REPORT OF THE COMMISSION

Appointed to Inquire into and Report upon

THE SANITARY CONDITION

OF THE

CITY OF PERTH

AND THE

TOWN OF FREMANTLE,

ESPECIALLY WITH REGARD TO THE QUESTIONS OF

WATER SUPPLY AND THE DISPOSAL OF SEWAGE.

Presented to the Legislative Council by His Excellency's Command.

PERTH:
BY AUTHORITY: RICHARD PETHUE, GOVERNMENT PRINTER.
1885.
No. 20.
SANITARY COMMISSION.

COMMISSION.

By His Excellency Sir Frederick Napier Broome, Knight Commander of the Most Distinguished Order of Saint Michael and Saint George, Governor and Commander-in-Chief in and over the Territory of Western Australia and its Dependencies, &c., &c., &c.

To Alfred Robert Waylen, Esquire, Doctor of Medicine, Colonial Surgeon, Justice of the Peace; the Honorable Clayton Turner Mason, Member of the Institute of Civil Engineers, Director of Public Works and Commissioner of Railways, Justice of the Peace; George Shenton, Esquire, Mayor of Perth, Member of the Legislative Council, Justice of the Peace; Barrington Clarke Wood, Esquire, Mayor of Fremantle, Justice of the Peace; Henry Calvert Barnett, Esquire, Member of the Royal College of Surgeons of England, Colonial Surgeon, Fremantle, Justice of the Peace; George Walpole Leake, Esquire, Queen's Counsel, Police Magistrate of Perth and Resident Magistrate of the Swan District; Edward Scott, Esquire, Member of the Royal College of Surgeons of England.

WHEREAS it is expedient to inquire into and report upon the Sanitary condition of the City of Perth and the Town of Fremantle, especially with regard to the questions of Water Supply and the disposal of Sewage:

Now, THEREFORE I, FREDERICK NAPIER BROOME, Governor, as aforesaid, have thought fit to appoint, and do hereby appoint you the said Alfred Robert Waylen, Clayton Turner Mason, George Shenton, Barrington Clarke Wood, Henry Calvert Barnett, George Walpole Leake, and Edward Scott, to inquire into and report upon the Sanitary condition of the City of Perth and the Town of Fremantle, especially with regard to the questions of Water Supply and the disposal of Sewage, and to make recommendations in connection therewith.

And I do hereby desire and request that you do, as soon as the same can conveniently be done (using all diligence), report to me, in writing, your proceedings in virtue of this Commission.

And I further will and direct, and by these presents ordain, that this Commission shall continue in force until you have finally reported upon the matter aforesaid, or otherwise until this Commission shall be revoked by me; and that you, the said Commissioners, shall have liberty to report to me your several proceedings from time to time, as the same or any part thereof may respectively be completed and perfected.

And I do appoint the said Alfred Robert Waylen to be Chairman of the said Commissioners.

Given at Government House, Perth, this seventh day of November, in the year of our Lord one thousand eight hundred and eighty-four.

By His Excellency's Command,

MALCOLM FRASER,

Colonial Secretary.

REPORT.

To His Excellency Sir Frederick Napier Broome, Knight Commander of the Most Distinguished Order of Saint Michael and Saint George, Governor and Commander-in-Chief in and over the Territory of Western Australia and its Dependencies, &c., &c., &c.

HAVING been appointed by Your Excellency as Commissioners to inquire into and report upon the Sanitary condition of, and as to a Water supply for the City of Perth and Town of Fremantle, as set forth in the above Commission under Your Excellency's hand, dated November 7th, 1884, we beg to submit the following Report:—

1. The names of Messrs. George Randell, the Mayor of Perth, and William Traylen, a resident in Perth, were afterwards added to the Commission, which on the 31st day of January last entered on its duties.

2. As it appeared to us that our duties were restricted to the questions of Water Supply and the disposal of Sewage in Perth and Fremantle, this report will be confined to those topics only; and we will commence with

Sewage and its disposal.

3. At present, these two towns, though in existence since 1829, do not cover very large areas of ground, nor are they densely populated. Neither town presents the spectacle so frequent in towns and cities in the colonies and elsewhere, of people massed together in crowded courts, ill-fed, ill-nurtured, and without air or water. The area of Perth is about 3000 acres, with a population of 5000, that of Fremantle is about 1800 acres, with a population of 3600, according to the last census, with a mild, dry, and genial climate, preventing the spread of diseases which may arise from the before-mentioned causes. Typhus fever and cholera are unknown, while typhoid fever and choleraic diarrhoea are infrequent; but fevers and intestinal disorders, diseases resulting from blood-poisoning, are more or less prevalent; and the existence of these disorders must increase as the population increases, while, if sanitary precautions are adopted, the risk can be reduced to a minimum.

4. That sanitary evils in these towns do exist, will be shown by this report; and we feel convinced that remedial and precautionary measures alone are necessary to make these towns perfectly
healthy. But the townspeople must assist in attaining such a condition: and their governing bodies have in their hands means, ample or very nearly so, for the purpose.

5. The remedial measures are simple; nor need their application be onerous, in a money point of view; nor oppressive to individuals. And the precautionary measures we suggest, so far as they are likely to affect a more numerous population in these towns, can, if early prescribed, be enforced and their neglect punished.

6. The more populous part of Perth is situated on a sandy soil, based on a substratum of clay, sloping on the South-west to Perth Water, and on the North-east to a depression through which the waters of Monger's Lake and its adjacent lagoons find their way into the Swan River. Neither Perth Water nor the Swan River have a rise and fall of tide sufficient to carry off by scour what might be conveyed thither by sewers.

 Fremantle is built on the western face of the limestone hills near the sea, and on the isthmus which connects those hills with the low eminence known as Arthur's Head, and is bounded on the North-west by the shallow waters of the mouth of the Swan River, and on the South-west by the shore of Gage's Roads; and the rise and fall of tide, both in the river and the sea, are of the same nature as at Perth.

7. We therefore unanimously condemn the construction of sewers for the present in either Perth or Fremantle.

8. We made numerous, and very careful, inspections of places in Perth and Fremantle. In no case did we meet with any obstruction from the owners or occupants, who offered us every facility and information in their power. We found, in the more closely inhabited portions of each town, places excessively foul, from human and animal ordure, butcher's offal, the droppings of fowls, and general litter, in some instances affecting the wells of drinking water and water used by bakers; and yet, with all this, there is no excessive amount of disease, excepting such as is purely preventable.

9. We took evidence on this subject, and in order that Your Excellency may be enabled to concur in or dissent from our conclusions, we print (suppressing names of occupants of foul places) that evidence in extenso in the Appendix.

10. It is obvious that every place where human beings dwell must have closet accommodation, and that their excreta must be deposited for a time, however short, where it first drops. There can be but two modes of deposit, either in cesspits or pans or other receptacles of a temporary sort. The great objections to cesspits are that the matter (unless the cesspits be made, and continue to be kept, impervious to leakage) will poison the soils and water in the wells. That (unless kept frequently emptied) their contents will ferment, and exhale gases noxious alike to health and decency. But occupants of tenements can themselves furnish a very large supply of ashes by burning all the house sweepings, wood chips, litter, and rubbish. This, in the first instance, the municipalities should supply, or be able to furnish to houses. But occupants of tenements can themselves furnish a very large supply of ashes by burning all the house sweepings, wood chips, litter, and rubbish. These substances when burnt afford a fine impalpable ash, which not only covers excreta, and prevents them being offensive, but arrests and absorbs the gases in the first stage of exhalation; and such ashes would largely supplement the dry earth, which the municipalities would provide.

11. We therefore recommend that the use of cesspits be abandoned; and, if necessary, that such abandonment be enforced by process of law.

12. The only mode of preventing disease and discomfort to the residents of these towns is, so far as we can judge from experience and inspection, by adopting the dry earth system, supported by a rigid system of scavenging (so far as regards human excreta) and by causing all yards, outhouses, and enclosed places to be carefully kept free from animal and fowl droppings, from pigsties, and from offal and blood of slaughtered animals, and from litter; and that all matters having a tendency to ferment, or decompose, or secrete germs of disease, be either burnt on the premises or removed by scavengers.

13. Of course, if earth closets be used, there must be either dry earth or ashes supplied for use as deodorants. This, in the first instance, the municipalities should supply, or be able to furnish to houses. But occupants of tenements can themselves furnish a very large supply of ashes by burning all the house sweepings, wood chips, litter, and rubbish. These substances when burnt afford a fine impalpable ash, which not only covers excreta, and prevents them being offensive, but arrests and absorbs the gases in the first stage of exhalation; and such ashes would largely supplement the dry earth, which the municipalities would provide.

14. An observance as well of sections 19, 20, and 21 of "The Building Act, 1884" (48 Vic., No. 15), as of the provisions of part 6 of "The Municipal Institutions Act, 1876" (the 40th of Victoria, No. 13), can be enforced by the governing bodies of Perth and Fremantle. Section 63 of this last Act is so ample as to need little more in the shape of legislation as to closets, cesspits, &c.; and its sections 63 to 68 (both inclusive) contain the most explicit provisions on the subject of nuisances; and their abatement is provided for by sections 69 to 74, both inclusive.

15. There is a most valuable provision in section 76 of this Act, to the effect that "each Council (the governing power of towns) "shall provide in proper and convenient situations a place or places for "the deposit and collection of sewage, &c." This duty is imperative, and can be enforced by mandamus, should "Councils" neglect to provide them; and we think that such places might easily be furnished, by application to the Crown, when they could be provided outside of the towns; at the same time, care might be taken that sewage, &c., might be used and deposited for horticultural purposes only, under proper supervision and regulation within the limits of townships.
16. The penalties for disobedience of the provisions of the Act are also ample,—see sec. 81 in particular. Section 69 empowers the Councils to abate nuisances, and in the events therein specified imposes on them the duty of removing, abating, or discontinuing a nuisance.

17. The general enactments of these measures are, as we have pointed out, large. If detail be needed, sec. 49 provides for the enactment of By-Laws.

18. Rates are leviable under part 7 of the Act (commencing with sec. 82). Although these rates may be onerous in the first instance, they are more likely to diminish than to increase. And the sale of manure is likely to prove a source of income. But the question with which we are dealing is not merely of expense and outlay of money, but is of the paramount and all-important question of public health and decency and comfort.

The municipalities have, therefore, ample power to levy a scavenging rate, and to enforce cleanliness, as well under the 40th Vic., No. 13, as by By-Laws: in addition to the general, but somewhat imperfect, provisions given by the 27th and 28th sections of "The Police Ordinance, 1861" (25th Vic., No. 15).

19. We have therefore particularised existing evils, and pointed out means of preventing them; and we conceive that on this head our functions prescribed by the Commission are exhausted, so far as relates to sewage.

20. We may add that we have received valuable assistance on this subject from Dr. Barnett, by his memorandum dated the 2nd of March last; by a perusal of Council Paper No. 27 of 1879, headed "Correspondence and Reports upon the Sanitary Condition of the Colony;" and from a pamphlet (also written by Dr. Barnett) printed in 1876.

21. In conclusion, your Commissioners suggest that in order to ensure sanitation in towns, the following measures be adopted:—

a. That Inspectors of Nuisances be appointed for that purpose alone, and be entirely independent, as regards their duties, and not in any way to be under the control or orders of the Municipal Councils.

b. That it is desirable that a Board of Health should be appointed by the Governor for Perth and Fremantle, and that the Inspectors be appointed by and act under the control and direction of such Board.

c. That the Mayors of Perth and Fremantle should be, ex officio, members of such Board.

d. That in all cases earth closets be eventually used, to the exclusion of privies and cesspits; and that all privies and cesspits be, within the area mentioned in the next sub-paragraph, and within a certain period to be fixed (not exceeding six months), emptied and filled up; and the provisions of the 6th part of the 40th Vic., 13, enforced by all Municipal Councils, particularly of Perth and Fremantle.

e. That the dry earth system should be made compulsory within certain limits, to be defined by streets, or other well defined boundaries, as colored pink on the plans in the appendix.

f. That a scavenging rate be imposed in such areas: and a system adopted for compulsory deportation of excreta, and house and other refuse from houses and premises in these areas: having mainly in view promptitude and completeness of removal, combined with cleanliness.

g. That power be given to the Board of Health to deal with all wells and water.

h. That the sewage be disposed of outside Municipalities; or only in such places, inside the Municipalities, as the Inspectors may approve.

22. We thus, at the risk of iteration, embody suggestions made in the former part of this report.

As to Water Supply.

23. On this topic, except so far as it is referred to in the former part of our Report, and so far also as it is the subject of communications from the Rev. Mr. Nicolay and the report of Mr. Hardman (both printed in the Appendix), we relied on our own local and personal knowledge. We therefore feel warranted in making this Report.

24. The sources available for drinking water in Perth are the following:—

a. Wells sunk into the surface of the earth.

b. The roofs of houses and the preservation of water in tanks.

c. The Lagoons at the back of Perth, and particularly Monger's Lake and Smith's Lake.

d. The Rivers and brooks issuing from the Darling Range.

25. The sources of water supply in Fremantle appear to us to be the following:—

a. Those mentioned in sub-paragraphs a, b, of paragraph 24.

b. The water drawn from the limestone in the Convict Prison, and generally from what we believe to be the natural reservoirs in the Limestone range near that Town.
26. We are unanimous in advising that, from a sanitary point of view, water should be supplied from a source capable of affording an ample quantity, pure and uncontaminated with foreign matter. This, however, can only be completely accomplished by means of pipes leading from reservoirs to each house, and it should be the subject of specific legal enactment; the water rates forming part of the general revenue of the Colony; and the whole system being under the supervision and control of the Executive Government of the Colony: who should levy and receive all “water rates.”

27. So far as Perth is concerned, we have the satisfaction of presenting in our Appendix an exhaustive report from Mr. Hardman, the Government Geologist. We regret that the near departure of this gentleman from the Colony does not permit him to investigate and discuss the sources of water supply for Fremantle.

28. Our conclusions drawn from Mr. Hardman’s report are, that for Perth, pipes laid from the Helena River or some other river or creek issuing from the Darling Ranges, a distance of 19 miles from Perth, must eventually be the source from which Perth shall be supplied with pure water.

29. Mr. Hardman also suggests that water for the City might be furnished from deep wells sunk in the Limestone to the westward of Perth.

30. As an interim scheme, water could be procured from Monger’s Lake. But as this Lagoon might be drained by the Crown or private owners of the land, we venture to recommend that for the present, at least, the soil of so much of this Lagoon as still remains in the hands of the Crown be not permanently alienated or drained.

31. The details of the inception, completion, and maintenance of a Water Supply Scheme must be the subject of legislation, like Railways.

32. We wish specially to record our appreciation of the valuable assistance rendered to us by Mr. Hardman and the Rev. C. G. Nicolay in the course of our investigations; and also to express our thanks for the zeal, industry, and ability displayed by Mr. Charles Darcy Longson, our Secretary.

33. The Commission, in respectfully submitting this report, would beg to express a hope that the result of their labors may meet with the approval of Your Excellency.

ALFRED R. WAYLEN, M.D., Chairman,
CLAYTON T. MASON, M.I.C.E.,
GEO. SHENTON,
B. C. WOOD,
H. CALVERT BARNETT,
G. W. LEAKE,
EDWARD SCOTT,
G. RANDELL,
WM. TRAYLEN.

While concurring in much of the Report, I beg to ask that the following may be attached as a rider:—

1st.—That, in my opinion, the Sanitary Clauses of “The Municipal Institutions Act, 1876,” can be much simplified, and thus more easily enforced.

2nd.—That the Inspector of Nuisances should be appointed by the Local Boards of Health, viz., the Municipal Councils.

3rd.—That a Central Board of Health should be appointed for the whole Colony; such Board to have power at any time to extend areas.

4th.—That it would be doubtful policy to make the “Mayors” ex officio members of the Central Board.

5th.—That the introduction of the “Dry-earth System” be more gradual, and a much longer period given for its final adoption.

6th.—That the words “Local Boards” be substituted for that of “Inspectors” in sub-section k.

G. RANDELL.

Rider re Water Supply for the City of Perth.

I am unable to agree with Mr. Hardman as to the probable cost of the gravitation scheme from the Helena or Canning; as in my opinion it would involve an expenditure of at least one hundred thousand (£100,000) pounds.

CLAYTON T. MASON.
Appendix.

Evidence taken from Mr. W. E. Victor, the City Surveyor of Perth.

I am the City Surveyor of this town. Cesspits are cleaned out periodically by night-men, but at no stated periods. I have no control over the night-men as regards the time for cleaning cesspits; the time to be commenced has been commencing at from 10 to 11 p.m. When cesspits are declared a nuisance, the householder can be called on by the Council to have it cleaned. I believe the sewage when taken away is used for garden purposes. I am not aware that the same. I have designed for them drain, (2) night-carts, and tenders are now being called for the construction of the same. Cess-pits are mostly made of brick and lined with cement. Under the new Building Act, I have control over the construction of cesspits and cesspits; I think the cesspit the best plan. The Council intend framing regulations under the Building Act; at the present time there is no improvement under the new Act. If a system of inspection was made, and householders made to use earth, I think the dry earth system would be best. I have formed no idea as to the cost of conveying all cesspits into the "dry earth system."
Visits made by the Commission in the City of Perth, on the 30th January, 1885, accompanied by Mr. Thos. Halliday, the Inspector of Nuisances for the City.

The first visit was made to "** * * Cottages West," in Murray Street, which had one large cesspit nine feet (9ft.) long, six feet (6ft.) wide, and four feet (4ft.) deep; the cesspit had three (3) seats for the accommodation of twenty-three (23) persons; the cesspit had within a few days been attended to, and as large quantities of sawdust had been scatted over it, the Inspector declared that he saw no cause for complaint.

"** * * Cottages East" had one double closet for the use of sixteen (16) persons; this pit had also recently been attended to; the stench, however, was very offensive.

At a house between Murray and Hay Streets, a closet attached to the stable was found in a very offensive state and quite full; but the earth closet for the use of the family, near to the house, was in very good order.

At an hotel in Murray Street everything was found in a very clean state; a dry earth closet is used at this place, and is cleaned out every day, and the contents emptied into a large tub, and mixed with lime; this tub is emptied twice a week by nightmen, under contract; the urinal, which is also emptied twice a week, was found in a clean state.

At a private house in Hay Street, a cesspit with two double closets for the accommodation of fourteen (14) persons was found in a filthy condition; it had not been cleaned out for twelve (12) months; the well at this place is within eight (8) yards of the cesspit, and a tenant declared the water, although clear, was bad.

An inn in the same street was found in a fair state, with a dry earth closet attached; but no earth seemed to have been used.

"** * * Cottages" off Hay Street had two (2) closets for the use of twelve persons; the closets were in a bad state, but the well water was declared good by the tenants.

At a lodging house in Murray Street, one dry earth closet was found in a fair state; it accommodates fifteen (15) persons, and sawdust seen as used plentifully; it is emptied twice a week by contract.

"** * * cottages" in Murray and Wellington Streets, for the accommodation of thirty-one persons, had only two closets, with cockts; they had recently been cleaned and were in a fair state; the yards, however, were covered in rubbish and refuse. The wells on this property are very shallow, being about twelve feet deep, and the top level with the ground.

The yard, rubbish pit, and dry-earth closets of an hotel in Wellington Street were found in a very clean state, lime being plentifully used as a deodorant.

At ** * * cottages" off Wellington Street, one double closet for the use of nineteen persons was found in a filthy state, and the odour offensive and unhealthy; this closet is within thirty (30) feet of the cottages, and the well is about eighteen (18) feet deep.

"** * * cottages" in Murray Street, to accommodate twenty-nine (29) persons, had three cesspits, for the use of nineteen persons only, and evidently not been attended to for a considerable time; the yard was also in a filthy state, being covered with rubbish and refuse.

On the property of one of our large firms, the closets were all found in a filthy condition; in Wellington Street the wooden cottages, in which twenty-six (26) persons reside, had two closets unprovided with either bucket or cesspit; the tenants complained that the water was unfit either to drink or for household purposes through the well being so adjacent to the closets; the yards were found covered in rubbish and refuse, and the ground impregnated with sewage. Between Wellington and Murray Streets, on the same property, two closets were found in a bad state, and between Murray and Hay Streets, on the works, one closet, with no bucket nor pit, was in a most wretched and filthy state; as many as eighty (80) men are sometimes employed in this yard.

At the "Perth Prison" the dry-earth system is properly carried out, and everything was found in a perfect state, and is plentifully used and the buckets emptied every day into a large tumbler cart, the contents of which are taken away to Calloway's gardens three times a week.

The yard, rubbish pit, and dry-earth closets of an hotel in Barrack Street were found clean, and the urinal draining into a dry-well.

At a large Boarding House in Barrack Street, the two closet cesspits were found quite full and the smell very offensive; the bottom of the yard was covered with rubbish and refuse; the water in the well was declared good by the tenant.

In an hotel in Hay Street was next visited, and the urinal found in a dilapidated state and the smell very offensive; the urinal drains into a well about thirty yards away and is emptied twice a year; four (4) dry-earth closets are on the property, all of which were found in a very dirty state and smelling offensive, owing to earth or any other deodorant not being used; the buckets are emptied twice a week under contract; a large pit for rubbish and manure is emptied every week; two piggies are also in the yard about forty yards from the Hotel.

A Butcher's yard off the same street was seen in a very dirty state, covered with rubbish and refuse; and the smell of rotten meat found very offensive; there was also a large pigsty in the yard.

The yards of several shops and dwelling houses in Barrack and William Streets were next inspected, and all found covered with rubbish and refuse; and all the closet cesspits full and the smell offensive.
The urinal of an Hotel next to the previously mentioned was found in a very bad state, there being no receptacle for the urine, except the floor.

At the Government School in James Street, all the dry-earth closets were found kept in a very dirty state, and no earth used.

At the Railway Station the dry-earth closets were found fairly well kept; the urinal at this place drains into a small dry-well in the centre of the floor.

Visits made by the Commission to various houses, &c., in Fremantle, on the 6th February, 1885, accompanied by Mr. Wm. George, the Inspector of Nuisances for the Town of Fremantle.

The first visit made was to an Hotel in High Street, where two closets on the dry-earth system are used, one being found in a very foul state; earth is not used in either of the closets; the yard also was found very badly kept.

At another "Hotel," in the same street, one closet, on the "water carriage" principle, was found in a fair condition; this closet is within a few yards of the dining room and saloon, and is drained into a large cemented cesspit in the yard, which is cleaned out every two weeks. Two cesspit closets in the yard were in a dirty state, and are connected with the manure pit; in the yard was also seen a large rubbish box, quite full; it is emptied once every two weeks.

At a large "Boarding House" in Henry Street, everything was found in a very disgraceful condition. The yard full of rubbish and sewage, the cesspit closets nearly full, and smelling very foul (they had not been cleaned out for nine months), the urinal choked up, and the smell very offensive; the pump also in a very bad state, and the top boards coated with foul matter. This house was considered the worst (with the exception, only, of a Bakery afterwards visited), and most unhealthy of any seen in Perth or Fremantle.

A butcher's yard in the same street had three (3) cesspit closets, all of which were nearly full, and the smell very offensive (these had not been cleaned out for six months); the manure and rubbish pit was in a clean state, it is emptied every two days. The well here is about 15 feet deep and about thirty (30) feet from and between the closets.

At another hotel in High Street everything was found in a perfect state of cleanliness, the two closets and the yard being kept very clean, and the water in the well quite pure.

At "Hotel" in Cliff Street was next visited, and the public urinal and the dust and rubbish pit found in a clean state, as was also one cesspit closet in the main yard; this closet is kept sweet and clean by the use of carbolic acid; although acid is also used in the cesspit closets in the outer yard they were found smelling very foul. A water closet was found well ventilated and clean. The water used for drinking purposes is taken from a large cemented tank (capable of holding 6,000 gallons) from under the back buildings; that for washing purposes from the well in the yard about fifty (50) feet from the cesspit.

At the "Customs House" the dry earth closets and urinals were all in a very foul state and the smell most offensive; while at the "Water Police" Quarters, although no earth is used in the pans, everything was found in a clean state; the pans are emptied every morning by prisoners.

A large shop in High Street was next visited, and the yard and well found in bad condition, and the two (2) cesspits and urinal in a filthy state; they had evidently not been cleaned out for some considerable time. A butcher's yard and pigsty in Packenham Street were found very clean, plenty of sand being used in the "dry-earth" closet.

At some Cottages, in the same street, the well, cesspit, and yard were all found in a filthy state, the sides of the well being covered with green filth, and the water smelling very foul; the well is within five (5) yards of a large cesspit (165 ft) sixteen feet square and (75 ft) seven feet deep, which, when last cleaned, occupied the time of one man for three weeks, working every night, at a cost to the landlord of (49) nine pounds; the cesspit, drain, and dustpit were all in a very foul state, and the smell very offensive. The floors of these cottages are all six inches below the level of the yard, and were occupied by fourteen persons. In the same street some more cottages were found in the same filthy condition, the well-water full of vegetable and animal matter and unfit either for drinking or household purposes; while the pans in the closets (which are within a few yards of the cottages) were all full of fluid, a solid filth, and the smell most offensive. Sore eyes are prevalent among the tenants.

At some attached private houses in High Street, the water from the well was found full of organic matter, and when boiled shows a thick black scum on the top; closets on the dry-earth system are used, but no dry-earth. The yards were all full of rubbish and refuse.

A bakery yard in High Street was then visited, and found in a filthy state; the two cesspits being very dirty, and the smell offensive; a shallow well from which the water is used is within five (5) yards of one of the cesspits.

In the same street, at another baker's, a most filthy state of things was found; the yard covered in large pools of animal filth and sewage, and the cesspit, which is in the corner of the stables, smelling very foul; the well here is within fifteen yards of the cesspit. In all the experience of the members of the Commission, a more filthy condition of any place could not be conceived.

At a Bank in the same street, a closet on the dry-earth system was in a bad smelling state, through earth not having been used. The well-water at this place is unfit to drink.

The visit terminated at an Hotel in South Terrace, where the cesspit closet near the front of the house was found in a foul smelling state, through the want of ventilation; the cesspit closets in the yard were fairly clean.

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**Short Minute on Sanitation of Fremantle.**

The Commissioners, during their late visit to Fremantle, had an opportunity of satisfying themselves of the urgent need which exists for immediate sanitary reform.

The chief matters required are—

1. An abundant supply of pure water.

2. Compulsory use of the dry earth system, and filling up of all cesspits and some wells in the low-lying or crowded parts of town.

3. A Building Act which shall, among other matters, include the compulsory ventilation on approved principles of all houses to be in future erected, and the elevation of the lower floors of such houses to a sufficient height above the ground.

**Drainage** I shall not touch on, for I believe it to be almost impracticable on account of the low level of the populous parts of the town.
1. On this point I am of opinion that the supply of excellent water obtainable from the Convict Establishment should be utilised, without delay, by erection of windmills and laying on of pipes to those quarters of the town where it is most urgently needed.

The supply may possibly prove insufficient for the wants of all the town, and at best could only be a temporary measure, as it is certain that in a few years the population will immensely increase; but I would recommend that it should be utilised to its fullest extent at once, and that the opinion of the Government geologist be obtained as to the most advisable plan for future supply on a much larger scale than that which is now required.

2. The Commission have seen for themselves that in High Street, and the small and crowded streets adjoining it, houses are supplied in many instances from wells which are sunk through a porous soil in the closest proximity to abominable cesspits, and even the water which is used in making the bread for the supply of the town is obtained from wells sunk in proximity to the incessant soakage of human and equine evacuations. We insist on slaughter houses being far away from other houses, and, for other reasons, there is equal need that bakeries should be placed where the supply of water is above suspicion of taint. The heat used in baking destroys to some extent the ill effects of the putrescent matter contained in water, but does not do so completely. You may boil a piece of putrid meat for a whole day, but the product will not be fit for human use; and low fever, diarrhoea, and skin affections almost certainly result when such drink is used. I would beg to repeat the statement which I made in page 10 of my small pamphlet on sanitary matters, published in 1876:

"In Western Australia we shall find extreme difficulty in getting such a system carried out in its integrity, and, unless this is done, it is worse than useless."

Of the truth of this, we had ample proofs during the late visit of inspection, when we repeatedly saw the so-called dry earth system represented by large buckets full of urine and most offensive faecal matter.

It is important that the cesspits should not be closed until all arrangements are complete for carrying out the new system.

3. The question of ventilation is most important; but though I have much to say on it, I shall not at present do more than generally indicate its absolute necessity.

March 2nd, 1885.

H. CALVERT BARNETT.


Before drawing up this report, it has been necessary to make a careful geological examination of the surrounding country, and a brief description of the geology of the district will be useful in explaining the conclusions arrived at.

I.—GEOLOGY OF PERTH AND VICINITY.

To the west of Perth, and extending as far as the sea coast, the formation consists of a thick deposit of sandy limestone and highly calcareous sandstones or cornstones. These are in places more than 200 feet thick, and are in part of aqueous origin, and in part Eolian drifts or blown sands, afterwards consolidated by the action of rainwater, which, removing in solution carbonate of lime from the loose surface largely made up of finely comminuted fragments of shells, deposits it lower down, thus binding the mass into a more or less solid rock. In the lower beds of this formation marine shells of species now existing in the neighboring ocean are abundant, so that the whole must be of very recent age, and above it lie beds (sometimes of considerable thickness) of still more recent blown sands.

Proceeding eastwards, it is found that the well-marked limestone feature disappears, and passes into or is succeeded by more or less sandy clays, which are covered by thick loose sand. Occasionally these sandy clays are partially consolidated into a friable rock, as at Redcliffe, near the Perth Racecourse; but this is not frequent. In these clays sometimes occur beds of hard limestone, suitable for building stone and road metal, but never of any great thickness, perhaps 4 or 5 feet at most. They appear to occur in lenticular patches only, not in continuous beds.

Approaching Guildford, the formation again changes, and we have a series of red, purple, and yellow clays, sometimes containing ironstone pebbles, and often suitable for brick clay, &c. These are interstratified with beds of sand, frequently very coarse, and not unoften hardened into a sandstone rock. These beds extend up to the foot of the hills (the Darling Range), being covered in places by thin deposits of sand and alluvium. They extend north and south for many miles; for instance to the Upper Swan bridge on the north and below Narrogin on the south; but these are by no means their limits, as
they have been traced by Gregory and others to Gingin on the north and to the Harvey River on the south.

In some instances the indurated clays containing ironstone pebbles have been used for road material, as for instance those at Blackadder Bridge, while hard sandstone crops out now and then. A few miles east of the Upper Swan Bridge there are beds of thick hard red sandstone with grits containing large pebbles of hard quartzose grit. At Narragin are beds of hard sandstone with indurated clays containing ironstone pebbles, the whole being known locally as ironstone; and hard compact sandstone crops out occasionally in ridges to the North of Guildford. For example, near Mr. W. Harris’ property, and on that of Mr. G. W. Leake, P.M.

On Mr. Leake’s farm the following typical section was noted:

Section No. 1.

<table>
<thead>
<tr>
<th>Material</th>
<th>n</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard clay</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Loose coarse grit</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Indurated mottled red clay</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sandstone with ironstone</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

The total thickness of these clays, sands, and sandstones has not been ascertained, but wells have been sunk through them for depths of 30 or 40 feet. I have been informed that at the bottom of one of those, solid rock, supposed to be granite, was reached. To this I shall refer hereafter.

The stratification of these rocks is generally horizontal, or nearly so. Occasionally there is a slight dip of about 5°, but it is not continuous.

The deposits in question may be regarded as belonging essentially to the same Geological Epoch, viz., the Recent. But there is some slight difference in their chronological age, the Guildford clays being probably the newest of the series, and have been most likely deposited in a wide lagoon, protected from the sea action by the line of previously thrown up limestone and sand ridges, which stretch along the coast North and South.

So far we have only considered the comparatively superficial deposits. However, a valuable addition to our knowledge of the geology of the district has been made by a deep boring, put down some years ago at the Pound in Perth, near the present Railway Station. Specimens of the strata gone through have been preserved and arranged in the order in which they were pierced, and are now to be seen at Fremantle in the Mining and Geological Museum, under the care of the Rev. C. G. Nicolay.

I have examined and tested these specimens, and have drawn up the following descriptive section, which cannot fail to prove of interest. I have also obtained some useful particulars from Chief Warder Townsend, of the Fremantle Prison, who superintended the work.

Except during the first few feet through the surface sand, water was entirely wanting, and he was obliged to use water from above in order to clean the tools when necessary. Beds 29, 65, and 101 had each a hard crust (possibly carbonate of lime), and in 101 the tool went through "the branch of a decayed tree with silt around it." It is a pity none of this has been preserved, so as to determine the exact age of the formation. The fact, however, proves that the beds cannot be older at most than Upper Tertiary.

Section No. 2. In deep boring at the Pound, near Railway Station, Perth:

<table>
<thead>
<tr>
<th>n.</th>
<th>Material</th>
<th>n.</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 20.-Surface clay, sand, &amp;c., with water</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>29.-Grey sandy clay</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>38.-Coarse grey soft sandstone, very porous</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>47.-Bluish grey clay, streaked red with iron</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>56.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>65.-Bluish clay, streaked red with iron</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>74.-Do. very close grained</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>83.-Dark grey loose sandstone, porous</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>92.-Do. fine grained</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>101.-Brownish sandy clay</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>110.-Soft calcareous sandy mud or marl</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>119.-Do. very calcareous</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>129.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>137.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>146.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>155.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>164.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>173.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>182.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>191.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>200.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>209.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>218.-Do. do.</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

108 218
The beds from 101 feet to 218 feet inclusive are highly calcareous and not unlike chalk marl, and are apparently very porous. They cannot be at all regarded as clays, although they have been mistaken for such.

The next series of rocks to be considered are those of the Darling Range. These hills, extending for many miles in a North and South direction, and attaining a height of 1200 to 1500 feet, are composed of a variety of igneous and metamorphic rocks. Amongst the former are Granite, Syenite, Diorite or Basalt, and in the latter division may be recognised various forms of Schist, Slate, Gneiss, and Quartzite. Being the most ancient rocks in the district they are overlaid by those already described, and there can be very little doubt that they extend under those newer formations far to the Westward of Perth, for they are found to the southward at Cape Naturaliste, and to the North of Champion Bay, and there is every probability that they are continuous between the two places, although now hidden from us by the sea, and by more recent deposits.

At what depth we might find these Darling Range rocks beneath Perth must, however, remain a matter of conjecture.

I have drawn a sketch Section to explain the relations of these different formations to each other, and to accompany this Report. In this the igneous and metamorphic rocks are shown in undulating ridges, covered by horizontal layers of the more recent formations—in near the base of the hills the junction is usually obscured by layers of more recent ironstone gravel.

On referring to this section it will be observed that the general level of the country from Perth to the base of the hills east of Guildford is approximately the same. The slight differences, which rarely exceed from 30 to 60 feet, being due to superficial accumulations of sand or recent gravels.

I wish to lay particular stress on the following facts:

1. All the beds of rock known in the district which overlie the metamorphic rocks are nearly or altogether horizontally stratified.

2. That in no case can any evidence be obtained in the district of any great thickness of pervious strata coming to the surface overlying and overlaid by impervious strata.

Bearing in mind these facts, the question of Artesian Water Supply may be considered.

II.—ARTESIAN WELLS AND THE PRINCIPLE INVOLVED IN THEIR CONSTRUCTION.

Artesian wells—so called because they are supposed to have been first used in the province of Artois, France—can be only formed under the following conditions:

1. The strata must assume a basin-shaped form.

2. There must be series of strata consisting of an impermeable bed above, then a porous bed or series of beds such as sand, sandstone or chalk; and finally a second impermeable layer through which the water accumulated in the middle bed cannot percolate.

3. In order that the water which collects in the porous strata may rise to some height above the surface at the point where the well has been sunk, it is necessary that the level of the water-bearing strata where it receives its supply from the rainfall shall be at a greater elevation than the highest requisite point of delivery.

4. To insure a sufficient supply from an Artesian Well, the pervious strata which hold the reserves of water must present a sufficient surface or "available area" to admit of an adequate amount of water being collected and stored away to meet the necessities of the given district where it is required.

It is obvious that under the conditions just pointed out, the water supply will depend altogether on the area of the porous rock exposed, and on the amount of rainfall of the district.

But no such conditions as just laid down obtain here. We have no basin-shaped strata, we have no such alternations of the pervious or impervious strata showing a wide outcrop of the latter, nor have we any considerable elevation, above Perth, of the few thin outcrops of sand and sandstones which are met with.

If the section of the country around Perth be compared with a typical section of a district in which Artesian water is found, it will at once be seen that there is no likelihood of obtaining a water supply on such principles here. As an example consider the London basin. There, water is obtained from the chalk and greensand formations which crop out at a considerable distance south of London and at a higher elevation, striking from Rye to Horsham, and exposing a large surface to absorb the rainfall. Towards London they are covered by more or less impervious strata, the principal of which is the London clay, through which wells have to be sunk in order to reach the water stored up in the pervious, or porous, chalk or greensand, whence, by reason of the hydrostatic pressure due to higher level, it rises readily to the surface.

Another typical district is the Paris basin, in which the strata are essentially the same as those of the London basin. Here deep borings have been sunk through the Tertiary formations (corresponding to the London clays) through the chalk and other members of the Upper Cretaceous rocks, to the lower
greesand. I need only refer here to the famous wells of Grenelle and Passy, carried down to the depth of 1673 feet, and 1719 respectively. The outcrop of the greensand at Verdun, 150 miles to the North-east of Paris, is about 700 feet above the level of the sea, while the plain of Grenelle is but 104 feet above that level. The water here rose to a height of 122 feet above the ground; the point of saturation was therefore 474 feet below the outcrop of the greensand.

The sketch section of the Paris basin will, I trust, sufficiently explain the principles on which Artesian wells are sunk. (See accompanying sections.)

If, therefore, this section be compared with that showing the geological structure of the country around Perth, it will be clearly seen how hopeless it would be to expect Artesian water here—that is water which would overflow the well or borehole.

III.—Other Sources of Water Supply.

Ignoring then the idea of obtaining Artesian water in Perth, four other schemes present themselves. Two of these depend on well sinking and pumping, one on pumping alone, and the fourth on the principle of gravitation.

1. I shall consider the Gravitation scheme first, as it seems to be the best and simplest plan for affording a certain and inexhaustible supply of water both for Perth and Fremantle.

In this case there is a choice of two sources, viz., the Helena River, and the Upper Canning River. In both there are unfailing supplies of fresh water during the year, and, although during the dry season the water only shows in isolated pools, there could be no difficulty in building dams and reservoirs sufficient to conserve more than an ample yearly supply. In fact the drainage area in the case of the Helena is so extensive that the only matter for consideration, outside the cost of the undertaking, would be the provision, of adequate waste weirs or over-flows, by means of which to carry off the superfluous winter waters, so as to preclude possibility of accidents.

This would be simply a question of engineering; but the principal point would be the expense of the work. Judging from similar operations in the mother country, where the price of labor is about one third less than it is here,—not to speak of the difference in value of materials—it is probable that a gravitation scheme either from the Helena or the Canning would cost from £40,000 to £50,000.

2. Another plan which suggests itself, is to utilise the water of Monger's Lake, a natural reservoir a few miles north-east of Perth. It has an area of about 520 acres, and assuming the average depth of water to be 6 feet, would contain about 519,000,000 gallons of water. Perhaps this estimate is excessive; but at least 3 feet of water could be reckoned on during the year, giving a yield of 350,000,000 gallons, about.

Assuming that the supply of water would be sufficient, and constant, and that the quality of the water itself would be all that could be desired, this plan would necessitate the erection of pumping machinery, together with a service reservoir at a sufficient height to command the upper levels of Perth City; for the lake level is only 32 feet above Perth Water. It appears to me that there would be considerable difficulty in constructing such a reservoir.

3. Wells in the "Limestones" to the westward of Perth.—From what has been stated in the Geological sketch, at the commencement of this report, it will be understood that these rocks are of a very porous character; consequently, a great portion of the rainfall of the district must be absorbed by them, to be retained until it finds a natural outlet by means of springs, or until it is tapped by artificial means, such as wells. These limestones, which are in some places over 200 feet thick, usually overlie a clayey bed, which occurs above sea level; and invariably when wells have been sunk through the limestone to this clay a copious supply of water has been obtained, varying with the depth and diameter of the well.

If we consider the average amount of rainfall in the Perth District we cannot fail to see that an enormous quantity of water must be stored up in rocks such as those referred to.

I find the mean rainfall in Perth for the past 8 years, viz., from 1876 to 1884, has been 32.73 inches. This gives us 464,374,200 gallons per year per square mile. Allowing for evaporation and surface drainage, we may estimate the amount absorbed to be at least 0.4 of the total rainfall. This would give available water to the extent of 185,749,680 gallons per year for each square mile, equal to 84 gallons per head per day.

These must not be taken as absolutely correct estimates, for conditions may vary considerably; but they will help to give a rough idea of the quantity of water we may expect to find in porous strata.

Under favorable circumstances, therefore, each square mile of country ought to yield 500,000 gallons of water per day.

From these considerations, it would appear that a supply of water, sufficient for the present wants of Perth, might be easily obtained from the "Limestone" rocks. Two or three wells of, say, six feet in
diameter, and connected by tunnels so as to afford a storage reservoir, would probably yield an ample quantity for all purposes. Of course pumping machinery would in this case also be requisite.

The most suitable locality for such an experiment would be on the hills about a mile to the West of Perth. This would give a sufficiently large gathering ground, and a service reservoir could be easily constructed, which would command all parts of the city.

4. Deep Sinkings below the Limestone.—Although I have discouraged the idea of obtaining water near Perth by means of Artesian wells, it must not be supposed that it would be useless to expect to find water in the deeper seated strata underlying that city. On the contrary, there is every reason to suppose that those strata contain a very large quantity of water.

It must be clear that the amount of water carried away by the rivers from the hill country falls very far short of the rainfall, and therefore the excess, after deducting a reasonable percentage for evaporation, must find its way through the various fissures and permeable beds of the rocks over which it flows.

Percolating downwards this excess of water will saturate to a certain point the porous beds which underlie Perth, and which themselves rest on the Metamorphic and Igneous rocks, which, as already pointed out, we may infer continue from the Darling Range, and lie probably at no very great distance below the surface.

I have been assured by Richard Wynne, Esq., of Guildford, that a boring in search of water was put down near the Railway Station in which, at 36 feet, the solid rock—conjectured to be granite—was met with; marine shells of a species common on the coast at present were found in this boring just above the rock.

I have not been able to obtain full particulars of this section, but a well sunk not far off went through the following strata*:

<table>
<thead>
<tr>
<th>Section. Well near Guildford Railway Station.</th>
<th>feet.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown clay</td>
<td>... 6</td>
</tr>
<tr>
<td>Whitie brown hard clay</td>
<td>... 3</td>
</tr>
<tr>
<td>Blue clay</td>
<td>... 14</td>
</tr>
<tr>
<td>Sand with water</td>
<td>... 3</td>
</tr>
<tr>
<td></td>
<td>26</td>
</tr>
</tbody>
</table>

* Information from Mr. Wallis, well sinker.

In all probability the section in the borehole was similar to this. The chief interest that attaches to it are the finding of shells, proving that the sea or at least a river capable of supporting marine life formerly flowed over this spot; and the discovery of the supposed granitic rock.

If this be correct, the likelihood is that the same series of rocks may be found at no great depth below Perth, perhaps 400 feet at most.

In the accompanying sketch Section I have drawn a suppositions outline of the extension of the older rocks in this neighborhood. While such a disposition of strata is not only possible but likely, it must be remembered that the section, which is partly designed to show the possibility of finding a supply of water in the Perth valley, is purely hypothetical in this respect.

The water flowing down through the porous beds would lodge in the various depressions of the underlying rock; and if these be deep enough a natural reservoir may occur capable of containing a considerable quantity of water, which will rise as close to the surface as does the outer-lip of rock forming the basin.

That the porous beds of the strata underlying Perth are saturated with water up to a certain point, there can be no manner of doubt. And, failing simpler methods of obtaining a supply, I consider the sinking of a deep well would be quite justifiable. Amongst similar cases might be quoted the deep wells which have been sunk in the horizontal strata of the New Red Sandstone of Lancashire, Derbyshire, Staffordshire, and neighboring counties. These Triassic rocks are saturated with water at a certain depth, and many large manufacturing towns derive their entire supply from them. Of course in these cases pumping is resorted to, as the water does not nearly approach the surface.

I may now conclude this Report; trusting that I have entered as fully as necessary into the various reasons which preclude the possibility of an Artesian Water Supply for Perth, and have on the other hand made clear the probability of procuring water by other means at a moderate expense.

EDWARD T. HARDMAN,
Govt. Geologist.

31st March, 1885.
**Memorandum on Water Supply, Perth and Fremantle.**

**PERTH.**

Assuming that the ideas of obtaining a supply of water for Perth from the surface of the clays underlying the superficial sands, or from the lakes in the neighborhood of the city, would not be entertained, it remains to consider whether water may be found below the clays, or whether it would be necessary to fetch it from the Darling Range, there being no catch-water basin for the supply of a reservoir.

Boring has been tried already to the depth of 218 feet, without finding water, or piercing the clays. The section presents nothing but clay, specimens of which are in the Government collection here, and should be examined.* The depth shows that there must have been at that place, i.e., near the pound, as in the bed of the river, and on the West side, below Perth Water, violent disruption of the surface rocks, which seriously complicates the problem, so far as Central and West Perth are considered; but to the East the clays and superficial deposits form the banks and bed of the River Swan, and between this and the Darling Range there is no appearance of any serious dislocation. In that direction, therefore, the clays may be found of their normal thickness near the city, and, as the distance from the range would not be more than 10 miles, the thickness of the clays there is not probably great. If the estimate for Fremantle (q.v., inf.) be correct, and the general dip of the underlying rocks similar throughout the plain at the foot of the range, as its appearance seems to indicate, their thickness would probably be under 100 feet.

It is quite possible that an examination of Bennett's Brook might afford sufficient indication on this point, and so save time and expense; some useful information might also, possibly, be obtained from those who have driven piles into the bed of the Swan at Guildford, as well as from the results of the examinations of the bed of Perth water made by the late Commissioner of Public Works, and again from the position of the granite rocks in the bed of the Canning River. In both the former cases it is probable that nothing would be known beyond the surface level of the indurated clay; the latter might prove more satisfactory. Information on these points should, however, be obtained, and the results correlated before any final decision is arrived at; but from the character of the rocks at the foot of the range, as shown at Cardup and elsewhere, it may be concluded that water would be found below the clays, though there is nothing as yet known to justify the anticipation that it may be obtained by the artesian system of well-boring.

**FREMANTLE.**

With respect to Fremantle, our information is more sufficient and satisfactory, as it should seem that the whole drainage of the plain is available.

All the wells sunk through the surface limestone in East Fremantle have water at (about?) the same level, probably below the surface level of the sea, but this may easily be ascertained, say from the well at the Invalid Depot as most accessible. The rock is the same throughout, i.e., limestone formed by blown sand (Ventose). It is not yet known accurately on what this rests; but as clays, similar to those between the range and the sea, are found at the bottom of Gage's Roads and Cockburn Sound, it may be concluded that they are continuous beneath the limestones, that the drainage is on their surface, and that they must dip from the base of the range to the sea bottom. This would not give more than from 3 to 4 feet in a mile, but that would be sufficient to account for the gentle flow of water which is always observable in the wells (as above) coming from the north of east, and for the apparently inexhaustible supply of water in them. Mr. Hope, P.W. of the Convict Establishment, Fremantle, reports that the bath-house well, from which water is now supplied to Fremantle, will yield 3600gals. per hour, without exhaustion, at all seasons. It follows that a well or wells, dug anywhere through the limestone, would supply Fremantle, but it should also follow that there is no necessity to go high up the hill, unless for convenience in making the necessary reservoir in the limestone, to acquire sufficient fall, or to raise wind, if that power should be utilised, as might be most economical, for raising the water. The position of the well should therefore be determined by the quality of the rock and the elevation necessary to give the requisite fall to the main supply pipes.

The well water of East Fremantle contains, by analysis, about 5 per cent. of carbonate of lime. This, of course, might be eliminated without difficulty, if thought necessary, either in its flow from or into the reservoir, by a modification of Dr. Clarke's process; or, for domestic use, by boiling.

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* The term "clay" is not quite correct, as the lower strata were found, on examination, to be calconeous.
GENERAL.

There is yet another source of supply which suggests itself in both cases, as certainly the cheapest, if not the best, viz., by collecting the rain water falling from the house roofs in tanks. An average of 23 or 24 inches yearly rainfall would give abundance for drinking and culinary purposes, even to the smallest houses. Rain water thus obtained, at Fremantle, kept for 3 years, cannot be distinguished from that bottled this year; but there might be difficulty in avoiding waste, insuring the proper cleansing of the tanks, and care in keeping up the supply, &c.

C. G. NICOLAY,
C.E., F., 27-12-84.
PLAN
SHOWING
The more populous portions of
THE CITY OF PERTH.

To accompany Printed Paper No. 30 of 1885.
SKETCH OF SECTION
PARIS BASIN

Tertiary
Upper Cretaceous
Lower Greensand
Impervious Beds

Pari to Verdun 66 1/2 miles.

DIAGRAMATIC SECTION TO ACCOMPANY REPT ON WATER SUPPLY.

Edward T. Hartman
Govt Geologist
31 Jan 1895