Copy of Report

# Auckland Water Commission.



June, 1927.

# REPORT

To His Excellency Sir Charles Fergusson, Baronet, Knight Grand Cross of the Most Distinguished Order of St. Michael and St. George, Knight Commander of the Most Honourable Order of the Bath, Companion of the Distinguished Service Order, Member of the Royal Victorian Order, Governor-General and Commander-in-Chief in and over His Majesty's Dominion of New Zealand and Dependencies.

MAY IT PLEASE YOUR EXCELLENCY.—

Whereas by warrant dated the 11th day of March, 1927, the undersigned were directed to inquire into and report upon the following questions in relation to the water supplies for the metropolitan area and the City of Auckland:—

1. (a) Whether the sources of the existing public water supplies of the localities described in the Schedule thereto are and will be adequate for existing requirements and for future requirements during the next forty years, making due allowance for probable increase of population during that period;

(b) Should it be considered that the said sources of supply are or will be inadequate for such requirements as aforesaid, when whether such sources of supply should be augmented or replaced by any one or more of the following means:—

(i.) Extension of the existing catchment areas;

(ii.) Extension of existing waterworks (other than catchment areas);

(iii.) Adoption of new sources of supply;

(iv.) In particular the obtaining of a supply from the Waikato River or Lake Taupo.

2. (a) Whether the present sources of the said public water supplies provide a safe and potable water;

(b) If and so far as it is considered that the said present sources do not provide a safe and potable water, then the means that should be taken to render and maintain such waters safe and potable.

3. (a) Whether the methods adopted in the said public water supplies of distribution of water to consumers are satisfactory;

(b) If and so far as such methods are not considered satisfactory, then the most desirable and suitable constitutional means or form of control and management of such methods of distribution and of any methods of distribution that may be considered necessary or desirable for future requirements within the next forty years.

4. And generally to inquire into and report upon the hygienic and economic adequacy and efficiency of the said public water supplies (regarded both as to existing requirements and as to anticipated requirements during the next forty years) in respect of:—

(a) Collection and storage of water;

(b) Purification of water;

(c) Distribution of water to consumers

and such other matters arising thereout as may come under your notice in the course of your inquiries which you consider should be investigated in connection therewith.

And having regard to the local scope of the said inquiry, we were further directed to consider what sums representing the whole or any portion of the costs of our inquiry should be borne by the respective corporate bodies represented by the local authorities of the localities set out in the said schedule as set out in the said warrant, or by any of them;

And whereas we have held the inquiry as directed;

Now, therefore, we have the honour to submit the following report for Your Excellency's consideration.

## SITTINGS HELD.

A preliminary meeting of the Commission was held in Wellington by your Commissioners at 10 a.m. on Friday, 18th March, 1927, when details of procedure and course to be followed were discussed and arranged, and it was decided that the Commission should formally open at Auckland on Monday, 28th March. Accordingly, therefore, the Commission was formally opened at Auckland on the 28th March, 1927, at the Hospital Board Offices, Kitchener Street, at 11 a.m., and the Order of Reference was read.

The Commission sat at Auckland for the purpose of hearing evidence there on the 28th March, 1927; 1st, 4th, 5th, 7th, 8th, 29th, and 30th April; 2nd, 3rd, and 4th May 1927; and in the interval between the various sittings—other than the adjournment for the Easter period—the Commission visited the various districts concerned in the inquiry for the purpose of ascertaining the nature and extent of the developments of population in those districts and their situation and inspected their available water supplies and plant (if any), and, generally, for the purpose of obtaining first hand information as to the needs of the various districts so far as the water supplies were concerned.

The Commission also made careful inspections of the several catchment areas, either actual or proposed, in the Waitakerei Ranges, and visited all the water works, service reservoirs, pumping plants, and dams already erected, and visited the sites of proposed further dams of the Auckland City Council. It also carefully inspected the works at Lake Pupuke (Takapuna) and the proposed further water conservation area at Rangitopuni.

Your Commissioners also visited the watersheds of proposed additional water works in the Hunua Ranges, and visited various towns on the route of the proposed Taupo Pipe Line with a view of personally ascertaining their respective requirements and subsisting supplies.

## PARTIES.

At the sittings the following parties were represented:—

Mr. Rogerson appeared on behalf of Mount Eden Borough; Mount Albert Borough; Newmarket Borough; Takapuna Borough; and Avondale Borough; the Road Districts of One Tree Hill and Mount Roskill; the Town Districts of Manurewa, Papatoetoe, and Ellerslie; and the County of Manukau. Mr. Rogerson intimated during the course of the proceedings that the undermentioned local bodies had communicated with him asking to be associated with the parties he represented in support of the formation of the proposed Water Board: Huntly Town Board, the Borough Councils of Otahuhu, and Pukekohe, Howick Town Board, and the Glen Eden Town Board.

Mr. A. H. Johnstone appeared for the Auckland City Council; Mr. Powell, C.E., for the North Shore (Boroughs) Water Board; and Dr. Chesson, Medical Officer of Health, represented the Health Department.

Formal notice citing as parties to the inquiry were given to the following:—

The Mayor, Councillors, and Citizens of the City of Auckland.

The Mayor, Councillors, and Burgesses of the Boroughs of Birkenhead, Northcote, Takapuna, Devonport, Avondale, Newmarket, Mount Eden, Mount Albert, Onehunga, and Otahuhu.

The New Lynn Town Board, the Ellerslie Town Board, the Glen Eden Town Board, the Henderson Town Board, the Papakura Town Board, the Howick Town Board, the Manurewa Town Board, and the Papatoetoe Town Board.

The Chairman, Councillors, and Inhabitants of the Counties of Waitemata and Manukau.

The Chairman, Councillors, and Inhabitants of the Mount Wellington Road District, Panmure Road District, Mount Roskill Road District, Tamaki Road District, and the One Tree Hill Road District.

## EVIDENCE.

Full opportunity was given to all parties who had appeared before the Commission for the production of evidence, and in addition to this, advertisements were from time to time inserted in the local newspapers calling for any other persons interested, if they so desired, to attend the Commission for the purpose of giving evidence. Several persons availed themselves of this invitation and appeared, and gave evidence to the Commission.

## PREFATORY REMARKS.

Where possible the questions in the Order of Reference have been answered specifically, but we found it necessary to deal with certain of the questions stated in more or less general terms to us, by a full discussion of certain particular issues which, in the early stages of our investigations, became apparent as vital ones. We have been careful, however, to so frame our report as appears to us to fairly cover the ground which Your Excellency commanded us to cover.

Any relevant matters advanced by any one of the parties to the inquiry, even though not within the specific terms of Your Excellency's Commission, have been dealt with by us to the best of our ability.

## AREA REQUIRING SUPPLY.

The duty of your Commissioners is to consider the matter of present and future water supply to Auckland City and certain Boroughs and Town Districts named in the Schedule attached to Your Excellency's Commission, together with such other areas in the vicinity of the City as now are, or within the next forty years, will probably become so closely populated as to require a public water supply.

Now, the area that at present has, or is in need of, a public water supply, includes the areas of all the local bodies that make up the Eden County, together with the four North Shore Boroughs, the New Lynn, Glen Eden, and

Henderson Town Districts, and a portion of the Waikomiti Riding of the Waitemata County, and of the Mangere Riding of the Manukau County.

This area is co-terminous with the Auckland Urban Area as delimited by the Government Statistician, except that the Urban Area only includes portion of the Town Districts of Glen Eden and Henderson. To the above described areas should be added the Papatoetoe and Manurewa Town Districts, these town districts having no water supply, but being in need of such.

Attached to this report is a map showing the Auckland Urban Area—See Appendix "C."

The population of the districts so indicated, as disclosed by the 1926 census, is as follows:—

| | |
|---|---|
| Auckland Urban Area .. .. .. .. | 193,385 |
| Other areas named, including an estimate of 900 on account of the excluded portions of Glen Eden and Henderson Town Districts .. .. .. .. .. | 3,857 |
| | 197,242 |

The District now delimited as the Auckland Urban Area has in the four quinquennial periods, 1906 to 1926, maintained an average yearly rate of increase of 3.7 per cent, and were that rate maintained the population of the Urban Area would reach, by 1966, the total of 830,000. This estimate, of course, assumes such expansion of the boundaries of the Urban Area as the growth of the population would call for.

Auckland City in the last twenty years has experienced a period of great prosperity and development, and during the same period the Province has made remarkable strides, both in the opening up and improvement of farm lands, and in the construction of developmental works of Dominion importance. All this has been reflected in the growth of the City population.

Your Commissioners, in considering the probable increase of population in the Urban Area, formed the opinion that the rate of increase as

manifested in the last twenty years will not be maintained, and that the degree of slackening will be material. We deemed it advisable to consult the Government Statistician on this point, and, in accordance with the Commission's request, that officer supplied a statement, which includes an estimate that by 1966 the population of the Auckland Urban Area will have increased to 561,000, the estimate being based on a diminishing ratio of increase.

As far as your Commissioners are able to judge, this figure sizes up the probabilities of the case very well, and, adopting it, we estimate that by 1967 the population of the area in and around Auckland City that will have a water supply may be taken as 575,000.

The probable increase in the Urban population from 1926 to 1966, as forecasted by the Government Statistician, is equivalent to an *average* annual rate of increase of 2.7 per cent., and it is interesting to compare this figure with the figure of 3.7 per cent which we have already given as the annual rate of increase from 1906 to 1926 of the District now delimited as the Auckland Urban Area, and with the figure of 2.1 per cent which is the average annual rate of increase of the population of the Dominion from 1906 to 1926. It will be seen that we have assumed, as far as Auckland Urban Area is concerned, an average increase lower than the average for that area for the last twenty years, but higher than the average increase for the whole of New Zealand for the same period.

The Commission feels that the information supplied by Mr. Malcolm Fraser, Government Statistician, is very valuable, and his letter and a table giving the population as disclosed by the four censuses from 1906 to 1926 for the various local bodies in and around the Urban Area are included in the appendices to this report.

## CONSUMPTION OF WATER PER HEAD OF POPULATION.

Regarding present and future consumption of water per head of population, the City Engineer

gave in evidence the following particulars of water supplied from the city mains for year ended 31st March, 1926:—

| Area Supplied. | Total Supply Per Day. | Population Supplied. | Consumption Per Head Per Day. |
|---|---|---|---|
| City Area .. .. | 6,838,000 | 90,000 | 76 |
| Outside City Area | 1,345,000 | 60,000 | 22.5 |
| | 8,183,000 | 150,000 | 54.5 average |

At the North Shore the water consumption for last year averaged 47.4 gallons per head per day.

The general tendency is for water consumption in a city to increase, especially when not metered. Your Commissioners, in estimating the future requirements for the Auckland Urban Area, propose to adopt a figure of 60 gallons per head per day. That, we consider, is a liberal figure. and, with reasonable care and the avoiding of undue extravagance, the average consumption should be kept below it.

We think it, however, quite suitable as a basis for forecasting the future water supply requirements in the Auckland Urban Area, and are accordingly adopting the figure of 60 gallons per head per day as the basis.

## EXISTING WATER SUPPLIES WITHIN THE AUCKLAND URBAN AREA.

It is necessary to first give a summary of the existing water supplies in the area outlined in the first portion of this report. Commencing with Auckland City itself. The Auckland City supply is, with the exception of an emergency supply, taken from Western Springs, derived from catchment areas in the Waitakerei Ranges, which lie between the City and the West Coast. These ranges have a plentiful rainfall, which, in general terms, may be stated as 50 per cent greater than the Auckland rainfall. The catchment areas are

mostly clad with forest, and in each catchment considerable storage is provided by reservoirs formed by impounding dams.

Particulars of the existing developments, together with the Upper Huia gravity scheme, which work is in hand, and is expected to be completed by the end of 1929, are as follow:—

| Name of Development. | Area of Catchment Acres. | Storage, Million Gallons. | Estimated Yield, Million Gallons Per Day. |
|---|---|---|---|
| Waitakerei .. .. | 2,100 | 450 | 4½ |
| Nihotupu .. .. | 2,374 | 600 | 5½ |
| Upper Huia .. .. | 2,040 | 500 | 4½ |

It will be noted that the full estimated yield of the Waitakerei development will not be available until the end of this year (1927), as the work of raising the Waitakerei dam—now in hand, and which will increase the storage to the figure given—will not be completed until the end of the present year. It is thus estimated that there will be available from the Waitakerei Ranges by the end of this year a supply of 10,000,000 gallons per day, and by 1930, when the Upper Huia works are complete, a supply of 14,500,000 gallons per day. The basis on which these yields are computed is explained in a following section of this report, in which possible future sources of supply, including additional sources in the Waitakerei Ranges, are discussed, and further explanation here is not necessary.

The additional works that are in hand, and which should be completed and in operation in a few weeks from the date of this report, are the filter plants at Waitakerei and Titirangi, which are required to filter the Waitakerei and Nihotupu supplies respectively.

The only other source of supply which the Auckland City Council possesses is from the

Western Springs, situated in the western portion of the City and to the north of the Borough of Mount Albert. Up to the year 1900 these springs were, for many years, the sole source of supply to the City of Auckland, but in that year the first supply was turned into the mains from Waitakerei. As time went on, the Western Springs gathering ground was built on to an increasing extent, and the water from the Springs became subject to contamination, with the result that Western Springs was discontinued as a source of a permanent supply, and since then it has only been put into use as an emergency supply after chlorination. Western Springs has, in the past, furnished a supply of 1,000,000 gallons per day. The question of its continued use is referred to at a later stage of this report.

A number of the local bodies adjoining Auckland City have no supplies of their own, and in consequence purchase water from the City, the charge for these supplies being 1/- per 1,000 gallons as the water is delivered to the service reservoirs or mains of the local body taking the supply. The following table gives some data regarding these supplies purchased from the City:—

| Name of Body. | Population Census, 1926. | Consumption Per Day in 1926. | Consumption Per Head Per Day. |
|---|---|---|---|
| Newmarket .. .. | 3,199 | 222,000 | 69 |
| Mount Eden .. .. | 18,037 | 521,000 | 29 |
| Mount Albert .. | 17,471 | 303,000 | 17 |
| New Lynn .. .. | 2,535 | 64,000 | 25 |
| Avondale .. .. | 4,565 | 52,000 | 12 |
| Mount Roskill .. | 4,721 | 92,000 | 18 |
| Tamaki .. .. .. | 3,409 | 85,000 | 17 |
| Henderson .. .. | 963 | | |

Of the above, the Henderson Town District is outside the Auckland Urban Area.

Particulars of the water supplies owned by

local bodies, other than the Auckland City, within the Auckland Urban Area, are as under:—

| Name of Local Body. | Source of Supply. | Present Daily Supply—Gals. | District Supplied. |
|---|---|---|---|
| Onehunga Borough | Underground Stream | 800,000 | Onehunga and Ellerslie |
| One Tree Hill Road Board | Underground Stream | 224,650 | One Tree Hill |
| Otahuhu Borough | Underground Stream | 98,000 | Otahuhu |
| North Shore Boroughs | Lake Pupuke | 965,000 | North Shore Boroughs |

The underground streams described above are derived from the rainfall on the neighbouring gathering ground. This gathering ground is largely covered by lava, scoria, and cinder beds ejected from some of the volcanic cones on the Auckland Isthmus. These beds act as reservoirs for that portion of the rainwater that passes underground, and thus the yield from the underground streams is remarkably uniform. In general, the several gathering grounds are now largely built on.

The water from the above sources is pumped to service reservoirs for distribution, and is chlorinated on the way. The question of the potability and safety of these waters and of their continued use will be fully discussed at a later stage in this report.

Regarding the quantities supplied daily, as stated in the foregoing table, it should be noted that the Onehunga Borough supply is not metered, and the figure given is an estimate which is probably on the high side. The figure of 965,000 gallons per day, which is given for the four North Shore Boroughs, was the average supply per day for last year; but it will be later shown that the available average yield from Lake Pupuke is only approximately 410,000 gallons per day, or 150,000,000 gallons per year.

## PROPOSED FUTURE SOURCES OF SUPPLY.

Various sources of supply for future requirements of the Auckland Metropolitan Area have

been examined and investigated by the Commission. These are as follow:—

1. Sources of supply for the North Shore Boroughs;
2. The supply by development of additional catchment areas in the Waitakerei Ranges;
3. The supply by development of catchment areas in the Hunua Ranges, including the Mangatawhiri and Mangatangi Streams;
4. A supply from the Waikato River—
   (a) By pumping from the Lower Waikato near Mercer or Tuakau, then gravitating to Auckland City;
   (b) By pumping from Arapuni Lake to a reservoir on Mangatautari Mountain, then gravitating to Auckland City.
5. By gravitation from Lake Taupo.

These several possible sources of supply are examined in the following:—

1. Supplies for the North Shore Boroughs:

A discussion on these is left to that section of the report dealing with the North Shore Boroughs;

2. The Auckland City Council's proposals provide for the full exploitation of the following catchment areas in the Waitakerei Ranges:—

| Stream. | Area of Catchment—acres. | Proposed Storage, Million Gallons. | Estimated Yield, Million Gallons. |
|---|---|---|---|
| Lower Nihotupu .. | 3,100 | 900 | 6 million p.d. |
| Lower Huia .. .. | 3,420 | 1,200 | 8 million p.d. |
| Karamatura .. .. | 840 | 100 | 8 million p.d. |
| Whatipu .. .. | 1,360 | 300 | |
| Pararata .. .. | 1,980 | 400 | |

The above figures for catchment areas, storage and yield in these streams are those given by the Auckland City Engineer, and are based on surveys

made by him and on rainfall and run-off records taken in the Nihotupu and Huia Valleys from the years 1911 and 1917 respectively, and analysed in the light of the Auckland City rainfall records since 1855.

The City Engineer estimates that as a minimum in a dry year a run-off of 1,680 gallons per acre of catchment area per day for that year would be available, or equal to 27 inches of rainfall, reaching the streams. A good deal of evidence was given on the question of run-off, and as a result of their consideration of this evidence your Commissioners consider that the foregoing estimate is a reasonable one and sound. It must be borne in mind, however, that an unusual or unprecedented combination of dry years may be experienced, in which the yield would fall below this estimate, and if such did occur with the development of water supply closely following the growth of population, a shortage may be experienced requiring restriction of supply.

Your Commissioners desire here to point out that if by reason of an unprecedented dry period it is necessary for the local authorities to impose certain restrictions upon the use of water—such, for instance, as the forbidding of the watering of gardens by hose—it is not such a serious hardship that it cannot be undergone by the consumers of water. Moreover, such a period of drought is not altogether a disability, because when it occurs the local authorities become more active in checking waste with permanent resultant saving. The American experience shows that if there never is a check on consumption it gradually creeps up until in some of their cities it is as high as 200 gallons per head per day. It is sound water engineering practice to provide for ample water supplies for all reasonable occasions, but there comes a time when it is unsound engineering practice to have more water than sufficient for reasonable needs, because provision for more than this means capital loss until requirements reach the proper capacity of the water works.

Of the areas noted in the preceding table the City Council has acquired the whole of the catch-

ments in the Lower Nihotupu and Lower Huia Valleys. The Lower Huia is wholly under forest, and the Lower Nihotupu is partly under forest and partly old farming clearing. This latter is going back into second growth and scrub, and it is only a matter of time before forest will largely regenerate itself. Thus, these two areas will make clean and satisfactory gathering grounds.

The City Engineer supplied the following estimates of the cost per 1,000 gallons of delivering water into the City exclusive of service reservoirs and reticulation mains, but inclusive of filtration and pumping charges:—

Lower Nihotupu—5.98 pence per 1,000 gals.
Lower Huia— 7.44 pence per 1,000 gals.

These figures will be compared later with costs of Hunua Ranges and Waikato pumping developments.

In respect to the Karamatura, Whatipu and Pararata developments, all these valleys lie to the west of the Huia, and are more remote from the City. Detailed surveys have not been made, but supplies from these sources would involve expensive pipe lines along a rough coast-line, followed by pumping on the same scale as required for Lower Huia, so that the cost is sure considerably to exceed the cost of the Lower Huia development, and by comparison with other sources of supply will probably be found not to be justified. This remark does not apply with such force to the Karamatura Stream, as that is situated comparatively close to the Huia Valley; but even here the probable extra cost of development is likely to cause the Karamatura scheme to be put aside on the score of too high a cost in comparison with other developments.

3. The headwaters of the Mangatawhiri, Mangatangi and Wairoa streams are situated in the Hunua Ranges distant in a direct line in a south-easterly direction 30 miles from Auckland City. These ranges are of a greywacke formation, rising to a maximum elevation of 2,140 feet, the two main streams, the Mangatangi and the Mangata-

whiri, flowing south-west and entering the Waikato River at Mercer.

The City Council has carried out exploratory work in this area, but no detailed survey has been made. The City Engineer has supplied levels and plan showing that a gravitation supply to the Khyber Pass service reservoir can be obtained, length of aquaduct from the more distant Mangatangi stream being 38½ miles. He estimates the yield, etc., from these two valleys as follows:—

| Stream. | Area of the Proposed Catchment-Storage. | Estimated Yield. |
|---|---|---|
| Mangatawhiri | 4,800 | 1,400 } 23 million gallons |
| Mangatangi | 5,400 | 1,800 } daily |

The Mangatangi area at present is wholly under virgin bush, and the Mangatawhiri is partly under bush and partly under farm clearing. The estimate of yield is based on a comparison of this country in respect to elevation, topography and aspect with the Waitakerei Ranges, and though, in the absence of any rainfall records and run-off gaugings, this may suffice for a preliminary examination, it is nevertheless most important that steps be taken at once to establish adequate rain recording stations and run-off gauging stations.

The City Engineer estimates the cost of development as follows:—

| Development. | Capital Cost. | Cost per 1,000 Gallons. |
|---|---|---|
| First Stage of Mangatawhiri .. .. .. | £1,600,000 | 7.54 pence |
| Complete Stage of Mangatawhiri and Mangatangi .. .. | £1,100,000 | 5.70 pence |
| | £2,700,000 | |

Your Commissioners have checked these estimates as far as can be done with the information available, and they appear to be sound.

Some information regarding the utilisation of the Mangatangi stream and a suggestion regarding the location of the pipe-line were supplied to

the Commission by Mr. J. F. McArthur, Engineer to the Franklin County Council. This proposal certainly appears worth examining further, and this, no doubt, will be done when detailed surveys are being made.

Your Commissioners are satisfied that these areas afford a potential source of water supply of high standard, and the quality of the water is confirmed by analysis, both bacteriological and chemical.

4. The Waikato River is originally derived from Lake Taupo, but the very large area that it drains is in the main settled and farmed, and in its basin there are some large centres of population. The volume of the river is largely increased as it progresses towards the sea, so that by the time Mercer is reached, its volume is a considerable number of times its volume as it leaves Lake Taupo. The water as it comes from the Lake may be taken as a pure supply which would not require filtration; but at Mercer it would require filtration, and probably chlorination. Subject to these two requirements, the Waikato River at Mercer is a pure supply, because it can by modern methods be made a safe and potable water of first quality. It becomes, therefore, a question of balancing cost of supply from the Waikato at or near Mercer against other possible sources of supply.

(*a*) The point nearest to Auckland from which a supply from the Waikato River could be taken is near Mercer or Tuakau. There would not be a great deal of difference in the cost of water as supplied from a development at either of these localities, and choice would be made as the result of detailed surveys.

To enable a direct comparison to be made with the cost of bringing a supply from Mangatawhiri to the City, a supply from the Waikato River equal to delivering an average of 11,000,000 gallons per day was estimated for, that being the quantity that the Mangatawhiri is assumed to yield.

Assuming electric current to be available at £8/10/- per kilowatt year, and providing for

storage reservoirs at proper elevations near the Waikato River, and at One Tree Hill of a total capacity of 25,000,000 gallons, and estimating on a main of a capacity of one-third in excess of 11,000,000 gallons daily to provide for seasonal variations in draw-off, your Commissioners estimate the cost, including all charges of water pumped from the Waikato near Mercer, delivered into City service reservoirs, at 7.70 pence per thousand gallons. This includes cost of chemical and mechanical purification of the water.

This figure is not materially different from the figure of 7.54 pence per 1,000 gallons given by the City Engineer as the cost of the first stage of development in the Mangatawhiri Valley. A slight advantage in this respect is with the Mangatawhiri development, but this point will be further commented on in a following portion of the report.

Included in the estimates submitted to your Commissioners on behalf of the local bodies advocating a Water Board was one for an emergency supply of 3,000,000 gallons per day by pumping from the Waikato River at Mercer, the water being delivered through a 15,000,000 gallon main to be laid from Auckland to Mercer as the first section of the 42 inch main to Taupo. The cost of this emergency supply on the assumption that the full 3,000,000 gallons were delivered and consumed is shown on this estimate to be approximately 8.5 pence per 1,000 gallons.

This estimate of cost is much too low, the several portions of it being each under-estimated. For the conditions stated we find that the cost of this emergency supply would be over 18 pence per 1,000 gallons, the chief reason for this high cost being that as a temporary measure a long main of 15,000,000 gallons capacity, involving huge capital expenditure, was to be utilised for a supply of one-fifth of capacity of main.

We have indicated that the cost of an 11,000,000 gallons per day supply from the Lower Waikato would be approximately 7.7 pence per 1,000 gallons. We desire to add that for a supply of a

greater or lesser amount than the one assumed, that is, of 11,000,000 gallons per day, the total capacity and working costs would vary approximately with the amount of supply, assuming the various portions of the works were designed for a capacity equal to that proposed supply. Thus under those conditions, the cost per 1,000 gallons of a Lower Waikato pumping scheme remains fairly constant, noting that for a supply less than 11,000,000 gallons the cost per 1,000 gallons would be rather more than, and for a supply over 11,000,000 gallons per day, rather less than that for the cost per 1,000 gallons in the 11,000,000 gallons per day typical case.

(*b*) In respect of the Provisional Committee of the Proposed Auckland Provincial Water Board, an estimate of cost is submitted for a supply to be obtained from the Lake formed above the dam now being built across the Waikato River in connection with the Arapuni hydro-electric development.

Your Commissioners, in investigating this proposal, made investigations on the basis of a supply of 11,000,000 gallons per day for the purposes of comparison with the Mercer pumping scheme, and with a supply from Mangatawhiri, as already discussed.

This supply from Arapuni involves pumping, and the water must be lifted from the surface of the Arapuni Lake to a reservoir on Maungatautari Mountain to a height identical with the height water must be lifted from the Lower Waikato River, near Mercer, to deliver to the nearby elevated reservoir for gravitation to Auckland City. Thus the cost of pumping at Arapuni is directly comparable with the cost of pumping from the Lower Waikato, with this exception, that as water would be taken from the Lake created for power purposes the quantity of water available for power generation would be reduced by the amount of daily draw-off for water supply purpose. It is probable that the Government would have to increase its charges for current supplied for water pumping purposes by an amount to compensate it for this loss. However, this is at

present indefinite and intangible, and no account is herein taken of this probable extra charge.

In the Arapuni Lake the water would be held there under storage for an average period of eight or nine days, this assisting to maintain its purity. As, however, there will be a public reserve surrounding the whole of the lake, sterilisation of the water to take care of possible contamination would be necessary. The cost of this, however, would be relatively small.

The distance from Mercer to Arapuni is approximately 83.5 miles, so that the cost of a supply of 11,000,000 gallons per day from Arapuni would exceed the cost of a similar supply from the Lower Waikato by the daily charges on account of the capital, renewal and maintenance expenditure of 83.5 miles of 39-inch high pressure main, with the necessary bridging, break pressure, reservoirs, etc.

Your Commissioners estimate that the foregoing supply of 11,000,000 gallons per day from Arapuni would cost 7.0 pence per 1,000 gallons more than a similar supply from the Lower Waikato, making its cost delivered to the City reservoir 14.7 pence per 1,000 gallons, as against 7.7 pence for a supply from the Lower Waikato. This ratio of cost would generally hold in respect to a supply greater or lesser than the one assumed, and it thus affords a fair basis of comparison.

## PROPOSED SUPPLY FROM LAKE TAUPO.

5. Your Commissioners now come to the question of a supply from Lake Taupo, which proposal is the essential part and purport of the report submitted to and adopted by the Provisional Committee of the proposed Auckland Provincial Water Board.

Counsel for the group of local bodies favouring the formation of a Water Board led evidence from responsible officers of the Provisional Committee of the proposed Board to the effect that a supply from Lake Taupo was not a matter for the present, its magnitude and cost making it premature, but that a supply from Lake Taupo might be brought to the City in the more or less distant future.

There are certain aspects of the Lake Taupo scheme, for instance, the boldness of the scheme, the magnitude of the proposed works, the clearness of the water, its inexhaustible quantity, and its presumed safety as a potable water, and the fact that a long conduit reaching from Taupo to Auckland City would be available for supply to many local bodies and people *en route*, and these aspects, from their very nature, appeal to the imagination and tend to create a feeling in the public mind that a water supply from Lake Taupo would be a splendid thing and worthy of the important district it would serve.

Your Commissioners have, therefore, examined the Lake Taupo project with some care. The report to the Provisional Committee of the proposed Water Board contains an estimate of the approximate cost of bringing in a supply of 15,000,000 gallons daily to Auckland City. This estimate is given as £2,482,000. On investigation this estimate is found to have been framed making omissions in certain important respects and underestimating in others, so that its value is heavily discounted.

The route selected by the Engineers reporting to the Provisional Committee involves a tunnel ten miles in length between the intake works and where the aquaduct enters the Mangakino Stream. This tunnel was estimated to cost £220,000, or just over £4 per lineal foot, the proposal being to carry the steel main through this ten-mile tunnel, which was to have dimensions of 7ft. x 6ft., and it was not considered necessary to line the tunnel.

Your Commissioners consider the construction of a ten-mile tunnel of such small dimensions is impracticable, because it is unsound as an engineering proposition, and it would be impossible to place the proposed water main in it.

Your Commissioners consider the tunnel should have finished internal dimensions of not less than 9ft. wide, and a cross sectional area of not less than 72 square feet, that the tunnel should be concrete lined and act itself as the conduit, instead of merely having a steel main placed therein. Such a tunnel would cost at least £1,000,000 if

the conditions were reasonably favourable for construction.

Even a layman should be impressed by the fact that a tunnel of such length introduces factors of difficulty in construction, and of multiplied costs that are not known in tunnels of the length constructed in this country, and the small size of the proposed tunnel would add to the difficulty. The greater part of the tunnel would have to be built from a series of shafts sunk from the surface above, and the depth of these, according to the section supplied by the Engineers reporting to the Provisional Committee, would vary from 200 feet to 400 feet in depth.

There is the need for provision of adequate ventilation plants, of pumping plants for handling the water met with underground, the provision of adequate hoisting apparatus, and of special plant for underground transport. There is also the cost of an electric generating station to provide power for operating the plant, or, alternatively, of bringing of power from Arapuni, which would involve the cost of a 25-mile high tension transmission line.

There is the likelihood of considerable underground water having to be dealt with, and the possibility of bad ground being encountered. All these considerations make the tunnelling proposal one of great magnitude.

Your Commissioners have estimated the cost of the tunnel at £1,000,000, but express a doubt as to whether a tender as low as that would be received if tenders were invited.

The estimate supplied to the Provisional Committee of the Provincial Water Board only allows a sum of approximately £4 per lineal foot for the cost of making this great tunnel, and, in the Commissioners' opinion, the estimate on this basis is so small as almost to justify the term "fantastic."

Dealing with the other portion of the estimate, in our opinion the cost of the steel main in place is under-estimated, and little or no allowance appears to have been made for housing of staff, extensive bridging required to carry the main over

the various rivers and swamps met *en route*, telephone lines and roading.

Your Commissioners consider that to contruct a conduit to bring in a supply from Lake Taupo of 15,000,000 gallons per day to Auckland City on the lines proposed by the Provisional Committee would cost not less than £5,250,000.

It is well known that in any water supply system there is considerable seasonal variation in the demand upon or draw-off from such system. So that, a main built to carry 15,000,000 gallons per day would be doing full duty when it delivers an average of, say, 12,000,000 gallons per day throughout the year. Therefore, the cost of the foregoing Taupo development, on the basis of an average daily supply of 12,000,000 gallons, allowing for operating, maintenance, and renewal charges, as well as for capital charges, is over 19 pence per 1,000 gallons. It is also clear that a very long period would elapse while the demand upon such a huge supply was growing up towards the maximum it was designed for, and during such period the burden of the cost would be a crushing load upon the district it had to supply.

It is not certain that a water supply, pure and tasteless as the Taupo water would be at the intake end, would be delivered to the City after a journey of 150 miles through a steel main in that same desirable condition. Both the colour and the taste may be detrimentally affected after such a long passage through a steel conduit. This conclusion derives support from some of the English and American experiences.

Unfavourable features of the Lake Taupo scheme are the possible risk of great damage to, or failure of, the long tunnel by reason of earthquake shocks, or other earth movements; also the risk of interruption of supply by failure of such a long main at some one point in its length.

These risks of interruption or failure of the supply are there, and must be allowed for, and unless there were no reasonable alternative present, these disabilities are such that even if the

cost did not veto such a scheme, the hazard attendant thereon would. Ordinary prudence would also require the duplication of the main, but if the cost of the original proposal were not to veto it, this additional cost would certainly do so.

It will be shown further in the report that towns and boroughs in the Waikato Valley either have no need of water from Taupo, or could not take supplies from such a source because of excessive cost. Therefore the Taupo Scheme and the Arapuni Pumping Scheme can only be considered in reference to a supply for Auckland and its surrounding district, and each must stand or fall by comparison with the Lower Waikato Pumping Scheme or the Mangatawhiri and Mangatangi Development.

We consider that on all grounds both the Arapuni and Taupo Developments are absolutely out of the question, and that the cost of water supplied from either would at the most favourable stage be, in the case of Arapuni, double, and in the case of Taupo, materially more than double, the cost of a supply from either the Lower Waikato or from the Hunua Ranges catchments.

Dr. R. H. Makgill, Advisory Medical Officer of Health, in his evidence, dealt with the question of a water supply for Auckland City from the Waikato River or from Lake Taupo, and as he speaks with authority on matters such as water supply, we propose to quote such portions of his evidence as deal with the matter now being considered. Dr. Makgill says:—

> "When the Waitakerei catchment area has been fully exploited, another valuable source of pure upland surface water within easy reach of Auckland is presented by the Hunua Ranges, and it would be a wise policy to secure this area as a water supply reserve at an early date, before the presence of settlement renders it liable to pollution. In the end recourse must be had to the Waikato River, which will entail filtration and the expense of pumping. I cannot regard as

otherwise than extravagant the suggestion to tap this river in its upper reaches. There is a certain charm in looking on Lake Taupo as a great natural reservoir, but, apart from the engineering difficulties and costs, the water from this lake is—theoretically at least—not so safe as that from the Waitakerei Ranges, owing to the large native population living on its banks. In actual practice the danger from this source is—owing to the large volume of water in the Lake—very remote. But consideration of this point detracts from the somewhat sentimental enthusiasm as to the purity of the Lake displayed by the advocates of this means of supply. In my examination of the Waikato water the presence of suspended mineral matter was always noticeable. Probably this is derived from the pumice lands through which it flows, and its presence will necessitate treatment from whatever point it may be drawn. If all the towns and villages between Lake Taupo and Auckland are to obtain a share of the water—as some enthusiasts predict—it would mean that a large part of the river must be diverted into an artificial channel—a conduit of such size as to constitute almost a duplicate of the existing river. . . . . If a fraction of the proposed expenditure on a vast pipe-line from Taupo were to be devoted to minimising the pollution of the Waikato River by drainage from towns and villages on its course, and to the preparation and administration of purifying beds at the point from which the water is to be taken, the resultant would be a water of greater purity and safety than that afforded by the Lake.

"When one considers what has been done in the direction of purifying the Thames and other rivers in England by means of filtration beds, the cleansing of the Waikato in its lower reaches does not appear as a serious problem."

## COMPARISON OF PRACTICABLE SOURCES OF SUPPLY.

As both the supply from Lake Taupo and a supply from Arapuni by pumping are shown to be unjustifiable and impracticable on economic grounds, the possible sources of future supply for the Auckland Urban Area are now summarised as follow:—

| Source of Supply. | Estimated Yield. | Estimated Cost per 1,000 Gallons. |
|---|---|---|
| Lower Nihotupu Pumping .. | 6 million gals. daily | 5.98 pence |
| Lower Huia Pumping .. | 8 million gals. daily | 7.44 pence |
| Mangatawhiri and Mangatangi | 23 million gals. daily | 7.54d. for 1st stage & 5.70d. for complete stage |
| Lower Waikato Pumping .. | Unlimited | 7.70 pence |

It has already been emphasised that figures quoted for the Mangatawhiri and Mangatangi developments are provisional and based on preliminary investigations only, and that proper gauging stations should be established in those valleys and that detailed surveys should be put in hand.

We are satisfied that, following on the completion of the Upper Huia gravity scheme (which work is now in hand by the City Council), the Lower Nihotupu pumping development should next follow. But in respect to the others, a final judgment can hardly be made till more dependable figures as to yield and cost of development of Mangatawhiri and Mangatangi are available, and the cost of the Lower Waikato Pumping has been more fully investigated.

Assuming, however, that figures given are sufficiently correct, it is seen that the cost per 1,000 gallons of the full development of the Mangatawhiri and Mangatangi will be considerably below the cost of the Lower Huia pumping. Hence, there would be good reason for deferring the Lower Huia and going on with the Hunua Ranges

Development. The location of the main from the Mangatawhiri catchment would be admirably situated for a supply to the areas between Papakura and Penrose and between Panmure and Remuera. There is every reason for anticipating that the growth of population in these areas in the coming years will be most marked. There is the further point that the water supply to the Auckland Urban area would be better balanced and be more secure against serious interruptions if brought in from two entirely different areas.

Comparing now the Lower Waikato Pumping proposal with the gravity development of the Mangatawhiri and Mangatangi catchments, the preliminary estimates quoted indicate that the cost of the first stage of the latter up to the limit of the Mangatawhiri yield is likely to be cheaper than an equivalent supply by pumping from the Waikato, but that when the complete stage of the supply from these upland catchment areas is reached, the cost of that supply will then have fallen materially below the cost of an equivalent supply from the Waikato River.

Attention, however, must be drawn to the fact that the whole of the sewage of the many boroughs and other centres of population in the great basin of the Waikato either at present is, or in the future will be, discharged direct into the river or its tributaries. A river such as the Waikato has great capacity for self-purification; and, in addition, the treatment plant at the Lower Waikato Pumping Station would be fully able to supply a water satisfactory in all respects. Nevertheless, sentimental and aesthetic considerations would demand that once the Waikato were adopted as a source for such an important water supply as that now discussed, proper sewage treatment plants would have to be installed, in all cases, before sewage would be allowed to continue to discharge into the river. Such a demand might receive some support from considerations of hygiene.

The cost of such sewage treatment cannot, at this stage, be estimated, but it would add somewhat to the cost to the general community of

supplying Auckland City with water from the Lower Waikato River.

That consideration at least indicates that, if there is no great difference in the actual cost of two water supply schemes, a supply from a clean forest-clad upland area, such as that of the Mangatawhiri and Mangatangi catchments, would be chosen before a supply from a river the development of which would involve a demand upon the inhabitants of the river valley that they incur costs to put their sewage treatment works in order.

The Commission therefore concludes, from an examination of all data before it (subject to confirmation as a result of the surveys and other detailed investigations needed into the matter of yield and cost, of supply from Hunua Ranges and cost of supply from Lower Waikato River) that the supply in the Hunua Ranges should be developed before the Lower Waikato be resorted to.

We again stress the importance of a full investigation without loss of time into the Hunua Ranges catchments, as a decision on the question as to whether the Hunua Ranges Development should precede or follow the Lower Huia Pumping Development depends on this investigation, and further, if the investigation confirms that the Hunua Ranges Development should come before any development from the Lower Waikato, then it is most important that steps be taken to secure the reservation of all bush-clad portions of both the Mangatangi and Mangatawhiri catchments before further bush-felling is done. The importance of this cannot be overstated. As previously pointed out, the whole of the Mangatangi catchment and most of the Mangatawhiri catchment is under virgin forest, and to allow this forest to be cut with the prospect of the area being required for water conservation purposes would be lamentable and its effects irreparable.

Regarding the population that can be served from the schemes that are discussed in the foregoing, we can take it that the existing supplies of the city and the other local bodies in the Auck-

land Urban Area, excluding the North Shore Boroughs, are barely sufficient to supply the present population of, say, 170,000 people, and that the position will not be safe till the Upper Huia works now in hand are complete, but by the time the latter are complete, a safe supply for a population of 265,000 on the basis of 60 gallons per head per day will be available—this is assuming that the One Tree Hill and Onehunga Districts continue the use of their underground sources of supply.

Then, taking the yield of Lower Nihotupu at six million gallons daily, Hunua Ranges as twenty-three million gallons daily, and Lower Huia as eight million gallons daily, a total of thirty-seven million gallons daily, these quantities would, on the same basis of 60 gallons per head per day, provide for a supply to an additional population of over 615,000 people, or for a total population within the area of supply of 880,000. This number is far in excess of the probable population as in 1967, or the end of the forty-year period mentioned in the Commission's order of reference. The Commissioners consider that by 1967 the population within the area to be served may be estimated at 575,000; this figure, of course, includes the population of the North Shore Boroughs, which may be supplied from Rangitopuni.

It does not appear to us that we can analyse the position any further or throw any more light on the matter except to remark that the successive stages of development of the water supply to such an important and growing district as the Auckland Urban Area must be planned well in advance, and then carried out sufficiently far ahead of actual requirements so that a period of shortage, or of insufficient supply to meet requirements, cannot arise.

## NORTH SHORE BOROUGHS' WATER SUPPLY.

The four North Shore Boroughs of Devonport, Takapuna, Northcote and Birkenhead have wholly derived their water supply, up to the present, by pumping from Lake Pupuke.

The Commission is of opinion, from the evidence and data before it, and from its study of the locality, that this Lake derives its water from the rainfall upon the Lake and upon the immediately adjoining catchment. The level of the Lake varies according to the annual rainfall and the draw off by pumping. During recent years the level has been falling, and in the period from January, 1922, to March, 1927 (five years two months), it has fallen six feet six inches—this in spite of the fact that the Auckland rainfall during that period averaged 53 inches, or 23 per cent. more than the average since the year 1855. In March of this year the level of the Lake surface was only one foot above mean high water.

In 1912 the late Mr. H. E. Metcalfe, M.Inst.C.E., estimated that the average yield of Lake Pupuke was about 200,000,000 gallons, and in 1927 Mr. F. E. Powell, C.E., in the light of the further experience, estimates that the available supply in a year of average rainfall is from 130,000,000 to 150,000,000 gallons yearly. Taking this latter figure, the Lake can supply a population of 8,200, based on a consumption of 50 gallons per head per day.

The population of the four Boroughs, according to the 1926 census, was 21,254, and the total quantity of water pumped for the year ended 31st March, 1927, from the three pumping stations now in operation was 352,000,000 gallons. This quantity is close on to two and a-half times the average quantity that can be yielded by the Lake per year, unless the Lake level is progressively and continuously lowered. It is obvious that it has only been possible to meet requirements from the Lake supply because of the recent and continuing cycle of years of rainfall, much over the average, and because the level of the Lake has been steadily lowered as a result of the excess draw off. It has been feared that were the Lake level to fall below sea level, there would be an inflow of sea water, which would destroy the potability of the Lake waters, and

while, for reasons which it is not necessary to go into here, it seems improbable that such flow of sea water would take place, your Commissioners consider it quite wrong and unsound to maintain the North Shore water supply by drawing upon the reserve of water in the Lake.

Your Commissioners comment that the consumption per head by the present population will receive augmentation in the next year or two, as the important growing Borough of Takapuna has in hand the installation of its Sewerage System, and this will be completed within that period. As against that, it is noted that the Borough of Devonport takes from the Lake approximately 77 gallons per head per day, as against approximately 30 gallons per head per day for the other three Boroughs.

This difference appears to be largely due to excessive waste within the Devonport Borough, owing to defective plumbing or to a leakage from its mains, and steps should at once be taken to reduce this loss, for, apart from the cost to the Borough of supplying water thus wasted, there are urgent reasons for conserving the available water as much as possible.

An adequate review of the present position of the North Shore Water Supply must take into account the continued rapid growth of population in the North Shore Boroughs, and that the cycle of wet years lately experienced in Auckland may be followed at any time by dry years, or even by years of average rainfall, when the Lake level would fall at a much faster rate than it has done since 1912.

A consideration of all the facts or conditions discussed in the foregoing amply indicates that the position of the North Shore Boroughs is very critical, and will become increasingly so till the supply is augmented.

Before dealing with the source of a new supply, the past and probable future growth of these marine suburbs will be examined. In 1906 the population of the district, now constituted into four Boroughs, was 8,343, and in 1926 the

population had grown to 21,254, the average yearly rate of increase being 4.8 per cent. If that rate of growth were maintained by 1946, the population would have grown to 54,200, and by 1966 to 138,000.

Such a rate of growth appears beyond the bounds of any reasonable possibility, and we consider it sufficient to anticipate that by 1967 the population of the four boroughs, with such increase to their territories as may take place, may have reached 65,000 persons, this giving approximately the same average annual rate of increase as in the case of the forecast of the increase in population of the Auckland Urban area during the next forty years.

Such extension of territory may include some of the bays north of Takapuna Borough. It appears that the population of these bays in the summer holiday season is in the vicinity of 5,000 persons. Sooner or later these bays must have a water supply, and the rational course appears to be the provision of a supply from the North Shore Boroughs as soon as the need for such arises.

At first glance it may appear that the forecast of an annual rate of growth of 2.7 per cent., as against the rate for the last twenty years of 4.8 per cent., is unduly conservative. But it must be remembered that the North Shore is in the main a residential area for people with daily occupations in the City. The lack of connection to the railway system, and the retarding influence of transport across the Harbour, will prevent any great industrial development on the North Shore. Then, considered as a residential area, it is the sea frontages that are so desirable, and the questions of distance, loss of time and increased cost of transport as building extends out from ferry termini will have a retarding influence. It is in view of these considerations that we have adopted the figure of 65,000 as our estimate for the probable population in 1967 on the North Shore.

## PROPOSED NEW NORTH SHORE SUPPLY.

Several proposals for augmenting the Lake Pupuke water supply have been investigated since 1912. Data and plans in reference thereto were supplied to your Commissioners, who had the advantage of the evidence and well thought out opinion of Mr. F. E. Powell, Consulting Engineer to the North Shore Water Board. Of these, the two that merit consideration in view of the requirements of the district are the Rangitopuni Scheme and a supply from the Auckland City Council's Waitakerei Dam.

The Rangitopuni Scheme proposes a dam on the Rangitopuni Stream at such a point as would furnish a catchment area of 12,500 acres. It is proposed for the first stage to construct the dam at such a height as would impound 300 million gallons. Of the catchment area, the great bulk is open country, and most is under freehold tenure. Generally it is suitable for farming purposes, and though at present farming is carried on to only a limited extent, the land is considered suitable for much more intensive farming, and its situation is very favourable for this. Owing to the low elevation of the valley, this scheme involves pumping the water to a reservoir to be placed on Pukeatua Hill, from which water would gravitate to the service reservoirs in the several Boroughs. The estimate provides for acquiring some 1,327 acres surrounding the reservoir site, leaving the remainder of the area for farming purposes. The estimate also provides for chlorination and dechlorination.

The Rangitopuni Proposal, as placed before the Commission, proposes a main capable of delivering just over 2,000,000 gallons per day to the area to be supplied. On the basis of delivering 1,000,000 gallons per day, it appears that the cost of water delivered in the service reservoirs would be 15.0 pence per 1,000 gallons, and when the consumption increases to 2,000,000 gallons, the cost would reduce to 9.0 pence per 1,000 gallons.

## SUPPLY FOR NORTH SHORE FROM WAITAKEREI.

The Auckland City Corporation has offered the North Shore Boroughs' Water Board a supply of filtered water at 6d. per 1,000 gallons at the break pressure tank at Waitakerei. The Board would then have to construct a main—18-inch main proposed—to Birkenhead reservoir, and branch mains to the service reservoirs of the other Boroughs. This main would deliver over 2,000,000 gallons per day, and the cost of water from this source delivered to service reservoirs is estimated by the Commission at 16.6 pence per 1,000 gallons for a supply of 1,000,000 gallons per day, and at 11.3 pence for a supply of 2,000,000 gallons per day, these figures including the City Council's charge of 6d. and capital and maintenance charges in connection with the proposed additional capital expenditure.

Collecting these figures for the purpose of comparison, we have estimated the cost per 1,000 gallons as follows:—

| Source of Supply. | 1,000,000 gallons per day supply. | 2,000,000 gallons per day supply. |
|---|---|---|
| Rangitopuni .. .. | 15.0 pence | 9.0 pence |
| Waitakerei .. .. | 16.6 pence | 11.3 pence |

The above figures are derived from estimates supplied by Mr. Powell as to the cost of the two proposals; these estimates were checked and concurred in as being sound, and they indicate that water from Waitakerei will cost about twopence (2d.) more per 1,000 gallons than water from Rangitopuni. The supply of water from Rangitopuni would have the further advantage that it would make the whole supply to the several North Shore Boroughs self-contained and self-owned. The Rangitopuni Main would also be well situated for supplying the very considerable population that is developing at the various bays on the seaboard north of the Takapuna Borough. As a further advantage, the Rangitopuni development would materially postpone the time when Auckland City has to go further afield on a

scheme of greater magnitude than any it has yet undertaken.

On the other hand, the scheme provides for leaving the catchment area—except 1,320 acres—in private hands, and it would continue to be farmed, and the tendency will be for farming in the future to be carried on more intensively than at present. There is also an important system of roads running through the centre of the area. It has to be pointed out that the catchment area is far from being a good one. It is open country, clay formation, and the run off would be described as "flashy." In heavy continuous rains the run-off would be a high proportion of the rainfall, but in a long, dry summer it would become very low. The point of this last comment is not that the catchment would not give the yield needed—it being possible to provide all the storage that the present and future needs of the district to be served will need—but when the run-off is so low, the reservoir would lack the refreshing and aerating influence of a more vigorous stream.

A modern treatment plant, well managed, will, however, produce a perfectly safe water from the Rangitopuni reservoir; but this reservoir at the water level proposed for first development, having an area of 190 acres for the storage of 300 million gallons, has an average depth of but six feet. With its small depth, its gradually shelving bottom, and the relatively high summer temperature of the water, the reservoir will be subject or liable to excessive growth of aquatic vegetation, and algae will flourish. These can be controlled at some expense, by, for instance, a copper sulphate or bluestone treatment of the reservoir waters, but the reservoir waters are likely to have a high content of vegetable matter, and this condition may adversely affect the taste of the water.

A proper filtration plant will effectively rid the water of the presence of the suspended vegetable matter, and result in a clear water. Your Commissioners consider that, rather than

the installation of chlorination and dechlorination plant, the scheme calls for an up-to-date filter plant alongside the draw-off from the dam, operated with a suitable coagulent and perhaps with excess lime treatment, the lime acting as a sterilising agent. With proper management of a plant such as this, in conjunction with fair sedimentation in the reservoir, there is likely to be no need for chlorination. There is the further possibility that chlorination is liable to accentuate whatever taste may be due to the presence of algae in the waters of the reservoir, and for that reason may be undesirable unless essential.

This discussion will indicate to the Board certain possible unsatisfactory features of Rangitopuni water in respect to taste or palatability, which may have to be dealt with, and the Board will, no doubt, understand that the history of water supply undertakings contains information of much successful work of this nature. However, the Rangitopuni water may not on treatment be up to the standard of filtered Waitakerei water, and it should be remembered that the prospective consumers have been used to the Lake Pupuke water, which (except when suffering from an overdose of chlorine) is of the highest standard in respect to taste.

Still, 2d. extra per 1,000 gallons is a large sum to pay for Waitakerei water, as against Rangitopuni water, and the Board is advised to look further into the question of the taste and method of treatment of Rangitopuni water before coming to a final decision on the question of Rangitopuni *versus* Waitakerei. A simple calculation will show the Board that, on the basis of the estimated difference in cost given a little earlier in this report, a total consumption of one million gallons daily in the four Boroughs means a difference in annual cost of £2,433 as between Rangitopuni and Waitakerei, and when the consumption becomes two million gallons daily, the difference in annual cost increases to £6,995.

The question of the selection of the Waitakerei scheme as against the Rangitopuni scheme resolving itself into one of price, as against quality, is peculiarly one for the ratepayers of the North Shore themselves. We can carry the matter no further than by stating that if we were ratepayers of North Shore and the question were submitted to us, we most likely would answer: "We will take the cheaper article and risk the quality." But North Shore ratepayers may prefer to pay a higher price for a possibly better article.

The Commission, however, again emphasises that the position in respect to the supply from Lake Pupuke is sufficiently critical as to make it imperative that steps be taken to bring in the new supply without further loss of time.

Lake Pupuke is, however, too valuable a source of supply to discard, and it should be retained not only for use in emergencies, but as a permanent part of the water supply of the North Shore. The questions of control and necessary safeguards are discussed in what follows. In recommending the utilisation of the Lake as a permanent supply, we are fully aware that once a new supply commences to deliver water, the saving in continuing to pump from the Lake would only be the difference between the Lake pumping and operating costs and the pumping and operating costs of the new supply if from Rangitopuni, or of the City Council's charge of 6d. (sixpence) in the case of a Waitakerei supply. Still, the saving should be worth while. Then, as the demand on the new supply grows up to the limit of its capacity, Lake Pupuke water would have its full value as an independent supply.

## CONTROL OF LAKE PUPUKE AND FUNCTIONS OF WATER BOARD.

At the present time the Lake has built on its shores three separate pumping plants belonging, respectively, to Devonport, Northcote and Birken-

head Boroughs. Devonport pumps water into the Takapuna Borough's mains.

Three pumping plants, with three separate engineers in charge, and their separate assistants, and three separate chlorination plants are all operating to supply the needs of some 21,000 inhabitants, all of whom are residents of the northern side of the Auckland Harbour. The members of your Commission are all resident in the south, and can claim to view this matter with an entirely impartial eye.

We see four separate Boroughs, comprising some 21,000 people, all having what should be community of interest, yet these four boroughs are separated by more or less arbitrary boundaries, and require the paraphernalia of four mayors, four sets of councillors, four town clerks, with four sets of officers and staffs, and three sets of water engineers, to manage the municipal affairs of these people. Superadded to these, they have also a Water Board, created by Statute (The North Shore Boroughs [Auckland] Water Supply Act, 1924), to concern itself particularly with the welfare of the Lake and to endeavour to augment their water supplies.

Some day the question of the whole of these Boroughs amalgamating with Auckland City, and becoming part of Greater Auckland, may come up for serious consideration. But at the present time it was not mooted to the Commission, and we may take it that such an amalgamation may be taken as entirely remote from consideration in the near future.

The North Shore Boroughs may, with considerable cogency, claim that there is not at present such a community of interest with Auckland as would justify serious overtures in the direction of amalgamation. In this respect it may be remarked that on the Auckland side of the Harbour there are some Boroughs which are in a position very different from that of the North Shore.

The four North Shore Boroughs are already united upon the question of control of Lake

Pupuke and upon the question of augmenting the water supply to the North Shore. The North Shore Boroughs (Auckland) Water Supply Act, 1924, provides for this, and the Water Board is composed of representatives of these four Boroughs. It is obvious, therefore, that community of interest on the question of water, at least, is admitted.

If it be true that there is community of interest as far as water is concerned, it appears to your Commissioners that the whole circumstances in relation to these four Boroughs and their situation and needs all point to the desirability of early steps being taken to secure amalgamation. We are of course ignorant upon such questions as comparison of rating burdens, liability for loans and other like matters, but it does appear to us that if amalgamation is possible, then efforts should be made to bring it about. Were it done, then all questions as to control of the Lake, the provision of an augmented water supply and questions of possibly conflicting rules or by-laws as between individual boroughs, and as between the Boroughs and the Water Board, would more or less quickly be composed.

It seems to your Commissioners that the first steps toward the improvement of the existing water supplies and the acceleration of the bringing in of augmented supply would be to effect amalgamation of the four North Shore Boroughs.

If amalgamation is not possible—a matter in your Commissioners' opinion to be regretted—then the best that can be offered is to arrange to hand over to the North Shore Water Board the present pumping plants in the Lake. There would, no doubt, be certain adjustments required to consummate this. The reason why we say that one authority will have to handle the Lake supply is that, in our opinion, it is necessary to discard the present near shore intakes and put a pump intake well into the Lake. The putting in of three separate plants was, in our opinion, a mistake, and a wise man does not repeat the same mistake. It would be the height of

absurdity to put in three separate intakes well into the Lake.

Your Commissioners in another part of this report have recommended the substitution of up-to-date liquid chlorine plants for the obsolete bleach powder plants now in use. Only one of these plants would be necessary if chlorination were called for and the pumping confined to a single inlet.

Your Commissioners have also recommended that building on the watershed of the Lake be permitted, provided that steps be taken to secure hygienic conditions as far as concerns house sewage on the Lake watershed.

Your Commissioners do not anticipate that any engineering difficulties should arise in getting an intake pipe well into the Lake. The pipe line itself could be ball and socket jointed, and carried by a line of pontoons suitably anchored in the Lake. There should not be any serious engineering difficulty in arranging for the new intake to connect with the present mains.

The analyses show that samples taken from the centre of the Lake produce a water free from B. coli. We have in another part of this report explained why this is to be expected in a large body of water. If this satisfactory position be maintained, then it is quite possible that no chlorination will be called for by the Health Department.

If amalgamation between the four Boroughs does not take place, then the dividing line between the ambit of jurisdiction of the Water Board, as compared with the ambit of jurisdiction of the individual boroughs, will require adjustment. The Water Board would, no doubt, confine its activities to the pumping of water from the Lake and delivering it to the various service reservoirs, the supplies to the respective boroughs being metered at a suitable point. All reticulation would be under the jurisdiction of the respective Boroughs.

If an augmented supply were brought in from Rangitopuni or from Waitakerei, the Water

Board would be finished with this supply when it delivered at the same points as in the case of the supply from the Lake. The Water Board would have to be the deciding authority as to when it would take from the Lake or the other source.

As far as the watershed of the Lake itself is concerned, the Water Board is the authority which, by Section 43 of the North Shore Boroughs (Auckland) Water Supply Act, 1924, is clothed with the power of maintaining the purity of the Lake. The exercise of this authority may involve property in the Takapuna Borough, or involve proceedings against burgesses of that Borough. We do not know whether this concurrent jurisdiction exercisable by the two bodies in one district has caused any difficulty, but it is a matter which should be settled between the Water Board and the Takapuna Borough. It will probably minimise possibilities of friction if the Board were to delegate to the Borough the conduct of all proceedings against Takapuna burgesses.

## RESTRICTION ON BUILDING ON LAKE TAKAPUNA WATERSHED.

It will be abundantly clear from what has already been said that your Commissioners regard Lake Pupuke, otherwise known as Takapuna Lake, as a valuable source, not only of an emergency supply, but for a permanent supply.

Your Commissioners accept the view that the Lake is fed by rainfall upon its surface, and by the run-off and percolation from the rainfall upon the area that slopes towards the Lake.

The Lake has an area of 270 acres, and the watershed area of the Lake is 200 acres. This watershed area comprises the basin of the Lake and the ridge around it. On various portions of this watershed area dwelling houses are built, and, from a residential point of view, the area is very attractive, and sections in the locality command a fairly high figure. Particulars of the whole of the properties on the watershed

area were supplied to the Commission. The summary of this list is as follows:—

| | |
|---|---|
| No. of houses on ridge or inner slope .. | 62 |
| No. of septic tanks on watershed .. .. | 7 |
| No. of septic tanks on slope away from Lake .. .. .. .. .. .. .. | 4 |
| No. of houses drained out of Lake watershed .. .. .. .. .. | 14 |
| No. of houses, including schools, connected to Borough sewer .. .. | 5 |
| No. of houses drained by various means in Lake watershed (6 have septic tanks) .. .. .. .. .. .. | 45 |
| No. of pumping stations drained by various means in Lake watershed .. .. .. .. .. .. .. | 3 |
| No. of cowsheds drained by various means in Lake watershed .. .. | 2 |
| No. of quarries working.. .. .. .. | 1 |

Some of the houses included in the list are not built in the actual watershed of the Lake, but portions of the sections upon which they are built are in the watershed, and in some cases there are gardens and poultry on this land; in some cases, gardens only; others, poultry only; and some sections are just in a rough, overgrown condition. Some of the vacant land in the watershed has cattle or horses grazing on it, which have access to the Lake. Besides possible contamination from the before-mentioned properties, there are several streets from which the road water gains access to the Lake.

It is not possible to obtain accurate figures without extensive soundings being made, but on the data supplied to the Commission there should be, say, twelve thousand million gallons in the Lake, on a very rough approximation.

Notwithstanding the contamination arising from the population on its catchment, some 352 million gallons were pumped during the year ending 31st March, 1927, and, after chlorination treatment, consumed in the four North Shore Boroughs.

Certain regulations have been made under the North Shore Boroughs (Auckland) Water Supply Act, 1924, designed to prevent pollution of the Lake.

When an owner of a section of land desires to build upon it, he frequently assumes that if there is no system of drainage provided by the local authority into which he can drain, he is free to get rid of his drainage the best way he can by means of a septic tank or a soak hole, or by some similar means. Once it gets into the ground in such a manner that he, the owner, is no longer troubled by it, he is inclined to look upon the position as satisfactory without giving proper consideration to the fact that the means adopted by him may cause pollution to the sub-soil waters, and if these sub-soil waters ultimately reach a lake used by the general public as a source of their water supply, he, the owner, looks upon himself as possibly aggrieved when the public objects to his sub-soil pollution of their household water, and insists upon the owner so using his dwelling house and disposing of his drainage that no pollution is caused.

Speaking generally, the above is the position at Takapuna. Except for some five premises, which could be drained to a sewer, the Borough has not yet been able to provide sewerage for the houses on the Lake-side, and owners have found themselves in the position that they have attempted with more or less success—probably less—to get rid of their sewage. The Borough or the Water Board, backed by the Medical Officer of Health at Auckland, has taken up the attitude that it will not permit the building of further dwellings pending the report of your Commissioners as to what is best to be done in the circumstances. The owners not having a public sewer into which they can drain, we take it, want to provide the best means for disposal of their sewage on their own land. The Health Department, or the Borough, or the Water Board, answers that there is no satisfactory means of doing this without hurting somebody else by polluting either the Lake or the waters reaching the Lake. The law generally permits anyone to use his land as he likes, so long as in so doing no one else is injured, *sic utere tuo ut*

*non alieno laedas.* The position of the owners of the land at the Lake-side is that they find difficulty in doing what they want with their land without running counter to this legal rule.

In effect the landowners of the Lake-side now say:—

> "It is a great hardship to us that we cannot use our land in the ordinary way. We have to pay rates, and they will not allow us to build because they have not provided us with a sewer to drain into. We, as ratepayers of the Borough, are entitled to be provided with the same drainage facilities that other burgesses of the Borough enjoy; or, at any rate, if you cannot do this, then let us do the best we can under the circumstances."

Your Commissioners appreciate that there is, from the owners' point of view, an element of hardship, but from the public point of view much greater damage would ensue if unrestricted pollution of the Lake were permitted.

One way to end all the trouble on this head would be to acquire, under the Public Works Act, 1908, the whole of the properties on the Lake side, pull down all buildings, fence the Lake in, and thus isolate the Lake as far as possible from human contamination. No definite figures were given to the Commission as to what the compensation payable to the owners would amount to if this course were adopted. We can assume that it would amount to £200,000, if not more. Indeed, the cost would be such that it would exceed the value of Lake Pupuke as a water supply, so that to deal with the subject by way of purchasing the whole catchment area is out of the question.

Your Commissioners are of opinion that not only would this expenditure not be justified, but the acquisition of the land, with its huge bill of compensation, is not necessary. Our reasons for so stating are set out in another portion of this report, but it will be convenient if we summarise them again.

The large area of the Lake acts as a self purifier of its waters, and good water, possibly free from all deleterious bacteria, can be obtained if the pumping inlet is placed well into the Lake. Even if such water were to show a certain B. Coli content, a modern system of chlorination can make the water safe. Except for contamination from the weeds on the Lake side and possible human contamination, the Lake waters are the purest in Auckland.

Your Commissioners are also of opinion that, as soon as possible, steps should be taken to provide an efficient sewage scheme for the houses on the Lake side and such other sections as are not yet built upon. We appreciate that if the immediate sewering of the whole catchment area were insisted upon, this might impose too severe a tax on the Takapuna Borough finances.

If it should ever happen that the sewering of the Lake catchment area—a matter of extreme importance—were unduly delayed, the Department of Health has reposed in it the necessary power to enforce the sewering of the area in question; but your Commissioners feel assured that the Takapuna Borough Council, fully realising their grave responsibilities in this connection, will provide a complete sewerage system for the Lake area without loss of time.

Your Commissioners further state that it is their considered opinion that, provided reasonable means are taken to ensure, as far as possible, the purity of the Lake waters, the present restriction placed on building should be removed. But when building permits are issued, steps should be taken to see that the best and most efficient means are provided for disposal of nightsoil and household drainage; the making of proper provision as to disposal of drainage and nightsoil to be at owners' expense and be subject to approval of Health Department. We appreciate that any such means will not be as perfect as draining into a sewer, and it should be made plain to owners availing themselves of this privilege that as soon as the Borough's sewer is available, they must, at their own expense, connect up to it. The catchment

area should be under sufficient inspection to ensure that suitable methods of sanitary hygiene are being followed.

The removal of present building restrictions should create building activity, thus hastening the day when a full sewerage system will be made available.

Lastly, your Commissioners recommend that the removal of restrictions on further drainage into the watershed of the Lake should not be effective until the pumping intake is put out well into the Lake. We hold a strong opinion that this should be done without loss of time. This work, besides eliminating many of the dangers of contamination, should ultimately result in a saving in cost of pumping when one plant only is maintained.

## WATER SUPPLIES TO OUTSIDE DISTRICTS.

In the course of your Commissioners' investigations, it was necessary to ascertain whether the suggested water supply main from Lake Taupo would, or could, be made use of by any of the local bodies within the Waikato Valley near to whose territory the main would pass.

We accordingly visited the several boroughs and town districts noted below, and discussed the matters with members and officers of the several councils, with the following results:—

### TUAKAU TOWN DISTRICT—POPULATION 632.

This town district has no water supply, and the Chairman of the Town Board stated that if a supply were brought in to the City from the Waikato, he thought his Board would be only too anxious to purchase a supply therefrom. He had not, however, gone into the question of Cost.

### HUNTLY TOWN DISTRICT—POPULATION 1,727.

In 1920 the Huntly Town District obtained, through the Public Health Department, a report from the Public Works Department on a water supply and sewerage scheme, which was then

estimated to cost £41,000. At that time the Huntly Town Board came to the conclusion that a scheme involving such an expenditure was beyond its resources, and the matter was dropped. The scheme then proposed provided for pumping water from wells sunk in the sand beds alongside the River, filtration being afforded by the passage of the water through these beds.

In putting their needs before the Commission the members of the Town Board hoped that the Taupo Scheme would supply water at such a low rate that it would be cheaper and better than the local pumping proposal that was submitted to the Board in 1920. We have already shown, however, that a supply from Lake Taupo or from Arapuni is so costly that it is out of the question. So that Huntly, if it wants a water supply, must develop its own by pumping from the Waikato River. The cost of such a supply is relatively low, and the attention of the Town Board is drawn to the experience of the Hamilton Borough in this respect.

NGARUAWAHIA BOROUGH—POPULATION 1,222.

Ngaruawahia draws its water supply by gravitation from the bush-clad hills on the opposite side of the Waipa River to the Borough. This supply is sufficient and suitable for the community's needs. The capital charges of this development provide the main portion of the cost of the installation, and as these charges have to be met anyway, Ngaruawahia has no interest in any other proposed supply.

HAMILTON BOROUGH—POPULATION 14,018.

The Hamilton Borough takes its supply from the Waikato River, the water being sterilised by a liquid chlorine plant at the pumping station. It is then pumped to a reservoir, and filtered and dechlorinated after leaving the reservoir. The cost, including all charges, of filtered water delivered to the borough mains is stated to be 3.35 pence per 1,000 gallons. Various additions to the plant are needed, and when these are

installed, the cost on present day consumption will be increased to 5.05 pence per 1,000 gallons. The Council considers that the water supply, which is not generally satisfactory, will, when additions to the plant are made, be satisfactory in all respects. In view of this fact and the low cost of the Borough's supply, the Council has resolved that it is not prepared to enter into any Provincial Water Board Scheme.

## CAMBRIDGE BOROUGH—POPULATION 2,026.

The Cambridge Borough has its own supply, the water being brought from springs issuing from the side of Maungatautari Mountain, the length of the main to convey the water to the Borough being about ten miles. The water is of excellent quality and of ample quantity, and here, again, the cost to the Borough is almost wholly on account of the capital charges, which have to be met in any event. Thus the Cambridge Borough has no interest in any other proposed supply.

We see, therefore, that the position in the Waikato Valley is that the various local bodies either have a sufficient or suitable supply, or, not having such, are looking for a supply that is cheap and within their limited financial means.

The example of Hamilton is sufficient to indicate that the cost of pumping for a local supply is low, and in the case of Huntly, for instance, no other possible source could compete with it.

The general conclusion to be drawn from the foregoing is that a supply from Lake Taupo could not build up a demand on the strength of supplying to towns en route, and it would have to depend wholly on the sale of water to the district that would finance the project.

## POTABILITY OF WATER.

Chemically pure water is a combination of hydrogen and oxygen—a water only found in a chemical laboratory—but the term "pure," when popularly applied to water, is used to indicate that it is free from any objectionable matter. The

word "safe" is applied to a water as indicating a water free from pathogenic or toxic matter, while the word "clear" is used to indicate its freedom from suspended matter. There are other terms used with reference to waters—such as "hard" and "soft"—but it may be taken that a water which is pure, safe, and clear, is a good potable water suitable for consumption in cities.

All so called pure, safe, and clear waters are, when subjected to analysis, found to contain various substances; but unless these foreign matters interfere with its purity—using this term in its ordinary sense—then the water is a pure, safe, and clear water.

## COLOUR OF AUCKLAND CITY WATER.

The objection advanced against the Auckland supplies from the Waitakerei Ranges was its colour. It is not what would be called "clear"; but, except in this respect, no objection was offered to the Commission on the score of purity and freedom from contamination. The want of clearness, when expressed in terms used by analysts of water, would be described as having a certain turbidity. It is caused by clay, impalpable sand, or other earthy materials, or by fine vegetable matter carried in suspension in the water. The ordinary understanding from an analyst's point of view of clear water is one which has not more turbidity than five parts per million. A turbidity of 100 parts per million gives a cloudy appearance. An analysis of typical samples of Waitakerei water, made by Mr. A. J. Parker, gave varying turbidities from under 10 to 30 parts per million (U.S. Geological Survey Standard). The test for turbidity is based upon the depth at which a platinum wire one millimeter in diameter can be detected by the eye. A graduated rod about four feet long has such a wire inserted at right angles to it near one end, and an open eye piece near the other end 47½ inches distant from the wire. That turbidity that causes the wire to disappear at a depth of 100 millimeters (i.e., 3.927 inches) is called 100. The filtration plants

now almost completed at Nihotupu and Waitakerei have a guaranteed efficiency for removal of turbidity to such an extent that the platinum wire must be visible at a depth of four feet (i.e., 1,219 millimeters). This test is the standard one adopted by water supply authorities as providing a clear water.

The plants at Nihotupu and Waitakerei are rapid sand filters, built with open chambers, in which the raw water passes downward through the filter beds. Your Commissioners have had the advantage of inspecting a filter plant by the same makers (a British firm of high standing) which is in operation at Papakura. The latter is of the pressure type, but one type would be as efficient as the other. The Papakura filter plant shows admirable results, and the water produced is most attractive in colour.

We have no doubt that after the filtration plants at Waitakerei and Nihotupu are in operation, no complaint will arise on the score of colour. As soon as filtered water is supplied, it will, however, be necessary for the various local authorities purchasing water from the Auckland City Council to flush all their reticulation mains and dead ends so as to ensure, as far as possible, the removal of the foreign matter in the mains as the result of the non-filtration of the present supply.

## COLOUR OF OTHER WATERS IN THE METROPOLITAN AREA.

No complaint has been made on the score of colour concerning any supplies provided by Onehunga, One Tree Hill, Otahuhu, and the North Shore Boroughs.

## TASTE.

As far as Auckland water is concerned, no complaint is made on the ground of taste; but certain of the witnesses deposed to an objectionable taste or odour, due to the presence of chlorine in the water supplied in the North Shore district. All the water supplies, with the exception of Auckland City, are chlorinated for the purpose of eliminating the possibility of the presence of any toxic germs.

Your Commissioners inspected the plants where chlorine is used, and found different systems in operation. We shall later deal more fully with chlorinating processes, but at the present time we refer to them for the purpose of offering suggestions for eliminating any objections due to the presence of chlorine in the water as delivered to the consumer.

One Tree Hill pumps its water from a well at Onehunga to a reservoir on One Tree Hill; but before reaching the consumer the water passes through a pressure chlorinating filter—Hamilton adopts the same system. At Onehunga the water passes through the dechlorinating filter immediately after it leaves the pumps—Papakura adopts the same system. In none of these districts where dechlorinating filters are in use was any complaint made as to the taste or smell of chlorine in the water, although some persons—no doubt for sentimental reasons—object to drinking chlorinated waters. No attempt is made at North Shore to dechlorinate the water by direct means, and the only dechlorination most of it receives is such as it may get by being in a reservoir for a comparatively short period.

Your Commissioners understand that the Takapuna Borough's supplies are pumped direct into the mains.

The presence of infinitesimal quantities of free chlorine in the water may not be harmful to consumers, but it is obvious that if the North Shore Boroughs desire to overcome complaints on the score of chlorine, either in taste or smell, the remedy is to instal dechlorinating filters, or to instal better chlorinating plants, which could be so adjusted as safely to use the minimum of chlorine required as an effectual germicide. We shall later discuss the necessity for chlorination of the Lake waters.

## CORROSION OF PIPES.

Samples of pipes and a fitting taken from the Devonport Borough's mains, in use for some years, were produced to the Commission. The samples showed marked corrosion, the diameter of the pipe

of one sample being reduced to approximately one half.

The only evidence submitted to the Commission with respect to corrosion was that given by Mr. F. L. Armitage, who has carefully considered this matter, and wrote a paper on the subject of this corrosion which he read at a meeting of the Australasian Association for the Advancement of Science at Wellington in January, 1923. After fully describing the corrosion and discussing its probable source and mentioning that he had found in the Lake many iron bacteria, he states:—

> "The material is most probably formed from iron dissolved from the inner surface of the pipe by the action of water and carbon dioxide, and deposited further down the main on the surface as iron peroxide.
>
> "Electrolytic action, no doubt, also plays a great part, and the presence of the colloidal ferric hydroxide formed would increase the rate of production of the corrosion."

As this is the only evidence on the matter, the Commission cannot carry it any further. Apparently trouble of the kind experienced at North Shore has not been very marked in the Auckland water pipes. All the Commission can suggest is that the subject be further investigated, and experiments undertaken with a view to finding a cure for the trouble.

## ANALYSIS OF WATERS.

It will be convenient if we make some general observations upon the questions of analysis of waters and the interpretation of analyses. To determine whether a water is suitable for drinking purposes, and to determine what purification or modification (if any) is necessary to render it so suitable, certain examinations are necessary. These are:—

(a) A physical examination on such points as turbidity, taste, colour, odour, etc.

(b) A chemical examination to ascertain its composition and the chemical organic and inorganic impurities in it.

(c) A miscroscopical examination for the purpose of ascertaining the number of miscroscopic organisms per cubic centimeter.

(d) A bacterial examination to ascertain the number of bacteria per cubic centimeter and the identifying of such bacteria.

The Medical Officer of Health, having before him the results of these analyses, after making due inquiry as to the situations and source of the water, will then be in a position to say whether the water is a pure, clear, and wholesome water, or whether some filtration or sterilisation is necessary to make it so.

The Health Department makes periodical analyses of the waters, and keeps a continual watch for the purpose of ensuring that, when consumed, the water will be pure and wholesome. We have had placed before us the results of innumerable examinations made of the various waters in and around Auckland.

As far as chemical impurities are concerned, it may be taken as proved that none of the drinking waters used in the Auckland district contain any chemical impurities which in any way affect their wholesomeness. For instance, they all show slight traces of salt, as is always the case in waters collected near the sea. When examined microscopically or bacterially, most of the waters contain harmless bacteria, and in a good many of them bacillus coli has been found in varying quantities.

The bacillus arising from and causing certain epidemic diseases, breed only in the bodies of infected persons or in the bodies of "carriers," whence they are discharged in the urine or faeces. Of these diseases, those suggested as being of most significance in water supplies in this country are typhoid and diarrhoea. The suggested danger is that these diseases are capable of being water-borne. If a City's water supply became infected with typhoid bacillus, it might cause an epidemic of that disease. We shall later deal with the germicidal effect of the storage of water, that is, the capacity of stored water to free itself of

harmful germs; but at the present time we are dealing with what would be taken by an analyst as some evidence of want of safety in a water. Analysts of water, when considering the question of the safety thereof, look for a particular bacillus called bacillus coli, and, when found, they draw certain conclusions from its presence.

It is necessary to make plain to such laymen as may read this report what the finding of bacillus coli signifies.

Bacillus coli (or B. coli, as it is usually designated) is a particular bacillus which is found in the excreta of all humans and animals. Therefore, if B. coli be found in a water, it is assumed that the water has at some time or other come into contact with some excreta from a human or animal. The droppings of a bird, sheep, or a rabbit on a hillside may infect with B. coli the stream in that locality due to the rain washing some portion of those droppings into such stream; and if that stream joins a lake, the lake at or near the junction of that stream may show evidence of B. coli. The excreta of the trout in Lake Taupo, or any other lake or stream, teem with bacillus coli. Storage in a lake for a matter of four weeks will absolutely destroy all such bacilli, and this is why water, when taken from the middle of a lake, may be free from traces of B. coli, while water taken from the edges of the same lake is likely to show traces of B. coli.

The Medical Officer who finds B. coli in any quantity of water less than 100 c.c., therefore, assumes that the water has been contaminated by some kind of excreta at some time or other in its journey to the place where the sample of water was drawn. By the use of the word "contamination," we do not intend to convey the meaning that this word has to the ordinary layman. We use it in the sense that an analyst would use it, viz., that the water is not the perfection of bacteriological purity which he looks for before he says that a substance is bacterially pure.

Having found sufficient B. coli to justify him from an analyst's point of view in treating the

water as contaminated, he knows that such contamination may possibly arise from contact with human excreta, or from contact with some animal excreta.

Taking the case in which an analyst is satisfied that the B. coli found by him is derived from animal, as distinct from human excreta, which would be the fact in a water derived from an isolated source free from the possibility of human contamination, he would be justified in disregarding as inimical to public health the traces of B. coli found by him. Although certain diseases that affect animals, viz., bovine tuberculosis, hydatids, foot and mouth disease, and anthrax, are looked upon as being possibly capable of being water-borne, no cases of the communication of such diseases to man have, so far, been proved to have been water-borne.

If the analyst's knowledge of the source of the water is such that it is under suspicion as being liable to possible human contamination, then he will assume that the B. coli which he finds may have been the result of human contamination. Even if the source of the water is a pure source, and the analyst finds a comparatively large proportion of B. coli in the water, he will assume that there is a possibility of human contamination.

Water polluted with human excreta is a water dangerous to public health. As B. coli is always present in water contaminated by the sewage from human beings, a Medical Officer of Health, unless satisfied that the B. coli he finds are due to animal and not human contamination, will, for abundance of caution, always assume the possibility of human contamination and call for sterilisation of the water.

It will thus be seen that the finding of B. coli in water does not mean that the Medical Officer of Health fears danger to health from that particular bacillus, but it means that, provided there is any risk that its presence is due to humans and not to animals, then the water may possibly contain some deleterious bacilli—such,

for instance, as the typhoid bacillus—which he has not found. He does not undertake the task of looking for any possible deleterious bacilli, but assumes that such may possibly be present. B. coli is easily found and identifiable, whereas other bacillus, such as typhoid, are not by any means easily found, although they are identifiable, if found.

Shortly put, therefore, bacillus coli in water is not, strictly speaking, a contamination of water, but may, under certain circumstances, be evidence of the risk of contamination by bacilli of a harmful nature.

## DIFFICULTY OF ISOLATING DELETERIOUS BACILLUS.

Some further explanation should perhaps be here added as to why an analyst looks upon it as more or less futile to search for deleterious bacillus, even if there. The B. coli is present in millions in every form of excreta, and it follows that if that bacillus be present in water, the chances of finding it are good. Birds, animals, and fish, besides humans, are continually discharging the bacillus everywhere. But typhoid bacillus, if being discharged, is confined to the excreta of that one unfortunate person in, say, ten thousand, who happens to be suffering from that disease, or is a carrier of that disease. If the chances of B. coli getting into a stream are, say, one in one, then the chances of typhoid bacillus getting into the same stream may be one in a million, or even more. In order to err on the side of extreme caution, an analyst having found B. coli in a water, instead of attempting to prove the negative fact that the same water is free from any harmful bacteria, assumes the possibility of its presence. The layman has no conception of the nicety of the process necessary to locate and identify B. coli and estimate the quantity of water in which same has been found. If B. typhosus happened to be present in a sample, it would perhaps be one colony among thousands of other colonies of other bacteria. It is therefore

easy to miss. No bacteriologist having found B. coli in number would be prepared positively to report as not present other and noxious bacteria which could come from the same source as B. coli. The process of detecting and identifying B. typhosus is of very much greater nicety than the like process concerning B. coli. Accordingly, therefore, the practice of bacteriologists is to treat B. coli as indicative of the possible presence of the pathogenic bacteria which come from human excreta.

VARIATION IN TREATMENT OF RELATIVELY PURE AND POSSIBLY IMPURE WATERS.

The water pumped from Lake Pupuke (Takapuna) by the North Shore Boroughs is taken from near the edge of the lake. Samples of water taken below the surface level from the centre of the lake on several occasions between 1923 and 1927 show no bacillus coli as found in 100 cubic centimeters of water; but samples taken over the same period on the margin of the lake near the North Shore Boroughs intakes show varying results, ranging from complete absence of bacillus coli 100 cubic centimeters up to bacillus coli in one-tenth of a cubic centimeter. The latter, due to the fact that the lake is possibly subject to human contamination, would be looked upon as a water unsafe without sterilisation. As already pointed out, the presence of bacillus coli is not of itself harmful, but is looked upon as indicating the possibility of harmful contamination.

To illustrate the application of different treatment to two waters showing identical analyses, we will take the cases of the Waitakerei and Lake Pupuke (Takapuna) watersheds. The former is looked upon as virtually free from human contamination, and is situated in upland country clothed with natural native bush miles away from the city. Lake Pupuke is entirely surrounded by population, and on the watershed of the lake are farms and houses. The presence of bacillus coli in 50 cubic centimeters of Lake Pupuke water would be taken as indicative of

danger; but the presence of such a proportion of the same bacillus in the same quantity of Waitakerei water would not necessarily cause any alarm. One might say that all those supplies, which are drawn from areas liable to human contamination, are always under suspicion, and are treated as requiring chlorination when there is any corroboration of contamination by the finding of bacillus coli in the water. On the other hand, those areas looked upon as free from the possibility of human contamination are permitted to disclose bacillus coli in larger quantity—using the term in its microscopical sense—without this fact causing undue concern. It is for this reason that chlorination is called for at Lake Pupuke, One Tree Hill, Onehunga, Otahuhu and Papakura. Although B. coli in small quantity is sometimes found at Nihotupu or Waitakerei, chlorination is not called for.

Your Commissioners noted that recently some chlorination was being resorted to at Nihotupu by the Auckland City Council without request from the Health Department. This was done for abundance of caution, because a number of men were at work at that time getting out some old plant which had been left on the Nihotupu watershed.

It is here worth noting that Lake Taupo, which was advanced as the most perfect source for an Auckland water supply, contains bacillus coli. A sample taken in April, 1927, in Western Bay, of that Lake, disclosed bacillus coli in 50 cubic centimeters.

## QUALITY OF WATERS.

As we before said, the only objection offered as to quality of the Nihotupu and Waitakerei water is on the score of colour, and this objection, we consider, will disappear when the new filters—which were well in towards completion when inspected by your Commissioners—are in operation, and it should be a matter of only a few weeks from the date of this report before they are in use.

On the score of safety, objections were made by the Health Department at Auckland to practically all the supplies other than Waitakerei and Nihotupu. The basis of this objection is that the sources of these other supplies are liable to contamination either human or animal. The Auckland City Council has gradually eliminated all occupation of its watersheds, but the watersheds of all other supplies are liable to possible contamination—some more so than others. The Western Springs, which belong to the Auckland City Council, are not now used except in case of emergency, and this supply is situated in the midst of a closely populated district, and portion of the gathering ground is not sewered. When necessity has compelled the use of Western Springs, the water is well chlorinated.

One Tree Hill and Onehunga draw their supplies from wells situated right in Onehunga itself. Otahuhu is in a similar position. The Health Department admits that proper chlorination is effective to make these possibly contaminated waters safe; but it naturally prefers waters which come from an absolutely reliable source. The Department is not satisfied with the method of chlorination of some of the plants. It must be admitted that experience has proved that even badly contaminated waters can be made safe by chlorination, if effectively done. This being the position, it follows that, provided the waters are efficiently chlorinated, the Pupuke Lake (Takapuna) supplies and the One Tree Hill, Onehunga, Otahuhu, Papakura and Western Springs supplies can be made safe.

Amongst other evidence, the Commission had before it that given by Mr. F. L. Armitage, Bacteriologist at the Auckland Hospital, a gentleman who has had great experience in the analyses of water during the last fifteen years, and who has made innumerable examinations of the water supplies in the Auckland Metropolitan Water Area. Mr. Armitage's evidence very much impressed us, and his views have been confirmed by further

inquiries that we have made from the Department of Health at Wellington. As part of Mr. Armitage's evidence, he quoted the following passage from an editorial in "Engineering and Contracting" of November, 1922:—

> "Increased demands for water for use by cities and the lessened opportunities for securing uncontaminated supplies are vastly increasing the use of purification systems. Easily available supplies of pure water have practically ceased to exist—either because they have long since been appropriated, or because habitations and industry have expanded over watershed areas that once were clean.
>
> "Cities that formerly had abundant supplies of good water have increased in population beyond expectation, at the same time that per capita consumption has increased, until the old supplies have become entirely inadequate, and the cities have been forced to augment them with water brought from a great distance or with water purified from what was once considered a wholly unsuitable source.
>
> "In the public mind there still lingers the idea that pure water can only be had from a pure source, and so strong is this idea that it sometimes leads to the expending of needlessly large sums in bringing water from a distance when much cheaper and equally wholesome supplies could be had by taking water near at hand and purifying it by approved modern methods.
>
> "More instances of this sort should not occur, for the waste of public funds is as inexcusable as is the waste of private funds.
>
> "Engineers and engineering societies should harp before the public on the fact that by proper treatment an admittedly contaminated supply may be rendered throughly suitable for domestic consumption, and may, in fact, be much purer than a vastly more expensive supply brought from a distance without purification."

While admitting that although clearing and isolation of mountain and upland reserves improved the safety of the water collected from such areas, Mr. Armitage indicated some doubt as to whether the expense thus incurred was always justified. We quote his evidence:—

> "The clearing of such watersheds from farming and other occupations has often been carried out at very great expense, but such a policy does not make the water safe, no matter how much it may improve it.
>
> "Most of the pollution of our water is due to vegetable or animal refuse, which has never yet been found to be the cause of infectious disease in man; it is possible that bovine tubercle introduced into the water by tuberculous cattle might be the cause of disease in human beings, and even that anthrax and foot and mouth disease might be so transmitted, but no such cases have yet been recorded.
>
> "Excreta from human beings, however, is the real danger to a water supply. The micturition of one careless or ignorant picnicker or traveller who happened to be a carrier, under conditions that gave access for the urine to a water supply would be quite sufficient to cause an outbreak of typhoid unless the water were subsequently subjected to some efficient purification process."

When Mr. Armitage says that clearing and isolation do not make the water safe, he was speaking as a bacteriologist and using the term "safe" in the sense as understood by bacteriologists.

Mr. Armitage also quoted from the "Lancet" of January 2nd, 1926, page 29, where Sir Alexander Houston discusses the utilisation for domestic purposes of water of doubtful origin, and he supported his view, amongst others, by considerations such as these; that great progress has been made by rendering impure waters safe to drink; that we have ceased to be obsessed by purely sentimental considerations; that over one-seventh of the population of England has been, and is, drink-

ing with impunity high purified water derived from sources of questionable origin; and that if the absence of bacillus coli is to be taken as implying the absence of microbes of water-borne disease, this organism can be practically eliminated by storage and filtration, and if chlorination processes are superadded, absolutely destroyed.

On account of the serious objection which was taken to water from Lake Pupuke as being liable to human contamination, and on account of like objection which was taken to Western Springs, which are more liable to human contamination than Lake Pupuke, Mr. Armitage was asked:

> "Assuming that the area around the Lake was allowed to be built upon, and assuming that the houses were all properly sewered, what view do you take as to the continued use of Lake Pupuke?"

He replied:—

> "Absolutely safe. It is the purest water supply in Auckland District. Even if it did become contaminated to that extent, there is such a thing as chlorination. It would not be as bad as the huge water supplies in England and America, which are polluted worse than Lake Pupuke ever could be."

Mr. Armitage was also asked specifically whether, if there was proper and efficient purification, would the water now gathered from the wells south of Auckland, namely, Otahuhu and Onehunga, be perfectly good potable water. Mr. Armitage answered that it most certainly would, and that the same was true of Western Springs.

Your Commissioners believe the position to be as is stated by Mr. Armitage, and, in addition to the authorities which he himself quotes, he is supported by a number of other authorities and by modern water supply practice in England and North America. His views in this respect are also confirmed by the Director, Division of Public Hygiene, at Wellington.

Howsoever pure the source of a water supply, there is, of course, a possibility that that water

supply may be accidentally contaminated before reaching the consumer; but, speaking within reasonable limits, howsoever polluted a supply may be, it is true that modern systems of filtration and chlorination have so advanced that water seriously poluted and of bad colour can be made into perfectly safe, clear and wholesome drinking water. It is well known that the people of America are great water drinkers, and seventy per cent. of the people of North America are to-day drinking water which has been sterilised with liquid chlorine.

## PURIFICATION BY FILTRATION.

Your Commissioners, in another portion of this report, have dealt with the subject of filtration in its effect upon the turbidity of waters. But, in addition to removing inorganic matter in suspension in the water, filtration actually affects the removal or reduction in the bacterial content of the water.

There are many means adopted for the filtration of waters. The provision of areas to permit of sedimentation bains is one method, another is to provide filter beds. These methods need a lot of space. But filtration methods are now modernised, and equipment is in common use which occupies small space, interferes little, if any, with the flow of the water, and is most effectual in results.

The only filtration plants in actual operation the Commission found in the places inspected by them were the plants at Papakura and Hamilton. The Waitakerei and Nihotupu plants were not completed when inspected. The two plants in operation were giving complete satisfaction.

The matter in water which causes what is known as turbidity and gives it a bad colour is mostly of impalpable fineness—too fine to be removed by being passed through fine sand or any other similar filtration material. Accordingly, therefore, in order to secure complete removal of the impalpable suspended matter in the water it is necessary to cause these fine particles to be collected into groups or composite masses. This is done by the use of coagulents, the common

coagulent used being a soluble salt of alumimum. The effect of the use of such coagulents is to cause the suspended matter to be converted into flakes or flocs, which are then trapped in the sand in the filter, and the filtration process also removes all traces of the coagulent used.

In operation, the top of the sand in the filter becomes coated with a gelatinous mass which enmeshes all suspended matter. This coagulent jelly also acts as a trap to catch bacteria. The jelly gradually thickens as filtration proceeds until water passes through it too slowly for economical working.

It is then necessary to clean out the filter, and this is affected by forcing clean filtered washing water into the bottom of the filter, and thus reversing the flow of the water. This washes the coagulent jelly away, the dirty water being carried away to a sewer or other outlet. It is not the practice to wash away the whole of the coagulent jelly, but a thin film of this jelly is left on the top sand so as to help to clarify the first lot of water that comes through before a new deposit of jelly is created. As a matter of fact, the makers of the Auckland City's filters provide a means for the refiltration of the first lot of water that enters after the filters are cleansed.

The filters are built in units, so that there is no interruption to the flow of the water while one unit is being cleaned.

In addition to putting in clean washing water, the filters at Waitakerei and Nihotupu are designed to force air into the bottom of the filter as well as washing water, thus assisting cleaning and aerating and sweetening the sand in the filter.

It will be seen, therefore, that water subjected to this filtering process must necessarily lose a large proportion of its bacteria content.

It is of interest to examine the actual bacterial results obtained at the St. Louis Purification Plant (United States of America) in the year 1920-1921. Details of the examinations made each month are given as the result of filtration by a filter similar to the filters at Waitakerei and Nihotupu. Taking the whole year, the average

bacterial content of bacillus coli was .3613 per cubic centimeter before filtration, while after filtration it averaged .0685. The filters are thus shown to have removed eighty per cent. of the bacillus coli content.

The guaranteed bacterial efficiency of the Candy filters being installed at Waitakerei and Nihotupu is that after filtration no sewage organism (*i.e.*, bacillus coli) can be detected in 10 cubic centimeters. This is a very rigorous test.

Accompanying the catalogue issued by the makers is a copy of a letter written in 1925 by the Engineer of the West Hampshire Water Company (England). That company installed certain Roughing, or Prefilters, for the purpose of prefiltering crude river water before it reached their filter beds. These filters showed that after filtering the water contained 90 per cent. less bacillus coli than before prefiltering.

It will thus be seen that filtration alone considerably improves the safety of waters, and there will be cases where the bacilli content of the water is so low that filtration alone without chlorination will be sufficient to make a clear and wholesome water.

## THE EFFECT OF STORAGE OF WATER.

Water itself possesses the valuable property of self-purification from bacteria if stored in a large quantity. A water showing a large bacillus coli content, if stored in a large reservoir or dam for a period of four weeks, should entirely free itself of such bacillus. Even if the bacillus is a deleterious bacillus, such as typhoid, the same result ensues. The fact, therefore, that municipalities are able to store water in dams or reservoirs constitutes another valuable safeguard to public health, so long as the quantity of water in such dam or reservoir is such that the water being drawn off will have been four weeks in storage.

There is, of course, the practical difficulty of making certain that a particular body of water has remained in a virtual state of repose for the

necessary period to destroy all noxious germs. The stream running into a dam may set up a current which flows more or less directly out of the dam, thus "short circuiting" the storage of that particular stream's water. The wind disturbs the surface, and may blow a portion of the water recently infected into such a position that it reaches the mains quicker than it otherwise would, taking into consideration the quantity of water supplying the dam as compared with what is taken out. It would therefore be too much to say that if a dam was being filled with badly infected water, and the capacity of such dam was such that the water should remain in it for at least four weeks, it would be safe to continue to draw off the water from such dam, relying solely on self-purification. Pathogenic bacteria, such as B. typhosus, settle in water, as other bacteria do, and they are killed by exposure to sunlight near the surface, and they may be eaten by protozoa, as other bacteria are eaten. They do not live upon dead organic matter, and they do not multiply in water. Water to them is an unfavourable environment, and give them a certain time in it and they will die. It is well known that bacteria live longer in winter than in summer. But almost always they tend to disappear in water in accordance with the "die away curve"; their rate of decrease remains fairly constant for a given set of conditions, this rate being in round numbers about twenty to forty per cent. per day. Thus an infected water purifies itself in the course of time.

Storage of water in a large quantity, such as takes place at Nihotupu, Waitakerei and in Lake Pupuke (Takapuna), is therefore all in favour of purification of the water.

## CHLORINATION.

We have come to the conclusion that the possibly contaminated supplies can be made safe if efficiently chlorinated. We shall now discuss the various methods of chlorination adopted. At the outset, it should be pointed out that, while admittedly chlorine is a powerful germicide, the question as to whether enough has been used to make contaminated water safe depends upon the results as shown by bacterial examination after chlorination. If such examination shows that enough chlorine is not being used, then more must be used. Conversely, it is undesirable to use more than is necessary, because in cases where there are no dechlorination plants, too much chlorine taints the water and gives rise to complaint. Where there is no dechlorination plant, the temptation is to endeavour to reduce the quantity of chlorine to a minimum, so as to taint the water as little as possible. Where dechlorination plants are installed, it does not matter if an overdose is used, because the chlorine is removed before reaching the consumer. There is then no temptation to risk too small a dose.

Your Commissioners are of opinion, therefore, that in all places where chlorination is necessary, dechlorination filters should be installed, unless such an efficient chlorination plant is installed as will render dechlorination unnecessary.

To make chlorination effective, it is desirable to know definitely what amount of chlorine is reaching the water. In the Auckland district chlorination is applied to water in two ways, *viz.*:—

(*a*) Either by the use of liquid chlorine, or

(*b*) By the use of a solution of chloride of lime (bleach powder).

When liquid chlorine is used, the quantity of chlorine reaching the water can be regulated with reasonable certainty. But that is not so with

chloride of lime. The constituents of chloride of lime, other than chlorine, are of no assistance in sterilisation, and, moreover, when the chloride is used, the precise quantity of chlorine to reach the water is not by any means certain. There is only a certain percentage of chlorine in chloride of lime, and this percentage varies. The longer the chloride of lime is kept, the less the chlorine in it, and exposure to the atmosphere causes loss of chlorine. In use, the chloride of lime is dissolved in water, and there is only a rough-and-ready method of determining the quantity to use to get a desired strength of chlorine.

We were much struck by the more or less primitive methods employed in chlorinating at One Tree Hill, Onehunga, and the North Shore Boroughs. At Papakura there is a much better plant. At Hamilton liquid chlorine is used, and there is installed there an admirable equipment for regulating the precise quantity of chlorine to reach the water. At Onehunga the water, immediately after being chlorinated, is dechlorinated, thus leaving only a very short period for the chlorine to act.

Upon the question of the best means of chlorination, it may be here remarked that in the United States of America the popularity of chlorination by liquid chlorine has increased tremendously. In 1913 over 1,700,000,000 gallons per day were being treated by chloride of lime. By 1924, approximately 3,750,000,000 gallons were sterilised by liquid chlorine, and probably less than 50,000,000 gallons per day by the bleach powder. In "Water Works Practice," the manual issued by the American Water Works' Association (1925), it is estimated that seventy per cent. of the population of North America are drinking water treated with liquid chlorine. In the United States there are some 6,000 installations of chlorinating equipment, and of this number all but about fifty are using liquid chlorine.

It will be obvious, therefore, the chlorinating by liquid chlorine is fast superseding the out-of-

date method of using bleach powder, as is, with the exception of Hamilton, practised in all the chlorinating plants at Auckland.

It must, however, be admitted that, notwithstanding the use of out-of-date chlorinating plants, analyses of One Tree Hill water, taken periodically since the year 1923, have shown almost a complete absence of bacillus coli in 100 c.c. of its chlorinated water. The same remark is true as to Onehunga, Papakura and the North Shore Boroughs. This result is a testimonial to the care exercised by the officers in charge of these plants; but it is quite possible that, owing to being provided with out-of-date equipment, they may be attaining this result by over-chlorination.

In the case of Otahuhu, the record of analyses of chlorinated waters is not satisfactory in some periods. Commencing from 1923, the records show that eight of the twelve monthly analyses in that year disclosed bacillus coli in quantity ranging from 50 c.c. to 5 c.c. In February and March, 1924, bacillus coli were disclosed, but for the rest of 1924, and up till November, 1925, the samples were clear of B. coli. In December, 1925; March, 1926; December, 1926; and February and March, 1927, some bacillus coli were found. It would be better to over-chlorinate than permit this to happen. The remedy, we suggest, is to instal a better plant, and if this is not possible, then that more care be exercised with the plant that they have.

In the United States, where, as previously pointed out, chlorination by liquid gas is mostly practised, it is not the practice to use dechlorinating plants, and the explanation of this, no doubt, is that the efficiency of the liquid chlorine plants is such that it is possible to so regulate the chlorine which reaches the water as to provide an efficient germicide without putting such an excess quantity of chlorine into the water as to taint it. The cost of an efficient liquid chlorine plant is much less than the cost

of an out-of-date bleach powder plant when there is added to the latter the cost of a dechlorinating plant.

Your Commissioners believe, if inquiries were made by the various local bodies as to the cost of an efficient and up-to-date liquid chlorine equipment, it would be found that such is obtainable at comparatively moderate cost, and that the working cost of such is not excessive. If it is desired to avoid the expense of the purchase of dechlorinating filters—a fairly expensive item—it is quite possible that a liquid chlorine plant could be obtained which is so adjustable that sufficient chlorine could be applied to the water to make it safe without leaving any undue taint in the water.

We understand that the Devonport Borough pumps the water that it supplies to the Takapuna Borough direct into the Takapuna Borough's mains without the intervention of any service reservoir. If this be the case, and the water is over-chlorinated, it would not be surprising that the Takapuna consumers find traces of chlorine in the water when it reaches them. When chlorinated water is allowed to stand in a reservoir for some time, it loses a certain proportion of its chlorine, and if it is left there long enough, the chlorine taint will entirely disappear.

Another advantage of the use of liquid chlorine equipment, instead of chloride of lime equipment, is that the chlorine is retailed in a pure liquid form in steel cylinders; whereas chloride of lime is retailed in casks, and it might happen that one particular cask is so weak in chlorine as not to provide a sufficient dose when handled, as usually handled, in a bleach powder plant. A water which is dangerous without chlorine requires to be subjected to a sufficient dose, but where there is a risk of the dose not being uniform, as is the case where bleach powder is used, then there is to the consumer an element of risk by using a bleach powder low in chlorine content. This element of risk is not present when a liquid chlorine plant is used. When

chlorination is necessary, the omission of the necessary dose for only one day might result in some unsafe water reaching the mains.

As an indication of the economy of the use of liquid chlorine, Sir Alexander Houston's report on the Metropolitan Water Board (London) Works for the year ending 31st March, 1926, shows that the cost of chlorine for treating water at Sunbury is 8.6 pence per million gallons, and 6.5 pence per million gallons for the chlorine used in treating New River water.

During the course of his evidence, Mr. Armitage suggested as worthy of consideration the appointment of a specially trained and experienced officer, whose duty it would be to see to the proper adjustment of chlorinating plants, take charge of the arrangements for laboratory tests, and collate results, and who could also collect rainfall, flow, topographical details, and arrange such records so that all the requisite data would be obtainable when required by the Medical Officer of Health, or the local bodies concerned.

This suggestion is worthy of consideration by the various local bodies interested, as well as by the Health Department. They could, no doubt, mutually arrange as to proportionately sharing the salary of such an officer.

## PROPOSED WATER BOARD.

The following local bodies, represented at the Commission by Mr. Rogerson, strongly advocated the creation of a Water Board: Mount Eden, Mount Albert, Newmarket, Takapuna, Avondale, One Tree Hill, Mount Roskill, Manurewa, Huntly, Papatoetoe, Ellerslie, Manukau County, Otahuhu, Pukekohe, Howick, and Glen Eden. The proposal for the creation of a Water Board was the result of a conference held on 25th August, 1924, of various local bodies purchasing water from Auckland City and other local bodies in the areas within or in the vicinity of what has been called "Greater Auckland," or "Auckland Urban Area." This conference resolved that the time had come for the formation of a Water Board, and agreed

to pay the preliminary expenses of a report. A sub-committee appointed for the purpose by this conference subsequently instructed Messrs. Rogers and Gray to make a report, a copy of which, dated 23rd March, 1925, was supplied to the Commission.

With a view to obtaining incorporation into a Water Board, a Local Bill, called "The Auckland Provincial Water Board Bill, 1926," was duly introduced to Parliament in 1926. This Bill, after passing various stages, was ultimately deferred pending a report by a Commission to be set up to inquire into the question generally. Your Commissioners were, on the 11th March, 1927, appointed as such Commission.

The Bill provided for creating an Auckland Provincial Water District comprising the following:—

The Borough of Mount Eden.
The Borough of Mount Albert.
The Borough of Newmarket.
The Borough of Devonport.
The Borough of Takapuna.
The Borough of Birkenhead.
The Borough of Northcote.
The Borough of Avondale.
The Borough of Otahuhu.
The Road District of One Tree Hill.
The Road District of Mount Roskill.
The Road District of Tamaki West.
The Town District of New Lynn.
The Town District of Ellerslie.
The Town District of Manurewa.
The Town District of Papatoetoe.
The Town District of Howick.
The County of Manukau.

Provision was made for adding other areas or excluding named areas, with provision also for appropriate alteration of the Water Board District. The Bill contained provision for the election of members by the Ward system and for meetings and other usual provisions.

Under the heading of "Finance" provision is made for raising loans in the manner prescribed

by the Local Body Loans Act, 1913, with power also to raise loans for a defined part of the district. Power is also given to the constituent local bodies to advance funds to the Board for preliminary expenses. Rating powers are given with power to delegate the collecting to the constituent local bodies.

As to construction and purchase of water works, very wide powers are given, and provision is made for compensation to persons injuriously affected by the Board's operations. The Bill also contains provision necessary to clothe the Board with authorities sufficient to enable it to function and provide water supplies where required.

The Bill as originally introduced contained no provision concerning Auckland City; but the promoters of the Bill agreed to insert in it a clause entitling Auckland City, if it so desired, to come in and become part of the Board's district at any time within six months from the constitution of the Board, and further provision was made that the Auckland City could call on the Board to take over its whole waterworks undertaking, including reticulation, at a price and terms to be settled in accordance with the Public Works Act, 1908.

A number of the proposed constituent authorities had either waterworks plus reticulation systems, or reticulation systems without waterworks. No provision is made in the Bill as to what is to happen to these works and reticulation, except a general power to purchase, and a dispute might have arisen if a local authority wanted its works taken over and the Board refused to do so.

Your Commissioners heard a great deal of evidence on the question of the proposed Water Board.

The report and estimates of Messrs. Rogers and Gray, supplemented by certain other data presented by the Chairman of the Provisional Committee, was considered by the various local bodies interested. This information was published in pamphlet form and a copy produced to the Commission. We have, in another portion of our report, indicated our considered opinion that the

estimates there given are seriously under-estimated.

The financial statement accompanying the Engineers' report was, of course, based on the estimates in such report. The annual charges on the whole Taupo scheme were placed at £151,000, while like charges on the proposed alternative pumping scheme from Arapuni were estimated at £108,900.

The population in the Boroughs, Town Districts, and Road Districts estimated to be served by the scheme, was 125,000, and it was assumed these people would require 6,250,000 gallons of water per day on the basis of 50 gallons per head. This consumption, at 1/- per 1,000 gallons, was estimated to produce £114,000 per annum, and this was stated to be more than sufficient to meet charges on the Arapuni scheme.

Elsewhere we show that water from Taupo would cost 19 pence per 1,000 gallons under the most favourable conditions when it is supplying to its maximum capacity, and we have further shown the Arapuni scheme to be unsound, and that if water is to be taken from the Waikato River it should be taken from that river near Mercer. The estimated population to be served was the presumed population that would take the water in 3½ years from 1925.

The pamphlet states that the population, exclusive of the City area, was, at 1st April, 1924, computed at 113,700, and this figure, we take it, was increased to 125,000 by reason of the fact that there were 3½ years to elapse before water could be brought in. In this population is included the boroughs of Cambridge, Hamilton, Ngaruawahia, and the town district of Papakura. We have shown that these bodies already possess satisfactory supplies, and that there is no prospect of their taking water from the Board. The pamphlet shows a total of 20,875 as being the population of these districts as at 1st April, 1924, and allowing for a proportionate increase in population in the 3½ years mentioned, the population may be assumed to have then increased to 23,500. By deducting this total of 23,500 from the 125,000

estimated population to be served, it reduced the estimate to 101,500, which makes the consuming population to be over-estimated by 18 per cent.

But there are also other districts owning water supplies as to which it is, to say the least, doubtful whether they would take the Board's water when its price is compared with the price of their present or potential supplies. These districts are:

| | Population: |
|---|---|
| Birkenhead | 3,022 |
| Northcote | 2,358 |
| Takapuna | 6,044 |
| Devonport | 9,830 |
| Onehunga | 9,181 |
| | 30,435 |

The same remarks would be true of One Tree Hill, which has a population of 7,171, if this district is one of the Water Board's potential customers.

If the Board proposes to take over the water supplies of these districts and "scrap" the plants, the cost of these scrapped plants must be added to the capital cost of the scheme. And superadded to this must not be overlooked the fact that those Boroughs which are now purchasing water from Auckland, viz., Avondale, Newmarket, Mount Eden, and Mount Albert, are paying one shilling per 1,000 gallons. However anxious some or all of these bodies are to go elsewhere, the ratepayers of these districts will, we think, pause when they appreciate what the cost of water from Taupo or Arapuni is going to be. And if the proposed new supply were from Mercer or Hunua Ranges, then it is clear that a Water Board supplying to a relatively small population could not supply water from these services as cheaply as Auckland City could.

It cannot be overlooked that the local bodies who appeared before the Commission all assumed that the Taupo or the Arapuni scheme was going to provide a supply of water from an inexhaustible source and as cheaply as Auckland was supplying it, and that this price would gradually reduce as consumption increased.

We have not disregarded the fact that counsel for these Boroughs supporting a Water Board virtually jettisoned the Taupo scheme at the outset and claimed that they were not necessarily committed to the Arapuni scheme; but we feel it to be the case that had it not been for the Taupo scheme, with its apparent magnitude and cheapness, being placed attractively before them, there would not have been so much talk of a Water Board. In this connection it is interesting to note that in the Local Authorities Handbook of 1926, Mount Albert Borough, while stating that it derives its water supply from Auckland, adds:—

> "But it is hoped in the near future supplies will be available under the Provincial Water Board's scheme from Lake Taupo."

If a Water Board were created, and it brought to the various districts it proposes to serve, water at a reasonable price, and took away from Auckland City its Avondale, Newmarket, Mount Eden and Mount Albert customers, Auckland would then be in the position of losing consumers who would, on a basis of 50 gallons per head per day, consume 1,810,500 gallons per day. Its ratepayers have already spent, or are committed to the expenditure of, £1,597,000, so as to provide water sufficient for 242,000 persons on the basis of 60 gallons per day. Auckland will have (on the 60 gallon basis) water for nearly 250,000 people on completion, by 1930, of the works at present in hand. By that time Auckland's present customers, including the places to which it sells water, should be about 170,000, this not including North Shore, which may not go in for a supply from Auckland sources. It would, if deprived of its customers, have a surplus supply, and it would not overtake this surplus for possibly another ten years—say, the year 1940.

If the Water Board found new sources of supply and took away consumers who now total 45,000 persons, consuming about 500 million gallons yearly, the result would be that the present expenditure, instead of being now incurred, could properly have been postponed for a number of

years. This means capital loss, which loss will fall on Auckland citizens.

Your Commissioners, moreover, cannot see any wisdom in a proposition which involves providing a second supply to some of the inhabitants of the Auckland Urban Area when the supplies actually in hand, or ready by the year 1930, will provide ample for their then requirements, with reasonable provision also for future requirements.

The promoters of the Water Board may say that if they took their supplies from a cheaper source—say Mercer—they would not lose as much as the Arapuni and Taupo figures show. But if another authority brings another supply into the Auckland Urban Area when a sufficient supply of water is there already, it is obvious that waste and loss is incurred, and it will be persons resident in the Auckland Urban Area who will have to bear this loss. It does not require a financial genius to appreciate that two water supplies are a waste of money when one is sufficient.

The above remarks have reference to certain practical difficulties. We appreciate that the Boroughs who ask for a Water Board do so because they believe it is going to provide them with an abundant supply of pure water at a reasonable price. If a Water Board cannot give them this, we doubt whether the Boroughs would want a Water Board.

A number of witnesses called by Mr. Rogerson voiced the complaint that the outside bodies who purchased water from the City had no voice in the management of the water works. This was suggested as a grievance only to be cured by the creation of a Water Board upon which they were to have representation. Some of these outside bodies, such as the Boroughs of Newmarket, Mount Eden and Mount Albert, pressed the point that unity in a matter of water supply was of supreme importance. The unity that they visualised was a Water Board. They shut their eyes to another very obvious form of unity, viz., amalgamating with Auckland City, and thus becoming citizens and partners in all things belonging to the City and each mutually sharing the fair proportion of

each other's burdens. A glance at the map of Eden County will show Newmarket as an "island" Borough completely surrounded by Auckland City. The Mayor of Newmarket gave evidence before your Commissioners advocating unity on questions of water supply, but he overlooked the fact that the existence of his Borough, surrounded by Auckland City, is the negation of unity.

Your Commissioners asked what was the attitude of Auckland City to the question of amalgamation, and was informed that Auckland City welcomes amalgamation and has accepted all overtures on this head from neighbouring bodies.

## ANALYSIS OF ARGUMENTS SUBMITTED FOR WATER BOARD.

In your Excellency's Warrant to your Commissioners there was contained the following questions:—

"3. (a) Whether the methods adopted in the said public water supplies of distribution of water to consumers are satisfactory.

"(b) If and so far as such methods are not considered satisfactory, then the most desirable and suitable constitutional means or form of control and management of such methods of distribution, and of any methods of distribution that may be considered necessary or desirable for future requirements within the next 40 years."

It was with particular reference to the above questions that, on behalf of the supporters of the creation of a Water Board, it was submitted, firstly, that the present methods were unsatisfactory, and, secondly, that the creation of a Water Board was the most satisfactory and desirable form of control.

The attack as to administration, price, quality, etc., was directed against Auckland City. Mr. Rogerson, in his admirable address to your Commissioners, submitted certain assignments of complaint against Auckland City, and, shortly, these were:—

(a) That Auckland has charged the outside bodies too much for the water it supplies;

(b) That the water supplied was deficient in quality;

(c) That it was, on occasions, deficient in quantity, due to want of proper foresight.

Mr. Rogerson claimed to have established the above complaints, and he further submitted seven reasons why a Water Board was to be preferred to administration by the Auckland City Council, or to any other form of government dealing with water supply. These reasons briefly were:—

(i.) Consumers being the owners of the whole undertaking would get their water at cost.

(ii.) The Water Board being confined to only one sphere of activity could give the subject close and undivided attention.

(iii.) City Councillors have too much to do, with the result that business men are unable to offer themselves as Councillors.

(iv.) The multiplicity of a City's activities militate against due attention being given to individual matters.

(v.) That the City would experience financial difficulties with reference to works connected with supplies outside the City.

(vi.) The area of a Water Board's jurisdiction is quickly adjustable to alteration of circumstances.

(vii.) A City would encounter difficulties in carrying out works beyond its boundaries.

The three complaints form the basis of claim for a change of management, and the seven reasons form the grounds advanced for the creation of a Water Board.

Unless the complaints, if established, are of sufficient gravity to justify the deprivation of the City of its waterworks, we may take it that there would not be sufficient reason for taking this drastic step: *a fortiori* if the complaints are not established.

The first complaint is that Auckland has charged the outside bodies too much for water supplies. A return put in of the amounts paid

for water by the various purchasing bodies for the twelve months ending 31st March, 1926, is as follows:—

| | |
|---|---|
| Newmarket | £4,125 |
| Tamaki | 2,226 |
| Mount Eden | 9,360 |
| Avondale | 870 |
| Mount Albert | 7,060 |
| Mount Roskill | 1,925 |
| New Lynn | 1,537 |
| Henderson (estimated) | 110 |
| | £27,213 |

The amounts transferred by the Auckland City Council from its ordinary Water Account to its General Account for the years 1904 to 1926 are as follow:—

WATER TRANSFERS TO GENERAL ACCOUNT.

| | | £ | s. | d. |
|---|---|---|---|---|
| 31st March, 1924 | General Debit | 17,112 | 16 | 10 |
| ,, 1905 | Debit | 3,496 | 17 | 11 |
| ,, 1906 | | 7,588 | 15 | 9 |
| ,, 1907 | | 11,009 | 9 | 1 |
| ,, 1908 | | 23,243 | 15 | 1 |
| ,, 1909 | | 29,186 | 6 | 6 |
| ,, 1910 | | 14,229 | 8 | 2 |
| ,, 1911 | | 15,000 | 0 | 0 |
| ,, 1912 | | 15,000 | 0 | 0 |
| ,, 1913 | | 15,000 | 0 | 0 |
| ,, 1914 | | 15,000 | 0 | 0 |
| ,, 1915 | | 15,000 | 0 | 0 |
| ,, 1916 | | 43,287 | 14 | 8 |
| ,, 1917 | | 20,000 | 0 | 0 |
| ,, 1918 | | 20,000 | 0 | 0 |
| ,, 1919 | | 20,000 | 0 | 0 |
| ,, 1920 | | 20,000 | 0 | 0 |
| ,, 1921 | | 20,000 | 0 | 0 |
| ,, 1922 | | 10,000 | 0 | 0 |
| ,, 1923 | | 10,000 | 0 | 0 |
| ,, 1924 | | 15,000 | 0 | 0 |
| ,, 1925 | | 20,000 | 0 | 0 |
| ,, 1926 | | 58,219 | 3 | 0 |
| | | £437,374 | 7 | 0 |

The Town Clerk (Mr. J. S. Brigham) in his evidence supplied a detailed statement of the cost to the City of water produced for the year ended 31st March, 1926, during which the total produc-

tion was 2,987 millian gallons. The cost, including that of reticulation within the City and of pumping water to those outside local bodies that require water to be lifted from the City service reservoirs, is given as 6.37 pence per 1,000 gallons.

The Town Clerk went on to point out that the interest and sinking fund charges on the loans raised (£670,000) to carry out the works now being completed or in hand—raising the Waitakerei Dam, constructing Upper Huia Works, and building filters—would cost yearly £42,117. That sum, he stated, would, without allowing for the necessary maintenance and operating costs, represent an extra charge of 3.72 pence on the 1926 water production, so that if no increase in consumption takes place by 1930—this being the date when all these works will be completed—the water supply would have to meet charges totalling 10 pence per 1,000 gallons.

Normal growth of consumption is bound to continue, so that the precise position indicated by Mr. Brigham will not arise; but it is clear that with any new large addition to capital expended for the purpose of increasing production there must be a material increase in the cost of water until such time as the consumption grows once more towards the production capacity of the new development. The losses on the new development suffered while the demand is being built up may, on a long view, be regarded as an addition to capital cost, and in due course they would be liquidated when the new development begins to pay for itself. On this basis the influence of the extra capital charges would not be very marked upon the cost of production of water. But this consideration is of importance when the question arises whether a small community can successfully build large works. Such a community can ill bear the heavy capital charges in the early stage of development of its scheme. It may be sound economy for a small community to do so, but such an one is likely to find itself unable to carry on in the early and perhaps prolonged unprofitable stages of such a scheme.

It appears to your Commissioners that the statement, as supplied by the Town Clerk at Auckland for water cost for the year ended 31st March, 1926, was for a period when conditions were favourable to low cost because consumption was practically up to the then capacity, but future developments will be more costly, and from the present time onwards filtration will add a charge of from ¾d. to 1d. per 1,000 gallons.

It is a matter of some difficulty for your Commissioners to form a precise estimate of the actual cost to the City of the water it sold to outside bodies in the year 1926. Mr. Brigham's figures include costs in relation to reticulation in the City itself, and these items should not be included when considering the actual cost of water sold outside Auckland. In any examination into the cost to Auckland City of water supplied to outside bodies, the question must arise as to what is the fair capital cost upon which to base interest and sinking fund charges. It could, with some reason, be contended that the present capital value should be taken, or that, at least, these charges should be reckoned upon the original capital expenditure. In figures presented by Mr. Brigham the interest charges appear to be computed upon the balance of the original loans, after a portion has been amortized. It is quite possible that, upon the figures presented by him, the cost for that year could be stated at about sixpence per 1,000 gallons; but we have in the foregoing indicated some factors that, apart from the capital charges in respect to existing development, will make future costs higher than those for the year 1926.

Later in this report we make a recommendation with reference to legislation designed to settle questions of price by arbitration. Your Commissioners consider, under the circumstances, that it would be inadvisable for them to endeavour to name what is the precise cost of the subject of further discussion and further evidence, and no good purpose would be served by your Commissioners, on the limited facts at their disposal, submitting a figure, which might in the future

cause embarrassment to one or other of the parties.

The supporters of the Water Board claim that they should be entitled to get water from the City at cost price, but they would probably not be prepared to concede to the City the right to claim from them a share of the City's losses on water supply, if the business were being run at a loss. The price paid by Auckland's citizens, whether by meter or by way of water rate, is such that a profit is made by the City. If the City fixed its water rate at such a figure as would return a loss, outside purchasing bodies would resent any suggestion that they should, because of such losses, pay more for the water sold to them. If some local calamity, such as an earthquake, were to wreck the City's dams and mains, would the outside bodies be prepared to pay any portion of the cost of reinstating?

All the above considerations are pertinent to the question whether it is proper for a local body owning water to make, with propriety, a profit on water sold to a neighbouring local body. The ratepayers of the selling local body take all the risks of the capital they embark, and if their expenditure is unwise the loss falls on the ratepayers who provided the money.

It seems to your Commissioners that there is nothing unfair or inequitable in a local body which has taken all the risks in providing a supply making a reasonable profit from any neighbouring local body which prefers not to go to the risk and expense of obtaining its own supply, or which is unable, by reason of the want of a suitable supply, otherwise to provide for itself. When such purchasing body, for reasons which appear to it to be good, prefers not to amalgamate with the supplying local authority, when such supplying local authority is prepared to agree to amalgamation, then, to your Commissioners' minds, it appears to follow that the purchasing local authority must be taken to be agreeable to pay a reasonable profit to its water-vending neighbour, because it purposely prefers that the position be-

tween it and its neighbour should remain that of vendor and purchaser, and not that of partners.

The charge against Auckland is that it has charged too much for the water it sells. The figures certainly show that Auckland is making a profit on its water undertaking. How much of this profit is referable to sales to outside bodies and how much is referable to sales to its own ratepayers, it is difficult to estimate. The outside bodies consume about one-sixth of the water, but to their sales may be due more or less than one-sixth of the profit. The more water that Auckland can sell to its own ratepayers or to outside bodies, the cheaper the cost of production.

The price of 1/- per 1,000 gallons has been in vogue for a long time. It has more or less always been the price, and was, no doubt, originally fixed as a convenient round sum representing some profit—but without knowing precisely how much —to the City. This price of 1/- a 1,000 gallons is a very common charge for water. It is taken to be worth about that as a sort of market rate. No doubt, when the purchasing local bodies contemplated reticulating their respective districts, they approached the City to see if they could have water, and at what price, and having been offered water at 1/- per 1,000 gallons, they accepted the City's offer, after submitting the matter to their respective ratepayers. There does not seem to have been any very serious complaint at the price, until it was raised at this Commission.

Had any evidence been offered that Auckland City had at any time been endeavouring to drive a hard or unconscionable bargain with any of its purchasers, different considerations would arise, but the position appears to be that the price of 1/- was apparently originally fixed by agreement, and has so remained without any serious complaint. Under these circumstances, we do not think that we would be justified in finding that by reason of the price which it has charged, the City has been guilty of something which would entitle the local bodies promoting the creation of a Water Board to have the management of the City's water undertaking taken out of its hands.

We shall later in this report offer to Your Excellency certain suggestions with regard to fixing the price and terms of the supply of water by the Auckland City Council.

We will now turn to the second ground of complaint, that is, lack of quality, raised against the Auckland City Council.

The lack of quality lay in undue turbidity, and this condition of the water was not disputed before your Commissioners. Nevertheless, the water, notwithstanding its turbidity, is quite wholesome.

Filtration plants now in course of completion will shortly be put into operation, and the turbid condition of the water will then be removed, and this ground of complaint will cease. This provision of these expensive and elaborate filtration plants, with the added cost of operating, was not a matter to be undertaken lightly, and it is not an uncommon experience that decisions in respect to such policy matters, and the making of subsequent loan arrangements to carry such policy into effect, take some time to carry through. The City Council also has some justification for allowing time to try out the effect of storage in improving the quality, including that of colour, in respect to the mass of impounded water behind the big Nihotupu dam.

Reviewing all these circumstances, we do not consider that the complaint under this head affords any grounds for interfering with the City's management of its water supplies.

In so stating we do not overlook the fact that the complaint is made as justification for the institution of a Water Board, but in our opinion a Water Board without the whole Auckland Urban water supplies being in it would not be practicable.

The remaining complaint amounts to a charge of want of foresight and lack of prosecution of required works on the part of Auckland City. It is suggested it did not look far enough ahead, and the provision of certain works was subject to such delays that the sufficiency of the supply was imperilled and that certain subsidiary works had to be undertaken as emergency measures.

The difficulties that the City Council has had to face in this connection largely arise out of the time taken to construct the Nihotupu works. A contract for that dam was let in 1915, and instead of being completed by 1918 or 1919, the work was not complete till 1923, the delay due to war and post-war conditions being such that the Council could not control or foresee. In the early years of the Waitakerei development some time appears to have been lost in deciding policy and major engineering questions; but, with the exception of that, we consider the City Council has displayed foresight and has actively prosecuted its water supply development. It is unsound to carry out works any further in advance than is required to provide for the ordinary demand, together with normal increase of such demand, and it is a fact that at stages where the demand has just been about to overtake the capacity of their completed development, none of the City's customers has had to be short of water. We do not look upon a restriction upon watering gardens in a dry summer as any real shortage. The City of Wellington has had a like restriction imposed on it for years.

We are of opinion that no substantial case has been made out on this head.

Having come to the conclusion that the complaints made would not justify drastic action against the Auckland City Council, we report that, in our opinion, no sufficient case has been made out for taking its water undertaking out of the hands of the Auckland City. We have also expressed our considered opinion that without Auckland City being included the Water Board would not be practicable.

It will, however, be convenient if we shortly refer to Mr. Rogerson's seven reasons for the creation of a Water Board:—

(i.) Consumers would get their water at cost. They might do so; we doubt it. But with Auckland out of the Water Board, the cost of water would be too burdensome for the other bodies to bear. The Water Board would have to add something to the cost as

an ordinary business precaution, in the same way as electric power boards do. In our opinion, Auckland should not be compelled to go in, and is entitled to a reasonable profit on its sales. The remedy open to any local bodies that desire to share in these supplies and in their management is to amalgamate with Auckland.

(ii.) That a Water Board having only one sphere of activity could give undivided attention to water.

Multiplicity of boards is, in our opinion, bad. A City Council has a Water or Works Committee which devotes special attention to water supply, and, moreover, the City already has a trained staff familiar with the whole details of the undertaking.

(iii.) That the best men will not volunteer for service on a City Council because there is too much to do.

If this is true, then the whole basis of municipal government is unsound. To carry this argument to its logical conclusion, every city ought to have a multiplicity of councils relegated to special spheres of the council's activities.

(iv.) The same answer can be made to the suggestion that a city's activities are too many to give each proper attention.

(v.) That the City might find difficulty in finance in relation to works to provide for areas outside the city.

There may be something in this point, and we are dealing with it in another portion of this report upon the subject of legislation to protect outside consumers.

(vi.) We do not think there is anything in the claim as to elasticity of boundaries of a Water Board. It must of necessity depend upon mutual agreement between the Board and the residents of the proposed new area.

(vii.) That a City Council would encounter difficulties in relation to works outside its boundaries.

We do not see that a Water Board is in any better or worse position in this respect than the City.

To sum up our conclusions, we are of opinion that the creation of a Water Board, so far as the Auckland side of Auckland Harbour is concerned, woud be most ill-advised and is unnecessary. It would not result in cheaper water to the local bodies outside Auckland City, but, on the contrary, would result in loss to the general body of the citizens of the Auckland Urban Area.

## PROPOSED LEGISLATION.

Your Commissioners have given very earnest consideration to the question as to whether some legislation may not be necessary to provide a measure of protection to the various local bodies who are purchasing water from Auckland City. In this report your Commissioners have come to the conclusion that no sufficient case has been made out for the creation of the proposed Water Board, and your Commissioners are also of opinion that they cannot find that the conduct of the Auckland City in relation to water supply has savoured of unfairness to the outside bodies. Indeed, it would appear to your Commissioners that the settled policy of Auckland City in relation to water supply has always been that it looked upon itself as bound to supply any neighbouring district in need of water. and the price and terms were, no doubt, settled as the result of negotiation between the parties. The fact that Auckland City seems genuinely desirous of helping outside bodies is indicated by the offer it made to the North Shore Boroughs to provide filtered water from the break pressure tank at Waitakerei at 6d. per 1,000 gallons, and Auckland City, in making the offer, no doubt took into consideration the fact that the North Shore Boroughs needed some help.

Although, in the opinion of your Commissioners, nothing in the history of Auckland's management of its water undertaking shows any desire to take undue advantage of neighbouring local bodies, it was virtually admitted by the Auckland City at the inquiry before your Commissioners that the price of 1/- per 1,000 gallons charged to various purchasing bodies would stand a reduction. Mr. Johnstone—counsel for Auckland City—said as to this:—

> "That price may or may not be a fair price. That is a matter for negotiation. Nobody has come forward and put up a good case that has not had good treatment."

It is, we think, true that Auckland has endeavoured to be fair—that is, fair to its own citizens and fair to the purchasers of water. The outside bodies might be inclined to look at this matter from the point of view only of fairness to themselves, and, on the other hand, the Auckland City may be inclined to give undue weight to considerations of fairness to its own ratepayers.

It seems to your Commissioners that when it is taken into consideration that Auckland City already owns the best supplies near Auckland, and that Auckland could best exploit the other sources of supply, such as those from Hunua Ranges and from the Lower Waikato, then regard must be given to the fact that other local bodies who are compelled to purchase water from Auckland may, at some time or other, require more protection than is afforded by a mere right of negotiation.

Your Commissioners take the wide view that all residents of the Auckland Urban Area are all citizens of Greater Auckland, and are all united by community of interest, divided though they be by more or less arbitrary boundaries, and that they enjoy within their respective boundaries all the advantages reputed to follow from Home Rule. However improbable the possibility of peril to the citizen right of each of these residents of Greater Auckland to a fair share of water, your Commissioners feel that this right is entitled to reasonable protection. Protection is necessary if

for no other reason than that it will help to equalise the position of the parties in negotiation one with the other.

Accordingly, therefore, your Commissioners respectfully recommend that the right of outside bodies to a share in the Auckland City's water supplies be recognised to this extent, that any of these outside districts whose boundaries are actually within what we shall call the Auckland Water Supply District, or any part of such districts as is prepared to reticulate and supply water to its inhabitants, is to be entitled to call upon Auckland for a water supply to be delivered into mains to be provided by the local body requiring water, within reasonable time, at a reasonable price and upon reasonable terms. Upon the question of price, your Commissioners express their considered opinion that the price should not be the cost price, but should be such a price as, having regard to all the circumstances, will return to the City of Auckland a reasonable profit. In another part of this report your Commissioners have given reasons for this conclusion.

This right to call for arbitration should be available also to those bodies now purchasing water from Auckland City.

In order to provide a tribunal for the settlement of any question as to the price of water and the terms generally as between Auckland City on the one hand and the purchasing local body on the other, your Commissioners recommend that legislation should be introduced providing for the settlement of any disputes by arbitration: one arbitrator to be appointed by the purchasing body and one by the Auckland City, and an umpire to be appointed by the arbitrators: in default of agreement by the arbitrators the umpire to be nominated, say, by the Minister of Public Works. In framing any legislation it should be made clear that Auckland City is to be entitled to a reasonable profit on the sale of its water, but that otherwise the arbitrators, or the umpire, as the case may be, have a wide discretion as to the circumstances which in their opinion might weigh with

them in fixing the terms and the quantum of profit for Auckland City.

The limits of the Auckland Water Supply District intended to be effected by this proposed legislation should be defined. Your Commissioners recommend that the following should constitute the proposed Auckland Water Supply District:—

The whole of the Auckland Urban Area as defined on the map attached to this report (Appendix C), with the addition of the excluded portion of the Henderson and Glen Eden Town Districts, and with the addition also of the Papatoetoe and Manurewa Town Districts, and with the addition also of those portions of the Mangere and Papatoetoe Ridings of the County of Manukau as are bounded on the western side by a line one mile to westward of the Main Trunk Line, and on the eastern side by a line one mile eastward of the Great South Road.

In respect to local bodies or districts actually contiguous to Auckland City boundaries, it should be the duty of Auckland City to bring to its boundary, at a place to be nominated by the purchasing local body, a main of size sufficient reasonably to provide for present and future requirements; the cost to the City of such main to be a factor to be taken into consideration in ascertaining the price to be charged by Auckland City for its water.

In respect to local bodies or districts within the proposed Auckland Water Supply District, but not actually contiguous to Auckland City, Auckland City should have the right to lay mains through intervening districts, the cost of such mains to be borne by the district or districts requiring supply. But in the event of two or more districts requiring supply, it will then be necessary for the main to be of sufficient size to supply these districts, and in the event of any difference between these districts as to their proportion of the cost of main, such difference to be settled by arbitrators, as provided *mutatis mutandis* for difference between Auckland City and other districts.

If legislation on the lines suggested were introduced, it should afford a means for removing any complaints, if such be justified, that Auckland is making too great a profit on its water.

In view of the fact that your Commissioners are of opinion that the question of price should be the subject matter of arbitration, your Commissioners feel that it would not be proper for them to express any opinion as to whether or not the price of water charged by Auckland City is or is not reasonable. Your Commissioners are in hopes that all present differences as to price will be composed as the result of friendly negotiations and without the necessity of resort to arbitration.

There remains also another matter for consideration upon this branch of the subject. It was suggested by Mr. Rogerson that difficulty might arise as to finance if Auckland City, having been required to provide a supply for a particular district, submitted to its ratepayers for approval a loan proposal to provide the funds to construct the necessary main, or the funds necessary to construct the additional works called for to obtain the necessary additional water, and the Auckland ratepayers rejected the loan proposal. The fact that the arbitration tribunal proposed by your Commissioners would be directed to fix such a price as would provide some profit to Auckland should, in the opinion of your Commissioners, go a long way to ensure approval by Auckland citizens of any loan proposal. But the fact cannot be overlooked that Auckland ratepayers, being possibly dissatisfied as to an award, might be inclined to indicate such dissatisfaction at the poll on the necessary loan proposal. To provide for this eventuality, your Commissioners suggest that legislation on the lines of the compulsory provisions of the Health Act, 1920, be enacted to meet the case. Under the Health Act, 1920 (Section 22), local bodies must, when required by the Board of Health so to do, provide such sanitary works as the Board of Health requires. Section 23 of the Act contains provision for appeal from a requisition, but such a provision should not be made in this

case. Section 140 of the Health Act contains provision for the finance for requisitioned works, and Section 24 gives authority to raise a loan without taking the steps required by the Local Bodies' Loans Act, 1913. Provision on the lines of the above could, without undue difficulty, be framed to meet the case under discussion.

## EXPENSES INCURRED BY THE PROVISIONAL COMMITTEE OF THE PROPOSED PROVISIONAL WATER BOARD.

At the close of the address delivered by Mr. Rogerson, Counsel for the Local Bodies, advocating the Water Board, on the conclusion of the Commission's public sittings, he brought up the matter of the expenses, amounting to £758 18s. 11d., incurred by the Provisional Committee in relation to the proposed scheme and the institution of a Water Board. These expenses are as follow:—

| | £ | s. | d. |
|---|---|---|---|
| Engineering Charges and Expenses | 414 | 7 | 0 |
| Legal Expenses | 210 | 0 | 0 |
| Rent, Chamber of Commerce | 3 | 0 | 0 |
| Printing | 50 | 0 | 0 |
| Expenses—Wellington | 55 | 4 | 5 |
| Typing | 8 | 12 | 0 |
| Motors | 7 | 5 | 0 |
| Analyses | 10 | 10 | 0 |

Counsel stated that it was the intention, and provision was inserted in the Bill ensuring, that these expenses were to be reimbursed by the Water Board when formed. He urged that it was the Auckland City Council's opposition that prevented the passing of the Bill last session, and so prevented the several local bodies obtaining a refund of their respective shares of the expenditure incurred. For that reason, and for the reason that the expenses were incurred for the benefit of the public generally, he claimed that these expenses were, in some measure, a charge upon the City Council, and your Commissioners were asked to make a recommendation accordingly.

It seems to your Commissioners that the expenses are properly payable by those bodies which

were associated in the promotion of the proposed Water Board.

Owing to the limitations which are imposed on local bodies as to expenditure to be incurred by them, and the limits provided as to the unauthorised expenditure they are permitted to expend, some difficulty may arise as to the right of local bodies to pay their respective shares of the expenses. The position in the opinion of your Commissioners, is that these local bodies have incurred liability in good faith and with the laudable intention of advancing the interests of their respective districts.

Your Commissioners therefore respectfully recommend that, if required by the respective local authorities interested, the necessary validating legislation be passed to give to each local body concerned the authority to pay from its general fund its respective proportionate or agreed share of such expenses.

## COSTS OF COMMISSION.

Your Commissioners were further directed that, having regard to the local scope of this Commission to consider what sums representing the whole or any portion of the costs of our inquiry should be borne by the respective local authorities set out in the Schedule to your Warrant to us.

We are of opinion that the scope of the Commission is entirely local, and that the whole of the costs of our inquiry should be paid by the local bodies particularly interested. We, therefore, in pursuance of the powers contained in the Commissions of Enquiry Act, 1908, do order that the whole costs of our said enquiry shall be paid by the following local bodies in the respective proportions set out hereunder opposite the respective name of each such local body:—

| Name of Local Body. | Proportion of Costs Payable. |
|---|---|
| The Mayor, Councillors and Citizens of the City of Auckland .. .. .. .. | Twenty-five one-hundredths |

| Name of Local Body. | Proportion of Costs Payable. |
|---|---|
| The Mayor, Councillors and Burgesses of the Borough of Newmarket .. .. .. | Seven one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Onehunga .. .. .. | Six one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Takapuna .. .. .. | Six one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Northcote .. .. .. | Two one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Mount Albert .. .. | Ten one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Avondale .. .. .. | Three one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Mount Eden .. .. | Seventeen one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Otahuhu .. .. .. | Two one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Birkenhead .. .. .. | Two one-hundredths |
| The Mayor, Councillors and Burgesses of the Borough of Devonport .. .. .. | Eight one-hundredths |
| The Chairman, Councillors and Inhabitants of the Ellerslie Town District.. | One one-hundredth |
| The Chairman, Councillors and Inhabitants of the Mt. Roskill Road District | Three one-hundredths |
| The Chairman, Councillors and Inhabitants of the Tamaki Road District .. | Two one-hundredths |
| The Chairman, Councillors and Inhabitants of the One Tree Hill Road District .. .. .. .. .. | Six one-hundredths |

## ACKNOWLEDGMENT.

Your Commissioners desire to record their appreciation of the efforts made by Auckland City and its officials in affording every facility for your Commissioners to acquire first-hand information as to the existing and potential Auckland water supplies.

The North Shore Boroughs and the Health Department also greatly assisted the Commissioners.

Your Commissioners at every place visited by them were courteously assisted by all local officials.

We acknowledge also our indebtedness to the parties and the counsel who appeared before the Commission for their unfailing courtesy during the whole proceedings and for greatly lightening your Commissioners' labours.

## APPENDICES TO REPORT.

During the hearing before your Commissioners, a large number of exhibits were put in, comprising reports, tables, graphs, plans and sundry other documents. Many of the exhibits were very helpful to your Commissioners in the preparation of their report, but your Commissioners do not deem it necessary to append to this report any of the said exhibits, with the exception of the following:—

Letter from Government Statistician, dated 25th May, 1927. (Appendix A.)

Table showing populations of Auckland and adjoining districts from 1906 to 1926. (Appendix B.)

Plan of Auckland Urban Area. (Appendix C.)

We have the honour to forward a transcript of the shorthand report of the evidence taken, including transcript of report of addresses by counsel and parties, and also the several exhibits produced by the witnesses.

IN WITNESS WHEREOF we have hereunto set our hands and seals this fifteenth day of June, 1927.

(Sgd.) A. W. BLAIR, Chairman.
A. D. DOBSON, Commissioner.
A. J. BAKER, Commissioner.

Census and Statistics Office,
Wellington, 25th May, 1927.

The Chairman,
Auckland Waterworks Commission,
Room B. (Old) Parliament Buildings,
Wellington.

Dear Sir,

Referring to our recent conversation, I now return herewith the population statement left by you, with the figures checked throughout.

In regard to the future population of the area outlined in your statement, I note that it is practically co-terminous with the Auckland Urban Area. I have, therefore, considered figures on the Urban Area basis, since certain data are already on record for that area.

In considering the question of population "futures," a projection of the logistic curve is perhaps the most usual mode. However, for an area such as this, I am of opinion that it would be preferable to use a simple diminishing ratio of increase, which gives figures as under:—

AUCKLAND URBAN AREA.

| | | |
|---|---|---|
| 1926 | 193,385 | (census) |
| 1931 | 232,000 | |
| 1936 | 274,000 | |
| 1941 | 318,000 | |
| 1946 | 365,000 | |
| 1951 | 412,000 | |
| 1956 | 461,000 | |
| 1961 | 510,000 | |
| 1966 | 561,000 | |

The foregoing may be regarded as a moderately conservative estimate. So far as can be foreseen, there is no likelihood of actual development falling seriously below this level, although, on the contrary, it is always possible that there may be acceleration to a considerable degree by the emergence of fresh population "stimulants."

Yours faithfully,

(Sgd.) MALCOLM FRASER,
Government Statistician.

## POPULATIONS IN AUCKLAND CITY AND IN ADJOINING LOCAL BODIES, AS DISCLOSED BY CENSUSES FROM 1906 TO 1926.

| | 1906. | 1911. | 1916. | 1921. | 1926. |
|---|---|---|---|---|---|
| City .. .. | 37,736 | 40,536 | — | — | — |
| Parnell .. | 5,253 | 5,465 | — | — | — |
| Grey Lynn .. | 5,882 | 7,454 | — | — | — |
| Arch Hill .. | 1,952 | 2,120 | — | — | — |
| Eden Ter. .. | 2,338 | 2,595 | — | — | — |
| Epsom .. | 1,591 | 2,699 | — | — | — |
| Pt. Chevalier | 902 | 1,295 | — | — | — |
| Remuera .. | 3,082 | 5,284 | — | — | — |
| | 58,736 | 67,448 | 70,873 | 81,712 | 87,837 |
| Birkenhead .. | 1,266 | 1,703 | 2,116 | 2,507 | 3,022 |
| Devonport .. | 5,073 | 7,041 | 7,613 | 8,761 | 9,830 |
| Northcote .. | 1,116 | 1,422 | 1,651 | 2,040 | 2,358 |
| Takapuna .. | 888 | 1,446 | 2,756 | 3,910 | 6,044 |
| Mt. Eden .. | 6,888 | 9,381 | 12,555 | 14,635 | 18,037 |
| Mt. Albert .. | 3,583 | 6,700 | 9,654 | 11,345 | 17,471 |
| Newmarket. | 2,342 | 2,780 | 2,863 | 3,083 | 3,199 |
| Onehunga .. | 3,693 | 4,651 | 5,913 | 7,073 | 9,181 |
| Avondale .. | 1,489 | 2,103 | 2,451 | 3,230 | 4,565 |
| Otahuhu .. | 1,302 | 1,847 | 2,328 | 2,813 | 4,093 |
| Ellerslie .. | 688 | 947 | 1,363 | 1,615 | 2,407 |
| New Lynn .. | 200 | 592 | 1,041 | 1,386 | 2,535 |
| Manurewa .. | 298 | 423 | 430 | 751 | 1,350 |
| Papatoetoe .. | 193 | 386 | 1,062 | 1,171 | 1,604 |
| Panmure .. | 217 | 255 | 243 | 200 | 253 |
| One Tree Hill | 1,915 | 3,365 | 4,208 | 5,197 | 7,166 |
| Mt. Roskill. | 883 | 1,113 | 1,785 | 2,370 | 4,721 |
| Tamaki .. | 415 | 645 | 1,010 | 1,723 | 3,409 |
| Orakei .. | 25 | 34 | 73 | 80 | 70 |
| Mt. Wellington | 396 | 419 | 542 | 773 | 1,024 |
| | 91,606 | 114,701 | 132,530 | 156,375 | 190,176 |

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