Madras Municipal Commission

Report on the Present conditions of

Madras Water Works

Madras Municipal Commission.
Report on the Present Conditions
of Madras Water Work

Book No : 15710

NT.

GINEER.

MADRAS:
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A a Sche

improve

2. Since May last, having been relieved of a portion of Madras, I have been able to give a great portion of

Surveys when commen or acquiring the information considered necessary by the Chief Engine tion, and in addition to this, I have been able to prepare plans for which will s of the present supply, and which ar Engineer for Irrigation as stated in ove referred to.

3. I ners, firstly, why some

Necessity of im- provement. to Madras is needed at scheme to be laid before you, other methods quality of water to Madras. In doing this I reply to er reference as to whether it is preferable to filter the water r the Lake.

4. The Wa yed to Madras from the Red Hills Lake by

Present open Channel. pen Channel which was calculated to deliver about gallons per head per day for a population of 545,000. When designed it was supposed that the Channel would have a good current and the growth of vegetation be thus prevented. These expectations I regret to say have not been fulfilled, and at present it is most difficult to keep the Channel clear of weeds. This may partly be caused by the intermittent system of supply which we have been of late forced to adopt, and by which method the Water is as it were dammed up and allowed to rest in the Channel for a period of 6 hours during the day and 12 during the night. There is also another evil resulting from

31.31, we a
…sent arrangements, bu
can be raised against th
… a position that in drawing off the
slimy mud.

9. It may be safely … said, that so
At what Level potable water can be had.
Hills
mea…
Madras can then only dep
from 46 to 36—impure fr
arrangements) below that le
cubic yards.

10. It cannot be stated with the … tank will
Probabilities of future supply.
full again, or that … ing the y
higher than a level … water can b
had. Madras is therefore in the positi… certain supply o
potable water all the year round, in fact … t such a belie

11. There are other objections to the … pendent of the heigh
Further objections to Channel.
of its off-take. The Channel is eminently suited to be a breed
ing ground for fish and infusoria of all descriptions, and thes
eventually get into our pipes: did they not do so they would tend to keep th
water clean, but as the pipes are not always full and as these infusoria attach

* When any levels are given the datum is Mean Sea Level.

two or three days … in a very great measure be prejudicial to the … should be…

15. Having thus shewn, I hope satisfactorily, that something should be … I now propose to consider Schemes for its
to improve our present water supply, … improvement.

16. One is nat … means … pply can be
Schemes for Im…
… The … four ways in
… Channel and be filtered in
… 25.00 at the head, and
… the way to Madras, and
… to filter the water near Koo-
… above ground and then filter
… th pipes.
… Channel at its present level.
… dismissed with the remark
1 … water so long as the lake is
First and fourth need not be considered.
… that the filtration of the last 5 feet in
… be more costly.* We might of course arrange
consequence of its … at the off-take of the Channel to raise the water when
to have Engines permanently at the off-take of the Channel to raise the water when
it fell below the level of 31.31, but as we must employ engines at Madras, this
double set of machinery would be a most expensive arrangement.

* For reasons see page 7 para. 36.

...and settling tanks could ... occupied by Mr. Branson and the lands adjacent to the north.

Levels of ground and details of levels of works, &c.

20. The level of this ground is about 17.00 above mean sea level. There are two methods of constructing the settling tanks and filter beds, the first being to have the settling tanks partly above ground (say at same level as the Chan... would the ... et deep and the filter beds with their highest wate... d the second being to have both fil... and settling ... rst method, the loss of head below present arrang... second method the loss would be 22 feet—but th... be very much greater than in the latter. The ... way would require less land. ... and would

Pressure in town at present.

21. The water pressure in the higher p... present very low.

Height water would require to be raised.

22. The water (taki... the second method ... settling tanks and ...fers) would then ha... raised at least 22 feet to give the same pressure as at present, but it would be expedient to raise it at least 35 feet (this would be 42 feet above Mean Sea Level, and is 10 feet less of head than the scheme proposed to be adopted.

* We must calculate loss of head at 1 foot above the bottom of the settling tank which is the same level as the water filters, as we cannot keep filling and emptying the settling tanks at the ... time without destroying their utility.

ings and machine...

No allowance made for Houses.

26. It will be observed that no allow... men as might be needed, or for fencing the compound ... decidedly be advisable I think from the proximity of the works to the town.

Proximity to town an objection.

27. The proximity to the town is an objection as the water is very liable to be tainted by the foul atmosphere. The reservoir into which the water goes after filtration might be covered, but this would again add to ...

28. ... No ... will be advisable to detail it in a

	Rs.
...No. 3.	
...ead Sluice to Centre of Lake...	15,000
...uice	3,000
...per than at present 197120	
C... ...	37,000
... ...	5,000
Pullin... placing by syphons... ...	6,000
Under-p...	8,100
Culverts	300
Removing ...ooden Bridges...	5,50,000
Construction of ...pensating Reservoirs, &c. ...	1,68,750
Engines including ...ildings to raise water 28 feet. ...	4,000
Stand pipe and towe...	
27" Main from Koono... asonry shaft 3 miles 4 furlongs and relaying present four ...alf with same size of piping	2,19,450
Land	4,000
Total...	10,20,600
Contingencies 10 per cent.	1,02,060
Rs...	11,22,660

... great difference, in fact we might have very nearly approximated to the cost of this scheme by deducting half the cost of the alteration on the Channel, and adding the cost of this which comes to 2,19,450 for the piping and laying, which might be done below present Channel bed. The sides of the Channel might after being cut down level with the bottom, be made available as a road to the works, or it might be filled up for this purpose.

...m to Madras.

33. The cost of Maintenance in last sche... at per annum Rs. 646 per H... at work, ... on same rate for this, it wo... Rs. 58,140 ... would not however be the same rate as there is 3½ miles cartage ... done would probably cost Rs. 4,000 a year.

Cost of Maintenance.

34. There is one great objection to both the ... is, that they cannot well be executed with... no water from Madras for some considerab... time. This objection could be got over (at of course increased cost) by ... a parallel Channel, the length being determinable on whether No. 1 or ... scheme were adopted.

Objections to Schemes Nos. 2 and 3.

35. In making such a Channel it would be the least expensive way to make it so, that one-half of the embankment was the bank of present Channel. Such a Channel from Red Hills to Madr... would probably cost Rs. 1,50,000.* The cost of a parallel Channel to Koon...

Constructing parallel Channel.

* I judge this from the cost of the present Channel 1,75,000. One half or 3 miles of Channel is in ...ting, and the other in embankment, there would therefore be no saving in making a Channel 6 feet lower, far as the Ea... work is concerned on the first half, but there would be a saving by the earthwork and under Bridges on the second h...

PROPOSED SCHEME FOR FILTERING AR...

ATTACHED TO THIS REPORT ARE THE FOLLOWING PLANS—

1. Small Scale plan shewing routes to Red Hills and route adopted on sheet No. 1
2. Large Scale plan of route adopted, shewing position of Tower, Pumping station, Filtering Beds, &c.... ... ... on sheet No. 2 to 8
3. Section of Route ... ... on do. No. 9 & 10
4. Section from off-take to Filters ... ... on do. No. 11 & 12
5. Plans S... and Elevation of Tower and Gangway ... ... on do. No. 13 to 15
6. Prop... Elev... Pumping Well, Engine and ... ... on do. No. 16
... ...ettin... ...ter Beds, Sand Wash- ... ... on do. No. 17 to 19
6. ...es or Pipes ... present laid and ... ... on do. No.

38. ... quired to be determined was the position of the off-... I have placed about 900 feet South West along the ... the Polal Sluice. Between this point and the Sluice, the bed ... contour parallel to the bund is practically level, and the slightly inc... ...ch might be had to the North East does not I think warrant th... ...nditure which would be incurred were the off-take placed North East ... ...olal Sluice. Again to the South East the tank gets slightly shallower, so ... at we cannot move further in this direction; the point selected is I think decidedly the best place for the off-take.

Off-take.

39. The next point which demanded attention was the site for the tanks and filters. These I have placed on high ground as shewn, though not quite the highest ground. The loss of head however is very little, and indeed the very highest land is not of sufficient area to accommodate

Position of Filters.

4.—The route to the end of the 42" Main at the Masonry Shaft, would be longer.

41. Having thus fixed the ends of the routes, the alternative routes were next considered as shown in sheet No. /

Alternative routes.

42. I decided on the route marked No. 1 through Perambore for the following reasons.

Route decided on.

43. The route by the road is too c..., and that m... ...ugh slightly shorter than No. 1 passes away fro...

The other routes.

44. The route marked No. 1, is altogether the ... nearest road along which the piping ca... ... carried, and I think this is a great desideratum. ... passes near the Perambore Works of the Madras Railway, where there are a ... number of people who will gladly use the water, and the Company itself I th... will be glad to take advantage of it. The route avoids all tanks through which piping could not be laid in the wet season. It avoids passing near houses or through any property which might be injured in laying the piping, and it, as far as possible, avoids topes through which it is costly to lay piping, and which might probably injure the pipes in future or render it difficult to get at them in case it were required to do so. It was impossible without increasing the length of the piping considerably to avoid these topes altogether. The route also passes near the Lunatic Asylum which may also be provided w... ... ...

Reasons for selecting route.

Filt... done a...

50. In the first place we should requi... ... from lake; if raised high enough we might reduce the size and th... fore the cost of the Main to Madras below what it is in the scheme I propose.† But this advantage is more than counterbalanced by this, that unless at Madras we have a compensating reservoir at a high elevation, we must have engines of double the power we would otherwise need, and still a compensating reservoir at a low level from which they would pump, so as to allow of filtration proceeding regularly, and we must also have engines at the Red Hills—and that of very little less power ... the *only* engines in the scheme I am proposing. Indeed there i... ... ...t of construction will be more, if laterite ... ...n having the water filtered near Madras, and as I... is on ... grounds objectionable. There is no ground higher th... this is below many parts of the town.

* Giving reasons for the above.

WATER TOWER.

51. This I ... ...e point previously described and at a distance of 74 fe... ... top of the inner slope of the bund. It is not quite a... ...est level of the bed of the tank, but a small Channel will be constructed as s... ...n, so that water can be obtained down to the ...ll depth required. The lowest level from which I propose to draw off is 22.00. ...e tower I propose to found at a level of 14.00 on concrete made of Morgan's ...ment which could be lowered through water if necessary, should a difficulty be

Position and levels.

* See note by Secretary to Government Department Public Works Irrigation.

† It would not require to be raised quite to the level of the proposed filter beds, to do this as the size of the Main in the scheme proposed is increased on account of the water not being drawn regularly all day, and in this alternative proposal, the compensatory reservoir would be in Madras

...atings will be fixed ... the tower I propose to be in brickwork ... cement.

CULVERT.

52. I have shewn a culvert for conveying the pumping main from the tower through the embankment, and this has an entrance placed as shewn beyond the outer face of the bund.

Culvert shewn on plans.

53. I have shewn this in deference to the views of the Chief Engineer for Irrigation, but I beg to submit for co... whether such is needed, and whether a large amoun... ...dle round the pipe and two or three collars of brickwork at intervals ... ...vent any flow of water from the tank through the bund. The present ... ...s no clay puddle wall as far as I am aware, and this may be a reason agai... ...e alternative proposal, I however record such for consideration.

Culvert may possibly not be required.

54. If the culvert be constructed, the piping will be supported on cross walls each nine feet apart as shewn.

Support for piping.

55. The entrance to the culvert will be covered over, and a trap door pl... in the cover with a ladder underneath for admission.

Entrance to Culvert.

GANGWAY.

56. The Gangway consists of two lattice girders, their top and botton formed of T irons, and their bracings of flat ir... ...upported ... irons

Con...uction

top of the girders will be cased in wood to form a hand-railing ... is divided into two spans each of 33 feet ... end ... tow... shewn, and the opposi... masonry will suppo... sheet ...

Two spans.

Po...

we can p... I have made ... remark as I do not con... immediately behind the ... probability be very soft and after ... I am led to believe that there is a leakage through from the tank ... bund. The foundations for the Engines and pumps at this site would be ... expensive, and as the ground is also liable to flooding, they would require to be raised considerably above its level. There is again the risk that the operations in excavation might tend to create a rush of water through the bund and the continual vibration of large pumping Engines would not I think be favorable to its safety. On the plan I have marked two sites, Nos. 1 and 2 where I think they would be favorably placed.

Foundations unsafe at back of bund.

Probable injury to Bund.

59. I am ...iently acquainted with the construction of the force pumps used in water works to state the following positively, but I believe that at whatever level they are placed they will require to pump from that level whether the tank be at a higher level or not: with however an atmospheric pump, we can always draw safely 20 feet, and on this account I prefer site No. 2 which is at a higher level, because we would be able with an atmospheric and force pump to take the full advantage of the level of water in the Lake and only have to draw from that level. Thus suppose the inlet valve of the pump were at a level of 42.00, if the tank were at 42.00 we should only have to force from 42.00 up to the level of the filters and at most only have to draw between 42.00 and at whatever level the tank stood. If this same advantage is to be gained by a force pump, then there

Force pumps

Atmospheric Pumps

e in site No. 2, except perhaps that is on more accessible ground, able to floods as site No. 3. There is, however, an objection and it is this that we must draw atmospherically through ...s could originally be ... in so, or what it ... It would ... bjec- ... d

... a.

61. I ... to be raised f... a level of 20 feet to a level of 70 above ... can se ... 00,000 gallons per d...

62. The Power required for this is found by the following calculation.

Calculations for Engines.

$$\frac{\overset{\text{gallons.}}{6{,}000{,}000} \times \overset{\text{lbs.}}{10} \times 50 \text{ feet.}}{33{,}000 \times \underset{\text{hrs.}}{24} \times \underset{\text{min.}}{60}} = \text{say } 64 \text{ H. P.}$$

this, however, is only the nominal H. P. required. It is necessary to have reserve power in case of accident, and I therefore propose three Engines, any two of which can do the work, so that we require three Engines each 32 H. P. nominal.

63. For Engines of this H. P. (nominal) about ... of area for each H. P., is allowed by the makers, and ... the steam at 30 lbs. pressure over six inches, and the sp... ...n 200 feet a minute, we have the actual H. P., for which amount w... ..., viz. :—

Actual H. P. required.

$$\frac{\overset{\text{H. P.}}{32} \times \overset{\text{inch.}}{7} \times \overset{\text{lbs.}}{30} \times \overset{\text{feet}}{200}}{33{,}000} = 41^{*} \text{ H. P. actual.}$$

This is the amount for which I have allowed in the estimate (3 Engines of 41 H. P. each.) We have already seen that the area of the cylinders is 224″ therefore the diameter $= \sqrt{\frac{224}{7854}} = 17$ inches.

Stroke of Engine.

64. The stroke is usually twice the diameter this gives 34″ = 2.83 feet.

This brings us to the calculations for the size of the pumps.

* It is supposed that this amount will also cover the extra head due to friction in the pumping main.

PUMPS.

65. Let there be 3 pum... the wo...

No. of pumps.

same ...

m...

main. ... for their foundations leads to economy ... them, but also in allowing of the reduction of the size of the Engine House. A similar plan has been adopted at the Eastbourne Water Works with success. The air vessels should be of about 38 cubic feet in capacity.

Economy in foundations.

67. The cost of pumping Engines varies very considerably. The cost of the Engines at Cork Water Works (Sir J. Benson) was £55 per H. P. and at the London Sewage Works the Engines were estimated at £70 per H. P. Both the above included Engine and Boiler houses, Chimneys, &c. The Board of Health have adopted a standard of £50 per H. P. and Mr. Neville in his work on Hydraulics says that the cost per H. P. will vary from £50 to £100. I have taken the extreme limit and put the cost per *H. P. nominal* at Rupees 1,200 allowing for contingencies and carriage, exchange, &c. this amount will I think cover all probable expenses, and I include the Engine House and Buildings in this sum.

Cost of Engines—Cost at other places.

PUMPING MAIN.

68. I propose that the pumping Main be 18″ in diameter. The amount of water raised per minute by the Engines is 666 cubic feet and this would equal a velocity through one pipe of 6.0 feet per second which is not excessive. This main should be furnished with two or three intermediate stop valves to prevent the water returning in case of accident and a loaded blow off valve will also be necessary for each pump.

Size of Pumping Main.

FILTER BEDS AND SETTLING TANKS.

69. These are fully detailed in the drawings attached to this report, see ...wings. sheets No 7 and ... In designing them, economy ... v. tudied. By the plan ... ble on ground ... eservoir ... not ... er

... nd ... ,000 ... will be ... being ... vailable ... ther ... ks are therefore ... able to con ...

cubic feet gal

$45,000 \times 8 \times 6 = 2,160,000 = 13,500,000.$

Time of filling and empting tanks. As however one tank will always be out of use for the purpose of cleaning, we can only calculate on 11,250,000 gallons; as each tank holds $2\frac{1}{4}$ million gallons, it will take 9 hours to empty itself—so that it will take 45 hours to empty the five tanks as however it will also take 9 hours to fill each of them, we must deduct this amount and thus the water will be allowed 36 hours for settling, when only five tanks are in use; but 45 hours when all the six are in use. This time I think will be sufficient for whatever state in which the Red Hills Tank may be. When the tanks require to be cleaned, the remaining water in them will be let off by a drain which is sunk below the level of the tank, and towards which the beds of the tanks slope. The drain is on a gradient of 1 in 500. The beds of the tanks being a smooth surface, they will be readily cleaned, first by washing them with remaining water 12″ deep, and by then attaching a hose to the supply pipe of the tank. These drains will be led into tanks which are around the base of the hill—the water may therefore be made available for irrigation or other purposes to a small extent. These drains will be partly tile drains, and partly open cuts or Channels.

FILTER BEDS.

71. There are five filter beds, one of which will always be out of use for cleansing purposes. They have each an area of 2,336 square yards, or with 4 filters 9,344 square yards. The rate of filtration will be 642 gals. per square yard in 24 hours—which this gives 6,000,000 which is

Rate of filtration.

the quantity required. This would be about 5.5 inches per hour. The rate of filtration to be efficient should never exceed 6 inches per hour. This rate has however so ... mes been exceeded, and the following table exhibits th ... Compa ... filter beds.

Rate of Thames Company.

73. ... the ... Distribution how effected. ... well, pipes lead ... enter the filter beds ... slightly higher level ... ing valves ... placed at the various collecting wel...

74. ... filter beds as designed shew three feet of water above the filtering media, which are—

Filtering Media.

2 feet fine sand.

1 foot sand size of shot.

1 foot gravel size of walnuts.

1 foot gravel large size.*

75. ... the lower layer are the drains 6″ and 9″ in breadth according to their position in the filter bed. I propose that they be of $4\frac{1}{2}$″ brick walls and flat tiles laid over them. The bricks will be perfora... as also the horizontal tiles—these it is probable can be made in thi country.

Drains for con... away filtered water.

76. There ... available methods of forming the sides and floors of the ...ting tanks and filter beds. They are—1st of Brickwork laid in Chunam and pointed with Cement, and 2nd Laterite similar to that u... in the ... Hills Tank Bund and plastered with Morgan's or Portland ceme... I have estimated for executing the works in either way—in either case I propose to lay the masonry on puddle one foot th...

Formation of sides and floors of Filter Beds.

*The supply of filtering material is an important point. Sand can be had best I fancy from the Cortilliar River. Small gravel may be got at the Red ...ills, their upper strata are composed of it. It would however require extensive washing. Larger gravel might probably be had from the Cortilliar, but there can be little difficulty in procuring this. The lower layers of the filter beds seldom if ever acquire renewal.

77. After filtration the water is carried by drains and pipes into the main collecting well—the pipes from Nos. 1 and 2 filter will be carried under filter No. 3, and the pipe brought to the same at the well as the ... filters. From this collecting ... he water ... When ... filter in ... valve ... lves ... ble ... the ... ll ... rs ... ter ... ould not ... as to allow ... quantity of water ... quired ... 4 hours is 3,000,000 gals. Of this, however, on ... is drawn off in 6 hours, but as the filters only pass 1,500,000 gals. in this time, we require to make up for this difference of rate in receipt and supply. It is also necessary to keep always a head of water above the pipe. I have allowed for a reservoir able to contain 2,000,000 gals. if necessary, but except in exceptional circumstances, all this quantity would not be needed. The following shows approximately the varying rate at which water is taken in Madras.

Collection of Filtered Water.

			Gallons.	
		A.M. A.M. Let	1,500,000	be the amount in tank at 6 A.M.
3 hours	Filtered from 6 to 9	...	750,000	
			2,250,000	
	Drawn from 6 to 9	....	1,500,000	
			750,000	This will be the amount in tank 9 A.M.
6 hours	Filtered	A.M. P.M. 9 to 3...........	1,500,000	
			2,250,000	
	Drawn	P.M. P.M. 9 to 3...........	1,000,000	
			1,250,000	do. do. at 3 P.M.
3 hours	Filtered	3 to 6...........	1,750,000	
			2,000,000	
	Drawn	3 to 6...........	1,500,000	
			500,000	do. do. at 6 P.M.
12 hours	Filtered	P.M. A.M. 6 to 6...........	3,000,000	
			3,500,000	
	Drawn	6 to 6...........	2,000,000	
Total 24 hours.			1,500,000	do. do. at 6 A.M.

It will be observed that half the quantity is drawn 6 hours, viz., from 6 to 9 A.M. and 3 to 6 P.M.

The lowest at which the tank stands is 500,000 gallons and th... of the water when the tank holds 2,000,000 gallons is 10 feet, there ... be le... than 2½ feet in th... nk, or perhaps rather more (say ... tank sloping sides. As designed, ... is to ... ,000 ... settling tanks a... when the ... me le... they are

81. Th...

It is a large box formed of ...

The upper floor is formed of p... ...e sand to be cleaned is laid; between the floors the water is admitted at some pressure from the pumping Main. It enters between the floors and passing up through the sand which is being vigorously stirred by men with peculiar spades, carries off any earthy substance with it. The box is divided into three tubs, so that a large or small quantity can be washed. Two of these boxes are shewn on the general plan of the filter beds, &c. and have attached sheds for storing sand cleaned and that not so.

PIPES, VALVES, &c.

82. On the pumping main reaching the main valve house, it is divided into three branches to the three pairs of tanks, and in this house are the valves for cutting off the supply of water from any pair of tanks. On approaching the settling tanks, each branch is again divided into two, with valves to each tank. From the valve house just referred to, there will be an electric communication with the Engine House regulating the supply from the pumps to the settling tanks, or a self-acting communication could be made by allowing the water when it gets high enough in the tanks to run back through a small pipe to the Engine House and blow a whistle. This valve house should be erected with an upper story so as to allow of the levels of the water in the filter beds and tanks being carefully watched. The next most important valves are those at the main collecting well, (see drawing No. sheet N°4/8), there will also be a valve on the Main from the Reservoir to the Town and valves will also be placed on the other pipes where necessary.

MAIN FROM RESERVOIR TO MADRAS.

Size of Main. 83. The size of the Main depends on the quantity to be supplied, the rate at which it must be supplied and the head of water obtainable.— The [illegible] to be supplied is 6,000,000 gallons per day, [illegible] antity it must be able [illegible] the demand will exceed this, [illegible] er of the pipe for the poss [illegible] demand so [illegible] day—

[illegible] west level [illegible] The point [illegible] which [illegible] at a [illegible] 00 and this gives 52 feet [illegible] ever for 50 feet head. The 42 inch main towards the town is about [illegible] level; at some points the branches are higher. This will not however to a great extent influence the calculation for the main.

84. I have calculated the diameter of the main by the two following formula which give the results set against them—

	inches.
* Beardmore's which gives the diameter as	34·40
† Hawkesley's do do as	37·33

By NEVILLE's tables the velocity of discharge from a 36 inch pipe under same conditions is 38.8 inches per second, and this would give 22.2 cubic feet per minute which is the amount we require.

Calcutta Main. 85. In Calcutta the size of the pipes was determined by *Hawkesley's* formula and calculated to supply 6,150,000 gallons per diem at an average rate, (the compensating resevoir is in this case at end of the main next Calcutta), but by experiments made in 1870, it was found that the actual discharge was at least 8 million gallons an increase of 30 per cent. I think I am therefore warranted in estimating for a 36 inch main and this is what I have done.

Present Madras Main. 86. The present main (42″) is of course larger than this, because it has less head (23 feet less); but as this head is obtained only half a mile distant from the point of junction, the pipe is on that account

* Beardmore's formula is $D = \cdot 235 \sqrt[5]{\frac{l \times q^2}{h}}$ in which, D = diameter in feet. l and h the length of pipes and head in feet and q the quantity to be discharged in cubic feet per second.

† Hawkesley's formula is $D = \frac{1}{15}\sqrt[5]{\frac{g^2 l}{h}}$ in which g = No. of gallons to be discharged per hour, the length of pipe in yards, and h the height in feet and D the diameter of the pipe in inches.

less in diameter than it would be were this head obtained at Red Hills or a similar distance away.

87. I think it will be expedient to replace the part of this main between the point of junction [illegible] masonry [illegible] pipes suited the consumption of [illegible] between [illegible] unction of the [illegible] aid [illegible] over [illegible]

an [illegible] here, so [illegible] between [illegible] cannot be [illegible] way to Madr[illegible] not at present [illegible]

Valves, &c., for Main. 88. The ma[illegible] which would close on any [illegible] taking great increase in the velocity of flow. Air be needed and a few stop valves should be provided to divide the main into short districts to enable it to be readily repaired if need be.

89. I have now described the works which I propose, I think fully enough to shew their main points, and to enable it to be said whether they can be executed for the amount set down in the estimate.

Storage Reservoir. 90. There is however another point to be referred to, and that is the construction of a storage reservoir in the old Lunatic Asylum compound, the cost of which I have not included in the scheme. The level of the ground is about 12.00 and its area is about $11\frac{1}{2}$ acres. The highest points which we need to supply are at a level of 20·00. It is therefore evident that any reservoir must be above the level of the ground. I propose that if it is thought absolutely necessary to have a storage reservoir, to construct it so that its highest water level may be 10 feet above ground level, or a level of 22.00; if the reservoir were made of an area equal to about 384,000 square feet for which there is an ample space, the reservoir would hold four days supply, and this is a much greater time than the main if properly laid would ever take to repair. Two days might be taken as the extent I think, and if so, the reservoir would only fall 5 feet and be at a level of 17.00 which would still supply Black Town and other low parts of the town* in which are the greater parts of the population. The cost of such a reservoir of masonry may be approximately stated at Rs. 2,00,000, and if covered as it should be, it would cost considerably more. It would be unsafe I think to put a earthen revetted embankment so near the town.

* If this plan is adopted the pipes over the Elephant Gate and Hospital Bridges must be relaid under the Canal instead of over the Bridge as they will be too high when this reservoir falls.

91. I think it necessary to institute a comparison between the areas of the works allowed in this scheme for settling and filtration—and those at Calcutta and it is as follows : —

Comparison between this scheme and Calcutta.

Sche... for Madras ... Calcutta.

feet.

Settling Ta...

...ilter Be...

...s, that ...he ...hat ...in ...ing ...proper- ...ily fr... ...6 million ...ailabl... ...28 in... ...way ...r cleaning ...Tanks ...looking ... the v... different quality of wate... whi... tion ... this scheme. I have already shewn that the area ... have ... is ... sufficient, and Calcutta can be no guide in this respect.

93. To give however other evidence. Take the five "Thames Companies" viz., The West Middlesex ; Grand Junction ; Southwark and Vauxhall ; Lambeth and Chelsea. The average area allowed by these Companies for subsiding reservoirs is 4.22 square yards and for filters 2.34 square yards per 1000 gallons in 24 hours, this for the scheme under consideration would be

$$\text{Settling Tanks} \quad \frac{6{,}000{,}000 \times 4.22}{1{,}000} = \overset{\text{Sq. yds.}}{25{,}320} = \overset{\text{Sq. feet.}}{227{,}880}$$

$$\text{Filter Beds} \quad \frac{6{,}000{,}000 \times 2.34}{1{,}000} = 14{,}040 = 126{,}360$$

94. It will be seen that the Calcutta area is greatly in excess in both cases. The settling tanks I propose are slightly larger in proportion while the filter beds are slightly less—it will, however, I think be admitted that Thames Water is never so clear as water from the Red Hills Lake taken from near the surface.

Calcutta in Excess.

ESTIMATE.

95. In making the estimate I have not gone fully into detail, only sufficiently so to get at a close approximation to the cost. I have allowed ample rates, and having been guided by prices lately paid in the district.

* The depths in this scheme and at Calcutta are the same.

† See Jackson on Calcutta Water Works.

96. The following is my Estimat... the works, such as I have detailed in the foregoing reports and on the draw... ...ached :—

Particulars.	If of Brickwork.			If of Laterite.		
	Rs.	A.	P.	Rs.		
Tur...						
Valve Ho...						
Offices, Stores, ...						
Gateway ...						
Sand washing Boxes, (2) &c., including Piping ...						
Drains, Pipe and Tile, &c ...						
6·28 miles of 36" Main to Madras, including laying and carting an average of 6 miles ...						
Stop, Self-acting, and Air Valves, on do. ...						
Valves, Piping, Branches, Junctions, &c., and Machinery at Filters ...						
Total...	12,42,122	0	0	9,64,07[illegible]		
Add for contingencies, &c., 10 per cent...	1,24,212	0	0	96,408	0	0
Grand Total...	13,66,334	0	0	10,60,480	0	0

The above estimate shews the cost of the several works in Brickwork and in Laterite. The tower which I have shewn to be of Brickwork in each estimate might perhaps be also of laterite, but I fear that the latter material is too porus to make satisfactory work in the tower. The difference of the cost of Laterite and Brickwork is very great. I have estimated that good Brickwork can be done at Rs. 12 per cubic yard, which is a moderate allowance. Laterite Pitching which I propose should be used in settling tanks and filter is said to have cost at Red Hills Tank Annas 8 per cubic yard. I am unable to see how it can have been done for this amount. The price I have estimated these works at is Rs. 4 per cubic yard, and this includes plastering with Morgan's cement:—and I think there is little doubt that the work can be executed for this amount. It may then be safely considered that the cost of these works will not exceed $10\frac{1}{2}$ Lacs—were they to be carried out in full.

97. The consumption in Madras at present however is only $7\frac{1}{2}$ gallons per head instead of 15 gallons for which these works are designed. Therefore the full Engine power would not be at first required. As the three Engines estimated for can do one and a half times the work, one Engine will do half the work, and if two Engines are ordered at present we have one for the contingency of the other breaking down. We may then deduct the cost of one

Present consumption in Madras.

Engine less the cost of Buildings, say this is Rupees 1,000 per H. P. nominal and
H. P. Rs. Rs.
[illegible]is decreases the estimate by 32 × 1,000 = 32,000.

98. Again the filter beds will be more than sufficient, and we may do without these and one pair of tanks, [illegible] would be about Rs. 1,15,000, so that the amount [illegible] first expended would not be more than [illegible]

[illegible] Mainte[illegible]

[illegible] the rates at which I have estim[illegible] various [illegible] shew whether the estim[illegible] be [illegible] ich p[illegible] the [illegible] rial [illegible] any's Wh[illegible] ked to [illegible] for some cost. [illegible] I also to [illegible] the Red [illegible] the cost of cartage [illegible] uld result.

[illegible] NTENANCE.

101. T[illegible] co[illegible] M[illegible] ance will depend greatly on the cost of coal which I have put down at Rs. 25 per ton delivered at the Red Hills. The monthly cost would probably be as follows :—

		Rs.
1	Superintendent at Rs. 250	250
3	Drivers at Rs. 60	180
3	Firemen at Rs. 20	60
112	Tons Coal ($4\frac{1}{2}$ lbs. per actual H. P. (82) per hour at work ...	2,800
12	Coolies at Rs. 6	72
10	Turncocks Rs. 20	200
	Sand for filters and cleaning*	550
	Oil contingencies, &c.	300
	Total...	4,412

This is equal to Rs. 53,044 per annum. As before shewn the present consumption is only $7\frac{1}{2}$ gallons instead of 15 gallons per head per diem, and the above is for pumping the whole 15 gallons. The cost for the $7\frac{1}{2}$ gallons per head per diem would amount to not more than 30,000 or 36,000 per annum, and this latter amount capitalized at 5 per cent. = Rs. 720,000. If we add this amount to the estimate of 9,00,000 it gives us Rupees 9,720,000 which will be the *first total cost.*

102. In concluding this report, I wish to remark that it includes with the accompanying plans, sections, &c., all the information desired by Government. If the estimate be adopted and the design for the Tower Culvert &c., be approved of by the Chief Engineer for Irrigation these works may be started at once as pointed

* The cleaning of filters has been taken at Rs. 2-8 per million gallons filtered in 24 hours. In England it c[illegible] about 10s. or 5 Rs.

out by Colonel Mullins in G. O. under reference. Probably every day now lost will increase their cost.

103. I cannot venture to hope that Government will accept the whole scheme as proposed by me without further professional advice, but I venture to ask that unless some practical objections c[illegible] be urged against my proposals that they be submitted on any doubtful [illegible] consideration [illegible] some consulting Engineer of eminence [illegible] he [illegible] necessary.

104. No[illegible] at increase [illegible] cipality to [illegible]

105. There is no [illegible] pality departmentally as [illegible] cost, and in much less time and much m[illegible] contractor, and of this I have had som[illegible] ence [illegible] respectfully to ask that His Grace the Governor [illegible] recom[illegible] views as to the placing of the works in the hands of a[illegible] ractor [illegible]

106. I beg that any omissions in this report, th[illegible] &c., may be criticized as leniently as possible. I have had little or no ass[illegible] in their preparation, and it was necessary for me on account of other duties to spend as short a time on this work as possible.

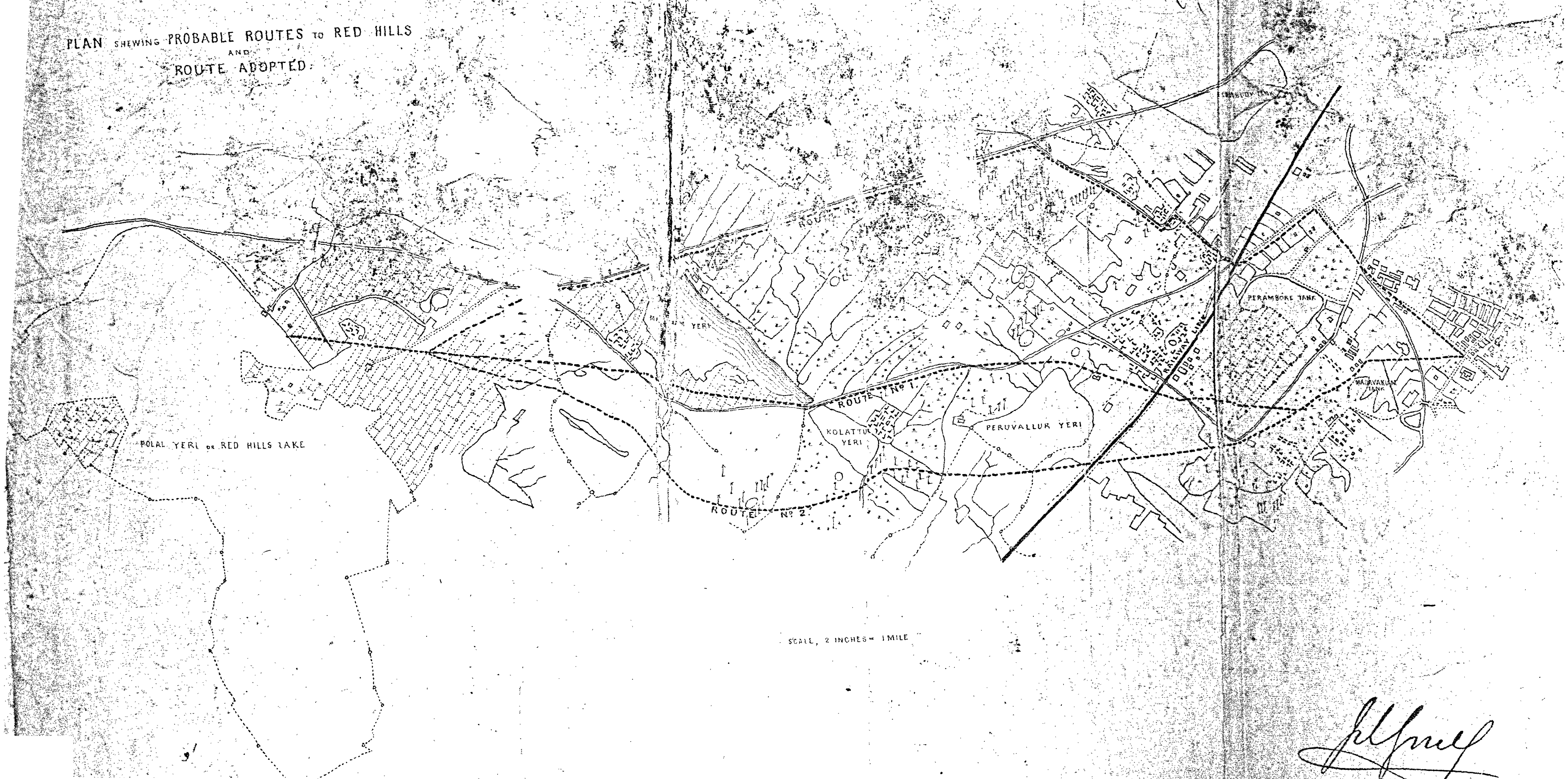
I have the honor to be,
Sir,
Your most obedient Servant,
J. A. JONES, Assoc: Inst. c. e.
Executive Engineer,
Madras Municipal Commission.

Mad[illegible], [illegible] *June* 1877.

DRAS MUNICIPAL WATER WORKS — IMPROVEMENT SC

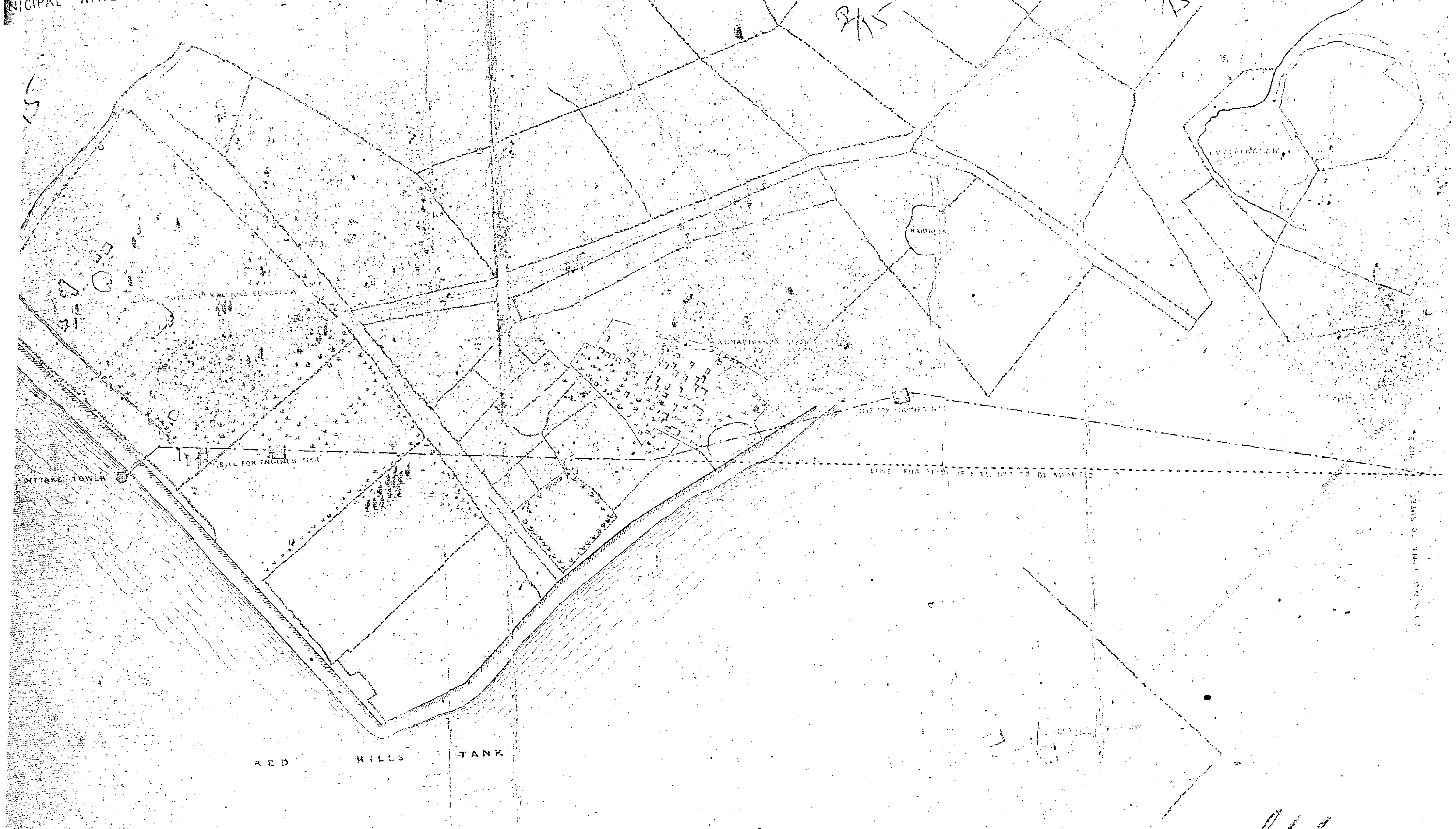
SHEET No I.

PLAN SHEWING PROBABLE ROUTES TO RED HILLS AND ROUTE ADOPTED.



Executive Engineer.

NICIPAL WATER WORKS — IMPROVEMENT SCHEME 187

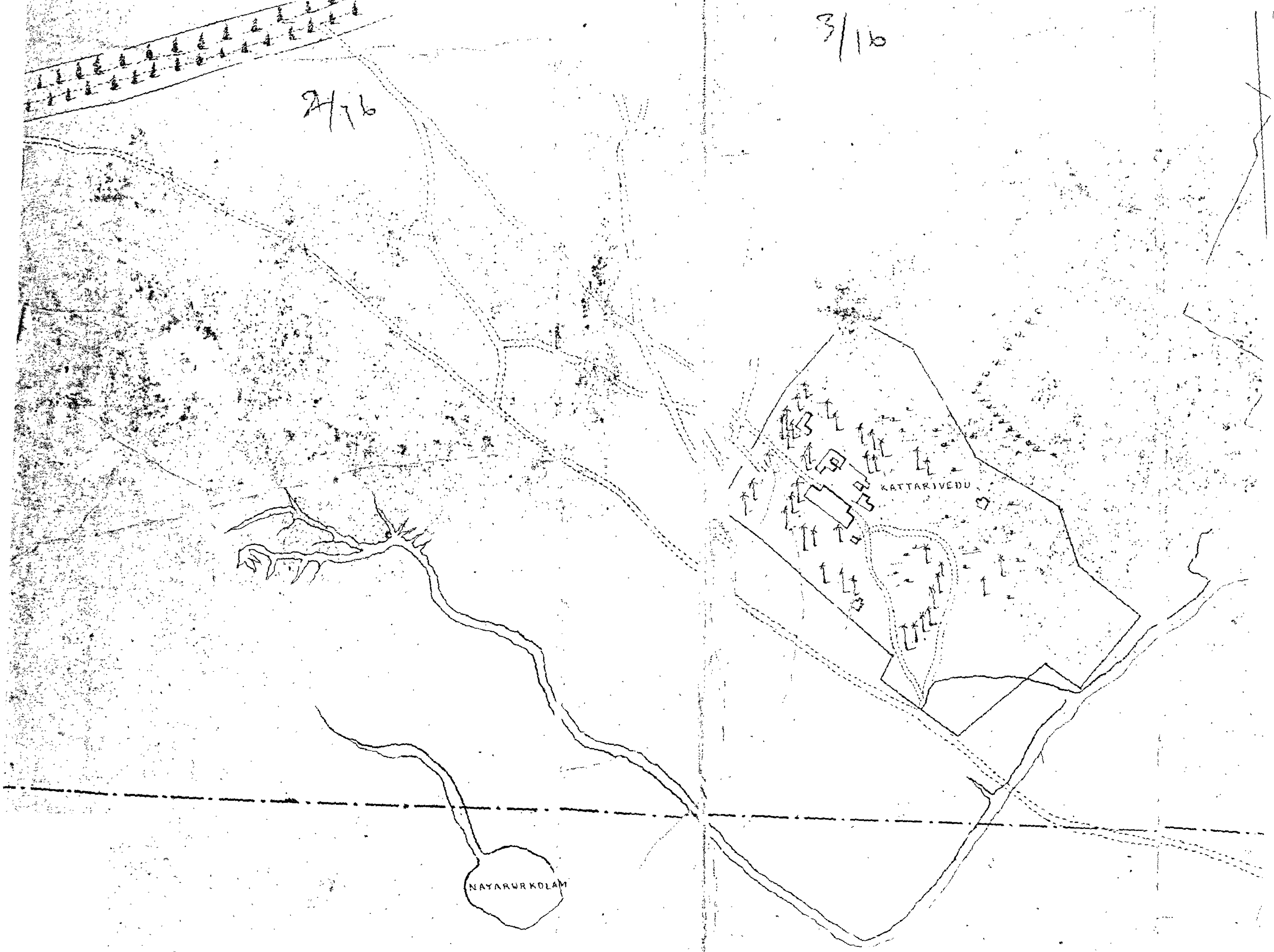


PLAN shewing PROPOSED LINE for PIPING between RED HILLS LAKE and MADRAS.

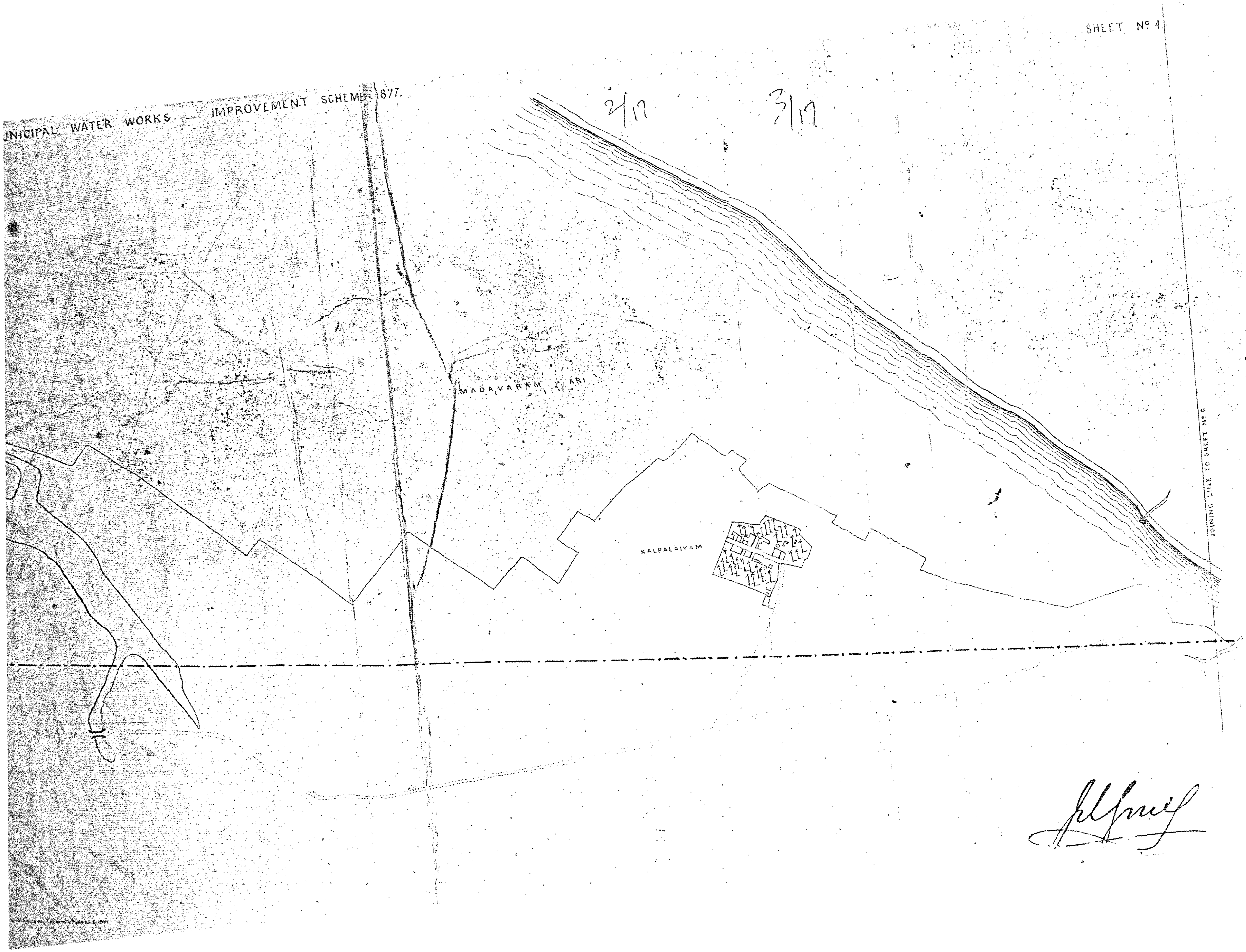
SCALE 5 CHAINS = 1 INCH.

Executive Engineer

SHEET No 3.



Executive Engineer.


UNICIPAL WATER WORKS — IMPROVEMENT SCHEME 1877.
SHEET No 4
2/17
3/17
MADAVARAM ARI
KALPALAIYAM
JOINING LINE TO SHEET No 5

APPENDIX No. I.

Table Shewing rates used to form Estimate.

Nos.	Particulars		Rates.		
			Rs.	A.	P.
1	Brickwork per	Cubic yard.	12	0	0
2	Laterite built in Chunam and plastered with Morgan's cement...	"	4	0	0
3	Clay Puddling	"	0	8	0
4	36" Piping delivered in Madras	Ton	80	0	0
5	Laying do per	Lineal yard.	3	8	0
6	18" Piping delivered in Madras	Ton	80	0	0
7	Laying do	Lineal yard.	2	12	0
8	Cartage of Piping per	Ton mile.	0	3	0
9	Excavation at site of Filters &c.	Cubic yard.	0	4	0
10	Cost of Valves, Bends, Sluices, &c. taken at same rates as Madras W. W. contract.				

APPENDIX II.

The following Statement shews the cost of "Gravitation and Pumping" works constructed in England for a supply of 20 gallons per head per day.—

Town.	Population.	Maximum daily supply.	Total Cost.	Cost for a supply of 20 gallons per head per diem.
		Gallons.	£	£
Gosport ...	22,000	222,000	21,000	1·75
Hartlepool ...	30,000	20,00,000	75,000	·75
Kendal ...	13,000	300,000	15,500	1·03
Liverpool ...	6,20,000	16,500,000	2,000,000	2·42
The Potteries ...	1,30,000	3,000,000	215,157	1·43
Merthyr ...	55,000	1,500,000	84,000	1·12
Newport ...	30,000	15,000,000	52,000	0·07

The cost of the scheme now proposed for Madras is, say Rs. 10,50,000 say ... £1,05,000
It has cost already ... ... Rs. 12,80,000 ... £1,28,000

Total... £2,33,000

This amount for a population of 400,000 = £0·58 for 15 gallons per head or say for 20 gallons ... ... 0·77

The average of the above towns is ... 1·37 for 20 gallons per head,

The cost of Calcutta Works was £570,596 for 429,535 people = per head... ... £ 1.33 for 15 gallons nearly
(say) 1.77 for 20 gallons per head.

It will be noted therefore that Madras even after this scheme has been carried out will be supplied with water at almost half the rate of the English towns noted and at considerably less than half what the Calcutta works cost.

J. A. J.

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APPENDIX III.

MEMORANDUM on a method of supplying Madras direct through a pipe without pumping, and by which the water may be able to be drawn when the Lake stands at any level—

I.—The bottom of Red Hills Lake at lowest point is 20·00.

II.—The fall between this level and the point at which the main is joined in the scheme to which this memorandum is attached is 20 feet.

III.—If a continuous pipe be laid to deliver water while the Lake is at any level not lower than 22·00, no part of the pipe can be above this level, and none of it should be higher than the line of vertical declevity.

IV.—The distance from the centre of the Red Hills Lake to the point previously described is about 40,820 feet—on a line of country near the present channel, but slightly lower than the level of its bed.

V.—The average depth of cutting required to lay this piping as above described would be 12 feet.

VI.—The means I would provide for drawing off the water would be as follows—

1. An Iron Cylinder 8 or 10 feet in diameter, which would be sunk, say 10 feet below the bottom of the Lake, and extend to about 6 feet above Full Tank level. The total length of this Cylinder would be 42 feet.

2. The Cylinder would be provided with valves at various depths below the Full Tank level.

3. The part of the Cylinder below the bottom of the Tank would be excavated and filled with concrete.

4. The main to Madras would enter through the side of the Cylinder, and be turned up through the concrete to the level of the bottom of the tank.

5. There would also be a valve on the main inside the Cylinder.

6. The Cylinder would be approached by a boat from the banks of the tank.

7. The main must be able to supply at least 6,000,000 gallons per day, but as half of this is drawn off in 6 hours, the main should be large enough to supply 12,000,000 gallons per day, and should be able to do this when the tank is as low as (say) 22·00.

8. The diameter of such a main would be 44 inches.

9. At times when the tank is at a higher level than (22·00) the quantity able to be delivered through such a main would be much increased.

10. The cost of such a scheme as the above is detailed below.

11. I have also shewn in a table what a 44 inch and 36 inch diameter main would supply at varying levels in of the tank, and the cost of a scheme with a 36 inch main.

12. In starting from the tank it would perhaps be the least expensive method to lay the piping along the Channel leading to the Soorapadu Sluic

13. The iron Cylinder would be floated out by means of pontoons, only so much of it being put together at first as would enable it to be lowered to the bottom of the lake without its higher end being covered.*

14. The following are estimates for the above scheme with a 44 inches and a 36 inch main

	44 inch Main.		36 inch Main.	27" dia
Cylinder and Tower in Tank	3,000		3,000	3000
Erecting do	2,000		2,000	2000
Machinery in do	2,000		2,000	2000
Cost of Main Lineal yards 13,606 ×	7,61,920		5,71,440	444000
Laying do	68,030		37,416	30000
Excavation	36,284		31,750	26000
Cartage of Main	10,714		8,035	7000
Valves in Main	8,400		5,760	5000
	890,348		661,401	519000
Contingencies	89,052		66,149	51000
Total...	9,79,400		7,27,550	570900

15. The amount of expenditure in Maintenance would be very little, certainly not more than what it costs to maintain the present Channel.

16. It will be observed that with this scheme there is no filtration, but its advantages over present arrangements would be that water would always be drawn from near the surface of the lake and that it could be drawn off to a depth of 11 feet below the level of present delivery Channel.

17. So long as the water remained above the level of the present Channel, the Head of water in Madras would be *at least* 2 feet greater than it *now is*, as there is about 2 feet fall in the length of the Channel.

18. A rise in the level of the water in the Lake above 31·31 does not practically increase the head to any extent in Madras at present, though it increases the quantity of water which can be delivered by the present Channel in a certain time.

19. By means of this scheme the head of water will vary, and when the lake is full the head in Madras will be about 44 feet at the point previously described.

* Such a tower as this composed of iron cylinders might probably be cheaper for the scheme with filtration than a brick tower if the tank stood at a high level.

× Taken as 4536 pipes each pipe 2740 lbs @ 80 Rs per Ton
(Say for 27" pipe 1" thick 5550 tons)

TABLE SHEWING the quantity of Water which would be delivered in 24 hours by pipes of 44 inches and 36 inches in diameter, at varying levels of the Red Hills Lake.

Tank Level.		Head taken as	Delivered by pipes of 44 in. diameter.	36 in. diameter.	27" dia
Above mean sea	22.00	20	1340 12,060,000	804 7,236,000	398 528200
	27.00	25	1500 13,500,000	900 8,100,000	447 402300
	32.00	30	1640 14,760,000	984 8,856,000	463 434700
	37.00	35	1784 16,056,000	1070 9,630,000	526 473400
	42.00	40	1900 17,100,000	1140 10,260,000	559 503100
	46.00	44	2022 18,198,000	1213 10,917,000	596 53640

NOTE.—The smaller quantities underlined thus —— are cubic feet per minute.

The larger quantities are gallons per day.

In reading the above table it should be remembered that Madras requires 6,000,000 gallons per day or 666 cubic feet per minute, but that during certain hours the consumption is double this quantity.

J. A. JONES.

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APPENDIX IV.

RED HILLS TANK.

Table showing Cubical Contents at half foot vertical intervals.

Height above mean sea level.	Contents at level in column 1.	Difference of cubical contents at each half foot.	Height above mean sea level.	Contents at level in column 1.	Difference of cubical contents at each half foot.
1	2	3	1	2	3
FEET.	CUBIC YARDS.	CUBIC YARDS.	FEET.	CUBIC YARDS.	CUBIC YARDS.
					2,103,979
22·31	944,514		34·81	33,646,893	
		541,133			2,179,526
22·81	1,485,647		35·31	35,826,419	
		614,314			2,253,893
23·31	2,099,961		35·81	38,080,312	
		687,191			2,326,067
23·81	2,787,152		36·31	40,406,379	
		759,496			2,403,165
24·31	3,546,648		36·81	42,809,544	
		833,007			2,509,506
24·81	4,379,655		37·31	45,318,050	
		905,787			2,581,662
25·31	5,285,442		37·81	47,899,712	
		962,747			2,644,721
25·81	6,248,189		38·31	50,544,433	
		1,017,892			2,704,458
26·31	7,266,081		38·81	53,248,891	
		1,073,917			2,764,504
26·81	8,339,998		39·31	56,013,395	
		1,127,810			2,827,344
27·31	9,467,808		39·81	58,840,739	
		1,183,244			2,927,260
27·81	10,651,052		40·31	61,767,999	
		1,238,905			2,900,823
28·31	11,889,957		40·81	64,667,822	
		1,251,627			2,983,425
28·81	13,141,584		41·31	67,651,247	
		1,334,328			3,065,310
29·31	14,475,912		41·81	70,716,557	
		1,397,725			3,145,221
29·81	15,874,637		42·31	73,861,778	
		1,464,376			3,229,074
30·31	17,338,013		42·81	77,090,852	
		1,535,388			3,310,764
30·81	18,873,401		43·31	80,401,616	
		1,603,633			3,399,281
31·31	20,477,034		43·81	83,800,897	
		1,655,489			3,479,667
31·81	22,132,523		44·31	87,280,564	
		1,732,440			3,558,171
32·31	23,864,963		44·81	90,838,735	
		1,806,345			3,634,392
32·81	25,671,308		45·31	94,473,127	
		1,881,189			3,715,062
33·31	27,552,497		45·81	98,188,189	
		1,957,987			3,793,626
33·81	29,510,484		46·31	101,981,815	
		2,032,430			
34·31	31,542,914				

R

(Re-Mending work)

செப்பனிடுபவர் பெயர் D. வரதன்

செப்பனிடுவதற்காக எடுத்துக் கொள்ளப்பட்ட நாள். 18.11.91

செப்பனிட்டு முடித்த நாள் 28.11.91

28/11/91

சரிபார்க்கும் மு.பா.எ. கையொப்பம்.

ஆராய்ச்சி உதவியாளர் கையொப்பம்.