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Read the following papers:—

No. 335. From the Superintending Engineer, 5th Division, to the Secretary to Government, Department Public Works, dated Cuddalore, 11th February 1868, No. 224.

- 1 Plan.
- 1 Estimate.
- 1 Specification.
- 1 Letter from Executive Engineer.
- 1 Indent.

1. With reference to the Order of Government of the 4th March 1867, No. 656, paragraph 3, I have the honor to forward, for sanction, an estimate of Rupees 41,000, with plan and specifica-

tion, for laying pipes for the drainage of the Race Course Barracks at Bangalore. The estimate is accompanied by an Indent for the pipes that will be required, the cost of which at the factory, taken from the manufacturer's price list, is £ 2,111-16-0, or about twenty-two thousand Rupees. Supposing that by the time they reach the Barracks their cost will be doubled, by charges for packing, freight, &c., then the total cost of the drainage of the Barracks will be eighty-five thousand Rupees, or considerably less than the sum that was assumed at the outset.

2. When an estimate for draining these Barracks was first called for, no mention was made of the system of drainage to be adopted, whether refuse water from the buildings was alone to be removed, or surface drainage was also to be taken off by the same channels. The scheme now submitted is for the removal of liquid refuse of all kinds from the hospitals, baths, wash-houses, cook-rooms, family-quarters, and stables. No provision is made for the surface drainage of the ground, on which the Barracks are built, as, from its natural slope, the water runs off at once.

3. For the conveyance of the drainage from the buildings, it is proposed to use glazed stoneware pipes, which are now invariably used, where practicable, in place of sewers of brick-work. They are quickly and easily laid, require a smaller amount of excavation, and their smooth internal surface allows the sewage to pass more rapidly than it could do in a brick-work sewer. Moreover, being formed of various shapes, bends and junctions can be more perfectly made than can be the case with brick-work. These are advantages common to all the glazed pipes. The particular form of pipes proposed to be adopted in this case, has the further advantage of affording great facilities in getting at any obstructions, as the saddles over two adjoining pipes can be lifted up.

4. Notwithstanding the distance from which the pipes will have to come, and the cost of carriage, both time and money will be saved by their use. The bricks procurable at Bangalore, though good enough for ordinary buildings, would not answer for sewer works. Bricks would have to be made specially for the purpose, which would cause delay, and afterwards, the pipes could be laid in much less time than an equal length of sewer could be built. The quantity of the three sizes of pipes in the Indent is one-third more than in the estimate, to allow for breakage in transit.

5. It will not be practicable to drain all the buildings to one out-fall, at least not without having to lay some of the pipes at a very great depth. The available directions, in which the drainage can be carried, are to the east and to the south, where there is ground which can be irrigated by it, and at a sufficient distance from the Barracks and other buildings to prevent any unpleasant effects.

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6. The levels from which the plan and estimate have been prepared were carefully taken by Lieutenant Pennycuik, and the whole scheme has been under consideration a long time. The Indent for the pipes was prepared more than a year ago, and although the work cannot be commenced until the pipes have been received, I have thought it advisable not to forward the Indent until the plan and estimate were ready to go with it, so that full information might be afforded as to the intended scheme and its probable cost.

7. The plan and estimate have not yet been submitted for the opinion of the Military authorities and the Sanitary Commissioner.

From Lieutenant J. PENNYCUICK, R. E., Executive Engineer, Bangalore, to the Superintending Engineer, 5th Division, dated Bangalore, 30th October 1867, No. 839.

1. I have the honor to forward herewith a plan of the Race Course Barracks, showing the mode in which it is proposed to carry out the drainage of the buildings included therein, with an estimate of the cost of the work, amounting to Rupees 41,000.

2. The ground on which the principal Barrack blocks are built forms a plateau nearly level, with a slight general fall from the western corner in all directions. From the edges of the plateau the ground falls away rather rapidly in all directions, except towards the north-west, and on the slopes thus formed are built the family-quarters, hospital, stables, and other subsidiary buildings.

3. From the north-east by the north to the south-west the ground is surrounded, at greater or less distance, by the Cantonment of Bangalore, and to the south-east the fall is of very short extent, the ground beginning to rise again about 100 yards from the furthest of the Barrack buildings (the Artillery married quarters). The available space for out-fall is, therefore, confined to the east and south, in either of which directions a drain may be carried for considerable distance with a good fall, and be finally discharged upon land where the sewage can be utilized.

4. Unfortunately, however, the whole of the Barracks cannot be drained in either of these directions, owing to the projection of the main plateau between the low buildings on each side. This will be easily understood by a glance at the levels marked in the plan.

5. The lowest buildings on the two side slopes are the last block of Artillery stables on the south, and the single separate ward of the Hospital on the east. The lowest corner of the former is about 39 feet, and of the latter 41 feet below the datum.

6. If the whole of the Barracks were to be drained to one out-fall, the same drain must take in both these points. As they are nearly 4,000 feet apart in a straight line, the very shortest drain between them would require a fall of at least 26 feet, so that at the corner of the hospital it would be something like 68 feet below the datum, or 27 feet below the ground. This line, moreover, would pass to the north of the Artillery married-quarters, under ground from 15 to 20 feet higher than the point it started from, giving an enormous amount of cutting, and rendering the work proportionately expensive.

7. This plan would be not only extravagant, but impracticable, for the eastern out-fall has a good slope, but not sufficient to allow us to waste 26 feet at starting.

8. This cause, *a fortiori*, prevents our avoiding the high ground above the Artillery married-quarters, by taking the drain round the foot of the plateau between these buildings, as its length would thereby be increased, and it would reach the hospital at a depth of between 40 and 50 feet below the ground.

9. I need not say more to show the impracticability of draining the whole ground to one out-fall; indeed I have already said more than is necessary, as the fact is self-evident from a glance at the plan.

10. It is, therefore, necessary to drain one portion of the Barracks to the east, and the remainder to the south.

11. The plan will supply any further information that may be required. The thick blue lines represent the main drains, the thin blue lines the branch drains, the double red circles,

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marked M. manholes for descending to examine and repair the pipes, and the single red circles, marked V., ventilating shafts. The black figures show the depth of the ground at the points where they occur below the datum line, and the red figures underneath them the depth of the centre of the drain below the ground, in feet.

12. The plan has been prepared by me from levels taken by myself with the greatest care; a contoured plan of the whole ground was constructed, on which the drains were laid down and transferred to the plan now sent. The contours are not shown on this, as they would only serve to confuse it. The levels of all the important points are marked in figures.

13. The distance beyond the Barracks to which it is proposed to carry the main drains are shown on the plan. These will be sufficient for sanitary purposes, and will allow the drainage to be discharged on ground where it can be utilized.

14. The eastern main drain is taken in rear of the hospital compound, so as to remove the ventilating shafts, from which disagreeable smell occasionally arises, as far as possible from the hospital buildings.

15. It is proposed to run a branch with a trapped sink from every cook-house, wash-house, and plunge-bath; from every stall of the stables, and from every Staff Serjeant's, and married men's quarters, but the estimate does not provide for branches from the privies, as it is presumed that the dry system of conservancy renders this unnecessary. Should it hereafter be considered necessary to provide for the removal of solid excreta, branches to the privies can easily be added.

16. It is of course not proposed to carry off storm water by these drains, as the natural drainage of the site is about as perfect as it can well be, and any attempt to interfere with it artificially would be both costly and injudicious. All that is proposed to do is to remove liquid refuse of all kinds from the buildings.

17. I have not thought it necessary to prepare sections of any of the lines of drains, as the levels both of the ground and of the drain pipe are marked on the plan at numerous points. The preparation of sections would occupy some time, and as they would be of little or no use I do not think it advisable to delay the submission of the project while they are being prepared.

18. Working drawings of the manholes and ventilating shafts will have to be prepared before the work is commenced, but these are more matters of executive detail than essential points in the project. The rates which I have allowed for them will probably be found sufficient.

19. The pipes which it is proposed to me are Jennings's patent "saddle and chair" pipes, which for facility of inspection and repair, and of adding new branches when required, are certainly superior to any others known. The cost of the pipes and other articles required to be obtained from England, according to your indent, will be about Rupees 29,000 at the factory, and will probably amount to Rupees 58,000 before they reach Bangalore. It will be understood that the cost of the pipes, &c., is not included in the estimate now forwarded.

20. For laying the pipes I have allowed three different rates for each size of pipe, one for depths under five feet, one from five to ten feet, and a third from ten to fifteen feet. For great depths the work will be very expensive, owing to the large amount of excavation required.

21. There must necessarily be some uncertainty as to the cost of work of this kind, as we have no precedents to furnish information. The rates entered in the estimate are based upon a careful calculation of the amount of excavation and other labor required, and will, I think, be found sufficient.

22. The proportion of piping required for the different depths has been calculated with the greatest care by myself. This calculation has been somewhat laborious, and has indeed been one of the principal causes of the delay in the submission of the estimate. It was no use entrusting the work to an Estimator, as checking his calculations would have been just as troublesome as making them myself; and it is only within the last few days that I have been able to give my own attention to the matter.

23. The plan was prepared, as you are aware, nearly a year ago, having been finished before I went away on leave in December last, and since then some slight alterations have been made in the positions of the stables, and one or two other buildings; but I have not thought it necessary to

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alter the plan on that account, as only a few of the smaller branches, and not the main lines, or the amount of piping required, will be affected.

24. In executing the work the most convenient plan will be to call for tenders in the form of a schedule of rates, at which payment is to be made to the Contractor for work done as determined by actual measurement. This will be better than a tender for a lump sum, as it will allow of additions or deductions on account of any slight alterations that may be necessary, being calculated more easily.

25. The schedule will not be long, nor the bills complicated, as the estimate consists only of seventeen items, viz., three rates for each size of pipe, one rate for manholes, three for ventilators, one for yard-sinks, and three for flap-traps.

26. Provision for the execution of the work in this way has been made in the specification, which is in somewhat more detail than usual.

27. I regret the long delay that has taken place in submitting this project, but I have already explained the reason of this delay, and believe that you will consider the explanation as sufficient.

Referred to the Military Department, with a view to the opinions of his Excellency the Commander-in-Chief and the Sanitary Commissioner being obtained.

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

Referred to the Commander-in-Chief (Quarter Master General's Department), for the observations of His Excellency, and to the Sanitary Commissioner for report.

(Signed) C. S. ELLIOT, Major,
Offg. Deputy Secretary to Government.

From the Quarter Master General, to the Secretary to Government, Military Department, dated Fort St. George, 7th March 1868, No. 1,914.

I have the honor, by order, to return the enclosures of your reference docket dated 20th ultimo, and to report, for submission to Government, that the Commander-in-Chief, when he recently visited Bangalore, inspected the site of the old Race Course Barracks, and His Excellency is of opinion that the plan proposed by the Executive Engineer, to carry out the drainage of the buildings, will meet the object contemplated.

No. 336. From the Sanitary Commissioner, Madras, to the Secretary to Government, Military Department, Fort St. George, dated Madras, 13th March 1868, No. 232.

1. With reference to the Orders of Government in the Military Department, of the 20th ultimo, directing me to report upon the scheme of drainage proposed for the Race Course Barracks at Bangalore, as submitted by the Superintending Engineer of the 5th Division, in his letter No. 224, of 11th idem, I have the honor to state, for the information of Government, that I proceeded on the 27th to that station in view to making myself fully acquainted with the details of the scheme, and to examine the locality in relation to the important question of utilization of the sewage in irrigation of lands in proximity to the barracks, as proposed in paragraph 5 of Colonel Foord's letter.

1 Memorandum upon the question of sub-soil drainage of the site selected for the new Central Jail at Trichinopoly.
1 Extract from an unfinished letter to the address of the Chief Secretary to Government, by the late Acting Sanitary Commissioner for Madras.

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2. The enclosures* alluded to in the letter under reference did not accompany it, but I obtained from the Office of the Executive Engineer at Bangalore copies of the plan and of Lieut. Penny-cuick's letter, and am indebted to Captain Meade for patient and careful exposition of the whole scheme.

- * 1 Plan.
- 1 Estimate.
- 1 Specification.
- 1 Letter from Executive Engineer.
- 1 Indent.

I have also made myself acquainted with the views of my predecessor, the Honorable Mr. Ellis (and of those of the Commission which he represented), upon the subject, as expressed in his report upon the station of Bangalore, submitted to Government in 1865.

3. The proposed drainage scheme, I note, applies only to "liquid refuse of all kinds from the hospitals, baths, wash-houses, cook-rooms, family-quarters, and stables;" that provision for *surface drainage* is intentionally omitted, as it is considered that "the natural drainage of the site is about as perfect as it can well be, and any attempt to interfere with it artificially would be both costly and injudicious;" while *sub-soil* drainage is not so much as even alluded to.

4. The liquid refuse it is proposed to remove by a series of glazed stoneware (impervious) pipes, ranging from three to nine inches in diameter, to two out-falls, one lying to the east, and the other to the south of the plateau occupied by the troops.

All buildings from which 'liquid refuse' of any kind is to be conveyed, will be put in communication with the sub-drains by 3-inch pipes with grated and trapped openings.

The drainage pipes will be provided at intervals with *manholes* for inspection, and with *ventilators* for escape of sewage gases.

No mention is made of any special provision for flushing; but that necessary operation, the present Executive Engineer informs me, is to be performed by turning on the water from the different taps for given periods each day.

Neither is any allusion made to the provision of charcoal filters, in connection with the ventilators, for deodorization of sewage gases, though Captain Meade is under the impression that they are to be adopted.

5. It is not intended to admit any matters from privies and urinals (which, it is assumed, will be conserved upon the dry earth system) into the tubular drains.

The liquid refuse will, however, possess the properties of "sewage," for although solid and fluid human excreta are to be excluded, the urine of some (800?) horses is to be admitted into that section of the drains which is to be led to an out-fall to the south of the plateau.

6. The points for consideration in a sanitary point of view are as follow:—
First.—Is the proposed system of drainage by glazed stone-ware pipes superior to that hitherto adopted in India (and of which alone we have any experience) of open-brick in chunam or stone-in-cement V or saucer-shaped drains?

Second.—Will it be safe to leave surface drainage entirely out of the question?

Third.—May not sub-soil drainage also be necessary?

Fourth.—Is there any sanitary objection to the utilization of the liquid refuse (sewage) in irrigation of the tracts of lands indicated by the Engineer?

7. The Government have, I believe, no experience of pipe drainage in this Presidency, and I am not aware that it has been introduced into any station in India. No precedent can, therefore, be quoted for or against the system.

Under these circumstances, I can only turn to the recorded opinions of the eminent men who compiled the "Suggestions in regard to sanitary works required for improving Indian stations," prepared by the Barracks and Hospital Improvement Commission. (Blue Book, dated 1864.)

8. Before, however, proceeding to give the opinion of that Commission upon the special question of tubular pipe drainage, I purpose to submit the conclusions they arrived at in regard to the whole question of drainage (in its association with water-supply) of Indian stations.

After stating that the object of the "Suggestions" is to "embody in a practical form those points of home experience in sanitary works and measures which appear to be more or less applicable to conditions" pertaining to India, and "which (works and measures) it is hoped with the required modifications may be useful in India and in tropical stations generally," the Commission enunciate that the essential requirements of all stations under the head of drainage include—

(1.) Surface drainage and paving.

(2.) Sewage and drainage, including sub-soil drainage.

9. Surface drainage.—Under the head of surface drainage they insist upon the following points:—

(a.) That all rain water from roofs should be collected by eaves gutters, and either (1) be stored (after filtration) for use, or (2) passed directly into the drains of the stations.

(b.) That the immediate surface surrounding buildings should be flagged or paved with closely jointed non-absorbent paving stones, with a sufficient slope to the surface channel to conduct water away from the foundations of buildings by carefully laid surface drains.

(c.) That open trenches dug in the ground, though an excellent means of drainage for temporary camps, are not adapted for surface drainage of permanent stations * * * wherever open surface drains are required they should be formed of impervious material.

10. Sub-soil drainage.—In regard to sub-soil drainage the following opinions are advanced by the same Commission:—

(a.) That sub-soil drainage is necessary as a means of prevention of miasmatic diseases, which are especially attributable to retention of moisture in the sub-soil. That the universal prevalence of malarial disease at Indian stations indicates a malaria-generating condition of the earth; that one of the first improvements required is to diminish or remove this condition, and that in order to do so, there must be necessary materials and skill for sub-soil drainage, and an outlet for sub-soil water; that drainage sanitary works should aim at providing a dry and wholesome sub-soil, a clean surface, and a pure atmosphere.

11. The Commission consider that the system of tubular pipe drainage is applicable to India, and that for all purposes of drainage glazed earthen-ware pipe drains of nine or twelve inches diameter will be found sufficient for 1,000 men.

These opinions are thus summarized by the Commission at page 7.

The leading principles to be kept in view are—

(1.) To provide, by carefully formed surface drains, for the removal of all the-rain fall except what sinks into the ground.

(2.) To provide for the rapid removal of this sub-soil water by land or sub-soil drainage.

(3.) To drain away the refuse fluids of all houses, &c., by closed sewers and drains.

12. Such are some of the expressed opinions of the Barrack and Hospital Improvement Commission in relation to sanitary drainage in India, opinions which I have given almost, and in many instances, entirely in their own words, and which I am desirous to give prominence to, as they have not yet obtained that consideration and attention at the hands of Engineers in this country that they so eminently deserve and demand; for surface drainage is still very indifferently provided for at any station, while sub-soil drainage has hitherto received no consideration whatever.

13. I purpose considering each of these requirements more fully, in relation to the drainage and water-supply of the area upon which the Race Course Barracks at Bangalore stand; and, first (as the subject more especially referred to me for report), the proposed scheme of "tubular pipe drainage."

Tubular pipe drainage.—Colonel Foord states in his letter that glazed stoneware pipes are now invariably used in place of sewers of brick-work, and gives in detail the advantages of the former over the latter system.

I have already remarked that the Barrack and Hospital Improvement Commission are favorable to this system of drainage.

Their views are thus expressed:—

(a.) That earthenware pipes make the best drains up to their sectional capacity, say 15 inches.

(b.) Half-socket pipes, laid with the half-socket down, make the best drain, as any pipe can be removed without breaking a pipe.

(c.) Common circular vitreous earthenware pipes, with ordinary junctions, are the best.

(d.) Drain pipe joints may be made with well tempered clay in sound ground; but should be made with cement or with hydraulic mortar in open or sandy ground, the joints should be so tight that no sewage can escape from the drain into the sub-soil. Manholes, as for sewers, should be provided in all drains, with means of flushing and ventilation.

(e.) Earthenware pipes of 4 inches in diameter are sufficient for water closets and sinks; these may join drains of 6 inches, the six joining 9 inches, 12 inches, and 15 inches, and these forming a tributary main or passing to a main sewer.

14. Such are some of the leading principles of drainage and construction of drains and sewers inculcated by the Commission so often alluded to. Their suggestions are illustrated by plans and drawings.

It may be said that Captain Pennycuick's plan is in general conformity with the principles advocated above. In some few, and possibly not very important, points it differs from that suggested by the Barrack and Hospital Improvement Commission.

The points are—

First.—Size of pipes.

Second.—Position of manholes and ventilators.

Captain Pennycuick proposes to use 3 inch, passing into 6 and 9 inch pipes.

The Commission recommend 4 inch, leading into 6, 9, 12, and even up to 15, if required.

Whether it will be advisable to increase the calibre of the pipes to that extent is a purely scientific question, to be left to the Engineer Department with reference to the quantity of sewage to be admitted into the drains, (and of which calculation has doubtless been made, though it does not appear in the letter under reference,) the gradients of the line, and other circumstances of locality.

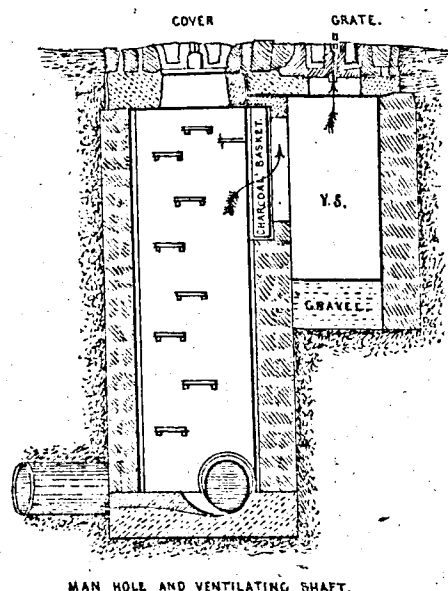
15. *Position of manholes and ventilators.*—In Captain Pennycuick's scheme the manholes and ventilators are at different (alternating) points. The Barrack and Hospital Improvement Commission recommend a combination of the two, and give a drawing of the same, which is re-produced in the margin. Captain Pennycuick has not yet prepared drawing of the manholes and ventilators that he proposes to adopt.

It will probably be found more convenient, economical, and advantageous on sanitary grounds to combine the two, and to introduce the charcoal screen, as shown in the drawing.

Some gases will doubtless rise at all the higher points of the line of drainage, and some means to deodorize them will be necessary.

It is true that the ventilating shafts open in every case, as shown in the plan, at a distance from any building, still the addition of charcoal filters will be safe and advisable.

16. In regard to 'flushing' the drains, I would remark that it is questionable whether the mere turning on of the taps in the wash-houses will suffice. The operation of flushing is better effected by the sudden admission of a comparatively small volume of water than by the continuous flow of a larger quantity. At home special provision is made at the manholes, both in brick and tubular sewers, by a plank or shutter by which the sewers can be flushed out in sections, either by ponding up the sewage itself and allowing its sudden escape into the next section, or by admission of water from reservoirs in connection with each manhole.



17. I purposely avoid touching further upon questions which do not involve sanitary considerations, and therefore do not comment upon the purely engineering aspect of the scheme, but accept the facts and arguments adduced in support of the necessity which is said to exist for giving two out-falls to the drains instead of one, which had it been practicable, would have been advisable on sanitary grounds.

18. The question of open masonry drains *versus* closed conduits must, however, be considered.

On referring to the opinion of my predecessor, the Honorable Mr. Ellis, and of the Commission of which he was President at the time of submission of the report upon the station of Bangalore in 1865, I find that preference was given to open V shaped drains over closed conduits.

Open drains recommended.—Mr. Ellis writes "without proper drainage these Barracks will become exceedingly foul, and no time should be lost in preparing a complete scheme for efficient drainage. In a climate like Bangalore, where light rain is of frequent occurrence, the open drains would, if properly constructed, remain without smell, and they could be easily flushed when rain does not fall. Under-ground drainage is so liable to get choked up, and then to prove at once a source of nuisance and expense for repairs that, in the opinion of this Commission, a system of open drains, similar to those so frequently seen at Bangalore, should be adopted."

The Committee assembled under orders of His Excellency the Commander-in-Chief on the 19th May 1865, of which General Haines was President, to take into consideration the recommendations of the President of the Sanitary Commission, recorded their opinion upon the subject as follows:—

"The special attention of Government is requested to the immediate preparation of a working plan of drainage, and (as recommended by the Sanitary Commission in paragraphs 91 to 94 of their report) a thorough system of drainage is required; water falling on the open spaces between, and the roofs of the Barracks and subsidiary buildings should be conducted by pipes into open V shaped granite channels, to terminate in a masonry conduit, whereby rain-water and foul-water, from cook-rooms, lavatories, and private dwellings could be carried off to a distance from cook-rooms, lavatories, and private dwellings could be carried off to a distance to leeward of the Race Course, there to be utilized, as in England, in the cultivation of meadow lands.

"The drainage from the hospital should be complete in itself, and, at its origin, independent of the general surface drainage.

"As the foundations of the Barracks are very low, it is also desirable that to ensure their dryness after rain, a pathway four to five feet in width, flagged with granite, should pass round each Barrack and block of family buildings, &c., on the road side of this the V shaped channel to receive rain-water from the roofs of the Barracks and rain-fall on the roads, should be constructed."

This Committee, therefore, gave a preference to open surface drains, (though it does not appear that any well-considered scheme of tubular or pipe drainage was before them,) and at the same time desired to give effect to the recommendations of

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the Barrack and Hospital Improvement Commission, by the institution of flagged pavements and V shaped drains round all barrack buildings.

In this view the Officiating President of the Sanitary Commission, the late Dr. Macpherson, in his letter of the 19th May 1865 concurred; but subsequently in letter No. 237, of 8th July 1865, that Officer modified his opinion, for in paragraph 2 of that letter he writes, "We recommend that all rain-water not conserved for domestic purposes, and waste-water from buildings, should pass from the surface through grated openings into well glazed stoneware branch pipes laid on to a main conduit, by which water should be conveyed to a distance from the Barracks."

19. The advantages generally held to pertain to open V or saucer-shaped drains are the capability of constant inspection, and the impossibility, except by great negligence, of any fouling of the drains.

The objection to them is the difficulty which has hitherto been experienced of making them impervious. As usually constructed, of brick and chunam, they are speedily destroyed by the action of sewage waters, percolation into and fouling of the sub-soil, sooner or later going on. Even stone drains are open to the same objection, the cement generally used not being capable of resisting the corroding action of sewage. Possibly asphalt would be found to resist this action and to make water-tight joints.

But independent of this difficulty, the present Executive Engineer, Captain Mead, informed me that there would be almost insuperable difficulties in the way of constructing open drains to drain to only two out-falls; that it is not possible to 'contour' the plateau upon which the Barracks stand so as to avoid deep cuttings; that in fact the drains could not be kept as *surface* drains, but would have at many points to be placed at considerable depths, and, as a means of safety, to be covered over.

20. Colonel Foord has given his unqualified opinion in favor of the tubular tile over the masonry drains, mainly on the ground of the difficulty, nay impossibility, of procuring materials (bricks or cement) capable of resisting the action of sewage; and seeing that engineering difficulties are said to stand in the way of a system of open V or saucer-shaped drains, on the score both of the 'fall' of the ground and of want of a reliable cement, I am justified in recommending the adoption of the impervious tubular pipe drain.

Not that I consider all risk of sewage percolation removed thereby, for there is still a risk. The joints require to be water-tight, and to this end a cement capable of resisting sewage action is equally required, and this Captain Mead does not hold out any promise of procuring; indeed, he admits that some escape of sewage will most likely take place at the joints, to which, however, he does not attach much importance on the ground that the water to be used by the troops is to be brought from a distance, and not to be derived from wells on the spot. But as wells do exist, and are now used; and moreover, as it has been proposed to collect and store waters falling upon the roofs of the buildings in underground reservoirs (to which subject I shall presently revert), the fact of the liability of leakage must not be lost sight of, and special provision must be made for speedily draining to an outlet, any sewage which may find access to the sub-soil.

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This subject will receive further consideration under the head of *sub-soil drainage*.

21. *Surface drainage*.—Surface drainage has been pronounced by the Engineer Officer unnecessary. To this opinion I must take most emphatic exception, for however favorable the configuration of the surface or of any surface may be to escape of storm-waters, a large portion of the rain-fall must and does find access by percolation to the sub-soil.

From information I have acquired, and from observation of the locality, I am further in a position to say that water lodges after rain in places, and is dissipated only by evaporation and subsidence into the soil, and that it does not run off so readily as to remove all risk of sub-soil dampness. Moreover, the soil itself is a ferruginous loam, of absorbent character.

The opinion of the Barrack and Hospital Improvement Commission upon this subject I have already alluded to. I have shown that they insist upon properly constructed drains, in *addition* to a surface from which water readily runs off. All their recommendations are in view to preventing water finding its way into the sub-soil, and to this end they advise that—

(1.) All rain water from roofs should be collected, and if not stored, be run off at once *into the drains*.

(2.) That the surface surrounding all barrack buildings should be flagged with closely jointed, non-absorbent paving stones, with sufficient slopes to the surface channel to conduct water away by *carefully laid surface drains*.

The "Commission appointed to enquire into the sanitary state of the Army in India" are also very strong upon the subject of drainage. They write (alluding to stations in which some provision is made for surface drainage) "the rain-fall no doubt partially runs away by the surface drains, *but the great bulk of it * * * goes to saturate the sub-soil with water.*"

The more efficient then the surface drainage is made, the less the risk of sub-soil dampness, which there is abundant evidence to prove is one of, if not the most important factor in the causation of miasmatic diseases. The "Royal Commissioners" must be again quoted upon this subject, they write, "inasmuch as wet or damp sub-soils are well ascertained causes of this class of maladies even in cold climates, in such a climate as India the neglect of sub-soil drainage within the area of stations is, doubtless, one great cause of increased sickness and mortality."

This quotation, it is true, applies to sub-soil drainage, but that is intimately associated with surface drainage. The more efficiently the latter is provided for, the less will be the necessity for the former.

VI. Notwithstanding then the opinion expressed by Captain Pennycuik in the 16th paragraph of his letter, and the support given thereto by Colonel Foord, I consider it my duty strongly to urge upon the Government the necessity for a carefully devised system of surface drainage upon the comprehensive plan suggested by the Barrack and Hospital Improvement Commission, suggestions which obtained generally the approval of the Honorable Mr. Ellis, and of the special Committee of which General Haines was President.

*Proceedings of the Madras Government, Public Works Department,
21st April 1868.*

The surface drains I would advocate are shallow V or saucer-shaped drains, made to receive all storm-waters not stored for use, and which should be made to follow the contours of the ground to as many outlets as may be considered necessary, with the sole object of rapidly carrying off all rain-fall not otherwise utilized, and not designed to admit liquid refuse from cook-rooms, &c., &c.

22. Is it possible to combine surface with the proposed tubular pipes drainage?

Will it, that is, be possible (having due consideration for the rain-fall at Bangalore) to admit the storm-waters into the drains designed for liquid refuse?

In England provision is made for admission of storm-waters into sewers and drains. At page 5 of the Suggestions of the Commission so often alluded to, the following passage occurs:—"Duplicate systems of sewers are not required, that is, sewers for storm flood waters and sewers for sewage. As previously stated, surface contours and natural valley lines may be improved, and main sewers may have overflow communications with such valley lines and natural courses, so as to relieve the sewers at all available points during heavy rains. At such times any sewage will be in extreme dilution, and the whole district will be in flood, so that any sewage will be washed away without causing injury."

Again, at page 8, under the head 'gullies,' they write, "All sewers and drains should have gullies and other inlet communications with the surface and sub-soil and other waters," and in plan IV they depict these 'gullies' as applied to the system of pipe drainage now under consideration.

In a foot note at page 6 they also illustrate the subject of pipe drainage, by reference to the town of Alnwick, in Northumberland, where, they write, "there have been falls of rain of tropical violence, causing great destruction at the surface, but the sewers were not injured," and from another source (Fulton and Williams on Drainage of Towns) I find that in that town "all the down spouts, yard grids, and street gullies, communicated direct with the sewer pipes."

They further write that, "In India and at all tropical stations, where there are heavy rains, any attempt at proportioning main sewers to area and rain-fall must break down."

Captain Tulloch, in his project for the drainage of the town of Madras, states that it is usual in England to have one and the same system of sewers to carry off both rain-water and sewage. He shows further, that the rain-fall in England is of that continuous kind that admits of apportioning the sewers to the rain-fall; but that at Madras the conditions of rain-fall are totally different, the falls occurring in bursts of great violence, (on one occasion as much as 20.58 inches fell in twenty-four hours,) and consequently that the association of drains for the removal of rain-fall and sewage is impracticable.

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The rain-fall at Bangalore is, however, much less than at Madras, indeed less than that pertaining to some parts of England.

In the Report of the Royal Commissioners upon the sanitary state of the Army in India, the rain-fall at the station, under consideration, is quoted at 25 inches. This is, however, believed to be below the average. The Bangalore Almanac, for the present year, cites it at 35 inches.

According to Mr. Glaisher, the monthly average for all England, from 1841 to 1855, is 24.605 inches. The distribution is shown in the margin, in contrast with the fall at Bangalore as given by Mr. Glaisher, in Vol. II of the Report of the Royal Commissioners on the sanitary state of the Army in India; and at Madras, as recorded by Captain Tulloch. The rain-fall then at Bangalore* is much less than at Madras, is more equable in its distribution, approaching in its conditions to that of England. The greatest average rain-fall recorded for any given month is 5.6 inches against 12.9 at Madras.

It would appear then possible to combine surface drainage with the projected tubular sewers, by admission of the storm-waters through the usual gully-holes, especially if the pipes were increased in size up to 15 inches.

Further, in England, according to Captain Tulloch, 4 inches have been known to fall in twenty-four hours. At Bangalore the maximum during the last six years is 3.30. If rain-falls of 4 inches can be admitted at home into tubular drains, the same provision would appear to be possible at Bangalore.

I do not express a positive opinion upon this subject, which is one of a purely scientific nature, but if the association of the two systems is not impracticable, it may lead to a saving of expense.

Surface drainage, that is removal of storm-waters by some system of drains, is, however, I consider essential to the maintenance of conditions necessary to healthiness of the sick.

23. *Sub-soil drainage.*—I have already noted that sub-soil drainage has no place in the scheme as proposed by Captain Pennycuik, and approved of by Colonel Foord. Indeed I may say that sub-soil drainage has hitherto received no consideration at the hands of Military Engineers in this Presidency, and in no instance

	England.	Bangalore.	Madras.
January ...	1.90	0.1	1.0
February ...	1.493	0.0	0.2
March ...	1.433	0.0	0.5
April ...	1.573	0.0	0.8
May ...	1.90	1.3	2.9
June ...	1.70	3.8	2.2
July ...	2.773	1.6	3.9
August ...	2.50	5.6	3.9
September ...	2.34	5.4	4.5
October ...	3.06	3.2	12.9
November ...	2.433	1.1	11.8
December ...	1.50	2.9	3.5
	24.605	25.0	47.9

* Note.—The greatest fall of rain for any one day of the six years ending 1867, is as follows:—

Year.	Day.	Inches.
1862 ...	26th October.	2.80
1863 ...	8th May.	3.20
1864 ...	29th September.	3.20
1865 ...	29th July.	3.30
1866 ...	25th September.	2.25
1867 ...	15th October.	2.70

has it been, that I am aware of, applied to any Military station. And yet there is on question upon which the Royal Commissioners upon the sanitary state of the Army in India dwell with more emphasis.

Alluding to drainage, as generally applied to Military stations, they write, "It is possible to sub-soil drain any extent of ground in England, and this process is attended not only with increased productiveness, but with improved health. Wherever sub-soil water comes within a certain distance of the surface of the ground, it interferes with healthy vegetation, and generates damp, fogs, and malaria, which have been found to diminish or disappear when the water level has been lowered by drainage—the invariable prevalence of malarial disease at Indian stations indicates a malaria-generating condition of the earth; and one of the first improvements required is to diminish or remove this condition." But in order to do so, there must be the necessary materials and skill for sub-soil drainage, and an outlet for sub-soil water; and again "There is no such thing as sub-soil drainage carried out at any station. The rain-fall no doubt partially runs away by surface drains, but the great bulk of it, amounting to many feet in depth during each rainy season, goes to saturate the sub-soil with water. The conclusion of the rainy season is generally attended with great increase in epidemic diseases, and inasmuch as wet or damp sub-soils are well ascertained causes of this class of maladies even in cold climates, in such a climate as India the neglect of sub-soil drainage within the area of stations is doubtless one great cause of increased sickness and mortality."

I had some few months ago, in my capacity as Garrison Surgeon at Trichinopoly, occasion to submit a memorandum upon sub-soil drainage in relation to the Central Jail now in course of construction at that station.

In that memorandum I advanced arguments in favor of sub-soil drainage of all new stations.

I find in my office the commencement of a draft report upon that memorandum, which my predecessor had contemplated submitting for the consideration of Government. In that draft the Acting Sanitary Commissioner proposed to inform the Government, "that he and the Honorable Mr. Ellis fully concurred in the views I had expressed. It was intended, in fact, to make the memorandum the basis of a reference to Government of the whole question of sub-soil drainage "as one of the essential portions of designs for all new Barracks and Hospitals.

The subject being, which is in my judgment, one of very great importance, and which has obtained the support of the Officers who preceded me in the office of "Sanitary Commissioner," I append to this report the memorandum, alluded to, and extracts from an unfinished report by the late Acting Sanitary Commissioner. The facts and arguments in the memorandum alluded to are, I think, generally applicable to the site of the Race Course Barracks at Bangalore, and justify my pressing upon the attention of Government the advisability of taking the question into consideration, not only in relation to the present report, but as regards all new sites selected for barracks, hospitals, and public institutions generally. Indeed, I would suggest that sub-soil drainage be made the subject of report by a Committee specially convened for the purpose.

This form of drainage is not only held to be necessary to free the sub-soil of any water finding its way into it by percolation, but to aid the oxidation of

organic substances prone to decomposition by ensuring the entrance of air into and through the soil, which is effected by escape being provided for sub-soil water.

It is further advanced by a writer upon the subject in the English Cyclopaedia, that it is essentially necessary when tubular pipe drainage is adopted. The passage is as follows:—

"The impermeable stoneware drains, which it is now the fashion to recommend indiscriminately, are in fact often a source of great mischief unless they are accompanied by a series of permeable sub-soil drains."

The mischief here alluded to is the escape of sewage which, I have elsewhere shown, the present Executive Engineer at Bangalore does not anticipate being able entirely to prevent.

Sub-soil drainage, therefore, (if it be determined to adopt every precaution to free the site of all possible causes of unhealthiness,) is as essential as either of the other requirements, surface and sewage drainage.

To recapitulate—the requirement under the head of drainage that I consider it necessary to advise Government to meet are—

- (1.) Surface drainage, as indicated in the "Suggestions" by the Barrack and Hospital Improvement Commission, for Indian stations either (a) by surface drains, or (b) by admission of storm-waters into the tubular drains.
- (2.) Tubular pipe drainage of liquid refuse or sewage.
- (3.) Sub-soil drainage by permeable or perforated "tile and shoe," or tubular drains.

The pipes necessary to sub-soil drainage can, I apprehend be manufactured on the spot.

24. The utilization of the sewage by irrigation, and the system of water-supply still remain to be considered.

Utilization of sewage.—Evidence in regard to the utilization of sewage in proximity to habitations its relation to public health is very conflicting. The balance is against it unless at considerable distances, not less than a mile.

But the liquid refuse to be removed from the buildings in connection with these barracks will not be entirely of the same nature as sewage at home, inasmuch as that it will contain no solid faecal matters, and liquid faeculence (urine) only of the horses.

But liquid refuse from cook-rooms, bath-rooms, &c., in itself constitutes a diluted form of filth, possessing all the properties of sewage, and, with the admixture of horse urine, may be for all practical purposes treated as sewage, especially as the conditions of climate in this country favor early decomposition of the liquid, rendering it impossible to distribute it to the land, as in England, as fresh sewage.

The distances to which it is proposed to convey the sewage from the extreme points of the boundary of the plateau are to the east 2,100 feet, and to the south 1,150 feet, on the plan the latter distance is stated at 3,000 feet from A, which is 1,850 from the point representing the south-west corner of the area included within the drainage scheme.

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21st April 1868.*

These distances are in yards 700 and 383 respectively; or 0.398 and 0.217 of a mile, being under half a mile in the one case, and less than a quarter in the other.

The more distant spot is destined to receive the liquid refuse from bath-rooms, cook-rooms, &c., while the nearest is to receive the more concentrated, and consequently more objectionable, sewage from the stables.

Both of these sites are out of the line of direction of the prevailing winds, which may be stated as north-east and south-west, and are, therefore, as far as direction is concerned, unobjectionable.

The liquid refuse to be distributed upon the land to the eastward being largely diluted, and containing no faecal sewage, will be more innocuous than that to be disposed of to the southward, and the distance selected is, therefore, possibly sufficient.

To be on the safe side, however, I would advise that it be extended to the half mile from the point marked A on the plan. At present it is I have shown 0.398 of a mile—to complete the half mile it will be necessary to extend the outlet one-tenth of a mile or 176 yards. This extension is the more necessary as the buildings which occupy this extremity of the plateau, the eastern corner, are the hospitals, to which a new pavilion is to be added, and which will extend a short distance to the southward of existing pavilions.

The site selected for the outlet for the liquid refuse to the south, I consider far too near, considering that the sewage, from admixture of the urine of about 800 horses, will be of a highly offensive nature.

Assuming the urine of each horse to amount to one gallon, and the number of horses of the Cavalry and two Field Batteries to be 800, the quantity of urine alone will amount to 800 gallons, or 128.4 cubic feet per diem.

The outlet pipes should, therefore, I advise be extended to at least a mile from the southern angle of the plateau. This will necessitate their being extended rather over three-quarters of a mile, or say 1,320 yards, and will convey the sewage to the land now under irrigation below the bund of the Coramungalum tank.

The Executive Engineer informed me that such extension will add but little to the cost of the project, and that should it be found necessary, still further extension could be made at no very considerable outlay; these distances are the least that should be adopted.

25. Nothing is said in the correspondence regarding the system of irrigation to be followed.

It is presumed that it will be either by surface channels, or total submersion, as usually practised in this country, and under intelligent and organized supervision, so as to ensure a speedy and profitable utilization of the sewage as possible.

The whole system will, in fact, require intelligent supervision by a staff appointed to the purpose. The water traps, manholes, and ventilators, will require regular inspection, the former especially, owing to the rapidity of evaporation in this country, will be apt to get out of order, and to allow escape of sewage gases; and as in the stables the grated openings will occupy the centre of the stalls, great care will be necessary to ensure that the traps act properly.

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I question the wisdom of placing the trapped openings in the centre of the stalls, with the risk of sewage gases escaping beneath the noses of the horses, and think it would be better to floor the stalls with an impervious material, and to lead the urine by surface gutters to the sinks placed at the foot of each stall, in positions (should it be determined to admit storm-waters into the drains) to receive the water falling from the roofs of the stables, or, should separate surface drainage be determined upon, just within the eaves of the buildings.

26. *Water-supply.*—This report must not be dismissed without a reference to the water-supply.

The project proposed of raising the water by steam power from the Ulsoor tank, passing it through a filtering bed and distributing it by pipes, is still under execution, but far from completion. Doubts are also entertained whether the filtration will so far purify the water as to render it fit for domestic use, and other means have been suggested of meeting the requirement of a pure water-supply.

The Honorable Mr. Ellis, the Commission which he represented, and the Committee under General Haines's presidency which assembled to report upon the suggestions of the Sanitary Commission, advocated storage of rain-water falling upon the roofs of the barracks and subsidiary buildings.

The late Governor, Sir W. Denison, also penned a Minute on the subject, in which he advocated the same method of provision not in supersession of, but supplementary to, the Ulsoor Tank project. He showed in that Minute that the area of each barrack block was above 24,225 superficial feet, that assuming the rain-fall at 2 feet, an amount of water could be annually stored equal to 48,450 cubic feet, or to 8½ gallons per head per man per diem, estimating the allotment of each barrack block at 90 men.

There are eight of these blocks, the collection for which would equal 3,022,173, gallons per annum, 8,280 per diem, or at the rate of, say, 8½ gallons per man per diem for 1,000 men.

I have elsewhere shown that the average rain fall at Bangalore is, by the local Almanac, given at 35 inches, which is believed to be nearer the mark than the 25 given by the Royal Commissioners upon the sanitary state of the Army in India; but accepting it at 30 inches, and allowing that half of this runs to waste, and that 15 inches only could be reasonably expected to be stored, we obtain, as the collection for the eight barracks alone, (without taking into consideration the numerous subsidiary buildings which have at least an equal area,) 4.132 gallons per head per man for a strength of 1,000 men, for $\frac{24,225 \times 8 \times 1.25 \times 6.23}{365} = 4132$ and $\frac{1111}{1} = 4.132$.

If efficient means then be taken to store all water falling upon roofs of buildings, in properly constructed under-ground tanks with filtering beds, (as pictured for instance at page 15 of the Suggestions of the Barrack and Hospital Improvement Commissions for Indian Stations,) a pure supply, far better fitted for domestic use than the water from the Ulsoor tank, will be obtained.

It is in fact surprising, especially as the scheme was advocated by Sir W. Denison, himself an Engineer, that steps have not before this been taken to adopt it. Commencement was, I believe, made, excavations existing which were destined to become storage tanks, but which it is now proposed to fill up again.

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I strongly advocate Sir W. Denison's views being acted upon by the Government. All the barracks, I believe, are now furnished with pipes to convey roof water to the ground into which it now sinks, to the risk of that dryness of the sub-soil surrounding buildings, which is so essential to health.

How much better, and more economical in the end, to convey it to reservoirs for use for domestic purposes, retaining the Ulsoor tank water for baths, lavatories, and all purposes for which pure water is not essential.

The cost, it is apprehended, would be small compared with the results, entailing only the provision of iron pipes and the necessary reservoirs.

Should the scheme be entertained, it will be necessary to make provision to allow the first portion of water falling upon the roofs to run to waste, such portions being more or less contaminated and unfit for use.

In conclusion, I may summarize the recommendations that it is my privilege to offer for the consideration of Government as follows:—

(1.) That all rain falling upon the roofs of buildings be collected by eaves gutters, and stored in properly constructed reservoirs for domestic use, that is for drinking and cooking.

(2.) That the water-supply to be brought from the Ulsoor tank be used only for baths, lavatories, and such like purposes.

(3.) That the immediate surface surrounding barracks and hospitals, be paved with closely-jointed non-absorbent paving stones, with a gentle slope to surface drains.

(4.) That natural drainage be improved, by all inequalities and irregularities in the ground being levelled, and by—

(a.) Either the provision of a suitable system of shallow V or saucer-shaped stone in cement drains, or

(b.) By admission of storm-waters into the tubular drains through properly constructed gully-openings, due provision being made for escape of any unusual rain-fall by "overflow" communications with natural water-courses.

(5.) That the proposed tubular system of sewage drains be adopted.

(6.) That "sub-soil" drainage be applied if not to the whole area, at least along the lines of the tubular sewage drains, so as to ensure the removal of all sewage that may find its way into the soil, either by leakage through the joints of the pipes or by accidental fracture of any pipe.

(7.) That the out-fall pipes to convey the sewage for utilization upon land be extended to the eastward, to a distance of half a mile from the eastern angle of the plateau; and to the south, to the distance of one mile.

Transferred, with Nos. 896 and 1,285, to the Department Public Works.

FORT ST. GEORGE,
20th March 1868.

(Signed) C. S. ELLIOT, Major,
Offg. Dy. Secretary to Government.

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21st April 1868.*

No. 337.

ORDER THEREON, 21st April 1868, No. 1,201.

MILITARY WORKS, No. 37.

1. With the first of the letters above recorded the Superintending Engineer of the 5th Division submits a plan and estimate for the drainage of the Race Course Barracks at Bangalore by means of drains formed of glazed stoneware pipes to carry off liquid refuse of all kinds from the hospitals, baths, wash-houses, cook-rooms, family-quarters, and stables, and discharge it in two directions at points 700 yards to the east and 383 yards to the south of the plateau respectively.

2. It is proposed to connect the drains by branches with each building, and to provide them with grated and trapped openings, ventilating shafts, and manholes. The drains will not however carry off the refuse from the privies and urinals (as these are to be conserved on the dry-earth system) nor are they intended to admit of the discharge of storm-water, as the natural surface drainage of the site is so good as to render any interference with it unnecessary.

3. The use of glazed stoneware pipes, varying from 3 to 9 inches in diameter, is preferred on the grounds that it is impossible to manufacture bricks at Bangalore capable of resisting the action of sewage, and that pipes can be more quickly and easily laid, will require a smaller amount of excavation and admit of a better discharge of the sewage than masonry drains.

4. The cost of the works is estimated at Rupees 85,000, of which Rupees 44,000 represent the value of pipes, &c., to be obtained from England.

5. The Superintending Engineer's report, together with the plans and estimates, having been referred, through the Military Department, to the Commander-in-Chief and the Sanitary Commissioner, His Excellency has given it as his opinion that the scheme will meet the object contemplated. The Sanitary Commissioner, however, though not objecting to the plan, considers that it does not go far enough. He approves of the tubular pipe drainage which, he states, is in general conformity with the principles laid down by the Barrack and Hospital Committee, but points out certain measures which, in his opinion, should be taken for flushing the drains, extending the out-fall pipes, and, improving their ventilating shafts, and strongly urges the necessity for adding a carefully devised system of surface and sub-soil drainage. Dr. Ranking also submits remarks on the utilization of sewage and the system of water-supply at Bangalore.

6. The Sanitary Commissioner's suggestions may thus be briefly summarized.

(1.) The provision of special means for flushing the drains.

(2.) The extension of the out-fall pipes.

(3.) The construction of ventilating shafts with manholes, and provision of charcoal filters.

(4.) The paving of the surface surrounding the barracks and hospitals with non-absorbent stone, and improving the natural surface drainage.

(5.) The application of sub-soil drainage either to the whole area of the plateau, or along the lines of sewage drains.

(6.) The construction of reservoirs for storing rain falling upon the roofs, for drinking and cooking purposes.

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7. On a careful consideration of the whole subject the Government are of opinion that the drainage of the buildings should be dealt with separately, and they approve of the adoption of the scheme recommended by the Superintending Engineer, but before addressing the Government of India upon the subject, Colonel Foord will be requested to submit a revised estimate providing for a better flushing of the drains, improved ventilation of the shafts, and an extension of the out-falls.

8. With reference to surface and sub-soil drainage the Government consider that the former may for the present be left to nature, and that the latter, which is scarcely requisite on the plateau, may be deferred.

9. The subject of the storage of rain-water falling upon the roofs of the barracks and subsidiary buildings on the Race Course at Bangalore, will be considered on the return from Europe of Captain Tulloch who has been specially instructed to study that method of water storage on his passage through Malta.

(True Extract.)

Colonel, R. E.,
Secretary to Government.

To the Superintending Engineer, 5th Division,
with one Plan, one Estimate, one Specification, and list of articles.
.. Military Department.
.. Sanitary Commissioner.

Erd. S. T. Augustin.

No. 232

OFFICE OF SANITARY COMMISSIONER,
MADRAS, 13th June 1868.

From,

The Sanitary Commissioner, Madras,

To,

The Secretary to Government,
Military Department,
Fort St. George.

SIR,

Enclosures Two.

1. Memorandum upon the question of sub-soil drainage of the site selected for the new Central Jail at Trichinopoly.

1. Extract from an unfinished letter to the address of the Chief Secy. to Govt. by the late U. S. Sanitary Commr. for Madras.

With reference to the orders of Government in the Military Department of the 20th ultimo directing me to report upon the scheme of drainage proposed for the Race Course Barracks at Bangalore, as submitted by the Superintending Engineer of the 5th Division, in his letter No. 224 of 11th idem, I have the honor to state for the information of Government that I proceeded on the 27th to that station in view to making myself fully acquainted with the details of the scheme, and to examine the locality in relation to the important question of utilization of the sewage in irrigation of lands in proximity to the Barracks as proposed in para 5 of Colonel Foord's letter.

2. The enclosures alluded to in the letter under reference did not accompany it, but I obtained from the office of the Executive Engineer at Bangalore copies of the

1 Plan
1 Estimate
1 Specification
1 Letter from Executive Engineer
1 Indent

plan and of Captain Pennycook's letter and am indebted to Captain Meade for patient and careful exposition of the whole scheme.

I have also made myself acquainted with the views of my predecessor, the Honorable Mr. Ellis (and of those of the Commission which he represented) upon the subject, as expressed in his Report upon the station of Bangalore submitted to Government in 1865.

3. The proposed drainage scheme I note applies only to "liquid refuse of all kinds from the Hospitals, baths, wash houses, cook-rooms, family quarters and stables"; that provision for surface drainage is intentionally omitted, as it is considered that "the natural drainage of the site is about as perfect as it can well be, and any attempt to interfere with it artificially would be both costly and injudicious"; while subsoil drainage is not so much as even alluded to.

4. The liquid refuse it is proposed to remove by a series of glazed stone ware (impervious) pipes ranging from 3 to 9 inches in diameter; to two outfalls one lying to the east and the other to the south of the plateau occupied by the troops.

All buildings from which liquid refuse

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refuse of any kind is to be conveyed, will be put in communication with the sub drains by 3 inch pipes with grated and trapped openings.

The drainage pipes will be provided at intervals with man-holes for inspection and with ventilators for escape of sewage gases.

No mention is made of any special provision for flushing; but that necessary operation, the present Executive Engineer informs me, is to be performed by turning on the water from the different taps for given periods each day.

Neither is any allusion made to the provision of charcoal filters, in connection with the ventilators, for deodorization of sewage gases, though Captain Meade is under the impression that they are to be adopted.

5. It is not intended to admit any matters from Privies and Urinals (which it is assumed will be conserved upon the dry earth system) into the tubular drains.

The liquid refuse will however possess the properties of "sewage" for although solid and fluid human excreta are to be excluded, the urine

of some (800?) horses is to be admitted, into that section of the drains which is to be led to an outfall to the south of the plateau.

The points for consideration in a sanitary point of view are as follows.

1st. Is the proposed system of drainage by glazed stone-ware pipes superior to that hitherto adopted in India (and of which alone we have any experience) of open brick in Chumam or stone-in-cement V or saucer shaped drains?

2nd. Will it be safe to leave surface drainage entirely out of the question?

3rd. May not sub soil drainage also be necessary?

4th. Is there any sanitary objection to the utilization of the liquid refuse (sewage) in irrigation of the tracts of lands indicated by the Engineer?

7. The Government have, I believe, no experience of pipe drainage in this Presidency and I am not aware that it has been introduced into any station

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in India. No precedent can therefore be quoted for or against the system.

Under these circumstances I can only turn to the recorded opinions of the eminent men who compiled the "suggestions in regard to sanitary works required for improving Indian stations" prepared by the Barracks and Hospital Improvement Commission: (Blue Book dated 1864.)

8. Before however proceeding to give the opinion of that Commission upon the special question of tubular pipe drainage, I purpose to submit the conclusions they arrived at in regard to the whole question of drainage (in its association with water supply) of Indian stations.

After stating that the object of the "suggestions" is to "embody in a practical form those points of home experience in sanitary works and measures which appear to be more or less applicable to conditions" pertaining to India and "which (works and measures) it is hoped with the required modifications may be useful in India and in tropical stations generally" the Commission enunciate

that the essential requirements of all stations under the head of drainage include,

1. Surface drainage and paving.
2. Sewage and drainage including subsoil drainage.

9. Under the head of surface drainage they insist upon the following points:-

Surface drainage.

A. That all rain water from roofs should be collected by eaves gutters and either (1) be stored (after filtration) for use, or (2.) passed directly into the drains of the stations.

B. That the immediate surface surrounding buildings should be flagged or paved with closely jointed non-absorbent paving stones with a sufficient slope to the surface channel to conduct water away from the foundations of buildings by carefully laid surface drains.

C. That open trenches dug in the ground though an excellent means of drainage for temporary camps are not adapted for surface drainage.

14 12
drainage of permanent stations. xx - wherever open surface drains are required they should be formed of impervious material.

10.

In regard to sub-soil drainage the following opinions are advanced by the same Commission.

Sub-soil drainage.

(a) That sub-soil drainage is necessary as a means of prevention of miasmatic diseases which are especially attributable to retention of moisture in the sub-soil. That the universal prevalence of malarial disease at Indian stations indicates a malaria-generating condition of the earth; that one of the first improvements required is to diminish or remove this condition, and that in order to do so, there must be necessary materials and skill for sub-soil drainage, and an outlet for sub-soil water; that drainage sanitary works aim at providing a dry and wholesome sub-soil, a clean surface, and a pure atmosphere.

These

11. The Commission consider that the system of tubular pipe drainage is applicable to India and that for all purposes of drainage glazed earthen-ware pipe drains of 9 or 12 inches diameter will be found sufficient for 1000 men.

These opinions are thus summarised by the Commission at page 7.

The leading principles to be kept in view are,

1. To provide by carefully formed surface drains for the removal of all the rain fall except what sinks into the ground.
2. To provide for the rapid removal of this sub soil water by land or sub soil drainage.
3. To drain away the refuse fluids of all houses &c by closed sewers and drains.

12. Such are some of the expressed opinions of the Barrack and Hospital Improvement Commission in relation to sanitary drainage in India; opinions which I have given almost, and in many instances, entirely, in their own

13. words and which I am desirous to give prominence to, as they have not yet obtained that consideration and attention at the hands of Engineers in this country that they so eminently deserve and demand; for surface drainage is still very indifferently provided for at any station, while subsoil drainage has hitherto received no consideration whatever.

I purpose considering each of these requirements more fully, in relation to the drainage and water supply of the area upon which the Race Course Barracks at Bangalore stand; and first (as the subject more especially referred to me for report,) the proposed scheme of "tubular pipe drainage."

Colonel Foord states in his letter that glazed stone ware pipes Tubular pipe drainage. are now invariably used in place of sewers of brick work and gives in detail the advantages of the former over the latter system.

I have already remarked that the Barrack and Hospital Improvement Commission are favorable to this

this system of drainage.

Their views are thus expressed.

A. That earthenware pipes make the best drains up to their sectional capacity, say 15 inches.

B. Half socket pipes laid with the half socket down make the best drain, as any pipe can be removed without breaking a pipe.

C. Common circular vitreous earthenware pipes with ordinary junctions are the best.

D. Drain pipe joints may be made with well tempered clay in sound ground; but should be made with cement or with hydraulic mortar in open or sandy ground. the joints should be so tight that no sewage can escape from the drain into the subsoil. Manholes as for sewers should be provided in all drains with means of flushing and ventilation.

E. Earthenware pipes of 1 1/2 inches in diameter are sufficient for water closets

16 4
closets & sinks; these may join drains of 6 inches, the six joining nine inches, 12 inches and 15 inches and these forming a tributary main or passing to a main sewer.

114. Such are some of the leading principles of drainage and construction of drains and sewers inculcated by the Commission so often alluded to.

Their suggestions are illustrated by plans and drawings.

It may be said that Captain Pennycook's plan is in general conformity with the principles advocated above. In some few, and possibly not very important points, it differs from that suggested by the Barrack and Hospital Improvement Commission.

The points are,

1st Size of pipes

2nd Position of manholes and ventilators.

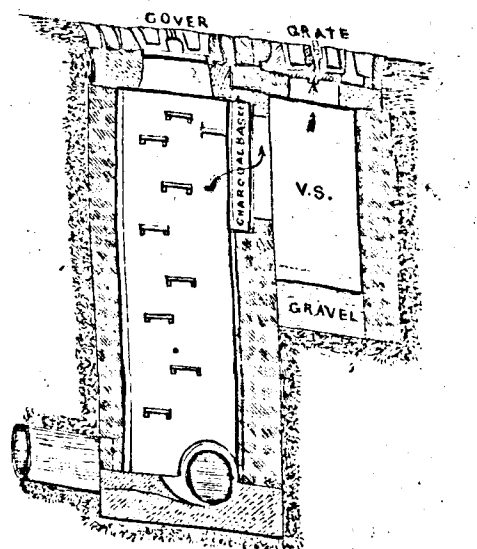
Captain Pennycook proposes to use 3 inch passing into 6 and 9 inch pipes.

The Commission recommend 4 inch leading into 6-9-12 and even up to 15 if required. Whether

Whether it will be advisable to increase the calibre of the pipes to that extent is a purely scientific question to be left to the Engineer department with reference to the quantity of sewage to be admitted into the drains (and of which calculation has doubtless been made though it does not appear in the letter under reference) the gradients of the line and other circumstances of locality.

15. In Captain Pennycook's scheme the manholes and ventilators are at different, (alternating), points. The Barrack and Hospital

Improvement Commission recommend a combination of the two and give a drawing of the same which is reproduced in the margin. Captain



MANHOLE AND VENTILATING SHAFT

Pennycook has not yet prepared drawing of the manholes and ventilators that he proposes to adopt.

It

17. 15
It will probably be found more convenient economical and advantageous on sanitary grounds to combine the two and to introduce the charcoal screen as shown in the drawing.

Some gases will doubtless rise at all the higher points of the line of drainage, and some means to deodorize them will be necessary.

It is true that the ventilating shafts open in every case as shown in the plan at a distance from any building, still the addition of charcoal filters will be safe and advisable.

16. In regard to "flushing" the drains, I would remark that it is questionable whether the mere turning on of the taps in the wash houses will suffice. The operation of flushing is better effected by the sudden admission of a comparatively small volume of water than by the continuous flow of a larger quantity. At home special provision is made at the manholes both in brick and tubular sewers by a plank or shutter by which the
sewers

sewers can be flushed out in sections either by ponding up the sewage itself and allowing its sudden escape into the next section, or by admission of water from reservoirs in connection with each manhole.

17. I purposely avoid touching further upon questions which do not involve sanitary considerations; and therefore do not comment upon the purely engineering aspect of the scheme; but accept the facts and arguments adduced in support of the necessity which is said to exist for giving two outfalls to the drains instead of one, which had it been practicable, would have been advisable on sanitary grounds.

18. The question of open masonry drains versus closed conduits must however be considered.

On referring to the opinion of my predecessor the Honorable Mr. Ellis and of the Commission of which he was President at the time of submission of the report upon the station of Bangalore in 1865, I find that preference was given to open V shaped drains over closed

closed conduits.

18 18
Mr. Ellis writes "without proper drainage these Barracks will become exceedingly foul and no time should be lost in preparing a complete scheme for efficient drainage. open drains recommended. In a climate like Bangalore where light rain is of frequent occurrence the open drains would if properly constructed remain without smell and they could be easily flushed when rain does not fall. Under-ground drainage is so liable to get choked up and then to prove at once a source of nuisance and expense for repairs, that in the opinion of this Commission a system of open drains similar to those so frequently seen at Bangalore should be adopted."

The Committee assembled under orders of His Excellency the Commander-in-Chief on the 19th May 1865, of which General Haines was President, to take into consideration the recommendations of the President of the Sanitary Commission recorded their opinion upon the subject as follows:

The

"The special attention of Government is requested to the immediate preparation of a working plan of drainage, and (as recommended by the Sanitary Commission in paragraph 91 to 94 of their Report) a thorough system of drainage is required - water falling on the open spaces between, and the roofs of the Barracks and subsidiary buildings should be conducted by pipes into open V-shaped Granite channels to terminate in a masonry conduit, whereby rain water and foul water, from Cookrooms, Lavatories and private dwellings could be carried off to a distance to Leeward of the Race Course, there to be utilized, as in England, in the cultivation of meadow lands."

"The drainage from the Hospital should be complete in itself, and at its origin independent of the general surface drainage."

"As the foundations of the Barracks are very low, it is also desirable that to ensure their dryness after rain, a pathway four to five feet in width, flagged with granite should pass round each Barrack and block of family buildings ~~yes~~, on the road side of this the V shaped channel

17
channel to receive rain water from the roof of the Barracks and rain fall on the road should be constructed."

This Committee therefore gave a preference to open surface drains (though it does not appear that any well considered scheme of tubular or pipe drainage was before them) and at the same time desired to give effect to the recommendations of the Barrack and Hospital Improvement Commission, by the institution of flagged pavements and V shaped drains round all barrack buildings. -

In this view the officiating President of the Sanitary Commission the late Dr. Macpherson in his letter of the 19th May 1865 concurred. but subsequently in letter No. 237 of 8th July 1865 that Officer modified his opinion for in para 2 of that letter he writes "We recommend that all rain water not conserved for domestic purposes and waste water from buildings should pass from the surface through grated openings into well glazed stone ware branch pipes laid on to a main conduit by which water should be conveyed to a distance from the barracks."

The 25

19. The advantages generally held to pertain to open V or saucer shaped drains are the capability of constant inspection and the impossibility except by great negligence of any fouling of the drains.

The objection to them is the difficulty which has hitherto been experienced of making them impervious. As usually constructed of Brick and Chumam they are speedily destroyed by the action of sewage waters, percolation into and fouling of the subsoil, sooner or later going on. Even stone drains are open to the same objection, the cement generally used not being capable of resisting the corroding action of sewage. Possibly asphalt would be found to resist this action and to make water tight joints.

But independent of this difficulty, the present Executive Engineer, Captain Meade, informed me that there would be almost insuperable difficulties in the way of constructing open drains to drain to only two outfalls; that it is not possible to 'contour' the plateau upon

upon which the barracks stand so as to avoid deep cuttings; that in fact the drains could not be kept as surface drains, but would have at many points to be placed at considerable depths and as a means of safety to be covered over.

20. Colonel Ford has given his unqualified opinion in favor of the tubular tile over the masonry drains, mainly on the ground of the difficulty, nay impossibility, of procuring materials (bricks or cement) capable of resisting the action of sewage, and seeing that these engineering difficulties are said to stand in the way, of a system of open V or saucer shaped drains on the score both of the 'fall' of the ground, and of want of a reliable cement, I am justified in recommending the adoption of the impervious tubular pipe drain.

Not that I consider all risk of sewage percolation removed thereby, for there is still a risk. The joints require to be water tight, and to this end a cement capable of resisting sewage action is equally required. and this Captain Meade does not hold out any promise of procuring indeed

indeed he admits that some escape of sewage will most likely take place at the joints, to which however he does not attach much importance on the ground that the water to be used by the troops, is to be brought from a distance, and not to be derived from wells on the spot. But as wells do exist and are now used; and moreover as it has been proposed to collect and store waters falling upon the roofs of the buildings in underground reservoirs (to which subject I shall presently revert) the fact of the liability of leakage must not be lost sight of, and special provision must be made for speedily draining to an outlet, any sewage which may find access to the subsoil.

This subject will receive further consideration under the head of subsoil drainage.

21. Surface drainage has been pronounced by the Engineer officer unnecessary. To this opinion I must take most emphatic exception for however favorable the configuration of the surface or of any surface may be

31 15
be to escape of storm waters, a large portion of the rain fall must and does find access by percolation to the subsoil.

From information I have acquired and from observation of the locality I am further in a position to say that water lodges after rain in places, and is dissipated only by evaporation and subsidence into the soil, and that it does not run off so readily as to remove all risk of subsoil dampness. Moreover the soil itself is a ferruginous loam of absorbent character.

The opinion of the Barrack and Hospital Improvement Commission upon this subject I have already alluded to. I have shown that they insist upon properly constructed drains in addition to a surface from which water readily runs off. all their recommendations are in view to preventing water finding its way into the subsoil and to this end they advise that

1. All rain water from roofs should be collected and if not stored, be run off at once into the drains.

That

2. That the surface surrounding all Barrack buildings should be flagged with closely jointed, not absorbent, paving stones, with sufficient slopes to the surface channel to conduct water away by carefully laid surface drains.

The "Commission appointed to enquire into the sanitary state of the Army in India" are also very strong upon the subject of drainage. They write (alluding to stations in which some provision is made for surface drainage) the rain fall no doubt partially runs away by the surface drains but the great bulk of it xxx goes to saturate the subsoil with water.

The more efficient than the surface drainage is made, the less the risk of subsoil dampness, which there is abundant evidence to prove is one of, if not the, most important factor in the causation of miasmatic diseases. The "Royal Commissioners" must be again quoted upon this subject. they write "inasmuch as wet or damp subsoils are well ascertained causes of this class of maladies even in cold climates,

climates, in such a climate as India the neglect of subsoil drainage within the area of stations is doubtless one great cause of increased sickness and mortality."

This quotation it is true applies to subsoil drainage but that is intimately associated with surface drainage. The more efficiently the latter is provided for, the less will be the necessity for the former.

Notwithstanding then the opinion expressed by Captain Pennycook in the 16th para of his letter and the support given thereto by Colonel Ford, I consider it my duty strongly to urge upon the Government the necessity for a carefully devised system of surface drainage upon the comprehensive plan suggested by the Barrack and Hospital Improvement Commission, suggestions which obtained generally the approval of the Honorable Mr. Ellis and of the Special Committee of which General Haines was President.

The surface drains I would advocate are shallow V or saucer shaped drains made to receive all storm waters not stored for use, and which should

should be made to follow the contours of the ground to as many outlets as may be considered necessary, with the sole object of rapidly carrying off all rain fall not otherwise utilized, and not designed to admit liquid refuse from Cookrooms &c. per.

22. Is it possible to combine, surface with the proposed tubular pipe drainage?

Will it, that is, be possible (having due consideration for the rain fall at Bangalore) to admit the storm waters into the drains designed for liquid refuse?

In England provision is made for admission of storm waters into sewers and drains. At page 5 of the suggestions of the Commission so often alluded to, the following passage occurs. "Duplicate systems of sewers are not required, that is, sewers for storm flood waters and sewers for sewage. As previously stated surface contours and natural valley lines may be improved and main sewers may have overflow communications with such valley lines and natural courses, so as to relieve the



the sewers at all available points during heavy rains. At such times any sewage will be in extreme dilution and the whole district will be in flood so that any sewage will be washed away without causing injury."

Again at page 8 under the head 'gullies' they write "All sewers and drains should have gullies and other inlet communications with the surface and subsoil and other waters" and in plan IV they depict these 'gullies' as applied to the system of pipe drainage now under consideration.

In a foot note at page 6 they also illustrate the subject of pipe drainage by reference to the town of Alnwick in Northumberland where they write, "there have been falls of rain of tropical violence, causing great destruction at the surface but the sewers were not injured" and from another source (Tilton and Williams on drainage of Towns) I find that in that town "all the down spouts, yard grids, and street gullies, communicated direct with the sewer pipes." They

They further write that "In India and at all tropical stations, where there are heavy rains, any attempt at proportioning main sewers to area and rain fall must break down."

Captain Tulloch in his project for the drainage of the town of Madras states that it is usual in England to have one and the same system of sewers to carry off both rain water and sewage. He shows further that the rain fall in England is of that continuous kind that admits of apportioning the sewers to the rain fall; but that at Madras the conditions of rain fall are totally different. the falls occurring in bursts of great violence (on one occasion as much as 20.8 inches in 2 1/2 hours) and consequently that the association of drains for the removal of rain fall and sewage is impracticable.

The rain fall at Bangalore is however much less than at Madras, indeed less than that pertaining to some parts of England.

In

In the report of the Royal Commissioners upon the sanitary state of the Army in India the rain fall at the station under consideration is quoted at 25 inches. This is however believed to be below the average. The Bangalore Almanac for the present year cites it at 35 inches.

According to Mr. Glaisher the monthly average for all England from 1841 to 1855 is 24.605 inches. The distribution

	England	Bangalore	Madras
January	1.90	0.1	1.0
February	1.493	0.0	0.2
March	1.433	0.0	0.5
April	1.573	0.9	0.8
May	1.90	1.3	2.9
June	1.70	3.8	2.2
July	2.773	1.6	3.9
August	2.50	5.6	3.9
September	2.34	5.4	4.5
October	3.06	3.2	12.9
November	2.433	1.1	11.8
December	1.50	2.9	3.5
	24.605	25.0	47.9

is shown in the margin, in contrast with the fall at Bangalore as given by Mr. Glaisher in Volume 2 of the Report

of the Royal Commissioners on the sanitary state of the Army in India; and at Madras, as recorded by Captain Tulloch.

The rain fall then at Bangalore* is much less than at Madras, is more equable in its distribution approaching in its conditions to that of England. The greatest average rain fall recorded for any given

*Note. The greatest fall of rain for any one day of the 67 years ending 1867 is as follows:-

Year	Day	Inches
1862	26 Oct.	2.89
1863	8 May	3.20
1864	29 Sept.	3.20
1865	29 July	3.30
1866	25 Sept.	2.25
1867	15 Oct.	2.70

Further, in England according

given month is 5.6 inches against 12.9 at Madras.

It would appear then possible to combine surface drainage with the projected tubular sewers by admission of the storm waters through the usual gully holes - especially if the pipes were increased in size up to 15 inches.

I do not express a positive opinion upon this subject which is one of a purely scientific nature, but if the association of the two systems is not impracticable it may lead to a saving of expense.

Surface drainage, that is removal of storm waters by some system of drains, is however I consider essential to the maintenance of conditions necessary to healthiness of the sick.

23. I have already noted that subsoil drainage has no place in the scheme

Subsoil drainage. as proposed by Captain Pennycook and approved of by Colonel Ford. Indeed I may say that subsoil drainage, has hitherto received no consideration at the hands of Military Engineers in this Presidency and in no instance has been

that

according to Captain Tulla 4 inches have been known to fall in 24 hours - At Bangalore the maximum during the last 6 years is 3.36. If rainfalls of four inches can be admitted at home into tubular drains the same provision would appear to be possible at Bangalore.

that I am aware of, applied to any military station. And yet there is no question upon which the Royal Commissioners upon the sanitary state of the Army in India dwell with more emphasis.

Alluding to drainage as generally applied to military stations they write "it is possible to subsoil drain any extent of ground in England and this process is attended not only with increased productiveness but with improved health. Wherever subsoil water comes within a certain distance of the surface of the ground, it interferes with healthy vegetation and generates damp, fogs, and malaria, which have been found to diminish or disappear when the water level has been lowered by drainage. the invariable prevalence of malarial disease at Indian stations indicates a malaria generating condition of the earth; and one of the first improvements required is to diminish or remove this condition." But in order to do so, there must be the necessary materials and skill for subsoil drainage and an outlet for subsoil water

water," and again - "there is no such thing as subsoil drainage carried out at any station - The rain fall no doubt partially runs away by surface drains but the great bulk of it amounting to many feet in depth during each rainy season goes to saturate the subsoil with water. The conclusion of the rainy season is generally attended with great increase in Epidemic diseases and inasmuch as wet or damp subsoils are well ascertained causes of this class of maladies even in cold climates in such a climate as India, the neglect of subsoil drainage within the area of stations is doubtless one great cause of increased sickness and mortality." -

I had some few months ago, in my capacity as Garrison Surgeon at Trinopolis, occasion to submit a memorandum upon subsoil drainage in relation to the Central Jail now in course of construction at that station.

In that memorandum I advanced arguments in favor of subsoil drainage of all new stations.

26
I find in my office the commencement of a draft report upon that memorandum which my predecessor had contemplated submitting for the consideration of Government. In that draft the Acting Sanitary Commissioner proposed to inform the Government "that he and the Honorable Mr. Ellis fully concurred in the views I had expressed." It was intended in fact to make the memorandum the basis of a reference to Government of the whole question of subsoil drainage "as one of the essential portions of designs for all new Barracks and Hospitals."

The subject being one which is in my judgment one of very great importance and which has obtained the support of the Officers who preceded me in the office of "Sanitary Commissioner", I append to this report the memorandum alluded to and extracts from an unfinished report by the late Acting Sanitary Commissioner. The facts and arguments in the memorandum alluded to are, I think, generally applicable to the

the site of the Race Course Barracks at Bangalore and justify my pressing upon the attention of Government the advisability of taking the question into consideration not only in relation to the present report, but as regards all new sites selected for Barracks Hospitals and Public institutions generally. Indeed I would suggest that subsoil drainage be made the subject of report by a Committee specially convened for the purpose.

This form of drainage is not only held to be necessary to free the subsoil of any water finding its way into it by percolation but to aid the oxidation of organic substances prone to decomposition by ensuring the entrance of air into and through the soil which is effected by escape being provided for subsoil water.

It is further advanced by a writer upon the subject in the English Cyclopaedia that it is essentially necessary when tubular pipe drainage is

is adopted - the passage is as follows.

"The impermeable stone ware drains which it is now the fashion to recommend indiscriminately are in fact often a source of great mischief unless they are accompanied by a series of permeable subsoil drains." -

The mischief here alluded to is the escape of sewage which, I have elsewhere shown, the present Executive Engineer at Bangalore, does not anticipate being able entirely to prevent.

Subsoil drainage therefore (if it be determined to adopt every precaution to free the site of all possible causes of unhealthiness) is as essential as either of the other requirements, surface and sewage drainage.

To recapitulate - the requirements under the head of drainage that I consider it necessary to advise Government to meet are,

1. Surface drainage as indicated in the "suggestions" by the Barrack and Hospital Improvement Commission; for Indian stations either

either (a) by surface drains or (b) by admission of storm waters into the tubular drains.

2nd. Tubular pipe drainage of liquid refuse or sewage.

3rd. Subsoil drainage by permeable, or perforated "tile and shoe" or tubular drains.

The pipes necessary to subsoil drainage can I apprehend be manufactured on the spot.

24. The utilization of the sewage by irrigation, and the system of water supply still remain to be considered.

Evidence in regard to the utilization of sewage in proximity to habitations in its relation to public health is very conflicting. The balance is against it unless at considerable distances - not less than a mile.

But the liquid refuse to be removed from the buildings in connection with these Barracks will not be entirely of the same nature as sewage at home, inasmuch as that it will

285
contain no solid faecal matters and liquid feculence (urine) only of the horses.

But liquid refuse from Cookrooms bath rooms &c in itself constitutes a diluted form of filth possessing all the properties of sewage, and with the admixture of horse urine may be for all practical purposes treated as sewage, especially as the conditions of climate in this country favor early decomposition of the liquid rendering it impossible to distribute it to the land as in England as fresh sewage.

The distances to which it is proposed to convey the sewage from the extreme points of the boundary of the plateau are to the East 2,100 feet and to the South 1,150 feet on the plan the latter distance is stated at 3,000 feet from A which is 1,850 from the point representing the South West corner of the area included within the drainage scheme.

These distances are in yards 700 and 383 respectively, or 0.398 and 0.217 of a mile being, under half a mile in the one case, and less than $\frac{1}{4}$ in the other.

The

The more distant spot is destined to receive the liquid refuse from Bath rooms, Cookrooms &c. while the nearest is to receive the more concentrated and consequently more objectionable sewage from the stables.

Both of these sites are out of the line of direction of the prevailing winds which may be stated as N.E. and S.W. and are therefore, as far as direction is concerned, unobjectionable.

The liquid refuse to be distributed upon the land to the Eastward being largely diluted and containing no faecal sewage will be more innocuous than that to be disposed of to the Southward, and the distance selected is therefore possibly sufficient.

To be on the safe side however I would advise that it be extended to the half mile from the point marked A on the plan. At present it is I have shown 0.398 of a mile - to complete the half mile it will be necessary to extend the outlet $\frac{1}{10}$ of a mile or 176 yards. This extension is the more necessary as the buildings which occupy this extremity of the plateau, the eastern corner, are the Hospitals,



Hospitals to which a new pavilion is to be added, and which will extend a short distance to the southward of existing pavilions.

The site selected for the outlet for the liquid refuse to the south, I consider far too near, considering that the sewage from admixture of the urine of about 800 horses will be of a highly offensive nature.

Assuming the urine of each horse to amount to one gallon and the number of horses of the Cavalry and 2 Field Batteries to be 800 the quantity of urine alone will amount to 800 gallons or 128.1 cubic feet per diem.

The outlet pipes should therefore I advise be extended to at least a mile from the southern angle of the plateau - This will necessitate their being extended rather over three quarters of a mile or say 1,320 yards, and will convey the sewage to the land now under irrigation below the bund of the Coramungalam tank.

The Executive Engineer informed me that such extension will add but little to the cost of the project, and that should it be found necessary, still further extension could be made at no very considerable outlay; these distances are the least that

that should be adopted.

25. Nothing is said in the correspondence regarding the system of irrigation to be followed.

It is presumed that it will be either by surface channels, or total submersion as usually practised in this country; and under intelligent and organised supervision so as to ensure a speedy and profitable utilization of the sewage as possible.

The whole system will in fact require intelligent supervision by a staff appointed to the purpose. The water traps, manholes and ventilators will require regular inspection. The former especially, owing to the rapidity of evaporation in this country, will be apt to get out of order and to allow escape of sewage gases; and as in the stables the grated openings will occupy the centre of the stalls, great care will be necessary to ensure that the traps act properly.

I question the wisdom of placing the trapped openings in the centre of the stalls with the risk of sewage gases escaping beneath the noses of the horses, and think it would be better, to floor the stalls with an impervious material and to lead the urine by surface gutters to

20 21
to the sinks placed at the foot of each stall, in positions (should it be determined to admit storm waters into the drains) to receive the water falling from the roofs of the stables, or, should separate surface drainage be determined upon, just within the eaves of the buildings.

26. This report must not be dismissed Water supply without a reference to the water supply.

The project proposed of raising the water by steam power from the Ulsoor tank, passing it through a filtering bed and distributing it by pipes is still under execution but far from completion. Doubts are also entertained whether the filtration will so far purify the water as to render it fit for domestic use and other means have been suggested of meeting the requirement of a pure water supply.

The Honorable Mr. Ellis, the Commissioner which he represented, and the Committee under General Baillie's presidency which assembled to report upon the suggestions of the Sanitary Commission, advocated storage of rain water falling upon the roofs of the Barracks and subsidiary buildings.

The

The late Governor Sir W. Denison also penned a minute on the subject in which he advocated the same method of provision not in supersession of, but supplementary to, the Ulsoor tank project. He showed in that minute that the area of each Barrack block was above 24,225 superficial feet. That assuming the rain fall at 2 feet, an amount of water could be annually stored equal to 48,450 cubic feet or to $9\frac{1}{2}$ gallons per head per man per diem estimating the allotment of each Barrack block at 90 men.

There are 8 of these blocks the collection for which would equal 3,022,173 gallons per annum. 8280 per diem, or at the rate of say $8\frac{1}{2}$ gallons per man per diem for 1000 men.

I have elsewhere shown that the average rain fall at Bangalore is, by the local Almanac, given at 35 inches, which is believed to be near the mark than the 25 given by the Royal Commissioners upon the sanitary state of the Army in India; but accepting it at 30 inches, and allowing that half of this runs to waste, and that 15 inches only could be reasonably expected to be stored, we obtain

as the collection for the 8 Barracks alone (without taking into consideration the numerous subsidiary buildings which have at least an equal area) 4,132 gallons per head per man for a strength of 1000 men, for $\frac{24225 \times 8 \times 125 \times 23 \times 4132}{365}$ and $\frac{4132}{1000} = 4.132$.

If efficient means then be taken to store all water falling upon roofs of buildings, in properly constructed underground tanks with filtering beds, (as pictured for instance at page 15 of the suggestions of the Barrack and Hospital Improvement Commissions for Indian stations;) a pure supply far better fitted for domestic use than the water from the Ulsoor tank will be obtained.

It is in fact surprising, especially as the scheme was advocated by Sir W. Denison himself an Engineer; that steps have not before this been taken to adopt it. Commencement was I believe made, excavations existing which were destined to become storage tanks but which it is now proposed to fill up again!

I strongly advocate Sir W. Denison's views being acted upon by the Government. All the Barracks I believe are now furnished with pipes to convey roof water to the ground into which it now sinks, to the risk

risk of that dryness of the subsoil surrounding buildings, which is so essential to health.

How much better and more economical in the end to convey it to reservoirs for use for domestic purposes retaining the Ulsoor tank water for baths lavatories and all purposes for which pure water is not essential.

The cost it is apprehended would be small compared with the results, entailing only the provision of iron pipes and the necessary reservoirs.

Should the scheme be entertained it will be necessary to make provision to allow the first portion of water falling upon the roofs to run to waste such portions being more or less contaminated and unfit for use.

In conclusion I may summarise the recommendations that it is my privilege to offer for the consideration of Government as follows.

1. That all rain falling upon the roofs of buildings be collected by eaves gutters and stored in properly constructed reservoirs for domestic use, that is for drinking and cooking.
2. That the water supply to be brought

brought from the Ulsoor tank be used only for baths lavatories and such like purposes.

3. That the immediate surface surrounding Barracks and Hospitals, be paved with closely jointed non-absorbent paving stones with a gentle slope to surface drains.

4. That natural drainage be improved by all inequalities and irregularities in the ground being levelled, and by (a) either the provision of a suitable system of shallow V or saucer shaped stone or cement drains or

(b) by admission of storm waters into the tubular drains through properly constructed gully openings, due provision being made for escape of any unusual rain fall by "overflow" communications with natural water courses.

5. That the proposed tubular system of sewage drains be adopted.

6. That "subsoil" drainage be applied if not to the whole area, at least along the lines of the tubular sewage drains so as to ensure the removal of all sewage that may find its way into the soil, either by leakage through the joints

joints of the pipes on by accidental fracture of any pipe.

7. That the outfall pipes to convey the sewage for utilization upon land be extended to the Eastward to a distance of half a mile. from the Eastern angle of the plateau, and to the south, to the distance of one mile.

I have the honor to be.

Sir,

Your most obedient servant

J. I. Hanning

Sanitary Commissioner for Madras.

11 Sep 1868
12 May 1868
124 @ 130
324 325

Fort Saint George,
20th March 1868.

Transferred,
with No 8968/1285,
to the Department
Public Works.

Untd. Secy Major
Off. Dy. Secy. to Govt.

Entd.

A 236

25th March/68 D. 2nd floor.

11/10/68
Military Secy
From, ~~11/10/68~~

The Sanitary Commissioner
for Madras.

To,
The Secretary to Government
Military Department
Fort St. George.

Dated 13th
R. 16 March 1868.
R. 24 March/68.
No 232.

Encls. 3.
No 1201-21st April 1868
Reporting upon the
scheme of drainage
proposed for the Race
Course Barracks at
Bangalore.
Transferred

Memorandum

The accompanying papers on the subject of the drainage of the Barracks on the race course at Bangalore are circulated for the order of Government. 2. On February last the Superintending Eng^r of the 5th Division sub-mitted a plan for the drainage of the race course barracks at Bangalore by means of drains formed of glazed stone ware pipes which would carry off liquid refuse of all kinds from the Hospital, Baths, wash

wash house, Cook
rooms, Family quarters
and stables, and dis-
-charge it in two direc-
-tions at points 700 yards
to the east, and 383 yards
to the south of the plateau
respectively. These drains
would be connected by
branches with each build-
-ing and they would be
duly provided with grated
and trapped openings,
ventilating shafts, and
man. holes. They would
not however carry off
the refuse from the
kitchens and urinals
(as these are to be con-
-served on the dry
earth system), nor are
they intended to admit
of

of the discharge of storm
waters, as the natural
surface drainage of the
site is so good as to
render any interference
with it unnecessary.

The use of glazed
stone ware pipes, vary-
-ing from 3 to 9 inches
in diameter, is preferred
on the grounds that it
is impossible to manu-
-facture bricks at Ban-
galore capable of resist-
-ing the action of sewage,
that pipes can be more
quickly and easily
laid, will require a smaller
amount of excavation,
and admit of a better
discharge of the sewage
than masonry drains.

The cost of the work
as projected by the su-
perintending Engineer

amounts to Rs. 85,000,
of which Rs. 44,000
represent the value
of pipes, &c., to be ob-
tained from England.

The paper having
been refined, through
the Military Department,
to the Commander
in Chief and the
Sanitary Commissioner,
His Excellency has
given it as his opinion
that the scheme will meet
the object contemplated.

The Sanitary Com-
missioner seems not
to object to the plan, but
thinks it does not go
far enough. He approves
of tubular pipe drainage,
which, he states is in
general conformity
with

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with the principles laid
down by the Barrack
and Hospital Improve-
ment Committee, but
points out certain mea-
sures which in his
opinion should be adopted
for flushing the
drains, extending the
outfall pipes, and im-
proving their ventilating
shafts, and he strongly
urges the necessity for
adding a carefully de-
vised system of surface-
and sub soil drainage.
Doctor Rankin also
submits remarks on the
utilization of sewage and
the system of water sup-
ply at Bangalore.
The Sanitary
Commissioner's sug-
gestions may thus be

briefly summarized.

1. The provision of special means for flushing the drains.
2. The extension of the outfall pipes to a greater distance from the plateau.
3. The construction of ventilating shafts with stem holes, and provision of charcoal filters.
4. The paving of the surfaces surrounding the Bazaar and Hospitals with non absorbent stone, and improving the natural surface drainage, either by open V or saucer drains, or by the admission of storm water into the tubular drains.
5. The application of sub soil drainage either to the whole area of the plateau, or along the lines of sewer drains.
6. The construction of reservoirs for storing rain falling upon the roofs for drinking & cooking purposes.

37

The orders of Govt are requested as to whether the scheme proposed by the Supyng. and recommended by His Excellency the Com. Commander in Chief may be approved of with merely such addition as will provide for the better flushing of the drains, the improved ventilation of the shafts, and the extension of their outfalls, or whether the Supyng. should be called upon to revise the plans and estimates to give effect to all the Sanitary Commission's proposals for combining with the removal of liquid sewage a system of

thorough surface and
sub. soil drainage;
and arrangements for
the collection and
storage of roof waters.

(21)

21/4/1901

From 25 April 1898, Ld. 335.

[Handwritten signature]

I would deal with the
the drainage of the buildings
separately. I would sanction
the system of tubular
drains for carrying off
contaminated water with
better provision for flushing
the drains. I would
leave the storm water
drainage for the present
to nature and adjourn
the question of subsoil
drainage which I think
can scarcely be requisite
on the plateau. The construction
of subterranean tanks for
the roof water I would
advise till the return of
Major Bullard who has
special interest in the matter.

I study that no tanks
of water storage within
the range through
Malta. N.P.

Approved
W.D.M.
by A

2.25 March 1898 A. 2nd part

Memorandum upon the question of sub-
soil drainage of the site selected for the new
Central Jail at Trichinopoly.

Trichinopoly.

1 The necessity of subsoil drainage of all
sites selected for permanent occupation has been
strongly urged by the "Royal Commission on the
Sanitary State of the Army in India" and the absence
of all provisions of this nature is advanced as one of the
great causes of sickness and mortality in India.

*Vide report of Commission
Vol I Page XLII & 374

2 All recent writers also contend for subsoil
drainage, and Professor Parker, whose work on Hygiene
may be accepted as a reliable exponent of the question,
states "In any locality intended to be permanently
used the ground should be drained with pipe drains.
Even in the driest of the lower soils this is desirable."

Parker's Hygiene 2nd Edition
page 274

3 The object of subsoil drainage is suffi-
ciently well known; but I may be permitted to
enumerate the principal advantages of it.

a. It relieves the soil of water which
is retained at varying depths according to
the nature of the soil itself and of the under-
lying strata.

b. It favors the access of air to the
soil since the escape of the subsoil water
thru' the drains has the effect of drawing
the air into, and through, the soil.

4 These two conditions; removal of subsoil
water and permeation of the soil by the atmosphere,
are held

are held by agriculturists to be essential to a healthy state of the soil, not only rendering it more suited to the growth of crops, but more favorable to the health both of man and animals.

* Johnston's agricultural Chemistry.

5. Measures in fact which generally tend to make a soil more productive tend also to improve its conditions in relation to the health of man.

6. Retention of subsoil waters causes a constant rise of moisture to the surface by capillary attraction (aided by evaporation from the surface) which leads to a circulation of water upwards, instead of air downwards; in fact that passage of the air thro' the soil which is so essential in relation, both to health and productiveness.

7. It is not only clayey soils which require subsoil drainage; but even light sandy or loamy soils when resting upon a hard or clayey bottom.

8. But, further, subsoil drains not only free the soil from moisture and favour its permeation by the air, but enable the rains to wash away noxious substances from it and to change their nature, for the entrance of air into and its passage through the soil, leads to an acid condition of the soil which, it has been advanced, characterizes a healthy soil, healthy that is in relation to its occupation by man.

Retention of water on the other hand impedes these changes, and the soil becomes loaded with those compounds resulting from slow decomposition

39
decomposition (putrefaction) of organic matter which impart an alkaline condition to it.

9. These facts constitute powerful arguments in favor of subsoil drainage of all sites selected for permanent occupation, and more especially when these sites are comparatively limited areas with a dense population, adding largely, constantly and progressively in spite of every precaution to the contamination of the surface soil.

10. It only remains for me then to apply these principles to the area upon which the new Central Jail is now being built.

11. The surface soil is a sandy loam of deep red color, in fact the soil known as "Lat" and is composed of sand, clay (in large proportion) and oxide of iron. Beneath this is a band of ferruginous gravel resting upon a mass of friable and decomposed a lower whole but becoming more compact below.

12. The Superintendent Engineer 6th Division in his letter No 1064 of 6th December writes that this stratum of gravel reaches to within two feet of the surface and varies from 4 to 5 feet in thickness and adds "the drainage could hardly be improved by artificial means" if it is meant by this that because this thickness of gravel exists, therefore drainage is not required, I would refer to the report of the Commissioners on the Sanitary State of the Army in India at page 374 "abstract of Statistical Returns" at which the following sentence occurs "It appears to be generally presumed, that because a soil is porous therefore it requires no drainage, whereas a porous subsoil is one

16 per cent according to a rough analysis made by myself.

+ Dr. R. A. Smith F.R.S.

is one which stands most in need while it most readily admits of efficient drainage. Once allow the porous subsoil to become saturated with the filth of a population, the sooner the site is abandoned, the better. Only by very careful drainage can the public health be protected from this contingency in such a climate as India.

13. The soil of the site of this jail is very permeable to water as far as the rocky base by which it (the water) is upheld.

The physical characters of the surface would lead any one conversant with the subject to suppose that this is the case. It is arid and sterile, with but little vegetation; characters which are held to evidence a moist or wet subsoil with bad drainage.

Some 5 years ago when I held medical charge of the 105th Foot it was proposed to encamp the Regiment; and I was directed to report upon a site selected near the Taber's rock, about 1 and $\frac{1}{2}$ miles to the west of the site upon which the new jail is now being built. This spot appeared to ordinary examination in every way eligible - high and dry - the soil a red sandy loam with little or no vegetation. But on sinking holes to determine the level of the subsoil water, it was found at 2 and 3 feet, the pits at the latter depth filling with water. I need not state that these associations are held to constitute the most unfavorable conditions in relation to the healthiness of sites.

14. I do not say that water is found at this level at the site of the new jail; but it is found at from 8 to 12 feet, and for 3 feet above this the soil where the wells were first sunk was wet. The subsoil was in fact wet at from 5 to 6 feet from the surface and this at a time when there had been but little rain

rain for months previous.

15. It would therefore be I think a great mistake to omit "subsoil" drainage of the site of this jail - for when we take into consideration the lamentable mortality which has attached to the jails of this Presidency for so many years, it becomes imperative to recommend the adoption of all those measures, which we may reasonably hope to aid in reducing that mortality; and subsoil drainage certainly must be held to constitute a most important factor in the complicated problem of "health of sites" selected for permanent occupancy, either as jails, Barracks or Hospitals.

16. Should these views be accepted and subsoil drainage of this jail determined upon, it is very necessary that no time should be lost, and the plan be matured and carried out before the foundations of the permanent building be laid.

17. I am induced to offer these suggestions and have reason to believe that the Engineer Officers do not consider subsoil drainage necessary, and in the hope that they may be induced to reconsider the question upon the basis of the reasons I have adduced.

18. It is scarcely my province to touch upon the plan to be adopted, but I may be permitted to remark that about 3 feet is laid down as the least depth for subsoil drains, or the rule may be followed of making the drains as deep as they can be "to run and deliver water" with preference to the available outfall. In the case of this jail the outfall is good.

19. As regard to the distance apart at which the drains should be placed 18 to 21 feet are given as safe distances, "at greater distances" it is alleged that "they may fail to dry the land."

20. As to the

20 As the jail is to be built upon the radial principle the proper position for the main drains would appear to be the intervals between the buildings with cross drains beneath their foundations so as to insure thorough dryness of their basements.

21 It will of course be necessary to compare surface with subsoil drainings, and judging from the probable yield of the wells which have been already sunk, it becomes an important question whether it will not be necessary to store the roof water by conducting it into properly constructed and reservoirs fitted with some filtering apparatus.

22 The surface drains should consist of shallow saucer-shaped drains placed so as to receive all drippings from the buildings; but they should have no connection with the system of drains designed to relieve the subsoil.

23 I do not know what the roof area of all the buildings within the walls may be, and so cannot calculate now approximately what amount of water may be stored; but assuming the annual rainfall at 30 inches, the Executive Engineer of the works will have no difficulty in making the calculation and in designing the capacity of the reservoir or reservoirs of collection and storage which I may add should be covered in to keep the water both cool and free from contamination from without.

Having diverged a little from my original intention of dealing only with subsoil drainage

I may

I may be permitted to recapitulate, and to state succinctly and in order the measures I advocate as essential viz:-

- 1st Subsoil drainage.
- 2nd Surface drainage (to have no communication with subsoil drains).
- 3rd Collection of rain water from roofs of buildings by a distinct series of pipes and conduits and its storage in underground tanks provided with filter beds of approved construction.
- 4th All wells to be covered over and water lifted by pumps.

/True Copy/

for Secretary Sanitary Commissioner
for Madras

Extract from an unfinished letter to the address
of the Chief Secretary to Government by the late Acting
Sanitary Commissioner for Madras. 47

1. I have the honor to forward for submission to
Government a Memorandum by Major Rankin
regarding certain recommendations advocated by him
for adoption in the new Central Jail at Trichinopoly.

2. Mr Rankin has so fully explained the advan-
tages, both to land, and to those occupying it, that have
been found by experience to follow the adoption of sub-
soil drainage, that I feel it only necessary to add that
the Honorable Mr Ellis and I fully concur in the views
he has expressed.

3. But if the principle, not of the desirability, but
of the actual necessity, of subsoil drainage be admitted
the application of it must be made one of the essential
portions of designs for all new Barracks and Hospitals.
The Authorities in England advocate its extension to whole
stations and towns.

4. Under these circumstances I think it well to
refer the whole question in a complete form for the con-
sideration of Government simply, promising that, in all Con-
struction of Government buildings, and notably in the new Lunatic
Asylum now in the process of erection in Coonoor, the
subsoil drainage should be insisted upon as
essential to the health of the inmates of these Institutions.

(True Extract)

for Secretary Sanitary Commissioner
for Madras

Enclosure in a letter from the
Sanitary Commissioner for Madras
to the Secretary to Govt. Madras. Dated
No 232 dated 13th March 1886.

1. M. A.
in No 1148 of 1888

1. M. A.

To the Quarter Master General's Office,
Fort St. George, 7th March 1868.
No. 1914.

113

From
Colonel Crawford Cooke,
Quarter Master General

To
Major General McMarshall
Secretary to Government
Military Department

Sir, I have the honor, by order, to return
the Enclosures of your reference despatch dated 20th
Ultimo, and to report for submission to Government
that the Commander in Chief, when he recently
visited Bangalore, inspected the site of the Old
Race Course Barracks, and His Excellency is of
opinion, that the Plan proposed by the Executive
Engineer, to carry out the drainage of the Buildings,
will meet the object contemplated.

I have the honor to be,

Sir,
Your most obedient Servant.
Wm. Cooke Colonel
Quarter Master General.

Enclosure in a letter from the
Military Commissioner for Madras
to the Secretary to Government
dated 23rd March 1868.

2.

P. 27. 11/13/68

W.D.
in the 1118-1119

N^o 839. *Sir* Executive Eng^r Office,
Bangalore, 30th October 1867.
45

From, The Executive Engineer,
Bangalore.

To, The Superintending Engineer,
5th Division.

Sir,
I have the honor to forward here-
with a plan of the Race Course Barracks,
showing the mode which it is proposed
to carry out the drainage of the build-
ings included therein, with an estimate
of the cost of the work amounting to
Rupees 4,100.—

2. The ground on which the principal
Barrack blocks are built forms a plateau
nearly level with a slight general fall
from the western corner in all directions.
From the edges of the plateau the ground
falls away rather rapidly in all directions
except towards the north west, and on
the slopes thus formed are built the
family Quarters, Hospital, Stables and
other subsidiary buildings.

3. From the north east by the north
to

Malabar 1868 Department

No 1285

Sir

Mr. D. D. D. D.

Mr. D. D. D. D.

Mr. D. D. D. D.

Mr. D. D. D. D.

Mr. D. D. D. D.

Mr. D. D. D. D.

Mr. D. D. D. D.

Return sent to
of the 20th Oct 1867 and
for submission to Government
that the plan proposed by
the Executive Engineer for the
drainage of the Race Course
Barracks Bangalore, will
not the spirit of the plan

to the South west the ground is surrounded, at greater or less distance by the Cantonment of Bangalore, and to the South east the fall is of very short extent, the ground beginning to rise again about 100 yards from the furthest of the barrack buildings (the Artillery Married Quarters.) The available space for outfall is therefore confined to the east and South, in either of which directions a drain may be carried for a considerable distance with a good fall, and be finally discharged upon land where the sewage can be utilized.

4. Unfortunately, however, the whole of the barracks cannot be drained in either of these directions, owing to the projection of the main plateau between the low buildings on each side. This will be easily understood by a glance at the levels marked in the plan.

5. The lowest buildings on the two side slopes are the last block of Artillery Stables on the South, and the single separate ward of the Hospital on the east. The lowest corner of the former is about 39 feet and of the latter

41 feet below the datum.

6. If the whole of the barracks were to be drained to one outfall the same drain must take in both these points. As they are nearly 4000 feet apart in a straight line, the very shortest drain between them would require a fall of at least 2.6 feet, so that at the corner of the Hospital it would be something like 68 feet below the datum or 27 feet below the ground. This line moreover would pass to the north of the Artillery Married Quarters, under ground from 15 to 20 feet higher than the point it started from, giving an enormous amount of cutting and rendering the work proportionately expensive.

7. This plan would be not only extravagant but impracticable, for the eastern outfall has a good slope but not sufficient to allow us to waste 2.6 feet at starting.

8. This cause, a fortiori, prevents our avoiding the high ground above the Artillery Married Quarters by taking the drain round the foot of the plateau between these buildings, as its length would thereby be increased and it would reach the Hospital at a depth of between 40 and 50 feet below

below the ground.

9. I need not say more to show the impracticability of draining the whole ground to one outfall, indeed I have already said more than is necessary, as the fact is self evident from a glance at the plan.

10. It is, therefore, necessary to drain one portion of the barracks to the east and the remainder to the south.

11. The plan will supply any further information that may be required. The thick blue lines represent the main drains, the thin blue lines the branch drains, the double red circles marked M. manholes for descending to examine and repair the pipes, and the single red circles marked V. ventilating shafts. The black figures show the depth of the ground at the points where they occur below the datum line, and the red figures underneath them the depth of the centre of the drain below the ground in feet.

12. The plan has been prepared by me from levels taken by myself with the greatest care; a contoured plan of the whole ground was constructed, on which the drains were laid down and transferred to the plan

plan now sent. The contours are not shown on this, as they would only serve to confuse it. The levels of all the important points are marked in figures.

13. The distance beyond the barracks which it is proposed to carry the main drains are shown on the plan. These will be sufficient for sanitary purposes, and will allow the drainage to be discharged on ground where it can be utilized.

14. The eastern main drain is taken in rear of the Hospital compound so as to remove the ventilating shafts, from which disagreeable smell occasionally arises, as far as possible from the Hospital buildings.

15. It is proposed to run a branch with a trapped sink from every cookhouse, washhouse, and plunge bath; from every stall of the stables, and from every staff Serjeants and Married Men's Quarters, but the estimate does not provide for branches from the privies, as it is presumed that the dry system of conservancy renders this unnecessary. Should it hereafter be considered necessary to provide for the removal of solid excreta, branches to the privies can easily be added.

calculation of the amount of excavation and other labor required, and will, I think, be found sufficient.

22. The proportion of piping required for the different depths has been calculated with the greatest care by myself. This calculation has been somewhat laborious and has indeed been one of the principal causes of the delay in the submission of the estimate. It was no use entrusting the work to an estimator, as checking his calculations would have been just as troublesome as making them myself; and it is only within the last few days that I have been able to give my own attention to the matter.

23. The plan was prepared, as you are aware, nearly a year ago, having been finished before I went away on leave in December last, and since then some slight alterations have been made in the positions of the stables and one or two other buildings; but I have not thought it necessary to alter the plan on that account, as only a few of the smaller branches, and not the main lines, or the amount of piping

49
piping required, will be affected.
24. In executing the work the most convenient plan will be to call for tenders in the form of a schedule of rates, at which payment is to be made to the contractor for work done as determined by actual measurement. This will be better than a tender for a lump sum, as it will allow of additions or deductions on account of ^{any} slight alterations that may be necessary, being calculated more easily.

25. The schedule will not be long nor the bills complicated, as the estimate consists only of seventeen items, namely three rates for each size of pipe, one rate for manholes, three for ventilators, one for yard sinks, and three for flap traps.

26. Provision for the execution of the work in this way has been made in the specification, which is somewhat more detail than usual.

27. I regret the long delay that has taken place in submitting this project, but I have already explained the reason of this delay, and believe that you

you will consider the explanation
as sufficient.

I have ~~you~~

/Sgd/ J. Pennycook L.R.E.

Exec. Engineer

Bangalore.

/True Copy/

Edwd L. Colb R.E.

Superinty Engineer,

S. Division.

Enclosure in letter.
No 24 dated 11th Feb.
1858 - from the High
Engineers of Ohio to
the Secretary to Goverment
Q. Q. W.

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13/8/10

8854/9284
W.D.

8/12/25/2

Thru,
Lieut-Colonel E. A. Hoord A.E.,
Superintg Engineer, 5th Division.

To,
Colonel Charles A. Orr A.E.,
Secretary of Government, D. S. W.

Sir,

With reference to the order of Government of the 4th March 1867, 42656, para 3, I have the honor to forward for sanction an estimate of rupees 4,000, with plan and specification, for laying pipes for the drainage of the Race Course Barracks at Bangalore. The estimate is accompanied by an indent for the pipes that will be required, the cost of which at the factory, taken from the manufacturer's price list, is £ 2,111-16-, or about twenty two thousand rupees. Supposing that by the time they reach the barracks their cost will be doubled by charges for packing, freight, &c., then the cost of the drainage of the barracks will be eighty five thousand rupees, or considerably less than the sum that was assumed at the outset.

When an estimate for draining the barracks was made, no mention was made of the

2. When an estimate for draining was first called for, no mention was made of the system.

Enclosures 5.

- 1 Plan
- 1 Estimate
- 1 Specification
- 1 Letter from Executive Engineer.
- 1 Student.

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system of drainage be adopted, whether refuse water from the buildings was alone to be removed, or surface drainage was also to be taken off by the same channels. The scheme now submitted is for the removal of liquid refuse of all kinds from the hospitals, baths, wash houses, cookrooms, family quarters and stables. No provision is made for the surface drainage of the ground, on which the barracks are built, as, from its natural slope, the water runs off at once.

3 For the conveyance of the drainage from the buildings it is proposed to use glazed stone ware pipes, which are now invariably used, where practicable, in place of sewers of brick work. They are quickly and easily laid, require a smaller amount of excavation and their smooth internal surface allows the sewage to pass more rapidly than it could do in a brick work sewer. Moreover, being formed of various shapes, bends and junctions can be more perfectly made, than can be the case with brick work. These are advantages common to all the glazed pipes. The particular form of pipes proposed to be adopted in this case, has the further advantage of affording great facilities in getting at any obstructions, and that, as the pipes are joining pipes can be lifted up.

Notwithstanding the distance from which the pipes will have to come, and the cost of carriage, the time and money will be saved by their use. The bricks procurable at Bangalore, though good enough for ordinary buildings, would not answer for

for sewer works. Bricks would have to be made specially for the purpose, which would cause delay, and afterwards, the pipes could be laid in much less time than an equal length of sewer could be built. The quantity of the three sizes of pipes in the indent is one third more than in the estimate, to allow for breakages in transit.

5. It will not be practicable to drain all the buildings to one outfall, at least not without having to lay some of the pipes at a very great depth. The available directions, in which the drainage can be carried, are to the East and to the South, where there is ground which can be irrigated by it, and at a sufficient distance from the barracks and other buildings, to prevent any unpleasant effects.

6. The levels from which the plan and estimate have been prepared were carefully taken by Lieut. Sanyal, and the whole scheme has been under consideration a long time. The indent for the pipes was prepared more than a year ago, and although the work cannot be commenced until the pipes have been received, I have thought it advisable not to forward the indent, until the plan and estimate were ready to go with it, so that full information might be afforded, as to the intended scheme and its probable cost.

7. The plan and estimate have not yet been submitted for the opinion of the Military Authorities and the Sanitary Commission.

I have the honor to be,
Sir,
Your most Obedt. Servant,
E. A. Ford
Superintending Engineer

Public Works Dept

Public Works Dept
 No. 1205
 Proceedings of the Madras Government
 Under date the 21st April 1868
 Read the following
 From the Sup^r Engineer
 5th Dec 11 (Here enter No. 224 of 11th July 1868)
 From the Sanitary Commissioner
 for Madras. (Here enter No. 232 of 13th March)

With the first of the letters above recorded the Superintendent Engineer of the 5th Division submitted a plan and estimate for the drainage of the Race Course barracks at Bangalore by means of drains formed of glazed stone ware pipes to carry off liquid refuse of all kinds from the Hospitals, Bachelors Quarters, Cook-houses, Family Lavatories and

Blessed & the
 Military Dept,
 with a view
 to the officers
 & Excellence
 the Committee
 in brief and
 Secretary can
 measure long

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I send to the Committee
 the Chief Justice's collection General & Special
 and to the Secretary Commissioner, for his
 use.

J. M. McKim }
 20th February 1868. }
 Messrs. D. & C.

[illegible]

To the Quarter Master General
of the Eastern District } 20th H.
with 4 Bundles of Paper &c returned }
Mar²⁰ 54y. E. M. P. B. S. of March 1868. CQ.

Stables, and discharge it
in two directions, at
points 700 yards to the
East and 383 yards
to the South of the
plateau respectively.

It is proposed
to connect the drains
by branches with each
building, and to
provide them with
grated and trapped
openings. ~~ventilating~~
shafts and ~~beams~~ ~~like~~ -
The drains will not
however carry off the
refuse from the prisons
and criminals (as these
are to be ~~condemned~~
on the dry earth system)
nor are they intended
to admit of the discharge
of storm water as the
natural surface drainage.

54
If the site is so good
as to render any in-
terference with it un-
necessary -

The use of glazed
stone ware pipes, varying
from 3 to 9 inches in
diameter, is preferred
on the grounds that
it is impossible to
manufacture bricks at
Bangalore capable of
resisting the action of
sewage, and that pipes
can be more quickly
and easily laid, will
require a smaller
amount of excavation
and admit of a better
discharge of the sewage
than masonry drains.

The cost of the
works is estimated
at Rupees 85,000, of
which

Rupees 44,000 represent the value of pipes to be obtained from England.

The Supt. Engineer's report together with the plans and estimates, having been referred through the Military Dept., to the Com-in-Chief and the Sanitary Commissioner, His Excellency has given it as his opinion that the scheme will meet the object contemplated.

The Sanitary Commissioner, however, though not objecting to the plan, considers that it does not go far enough.

He approves of the tubular pipe drainage which, he states, is in general conformity with the principles laid down

55/35
by the Barack and Hospital Committee, but points out certain measures which, in his opinion, should be taken for flushing the drains, extending the outfall pipes and, improving their venting shafts, and strongly urges the necessity for adding a carefully devised system of surface and sub-soil drains. The Ranking also submits remarks on the utilization of sewage and the system of water supply at Bangalore.

The Sanitary Commissioner's suggestions may thus be briefly summarized

1. - The provision of special means for flushing the drains -
2. - The extension of the outfall pipes -
3. - The construction of ventilating shafts with man-holes, and provision of charcoal filters -
4. - The paving of the surface around the Barracks and Hospitals with non absorbent stone, and improving the natural surface drainage -
5. - The application of Sub-Soil drainage either to the whole area of the Plateau, or along the lines of sewage drains -
6. - The construction of reservoirs for storing rain falling upon the roofs, for drinking and cooking purposes -

On a careful consideration of the whole subject, the

Government is of opinion that the drainage of the buildings should be dealt with separately, and they approve of the adoption of the scheme recommended by the Superintending Engineer, but before addressing the Government of India upon the subject, Colonel Ford will be requested to submit a revised estimate providing for a better flushing of the drains, improved ventilation of the shafts, and an extension of the outfalls -

With reference to surface and Sub-Soil drainage

57 7
The Government consider
that the former being
for the present be
left to nature, and
that the latter, which
is scarcely requisite
on the plateau, may
be deferred.

The subject of
the storage of rain
water falling upon the
roofs of the barracks
and subsidiary buildings
on the race course at
Bangalore, will be
considered on the
return from Europe
of Capt. Tulloch who
has been specially
instructed to study
that method of
water storage as

as paper thing
Matter —

6 To the Supply - ^{to be} ~~into~~ ^{one plan, one rate, one specific}
15 - Military Dept ^{and list of articles}
3 - Sanitary Commission

40
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Prob. Works 1868 Dep^u

Pro: of Govt for April

N^o 1201

Pro: of the Madras Govt
of 21 April 1868

to

Passing orders on the
project for the drainage &c of the
Vaco Course Barracks at
Bangalore