4	Salt Cota bridge	50-00	12-52	Masonry segmental arch	12-17	11-94
0 6½	Elephant Gate bridge	29-66	8-64	Wooden bridge	8-64	8-64
0 7	Central Station Railway bridge	49-00	10-94	Masonry segmental arch	10-52	10-28
1 4½	General Hospital bridge	64-00	9-35	Iron girder bridge	9-35	9-35
1 6	South Indian Railway bridge	49-00	11-04	Masonry segmental arch	10-62	10-38
2 3	Saint Mary's bridge	13-91	7-03	Wooden bridge	7-03	7-03
3 0	Government House bridge	29-00	11-49	Do. metalled	11-49	11-49
3 2	Marine Villa	32-00	10-40	Masonry segmental arch	9-74	9-53
3 6	Chepauk bridge	19-83	10-92	Iron piles rough stone abutments.	10-92	10-92
3 7½	Pycroft's road bridge	19-62	10-92	Masonry segmental arch	9-92	9-17
4 2	Soonkarammah Street bridge	19-62	11-29	Do. do.	10-29	9-54
4 6½	Ice House road	20-17	11-52	Masonry and wooden platform.	11-52	11-52
5 0	Elliott's road	19-83	11-68	Masonry segmental arch	11-68	9-93
5 3½	Barber's bridge	20-17	11-77	Masonry semicircular arch	10-44	9-35
5 5	Moondacunny Covil road bridge	27-33	9-71	Masonry and wooden platform.	9-71	9-71
5 6½	Cutcherry road	20-00	13-22	Do. do.	13-22	13-22
6 3	Brodie's road bridge	19-58	10-42	Masonry semicircular arch	9-09	8-00
6 3	Poonthotum aqueduct	20-17	10-89	Do. do.	9-68	8-77
7 1½	Yellapatha Mauda Covil road	20-42	10-05	Masonry wooden platform	10-05	10-05
7 1½	Soolay Gauthoy Syphon	20-25	9-22	Do. do.	9-22	9-22
8 0	Greenaway's bridge	21-83	10-00	Do. do.	10-00	10-00
8 0	Guindy bridge, span excluding tow paths.	21-00	13-03	Masonry segmental arch, skew	12-03	11-03
10 0	Lattice bridge do. do.	45-00	15-42	Masonry elliptical arch	15-17	15-09
42 0	Sadras bridge do. do.	43-00	12-14	Masonry abutments and wooden structure.	12-14	12-14
45 0	Ismalpett bridge do. do.	43-75	13-83	Masonry elliptical arch	13-58	13-50
		35-00	14-75	Masonry semicircular arch	14-38	14-13

* The figures

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.
6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.
7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.
8. Paragraph 9.—Agreed.
9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.
10. Paragraph 12.—New bridges should be provided for, but the removal of the present structures is not a matter of urgency.
11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to remove this lock and take a new isolated channel from 6 M. 6 F. through the ground to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.
12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep portion of canal between 17 M. and 19 M. might be included in this new line. Owing to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.
13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

18. Whether a flood-gate would be needed at the southern extremity near the Pulicat bar is not as yet clear.

19. Paragraph 22.—From Cusbah, 45 M., northwards a strong west bank, well above flood level, is essential, and the canal should be isolated up to 68 M., where a flood-gate may be placed. An interval will here have to be left for the passage of flood water, and the new cut to the west of the backwater, as suggested by Major Vibart, made up to Dugarápatnam, 69 M. This short portion will also need to be isolated by flood-gates at either end. The proposed basin at Dugarápatnam should, as elsewhere, consist of a simple widening of the channel.

20. Paragraph 24.—If on further inquiry the drainage which enters at 71 M. 5 F. cannot safely be barred from entering the canal, a flood-gate must be placed a little north. I do not consider a sluice weir, as proposed here, to be suitable. Another flood-gate will be needed a little south of the Swarnamukhi river. This reach of canal, 4 miles in length, will thus, with the embankments proposed, be thoroughly isolated in case of flood.

21. Paragraph 25.—The crossing of the Swarnamukhi river is a complicated matter, and calls for further examination. So far as can be judged, Major Vibart's proposed deviation from a point near the village of Govindapulli to Mullapulli, combined with training the river by means of embankments and strongly constructed cross bunds east and west, appears to hold out the best solution.

22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

23. Paragraph 30.—The Kistnapatam basin must be extended as proposed. A flood-gate will be required south of the basin, and as regards the canal to the north, the banks must be raised and the channel isolated.

24. Paragraph 31.—At Nellatoor it will be necessary to cut a fresh channel for nearly two miles (95 M. 4 F. to 97 M. 6 F.) a little east of the present line in rather higher ground, thus leaving the present channel free for the passage of drainage.

25. *Paragraph 32.*—The whole of the drainage here must be collected and passed across the channel at one point.

26. *Paragraph 33.*—Here again, of the three openings the central one must be kept clear for the passage of the drainage, closing the others.

27. *Paragraph 34.*—The Pennér river (114 M. 3 F. to 116 M. 6 F.) crossing is probably the most difficult matter to deal with in the length of the canal. Some Rs. 11,000 were spent in taking the silt out of the cut here (115 M. 4 F. and 116 M. 3 F.) within the first year of opening the canal, and in both the cyclones of 1879 not only has the same cut again silted up to within 9 inches of L.W.L., but the several branches of the river, five in number, show such a tendency to change their course that it has become a serious matter for consideration as to how the canal can here be kept open for traffic. Even were steam-dredges available, the canal would still be closed after each ordinary fresh in the river to all but top-boats and others of very light draft taking advantage of high tide, and the stoppage would be absolute after a cyclone flood of any intensity. No mere palliatives will therefore answer here, and my conviction is that the best and, in the end, by far the most economical course will be to train the Pennér in such a way from the head of its delta that the discharge shall take place entirely through its southernmost channel, closing all the others. This can be done by training the river from a point near the village of Utakoor, about three miles west of the canal, on the left bank. At the same time, groynes should be so constructed on the right bank, a little north of Kuddipalem, that the present line of river bank and the flood embankment within it shall be preserved from invasion. The left embankment would probably extend from Utakoor to the destroyed village of Palipalem. By this means not only would a sufficiently deep channel be always preserved in the southern branch of the river, but by closing the canal ends north and south with flood-gates, these would be preserved from the silting which now causes the difficulty. I do not consider that there should be any serious difficulty in training the Pennér as proposed, but further careful study of all the features is necessary.

28. *Paragraphs 37 and 38.*—Banking across the Ramatheertham drainage is inadmissible; it will be essential to cut a new line, of about six furlongs in length, to the west of the present line, so as to avoid getting dangerously close to the bar.

29. *Paragraphs 39 and 40.*—As with the Ramatheertham so with the Pydaru (123 M. 6 F.) and the Eskapally (126 M.) drainages, free vent must be allowed across the line of canal, but a strong west bank to keep out floods should be constructed. Whether it will be necessary eventually to isolate each of these portions with flood-gates (that at 117 M. is essential) cannot however be decided with certainty.

30. *Paragraph 42.*—The plan suggested of training the river so as to occupy and deepen out its central channel, and further to make a new cut to the west, of about two miles long, through ground 3 or 4 feet above M.S.L., seem essential. Since the cyclone of May 1879 the existing channel through the backwater has changed no less than four times.

31. Flood-gates will be required, one north of the Chippelairoo, at probably 134 M. and another at the 148 M. 2 F.

32. *Paragraph 46.*—The Ramapatam drainage, which enters at 148 M. 3 F. might have its outlet to the sea barred permanently, and the drainage thus taken into the canal utilised with a view to bringing a beneficial scour to bear on the northern portion towards the Elikeru.

33. *Paragraph 47.*—As regards this drainage it will be best to embank across the northern outlet, placing a flood-gate at 151 M. leaving the present southern opening (150 M. 6 F. to 150 M. 7 F.) free to discharge by the open bar.

34. To prevent the silting of the channel south of the Manneru, a flood-gate will be necessary at about 160 M.

35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment, but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878 some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Palaru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing channel should be closed, cleared and deepened, opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupu Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The laterite bridge, which with its nine elliptical arches of 18 feet span carries off all the residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. Paragraphs 59, 60, 61.—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

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48. Paragraphs 66, 67, 68.—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

49. Paragraph 69.—The reasoning here employed by Major Vibart in favor of isolating the different reaches of the canal which intervene between drainages that cannot safely, particularly during flood, be barred in the passage to the sea, derives additional force from the effects of the November cyclone which followed on the

one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

50. Paragraph 70.—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

CHEPAUK,
10th April 1880.

Appendix to G.O., No. 251 W., of 6th February 1880.

OBSERVATIONS BY THE CHIEF ENGINEER ON MAJOR VIBART'S BUCKINGHAM CANAL INSPECTION NOTES DATED 27TH SEPTEMBER 1879.

Paragraph 1.—The requisite survey establishment has been sanctioned, and the Superintendent of Works, Captain Awdry, is engaged in preparing the estimate for submission to the Government of India. Tide gauges have been established in all backwaters and open estuaries, as also at intermediate points along the canal.

2. *Paragraph 3.*—For sanitary purposes it is most desirable that the level of the water in the Cooum and Adyar rivers should, as far as possible, be maintained at 3.5 feet above mean sea level, and to do this the lock here proposed would be indispensable, as with the Covelong bar open (maximum rise of tide 2.92 feet above and low water 0.70 below M.S.L.) the water would otherwise escape through the southern canal. The necessity for constructing a dam here is not sufficiently apparent to warrant the work being included in the estimate as yet.

3. *Paragraph 4.*—Under the present arrangements for taking the tolls, the proposed landing place would not help traffic, but Captain Awdry has a proposal for altering the sections so soon as the channel shall be open as far as the Cheyoor backwater, which if combined with a proper opening, headway being given to the South Indian Railway bridge, would permit and encourage traffic through the Junction Canal.

4. *Paragraph 5.*—Appended is a detailed statement of the spans and headways of the bridges, the former being generally under 20 feet each, and the latter as low as 9.22 feet at M.S.L. The headway is thus only 5.72 feet when the level of the water is 3.5 feet above M.S.L., and is therefore much too low. The expense of altering all these bridges, fourteen in number, would be prohibitory for the present, but means should be found by corbeling or otherwise to provide an 18-inch wide board for the towing coolies to pass. To prevent water escaping from the Cooum when the Adyar bar is open, a lock should be built at south end of the Junction Canal. So long as it can be managed without injury to the channel or the bridges a scour may be provided for in order to remove silt.

STATEMENT showing the clear headway and span of Bridges over the Buckingham Canal.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges north of Cochrane's Basin.					
0 4	Ráyapuram Railway bridge	59	10.72	Iron girder bridge	10.72	10.72
1 4½	Washermanpettah bridge	43	10.00	Masonry segmental arch	9.60	9.40
3 6	Theroovattoor bridge	43	10.00	Do. do.	9.58	9.36

Statement showing the clear headway and span of Bridges over the Buckingham Canal—cont.

Mileage from Basin.	Name of Bridges.	Minimum span at M.S.L. in feet.	Maximum height above M.S.L. in feet.	Remarks.	Height available above M.S.L. for boats	
					With tops 10 feet wide.	With tops 13 feet wide.
M. F.	Bridges south of Basin.					
0 0	Basin bridge ..	50-00	12-52	Masonry segmental arch		
0 4	Salt Cotaar bridge ..	29-66	8-64	Wooden bridge	12-17	11-94
0 6½	Elephant Gate bridge ..	49-00	10-94	Masonry segmental arch	8-64	8-64
0 7	Central Station Railway bridge ..	64-00	9-35	Iron girder bridge	10-52	10-28
1 4½	General Hospital bridge ..	49-00	11-04	Masonry segmental arch	9-35	9-35
1 6	Saint Mary's bridge ..	13-91	7-03	Wooden bridge	10-62	10-38
2 3	Government House bridge ..	29-00	11-49	Do. metalled	7-03	7-03
3 0	Marine Villa ..	32-00	10-40	Masonry segmental arch	11-49	11-49
3 2	Chepauk bridge ..	19-83	10-92	Iron piles rough stone abutments.	9-74	9-53
3 6	Pycroft's road bridge ..	19-62	10-92	Masonry segmental arch	10-92	10-92
3 7½	Soonkarammah Street bridge ..	19-62	11-29	Do. do.	9-92	9-17
4 2	Ice House road ..	20-17	11-52	Masonry and wooden platform.	10-29	9-54
4 6½	Elliott's road ..	19-83	11-68	Masonry segmental arch	11-52	11-52
5 0	Barber's bridge ..	20-17	11-77	Masonry semicircular arch	11-68	9-93
5 3½	Moondacunny Covil road bridge ..	27-33	9-71	Masonry and wooden platform.	10-44	9-35
5 5	Cutcherry road ..	20-00	13-22	Do. do.	9-71	9-71
5 5½	Brodie's road bridge ..	19-58	10-42	Masonry semicircular arch	13-22	13-22
6 3	Poonthotum aqueduct ..	20-17	10-89	Do. do.	9-09	8-00
6 3	Yellapatha Mauda Covil road ..	20-42	10-05	Masonry wooden platform	9-68	8-77
7 1½	Soolay Cauthoy Syphon ..	20-25	9-22	Do. do.	10-05	10-05
7 1½	Greenaway's bridge ..	21-83	10-00	Do. do.	9-22	9-22
8 0	Guindy bridge, span excluding tow paths.	21-00	13-03	Masonry segmental arch, skew	10-00	10-00
10 0	Lattice bridge do. do.	45-00	15-42	Masonry elliptical arch	12-03	11-03
42 0	Sadras bridge do. do.	43-00	12-14	Masonry abutments and wooden structure.	15-17	15-09
45 0	Ismalpett bridge do. do.	43-75	13-83	Masonry elliptical arch	12-14	12-14
		35-00	14-75	Masonry semicircular arch	13-58	13-50
					14-38	14-13

* The figures in antique show the Bridges having the least headway.

5. Paragraph 7.—Observations concurred in.
6. Paragraph 8.—A flood-gate which would form no impediment to traffic would answer all purposes.
7. The sewage of all the north portion of Black Town should unquestionably be diverted from discharging into the canal by an intercepting sewer, to be constructed by the Municipality.
8. Paragraph 9.—Agreed.
9. Paragraph 10.—Approved, but the question will require further study. Some of the present lime kilns which occupy the needed ground must be removed.
10. Paragraph 12.—New bridges should be provided for, but the removal of the present structures is not a matter of urgency.
11. Paragraphs 13 and 14.—This lock has not sufficient height to clear it in maximum floods, and is at least half a mile too far north. It will be necessary to remove this lock and take a new isolated channel from 6 M. 6 F. through the ground to the east as far as 9 M. 3 F. where there should be a flood-gate. By these arrangements the canal will be preserved from the effects of the floods of the Kortalayár and of the Red Hill tank drainage, from both of which it now suffers greatly at times.
12. Paragraph 15.—From 11½ to 20½ M. should be taken in a new isolated channel east of the backwater, with flood-gates at either end. The existing deep portion of canal between 17 M. and 19 M. might be included in this new line. Owing to the oozy nature of the bottom in the existing backwater, dredging would have no permanent effect.
13. The opening into the Chintamony backwater will have in any case to be left open for the free passage of flood water. From immediately beyond this point, and to the entrance of the lake beyond the town of Pulicat, careful study is required. So far as can

be judged, however, a feasible plan would seem to consist in making an isolated channel 4½ miles in length along the west margin of the backwater, between 20½ M. and 25 M., with flood-gates at either end.

14. I do not approve of the proposal to bank across the opening at 20½ M., nor to take the canal along the east margin close up to the bar; this would certainly be dangerous for boats during flood.

15. Paragraph 17.—The only apparent means for ensuring a sufficiently protected line along all this portion will be to take a new isolated line, as proposed, along the depression which commences a little north of the Pulicat bar. Some palliatives are feasible, e.g., altering slightly the end of the south cut in the lake so as to carry it into deep water, but there is no radical cure apparently for the admitted difficulties of the present line, which is throughout exposed to the wide expanse of water on the west.

16. The only part of the line which can be considered as adequately protected between Pulicat and Cusbah is the short portion between 35 M. 7 F. and 38 M., and this of course can be taken into the new line.

17. From a peculiarity in the conformation of the Pulicat lake, it appears that, when the waters of excessive floods begin to subside, the canal from a little north of 36 M. acts as a surplus channel. A very beneficial scour is thus found to have been set up throughout the line to its southern debouchure in the lake at 27 M. This peculiarity should be turned to use for the new isolated line by the construction of a powerful head sluice in the west bank at 36 M., and a scour produced in the channel down to the bar whenever circumstances favor. A sluice with five or six openings, 6 feet wide each, would apparently suffice.

18. Whether a flood-gate would be needed at the southern extremity near the Pulicat bar is not as yet clear.

19. Paragraph 22.—From Cusbah, 45 M., northwards a strong west bank, well above flood level, is essential, and the canal should be isolated up to 68 M., where a flood-gate may be placed. An interval will here have to be left for the passage of flood water, and the new cut to the west of the backwater, as suggested by Major Vibart, made up to Dugarápatnam, 69 M. This short portion will also need to be isolated by flood-gates at either end. The proposed basin at Dugarápatnam should, as elsewhere, consist of a simple widening of the channel.

20. Paragraph 24.—If on further inquiry the drainage which enters at 71 M. 5 F. cannot safely be barred from entering the canal, a flood-gate must be placed a little north. I do not consider a sluice weir, as proposed here, to be suitable. Another flood-gate will be needed a little south of the Swarnamukhi river. This reach of canal, 4 miles in length, will thus, with the embankments proposed, be thoroughly isolated in case of flood.

21. Paragraph 25.—The crossing of the Swarnamukhi river is a complicated matter, and calls for further examination. So far as can be judged, Major Vibart's proposed deviation from a point near the village of Govindapulli to Mullapulli, combined with training the river by means of embankments and strongly constructed cross bunds east and west, appears to hold out the best solution.

22. Paragraph 27.—No remark called for further than that at either extremity of these 14 miles of canal flood-gates might with advantage be placed. It does not appear essential to make so long a deviation, (1 mile in length,) as proposed here by Major Vibart. If the present end of the channel as it enters the Kundalairoo river is turned east and north for about 2 furlongs, and made to enter the backwater close to the west of the Gungapalliem village, it will answer all purposes, as the backwater is believed to remain permanently deep at this point.

23. Paragraph 30.—The Kistnapatam basin must be extended as proposed. A flood-gate will be required south of the basin, and as regards the canal to the north, the banks must be raised and the channel isolated.

24. Paragraph 31.—At Nellatoor it will be necessary to cut a fresh channel for nearly two miles (95 M. 4 F. to 97 M. 6 F.) a little east of the present line in rather higher ground, thus leaving the present channel free for the passage of drainage.

25. *Paragraph 32.*—The whole of the drainage here must be collected and passed across the channel at one point.

26. *Paragraph 33.*—Here again, of the three openings the central one must be kept clear for the passage of the drainage, closing the others.

27. *Paragraph 34.*—The Pennér river (114 M. 3 F. to 116 M. 6 F.) crossing is probably the most difficult matter to deal with in the length of the canal. Some Rs. 11,000 were spent in taking the silt out of the cut here (115 M. 4 F. and 116 M. 3 F.) within the first year of opening the canal, and in both the cyclones of 1879 not only has the same cut again silted up to within 9 inches of L.W.L., but the several branches of the river, five in number, show such a tendency to change their course that it has become a serious matter for consideration as to how the canal can here be kept open for traffic. Even were steam-dredges available, the canal would still be closed after each ordinary fresh in the river to all but top-boats and others of very light draft taking advantage of high tide, and the stoppage would be absolute after a cyclone flood of any intensity. No mere palliatives will therefore answer here, and my conviction is that the best and, in the end, by far the most economical course will be to train the Pennér in such a way from the head of its delta that the discharge shall take place entirely through its southernmost channel, closing all the others. This can be done by training the river from a point near the village of Utakoor, about three miles west of the canal, on the left bank. At the same time, groynes should be so constructed on the right bank, a little north of Kuddipalem, that the present line of river bank and the flood embankment within it shall be preserved from invasion. The left embankment would probably extend from Utakoor to the destroyed village of Palipalem. By this means not only would a sufficiently deep channel be always preserved in the southern branch of the river, but by closing the canal ends north and south with flood-gates, these would be preserved from the silting which now causes the difficulty. I do not consider that there should be any serious difficulty in training the Pennér as proposed, but further careful study of all the features is necessary.

28. *Paragraphs 37 and 38.*—Banking across the Ramatheertham drainage is inadmissible; it will be essential to cut a new line, of about six furlongs in length, to the west of the present line, so as to avoid getting dangerously close to the bar.

29. *Paragraphs 39 and 40.*—As with the Ramatheertham so with the Pydaru (123 M. 6 F.) and the Eskapally (126 M.) drainages, free vent must be allowed across the line of canal, but a strong west bank to keep out floods should be constructed. Whether it will be necessary eventually to isolate each of these portions with flood-gates (that at 117 M. is essential) cannot however be decided with certainty.

30. *Paragraph 42.*—The plan suggested of training the river so as to occupy and deepen out its central channel, and further to make a new cut to the west, of about two miles long, through ground 3 or 4 feet above M.S.L., seem essential. Since the cyclone of May 1879 the existing channel through the backwater has changed no less than four times.

31. Flood-gates will be required, one north of the Chippelairoo, at probably 134 M. and another at the 148 M. 2 F.

32. *Paragraph 46.*—The Ramapatam drainage, which enters at 148 M. 3 F. might have its outlet to the sea barred permanently, and the drainage thus taken into the canal utilised with a view to bringing a beneficial scour to bear on the northern portion towards the Elikeru.

33. *Paragraph 47.*—As regards this drainage it will be best to embank across the northern outlet, placing a flood-gate at 151 M. leaving the present southern opening (150 M. 6 F. to 150 M. 7 F.) free to discharge by the open bar.

34. To prevent the silting of the channel south of the Manneru, a flood-gate will be necessary at about 160 M.

35. The spill of the Manneru floods over the left bank of the river must be stopped by an embankment; but the most essential work here, and one which there should be no delay in carrying out, is the deviation of the present channel for about three furlongs in length, as suggested by Major Vibart. Without any cyclone flood in 1878 some three miles of channel here silted up to a depth of over 2 feet with ordinary

freshets, and there can be no question that flood-gates are essential at both the Manneru and Palar ends of this reach of the canal.

36. *Paragraphs 49 and 50.*—Agreed. It is essential that the spill of the Paleru floods over its right bank should be barred by a strong embankment from the north end of the present Pakala bank as far as the canal.

37. *Paragraph 51.*—The short portion of canal, six furlongs in length, between the Moosee and Palar rivers, having silted up in both the May and November cyclones of 1879, barring navigation, some early and effective means must be found for curing the present defects.

38. Hand-dredging alone has not sufficed to allow of a passage being opened for any but boats of very light draft at high tide within two months after the last flood, and even then cargo boats drawing over 1' 9" have had to unload and have the goods carried by hand three-quarters of a mile. For a short time after the November cyclone there was a passage to the east, close to the united bars of the two rivers, but this did not last long. Had powerful steam-dredges been available, and at once set to work, a passage might no doubt have been opened at an earlier date, but at the best it may be assumed that, subsequent to each of the cyclones of last year, this portion of the canal must have been closed to traffic for five or six weeks; it is thus clear that exceptional measures are called for to prevent as far as possible the recurrence of such delays, which if allowed to continue must affect very injuriously the traffic on the canal. Were it feasible to divert one or other river, so as to discharge both streams by a single channel into the sea, the difficulty now experienced would vanish, but as this means cannot I consider be adopted, it appears that the most effective and economical plan will be to excavate a second channel parallel to, and a little west of, the present cut, six furlongs long. This channel, measuring 15 feet in breadth at bottom and carried to 2½ feet below M.S.L., should be excavated as soon as possible. When opened to traffic the existing channel closed by temporary banks and opened for traffic, and the new subsidiary canal closed by temporary banks and prepared to receive the traffic after the next flood. By thus working alternately on two channels alongside of each other a feasible palliative for the existing difficulties will at least be provided. No west bank will be needed for the new channel, all spoil going to form a high strong bank for the existing cut so as to insure its isolation. Flood-gates at each extremity of the latter will also be needed, if not indeed for both channels.

39. *Paragraph 57.*—The preservation and management of the stretch of canal from one mile north of the Moosee bar (about 170 M.) to the Gundlakamma river depends on the treatment of the spill of the former river during flood over its left bank. Whether it be feasible to train the river by means of a left embankment, starting from a point near the village of Tirupā Nayadipalum, and thus force the whole floods through the present bar, is not clear, but the subject should receive attention.

40. For the present, immediate relief will be given by cutting away entirely the banks which were injudiciously thrown across the Tondairoo creek at 177 M. 2 F. and again at 177 M. 6 F. The effect of any further flood will be to bring a beneficial scour to bear on the whole length of the channel northward, towards the Gundlakamma.

41. Should, however, the training bank for the left bank of the Moosee river as suggested prove feasible, it would in that case probably be desirable to cut a fresh channel for the canal in the four furlongs a little to the east, so as to keep clear of the Tondairoo creek as proposed by Major Vibart. There should be a flood-gate at the end of the canal as it enters the Moosee river.

42. *Paragraphs 57 and 58.*—The basin at Kottapatam may, as suggested, consist of nothing more than an enlargement of the channel to the east and north of the present bridge. This latter, though shaken by the November cyclone, is now sufficiently secure to last with repairs for some years, and though boats in passing it have to lower their masts, there is no serious inconvenience, as they invariably halt at the place.

43. The road dam immediately west of the bridge must be removed (as being much too close to the canal) to a point on the Ongole road 300 yards further west; and be

there reconstructed 100 yards in length, lowest point of invert being 1 foot above H.W.L. The materials of the present dam will nearly suffice for the new, and the same style of tail apron should be employed. The western embankment of the canal (south of the bridge) should be much strengthened, and the road well raised over the site of the present dam, so as effectually to prevent any future invasion by flood water. The residue of the Tondairoo drainage not vented by the canal, should be thoroughly repaired as its flooring is still sound. The unworkman-like additions made on either side of the arches to bear the parapets, and which were much injured by the November flood, must be removed and the roadway reduced to about $9\frac{1}{2}$ feet in width. The removal and reconstruction of the road dam above adverted to must be charged to the canal, but the alterations of the bridge ought to devolve on the Local Fund Board, who may also fairly undertake the construction of the proposed Moosafirkhana at Utapotu.

44. *Paragraphs 59, 60, 61.*—Northward from Kottapatnam (179 to 187 M.) the banks originally low have suffered severely during the November cyclone, first by the action of the storm wave from the east, there being no protecting "dunes" here, and second, from the land flood which supervened. But notwithstanding this destruction of the banks the channel has been, if any thing, improved owing to the fact that the surplus of the Moosee river flood vented itself through the Tondairoo creek, and finding its way into the canal scoured it throughout and cleared it of silt. Practically, therefore, little work is required in this reach. In a few places a strong, well planted, east bank will be needed to counteract the action of a storm wave; but on the west the less obstruction presented to the land flood the better, unless at some future time the expense of a sufficiently high and strong isolating west bank be considered essential. As matters stand, levelling down the bank as much as possible and bringing the tow-path into order is all that need be thought of. No vegetation seems to thrive here owing to the salt dust carried by the west winds which smothers and kills even the "woolsa" rush and the salt plant "eela," both of which thrive elsewhere. So long as the channel is not isolated no flood-gate is necessary at the Gundlakamma.

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48. *Paragraphs 66, 67, 68.*—Little remark called for. It may be doubted whether the position of the new lock at Feringy Dibba has been judiciously selected, and whether, looking to the great drainage which sweeps over the whole country south of Santaravoor, it would not have been safer to have given another flight to this latter lock, and dropped the canal thus direct into the Rompairoo drainage. It is now however too late to suggest any alteration of the arrangements here.

49. *Paragraph 69.*—The reasoning here employed by Major Vibart in favor of isolating the different reaches of the canal which intervene between drainages that cannot safely, particularly during flood, be barred in the passage to the sea, derives additional force from the effects of the November cyclone which followed on the

one which occurred in May and which is the subject of his report. But there is such a strong and, it must be admitted, well-founded objection to the delays inseparable from locks, added to the great expense of first construction and subsequent working, a regular establishment being necessary for each all the year round, that I have proposed for the present at least to construct flood-gates at the end of each reach. These would only be closed on extreme occasions to exclude silt and flood from the channel. They would be comparatively cheap in construction, could be made portions of locks at any future time should such be considered requisite, would in no way interfere with or delay traffic, and need only have a small establishment to look after them in the cyclone or flood period. Inlet weirs I also see no immediate necessity for, but the depth of the canal and even its section may now with advantage be much diminished to meet actual requirements. These and other subjects will however be discussed in a separate paper.

50. *Paragraph 70.*—The training of the several large drainages, and the necessity for a special study of each case, has been sufficiently pointed out in the above remarks, but here, as elsewhere, Major Vibart seems to favor the use of inlets and outlets of masonry for the disposal of minor drainages. I very much question the applicability of works of this character to the canal, as in hardly any case is there means of securing a proper outfall for the water on the down or eastern side of the channel. There may however be a few cases in which the principle might be accepted, and where this is the case the plan might be tried, adding however a capacious silt trap on the upper or west side of the canal. This should be kept always clear. It seems to me that all drainages which cannot be effectually shut out and diverted into other lines must of necessity be allowed free vent at a level across the canal, and that everything in the shape of an obstruction would be a mistake.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer.

CHEPAUK,
10th April 1880.

Remarks.

1877 January
1887

Pay Attended

1887
1888

60

1887
1888

60

1887
1888

1887
1888

60

Sum of all items

100

100

100

100

100

100

