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Public works **DEPARTMENT.**

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Read the following papers :—

No. 144. From the Superintendent Government Cinchona Plantations, to the Acting Joint Secretary to Government, dated Ootacamund, 23rd July 1870, No. 196.

I HAVE the honour to acknowledge the Order of Government, dated 4th May 1870, No. 1,183, and with deep regret I have to report that the embankment in course of construction, by the silting-process, across the Poorthy river was topped and breached by an unusually heavy flood on the 19th ultimo.

2. At that date the embankment was raised to 81 feet on the back or lower portion, and to 57 feet at the front or upper portion, giving an average height of 69 feet. The width of the bund up and down the river being 475 feet at the base and 383 feet at the top. The length of the embankment across the river-bed averaged 170 feet at the base and 418 feet at the top. The whole of the earth deposited in the embankment from the 26th September 1869 to the 19th June 1870 was 322,322 cubic yards.

3. The actual cost of the earth-work amounts to Rupees 7,585; namely, Rupees 3,240 expended in bringing the silting-streams to the site of the dam, and maintaining them in repair, and Rupees 4,345, the cost of excavating the soil and depositing it on the embankment.

4. The culvert constructed under the bund to carry off the ordinary flow of water in the river consists of an upper and a lower culvert. These culverts, which communicate by a circular valve 4 feet 2 inches in diameter, are built in an excavation made through the rocky side of the hill; the base of the lower culvert being $10\frac{1}{2}$ feet above the summer level of the river, and the upper culvert $17\frac{1}{2}$ feet, the deep bed of the river averaging 11 feet under summer level of the water. These culverts are constructed of stone: the lower culvert is 244 feet in length and 6×4 feet inside measurement; the upper culvert is 157 feet in length and 7×5 feet inside. On the outside of the upper culvert are two retaining walls of rough stone, 36 feet in length; the lower culvert also terminates in similar retaining walls. The cost of the masonry work and excavation for these culverts amount to Rupees 20,318; namely, the excavation for the site of the culvert, Rupees 3,375; the hire of stone-cutters, Rupees 11,331; the cost of lime, carriage, and the placing of the stones, Rupees 3,212; the hire of overseers and maistries, Rupees 2,400. The cost of valves amounts to Rupees 406; huts for coolies, superintendent, and overseers' houses Rupees 1,722; tools, carriage of grain, and sundries, Rupees 2,814.

5. The excavation for the escapement channels cut in the side of the hill for the discharge of the storm-water cost Rupees 2,130. The excavation of the first of these escapements was commenced in May 1869, and in July of the same year a second escapement was begun. In March 1870 a third escapement was commenced, and finished on the 4th June.

6. The proportion of soil to water in the silting-streams on reaching the embankment varies according to the nature of the soil in which the streams are working. When working in thoroughly decayed felspar rock, the water will carry off solid matter fully one-half its own volume; but when working in imperfectly decayed rock, the solid matter becomes reduced to from one-fourth to one-fifth the volume of water. Mr. Broughton, the Government Quinologist, has very kindly

given the aid of his analytic skill in accurately determining the proportion of soil to water in the silting-streams, while working in earth highly favourable and unfavourable for the process. That gentleman's report is appended to this communication.

7. It is necessary to explain that the silting-streams work day and night. During the night, or when the streams are unaided by labourers, the water at the point of excavation cuts the soil into deep ravines, forming miniature mountains and valleys, leaving ridges and spurs abutting against the face of the excavation. During the day, or from 8 A.M. to 5 P.M., the silting-streams are aided by labourers forking down these ridges and spurs. The earth as loosened by the forks or crow-bars rolls down into the streams flowing in the ravines or channels below, and is swept down and deposited on the embankment. The labour is employed to greatest advantage in reducing these ridges, so as to leave in the evening a face on the excavation as nearly perpendicular as possible. The water is then turned over this face in small streams, and during the night, it penetrates the soil and brings down heavy falls of earth, which is carried down and deposited by the water. In this way, when working in good soil, the silting-streams perform nearly as much work during the night as during the day; at other times, when the soil is rocky, they perform comparatively little work.

8. Mr. Broughton's sample of Silt No. 1 may be taken as an average of the deposit during the night, when working in good soil, while sample No. 2 gives a minimum of the night-work. Sample No. 1, taken at 9 P.M., or four hours after the men had left work, gives 22.58 per cent. of its own bulk of earth; No. 2, taken at 6-30 A.M., contains 10.36 per cent. of its own volume of earth; No. 3 was taken at 9 A.M., or one hour after the labourers had begun work, and at this time the silting-stream was found to be carrying down 45.36 per cent., or nearly a half of its own volume of solid matter; No. 4, also, taken when labourers were employed, and when the water was working in very favourable soil, contained 55.01 per cent. of solid matter, or nearly a quarter more than its own volume of earth. No. 3 may be taken as an average result for the nine hours during the day, when aided by labourers forking down the earth. Mr. Broughton has added the very interesting fact that the specific gravity of the soil, contained in the silting-streams, was 2.05, and the silting-water, after having made its deposit on the embankment, contains of solid matter only 1 in 100,000 parts.

9. With reference to paragraph 3 of the Order of Government under reply, I have the honour to state that the culvert has not yet been closed, as it is intended to make use of this means of discharging the summer water until the embankment is raised to its full height.

10. In April 1869 I first commenced to deposit silt by one stream on the north side of the river, and on June 4th of the same year, when the embankment was topped and breached by the freshes, it was 206 feet wide at the base, 187 feet at the top, and 25 feet high; 180 feet across the bed of the river, and 221 feet at the top, and contained 71,140 cubic yards of earth. The cost of depositing this was Rupees 582, which has been included in the sum of Rupees 4,345, the total

11. The work performed by the silting-streams in each month is as follows:—

	Cubic yards.
In April and May 1869 deposited....	71,140
„ September „ „ „ „ „ „	13,000
„ October „ „ „ „ „ „	22,489
„ November „ „ „ „ „ „	20,122
„ December „ „ „ „ „ „	19,586
„ January 1870 „ „ „ „ „ „	38,404
„ February „ „ „ „ „ „	33,635
„ March „ „ „ „ „ „	40,887
„ April „ „ „ „ „ „	29,035
„ May „ „ „ „ „ „	70,030
„ June „ „ „ „ „ „	35,134
Total ..	393,462

12. Although apart from the inquiry of the Right Honourable the Secretary of State, I trust I may be excused in describing the nature and effects of the accident to the bund. This accident was caused by an unusually heavy flood, and in consequence of an insufficient discharge for the storm-water. The storm began at 2 P.M., Wednesday, 15th June, and never moderated until 5 A.M., Monday, the 20th. On Wednesday night the water had risen 18 feet upon the embankment, and on Thursday morning 32 feet; the rise then became more gradual, in consequence of the greater storage to fill, and the volume discharged through the culvert being increased in consequence of the pressure. On Friday night the water had risen to 43 feet upon the embankment, and on Saturday night to 54 feet, the rise being at one time 3 feet an hour. At 1 A.M., Sunday morning, the water had risen to the level of the escapement, the depth of water in the lake being now 69 feet above the deep bed of the river, forming a beautiful expanse of water, extending for many miles, and winding in all directions among the mountains; notwithstanding the immense volume discharged by the escapement and culvert, the water still continued to rise in the lake, and at 1 P.M., Sunday, the water had risen to 81 feet, when it topped the outer-embankment, and, in its fall to the river, began to form a breach in the back part of the bund; this gradually widened and deepened with the increased flow of water, and in about two hours, it had cleared a passage through the back or highest portion of the embankment. The water then began to rush through in a heavy body and with great violence, carrying with it large blocks of silt, and reaching the main bund, which was 380 feet wide; the rush of water was checked by the resistance of the silt, and directed against the side of a rocky hill, through which it forced a passage in a few minutes, tearing out and carrying away immense rocks. At noon on Monday 20th the water had cut down to within 15 feet of the bed of the river, and is now flowing along a part of its natural bed, about one-half being still occupied by the silt; the water had no effect upon the silt until it was overtopped. The tenacity of the latter was truly astonishing: the banks of silt still stand almost perpendicular on either side of the breach, and even in the bed of the river, where the water is now flowing, banks of silt stand, over which the water has been rushing continuously for more than a month.

13. This accident has proved most unfortunate, inasmuch as it must more or less impede the development of the process. I feel confident, however, that it in no way affects the efficiency of the system of construction; on the contrary the execution of this work has demonstrated that there is no method as yet discovered by which earth-work can be so economically and substantially performed. Leaving out the cost of the silting-streams, which, in reality, should be charged only against the whole of the work when completed, and not against a portion, gives 90 cubic yards per Rupee; and charging the whole cost of the silting-streams against the portion of work actually performed, gives 51 cubic yards per Rupee. The earth at the same time being deposited over the greater portion of the embankment in a state so dense and impervious to water as to render it impossible to improve its quality by an application of human labour.

14. More or less danger must always attend the construction of works of this description across mountain-rivers liable to extraordinary floods, whatever may be the method of construction adopted. Providing side-escapements for the discharge of storm-water must necessarily be an expensive and unsatisfactory undertaking, and places the work continually in more or less danger in being overtaken by a heavy flood while passing from one escapement to another. Another source of danger in side-escapements arises from the great fall which the water must have back to the bed of the river, with an immense volume of water; this fall gives it an impetus sufficient to carry away and destroy every thing but solid rock. It therefore appears that the only safe system is to provide an under-discharge for the storm-water during the construction of the embankment. An ample discharge being secured by allowing the water to flow along its natural bed would render the work free from danger and risk; and should means be devised of cheaply and effectually securing this, there will be no difficulty in constructing embankments by the silting-process of any size desired.

MEMORANDUM.

At the request of Mr. McIvor, I have made some determinations of the bulk of solid earth carried down in the form of silt, when the silting-process was being carried on with different degrees of rapidity.

The data for these determinations were obtained as follow:—

About 0·9 of a litre of silt was collected in wide-mouthed bottles as it was flowing on to the bund. The volume and weight of this was carefully measured. It was then dried at a steam heat, and the weight of the dry earth was then taken; subtracting this weight from the total weight of silt, the weight, and consequently the volume of water contained in the silt, is thus determined, and the volume occupied by the dry earth is known.

But it was found that earth, taken from a depth of 10 feet near the site of the bund, contained water to the amount of 23·7 per cent. of its weight. Hence, the bulk of this contained water is added to the volume of the dry silt determined by the above method.

The following are the results obtained. The earth carried down by the water is obviously given in the bulk it would occupy under great pressure, and

containing 23·7 per cent. of its weight of water. The specimens were taken under the superintendence of Mr. McIvor:—

I.—Silt formed by stream of water flowing over cutting on hill-side in evening, no labour being employed in mixing water and earth.—The silt in this case contained 18·42 per cent. of its bulk of earth, or, in other words, the water carried down 22·58 per cent. of its bulk of earth, or, in other words, every 122·58 parts of the mixture contained 22·58 parts of earth and 100 of water.

II.—Silt formed from the same stream in morning, after flowing all night.—Silt contained 9·30 per cent. of its volume of earth, or, in other words, water carried down 10·26 per cent. of its bulk of soil.

III.—Silt formed from water pouring down cutting in hill-side, during which time it was worked with earth by manual labour.—Silt contained 45·86 per cent. of its bulk of earth, or, in other words, the water brought down 84·7 per cent. of its volume of earth.

IV.—Silt formed when the amount of earth was believed to be at a maximum.—The silt contained 55·01 per cent. of its bulk of earth; the water carried down 122·29 per cent. of its volume of earth, or 222·29 parts of the mixture contained 122·29 earth and 100 water.

It will be observed that the foregoing data afford the means of approximately calculating the specific gravity of the deposited earth when containing 23·7 per cent. of its weight of water. Thus the four determinations give a mean specific gravity of 2·05.

The water flows off the depositing silt quite clear and colourless. A determination of the amount of solid matter in solution in this water was made. To my surprise I found it contained but 1·235 of solid matter in 100,000 parts; and hence was water of extreme purity.

It is impossible to have a more striking instance of the minute amount of soluble matters that are contained in the rocks of the Neilgherries.

OOTACAMUND,
14th June 1870,

(Signed) J. BROUGHTON,
Government Quinologist.

No. 145. *Note by the Acting Chief Engineer for Irrigation.*

THE letter from Mr. McIvor is in reply to the Order of Government of the 4th May 1870, No. 1,183, calling for information required by the Secretary of State.

2. Since that Order was issued, the bund in course of formation by Mr. McIvor has breached, and this gentleman has taken the opportunity of describing this occurrence in addition to supplying information regarding the work executed up to the time of the accident.

3. Up to the 19th June, the date of the breach, the quantity of earth-work executed by the silting-process was cubic yards 393,462. This quantity includes 71,140 cubic yards, which were washed away on the 4th June 1869 by the freshes of that year.

4. The actual cost of the earth-works is reported to have been Rupees 7,585, of which amount the outlay on bringing the silting-streams to the site of the dam, and maintaining them in repair, was Rupees 3,240, and that on excavating the soil

*Proceedings of the Madras Government, Public Works Department,
10th October 1870.*

and depositing it on the embankment was Rupees 4,345. It follows, therefore, that up to the present time the—

Total cost has been at the rate of cubic yards 51.87 per Rupee.
Charge for silting channels do. " 121.44 "
Do. excavation and deposit do. " 90.55 "

or in other words the—

Cost of silting channels has been ... Pies 1.58
Do. excavation and depositing has been ... " 2.12

Total cost per cubic yard... 3.70

On the other hand, the total outlay upon the reservoir works has been—

	RS.
For earth-works as above ...	7,585
" the culvert—	
Excavation of site ...	3,375
Stone-cutters ...	11,331
Lime, carriage, and building ...	3,212
Overseers and Maistries ...	2,400
	20,318
For culvert-valves ...	406
" shelter for superintendence and huts for coolies ...	1,722
" tools, carriage of grain, and sundries ...	2,814
" escapement channels ...	2,130

Total expenditure... 34,975

5. Mr. McIvor's letter contains some interesting particulars regarding the proportion of soil to water in the silting-streams under different circumstances. As was to be expected the water during the night, when there is no labour employed in mixing up the soil with it, carries comparatively little earth. At the same time the quantity carried is not inconsiderable even under this, the least favourable, condition for work. The way in which the proportions were determined will be found in the Memorandum by Mr. Broughton, the Government Quinologist, appended to Mr. McIvor's letter. The results of these determinations are—

Working hours from 8 A.M. to 5 P.M.	In every 100 parts.
	Earth. Water.
Sample No. 1 taken at 9 P.M. ...	18.42 81.58
" " 2 " " 6.30 A.M. ...	9.30 90.70
" " 3 " " 9 A.M. ...	45.86 54.14
" " 4, time not stated ...	55.01 44.99
Taking the first two samples as a guide to night-work—	

	Cubic feet soil.
In the first case 1 cubic foot of water carried ...	0.225
" second case " " " ...	0.102
	0.327

Also the day-work—

	Average... 0.163
Sample No. 3 one cubic foot of water carried ...	0.847
" " 4 " " " ...	1.222
	2.069
	Average... 1.034

*Proceedings of the Madras Government, Public Works Department,
10th October 1870.*

Then the average for the twenty-four hours would be, deducting the rest of one hour in the middle of the day, $\frac{8 \times 1.034 + 16 \times 0.163}{24} = 0.453$, and a cubic foot a second would deposit consequently 39,139.2 cubic feet a-day, or, in round numbers 1,450 cubic yards daily. A considerably larger number of observations, taken at times when the water was working in different soils, would be necessary to afford reliable data for calculating the duty of a stream of a cubic foot a second, but the above particulars will nevertheless not be without interest and value.

6. Paragraph 11 of Mr. McIvor's letter shows the quantities of soil deposited in each month; the variations are very considerable, the—

Minimum being in September 1869 ...	13,000
Maximum do. in May 1870 ...	70,030

Notes taken by me in December last show, however, that silting was resumed late in September, and that up to the end of 27th. December the work was several times

interrupted. The soil deposited in May (taking twenty-six working days) gives 2,700 cubic yards daily nearly, or less than the average duty of two cubic feet a second, as given in the preceding paragraph of this note. I do not think any arrangements were made for gauging the water-supply carried by the several streams or channels brought in for silting. It will be desirable, wherever similar operations may be carried on in the future, to record as carefully as may be, first, the quantity of water brought to the work; and, secondly, that usefully employed in silting.

7. In paragraph 2 of his letter, Mr. McIvor reports the dimensions of the embankment, at the time of the accident, to have been as follows, and it may be here noticed that the bank was raised to a certain height for a considerable width, and then upon this a comparatively narrow embankment was placed:—

Higher bund ...	81 feet high.
Lower do. ...	57 " "
Width of bund at base ...	475 "
Do. at top (probably the 57 feet level is here meant) ...	383 "
Length of bund at base ...	170 "
Do. at top ...	418 "

My measurements of the heights are somewhat different to those given by Mr. McIvor, unless he has taken the deep bed of the river, which he puts at 21½ feet below the sill of the lower part of the culvert as his datum. There may be pools of this, or of even a greater depth, but I am disposed to think that the average level of the bed at the bund-site is not many feet below the bottom of the lower culvert.

8. I visited the bund-site at the end of last month. Mr. McIvor has correctly attributed the accident to the insufficient capacity of the escape channel provided; I have not the requisite data for calculating at all accurately the quantity of water which was entering the tank just before it breached, but I estimate the maximum discharge,* at the time the water was at its highest, at about 331,000 cubic yards per

* By the escape channel and culvert together. hour, equivalent to one-fifth of an inch of drainage per hour from a catchment basin

of 20 square-miles. Considering the position of the basin in a part of the country where the rain-fall is estimated at about 120 inches, and taking also into account the steepness of the hill-sides and the great fall of the rivers, I can hardly consider the circumstances to have been extraordinary, and, with the water-way allowed, the destruction of the bund appears to me to have been inevitable. It is not perhaps altogether an easy matter to provide against all contingencies at the site chosen for the construction of a dam by the silting-process. To pass all the water under the dam by a culvert, or under the hill-side by a tunnel, would be costly out of proportion to the quantity of water which the lake would be capable of storing, and consequently, if a reservoir is to be formed here, it will be necessary to run the risk, which will be incurred in getting the bund raised to a height at which a sufficient escapement channel can be provided at about the proper level for the end of a season's work. Mr. McIvor's escape was on the left bank, and its width at sole was 10 feet, with steep side slopes, and a bed-fall of 1 in 17. The soil was not suited to withstand the velocity generated by these arrangements, and, had the bund been 30 or 40 feet higher, I have no doubt a breach of large dimensions would have been formed on the line of the escape channel. The right bank of the river is, I think, the proper site for the temporary escape. The off-take presents at first sight some difficulties, but these can readily be overcome, and thereafter I believe that all that is requisite for getting rid of the water for one season may be secured; while, if rock be met with at a suitable level, it may be advisable to build a sluice on this side, to discharge the water stored so as to maintain a constant stream in the river. Just below the bund on the south side the hill recedes, and I propose to silt this hollow up to the required level. Then the head of the surplus channel would be partly on the bund and partly cut into the hill on which the bund rests; thence the channel would be carried across a hill which has already been excavated to a considerable extent to provide material for the bund, to a small ravine which runs down to the river about 300 yards below the bund-site. If, as appears probable from the face of the hill, rock be met with on the line of the channel at or but little below the required level, the arrangements can be made complete at little or no expense. If, on the other hand, there be no rock, the out-fall into the ravine is, I think, sufficiently distant from the bund to prevent any risk of the channel cutting back during the time it will be in use.

9. The sill of Mr. McIvor's escape channel of this year was 46.30 feet above the floor of the lower part of the culvert. As a great deal of the silt which was deposited during the past season remains, it will, I believe, be safe to place the sill of the escape for next season at 50 feet above the lower culvert floor, and ample waterway will be secured by making the channel 100 feet wide at its head and 60 feet at its lower end, with side slopes of 1 to 1 and a fall of 1 in 600, or 8 feet a mile for its bed. With a depth of 12 feet of water, and with the lake surface

* $50+12+3$, the latter being the head required for generating the velocity in the surplus channel from a still pool.

not exceeding +65,* leaving out of the calculation all velocity of approach, such a channel would discharge 12,310 cubic feet a second, or five times as much

as the discharge of the culvert and channel together when the accident occurred

in June. The maximum velocity of the water at the head of the escape channel would be about 10 feet a second, and it has been proved that the brown clay silt has stood a much higher velocity without erosion. I would, however, protect all the artificial soil in contact with the surplus water, by facing the bank with brush-wood laid 4 feet into the bank when the latter is silted, and the sill of the escape on the line of the bund might, with advantage, be paved with stone for a width of 30 feet, so as to maintain the proper level. The surplus channel should also be laid out with a flat curve, concave towards the river, so that what little set there may be against the hill-side, where a little erosion will do no harm. With these arrangements the proper height of the bund would be $50+12+3+6=71$ feet, or about 11 feet higher than the highest part of the bank this year. The base of the part of the bund above the level of the escape channel need not exceed 96 feet, namely, top width 12 feet, and four times the height of the bank, so as to allow slopes of 2 to 1 on both sides.

10. As far as I could judge the lower part of the culvert had not sustained any damage of consequence, and should it be found uninjured when the state of the river will admit of its being examined throughout, it will do very well for the purpose for which alone it will in the future be required, namely, to discharge summer water and slight freshes from occasional showers; the upper part of the culvert was much more roughly constructed, and as it evidently had no proper foundations at some places it must, I am afraid, be taken down and re-built. As, however, I propose to close it permanently at the end of the first season, and not to use it again to discharge the freshes of the south-west monsoon, it will suffice if the whole length be 300 feet, or say 60† feet instead of 157.

† The length of the lower culvert is reported to be 244 feet. feet for the upper part. Probably no new stone will then be required, but

the flooring should be built of very much better and more shapely stone than before, and the covering stones of the abandoned portion may be used for this purpose. The side walls should not be less than $2\frac{1}{2}$ feet thick at top and 3 feet at base; the inside dimensions need not exceed 4 feet in width and 5 feet in height, as the opening communicating with the lower culvert is but 4 feet in diameter: the flooring, if not laid on masonry or concrete built upon the rock, should have 2 to 3 feet of concrete under it: the mortar or chunam before used was very indifferent, and care should be taken to use only such a description of chunam as has been proved to be good.

The culvert then would be used to discharge the river-water during the dry season, and until the work of the season, which is closed by the setting in of the south-west monsoon, had been completed. About the first week in June, supposing the escape channel to be ready and the bund of a proper height, the culvert should be closed and entirely silted up, and this Mr. McIvor thinks he will be able to effect with facility. There will then be nothing to prevent the widening and raising of the bund going on continuously during the monsoon, when the silting-streams will have more water, and be able to execute a much greater quantity of work per month.

11. I have spoken of the temporary escape, and mentioned that it will probably be wanted only for one season, for, supposing work to go on throughout

the south-west monsoon, there can be little doubt of the entire completion of the bund in eighteen months from its commencement. The intended site of the permanent escape is in a valley to the south of the lake, and this valley is separated from the lake basin by a ridge the lowest part of which is a saddle, which is reported to be 120 feet above the intended full tank level. This saddle is supposed to be of soft material, and a silting channel runs across it; with the aid of water it may be cut down, provided no rock be met with in a very short time. It appears to me, however, to be essential that a cutting, at least 40 or 50 feet wide, should be made before any decision is come to regarding the re-construction of the main bund, for upon the feasibility of connecting the two valleys at a moderate expense may depend the propriety of forming a lake at all. I have not examined the country in detail, but I am not aware that any other suitable site than that already mentioned for a permanent escape is to be found, and it would of course be useless to make a reservoir, and then to find that the surplus water could not be safely got rid of. Every important point connected with a project of this sort ought to be ascertained and settled beforehand. Levels have been taken of some of the ground in the neighbourhood of the dam, but I have not as yet, owing to changes in the executive establishment on the Neilgherries, been able to get hold of them; and not having been able to find any permanent bench marks, or any interpretation of what the original levels mean, I cannot, at the present moment, give any such general outline of the way in which the formation of this reservoir should be carried out, if the attempt is to be made as is desirable and necessary.

12. The total loss incurred up to the present time, in consequence of the two accidents, and of the necessity for re-constructing a part of the culvert, is probably about 10,000 Rupees; and to this perhaps 3,000 Rupees may be added for silting up the escape channel formed this year, and the pits which have been cut within the proper line, or are inconveniently situated. In round numbers, then, 22,000 Rupees worth of work remain; and, provided the arrangement for the completion of the project can be satisfactorily and completely planned, it will, perhaps, be considered worthwhile to make another attempt to construct a reservoir at this site. What the work will cost I have not the means of stating. The bund-site was not contoured, and, without contour levels, the embankment cannot be plotted and its contents calculated. Probably, the silting of the bund will not cost more than 30,000 Rupees, and it may cost considerably less; this will depend upon the correctness of Mr. McIvor's calculations of the quantity of work done last season, and accuracy must have been very difficult of attainment.

13. With regard to the way in which the work should be carried on for the future, it is necessary that I should remark that the Secretary of State's instructions that Mr. McIvor should be interfered with as little as possible have been the cause of much disappointment not only to the Government and to Mr. McIvor himself, but to all who are interested in the successful application of a process, which promises to be of great utility in saving money, time, and labour, and in perhaps rendering feasible works which could not, without its aid, be attempted. Mr. McIvor understands better than any one else the management of silting streams, and the methods of turning them to account in excavating and afterwards distributing soil; but there are many other things to be considered and attended

to before the Government can obtain, either on the Mailkhonda road or elsewhere, an efficient reservoir, and unfortunately, though very naturally, such matters not being within Mr. McIvor's knowledge or experience, he has been unable to deal with them successfully. I do not make these remarks with any desire to disparage this gentleman; on the contrary, I believe very few would, under the circumstances, do as well as he has done, and his energy and resource are not only considerable, but in themselves of great importance on a work of this kind. Just as natural talent and ability will not enable a man to do the work of a Surgeon or Physician, or to navigate a ship in waters where the accurate calculation of position is essential to safety: so no one, without some special training, would be likely to be able either to estimate the discharge of a river correctly, or to provide suitably for the disposal of its waters. The part of the work which Mr. McIvor is fully competent to manage is the excavation and deposition of soil, and this he should be allowed to arrange for as he thinks best. I think, also, that, if the rest of the work be laid out for him, and some few instructions given, he will be able to superintend its execution as well as, and probably better than, any one likely to be available for the duty, and it will be convenient that all the labour should be under one direction. Moreover, there will be a certain quantity of earth-work to be done before the close of the dry season, and it is essential that the deposition of soil should be confined within the limits of the section of embankment to be finished by that time; as also that the arrangements made should be such as to ensure the progress of the work at a rate somewhat in excess of the average required to complete this work in proper time. Paragraph 11 of Mr. McIvor's letter, and the notes which I made from information furnished by him last December, show that the progress during the last working season was very irregular. Probably, 450,000 cubic yards of soil will suffice for the next season's work, and October to May may be taken as being the working season. A more accurate calculation of the quantities of earth-work should hereafter be made by the Executive Engineer, Neilgherry Range, but the above will serve as an illustration; then the regular monthly deposit should be 60,000 cubic yards, and taking twenty-five working days in the month, the daily quantity will be 2,400 cubic yards, and will require probably at least 2 cubic feet of water per second. If 3 cubic feet a second can be maintained in the channels throughout the season, and this is not a very large demand, so much the better; if not, a larger quantity should be used in those months when water is abundant to compensate for a short supply at other times. The Executive Engineer should arrange—

First, for the preparation of fairly accurate sections of the bund of the size required for the season's work, showing

- Stout stakes will do very well for these, a small bench 1 foot square denoting the level to which the stake refers and the stakes being numbered.
- for every yard of height the contents of each layer. A series of bench-marks* can be placed on either abutment hill, corresponding with these yard layers, and

then the progress of the work can be ascertained without difficulty, and if the soil be deposited in section, a very simple statement showing the quantity of earth-work required to be, and actually done on the last day of each month, may be prepared from a mere inspection. The outlines of the bund should be scoured on the hills on either side of the river.

*Proceedings of the Madras Government, Public Works Department,
10th October 1870.*

Second, for the gauging of each silting-stream at some convenient point near but outside of or above the excavations. Appropriate forms for the registration, of the supply should be drawn up to suit the particular plan of gauging adopted.

14. When the information necessary for determining finally the proper level of the reservoir when full, the level and dimensions of the permanent escape, etc. is received, the leading features of the project will be recorded in a form which will allow of their being better understood than is at present possible, and it will then be seen what the contents of the bund, when of full height, will be, and a sufficiently accurate estimate of the cost of the reservoir may be made out.

OOTACAMUND,
18th August 1870.

(Signed) J. MULLINS, Major, R.E.,
Acting Chief Engineer for Irrigation.

No. 146. ORDER THEREON, 10th October 1870, No. 2,439.

IRRIGATION, No. 15.

THE papers recorded in these Proceedings contain Mr. McIvor's report of the work done by him at the reservoir bund on the line of the Mailkhoondah road, and of the accident which occurred to this work on the 19th June last; also the observations of the Acting Chief Engineer for Irrigation on that report, with this officer's opinion as to the way in which the construction of the reservoir should, if resumed, be carried on; and remarks showing that further information on some important points is requisite before a proper decision can be arrived at.

2. The value of the silting-process as an economical means of excavating and depositing soil, as also for the formation of bunds for the retention of water, has been conclusively demonstrated by the results of the work of the past season. The material deposited is eminently stable and water-tight, and it possesses all the qualities which are desirable for a work of this kind. The breaching of the bund, after it had attained a height of nearly 60 feet above the sill of the lower part of the culvert, was caused by the insufficient water-way provided by the escape channel, and not by any defect in the bund itself, which stood firm until the water passed over its top, and then offered a very considerable resistance to the erosive action of the water. Masses of silt are still, after the water has been running over them for many weeks, remaining in the bed of the river, and the bund on the two sides of the river-channel stands with nearly vertical faces, and has been but little affected by the heavy rains which have fallen since the date of the accident.

3. The Acting Chief Engineer considers that an efficient temporary escape can be provided on the right bank of the river, and he thinks that its sill may with safety be fixed at 50 feet above the lower culvert floor; also, that if, in the first place, the bund be constructed of the dimensions requisite to provide for its safety on the setting in of the next south-west monsoon, so much additional work can be done during the monsoon towards making the bund of the full section required, as to ensure the completion of the dam in the second dry season. He also points out that out of a total expenditure of, in round numbers, 35,000 Rupees, work of the value of about 22,000 Rupees remains uninjured. So far then there is much in favour of a resumption of the work; the Chief Engineer, however, shows that the basin of

*Proceedings of the Madras Government, Public Works Department,
10th October 1870.*

the reservoir is divided from the valley in which the permanent escape is intended to be placed by a chain of hills, the lowest saddle of which is reported to be 120 feet above full tank level. If this saddle contain no rock, above the required level, the requisite cutting can be made through it at a very small expense by the aid of water, which is available on the spot; but should rock be found at a high level, the connection of the two valleys by a cutting would be economically impracticable, and unless another suitable permanent escape site can be found, it would be necessary to abandon the idea of forming a reservoir in this position.

4. The first thing to be done, therefore, is to make a cutting through the saddle first referred to, and the Government learn that Mr. McIvor needs a sum of Rupees 500 to enable him to do this; that amount will accordingly be at once placed, through the Superintending Engineer, 7th Division, at Mr. McIvor's disposal from the reserve under "Agricultural."

5. His Excellency the Governor in Council concurs in the opinion of the Chief Engineer for Irrigation that, should the Government decide to sanction the completion of the reservoir, the general arrangements should be under the control and supervision of professional officers; that the immediate charge of the works of all kinds should be given to Mr. McIvor, who should be furnished with definite instructions on all points of importance; and that only in respect of the details of the silting-process, with which this gentleman is fully acquainted, should the responsibility of making the necessary arrangements entirely rest with him.

6. This Order will therefore be communicated to the Superintending Engineer 7th Division, with a view to the Executive Engineer, Neilgherry Range, being instructed to take such levels, and collect such other information as may be necessary to the proper designing of the project and to the drawing up of complete instructions for Mr. McIvor's guidance, and the Chief Engineer will then submit for the orders of Government his views as to the way in which it should be carried out, so far as its leading features are concerned, together with an estimate of the cost based, as regards earth-works, on the rates at which this work has already been executed. This officer will also, if the construction of the reservoir be sanctioned, issue whatever instructions he may consider requisite, both in the first instance and afterwards from time to time. The Executive Engineer, Neilgherry Range, will be charged with the duty of seeing that the instructions are duly carried out, and of rendering all needful professional assistance to Mr. McIvor.

7. The Government desire that in drawing up the project, attention may be given to the provision of suitable works for discharging the greater part of the contents of the reservoir for purposes of irrigation.

8. A copy of these Proceedings will be transmitted for the information of the Secretary of State.

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,
Secretary to Government.

To the Chief Engineer for Irrigation.
Superintending Engineer, 7th Division.
To W. G. McIvor, Esq.
To the Controller of Public Works Accounts.

Exd. F. R. Bantleman.

Gobt. of {1870} Madras.

PUBLIC WORKS.

To

THE CHIEF ENGINEER FOR IRRIGATION.

- &c., &c., &c.

Dated October 10th.

Recd.

Encl.

G. O., 10th October 1870, No. 2,439.

OCTOBER

Nos. 144-146

Embankment.—Passing orders on papers regarding the work done at the embankment in course of construction by the silting-process across the Poorthy river, and the accident which occurred to this work on the 19th June last.

Memorandum

At the request of Mr. McIvor, I have made some determinations of the bulk of solid earth carried down in the form of silt when the silting process was being carried on with different degrees of rapidity.

The data for these determinations were obtained as follows:—

About 0.9 of a litre of silt was collected in wide mouthed bottles as it was flowing out to the bund. The volume and weight of this was carefully measured. It was then dried at a steam heat, and the weight of the dry earth was then taken subtracting this weight from the total weight of silt, the weight and consequently the volume of water contained in the silt is thus determined, and the volume occupied by the dry earth is known.

But it was found that earth taken from a depth of few feet near the side of the bund contained water to the amount of 23.7 per cent of its weight. Hence the bulk of this contained water is added to the volume of the dry silt, determined by the above method.

The following are the results obtained. The earth carried down by the water is ~~roughly~~ ^{approximately} the bulk it would occupy

great pressure and containing 23.7 per cent of its weight of water. The specimens were taken under the superintendence of Mr. McIvor.

I Silt formed by stream of water flowing over cutting on hill side, in evening, no labor being employed in mixing water and earth.

The silt in this case contained 18.42 per cent of its bulk of earth, (or in other words) the water carried down 22.58 per cent of its bulk of earth, or in other words every 122.58 parts of the mixture contained 22.58 parts of earth and 100 of water.

II Silt formed from the same stream in morning, after flowing all night.

Silt contained 9.30 per cent of its volume of earth, or in other words water carried down 10.26 per cent of its bulk of soil.

III Silt formed from water pouring down cutting in hill side during which time it was worked with earth by manual labor.

Silt contained 40.86 per cent of its bulk of earth, or in other words the water brought down 84.7 per cent of its volume of earth.

IV Silt formed when the amount of earth was believed to be at a maximum.

The silt contained 55.01 per cent of its bulk of earth, the water mixed down

122.29 per cent of its volume of earth, or 122.29 parts of the mixture contained 122.29 earth and 100 water.

It will be observed that the foregoing data afford the means of approximately calculating the specific gravity of the deposited earth when containing 23.7 per cent of its weight of water. Thus the few determinations give a mean sp. gr. of 2.05. The water flows off the depositing silt quite clear and colorless. A determination of the amount of solid matter in solution in this water was made. To my surprise I found it contained but 1.235 of solid matter in 100,000 parts, and hence was water of extreme purity.

It is impossible to have a more striking instance of the minute amount of soluble matters that are contained in the rocks of the Andes.

(Signed) John Brroughton

Oct 20 1873
14 June 1873

(True copy)

W. McIvor
Supt. Govt. Chin. Planting

Dr. McLean to Hugh Allen 11. Oct. 1870.

Deaths Taken At Date

19

Back Staff	Fore Staff	Staff	Red. Level	Level atm. h'd of river * 127.32
0.52*	12.38	11.56	11.86	
2.55	13.60	11.05	22.91	
3.43	9.63	6.20	29.11	
2.27	15.56	13.29	42.40	
1.65	16.62	14.97	57.37	69.95
2.55	6.35	3.80	61.17	66.15
0.63	13.78	13.15	70.52	56.80
2.87	16.15	13.34	83.86	
1.85	16.76	14.91	98.77	
2.29	13.62	11.33	110.10	17.22
4.97	4.53 +	0.44	109.66	17.66
		7.16	116.82	10.50
		10.50	127.32	0.00

Back staff on a peg Δ on trace (supposed to be full land level) on hill left end of bench or bank of river.

69.95 north end of branch highest part.
66.15 do do of do near edge of branch

56.80 { back staff on station 16.62 - fore staff
on left of escape channel

17.22 side of upper culvert
17.66 side of circular valve opening
10.50 side of lower culvert } according to
0.00 bed of river } Mr. McIlwain

144

J. N. 1870 Sept
 Sperry & Co. Cashier
 No. 3847
 From
 J. N. 1870
 Sept 29
 Recd
 Dec 29
 Sperry & Co.
 Cashier
 No. 3847
 The enclosed is a
 copy of the
 report of the
 committee on
 the subject of
 the proposed
 amendment to
 the constitution
 of the State
 of New York
 in relation to
 the right of
 suffrage.
 It is respectfully
 submitted to
 you for your
 consideration.
 Very respectfully,
 J. N. 1870
 Sept 29

the experiment in the Peilcherries has been
productive of practical results, and that
your Government has been led to form
a favorable opinion of its usefulness.

2. As the surveys and estimates
for the Perryar Project appear (judging
from the Reports of Captains Pyves and
Lieutenant Pennington, and the orders
that have been passed upon them in
your Proceedings) to be approaching
maturity, I take this opportunity of
requesting that, when the Project is sub-
mitted to me, the papers may be accom-
panied by a sketch map of the region,
including the country as far as Permede
on one side, and the courses of the Shurly
and Vagay on the other. None of the
names of streams near the site of the
dam are marked either on the atlas
sheet or on the latest Irrigation map.

I have &c.

Signed Brgyll.

Page 257

Byrd. Byrd.

Mr 3848/30

1/10

257
Note by the Acting Chief Engineer for Irrigation
The letter from Mr. McElroy is in reply to the
order of Government of the 4th May, 1870 N-1183
calling for information required by the Secretary
of State.

2. Since that order was issued the bund
in course of formation by Mr. McElroy has
breached, and this gentleman has taken the op-
portunity of describing this recurrence in addi-
tion to supplying information regarding the
work executed up to the time of the accident.

3. Up to the 19th June, the date of the
breach, the quantity of earthwork executed by
the silting process was cubic yards 393,462. This
quantity includes 71,140 cubic yards, which were
washed away on the 17 June 1869 by the freshets
of that year.

4. The actual cost of the earthwork is
reported to have been Rupees 7,585, of which amount
the outlay on bringing the silting streams to
the site of the dam, and maintaining them
in repair, was Rupees 3,240, and that on excavating
the

the soil and depositing it on the embankment was Rupees 4345. It follows therefore that up to the present time the

total cost has been at the rate of Rs. 51.87 per Rupee

charge for pitting channels do " 121.44 " "

do " excavation & deposit do " 90.55 " "

or in other words the cost of pitting channels has been 1.58 pice:

" of excavation & depositing " 2.12 "

Total cost per cubic yard. 3.70

On the other hand the total outlay upon the various works has been
For canals as above Rupees 7,585

" the Culvert
Excavations of pits Rupees 3,575
Stone cutters " 11,331
Lime, carriage & building " 3,212
Overseers & Maistries 2,400 " 20,318
" cartage, wages " 406
" Shelter for superintendence & hands for work 1,722
" Tools, carriage of grain & sundries 2,814
" Reservations channels 2,130
Total expenditure Rupees 34,945

Mr.

5 Mr. Ince's letter contains some interesting particulars regarding the proportions of soil to water in the pitting streams under different circumstances. As was to be expected the water during the night, when there is no labour employed in mixing up the soil with it, carries comparatively little earth. At the same time the quantities carried is not inconsiderable even under this, the least favorable, condition for work. The way in which the proportions were determined will be found in the memorandum by Mr. Broughton, the Government Geologist, appended to Mr. Ince's letter. The results of these determinations are

ing hours & to 5 P.M.	Sample	Time	100 parts	
			Earth	Water
ing hours & to 5 P.M.	Sample No. 1	taken at 9 A.M.	18.42	81.58
	" No. 2	" " 6.30 A.M.	9.30	90.70
	" No. 3	" " 9.30 A.M.	45.86	54.14
	" No. 4	time not stated	55.01	44.99
Taking the first two samples as a guide to night work.				
in the first case			1 cubic foot of water carries	C. 5.235
" second "			do do	0.102
				<u>0.327</u>
			Average	0.163

also the day 10000

Sample # 3 1 cubic foot of water carried 0.847

" # 4 " " " 1.222

2.069

Average 1.034

Then the average for the 24 hours would be, deducting the rest of 1 hour in the middle of the day, $2 \times 1.034 + 16 \times 0.163 = 0.1153$

and a cubic foot a second would deposit consequently 39,139.2 cubic feet a day or in round numbers 14,500 cubic yards daily. A considerable

larger number of observations, taken at times when the water was running in different pools, would be necessary to afford reliable data for calculating the duty of a stream of a cubic foot a second, but the above particulars will nevertheless not be without interest & value.

Para. 11 of his letter shows the quantities of soil deposited in each month. The variations are very considerable. The minimum being in September 1869 - 13,000

Maximum " " May 1870 - 70,030

Notes taken by me in December last show

however

27th

29th
however that pitting was resumed later in September, and that up to the end of December the work was several times interrupted. The soil deposited in May (taking 26 working days) gives 2,700 cubic yards daily, nearly, or less than the average duty of 2 cubic feet a second, as given in the preceding paragraph of this note. I do not think any arrangements were made for gauging the water supply carried by the several streams or channels brought in for pitting. It will be desirable, whenever similar operations may be carried on in the future, to record as carefully as may be, first the quantity of water brought to the work & secondly that usefully employed in pitting.

Para 2 of his letter Mr. McDowell reports the dimensions of the embankment at the time of the accident to have been as follows, and it may be here noticed that the bank was raised to a certain height for a considerable width & there upon this a comparatively narrow embankment was placed. Higher bank 81 feet high Lower " 57 " " width

Width of bund at base 475 feet

Ch. at top (probably
the 57 feet level is here meant) 383 "

Length of bund at base 170 "

Ch. Ch. at top 118 "

My measurements of the heights are somewhat different to those given by Mr. McCool, unless he has taken the deep bed of the river, which he puts at 2 1/2 feet below the sill of the lower part of the culvert, as his datum. There may be pools of this or even a greater depth, but I am disposed to think that the average level of the bed at the bund site is not many feet below the bottom of the lower culvert.

I visited the bund site at the end of last month. Mr. McCool has correctly attributed the accident to the insufficient capacity of the escape channel provided; I have not the requisite data for calculating at all accurately the quantity of water which was entering the tanks just before it breached, but I estimate the maximum discharge at the time the water was at its highest at about 33,000 cubic yards per hour, equivalent to 1/5 of an inch of drainage per hour from a catchment basin of 20 square miles.

by the escape channel & culvert together

31 10
Considering the position of the basin in a part of the country where the rainfall is estimated at about 120 inches, and taking also into account the steepness of the hill sides, and the great fall of the rivers, I can hardly consider the circumstances to have been extraordinary, and, with the water way allowed, the destruction of the bund appears to me to have been inevitable. It is not perhaps altogether an easy matter to provide against all contingencies at the site chosen for the construction of a dam by the piling process. To pass all the water under the dam by a culvert, or under the hill side by a tunnel, would be costly out of proportion to the quantity of water which the Lake would be capable of storing, and consequently if a reservoir is to be formed here it will be necessary to run the risk, which will be incurred in getting the bund raised to a height at which a sufficient escapement channel can be provided at about the proper level for the end of a season's work. Mr. McCool's escape was on the left bank, and its width at sole was 10 feet, with steep side slopes, and a bed fall of 1 in 17. The soil was not suited to withstand the velocity generated by these arrangements, and

and had the bund been 30 or 40 feet higher, I have no doubt a breach of large dimensions would have been formed on the line of the escape channel. The right bank of the river is, I think, the proper site for the temporary escape. The obstacle presents at first sight some difficulties, but these can readily be overcome, and thereafter I believe that all that is requisite for getting rid of the water for one season may be secured; while, if rocks be met with at a suitable level, it may be advisable to build a sluice on this side to discharge the water stored so as to maintain a constant stream in the river. Just below the bund on the south side the hill recedes, and I propose to pick this hollow up to the required level. I saw the head of the surplus channel would be partly on the bund and partly cut into the hill on which the bund rests. Hence the channel would be carried across a hill, which has already been excavated to a considerable extent to provide material

33 11
for the bund, to a small ravine which runs down to the river about 300 yards below the bund site, as appears probable from the face of the hill, rocks be met with on the line of the channel at, or but little below, the required level. The arrangements can be made complete at little or no expense. On the other hand there be, no rocks, the out-fall into the ravine is, I think, sufficiently distant from the bund to prevent any risk of the channel cutting back during the time it will be in use.

9. The sill of Mr. McGowan's escape channel of this year was 46.30 feet above the floor of the lower part of the culvert. As a great deal of the silt which was deposited during the past season remains, it will, I believe, be safe to place the sill of the escape for next season at 50 feet above the lower culvert floor, and ample waterway will be secured by making the channel 100 feet wide at its head and 60 feet at its lower end, with side slopes of 1 to 1 and a fall of 1 in 660, or 8 feet a mile for its

its bed with a depth of 12 feet of water and
 with the lake raised not exceeding + 65, ^{* 50 + 12 + 3} ^{The latter being the head required for generating the velocity in the surplus channel from a still pool.}
 ring out of the calculation all velocity of approach,
 such a channel would discharge 12,310 cubic feet a
 second, or 5 times as much as the discharge of the
 culvert & channel together when the accident occurred
 in June. The maximum velocity of the water at
 the head of the escape channel would be about 10
 feet a second, and it has been proved that the brown
 clay silt has stood a much higher velocity with-
 out erosion. I would however protect all the arti-
 ficial soil in contact with the surplus water
 by facing the banks with brushwood laid 4
 feet into the bank when the latter is silted, and
 the sill of the escape on the line of the bank
 might with advantage be paved with stone
 for a width of 30 feet, so as to maintain
 its proper level. The surplus channel should also
 be laid out with a flat curve, concave towards
 the

35. The river, so that what little get there may be may
 be against the hill side, where a little erosion
 will do no harm. With these arrangements the
 proper height of the bund would be $50 + 12 + 3 + 6 = 71$
 feet or about 11 feet higher than the highest part
 of the bank this year. The base of the part
 of the bund above the head of the escape chan-
 nel need not exceed 96 feet, viz top width 12
 feet, and 4 times the height of the bank,
 so as to allow slopes of 2 to 1 on both sides.
 10. As far as I could judge the lower part of
 the culvert had not sustained any damage of con-
 sequence, and should be so found - unimpaired when
 the state of the river will admit of its being
 examined throughout, it will do very well for
 the purpose for which alone it will do the fu-
 ture be required, viz to discharge summer water and
 slight freshes from occasional showers. The upper part
 of the culvert was much more roughly constructed,
 and as it evidently had no proper foundation
 at some places it must, I am afraid, be taken
 down and rebuilt. As however I propose to close
 it permanently at the end of the first sea-
 son, and not to use it again to discharge
 the freshes of the S.W. Monsoon, it will suffice
 if the whole length be 300 feet or say 60 feet
 instead

* The length of the
 lower culvert is reported
 to be 244 feet.

instead of 15 feet for the upper part. Probably
no new stone will then be required, but the flooring
should be built of very much better and more
shapely stone than before, and the covering stones
of the abandoned section may be used for this pur-
pose. The side walls should not be less than
2 1/2 feet thick at top, and 3 feet at base; the
inside dimensions need not exceed 4 feet in
width and 5 feet in height, as the opening
communicating with the lower culvert is but
4 feet in diameter. The flooring if not laid
on masonry or concrete built upon the rock
should have 2 to 3 feet of concrete under it. The
mortar or chunam before used was very indif-
ferent, and care should be taken to use only
such a description of chunam as has been proved
to be good.

The culvert then would be used to discharge
the river water during the dry season, and un-
til the work of the season, which is closed by the setting
in of the S.W. monsoon, had been completed. About the
first week in June, supposing the escape chan-
nel to be ready and the bund of a proper height,
the culvert should be closed and the pitted up, and
this Mr. Meek thinks he will be able to effect with
facility. There will then be nothing to prevent the
widening and raising of the bund going on con-
tinuously.

0

tionally during the monsoon, when the setting
streams will have more water & be able to execute a
much greater quantity of work per month.

11. I have spoken of the temporary escape, and
mentioned that it will probably be wanted only
for one season, for, supposing work to go on through-
out the S.W. monsoon there can be little doubt
of the entire completion of the bund in 18 months
from its commencement. The intended site of the
permanent escape is in a valley to the south of
the lake, and this valley is separated from
the lake basin by a ridge the lowest part of
which is a saddle, which is reported to be 120
feet above the intended full tank level. This saddle
is supposed to be of soft material, and a pitting
channel runs across it; with the aid of water
it may be cut down, provided no rocks be met
with, in a very short time. It appears to me, how-
ever, to be essential that a cutting at least 40
or 50 feet wide should be made before any decision
is come to regarding the reconstruction of the main
bund, for upon the feasibility of connecting the two
valleys at a moderate expense may depend the
propriety of forming a lake at all. I have
not examined the country in detail, but I am
not aware that any other suitable site than
that already mentioned, for a permanent es-
cape is to be found, and it would of course be
useless to make a reservoir and then to find
that

that the surplus water could not be safely got
rid of. Every important point connected with a project
of this sort ought to be ascertained and settled be-
fore hands. Levels have been taken of some of the
ground in the neighbourhood of the drain, but
I have not as yet, owing to changes in the pre-
cincture establishment in the neighbourhood, been
able ^{to get hold of things, not having been able} to find any prominent bench marks
or any interpretation of what the original
levels mean, I cannot at the present mo-
ment give any such general outline of the
way in which the formation of this reservoir
should be carried out, if the attempt is
to be made, as is desirable & necessary.

12. The total loss incurred up to the present
time, in consequence of the two accidents & of the
necessity for reconstruction of a part of the culvert,
is probably about 10,000 Rupees; and to this per-
haps 3,000 Rupees may be added for silting
up the escape channel formed this year, and the
pits which have been cut within the proper line or
are inconveniently situated. The round numbers
then 22,000 Rupees worth of work remains,
and, provided the arrangements for the
completion of the project can be satisfactorily
arranged.

and completely planned, it will
perhaps be considered worth while
to make another attempt to construct
a reservoir at this site. What the work
will cost I have not the means of
stating. The sand pile was not con-
structed and, without contour levels,
the embankment cannot be plotted
and its contents calculated. Pro-
bably the silting of the burial well
will not cost more than 5,000 Rs., and
it may cost considerably less: this
will depend upon the correctness
of Mr. McEwen's calculations
of the quantity of work done last
season, and economy must have
been very difficult of attainment.
With

13 With regard to the way in which the work should be carried on for the future, it is necessary that I should mention that the Secretary of State's instructions that Mr. & Mr. Ivor should be interfered with as little as possible have been the cause of much disappointment not only to the Government and to Mr. & Mr. Ivor himself, but to all who are interested in the successful application of a process, which promises to be of great utility in saving money, time and labour, and in performing fearful works which could not

15
4/15
without its aid, he attempted - Mr. Ivor understands better than any one else the management of sailing streams, and the methods of turning them to account in excavating and afterwards distributing soil; but there are many other things to be considered and attended to before the Government can obtain, either on the North Kent Road or elsewhere, an efficient person, and unfortunately, though very naturally, such matters not being within Mr. & Mr. Ivor's knowledge or experience, he has been unable to deal with them successfully. - I do not make these remarks with any intention to disparage the

Gentlemen: on the contrary I believe
very few could under the circumstances
do as well as he has done, and his
energy and perseverance are not only
considerable but in themselves of
great importance in a work of this
kind. But no natural talent
and ability will not enable a man
to do the work of a surgeon or physician,
or to navigate a ship in waters
where the accurate calculation of
fraction is essential to safety, so
no one without some special train-
ing would be likely to be able
either to estimate the discharge of
a river correctly or to provide suit-
ably for the disposal of its waters.
The part of the work which Mr. Meador

43
is fully competent to undertake is
the excavation and disposal of soil,
and this he should be allowed to
arrange for as he thinks best. I
think also that, if the rest of the work
be laid out for him, and some few
instructions given, he will be able to
superintend its execution as well as,
and probably better than, any one
likely to be employed for the duty,
and it will be convenient that
all the labor should be under one
direction. Moreover there will be a
certain quantity of earthwork to be
done before the close of the dry season,
and it is essential that the disposal
of soil should be confined within the
limits of the section of embank-
ment to be constructed by that time
as

as also that the arrangements made should be such as to ensure the progress of the work at a rate somewhat in excess of the average required to complete the work in proper time. Para II of Mr. Keck's letter, and the notes which I made from information furnished by him last December, show that the progress during the last working season was very irregular. Probably 250,000 cubic yards of soil will suffice for the next season's work, and October to May may be taken as being the working season: a more accurate calculation of the quantities of earthwork should

45 17
hereafter be made by the Executive Engineer. Velgherry (Camp), but the above will serve as a basis of calculation: then the regular monthly deposit should be 60,000 cubic yards, and taking 25 working days in the month the daily quantity will be 2,400 cubic yards, and will require probably at least 2 cubic feet of water per second - of 5 cubic feet a second can be maintained in the channels throughout the season, and this is not a very large demand, so much the better: if not a larger quantity should be used in those months when water is abundant to compensate for a short supply at other times. The Executive Engineer should arrange

1st for the preparation of fairly accurate sections of the bank of the river required for the season's work, showing for every part of length the contents of each layer. A series of bench marks can be placed on either abutment with correspondings with these yard layers, and then the progress of the work can be ascertained without difficulty, and the soil be deposited in section, a very simple statement showing the quantity of earthwork required to be, and actually done in the last day of each month may be prepared from a mere inspection. The outlines of the bank should be sketched on the hills on either side of the river.

2nd for the gauging of each rill or stream at some convenient point near but

x stout stakes will do very well for these, a small bench 1 foot square denoting the level to which the stakes are, and the stakes being numbered.

Appropriate terms for the registration of the supply should be chosen up to suit the particular plan of gauging adopted.

3rd When the information necessary for determining finally the proper level of the reservoir when full, the level and dimensions of the permanent escape is received, the leading features of the project will be recorded in a form which will allow of their being better understood than is at present possible, and it will then be seen what the contents of the bank when of full height, will be.

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be, and a sufficiently accurate
estimate of the cost of the reservoir
may be made out.

Wentworth - Major R. E.

Acting Chief Engineer
Potomac and for Irrigation -

18th August 1870

P. W. Dr to Engle dated 11. Oct. 27/90

P. W. 1870 Dept
P. W. of Govt for October
No 3848

From

The Ag. Chief Engrs
for Irrigation

To

The Secretary to Govt.

P. W. Dr

Noted 18th Sept 90
Recd: 29th Sept 90

Enclosure 2

Note regarding
Mr. McQuar's project
for forming a reservoir
by the construction
of an embankment by
the silting process
in the Keilyberry
Hills.

No 145

No 2439 - 10. Oct 90.

P. W. Dr
No 2439
Proceedings of the Madras Govt.

Read the following:-

From W. G. McIvor Esq. - H.E. dated 23rd July 90
" Chief Engrs for Irrigation - 18th Sept 90

Agree with the use of the
drift entirely. The use of
silt in the formation of a
bund has been proved by
Mr. McIvor's observations. His
work has been destroyed ^{completely}
by the insufficiency of his escape.
In determining whether a
bund is to be formed at the same
spot or not the Govt. should be
guided by the appropriateness
of the site for a useful storage
reservoir - and that appropriate
- rep must be decided by
the engineer who has proposed
having a view the formation
of a sufficient temporary
escape, a good permanent
escape, and the means
of draining off the greater
portion of the Lake to
supplement the water of
the Cauvery. If the
conditions mentioned above
are secured then I
think the bund should be
reformed. The silting process
may be done by Mr. McIvor
the masonry & channel
work may be done by the officers
of the D. P. W. P.

The papers recorded
in these Proceedings
contain Mr. McIvor's
report of the work done
by him at the re-
servoir bund on the
line of the Mail Khoo-
dah road, and of the
accident which occurred
to this work on the 19th
June last; also the
observations of the
Acting Chief Engrs
for

for irrigation on
that point, with this
Office's opinion as to
the way in which the
construction of the re-
servoir should, if re-
sumed, be carried on;
and remarks showing
that further information
on some important
points is requisite
before a proper decision
can be arrived at.

2. The value of the
silting process as an
economical means
of excavating and

AA.

21
depositing soil $5\frac{3}{4}$ ft
also for the forma-
tion of lands for
the retention of water
has been conclusively
demonstrated by the
results of the work
of the past season.
The material deposited
is eminently stable
and water tight, and
it possesses all the
qualities which are
desirable for a work
of this kind. The
breaching of the
bund after it had
attained a height of

of nearly 60 feet
above the sill of the
lower part of the cul-
vert, was caused by
the insignificant water-
way provided by
the escape channel,
and not by any defect
in the bund itself,
which stood firm
until the water passed
over its top, and
then offered a very
considerable resistance
to the erosive action
of the water. Masses
of silt are still, after
the

55
the water has been
running over them
for many weeks, re-
maining in the bed
of the river, and the
bund on the two sides
of the river channel
stands with nearly
vertical faces, and has
been but little affected
by the heavy rains
which have fallen
since the date of the
accident.

3. The Acting Chief
Engineer considers
that an efficient
temporary escape
can be provided out

the right bank of
the river, and in the
"may" with
he fixed at
50 feet above the lower
advent of low; also that
if, in the first place,
the bund be constructed
of the dimensions re-
quisite to provide for
its safety on the
sitting in of the river
S. R. Monsoon, so much
additional work can
be done during the
Monsoon towards making
the bund of the full
section required, as to

57
ensure the completion
of the dam in the
second dry season.
He also points out
that out of a total ex-
penditure of rupees
85,000 Rs.,
worth of the value of
about 22,000 Rs. re-
mains unincurred.
So far then there is
much to be gained by
a resumption of the
work; the Chief
Engineer however shows
that the basin of the
reservoir is divided
from the valley in
which the perpendicular

escape is intended
to be made by a
chain of hills, the
lowest saddle of which
is reported to be 120
feet above grade level.
If this saddle
contains no rock
above the required level,
the requisite cutting
can be made through
it at a very small
expense by the aid
of water, which is
available on the spot,
but should rock be
found at a high
level, the connection

59
of the two valleys by
a cutting would be
economically feasible,
and, unless another suitable
permanent escape
can be found,
it would be necessary
to abandon the idea
of forming a reservoir
in this position.
The first thing
to be done therefore is
to make a cutting
through the saddle
first required to, and
the Government learn
that the Government learn
that the Government learn

needs a sum of Rs.
500 to enable him
to do this; that amount
will accordingly be
at once placed, through
the Superintending En-
gineer 7th Div. at
his disposal dis-
posed from the Account
under "Agricultural"
His Excellency
the Governor in
Council concurs
in the opinion of
the Chief Engineer
or Engineer that,
should the Govern-
ment decide to sanction

61 25
the completion of the
reservoir, the general
arrangements should
be under the control
and supervision of
professional officers,
that the immediate
charge of the works
of all kinds should
be given to Mr. [Name]
who should be fur-
nished with definite
instructions on all points
of importance; and
that only in respect
of the details of the
settling process, with
which this gentleman

is fully acquainted,
should the responsibility
of making the ne-
cessary arrangements
entirely rest with him.

6. This order will
therefore be commu-
nicated to the Chief
Engineer 7th Divⁿ
with a view to the Se-
lective Engineer. Velgherry
Range being instructed
to take such levels,
and collect such other
information, as may
be

63 26
be necessary to the
proper designing of the
project, and to the
drawing up of complete
instructions for the
the Govt's guidance,
and the Chief Eng^r
will then submit for
the orders of Govern-
ment his views
as to the way in
which it should be
carried out, so far
as its leading features
are concerned, together
with an Estimate
of the cost based, as
regards earthworks,
on the rates at which

this work has already
been executed - This
Officer will also, if
the construction of the
reservoir be sanctioned,
issue whatever instructions
he may consider re-
quisite, both in the
first instance and
afterwards from time
to time. The Ex-
ecutive Engineer - Veil-
ghem Stange will
be charged with the
duty of seeing that
the instructions are
duly carried out, and

65 27
of rendering all needful
professional assistance
to Mr. & Mr. Dvor.

7 The Government
desire that in drawing
up the project attention
may be given to the
provision of suitable
works for discharging
the greater part of the
Contents of the reservoir
for purposes of irrigation.

8. A copy of the
Proceedings will be
transmitted for the
information of the
Secretary.

Secretary of State

Aug. 29/8/20

W. G.

To

The Chief Engr
for Army

S. Engr & Co.

W. G. McLean Esq.
London.

Recd 11/10/20

P. W. de la Roche Esq. 11/10/20

23/5/75

Sept. of {1870} Madras.

PUBLIC WORKS.

To the Chief Engineer for
Szigassien

Further Road 3/15 Eff 11
- Feb 1/21

Leo — $\alpha 138^{\circ} 29' 9''$
 Feb 2/8
 Leo — $\alpha 680^{\circ} 29' 8'' - 3 - 71$

11. 1. 1. 1. 1.

2010

Page 2

10th Dec 1876. No. 2439

Nos: 111, 112

Edward Hunt Prison orders
 papers regarding H. W.
the work done
 the embankment in course
 of construction by the Filby
 process across the Parker
 River and the accident
 which occurred to this
 work on the 19th June
 last.