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VICTORIA.

STATE ELECTRICITY COMMISSION OF VICTORIA.

REPORTS

ON

SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME

AND

INVESTIGATIONS IN STRATHBOGIE DISTRICT.

By Authority:
ALBERT J. MULLETT, GOVERNMENT PRINTER, MELBOURNE.

10998.

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REPORT ON SUGARLOAF-RUBICON SCHEME.

The Hon. the Attorney-General,
Melbourne.

SIR,

In accordance with sub-section (*c*) of section 11 of the State Electricity Commission Act, No. 2996, we now beg to submit to you the results of our investigations into the Water-power Resources of the Sugarloaf (Eildon Weir), Rubicon River, Snob's Creek, and Royston River districts.

In our Report of the 26th November, 1919, it was recommended that the " consideration of hydro-electric power schemes be deferred until further investigations now being carried out are completed." These further investigations resulted in a further Report, dated 16th November, 1920, on the Kiewa Hydro-electric Scheme. This Report included a description of the results to be achieved from the harnessing of the Kiewa River, Sugarloaf Weir, Rubicon River, and Snob's Creek, the conclusion being that a total output of not more than 37,000 kw. was available from those resources, the cost of the capital works involved being estimated at £3,715,527 on that date. Of this amount the Sugarloaf and Rubicon Scheme was estimated at £745,892 for a total output of 7,000 kw.

The conclusion and recommendation of the Commission in regard to this combined scheme was that " There is no present justification for embarking upon the execution of a hydro-electric scheme of the magnitude and nature outlined in this Report," this conclusion being chiefly governed by the fact that no market of sufficient size was then available or likely to be available for many years to justify the expenditure involved in works of the magnitude outlined. Particularly was it unsuitable as a source of supply to meet the demands of the Northern and North-Eastern Districts of Victoria, where the demands for energy in any one locality are so small and so irregular as to preclude the possibility of utilizing to advantage the output available from the scheme in question. It was, however, fully realized that the problem of supply to those districts demanded a solution, and, in concluding its Report, the Commission stated—

> The Commissioners are fully alive to the special circumstances of the North-Eastern District which is at present industrially undeveloped, and which contains a number of smaller towns not inconveniently far removed from possible sources of hydro-electric power.
>
> The Commissioners therefore propose to continue investigations directed towards evolving practicable hydro-electric schemes, on a much more modest scale than those considered in this Report, for the service of some of such North-Eastern towns or groups of towns. In this connexion, both the Sugarloaf Weir and the Rubicon River, considered as separate schemes, and not as part of the Kiewa Scheme, offer possibilities which seem sufficiently attractive to justify closer inquiry. Upon such inquiries the Commissioners propose to embark forthwith.
>
> With regard to the remaining portions of the North-Eastern District, not easily accessible by water power, the alternative of centralized heat power generation to serve individual towns or groups of towns is also deserving of and is receiving investigation.

WATER POWER—FACTORS GOVERNING ITS UTILIZATION.

Constant public references are still being made to hydro-electric schemes on the assumption that electricity produced therefrom must of necessity be " cheaper " and " better " than energy produced from heat-power schemes. In this connexion we cannot do better than draw attention to the statement appearing in our Kiewa Report :—

CHARACTERISTICS OF HYDRO-ELECTRIC SCHEMES.

> For a better understanding of the problems involved in such an inquiry, we venture in this Report to set out very briefly some of the principal factors, both engineering, economic, and topographical, which have to be taken into consideration.
>
> In every form of generation of power, the ultimate cost to the public may be divided into two parts, viz., that depending upon capital cost, and that depending upon operating cost. That scheme is the most economic in which the *total* of these two parts is the least.
>
> In a heat-power scheme the operating cost includes the cost of fuel and of its handling, and is therefore higher than the operating cost of a hydro-electric scheme, which, at its hydraulic end, is to a large extent automatic.
>
> It is this consideration which leads to a belief, widely held, that, broadly speaking, the generation of electric energy from water power is cheaper than its generation by the use of steam. That is, however, erroneous as an abstract proposition, because it omits to take into consideration that part of the cost of energy which depends on the capital cost of the whole scheme.
>
> Now, in the very nature of things, the capital cost of a hydro-electric scheme is, under average Victorian conditions, substantially higher than that of a heat-power scheme. The electrical apparatus (comprising generators, switchgear, and other auxiliaries), the transmission lines, and the distribution system are common to both. The hydraulic machinery of the one scheme takes the place of the steam-raising machinery of the other. But that ingredient of capital cost, which is inseparable from a hydro-electric scheme, and which is entirely absent from a heat-power scheme, is the cost of hydraulic headworks, necessary for the collection, diversion, conservation, conduction, and regulation of the waters of those rivers and streams whose resources are being tapped. Such works, if located in unsettled, mountainous country, difficult of access, are often exceptionally costly.

It is this latter portion of the capital cost which may alone, in a given case, reach such high figures as to have a paramount influence in rendering the hydro-electric scheme uneconomic as compared with steam; for the reason that the higher annual interest and sinking fund charges would in such a case overshadow any savings in operating charges due to the absence of fuel.

In addition, attention must be drawn to the existence in Victoria of deposits of brown coal of almost unlimited extent. These deposits, while providing low-grade fuel, are capable of being worked at a cost which compares more than favorably with other sources of heat-power such as black coal, thereby becoming a most formidable rival of water power when applied to the production of electrical energy.

HYDRAULIC RESOURCES IN VICTORIA.

Special attention has been directed by this Commission since its appointment in 1919 to the water-power resources of the State, to which end investigatory work on a studied plan has been vigorously prosecuted. As this investigatory work proceeds, it becomes increasingly clear that Victorian rivers, regarded as a source of electrical energy, compare adversely with those of other countries where hydro-electric schemes have been successfully launched and operated. Their disability in this regard lies chiefly in the wide fluctuations between summer and winter flow of the streams, and particularly the incidence of the drought years, during which periods the normal run of water is inevitably reduced, with a consequential restriction of the available output of electrical energy. Hence the reliability of output, which is a vital factor in any scheme for the supply of electricity, makes it essential that some other source of supply be linked up to supply deficiencies in such times of need.

As an alternative to the provision of steam plant as a standby, it is sometimes possible, as in the Kiewa Scheme, to locate suitable sites for the storage of water to tide over the periods of minimum flow. These works, however, add greatly to the capital cost of the scheme, with a corresponding increase in the price of energy produced, thus rendering still less favorable the comparison with a steam scheme based on low-priced fuel.

REASONS FOR DRAWING ATTENTION TO SUGARLOAF–RUBICON.

As already stated, in the consideration of the Kiewa Scheme as formulated by Mr. A. G. M. Michell, M.C.E., our attention was directed to the Sugarloaf-Rubicon portion of that scheme as a source of supply which might possibly meet the limited requirements of the North and North-East provincial districts of Victoria. This view was strengthened by the fact that the Sugarloaf Dam, now under construction, was proceeding towards completion, and with the co-operation of the State Rivers and Water Supply Commission, could be utilized for the production of electrical energy for periods during which water was being released for other purposes. The State Rivers and Water Supply Commission rightly insist that the production of electrical energy from this source shall be subservient to the demands on the water conserved for irrigation purposes, and the output in consequence restricted to the summer months. Yet, as the conservation works have been designed purely for irrigation purposes, the energy produced therefrom would not be called upon to bear any part of the capital cost of these works, and consequently very favorable rates could be anticipated, particularly if supplemented by other sources of supply from neighbouring streams.

To this end more detailed and comprehensive investigations were conducted by Messrs. J. M. and H. E. Coane, under instruction from the Commission.

ENGINEERING INVESTIGATIONS.

Based on the utilization of the Sugarloaf Reservoir and its known capabilities and limitations, investigations, as already stated, have been primarily directed to discovering neighbouring sources of water power capable of supplementing, during the winter months, the output from that source. Previous investigations of Mr. A. G. M. Michell, under the direction of the Commission, had already indicated the possibilities of the Rubicon River and Snob's Creek in this connexion, and these further investigations have now been brought to a conclusion, both as to the streams already named, and also as to other streams in the vicinity, such as the Royston River., with Messrs. J. M. and H. E. Coane as Consulting Hydraulic Engineers. Preliminary inquiry is also being made into future possibilities as regards the Murrundindi Falls and Yellow Dindi Creeks, situated close to the probable route of the transmission line to Melbourne. These streams, as the result of further investigation, may prove capable of exploitation in future years as the need arises due to natural expansion in the demand for electricity.

From the major investigations referred to, a combined scheme has now been formulated which is described in detail in the Reports annexed, viz., (1) Messrs. J. M. and H. E. Coane's Report on the Sugarloaf-Rubicon Hydro-electric Scheme; (2) the Report of the Chief Engineer to the Commission completing Messrs. Coane's Report on the electrical side. A brief description of these Reports is given hereunder :—

DESCRIPTION OF SCHEME.

The proposed scheme comprises, firstly, the use of the waters which will flow from the completed Sugarloaf Reservoir for irrigation purposes. Such flow will, however, be unavailable for a period up to three months in each year. It is necessary, therefore, to supplement this source of power from other streams. Surveys of the Rubicon and Royston Rivers and of Snob's Creek have shown that these tributaries of the Goulburn can yield a satisfactory winter supply. The combined resources may be considered as capable of supplying, in an average year, to hydraulic turbines in five power stations, the following power, viz. :—

	Brake H.P.	Equivalent in kws.
Monthly average for average year ..	19,220 ..	14,400
Maximum in April	12,970 ..	9,700
Maximum in October	24,730 ..	18,800

The total power of hydraulic turbines proposed to be installed is 25,800 brake-horse-power, which, on conversion to electric power, and allowing for all mechanical and electrical losses, is equivalent to an output of 15,750 kw. delivered at a point 52 miles distant.

The scheme embraces—

1. Power stations at Royston, Rubicon, Rubicon Lower, Snob's Creek, and Sugarloaf, all of which will feed into a common sub-station to be known as Rubicon "A," and situated about 8 miles from Sugarloaf.
2. Buildings at Rubicon "A" Sub-station and Terminal Station, Bundoora.
3. Transmission lines operating at 66,000 volts running to Bundoora (near Heidelberg), there connecting with the Melbourne high-tension network and, on the other hand, to Benalla. From Benalla main trunk feeders will run to power centres respectively at Wangaratta and at Shepparton.

   These latter towns will become the nuclei of a complete system of high-tension distribution to all towns, villages, and settlements within economic reach of either centre, thus providing for the supply of practically the whole of the settled portion of the Northern country.

ESTIMATE OF COST.

Capital Costs.—The total estimated capital cost of the works outlined in the Reports referred to is as under :—

	£
1. Sugarloaf-Rubicon Hydro-electric Scheme, comprising all hydraulic and electric work and appurtenances	551,370
2. Tower transmission line from Rubicon Sub-station to Bundoora, with terminal station and apparatus	241,800
3. Pole transmission line Sugarloaf to Benalla, with branches to Wangaratta and Shepparton, with sub-stations and apparatus	169,150
Total	£962,320

These estimates do not include any provision for interest during construction, nor the cost of subsidiary distribution from the terminal points or nuclei described, to the several centres of demand within range of those points.

Opera ing Costs.—The estimated costs of delivered energy at the various terminals are set out hereunder. It must, however, be clearly understood that these costs are based upon the precise conditions stated in each case, and cannot, without error, be applied to any other assumed conditions.

They are also in every case for bulk supply at the voltage stated, and upon the load factors given. They refer only to the scheme when fully developed, and on the assumption that the full output of which the scheme is capable, is being absorbed—

(*a*) Cost of 6,600-volt energy at Shepparton and Wangaratta Sub-stations for a supply to meet a combined maximum demand of, say, 5,000 kw. at a load factor of not less than 30 per cent.—0.79 pence per kw. hr.

(*b*) Cost of 22,000-volt energy at Bundoora Terminal Station for a supply to the metropolis to meet a maximum demand of not less than 15,750 kw. at a load factor of not less than 68 per cent.—0.28 pence per kw. hr.

For the purpose of such a supply as is described in (*b*) above, the estimates show that the relative costs of the current from various sources of supply would be as follows, always assuming that Sugarloaf-Rubicon is given, in its entirety, the best available metropolitan load:—

Sugarloaf-Rubicon	0.28 pence per kw. hr.
Morwell	0.243 ,, ,,
Morwell Extension	0.205 ,, ,,

The cost of supply, under similar conditions, from the Kiewa Scheme is not stated, for the reason that no market is, nor will be, available in the near future, capable of absorbing the 30,000 kws. which Kiewa is capable of supplying, at the load factor stated, viz., not less than 68 per cent.

Attention is drawn to the difference between the estimated costs for (*a*) and (*b*) quoted above, and estimated costs for supply under similar conditions as set out in the Chief Engineer's report. This is due to the necessity for taking into account interest during construction as required by a recent decision of Cabinet.

The scheme is capable of being divided into two stages, the first requiring the construction of the Sugarloaf-Rubicon and Royston Sections, with attendant works, together with the transmission lines and transmitting and receiving stations, whilst the final stage will comprise the Lower Rubicon and Snob's Creek Station and works. If this plan be adopted, it is not considered that the time occupied in construction will be materially lessened, but advantage could be taken of the relatively smaller output of the first stations to be completed.

However, the power demand in the metropolitan area is almost certain, by about that time, to be capable of providing the required load factor for the smaller output, viz., 11,500 kw., and advantage could be taken of this situation to begin feeding into the main system immediately the first generating sets are ready for operation.

The conclusion is therefore reached that the scheme should, if approved, be constructed in two main stages, as described, the total estimated capital costs being—

First stage	£550,390
Second stage	242,780
Total	£793,170

This estimate does not include cost of transmission lines to Benalla, Shepparton, and Wangaratta, with sub-stations and apparatus.

The operating costs of delivered energy remain practically identical whether the complete or the partial scheme is in operation.

CONCLUSIONS.

Regarded only as a source of supply for the service of the Northern and North-Eastern Districts of Victoria, it cannot be recommended that the scheme as presented be proceeded with, principally for the reason that the market available in those districts is not sufficiently large to afford the load required to enable the scheme in its entirety to be operated economically.

A careful survey has been made of the demands for electricity in the districts referred to. Based on that survey, it is estimated that a load of 6,000,000 kw. hrs. per annum will be available, with a maximum demand of 2,300 kw., at a load factor of about 30 per cent. To achieve the most favorable results from the combined scheme, a monthly average output of 14,400 kw. in the average year is required. It will thus be seen that the market from the North-Eastern and Northern Districts alone is quite inadequate.

Fortunately, however, just such a market will be available in the metropolitan area in 1928, and such a block of power corresponds very closely to the amount which the constant portion of the daily demand of the metropolitan area may be expected to reach in about the next six years. Thus a demand suitable for such a source of supply is expected to be available by the time that the supply itself can be made available. The question, however, to be considered is not merely whether such a demand can be provided, but whether it can be met more economically in this way than from other sources. Investigation has shown that if the only matters to be considered were the choice between the Sugarloaf-Rubicon Scheme and an extension of the Morwell Scheme solely for the purpose of meeting the growing demands of the metropolitan market by, say, 1928, then from the point of view of cost of energy the advantage is certainly in favour of the extension of the heat-power (Morwell) Scheme.

This conclusion has been reached even upon the assumption that the hydro-electric scheme would have to bear no part of the capital cost of the Sugarloaf Reservoir, which work has been undertaken and executed purely for irrigation purposes. If it were to be stipulated that the hydro-electric scheme should be charged with any portion of the Sugarloaf works, then such a scheme would be, from the point of view of the resulting cost of energy, hopelessly at a disadvantage as compared with a further extension of the Morwell Coal-power Scheme.

There are, however, very weighty considerations apart from the bare question of production costs in favour of the Sugarloaf-Rubicon hydro-electric project. One is that such a scheme will be almost wholly independent of any possibility of interruption by anything in the nature of industrial dislocation, and could, in an extreme event, serve to maintain the essential public utilities of the metropolis, such as sewage pumping, public lighting, and urgent transportation.

The other and much more important reason is that the Sugarloaf-Rubicon Scheme, as envisaged, forms the best means which the Electricity Commission has, after lengthy inquiry, been able to devise for the service of the rural districts in the Northern and North-Eastern Districts —the best, not only as regards appropriate size, expansibility and reliability, but also as regards the resulting cost of energy. The territory which can be so served embraces that important triangle of country bounded on the north by the River Murray from Echuca to Wodonga, on the South-East by the North-Eastern railway (including its Eastern branches) down to Euroa, and on the South-West by a line drawn roughly from Euroa to Echuca.

It is therefore clear that, although this scheme cannot be recommended, either for the service of the Northern Districts *alone*, or for the service of the metropolitan market *alone*, yet, as both these markets will be concurrently available to such a scheme, it has most striking advantages over any other proposal for the combined purposes, and is one which the Commission is able to strongly recommend to the Government for adoption and execution, particularly under the conditions stated, for the service of the North and North-Eastern Districts.

SERVICE OF RURAL DISTRICTS PRIOR TO SCHEME COMING INTO OPERATION.

Assuming that the scheme here presented is approved, and a commencement at once made with construction, the question would still remain of devising some temporary measures to meet the insistent and growing demands of the Goulburn Valley and North-Eastern Districts during the five years which must elapse before even the first stage of the scheme can be put into commercial operation.

Under the most favorable circumstances, the scheme, if approved and put into execution in the near future, cannot be completed in its entirety before about 1928.

The needs of the Northern country for electric supply are, however, of a most pressing nature, and that territory cannot wait five to six years for the complete realization of the scheme now recommended. It would be a wasteful and futile alternative to increase the numerous small existing local heat-power schemes, many of which are on the now obsolete direct-current system, having a most limited range.

The Commission therefore proposes that, as a measure for the early relief of the North and North-East, the whole of the main transmission lines involved in the scheme above described shall be commenced forthwith, that is to say, the main transmission lines from Bundoora to Rubicon, from Rubicon to Benalla, and from Benalla to Wangaratta and Shepparton. The construction of such lines is estimated to take two and a-half years, before which time energy from the Morwell Scheme will be available. This source will then be used to take up the regular supply to the Northern country, and will continue to do so until the Sugarloaf-Rubicon Scheme is ready to operate and take over the load some two or three years thereafter.

The capital cost of the transmission works now referred to is estimated to be £372,000, but this sum is, of course, part of the total of £962,320 above mentioned, and is merely anticipatory of the full scheme.

Inasmuch as the line between Bundoora and Sugarloaf will have to be constructed at the outset so as to be capable of handling a load of 11,000 kilowatts, while during the earlier years of its existence it will be called upon to deal with a load (for the supply of the North alone) not exceeding 3,000 kilowatts, it is obvious that the cost of transmission from Morwell will temporarily (*i.e.*, for a few years) exceed the ultimate cost of transmission from Sugarloaf.

It is proposed, therefore, that the rate for delivering 6,600-volt energy in bulk at the sub-stations at Wangaratta and Shepparton under these *temporary* arrangements shall be fixed at not more than 1.70 pence per kilowatt hr. on the basis of a 30 per cent. load factor, which is a rate which will be most favorable to consumers, and should easily compete with any available alternative proposal. Such a rate is, however, one which would involve an annual loss on operation during, say, the first two or three years, which loss would, however, be placed to a suspense account and be recouped thereafter, firstly by the assured steady growth of consumption, and secondly by the coming into operation in 1928 of the main Sugarloaf Scheme.

When the loss of the earlier years' operation has been thus recouped, and as the market expands, the rate for energy will be gradually reduced from 1.7 pence to less than 1 penny per kilowatt hour.

CONTROL OF LOW-TENSION DISTRIBUTION.

It will be observed that the localities which can be served by this scheme are situated in not less than 28 separate municipalities ; this is to say, that 28 municipalities will be interested in the problem of low-tension distribution. The important question, therefore, to be decided is how this distribution throughout the territory is to be controlled and administered. The circumstances are, of course, altogether different from those of the large and densely-populated metropolitan, city, and suburban areas, and of the larger provincial cities such as Bendigo, Ballarat, Geelong, &c. The consideration must be kept steadily in view that, although the scheme in its full development has many ramifications and covers a very large territory, it is nevertheless a single scheme requiring centralized and unified control and management, that all purely local interests must at all times and under all conditions be subordinated to the interests of the scheme as a whole, and the interests of the population as a whole, irrespective of quite arbitrary municipal boundaries. A proposal, therefore, to turn over the retail distribution, in its entirety, to no less than 28 separate municipalities would prove unworkable, and would involve the gravest risks of the failure of the whole scheme. Each local authority would naturally consider its own interests alone, and would be concerned solely with its own territory, regardless of any consideration for the correct lay-out of the distribution systems with respect to sound economic laws applicable to the whole territory. There would also be quite needless multiplication and overlapping of effort, a wide variation in the standard of efficiency practised in regard to both administration and maintenance, and resulting diversities of rates, charges, and conditions of supply on different sides of inter-shire boundaries, which would lead to endless friction between shires, and discontent among consumers.

In the opinion of the Commission, therefore, it is indispensable that the control of the whole of the low-tension distribution over the whole of the territory to be served should be in the hands of a single authority. Whether such an authority should be the Electricity Commission, which is quite suitably equipped and staffed for the efficient exercise of such a function, or whether a separate authority in the form of a local Commission or Trust should be created, is a matter for the decision of the Government and Parliament, and one on which the Commission holds no strong views. The important consideration is that there shall be a single controlling authority, and that it shall be organized and staffed in a manner which will insure competent and scientific management of the highest standard of efficiency.

INVESTIGATION OF STRATHBOGIE DISTRICT.

It is desired to record that in the consideration of the problem of supply to the North and North-East of Victoria, the Commission has investigated the water-power resources of the Strathbogie district, more particularly with a view to the utilization of the waters of the Seven Creeks for this purpose. The Report of the Commission's Consulting Hydraulic Engineers, Messrs. J. M. and H. E. Coane, on these investigations is annexed. As will be gleaned from the Report, full reliability through a drought period cannot be secured from any power development of suitable size in this district. The average h.p. available from a scheme which would be reasonably secure against failure during drought periods is 590 h.p., which is quite inadequate to cope with the requirements of the North and North-Eastern area of the State.

As a result of this investigation, the Commission has decided that no scheme based upon the use of the waters of the Seven Creeks can be devised which will be as economical and reliable for the service of the country as the Sugarloaf-Rubicon Scheme.

Whilst it is found necessary to postpone for the present further action on this investigation for the reasons set out previously, nevertheless these waters will be kept in mind as a means of supplementing and being linked up with the Sugarloaf Scheme when the demand warrants such supplementary measures being taken.

SUMMARY OF RECOMMENDATIONS.

The conclusions arrived at after full consideration of the foregoing, together with the accompanying data, are as follow :—

(*a*) That the complete scheme as detailed in the Reports be proceeded with, the total estimated cost being £962,320.

(*b*) That the construction of the transmission lines involved in the scheme be undertaken forthwith, so that supply may be given to the Northern country from the Morwell Scheme until the hydro-electric scheme is ready to operate.

(*c*) That further investigation of the possibilities of the water-power resources of the Strathbogie district be postponed for the present.

It is felt that this Report will be incomplete without reference is made to the fact that Mr. A. G. M. Michell, M.C.E., is responsible for drawing the Commission's attention to the principal of the sources of water power referred to in this Report, and on which the scheme recommended by us is based. It is desired that the fullest credit be given Mr. Michell for having brought these resources to our notice.

In conclusion, we desire to express our appreciation of the valuable services rendered by Messrs. J. M. and H. E. Coane, our Consulting Hydraulic Engineers, who were responsible for the completion of the very thorough investigations required, and for the design of the hydraulic engineering side of the project.

We are also indebted to the State Rivers and Water Supply Commission, which co-operated with our Consulting Hydraulic Engineers in every possible way in arranging the details of the linking up of the Sugarloaf Reservoir as part of the proposed scheme.

We have the honour to be,
Sir,
Your obedient Servants,

JOHN MONASH, Chairman.
THOMAS R. LYLE, }
GEO. SWINBURNE, } Commissioners.
ROBERT GIBSON, }

R. LIDDELOW,
Secretary.

6th September, 1922.

REPORT

TO

STATE ELECTRICITY COMMISSION OF VICTORIA

ON THE

SUGARLOAF–RUBICON HYDRO-ELECTRIC SCHEME

AS A MEANS OF

SUPPLYING POWER TO THE NORTHERN DISTRICTS OF VICTORIA AND THE MELBOURNE METROPOLITAN AREA.

BY

H. R. HARPER, CHIEF ENGINEER.

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LIST OF DRAWINGS.

The Sugarloaf-Rubicon Hydro-Electric Project as a Means of supplying Power to the Northern District of Victoria and the Metropolis.

INTRODUCTION.

The results of the separate investigations carried out by Messrs. J. M. and H. E. Coane, the Consulting Hydraulic Engineers of the hydro-electric resources of the Sugarloaf and Strathbogie districts, have been carefully studied both during the progress of the work of investigation and after the receipt of the reports in connexion therewith.

It became apparent as the investigatory work on the hydrological side advanced that while the Sugarloaf district could offer water potentialities which justified the most careful consideration of the suitability of a scheme providing for the development of the water-power in this district, the Strathbogie proposals are in quite a different category.

As pointed out by the Consulting Engineers, full reliability through a dry period cannot be secured from any power development of suitable size in the Strathbogie district. The average available power from a scheme in this district, which would be reasonably secure against dry period failure, is 590 h.p.—a quite inadequate amount to cope with the requirements even of the Northern District of the State. Moreover, the cost in this proposal of the hydraulic works alone would render the project unworthy of consideration at the present time. These facts are sufficiently emphasized in Messrs. Coane's report on this subject, and it is considered unnecessary to enter into a detailed demonstration of the disadvantages of any development at present at Strathbogie.

This report, therefore, will confine itself solely to the proposals on the electrical side to utilize the available energy from water-power in the Sugarloaf-Rubicon district.

The report of the Consulting Hydraulic Engineers has dealt fully with the method of utilizing the water-power potentialities of the Sugarloaf-Rubicon district; and in consultation it has been agreed that the most favorable plan involves the use of five separate stations containing generating plant.

In view of the number of stations involved and in order to minimize operating costs, it is proposed to arrange for automatic, or semi-automatic, operation of the whole of the generating plant in these stations.

This plan is made more practicable by the fact that three of the stations will contain only one generating unit, while the remaining two will contain, at most, only two units.

The proposed method of operation has been submitted to leading makers of such plant, and has received their complete concurrence, which is based on some considerable operating experience with this most modern development in the field of water-power utilization.

The operating centre of the Sugarloaf district will be a sub-station, Rubicon "A," conveniently situated to receive energy from the several stations, transform and feed it into the high voltage transmission lines.

This method of operation will result in the minimum attendance cost, without prejudicing appreciably the continuity of operation, which continuity is not of supreme importance in this scheme where the loss of one machine for a short time would not seriously affect either the general supply system or the costs of energy production from the Sugarloaf group. It is proposed to operate synchronous machines at Sugarloaf Weir, Snob's Creek, Rubicon Lower, and Rubicon, and possibly to install an induction generator at Royston.

The Rubicon "A" sub-station is indicated on the map submitted by the Consulting Hydraulic Engineers. It is situated $8\frac{1}{2}$ miles from the Sugarloaf plant, on the Rubicon River, from which, water for the water-cooled transformers will be drawn. The distances from the remaining stations to the sub-station are as follow:—

Rubicon	3.2 miles
Rubicon Lower	1.4 ,,
Snob's Creek	4.3 ,,
Royston	6.8 ,,

The transmission pressure for the main lines leaving Rubicon "A" is taken as 66,000 volts. In the case of the Sugarloaf Weir Station, the energy will be stepped up at the station and transmitted to Rubicon "A" at this pressure, but, in the case of the remaining four stations, it is proposed to generate at 6,600 volts and transmit at this voltage by overhead lines to the Rubicon "A" sub-station. The generating stations will thus be of a simple design conducive to low maintenance cost.

The diagram of the proposed electrical plant and its interconnexions are shown in outline on drawing (OM—305A) attached.

The operating proposals provide for the maintenance of a full shift staff at Rubicon "A," and an emergency shift of two men at the Sugarloaf Weir Station. An emergency attendant would also be available at Rubicon " A " for despatch to any of the automatic stations in case of trouble.

SUGARLOAF–RUBICON STATIONS AND INTERCONNECTING LINES.

Estimated capital costs—	£
Hydraulic works, pipe lines, buildings, turbines, &c. (*vide* Messrs. J. M. and H. E. Coane's Report)	354,870
Generators, exciters, switchgear, and transformers at Sugarloaf, Rubicon, Rubicon Lower, Snob's Creek, and Royston Stations, and at Rubicon " A " Sub-station	157,000
Pole line (66,000 volts) from Rubicon " A " to Sugarloaf Weir, 8½ miles	11,000
6,600-volt overhead lines	25,000
Buildings at Sugarloaf and Rubicon " A " to accommodate switchgear	3,500
Total	551,370

Estimated annual charges—	
Hydraulic works, &c. (*vide* Messrs. J. M. and H. E. Coane's Report)	34,702
Generators, exciters, switchgear, and transformers, &c.	17,300
Pole line (66,000 volts) from Rubicon " A " to Sugarloaf Weir	1,300
6,600-volt overhead lines	2,600
Buildings at Sugarloaf and Rubicon " A "	280
Operation—electrical	3,000
Total	59,182

Estimated output, Rubicon " A " Sub-station, at 66,000 volts—	
Kilowatt-hours per annum	115,000,000
Maximum load	16,640 kw.
Load factor assuming full availability of plant	79 per cent.
Load factor assuming 90 per cent. availability	71 per cent.
Annual cost per kilowatt of maximum load	£3.56
Average cost per kilowatt-hour (66,000 volts) assuming full availability (79 per cent. load factor)	0.1235 pence
Average cost per kilowatt-hour (66,000 volts) assuming 90 per cent. availability (71 per cent. load factor)	0.1375 pence

ACCESSIBLE MARKETS FOR HYDRO-ELECTRIC ENERGY.

The Sugarloaf-Rubicon plants are situated midway between two markets for electrical energy—the Northern area of the State, of which Shepparton and Wangaratta are centres, and the metropolitan area of Melbourne.

The extent to which both markets could absorb the energy whch the Sugarloaf Scheme could offer can be estimated with a reasonable degree of accuracy, the estimates being based, especially in the case of the Northern area, on a recent power survey.

POWER REQUIREMENTS OF THE NORTHERN DISTRICT.

A detailed power survey of the Goulburn Valley District has been carried out, the scope of the inquiry covering those areas whose centres are Shepparton and Wangaratta respectively. The total population of the whole district which could be served by distribution lines radiating from Shepparton, Wangaratta, and Benalla, is about 71,000, and it is to be observed from figures obtained during the power survey that the energy at present utilized in the district, in some form or other, is equivalent to about 12,000,000 kw.-hours, or 170 kw.-hours *per capita* per annum.

In the whole district the problem of fuel supply for steam or other heat plants is a very serious one, as the supplies of wood fuel are obtained with difficulty at steadily increasing prices, and the freight charges on coal render that fuel prohibitive in price.

There is not the least doubt that a hydro-electric scheme by which energy could be delivered to the two main centres of demand specified above at an average price below 2d. per kw.-hour at the 6,600-volt side of the main step-down stations, would be sure of very vigorous development.

Growing industries, too well known to need specifying, are established in both centres. The irrigation settlements around Shepparton, in addition to the numerous small power consumers, promise a good field for domestic supply developments, while not far from Wangaratta there is the possibility of a considerable demand for energy for mining purposes.

As the result of these investigations, it is considered that a very conservative basis for the purpose of estimating the cost of delivering energy to the North and North-East would be an assumed consumption at the Shepparton and Wangaratta centres of 3,000,000 kw.-hours per annum at each place, or a total of 6,000,000 kw.-hours per annum, with a combined maximum demand of 2,300 kw. and the load factor in each centre approximately the same.

There is, indeed, a prospect that this rate of consumption will be reached within one or two years of an adequate supply of energy at reasonable prices being made available. Further, it is not improbable that these figures would be far exceeded if power users in this district can be induced to scrap their existing steam plant and take all their requirements from the hydro-electric scheme.

In discussing the operating results of a feasible scheme, the influence of growth of consumption on the prospects of the scheme will be shown in detail.

In the above discussion of the power requirements of the North and North-East no reference has been made to the possibility of a considerable demand for power arising from the electrification of the main railway line on the Melbourne-Albury route. Such a development would obviously have a most important influence on the whole economics of power supply to the Northern District of the State. The Sugarloaf plants will be quite favorably situated to deal with railway demands for electrical energy, and the proximity of such a source of energy should likewise have an important influence on the economic considerations which bear upon the problems of railway electrification.

It has already been stated that the estimated initial demand of the North and North-East will be 2,300 kw., which should increase to about 5,000 kw. by 1935, or ten years after the supply is first given.

Of the total energy which can be generated in the Sugarloaf group, a fraction only can be absorbed in the Northern District even in ten years' time, and the only outlet for the bulk of the generated energy is the metropolitan market, unless some unexpected development occurs.

POWER REQUIREMENTS OF THE METROPOLIS.

It is estimated that by the year 1928 the power plants now being installed at Morwell and Newport should have arrived at the stage of full utilization, and the provision of additional generating plant to meet the growth in demand will have been arranged before that time.

About the same time the base-load requirements of the metropolitan area will approximate to a continuous demand of 15,000 kw., and these requirements offer the most favorable conditions for the economic utilization of hydro-electric energy.

This estimate, therefore, fixes the time before which it would be uneconomical to bring into operation this additional generating capacity, since the bulk of the energy generated must find an outlet in the metropolitan market, and the capital outlay could not be recommended for the purposes of meeting the demand of the North and North-East alone.

SUGARLOAF-RUBICON PLANTS SUPPLYING MELBOURNE AND THE NORTHERN DISTRICT SIMULTANEOUSLY.

If the bulk of the Sugarloaf-Rubicon water-derived energy is absorbed by the Melbourne system, it will be possible, as shown later, to divert to the North and North-East the energy required in that territory at a very favorable rate.

With the object of providing a supply to the Northern District, it is proposed to construct from the Sugarloaf Weir Station of the group a double-circuit transmission line, operating at 66,000 volts, to Benalla, a distance of approximately 53 miles. From Benalla transmission lines, each of single-circuit design and operating at 66,000 volts, would be constructed to Shepparton (37 miles) and Wangaratta (24 miles) respectively. At the Shepparton and Wangaratta centres step-down sub-stations would be provided equipped with the necessary regulating machinery.

Investigations are proceeding with the object of ascertaining the limits to which this system of transmission lines could be extended in various directions in this district, having due regard to the probable delivered cost of Sugarloaf energy and the cost at which energy is being or can be produced from locally situated plants.

The operating pressure (66,000 volts) of these main transmission lines from Sugarloaf to the north has been chosen to avoid separate transformer banks at Sugarloaf, and also to facilitate dealing with the anticipated growth in demand without heavy initial outlay on conductors.

There are no technical difficulties involved, and, except for a distance of about 15 miles from the Sugarloaf Weir, the transmission line to Benalla can follow a made road through cleared country.

The estimated cost of the works is as follows :—

TRANSMISSION LINES, ETC., TO SHEPPARTON AND WANGARATTA.

	£
Estimated capital costs—	
Transmission line (two circuits), Sugarloaf to Benalla—53 miles ..	74,250
Transmission lines (single circuit)—	
Benalla to Shepparton—37 miles	33,300
Benalla to Wangaratta—24 miles	21,600
Switching Station, Benalla	10,000
Sub--stations—	
Shepparton, 1,500 k.v.a.	15,000
Wangaratta, 1,500 k.v.a.	15,000
Total	169,150
Estimated annual charges—	
Transmission lines—	
Sugarloaf to Benalla	9,650
Benalla to Shepparton	4,430
Benalla to Wangaratta	2,880
Switching Station, Benalla	1,100
Sub-stations—	
Shepparton	1,600
Wangaratta	1,600
Total	21,260

To permit of the absorption by the metropolitan market of the bulk of the energy generated at Sugarloaf, it is proposed to construct from Rubicon " A " sub-station a transmission line 52 miles long to junction at Bundoora with the Melbourne system. At Bundoora a receiving sub-station would be constructed to transform the Sugarloaf energy to 22,000 volts, the pressure of the metropolitan distribution network.

The Rubicon-Bundoora transmission line would run for some miles through rough and heavily timbered country, and it is therefore proposed to use steel towers for supporting the steel-reinforced aluminium conductors. Suspension insulators would be used on this line, which would be constructed to carry two circuits finally, though initially a single circuit would probably be used.

SUGARLOAF–RUBICON–BUNDOORA TRANSMISSION LINES, ETC.

	£
Estimated Capital Cost—	
66,000 volt main transmission line, (52 miles) steel towers, two circuits ..	136,000
Clearing, survey, easements, &c.	11,300
Switchgear, transformers, &c., Bundoora sub-station	88,000
Building, Bundoora sub-station	5,000
Telephone and patrol booths, &c.	1,500
Total	241,800
Estimated Annual Charges—	
66,000 volt main transmission line	12,100
Clearing, survey, easements, &c.	800
Switchgear, transformers, &c., Bundoora sub-station	9,700
Building, Bundoora sub-station	400
Telephone and patrol booths, &c.	120
Operation—electrical	1,000
Total	24,120

Estimated Costs of Energy—

The foregoing estimates permit the following costs to be calculated of (A.) delivering energy to the centres of Shepparton and Wangaratta to the extent of a combined maximum demand of (*a*) 2,300 kw., (*b*) 5,000 kw. (load factor of 30 per cent.), and (B.) delivering the surplus energy produced by the Sugarloaf group of stations to Melbourne (Bundoora).

(a.A.) NORTHERN DISTRICT (SHEPPARTON AND WANGARATTA CENTRES).

Combined Maximum Demand 2,300 kw.—

Cost of generation and conversion at Rubicon " A " sub-station (66,000 V.) per kw. of above demand	£3.95 per annum
Cost of transmitting to Shepparton and Wangaratta centres including conversion to 6,600 V. per kw. of above demand ..	£9.25 ,, ,,
Total cost per kw. of above demand at Shepparton and Wangaratta centres (6,600 V.)	£13.20 ,, ,,
Average cost per kw. hr. at Shepparton and Wangaratta (6,600 V., 30 per cent. load factor)	1.2d.
Approximate selling price per kw. hr. at Shepparton and Wangaratta (6,600 V., 30 per cent. load factor)	1.36d.

(a.B.) SURPLUS ENERGY FOR MELBOURNE (BUNDOORA SUB-STATION).

	Kw. hrs. per annum.	
Total energy transmitted from Rubicon " A " Sugarloaf (66,000 V.)	115,000,000	
Less energy transmitted to the north (66,000 V.)	6,750,000	
Energy transmitted to Melbourne (66,000 V.)	108,250,000	
Energy received at Melbourne (22,000 V.)	88,000,000	
Cost of generating and delivering to Melbourne (Bundoora sub-station) 88,000,000 kw. hrs. (22,000 V.)—		
	Per annum.	Per kw. hr.
not including annual charges on 3,850 kw. of steam plant required to meet water power deficiency in month of June	£74,222	0.202d.
including annual charges above-mentioned	92,120	0.25d.

(b.A.) NORTHERN DISTRICT (SHEPPARTON AND WANGARATTA CENTRES).

Combined Maximum Demand 5,000 kw.

Cost of generation and conversion at Rubicon " A " sub-station (66,000 V.) per kw. of above demand	£3.95 per annum
Cost of transmitting to Shepparton and Wangaratta centres including conversion to 6,600 V., per kw. of above demand ..	£4.5 ,, ,,
Total cost per kw. of above demand at Shepparton and Wangaratta centres (6,600 V.)	£8.45 ,, ,,
Average cost per kw. hr. at Shepparton and Wangaratta (6,600 V., 30 per cent. load factor)	0.77d.
Approximate selling price per kw. hr. at Shepparton and Wangaratta (6,600 V., 30 per cent. load factor)	0.883d.

(b.B.) SURPLUS ENERGY FOR MELBOURNE (BUNDOORA SUB-STATION).

	Kw. hrs. per annum.	
Total energy transmitted from Rubicon " A " sub-station (66,000 V.)	115,000,000	
Less energy transmitted to the north (66,000 V.)	15,000,00	
Energy transmitted to Melbourne (66,000 V.)	100,000,000	
Energy received at Melbourne (22,000 V.)	81,500,000	
Cost of generating and delivering to Melbourne (Bundoora sub-station) 100,000,000 kw. hrs. (22,000 V.)—		
	Per annum.	Per kw. hr.
not including annual charges on 3,850 kw. of steam plant required to meet water power deficiency in month of June	£63,552	0.187d.
including annual charges above-mentioned	£81,450	0.24d.

NOTE.—The difference between costs of delivering or supplying energy, and selling prices of energy provides a margin for contingencies of 10 per cent., and a charge for administration.

Although the development of the Sugarloaf-Rubicon Scheme for the purpose of transmitting to Melbourne all the energy generated is not contemplated in these proposals, it is of interest at this stage to present (1) the average cost at which it is estimated such energy, representing the whole energy output of the scheme, could be delivered to the Bundoora Sub-station (Melbourne), and at the same time to compare this average cost with those at which it is estimated energy could be delivered to the Yarraville Terminal Station from (2) the 50,000 kw. plant now being installed at Morwell and (3) an extension of this plant of similar capacity.

These estimated costs are set out below :—

1. SUGARLOAF–RUBICON SCHEME (the whole of the energy output transmitted to Melbourne)—

Bundoora Sub-station—

Energy received (22,000 V.)	93,600,000 kw-hrs. per annum
Maxium load	15,750 kws.
Load factor, assuming 90 per cent. availability ..	68 per cent.
Average cost per kw.-hr., including annual charges on steam plant required to meet water power deficiency in the month of June	0.26 pence

2. MORWELL INITIAL PLANT—

Average cost per kw.-hr. of 22,000 V. energy delivered at Yarraville Terminal Station	0.223 pence

3. MORWELL EXTENSION PLANT—

Average cost per kw.-hr. of 22,000 V. energy delivered at Yarraville Terminal Station	0.185 pence

Attached to this report is a diagram (OM.433) indicating the amount of power that could be delivered to Melbourne from the Sugarloaf-Rubicon Scheme, throughout an average year, assuming that none was being diverted to the North and North-East. It will be seen that this scheme has the characteristic that the peak of delivered energy fails to coincide throughout with the winter-demand period of the metropolis. The maximum winter-month deficiency (due to shortage of water) occurs in June, and amounts to about 3,850 kws. Although not serious in relation to the maximum winter demand in Melbourne, it has been considered advisable to indicate in the estimates above, the financial effect of charging to the Sugarloaf Scheme (in regard to that portion of the energy being sent to Melbourne) the annual charges on a portion of the Morwell-Newport steam standby plant equivalent in capacity to the deficiency mentioned.

The financial results above detailed are conclusive in their indication that energy generated by the hydro-electric stations in the Sugarloaf District could be transmitted to the Northern District of Victoria, and made available at the centres referred to in this report at a very attractive price provided that the surplus energy produced at these stations is transmitted to the Melbourne area, the only market capable of absorbing it by the time that the scheme is ready to be brought into operation.

Apart from the fact that, as shown, the energy could be made available at Melbourne at a satisfactory cost, the proposal to supply a portion of the metropolitan requirements from a source not likely to be affected by industrial conditions, and by a transmission route far removed from the Morwell to Melbourne route, is one that has much to recommend it.

DEALING WITH THE REQUIREMENTS OF THE NORTHERN DISTRICT BEFORE THE YEAR 1928.

As already mentioned, the works of the Sugarloaf–Rubicon Scheme would not be required to come into operation before 1928, the plants being installed at Morwell and Newport having sufficient capacity to meet the anticipated demands up to and including the winter of 1927.

The question has been considered as to whether it is possible to provide for the Northern District a supply from some alternative source until the Sugarloaf-Rubicon Scheme comes into operation, and the conclusion has been reached that a supply from the Morwell system could be made available in the North and North-East early in 1925, provided that arrangements are made immediately to proceed with the construction of the main transmission line between Melbourne, Sugarloaf, Benalla, Shepparton, and Wangaratta.

The cost of energy delivered from Melbourne to the North during the period 1925 to 1928, approximately three years, would be appreciably greater than those previously indicated for Sugarloaf energy delivered to the same district, and are estimated as set out hereunder :—

TEMPORARY SUPPLY (2,300 KW.) FROM MELBOURNE TO THE NORTHERN DISTRICT.

The total capital expenditure necessary to provide for this temporary supply from Melbourne to the North and North-East is estimated to be as follows :—

	£
Transmission line (one circuit), Bundoora to Sugarloaf and sub-stations at Bundoora and Sugarloaf	158,700
Transmission lines, Sugarloaf to Benalla, Shepparton, and Wangaratta and sub-stations	169,150
Total	327,850

The capital cost and annual charges of the second of these items have already been shown in detail on page 19, those of the first are detailed hereunder :—

Estimated capital costs of transmission line (one circuit only), Melbourne to Sugarloaf District—	£
66,000-volt main transmission line (52 miles steel towers, one circuit	111,400
66,000-volt pole line from Rubicon " A " site to Sugarloaf Station	11,000
Clearing, survey, easements, &c.	11,300
Portion of sub-station and apparatus, Bundoora	15,000
Portion of sub-station and apparatus, Sugarloaf	10,000
Total	158,700

Estimated annual charges—	£
Transmission line (one circuit only)	9,490
Pole line, Rubicon to Sugarloaf Weir	1,300
Clearing, easements, &c.	800
Bundoora Sub-station	1,500
Sugarloaf Sub-station	1,000
Total	14,090

These charges, assuming a total combined demand of 2,300 kw. at Shepparton and Wangaratta centres, are equivalent to	£6.1	p.a. per kw. of demand
Annual cost of transmission lines, &c., from Sugarloaf to Shepparton and Wangaratta as stated previously ..	£9.25	,, ,,
Cost of energy purchased at Melbourne related to Shepparton and Wangaratta	£8.0	p.a. per kw. of demand plus 0.125d. per kw.-hr.
Total cost of supplying energy (6,600 volts) to Shepparton and Wangaratta	£23.35	p.a. per kw. of demand plus 0.125d. per kw.-kr.
Average cost per kw.-hour (30 per cent. l.f.)	2.25d.	
Average selling price per kw.-hour (30 per cent. l.f.) ..	2.5d.	

An average price so high as 2.5d. per kw.-hour at these centres would not be conducive to a healthy demand for electrical energy for industrial purposes, hence, in the accompanying table showing the financial results of this proposed scheme it has been assumed that the price at these centres during the first three years, or until the Sugarloaf energy becomes available, would be averaged at 1.7d. per kw.-hour. By suspending the annual sinking fund payments during this period the accumulated loss would not exceed about £31,000. This loss, together with the suspended sinking fund payments, could be liquidated within a reasonable time thereafter by reason of the substitution of the much cheaper Sugarloaf energy.

The detailed survey just completed, from which conservative figures regarding energy requirements were deduced, actually resulted in an estimated total possible energy consumption based on *present use* of energy in one form or another in the territory, of more than 12 million kw.-hours per annum.

It is clear that the scheme has very striking possibilities for the development of load, and the study of these possibilities indicates that the deficit shown in the accompanying table during the first three years can be contemplated without apprehension.

TABLE SHOWING FINANCIAL RESULTS OF PROPOSED SUPPLY TO SHEPPARTON AND WANGARATTA CENTRES OF THE NORTHERN DISTRICT OF VICTORIA.

Year.	—	A Combined maximum demand.	B Estimated total annual consumption at Shepparton and Wangaratta centres.	C Estimated average selling prices based on actual cost to those centres.	D Assumed average selling prices at those centres.	E Annual loss or gain based on assumed selling prices (col. D) and payments of interest and sinking fund (cols. F and G).	F Interest payments on capital expenditure.	G Sinking fund payments.	H Financial results if sinking fund payments be suspended for 3 years	J Accumulated balance.
	Morwell energy	kw.	kw.-hrs.	pence per kw.-hr.	pence per kw.-hr.	£	£	£	£	£
1926		2,300	6,000,000	2·5	1·7	−20,000	19,150	8,613	−11,387	−11,387
1927		2,300	6,600,000	2·4	1·7	−19,250	19,150	8,613	−10,637	−22,024
1928		2,300	7,260,000	2·3	1·7	−18,150	19,150	8,613	− 9,537	−31,561
							Total	25,839		
1929	Sugarloaf energy	..	7,986,000	1·18	1·5	+10,640	..	..	..	−20,921
1930		3,300	8,784,000	1·12	1·5	+13,900	..	..	..	− 7,021
1931		..	9,663,000	1·05	1·5	+18,100	..	..	..	+11,079
1932		4,000	10,629,000	0·97	1·25	+12,400	..	..	..	+23,479
1933		..	11,690,000	0·90	1·00	+ 4,875	..	..	..	+28,354
1934		..	12,860,000	0·84	1·00	+ 8,550	..	..	..	+36,904 available to liquidate sinking fund suspended payments with accumulated interest
1935		4,620	14,146,000	0·80	0·80	Nil				

EXTENT OF DISTRIBUTION FROM SHEPPARTON AND WANGARATTA AS CENTRES.

The extent of the distribution system based on transmission to and from the Shepparton and Wangaratta centres will be fixed by the cost at which energy is deliverable at the outlying towns.

The present indications are that there should be no difficulty in transmitting energy for distribution at favorable rates as far as Echuca, Nathalia, Cobram, Wahgunyah, Chiltern, and Beechworth to the north, and as far as Euroa to the south, and estimates are being prepared of the possibilities with regard thereto.

These limits include a very large area, and local transmission systems of considerable extent would be necessary to enable the energy to be distributed throughout the district.

A map (O.M.463) is submitted showing the general distribution of the potential demand for power in this district, particulars of which were obtained in the recent power survey.

RATES OF INTEREST AND DEPRECIATION.

In all estimates of annual charges interest on capital expenditure has been allowed at 6 per cent. Such estimates have also included, for purposes of depreciation, contributions based upon the estimated average life of the respective items of plant, and calculated on a sinking fund basis at 5 per cent. interest. No allowance has been included for interest on capital expenditure during construction.

RATE OF EXPENDITURE.

Messrs. J. M. and H. E. Coane have indicated the approximate rate of expenditure which would be necessary in financing the construction of the complete hydraulic works. To complete the estimate the sums to be set aside for the electrical portion of the work have been approximated, and the consequent totals covering the whole expenditure on the complete works from Melbourne to Shepparton and Wangaratta are as follows :—

	£
During—1923	50,000
1924	312,850
1925	115,000
1926	272,000
1927	212,470
	962,320

Further, that portion of the Sugarloaf–Rubicon scheme, comprising the hydraulic plants, the transmission line to Melbourne, and the Bundoora Terminal Station, can be carried out in two stages. During the first stage the Sugarloaf Dam, Rubicon and Royston stations as well as the Rubicon "A" sub-station, could be constructed, and the transmission line erected with one circuit only, providing for a load of 11,000 kws. In the second stage the whole of the works as outlined above would be brought to completion.

The division of capital costs between these two stages is estimated to be :—

First stage	£550,390
Second stage	242,780
Total	£793,170

H. R. HARPER,
Chief Engineer.
21st July, 1922.

REPORT

TO

STATE ELECTRICITY COMMISSION OF VICTORIA

ON

SUGARLOAF–RUBICON HYDRO-ELECTRIC SCHEME.

MESSRS. J. M. AND H. E. COANE,
70 Queen-street, Melbourne.

70 Queen-street, Melbourne,
2nd May, 1922.

The Chairman and Commissioners,
The State Electricity Commission of Victoria,
Melbourne.

GENTLEMEN,

Acting upon your instructions, we commenced, in May, 1921, an independent detailed investigation of the water-power resources of the Goulburn River and some of the more important mountain streams tributary to it in the Alexandra district.

In this, we have made use of data collected and recorded by Mr. A. G. M. Michell, M.C.E., and of surveys initiated by him but remaining incomplete at the date of his report upon the Kiewa Hydro-Electric Scheme. Under our direction, surveys and investigations have been extended so that the whole question might, in the light of as much information as possible, be closely considered before definite proposals were presented.

We have now the honour to forward our report describing the scheme that we regard as the most favorable for adoption, having regard to the fact that the water-power stations would all be linked up with the Morwell heat-power scheme. While our investigations have been confined to the hydraulic side, we have, to ensure proper co-ordination of results, been in consultation with your Chief Engineer, Mr. H. R. Harper, who is advising upon the electrical works required for the generation of current at, and its transmission from, the five water-power stations referred to in our report.

We are, Gentlemen,
Yours faithfully,
J. M. AND H. E. COANE.

SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME.

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SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME.

INTRODUCTION.

1. In conformity with instructions, we have investigated the resources of the Goulburn River at Sugarloaf Reservoir and of neighbouring mountain streams, with a view to the development of water-power in the locality. Throughout the inquiry, we have kept in mind the fact that a comprehensive scheme is being developed by the State Electricity Commission for the supply of electric current to all important centres, and that the principal generating stations will eventually be so interconnected that power drawn from them may at all times be utilized wherever it is most required. Provision for the pooling of resources in this way has an important bearing upon water-power proposals, and has largely influenced the proposed arrangement of machinery units in the scheme about to be described. The fact that each of the water-power stations referred to herein would be connected with the much more extensive Morwell network, to which they would be supplementary, has enabled larger, and consequently fewer and more economical, units to be relied upon than would otherwise be the case. The reason for this is that, in the event of a temporary cessation of supply from one of the water-power stations, the deficiency could promptly be made good by calling upon some other station in the system to continue the running for the time being. Further, the interlinking of the heat-power and water-power systems would be useful as a safeguard against shortage of power from the latter, in the event of a severe drought causing the streams to fall unusually low. On the other hand, it would probably be possible to maintain many of the essential services from water-power sources in the event of a complete stoppage at the steam stations.

OUTLINE OF THE SCHEME.

2. *Combination of Works described.*—At Sugarloaf, situated about 18 miles up stream from Alexandra by road, the State Rivers and Water Supply Commission is constructing a large storage reservoir to provide for growing irrigation requirements by regulating the flow of the Goulburn River. During each irrigation season, that is from October to April or May of the following year, a large volume of water will be discharged from the dam, and when the reservoir is full a considerable quantity will be passed over its spillway. In its passage from the reservoir to the river below, the water will have a considerable drop. From so much of it as passes through the undersluices, a considerable amount of power can be made available, provided that suitable works are installed whereby the energy of the falling water can be utilized. By the end of each irrigation season the reservoir will have been considerably depleted and the sluices will be closed, so that the storage may be replenished to meet the requirements of the next season. As irrigation interests would be paramount, the outlets from the reservoir would remain closed for several months in most years, and at such times the power plant would necessarily be out of commission. It is obvious, therefore, that while the reservoir was being replenished, independent sources of power would be needed. These exist in several mountain streams rising in the Cerberean Ranges to the south of the Goulburn River and within a few miles of Sugarloaf. As their discharges increase rapidly at just about the time that irrigation ceases for the season, power stations situated upon them would then be able to take up the running. The mountain streams decline during summer and autumn but, as they always have a fairly strong flow, they would, even in the dry months, provide a considerable amount of power which would supplement the output from the Sugarloaf station then in operation.

The possible combination of power from works at the Sugarloaf Dam with that gathered from power stations on mountain streams is a satisfactory feature, as neither source, without the other, would furnish a sufficiently continuous supply.

The scheme described in this report comprises works at Sugarloaf Reservoir and others on the Rubicon River (two stations), Royston River (one), and Snob's Creek (one); that is, five power plants in all. The three mountain streams referred to are not the only ones from which power might be developed eventually. The Murrindindi Falls and Yellow Dindi Creeks are all close to the route that would be followed by a transmission line leading to Melbourne, and offer opportunities for power supply. Investigations are in progress and point towards the possibility of about 3,000 horse-power being obtainable there from the natural flow of these creeks during an average autumn, with much more in winter and spring. If a storage site that is under consideration turns out to be favorable, the total horse-power during the dry months would be considerably greater than the figure just mentioned.

With the same objective, tributaries of the Goulburn above Sugarloaf are being inspected, while the Taggerty, Little River, Steavenson, Acheron, and Yea Rivers, all of which feed the Goulburn River lower down, are considered worthy of examination.

It will be shown that, while the aggregate amount of power that might be generated from the five power stations included in the scheme under description would not be uniform throughout the year, and while there would necessarily be seasonal variations depending upon rainfall and run-off, a very considerable output could be maintained at all times without interfering in any way with the irrigation interests.

Variations in output from water-power sources are less important when they feed into an extensive network, such as will be linked up with the Morwell system, than they would be were the water-power works entirely independent.

As regards monthly variations in output, the critical period in dry years would be the latter end of autumn, when the Sugarloaf Reservoir outlets, water being no longer required for irrigation, would be closed before the mountain streams had attained their normal winter discharges. On such occasions, and for short periods, it might be necessary to bridge over some deficiency of water power by drawing upon Morwell.

POWER AT SUGARLOAF RESERVOIR.

3. *Situation and Extent of Works at Sugarloaf.*—At Eildon, on the Goulburn River immediately below its junction with the Delatite River, the Sugarloaf Reservoir, which at its first stage will impound 300,000 acre-feet of water, is nearing completion. The position of the works is shown on the Drawing No. 1, also on the locality plan, Drawing No. 2, attached.

4. *Hydrological Data relative to the Goulburn River at Sugarloaf.*—The catchment area above Sugarloaf is 1,500 square miles in extent, and consists of mountainous country, mostly timbered, and with a rainfall averaging fully 50 inches per annum.

A large proportion of the gathering ground has a hard, rocky surface, from which the run-off is rapid. As a result, floods are common in winter and spring, and when snow on the high country melts about September a large flow may be relied upon. The maximum flood yet observed was gauged at 80,000 cubic feet per second for a few hours; this is the equivalent of a run-off of over 53 cubic feet per second per square mile, and, for the size of the catchment area, ranks high when compared with discharges observed in other countries. On the other hand, the flow of the river towards the end of summer is often relatively small; the minimum recorded at the reservoir to date is 210 cubic feet per second, or only ·14 cubic feet per second per square mile. In the absence of storage, the river near Sugarloaf would not, therefore, offer important possibilities for power development, even if fall were available. With the storage in preparation, however, much of the flood water will be impounded for use during summer and autumn, and, during its release from the Dam, quite a considerable amount of power can be made available. The average annual discharge of the river is regarded as ample for the periodical replenishment of a storage containing well over the 300,000 acre-feet now being provided at Sugarloaf. If the storage be increased in volume, as it most likely will be in the comparatively near future, the power possibilities would be improved.

The flow of the Goulburn has been systematically recorded at Murchison since 1882, and gaugings have, in addition, been observed at Sugarloaf continuously since December, 1915. Comparisons of the two sets of records have established fairly closely the relation between the discharges at these two gauging stations, and the State Rivers and Water Supply Commission has tabulated the estimated flow at Sugarloaf for the years 1882 to 1915 inclusive. These are reproduced in Appendix "A" attached, together with the gaugings at the Reservoir between 1916 and 1921. The figures are considered as nearly enough complete upon which to base estimates of power possibilities, and have been accepted by us for the purpose. The period of forty years over which they extend is an unusually lengthy record for this country.

The State Rivers and Water Supply Commission has kindly placed at our disposal a series of flow-summation curves of discharge that were prepared for its own purposes when considering the regulation of the river for irrigation. That Commission's intention is to provide a constant discharge from the reservoir of 50,000 cubic feet per minute for the months of October to April inclusive. We have checked the curves, and agree that, upon the data supplied as to natural flow of the river, this programme could have been successfully carried through in every year of the forty under review. We find, in addition, that the given discharge could have been continued every year until the end of May without detriment to irrigation interests. The reason is that the Waranga Basin is partly depleted at the end of every irrigation season, and that water sent down the river during May could always be used with advantage to replenish that storage. We have discussed the subject with Mr. Commissioner Dethridge, who considers that the proposal to maintain the discharge until the end of May will work in well with irrigation requirements.

5. *Power obtainable at Sugarloaf Dam.*—In view of what precedes, a minimum flow through the sluices of 833 cubic feet per second (50,000 cubic feet per minute) has been counted upon between the beginning of October in each year and the end of May in the following one. Only a drought of exceptional severity would be likely to run a reservoir of 300,000 acre-feet capacity so low as to render it useless for power development during the months stated. Should the storage capacity be increased by raising the dam, the chances of the reservoir running unduly low would be lessened. In four of the years out of the forty under review the reservoir would have been considerably depleted by the end of May, but this has been allowed for when framing the estimates of horse-power given below.

Investigation of the anticipated behaviour of the reservoir indicates that at about the end of May in each year the undersluices at the reservoir would have to be closed to enable the reservoir to fill during the rainy season. This, as previously mentioned, would necessitate the closing down of the Sugarloaf Power Station for several months in most years, during which the combination of power stations on the mountain streams would be called upon to take up the hydraulic load. The sections of the scheme in which the latter are included are described in general terms in paragraphs 12 and 13, and in more detail in succeeding ones. It is assumed that the Sugarloaf Power Station would be operated from October to the end of the following May, and, in addition, on all other occasions when the reservoir was overflowing. If this were done, irrigation interests could not, we consider, be adversely affected.

The extent to which power would have been available had suitable machinery been installed during the past forty years has been calculated—firstly, on the assumption that one unit of 7,500 brake horse-power had been in operation; and, secondly, that two units of that capacity had been running. The results are given in the form of monthly averages for every year in Appendix " B " attached, while the averages for each month of the year, over the series of forty years under review, are shown in diagrammatic form in Drawing No. 6. Diagram " A " indicates the average extent of power had one unit of 7,500 horse-power been installed, and Diagram " B " what it would have been had two units each of that capacity been working. Average power outputs for each month of the year appear in tabular form in paragraph 16. The average given for June is 800 horse-power for one unit installed. From this it must not be assumed that the Sugarloaf Power Station would be in operation every June. On the contrary, it would generally be closed down during that month. The number given is the total of the June figures divided by 40, the number of years over which the calculations extend, and not by the number of years during which the plant would have been actually running during that month. The same applies to other winter months.

6. *Sizes of Machinery Units for Sugarloaf Power Station.*—In the selection of machinery for Sugarloaf, as well as for each of the proposed interconnected power stations on mountain streams, the necessity for proper correlation of the units comprised in the scheme is most important. For example, it would clearly be unwise to install generating machinery at Sugarloaf capable of developing practically the whole of the power obtainable during the limited and irregular periods of full reservoir, whilst the mountain streams would at the same time also be furnishing their utmost outputs. If this were done, there would be such an excess of power produced in spring, above that obtainable in the other three seasons, that the disposal of surplus power might, in the early stages at any rate, be a matter of difficulty. Further, the capital cost of machinery which could not, owing to the absence of sufficient water, be operated during more than a short period in each year, and of transmission lines to carry the increased volume of current then produced, would burden the scheme financially. Based on considerations of this kind, the conclusion has been reached that at Sugarloaf the machinery installation should be limited in the first instance to one unit of 7,500 horse-power. This would develop all the power obtainable from the flow of 833 cubic feet per second which it is proposed to maintain regularly during the irrigation period, and the plant would be operated under full load at times whenever the reservoir was full. Subsequently it would probably be considered advisable to duplicate the machinery, and provision is proposed to enable this to be conveniently done. It is true that a second unit, if installed in the first instance, would provide a stand-by plant in case of mechanical breakdown; the modern hydraulic turbine is, however, so reliable in operation that we do not consider that the extra outlay would be warranted. The power station would generally be shut down each year on completion of the irrigation season, but in any event sufficient time would be available for overhaul.

7. *Hydraulic Works Proposed at Sugarloaf Dam.*—On Drawing No. 4, the rock-fill dam now under construction is shown in cross section and in part plan. The full supply level of the

reservoir will be 823 feet above sea level, but, as irrigation requirements increase, it will probably be raised, possibly to 875 feet reduced level. The concrete tunnel shown upon the drawing was built for the diversion of the river during construction, and will subsequently be used in conjunction with the tower for passing irrigation water from the reservoir to the lower river, down which it will flow to the irrigation districts. The main outlets from the tower consist of four cast-iron pipes 4 ft. 6 in. in diameter, and were designed for irrigation requirements and not for power development; they cannot be altered, as the works have long since passed the stage when that became impracticable. It is proposed to place one steel pipe of 9 feet diameter in the northern half of the tunnel and to connect it with two of the 4-ft. 6-in. pipes referred to by special Venturi expanding tubes and a breeches piece. This pipe would carry water under pressure from the reservoir to a turbine in a power house situated immediately below the toe of the dam as it will be built should the water level in the reservoir be subsequently raised to 875 feet above sea level. In the event of a second unit being decided upon, the whole of the piping, with Venturi tubes and breeches piece, would be duplicated, sufficient space being available for the purpose. The installation of two large pipes in the completed scheme is preferred to four smaller ones for hydraulic and constructional reasons.

The power house sketched on Drawing No. 5 shows generally the form of construction proposed. It would be founded on solid silurian rock that forms the original river bed, and the substructure, including the tail races, would be arranged for the reception of two units, though only one of them would be installed in the first instance. This would be advisable, as foundation work for a second unit could not be carried out at a later date without shutting down the first for a protracted period. The machinery required would consist in the first stage of a reaction turbine of the Francis type which would be direct coupled to an electric generator. Both turbine and generator would necessarily be of the vertical type, as the range in the level of the tailwater would be too great to permit of horizontal shaft machines being used. The maximum effective head under which the plant would operate with full supply level in the reservoir at 823 feet above sea level would be 105 feet and the minimum about 60 feet. Only on rare occasions would the lower limit be reached. The turbine runner would be specially designed, and its speed would be arranged so as to meet a wide fluctuation in head. Auxiliary machinery would be installed in the power house. The switch room and transformers would, however, for reasons of economy, be situated on the left bank of the river a short distance away. The turbine would utilize a flow of 833 cubic feet per second at all heads, and the complete outfit would be so arranged that it would be suitable for operation under higher pressures should the reservoir be raised another 52 feet, as has been suggested by the irrigation authorities.

In the event of a second machinery unit being decided upon at a later date, it would be on similar lines to the first one.

8. *Estimate for Hydraulic Works at Sugarloaf Power Station.*—The estimated capital cost of works proposed at Sugarloaf Dam for the housing of turbines and generators, and for the installation of one turbine unit with pressure piping, valves, &c., is given hereunder. Foundations would be suitable for the reception of an additional unit in the future, but the superstructure would be restricted to the requirements of only one in the first instance.

SUGARLOAF SECTION.

Estimate.

Foundations, tail races and draft tubes suitable for two units	£12,350
Walling and protective works downstream of the power house	4,390
Superstructure of power house to accommodate one unit of 7,500 h.p., with auxiliary machinery, overhead crane, &c.	6,700
Pressure pipe, 9 feet diameter, with special castings, valves, alterations to tunnel sluiceways and the provision of concrete seatings	13,320
Vertical shaft turbine, 7,500 h.p., with valves, governor, auxiliaries, and spare parts	20,750
Road approaches	500
Staff quarters, office and workshop	2,200
Total	£60,210

We have not included in the above any portion of the cost of the reservoir works. They were designed solely to meet irrigation requirements, and we consider that no portion of the cost should be charged against the State Electricity Commission. Customs duties, at rates now current, upon machinery of types that cannot as yet be manufactured in Australia, have been included in this, as in all the other estimates given in this report.

DEVELOPMENT OF POWER FROM MOUNTAIN STREAMS.

9. *Surveys, &c.*—To ensure the selection of the most satisfactory scheme for the development of power from the mountain streams previously referred to, investigation on an extensive scale has been found necessary. With the exception of the few preliminary traverses that had been made prior to the commencement of our inquiries, no reliable plans of the district were in existence, and most of the topographical data has had to be prepared from actual survey. As is usual in inquiries of the kind, the economic features of a variety of combinations of conduits and power stations and their co-ordination with regard to other power plants to be interlinked with them had to be considered in detail. All this has been done, and the arrangements found to be best suited to the conditions are outlined below. Each unit of the scheme is described in detail in paragraphs 17 to 20 inclusive. The proposed power stations are scheduled in paragraph 15, while the power obtainable is tabulated in paragraph 16 below.

10. *Topography of Catchment Areas of Mountain Streams.*—The catchment areas of the Rubicon and Royston Rivers and Snob's Creek are similar and can be described together. The watersheds, shown on Drawing No. 2, and to a larger scale on Drawing No. 3, follow high ranges, culminating in Mt. Torbreck, nearly 5,000 feet above sea-level. The gathering grounds are, for the most part, heavily timbered and covered with scrub. The whole area is State Forest, and at present three saw-mills are being worked within the Rubicon area. The hills are steep and rocky in places. The geological formation is granodiorite, and in appearance the country is not unlike the better known ranges above Warburton, though the Torbreck country is higher and steeper.

A characteristic of the valley of each of the streams is its comparatively small fall for some miles below its source. Then a sudden descent commences, the water passing over falls and cascades on its way to the lower reaches. Thus the configuration is favorable for power development. The areas of catchment above the points of offtake of proposed races leading to the several power stations areas under :—

Rubicon Power Station	26·5 square miles.
Royston Power Station	14·3 ,, ,,
Lower Rubicon Power Station	41·3 ,, ,,
Snob's Creek Power Station	11·1 ,, ,,

11. *Hydrological Data Relative to Mountain Streams.*—Rainfall observations on the catchment areas of the Rubicon and Royston have been taken by Nipher gaugings since 1919, and, as far as can be judged from these short records, indicate an annual fall of rain and snow amounting combined to approximately 65 inches. The bulk of the rain occurs in winter, but thunderstorms are common in summer. The soil is absorbent and, conditions being favorable to the formation of springs, the summer discharges of these mountain streams are remarkably good, considering the areas of their gathering grounds. In Appendix "C" the relation between discharge and extent of catchment is expressed in cubic feet per second per square mile. This is regarded as the most suitable unit on which the run-off from similar areas of catchment can be compared.

The discharges of these mountain streams were not recorded until gaugings were commenced on the Rubicon and Royston rivers in 1919. Regarding the minimum flow, no gaugings are available over periods of extreme drought, but it is agreed by those who have known the district for many years that the summer of 1919–1920 was an unusually dry one. Gaugings taken during that season showed that the combined flow of the Rubicon and Royston rivers did not fall below 21 cubic feet per second. This is about two-thirds of the normal discharge that we have allowed for in framing the estimates of power obtainable during an average autumn. The winter flow is, however, always in excess of diversions that would be economically practicable for power development purposes.

Drawing No. 8 shows in diagrammatic form the results of gaugings taken on both rivers up to the end of February, 1922. Their discharges, as observed between December, 1920, and April, 1922, are given in Appendix "C" herewith. The stream discharges of 1921 were normal, and estimates of the average power obtainable have been based largely upon them. Owing to the absence of gaugings, it has not been possible, as it was in the case of the Sugarloaf, to prepare tabulations of power that would have been obtainable had machinery been installed over a given series of years. We have, however, prepared an estimate of the average power that night be expected during each month of an average year, and regard the figures, which appear in tabular form in paragraph 16, as reasonably reliable.

Observations of the flow of Snob's Creek are not so complete as those on the Rubicon and Royston Rivers, but gaugings have been taken at frequent intervals since early in 1921, when conditions were normal, and during the summer of 1922, which was drier than that of the previous year. The minimum flow during very dry years has not been recorded, but the creek is reported by those who know it well to have a steady flow at such times. As in the case of the Rubicon and Royston Rivers, estimates of average power outputs have been based upon discharges believed to represent normal conditions. These figures will be exceeded in wet years, and will not be reached in dry ones, though as averages they are likely to be about correct.

12. *Rubicon and Royston Rivers : Scheme of Works Outlined.*—The arrangement of proposed works, considered the best, provides for the diversion of water from both rivers at points indicated on Drawing No. 3 attached. The offtakes are in each case situated immediately above the points where the rivers leave the more elevated portions of their valleys and commence their sharp declivity to the comparatively low lands bordering the Goulburn River. In this way advantage would be taken of the falls of nearly 2,000 feet that exist in both streams over sections of their courses, each only a few miles long. From such points of offtake independent conduits would convey the waters to a point where their flows could be conveniently combined into a single race. Along the latter they would be carried to the brow of a steep hill where there is a sudden descent to the junction of the two rivers at a place known as the Tin Hut. Here the stream would be sent down the hill in a pipe to a generating station, its power would be extracted by impulse turbines having a total maximum capacity of 10,200 horse-power, and the water would be returned to the river. The plant proposed at the junction is referred to in what follows as the Rubicon Power Station. It would be the most important of the power plants proposed for the generation of hydro-electric power from mountain streams within the system. The arrangement so far outlined is similar to that of a former proposal made by Mr. Michell, and we have satisfied ourselves that it would be the best obtainable.

In its passage from the Royston River, water diverted from it as described above would necessarily have to be dropped from a saddle in the main range forming the watershed between the two rivers, to the junction of the races mentioned above. At the foot of this drop it is proposed that an additional generating station should be established. Through it, energy that would otherwise have to be dissipated by stilling basins and thus lost would be recovered and fed into the system in the form of electric current. The maximum power obtainable here would be 1,000 h.p. This proposed generating station is termed the Royston Power Station, and its position is shown on Drawings Nos. 2 and 3.

Returning to the lower reaches of the Rubicon River, a third source of power is available between the Tin Hut, that is near the site of the Rubicon Power Station, and a point near the Timber Depôt further down stream. The Rubicon, which along this length carries the combined flow of the two rivers, falls 270 feet in a distance of two miles. By diverting a liberal flow along a race from the left or western bank just below the junction, and by returning it to the river through a pipe passing through a generating station indicated on the drawings as the Lower Rubicon Power Station a maximum of 2,000 h.p. could be developed. At this point the water so utilized would be returned to the stream undiminished in quantity and unimpaired in quality. There is no settlement above the Timber Depôt, so that no riparian rights could be in any way affected.

It will be seen that water abstracted from the Royston River would be passed through three power stations in succession, the total of the effective heads at full load being 1,835 feet. The Rubicon water would pass through two of them, the combined heads being 1,605 feet.

Between the point of high-level offtake on the Rubicon River and the Rubicon Power Station, the summer and autumn discharge of that stream would be almost wholly diverted through the hydraulic power works described, and the amount of water passing over the falls would be small. This would reduce the scenic effect at the falls until such times as the flow increased to a volume well in excess of that required for power development; in winter and spring there would however, be a considerable surplus of water and the falls would not be greatly affected. Cascades on the Royston River would be similarly affected, but they are rarely visited owing to their inaccessibility.

The Rubicon and Royston areas are connected with Alexandra by a steel rail tramway, along which steam-drawn trains are run as far as the Timber Depôt near the site of the proposed Lower Rubicon Power Station. Thence a wooden tram line, on which horses are employed to haul timber wagons, extends to the Rubicon Lumber and Tramway Company's saw-mill at an elevation of 2,694 feet. These tram lines would be of great assistance in the conveyance of machinery and materials, but would require overhaul and strengthening at some of the bridges. Arrangements could doubtless be made with the owners for haulage over them. The State Rivers and Water Supply Commission utilizes the steel rail section of the tram line extensively in connexion with its works at Sugarloaf Reservoir.

13. *Snob's Creek : Scheme of Works Outlined.*—The most satisfactory scheme for the development of hydro-electric power from this stream consists in the diversion of water to a point about two and three-quarter miles above the falls and its conveyance by an open conduit and by a pressure pipe to the proposed Snob's Creek Power Station as shown on Drawing No. 3. At this generating station the water would all be returned to the creek after passing through an impulse turbine capable of developing a maximum of 5,100 h.p. The works are more closely described in paragraph 20 hereunder.

An alternative proposal for diverting the flow to the Rubicon Valley was investigated, but found to be too costly. The advantage of such a diversion would have been the grouping of several of the power houses in one locality. It has been found necessary, therefore, for reasons of economy, to provide for independent power stations, each within its own catchment area.

The falls on Snob's Creek would be affected by the diversion of the summer and autumn flow in the same way as would those on the Rubicon, though in winter and spring the effect would not be so appreciable. In this respect it may be noted that hydro-electric works would be objects of interest to visitors, and that their presence would offset the loss of scenic effect at certain seasons. The country is dense bush, and, being free from settlement, riparian rights could not be affected.

14. *Storages on Mountain Streams.*—Were it possible to store water in large quantities at sufficiently high elevations within the valleys of the mountain streams, the utility of the latter for power generation would be greatly enhanced. Close search was made in each valley for suitable sites for impounding reservoirs above the points of proposed diversions, and, though several were sufficiently promising to be tested by survey, their capacities were in each case found to be too small to justify the large expenditure that would be required to construct them. It has, therefore, been found necessary to rely upon the natural discharge of each stream for the proposed generation of power.

POWER STATIONS AND POWER OBTAINABLE.

15. *Summary of Power Stations Proposed.*—The following is a list of power stations included in the scheme, with leading particulars as to sizes of turbine units and of the heads available for their operation:—

Sugarloaf.—One reaction turbine unit of 7,500 h.p. with provision for duplication at a later date. Head, with full supply level in the reservoir at 823 feet reduced level, 105 feet maximum.

Rubicon.—Two impulse turbine units of 5,100 h.p. each. Head, at full load, 1,350 feet.

Royston.— One reaction turbine unit of 1,000 h.p. Head, at full load, 230 feet.

Lower Rubicon.—One reaction turbine unit of 2,000 h.p. Head, at full load, 255 feet.

Snob's Creek.—One impulse turbine unit of 5,100 h.p., with two jets. Head, at full load, 1,230 feet.

The total power of the turbines proposed to be installed amounts to 25,800 h.p.

In each case the turbine would be direct-coupled to a three-phase generator.

16. *Power obtainable at all Stations.*—The following table shows the brake horse-power, exclusive of that required for the excitation of the generators, which it is expected would be developed at the turbine shaft of each power station included in the scheme. The figures are the estimated averages for each month of an average year.

In Column 1, the figures are averages based on the assumption that one unit had been in operation at Sugarloaf, immediately below a reservoir of 300,000 acre feet with full supply level 823 feet above sea, during the forty years 1882 to 1921 inclusive.

The figures in Columns 2, 3, 4, and 5 are based on estimated average flows of the mountain streams supplying water to the proposed power stations.

The total average combined horse-power from all five power stations is given in Column 6 for each month of an average year.

Month.	Sugarloaf.	Rubicon.	Royston.	Lower Rubicon.	Snob's Creek.	Total B.H.P.
	1.	2.	3.	4.	5.	6.
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
January	7,100	6,500	530	1,200	2,150	17,480
February	6,800	4,300	330	770	1,700	13,900
March	6,470	4,200	310	750	1,600	13,330
April	6,100	4,150	300	740	1,500	12,790
May	5,750	6,000	500	1,100	2,800	16,150
June	[illegible]800	10,000	930	1,900	5,000	18,630
July	4,200	10,000	930	1,900	5,000	22,030
August	5,920	10,000	930	1,900	5,000	23,750
September	6,660	10,000	930	1,900	5,000	24,490
October	6,900	10,000	930	1,900	5,000	24,730
November	7,230	9,050	750	1,680	4,380	23,090
December	7,290	7,900	600	1,450	3,030	20,270
Average per month ..	5,935	7,675	665	1,432	3,513	19,220

The average horse-power estimated to be obtainable at each of the power stations, and from all combined, is shown in diagrammatic form in Drawing No. 7. The winter figures for Sugarloaf have been referred to at the end of paragraph 5 above.

17. *Rubicon Power Scheme, with Estimate of Cost.*—The general outlines of the works proposed in this section are given in paragraph 12 above. The following is a description of the more important details. Referring to Drawing No. 3, it will be seen that water would be drawn from the Rubicon River at a level of 2,693 feet, where a diversion weir in concrete would be required. From offtake works situated on the right bank of the stream, an open channel or race having a capacity of 50 cubic feet per second would be carried round the hillside, generally in a northerly direction. At Lubra and Beech Creeks, inverted syphons would be required with small subsidiary works for the collection, in dry times only, of the flow of both of them. Between Beech Creek and the junction with the conduit bringing in water from the Royston River, several short flumes would be required at gullies, also a longer one across some ground that has shown a tendency to slide as the result of seepage from a small mill race, referred to below, that skirts the hill above it. Below the point at which the Royston waters would come in, the race would be increased in capacity to 85 cubic feet per second, and it would be continued on a slightly falling gradient to the pipe head basin at the brow of the spur, and at a level of 2,662 feet. Flumes, as well as cross-drainage works, would be required, but not on an extensive scale. The total length of race, including syphons and flumes, would be about 25,200 feet, say four and three-quarter miles.

The whole of the country traversed is heavily timbered, though on several sections the trees have been felled and left lying on the ground. Trial pitting has shown that little solid rock would be met with on the race lines, and that excavation would be moderately easy. The soil is of a porous character, and a thin lining in concrete would be desirable, not only to prevent erosion and losses of water by seepage, but also to permit of the adoption of reasonably high velocities of flow. The necessity for the prevention of seepage losses will be appreciated when it is stated that a single cubic foot per second of water lost from this race would otherwise have been capable of developing about 130 h.p. at the Rubicon Power Station.

The only existing diversion of water is by a small race from Lubra Creek for use in a Pelton wheel at Messrs. Clark and Pearce's sawmill. It carries only about two cubic feet per second, but, as this volume of water would provide 260 h.p. in dry times, arrangements could no doubt be made to acquire their rights and to furnish them with the small amount of electric power they would use.

Works upon the Royston River would include a diversion weir at an elevation of 2,943 feet, and a line of race about 6,500 feet long from the offtake to a pipe-head basin close to a gap in the range dividing the catchment areas of the Rubicon and Royston. It would have a capacity of 50 cubic feet per second and would be similar in construction to the Rubicon race. A pipe drop, about 1,700 feet long, would be required between the saddle and the Rubicon race. At the lower end of the pipe it is proposed that the Royston Power Station should be established. The power plant is further referred to in paragraph 18.

Returning to the lower end of the Rubicon race, the pipe-head basin already referred to, would be constructed with a lining of concrete, at a site that is well suited to the purpose, and would be provided with screens, scour pipes for washing out sediment, measuring weir, and head gates. From the basin the water would be conveyed down the steep spur by an almost straight pipe, to the power house at 1,220 feet above sea level. The pipe would be of wood stave for about 500 feet, where it would connect with a steel one extending to the Rubicon Power Station. The total length of piping would be about 4,500 feet and the static head 1,442 feet. The diameters would vary between 36 inches at its head and 27 inches at the foot of the hill. The pipes would be laid above ground for the greater part of the length. They would rest on concrete cradles, and suitable concrete anchorages would be provided. The configuration of the country is favorable for the pipe line; being steep, the pipe is not unduly long relatively to the vertical drop. A longitudinal section of the Rubicon race and the pressure pipe is given on Drawing No. 9, while similar sections of the Royston race and pipe will be found on Drawing No. 11.

The lay-out of the proposed Rubicon Power Station is sketched in Drawing No. 10. The hydraulic machinery would consist of two units, either or both of which would be supplied as required with water from the pressure pipe, controlled by valves suitably arranged. Each unit would consist of a 5,100 b.h.p. impulse wheel of the Pelton type, fitted with automatic governors and the latest and most reliable auxiliaries. Stream deflectors and needle valves would be provided to assist in speed regulation, and each machine would be direct-coupled to a three-phase generator. The whole would be reliable in operation and efficient, even at small loads. The intention is to operate both units, except at periods of low water, when one of the turbines would be laid off for inspection and overhaul.

The estimated amount of power obtainable at this station is tabulated in paragraph 16.

The following is an estimate of the cost of necessary hydraulic works, turbines, buildings, overhead crane, &c., required in connexion with the Rubicon Power Station. The cost of bringing water from the Royston River is included, as these works would be required whether the Royston Power Station were constructed or not. Estimates are based on current prices and ruling rates of wages and, as in the case of all the other estimates given herein, includes allowances for contingencies, surveys, and supervision.

RUBICON SECTION.

Estimate.

	£
Weir, headgates, screens, &c., at offtake on the Rubicon River	2,250
Rubicon Race, including clearing, excavation, syphons, lining, fluming, cross drainage works, and staff cottages	48,380
Weir, headgates, screens, &c., at offtake on the Royston River	1,980
Royston Race, including clearing, excavation, syphons, lining, and cross drainage works	9,980
Pipe-head basin at the lower end of the Royston Race, with screens, measuring weir, scour, &c.	790
Pipe drop, arranged as a pressure pipe to the Royston Power Station ..	7,260
Pipe-head basin at the lower end of the Rubicon Race, with screens, measuring weir, scour, &c.	1,370
Pressure pipe in wood and steel above the Rubicon Power Station ..	41,850
Special fittings and spare pipes	2,380
Plant required in construction, road connexions and strengthening of tramways	10,960
Power Station Buildings, including foundations, tail races, overhead crane, &c.	9,020
Turbines, two units of 5,100 h.p. each, with valves and pipe connexions, auxiliaries and spare parts	14,550
Staff quarters, store, workshop, and office	1,750
Total	152,520

18. *Royston Power Station, with Estimate of Cost.*—As previously described, a pipe drop is required at the lower end of the Royston Race as an integral part of the Rubicon Scheme. Reference to the table in paragraph 16 will show that the power obtainable from the water falling through this pipe would vary between 930 and 300 h.p. in an average year. One turbine having a rated capacity of 1,000 h.p., suitably housed, is proposed immediately above the junction with the Rubicon Race. The pressure pipe would be in wood stave for about 700 feet from its upper end and in steel plate for the remainder of its length. The diameters would average about 27 inches, and suitable regulating valves would be provided. Provision would be made for destroying the energy of the falling water whenever the turbine had to be shut down for attention. Thus a continuity of the supply of water to the Rubicon Station would be assured. The tail water channel from the power house would be at the same level as that of the Rubicon Race and would be directly connected with it.

Our estimate of the cost of the hydraulic works, turbines and housing is as under. The pressure pipe would be required in connexion with the Rubicon Scheme, and, as its cost has been included in the figures given in paragraph 17, it is not scheduled here; in consequence, the cost per horse-power proposed to be installed in this section is relatively low.

ROYSTON SECTION.

Estimate.

Clearing, excavation, and preparation of the Power Station site	£870
Power Station Buildings, including foundations, tail race, overhead crane, &c.	3,730
Connecting channel to the Rubicon Race, with spillway, &c.	720
Turbine, one unit of 1,000 h.p., with valves, connexions, spare parts and special by-pass	3,970
Staff quarters and workshop	670
Total	£9,960

19. *Lower Rubicon Scheme, with Estimate of Cost.*—Supplementary to the general description given in paragraph 12, the following additional particulars are furnished. The supply race would be an open one and would have a capacity of 85 cubic feet per second. It would convey water diverted from the Rubicon River at the site of a concrete diversion weir that would be placed across the stream a short distance below its confluence with the Royston River. The race would skirt the hills on the western side of the stream and would be comparatively easy to construct. The country passed through is timbered, but not heavily so, and little solid rock would be met with. The total length of the race would be 10,400 feet, or just a little short of two miles. From a basin at the lower end of the race a pressure pipe 680 feet long would be carried to the power station situated immediately on the left bank of the river. It would be 42 inches diameter in wood at the upper end, reducing to 36 inches diameter in steel at the lower one. At the power station it is proposed, as shown in Drawing No. 14, to install a horizontal shaft turbine of the Francis type capable of developing up to 2,000 h.p., depending on the volume of water available. The amount of power obtainable in average years is given in the table in paragraph 16 above. The estimated cost of the hyraulic works, turbines, and structures required in this section of the scheme is as under :—

LOWER RUBICON SECTION.

Estimate.

Diversion Weir on the Rubicon River, with levee, headgates, screens, &c.	£3,180
Lower Rubicon Race, including clearing, excavation, lining, fluming, and cross drainage works	16,240
Pipe head basin with screens, measuring weir and scour	1,080
Pressure Pipe to the Lower Rubicon Power Station, with spares ..	3,680
Power Station Buildings, including foundations, tail race, overhead crane, &c.	4,780
Plant required in construction, other than included elsewhere, and road approaches	1,350
Turbine, one unit of 2,000 h.p., with valves, pipe connexions, draft tube, and spare parts	6,210
Store, office, &c.	740
Total	£37,260

20. *Snob's Creek Scheme, with Estimate of Cost.*—The position of the various proposed works is shown on Drawing No. 3. At the point of offtake, about 2,305 feet above sea level, a concrete diversion weir would be required. In conjunction with it there would be headgates and screens on lines similar to those on the Rubicon and Royston Rivers. The race also would be similar to those already described, but in one short section, where the cross slope is particularly steep, an open flume would be the most suitable form of construction. For close upon a mile the country traversed is almost free from timber as a result of severe bush fires of many years ago. Otherwise the clearing would be moderately heavy.

Lining of the supply race is proposed in this case also, as every cubic foot per second of water conserved would develop over 110 h.p. when passing through the turbines. The race would be 20,900 feet, say 4 miles, long. Fluming would not be extensive, and suitable cross drainage works and spillways would be provided.

At the lower end of the race, which would be about 2,284 feet above sea-level, a suitable pipe-head basin would be constructed with headgates, screens, scour pipes, and measuring weir. The pressure pipe would be nearly straight, following a steep spur that would be in every way suitable. It would be in wood at its upper end, but in steel for the greater part of its length. The diameters would vary between 30 inches and 24 inches, the smallest section being at the lower end, as economy dictates.

The power station would be situated at the foot of the pipe line and at a level of 984 feet above sea ; it would contain one impulse turbine, having a maximum output of 5,100 brake h.p. It would be of the two-jet type, one of which would be thrown out of action when the supply of water was low. By this arrangement good efficiency would at all times be maintained. Automatic governors, operating stream deflectors, and needle valves would be provided, and the whole would be reliable in operation. The turbine would be direct coupled to a three-phase generator through a horizontal shaft, and the power house would be equipped with an overhead crane and the necessary auxiliaries. Owing to the configuration of the ground, the power house would have to be placed about 300 feet from the right bank of Snob's Creek. Tail water from the turbines would be discharged to the stream by a race of that length. The estimated amount of power that could be developed in an average year is given in the table in paragraph 16.

The cost of the hydraulic works and machines with necessary housing has been estimated as under :—

SNOB'S CREEK SECTION.

Estimate.

Diversion Weir, headgates, screens, and road approach at the offtake on Snob's Creek	£2,460
Snob's Creek Race, including clearing, excavation, lining, fluming, cross drainage works, and staff cottages	36,860
Pipe head basin, with screens, measuring weir, and scour	1,120
Pressure Pipe to Snob's Creek Power Station, with spares	23,580
Power Station Buildings, including foundations, tail race, overhead crane, &c.	5,070
Tail water channel between the Power House and Snob's Creek ..	370
Plant required in construction, road approaches, &c..	7,700
Wooden tramline for the transport of materials to the higher levels ..	7,940
Turbine, one two-jet unit of 5,100 h.p., with valves, pipe connexions, auxiliaries, and spare parts	7,970
Staff quarters, store, workshop, and office at Power Station	1,850
Total	£94,920

SUMMARY OF COSTS.

21. *Capital Cost.*—The estimated capital cost of the hydraulic works, water turbines, and buildings included in each section of the complete scheme is summarized as under. It will be seen that the total cost is set down at £354,870.

	Capital Cost.	Cost per Brake Horse Power Installed.
	£	£ s. d.
Sugarloaf	60,210	8 0 7
Rubicon	152,520	14 19 0
Royston	9,960	9 19 3
Lower Rubicon	37,260	18 12 7
Snob's Creek	94,920	18 12 3
Total	354,870	

22. *Annual Operation, Maintenance, and Capital Charges.*—The following table gives the estimated annual charges for operation, maintenance, replacement, and interest to be debited against the hydraulic sections of the undertaking. Replacement charges, commonly referred to as depreciation, are based upon the duration of the probable useful lives of the various works, structures and hydraulic machines. Interest has been calculated at the rate of six pounds per centum on the estimated capital cost :—

Section of the Scheme.	Annual Operation, Maintenance, and Replacement Charges.	Annual Interest Charges on Capital Cost at 6 per cent.	Total of Annual Charges.
	£	£	£
Sugarloaf	1,910	3,612	5,522
Rubicon	5,560	9,151	14,711
Royston	690	598	1,288
Lower Rubicon	1,730	2,236	3,966
Snob's Creek	3,520	5,695	9,215
Totals	13,410	21,292	34,702

The total of all the charges against the hydraulic works and machines is estimated at £34,702 per annum. The table in paragraph 16 above shows that, if all five proposed stations were operated continuously, the average of the combined loads on the turbines might be expected to be 19,220 h.p. during a year of normal stream discharge. It would, however, be necessary to provide for periodical inspection and repair so that, under working conditions, the average output would be reduced. On the assumption that it would be possible to develop an average of 17,300 h.p., that is ninety per cent. of 19,220 h.p., the cost per brake horse power per annum at the turbine shafts would be £2. This figure compares favorably with that at many large water power plants abroad and indicates a source of very cheap supply.

CONCLUSION.

23. The arrangement of hydraulic works and machines described in this Report would be suitable whether the generating plant be equipped for manual, for semi-automatic, or for automatic control, as may appear most desirable to the electrical engineers.

Regarding the time required for construction, it will be seen that many of the works would be situated at high elevations, where severe winters accompanied by snow storms are the rule. At Sugarloaf, the site of the power house would have to be coffer-dammed, and the laying of the foundations would have to be suspended for a season when the river downstream of the reservoir rose above a certain level. Similarly, operations on the mountain streams would be interrupted by fairly frequent floods. For these reasons, the bulk of the work would have to be carried out in the drier months. Assuming a commencement to be made about the end of 1923 with the construction of all the hydraulic works described above, the expenditure upon them would be distributed over the financial year following, about as under :—

TABLE OF ESTIMATED OUTLAY UPON THE SUGARLOAF, RUBICON, ROYSTON, LOWER RUBICON, AND SNOB'S CREEK SECTIONS.

	£
Year ending June, 1924	35,000
Year ending June, 1925	90,000
Year ending June, 1926	120,000
Year ending June, 1927	109,870
	£354,870

The time required for completion would be about three and a half years after commencement, but the rate of expenditure would necessarily depend so much upon weather conditions, that any forecast in this respect should be regarded as approximate only.

Should it be considered desirable to carry out the scheme by instalments, it would be necessary in the first of them to develop sources that would furnish a sufficient continuity of supply throughout the year. We would regard the Sugarloaf Station as essential for summer requirements, while, for the maintenance of the winter supply, the Rubicon and Royston sections, which are so closely connected as to be practically inseparable, would complete the combination in a satisfactory and relatively cheap manner.

The estimated brake horse power obtainable from a combination comprising the Sugarloaf, Rubicon, and Royston Sections would, in an average year, vary between 17,830 h.p. in October and 10,550 h.p. in April. The average over the twelve months would be about 14,275 h.p. if the plants were operated continuously. Allowing for periodical inspection, repair, &c., the average that would be available at the turbine shafts is set down at 12,850 h.p. The capital cost of the hydraulic works required for the development of that amount of power is estimated at £222,690. The annual charges, including interest, have been given in paragraph 22 above at £21,521, so that the cost per brake horse power per annum at the turbine shafts would be only £1 13s. 6d. This figure is 6s. 6d. below that given for the scheme in its entirety, but it will be noted that the more favorable sections have been selected for inclusion in a first instalment.

The time required for the construction of the Sugarloaf, Rubicon, and Royston Sections referred to would be little, if any, less than if all sections of the complete scheme were undertaken simultaneously. Assuming, as before, that a commencement with construction be made about the end of 1923, and that the works be limited for the time being to those just referred to, the distribution of expenditure upon them might be set down approximately as follows :—

TABLE OF ESTIMATED OUTLAY UPON THE SUGARLOAF, RUBICON, AND ROYSTON SECTIONS.

	£
Year ending June, 1924	25,000
Year ending June, 1925	60,000
Year ending June, 1926	80,000
Year ending June, 1927	57,690
	£222,690

Surveys and gaugings were commenced by Mr. R. J. Martin, while those upon the Snob's Creek area were continued by Mr. Ramsay Turner, B.C.E. To those gentlemen we are indebted for their careful work in the field. Technical discussions with Mr. H. R. Harper, Chief Engineer, and with Mr. E. Bate, Electrical Engineer to the Commission, have been helpful, and we now express our appreciation of their cordial co-operation.

J. M. & H. E. COANE.

70 Queen-street, Melbourne,
2nd May, 1922.

APPENDIX A.

DISCHARGE OF THE GOULBURN RIVER AT SUGARLOAF RESERVOIR DURING THE 40 YEARS 1882 TO 1921 INCLUSIVE.

The discharges for the period January, 1882, to December, 1915, are based on gaugings at Murchison; from December, 1915, onwards the discharges are those gauged at Sugarloaf.

Month.	Discharge in Cubic Feet per Second. Years.													
	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.
January ..	520	488	488	504	732	423	1,073	780	439	1,089	325	439	602	634
February ..	216	360	539	486	720	306	557	396	306	540	180	252	235	360
March ..	114	325	553	260	374	342	455	195	244	293	163	163	293	293
April ..	168	370	370	588	286	806	386	353	336	622	235	235	439	336
May ..	699	358	553	325	390	667	504	1,041	276	423	764	439	537	455
June ..	1,188	1,075	756	1,865	470	2,604	1,865	6,014	2,990	874	2,554	3,226	1,848	1,378
July ..	1,089	2,065	715	1,594	423	4,465	2,894	4,032	3,285	4,570	2,862	4,211	4,602	1,886
August ..	3,480	4,959	1,268	1,935	2,390	5,301	2,390	3,919	4,358	2,341	2,911	2,797	5,480	2,683
September ..	3,293	3,998	1,378	3,864	2,335	5,443	2,570	7,224	3,696	1,478	3,914	5,292	6,334	4,066
October ..	2,000	3,984	1,155	2,683	1,691	3,740	1,333	3,301	5,788	1,106	1,577	4,000	5,382	1,415
November ..	1,025	3,494	874	974	1,747	5,926	605	1,840	2,604	1,512	2,234	1,562	1,949	420
December ..	1,008	1,772	894	911	1,057	2,065	358	829	1,268	602	1,024	732	992	374

Month.	Discharge in Cubic Feet per Second. Years.													
	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
January ..	244	585	163	325	228	293	374	276	1,512	293	390	650	537	228
February ..	174	324	180	234	209	216	252	234	992	252	270	414	288	252
March ..	196	309	130	244	195	179	228	358	374	244	488	260	195	179
April ..	622	252	151	386	772	722	235	588	252	202	302	370	134	185
May ..	504	228	211	699	1,203	553	228	845	325	342	715	455	244	2,065
June ..	706	420	1,898	3,226	1,512	2,352	772	2,520	1,428	1,142	3,041	739	1,243	4,317
July ..	2,537	1,301	1,414	2,504	2,585	1,545	715	4,146	4,683	4,943	6,993	943	1,236	3,301
August ..	1,398	1,968	2,293	2,406	3,972	2,065	390	2,098	2,764	2,846	4,520	2,650	2,081	9,236
September ..	2,251	3,477	2,940	857	3,864	4,301	605	2,908	3,377	3,091	5,863	1,109	1,999	3,343
October ..	910	1,317	1,252	878	1,740	2,634	602	1,642	2,569	2,667	6,553	1,171	1,333	1,740
November ..	437	772	1,294	655	790	2,050	336	941	1,546	2,218	1,546	722	722	672
December ..	276	276	585	293	390	553	407	618	504	780	1,528	618	293	390

Month.	Discharge in Cubic Feet per Second. Years.											
	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
January ..	179	455	342	488	293	163	276	667	423	228	276	325
February ..	151	1,224	244	396	270	108	244	414	306	234	209	216
March ..	163	1,073	195	569	211	98	211	455	374	309	211	228
April ..	168	487	168	571	151	113	235	823	286	252	218	218
May ..	179	846	179	228	325	455	293	3,724	6,113	650	342	260
June ..	857	7,463	370	1,646	420	1,445	622	12,230	5,359	1,545	1,932	1,445
July ..	2,813	472	1,024	1,333	927	4,211	3,317	8,959	6,634	2,439	3,805	2,455
August ..	1,659	3,447	764	2,488	927	5,886	5,106	6,992	3,365	2,423	5,415	7,512
September ..	5,964	1,445	4,553	1,781	521	3,914	7,946	9,609	3,309	3,494	5,342	7,526
October ..	3,122	927	1,268	1,122	325	3,057	5,854	8,439	862	1,301	3,268	3,463
November ..	1,596	386	1,243	1,428	185	1,579	5,074	2,386	772	437	2,218	991
December ..	764	455	1,333	715	146	423	2,488	846	325	390	553	439

APPENDIX B.

TABLE SHOWING TURBINE BRAKE HORSE-POWER AT THE SUGARLOAF DAM DURING THE FORTY YEARS 1882 TO 1921 INCLUSIVE HAD MACHINERY BEEN INSTALLED.

Reservoir capacity, 300,000 acre-feet.
Full supply level, 823 feet above sea.
Lowest tail water, 707 feet above sea.

Each unit 7,500 brake horse-power.
Figures are averages for each month.

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.
	1882.		1883.		1884.		1885.		1886.		1887.	
January ..	7,500	7,500	7,158	7,158	7,307	7,307	7,228	7,228	7,307	7,307	7,500	7,500
February ..	7,019	7,019	7,019	7,019	7,087	7,087	7,087	7,087	7,158	7,158	7,087	7,087
March ..	6,520	6,520	6,733	6,733	6,875	6,875	6,772	6,772	6,946	6,946	6,772	6,772
April ..	6,166	6,166	6,378	6,378	6,733	6,733	6,520	6,520	6,520	6,520	6,591	6,591
May ..	5,882	5,882	6,095	6,095	6,520	6,520	6,166	6,166	6,237	6,237	6,378	6,378
June ..	..	..	..	..	..	..	..	..	..	..	..	..
July ..	3,509	4,846	3,437	6,911	..	..	5,421	11,150	..	..	7,087	14,249
August ..	7,158	14,391	7,087	14,249	4,772	9,982	7,228	14,534	2,292	4,607	7,019	14,108
September ..	7,158	14,391	7,087	14,249	7,300	12,500	7,158	14,391	7,228	14,534	7,019	14,108
October ..	7,228	14,532	7,087	14,249	7,500	10,674	7,228	14,534	7,228	14,534	7,158	14,391
November ..	7,306	9,243	7,158	14,391	7,377	8,025	7,377	8,865	7,228	14,534	7,019	14,108
December ..	7,228	9,317	7,228	14,534	7,377	8,218	7,377	8,366	7,307	9,533	7,228	14,534

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.
	1888.		1889.		1890.		1891.		1892.		1893.	
January ..	7,307	7,307	7,087	7,087	7,087	7,087	7,307	10,062	7,228	7,228	7,500	7,500
February ..	7,377	7,377	6,946	6,946	6,772	6,772	7,228	7,228	6,946	6,946	7,087	7,087
March ..	7,228	7,228	6,664	6,664	6,450	6,450	7,087	7,087	6,520	6,520	6,664	6,664
April ..	7,087	7,087	6,237	6,237	5,882	5,882	6,876	6,876	6,095	6,095	6,166	6,166
May ..	6,772	6,772	6,025	8,194	5,430	5,430	6,590	6,590	5,882	5,882	5,814	5,814
June ..	..	..	..	..	..	..	..	..	..	..	..	..
July ..	7,158	14,391	7,087	14,245	7,158	14,391	5,208	10,473	7,158	14,391	7,087	14,245
August ..	7,228	14,534	7,087	14,245	7,087	14,245	7,228	14,534	7,158	14,391	7,158	14,391
September ..	7,158	14,534	7,019	14,108	7,158	14,391	7,500	13,157	7,087	14,245	7,019	14,108
October ..	7,500	12,093	7,158	14,391	7,019	14,108	7,307	10,314	7,228	14,391	7,087	14,245
November ..	7,377	7,377	7,228	14,534	7,228	14,534	7,500	13,465	7,228	14,534	7,228	13,629
December ..	7,228	7,228	7,307	7,307	7,500	11,503	7,377	7,377	7,307	9,234	7,377	7,377

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.
	1894.		1895.		1896.		1897.		1898.		1899.	
January ..	7,228	7,228	7,307	7,307	6,772	6,772	6,733	6,733	6,772	6,772	7,158	7,158
February ..	7,019	7,019	7,228	7,228	6,378	6,378	6,591	6,591	6,378	6,378	6,772	6,772
March ..	6,733	6,733	6,946	6,946	5,740	5,740	6,095	6,095	5,810	5,810	6,378	6,378
April ..	6,520	6,520	6,591	6,591	5,430	5,430	5,740	5,740	5,154	5,154	6,095	6,095
May ..	6,095	6,095	6,237	6,237	5,010	5,010	5,010	5,010	3,980	3,980	5,810	5,810
June ..	..	..	..	..	5,354	5,354	..	..	..	..	3,330	6,698
July ..	7,087	14,245	5,313	10,683	..	..	..	..	..	..	7,228	14,534
August ..	7,019	14,108	7,228	14,534	..	..	1,683	3,386	5,210	10,475	7,228	14,534
September ..	7,019	14,108	7,158	14,391	7,228	14,534	7,158	14,391	7,158	14,391	7,377	7,870
October ..	7,019	14,108	7,500	12,714	7,377	8,355	7,500	11,944	7,500	11,463	7,377	8,062
November ..	7,228	14,534	7,500	7,500	7,518	7,518	7,307	7,307	7,500	11,740	7,377	7,377
December ..	7,377	9,029	7,158	7,158	7,019	7,019	7,228	7,228	7,307	7,307	7,228	7,228

APPENDIX B.—Table Showing Turbine Brake Horse-power at the Sugarloaf Dam—*continued*.

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Units.	TwoUnits.
	1900.		1901.		1902.		1903.		1904.		1905.	
January ..	6,520	6,520	6,946	6,946	7,087	7,087	6,733	6,733	7,228	13,338	7,158	7,158
February ..	6,095	6,095	6,591	6,591	6,733	6,733	6,378	6,378	7,500	9,253	6,875	6,875
March ..	5,740	5,740	6,095	6,095	6,378	6,378	5,882	5,882	7,228	7,228	6,520	6,520
April ..	6,095	6,095	5,810	5,810	6,095	6,095	5,648	5,648	6,946	6,946	6,095	6,095
May ..	5,648	8,647	5,648	5,648	5,570	5,570	5,648	5,648	6,520	6,520	6,095	6,095
June ..	..	..	..	..	..	..	..	..	..	..	..	..
July ..	5,310	10,684	5,315	10,110	..	..	7,087	14,245	7,087	14,245	5,316	10,684
August ..	7,019	14,108	7,228	14,534	..	..	7,228	7,228	7,228	14,534	7,158	14,391
September ..	7,019	14,108	7,087	14,245	..	..	7,158	7,158	7,158	14,391	7,158	14,391
October ..	7,087	14,245	7,228	14,534	..	..	7,228	14,996	7,228	14,534	7,158	14,391
November ..	7,500	7,500	7,228	14,534	3,653	3,653	7,377	8,790	7,500	13,767	7,228	14,534
December ..	7,228	7,228	7,377	7,377	7,158	7,158	7,377	7,377	7,377	7,377	7,377	7,377

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.
	1906.		1907.		1908.		1909.		1910.		1911.	
January ..	7,158	7,158	7,500	7,500	7,228	7,228	6,875	6,875	6,772	6,772	7,158	7,158
February ..	6,946	6,946	7,158	7,158	6,946	6,946	6,520	6,520	6,378	6,378	7,019	10,793
March ..	6,590	6,590	6,772	6,772	6,590	6,590	6,095	6,095	5,950	5,950	7,500	9,916
April ..	6,238	6,238	6,378	6,378	6,095	6,095	5,430	5,430	5,224	5,224	7,500	7,500
May ..	6,378	6,378	6,378	6,378	5,740	5,740	6,095	6,095	4,646	4,646	7,307	7,699
June ..	..	..	..	..	..	..	3,509	7,054	..	..	6,139	12,341
July ..	7,019	14,108	..	..	..	..	7,158	14,391	..	..	7,377	7,377
August ..	7,087	14,245	5,369	10,794	5,421	10,901	6,946	13,964	5,421	10,852	7,158	14,391
September ..	7,087	14,245	7,500	10,248	7,228	14,534	7,158	14,391	7,019	14,108	7,500	12,987
October ..	7,019	14,108	7,500	10,725	7,500	12,090	7,228	14,534	7,158	14,391	7,307	8,360
November ..	7,500	13,767	7,377	7,377	7,307	7,307	7,377	7,377	7,228	14,572	7,500	7,500
December ..	7,500	13,602	7,377	7,377	7,228	7,228	7,377	7,377	7,377	7,377	7,158	7,158

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.
	1912.		1913.		1914.		1915.		1916.		1917.	
January ..	6,772	6,772	7,500	7,500	7,087	7,087	6,238	6,238	7,017	7,017	7,308	7,308
February ..	6,520	6,520	7,087	7,087	6,772	6,772	5,141	5,141	6,662	6,662	7,158	7,158
March ..	6,095	6,095	6,772	6,772	6,520	6,520	5,155	5,155	6,238	6,238	6,948	6,948
April ..	5,430	5,430	6,664	6,664	6,020	6,020	3,974	3,974	5,741	5,741	6,734	6,734
May ..	5,015	5,015	6,520	6,520	5,882	5,882	2,921	2,921	5,016	5,016	6,592	13,250
June ..	..	..	..	..	..	..	..	..	..	..	6,876	13,822
July ..	..	..	7,500	12,090	..	..	..	..	1,470	2,957	6,948	13,964
August ..	..	..	7,158	14,391	..	..	7,017	14,108	7,017	14,108	7,017	14,108
September ..	1,693	3,420	7,228	14,534	..	..	7,158	14,391	7,017	14,108	6,948	13,964
October ..	7,500	11,613	7,500	10,248	..	..	7,158	14,391	7,017	14,108	6,948	13,964
November ..	7,500	11,380	7,500	12,836	7,158	7,158	7,228	14,415	7,017	14,108	7,228	14,528
December ..	7,500	12,090	7,377	7,377	6,772	6,772	7,500	7,500	7,158	14,391	7,378	7,768

Month.	Brake Horse-power.		Brake Horse-power.		Brake Horse-power.		Brake Horse-power.	
	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.	One Unit.	Two Units.
	1918.		1919.		1920.		1921.	
January ..	7,500	7,500	6,876	6,876	6,734	6,734	7,158	7,158
February ..	6,948	6,948	6,451	6,451	6,238	6,238	6,734	6,734
March ..	6,734	6,734	5,955	5,955	5,955	5,955	6,380	6,380
April ..	6,310	6,310	5,578	5,578	5,155	5,155	5,955	5,955
May ..	5,955	11,973	5,016	5,016	4,444	4,444	5,155	5,155
June ..	7,017	14,108	..	..	..	..	..	..
July ..	7,017	14,108	3,367	6,771	3,331	6,697	6,662	13,394
August ..	7,158	14,391	7,228	14,535	7,017	14,108	7,017	14,108
September ..	7,158	14,391	7,158	14,391	7,017	14,108	7,017	14,108
October ..	7,378	7,917	7,500	11,803	7,158	14,391	7,158	14,391
November ..	7,378	7,378	7,308	7,308	7,228	14,535	7,308	8,937
December ..	7,228	7,228	7,017	7,017	7,378	7,378	7,228	7,228

APPENDIX C.

OBSERVED MONTHLY DISCHARGES OF THE RUBICON RIVER AT THE TIN HUT.

Catchment Area = 22·8 square miles.

Month.	Discharge in Cubic Feet per Second.			
	Maximum.	Minimum.	Mean.	Mean per Square Mile.
1920.				
December	67	43	48	2·11
1921.				
January	84	18	33	1·46
February	36	13	18	·77
March	51	13	23	1·00
April	30	13	21	·90
May	84	13	25	1·09
June	177	30	72	3·17
July	784	36	104	4·54
August	263	67	115	5·03
September	Gauges damaged by floods.			
October	272	97	173	7·57
November	175	63	101	4·42
December	63	26	38	1·66
1922.				
January	26	20	20	1·01
February	26	14	17	·77
March	27	18	20	·88
April	57	17	25	1·10

APPENDIX D.

OBSERVED MONTHLY DISCHARGES OF THE ROYSTON RIVER AT THE TIN HUT.

Catchment Area = 18·5 square miles.

Month.	Discharge in Cubic Feet per Second.			
	Maximum.	Minimum.	Mean.	Mean per Square Mile.
1920.				
December	58	36	42	2·26
1921.				
January	93	18	33	1·91
February	36	11	17	·89
March	67	9	18	·99
April	30	15	20	1·02
May	93	13	26	1·42
June	188	24	72	3·89
July	718	33	98	5·29
August	251	67	116	6·24
September	Gauges damaged by floods.			
October	259	110	164	8·86
November	182	60	102	5·49
December	54	27	35	1·90
1922.				
January	28	18	23	1·23
February	30	15	19	1·03
March	23	15	18	·97
April	47	14	21	1·12

REPORT

TO

STATE ELECTRICITY COMMISSION OF VICTORIA

ON

WATER-POWER INVESTIGATIONS IN STRATHBOGIE DISTRICT.

MESSRS. J. M. AND H. E. COANE,
70 Queen-street, Melbourne.

WATER-POWER INVESTIGATIONS

AT

STRATHBOGIE.

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70 Queen-street,
Melbourne, 20th July, 1922.

The Chairman and Commissioners,
The State Electricity Commission of Victoria,
Melbourne.

GENTLEMEN,

In October last we initiated, at your request, a rapid examination of the possibilities of water-power development on a comparatively small scale, in reasonably accessible portions of the North-Eastern District, with a view to meeting the pressing demands for electricity in the north-eastern section of the State.

Various streams were examined, but none within easy range of the more important centres were found to be as promising as those in the Strathbogie District. A site for a generating station capable of utilizing the waters of Seven Creeks was found at a point within 10 miles of the North-eastern railway.

In due course, we were instructed to investigate the proposals in detail. This has been done, and we have now the honour to submit our Report, with drawings and estimates, concerning the hydraulic developments that would be required before a supply of electricity could be made available from the source referred to.

The results have been discussed from time to time with Mr. H. R. Harper, who deals with the electrical side.

We are,
Yours faithfully,
J. M. AND H. E. COANE.

REPORT UPON WATER-POWER INVESTIGATIONS AT STRATHBOGIE.

TABLE OF CONTENTS.

LIST OF DRAWINGS ACCOMPANYING THE REPORT.

STRATHBOGIE HYDRO-ELECTRIC INVESTIGATIONS.

A detailed investigation with regard to possibilities in the matter of water-power development in the Strathbogie district was commenced in February of this year. No gaugings of the discharges of any of the streams were available, so the inquiry had of necessity to be approached without hydrological data relative to the locality, other than a set of rainfall records. The question has been examined from every aspect and, after general reference to three schemes, each will be described in detail.

Briefly, the combination of works required to make water power available in this locality, for subsequent transmission in the form of electric current to the Northern and North-Eastern areas, would be as under :—

Scheme A would provide all the power that would be obtainable during a drought equal in severity to that experienced in 1914–15, the principal works comprising—

(*a*) a storage reservoir of 7,080 acre-feet capacity on Seven Creeks upon the Strathbogie tableland ;
(*b*) a closed conduit, about 26,200 feet in length, to convey water from the reservoir to Wombat Creek by the route shown on Drawing No. 3 ;
(*c*) a power station situated on the bank of Wombat Creek, in which water turbines sufficient for the development of a maximum load of 2,000 horse-power could be installed.

If necessary, a second reservoir could be provided on Seven Creeks as a safeguard against failure should a drought of unprecedented severity occur.

Scheme B would develop all the power obtainable in a dry year, but reliance would have to be placed upon inter-connexion with some other source of supply during periods of drought. The principal works required would be—

(*a*) a storage reservoir, as in Scheme A ;
(*b*) a closed conduit, 26,400 feet in length, similar to that in Scheme A, but of larger capacity ;
(*c*) a power station at Wombat Creek for the development of a maximum output of 4,100 horse-power.

It would be possible to provide additional storage by a second reservoir on Seven Creeks, but the cost would be against its adoption in this scheme, in which, as stated above, reliance would have to be placed on independent sources of supply during very dry times.

Scheme C is based upon the utilization of the natural flow of Seven Creeks, and would involve the construction of the following :—

(*a*) a diversion weir on Seven Creeks with pondage sufficient to meet the hourly fluctuations of the turbine discharge ;
(*b*) a closed conduit, about 28,440 feet in length, from the diversion weir to Wombat Creek ;
(*c*) a power station on Wombat Creek to develop a maximum of 1,200, but a daily average, throughout the year, of only 300 horse-power.

This scheme, in which a storage reservoir is not included, would clearly not be suitable for adoption, partly on account of the unreliability of the system during droughts, and partly because the total amount of power that could be generated would be comparatively small and its cost relatively high.

The favorable situation of the generating station, the site of which is common to all three schemes, with respect to some of the more important centres of northern Victoria will be apparent from an inspection of Drawing No. 1 attached. It is within 10 miles of Euroa, an important town on the North-Eastern railway, and the head-works could be approached by a well-graded road, the construction of which is well advanced.

1. TOPOGRAPHY.

The catchment area of Seven Creeks, indicated on Drawing No. 2. consists for the most part of a tableland of undulating country encircled by a rugged range of hills. They rise from 1,500 to 2,000 feet above the plains in the vicinity of Euroa and reach their highest elevation at Mt. Wombat, which is 2,659 feet above sea level. The geological formation is granite. The soil of the tableland proper is of a sandy character, being derived from decomposed granite rock, but much of it is suited for agriculture. The surrounding hills are, however, rough and steep, being used chiefly for the grazing of sheep.

The Village of Strathbogie, which would not be affected by any of the works described below, is at an elevation of nearly 1,600 feet.

The mountain sides, along which pipe-lines would have to be run for the greater parts of their lengths, are steep and very rocky. In places there are large outcrops of extremely hard granite, many of them several acres in extent and almost precipitous. A feature of the hill-sides is the generally shallow depth of soil overlying the rock. Such soil as exists is of so porous a character as to be unsuited for water-race construction. Seven Creeks, so named on account of its many affluents, commences its rapid descent at Polly McQuinn's, situated at the point marked A on Drawing No. 3 herewith, and drops nearly a thousand feet in the next few miles of its course. Owing to the configuration of the country, the whole of that fall could not be utilized for the generation of power, though about 70 per cent. of it could be so utilized.

2. HYDROLOGICAL DATA.

Seven Creeks and its tributaries, most of which join it upstream of the principal works described in this Report, receive the drainage from an area of 52⅓ square miles above the point from which diversions for water-power works would be made. Each inch of rainfall running off this area is equivalent to 2,800 acre-feet.

As no records of stream gaugings were obtainable, estimates of the flow of Seven Creeks had to be deduced from current meter observations made this year, from answers by old residents to our inquiries, as well as from inferences based upon rainfall records and experience elsewhere. Rainfall records have been useful, but the absence of stream gaugings extending over a long period makes it difficult to forecast the flow.

The catchment area has been cleared to a large extent, and this circumstance, combined with the porous nature of the soil, is unfavorable to a large percentage of run-off. This is more pronounced in dry years, and is one of the principal reasons why storage of as much as is possible, at reasonable cost, of the winter and spring flows, for use in summer and autumn, is essential to any scheme that would be successful at Strathbogie. As an effective gathering ground the tableland compares unfavorably with those in the Rubicon and Royston areas that have lately been investigated and reported upon by us.

Rainfall observations on the Strathbogie tableland were commenced in 1880, and, though the official records are missing over three and a-half of the intervening years to date, the average fall may be taken to about 40 inches per annum. The year of highest rainfall was 1917, when 62 inches fell; the lowest was 1914, when the total for the year was only 18 inches. The 1914 record was an unusually low one for this district, as evidenced by the fact that in only two other years of the 38 under record was the fall less than 32 inches: these were the drought year of 1902, when 23 inches were gauged, and 1919, when 24 inches fell.

Between 1st January and 30th June of this year 12·06 inches of rain were gauged, and the discharge of the creek was low in consequence, the run-off amounting to only about 9 per cent. of the rainfall. The average rainfall on the tableland for the months January to June inclusive is 18¾ inches, so that the total fall during the first half of 1922 was under two-thirds of the average.

The autumn just past has undoubtedly been a dry one, and we have been informed by several residents that Seven Creeks has rarely been lower in their experience than it was in March last. Others state that they remember it to have been appreciably lower in drought years, though all agree that the stream has never been known to run dry. Judging by the rainfall records, we believe that it was considerably lower in drought years, especially those of 1903 and 1915, than it has been in 1922.

3. WATER STORAGE.

The best site for a dam is at Polly McQuinn's, where a wall having a maximum height of 65 feet for a short distance across the bed of the creek, and a length along its crest of 1,000 feet, would impound 7,080 acre-feet of water in No. 1 Reservoir shown on Drawing No. 3 herewith. The content stated is equivalent to a run-off of 2½ inches from the catchment area.

This reservoir would extend from McQuinn's to the village, as indicated by hatching on the drawing referred to. The area of water surface with reservoir full would be about 482 acres. The land to be resumed, including a margin that would be liable to submergence, would be about 394 acres, and, in addition, about 188 acres of Crown lands, consisting of reserves along the creeks, would be flooded. The land is sparsely settled, though 55 acres of it are cultivated, and only two homesteads would have to be removed. Some roads would have to be diverted, but they are unmetalled, and the cost of the alterations would not be great. About 25 acres of land would be required for these road deviations, and provision would have to be made for clearing, culverts, and fencing.

Alternative sites for a dam for No. 1 Reservoir have been investigated, each involving a different method of construction. It has been found that at the site considered, from surface indications, to be a likely situation for an earthen embankment with a concrete cut-off and core wall, the foundations are defective, while the expense of a waste weir to provide for the safe passage of the heavy floods that are known to pass down the creek would be great. The construction of a dam of this type had, therefore, to be abandoned. The site best suited for a concrete dam, which might be of the gravity or the buttressed type, is at a bar of what appears to be solid rock immediately above McQuinn's Waterhole in the position marked A on Drawing No. 3. Borings to test the foundations would be required, but there are indications that the site is a good one, ample supplies of rock and sand being obtainable close at hand. The existing bridge across the creek at Polly McQuinn's would be submerged, and another would be required a few chains downstream, with road approaches to it.

Reviewing the probable behaviour of the reservoir during the drought period of 1914–15, the most severe recorded to date, some useful comparisons can be made. Assuming, as appears likely from the rainfall records, that the reservoir would have been full in October, 1913, the volume of water impounded, supplemented by the estimated natural flow of Seven Creeks and diminished by evaporation, would have, as far as can be judged in the absence of stream gaugings, permitted the abstraction of 10·3 cubic feet per second continuously. At the break up of the drought in May, 1915, the reservoir would have been practically exhausted, and, had dry weather continued beyond that month, the position would then have been serious. So much depends upon the distribution, duration, and intensity of rain storms, especially during droughts, that the aggregate fall in a given period is not a certain guide as to the run-off. In 1914, over 3 inches fell in May, and again in July; these would have replenished the stream flow considerably during those months. On the whole, the 1914–15 drought was a severe test, but it is impossible to say whether or not conditions so unfavorable will be experienced in the future.

Three sites for additional storages, upstream of No. 1 Reservoir, have been rapidly surveyed. The best is that shown on Drawing No. 3 and indicated as No. 2 reservoir. Its storage capacity is limited to 3,400 acre-feet and the surface area to 173 acres. The foundations are not so satisfactory as are those available for No. 1, and the cost of the Reservoir complete, including the acquirement of freehold lands that would be submerged, would be about £47,800.

If No. 2 Reservoir were constructed in conjunction with Scheme A, in which supplementary supplies of electric current from outside sources are not contemplated, the water within it should, in our opinion, be regarded as a supply to be held in reserve to meet the possible contingency of No. 1 becoming depleted in exceptionally dry times. While the provision of a second reservoir would ensure continuity of power development, the price to be paid for the security it would confer would be a high one.

4. POWER OBTAINABLE.

(*a*) Scheme A.

Allowing for compensation water to the creek below, and assuming an offtake to the power station, averaging 9½ cubic feet per second day and night, it would be possible to generate on the average 590 brake horse-power continuously at the turbine shafts. Owing to the hourly fluctuations of the demand it would, we are informed by Mr. Harper, be necessary in this case to provide for a maximum demand of 2,000 horse-power during a few hours of each day. To insure a continuity of supply from a reservoir of 7,080 acre-feet capacity, in the event of another drought equal in severity to that of 1914–15, the withdrawal of water and consequently the power output, would at all times have to be restricted to the volume and quantity mentioned above, except, of course, when the reservoir was actually overflowing. The bearing that additional storage would have upon this scheme is referred to near the end of paragraph 3 above.

(*b*) Scheme B.

Adopting the observed stream discharges of the autumn of 1922 as typical of those of a dry season for the Strathbogie district, and after making necessary allowances for evaporation and for compensation water to the stream below, it would have been possible with a storage of

7,080 acre-feet to develop continuously a daily average of 1,250 horse-power. Owing to the fluctuations of the load it would, in a scheme of this size, be necessary to allow for a demand of 4,100 horse-power during a few hours of each day.

In years of average rainfall there should be no difficulty in supplying the demand indicated, but we find that during droughts the run-off from the catchment area would not, as will be gathered from our remarks above, be sufficient to maintain an output averaging 1,250 horse-power continuously, and that some supplementary source of supply for electric current would be required. Judging by rainfall records, extremely severe conditions should not, however, occur oftener than perhaps once in eight or ten years on an average. The Commission's policy provides for the ultimate interlinking of all sources of supply. When this is accomplished, the consequences of a failure of Scheme B would not be so important, as the effect of a deficiency in a scheme of this magnitude would not be serious in a large network.

(*c*) Scheme C.

In the case of Scheme C, the natural flow of the creek would have to be depended upon from day to day, as, in the absence of storage, nothing better than pondage to equalize the fluctuations in the hourly demand for water would be provided. Based on this season's observations, the average horse-power obtainable continuously would not have exceeded 300, nor could a maximum demand in excess of 1,200 horse-power have been met. In the event of a severe drought, the absence of storage would lead to such a reduction in the output of power that reliance would have to be made for a time upon outside sources for most of the supply of electricity.

5. ALTERNATIVE SYSTEMS FOR SUPPLY OF WATER TO TURBINES.

Two methods by which water from Seven Creeks could be conveyed to a power station on Wombat Creek, situated where shown on Drawing No. 3, have been considered in detail. One was to take it across country by a fairly direct route, pumping it over a gap in the hills at a level 115 feet above Seven Creeks. This was found to involve a pumping main 4,000 feet long, a storage basin on the hill, an independent race from the higher reaches of Wombat Creek for charging the system, and a long supply pipe. Comparative estimates showed that this scheme would not be as economical as was at first thought might be possible, so it was abandoned. The alternative of gravitating the water to the turbines by way of the heavy irregular line of Drawing No. 3 was found to be better. The route is circuitous, but this is due to the configuration of the country and no shorter gravity line is possible.

6. CONDUITS FOR THE SUPPLY OF WATER TO THE TURBINES.

The country to be traversed by the conduit between the offtake from Seven Creeks and the Power Station is for the most part quite unsuited for an open channel, owing chiefly to the excessive amount of rock encountered and to the impossibility of carrying a race along the almost precipitous outcrops that occur along the grade that would have to be followed. In any event, a considerable proportion of the length would have to be in piping, and such of the conduit as could be built in open cut would have to be concrete lined, as the ground is too porous to hold water.

Another important consideration would be the difficulty and expense of regulating the supply of water to the turbines. The schemes under review would, in each case, operate under a low-load factor, and the demand for electric current would fluctuate from hour to hour to such an extent that it would not be possible so to regulate the flow through a series of open channels, pipes, and syphons as to meet the varying requirements of the turbines without spilling a lot of water to waste; such waste would be most detrimental to the success of the undertaking. We find, therefore, that for constructional as well as for hydraulic reasons, a combination of races and pipes would not be satisfactory in a scheme of this kind. With a closed conduit no water would be wasted, and its regulation, assisted by the use of surge tanks, would be comparatively easy. It is considered that the practice, now being largely adopted in modern water-power schemes, of providing a main supply pipe above ground, would best meet the conditions. It would obviate the difficulties referred to above, and, with proper precautions, the pipe would be watertight and safe against grass fires. There would be no danger from burning or falling timber, as what little of it exists would be cleared away, while there is practically no scrub to contend with. We have estimated for continuous-stave wood piping, which can be laid to follow horizontal as well as vertical curves, though pipes of other materials would also be considered.

Pipes for Scheme A.

The supply pipe in Scheme A, between the dam and a proposed service basin at a saddle in the hills near C, would need to be 26 inches in diameter. By this arrangement of continuous supply at a uniform rate of discharge the utmost economy would be secured in this section of the pipe-line.

The service basin required under Scheme A would hold about 8 acre-feet of water, a quantity sufficient to equalize the hourly fluctuations in the supply required at the Power Station.

Between the service basin and the pipe head at D, a pipe 40 inches in diameter would be wanted, as this section would have to be capable of supplying the maximum demands of the turbines.

Between the lower end of the main supply conduit described above and the power house there would be two lines of piping, each consisting of wood stave, 21 inches in diameter for about 450 feet at the upper end, and of steel, averaging 18 inches diameter, for the lower 1,850 feet. The pipes would be supported upon concrete piers, with concrete anchorages at intervals, and they would be provided with expansion joints and all necessary accessories. A single pipe of larger diameter could be used, and it would be somewhat cheaper than two. The security afforded by duplication against interruptions to the supply would, however, be so valuable as to be worth the difference in cost.

Pipes for Scheme B.

From No. 1 Reservoir the conduit would follow the hill-sides from A to B on Drawing No. 3. From B to C there would be an inverted syphon crossing a wide gully about 100 feet below grade. From C, which is near a saddle in the range of hills, the conduit would again traverse the hill-side to the pipe-head at D.

Between A and D the pipe would need to be 51 inches diameter throughout. The proposed site for the equalizing basin in Scheme A is too restricted in area for a similar work of a size suited to the requirements of Scheme B; as no other site is available it has of necessity been omitted.

From the point D, the water would be carried in two pressure pipes, each about 2,300 feet long, down a steep spur to the Power Station. Each pipe-line would vary in diameter from 27 inches to 24 inches.

Pipes for Scheme C.

In Scheme C the Reservoir would be omitted, but a comparatively small concrete weir would be required to divert water from the stream at a point about 2,000 feet above Polly McQuinn's. The total length of a conduit from this diversion weir to the pipe-head at D would be 26,140 feet, or practically 5 miles. Between the weir and the saddle in the hills at the point C on Drawing No. 3 a pipe of wood or other material would be required. It would be 24 inches in diameter and would discharge at a uniform rate throughout the day into an equalizing basin near C. From C to the pipe-head at D a 33-in. pipe would be necessary. The pipe track would follow the same route as in Schemes A and B.

The pressure pipe from D to the Power Station would vary in diameter between 21 inches and 18 inches. A single pipe-line has been allowed for, as the scheme would not be large enough to justify the installation of two of them.

7. POWER STATIONS.

For Power Stations, a site with rock bottom suitable for all three schemes has been found on the left bank of Wombat Creek, near the western boundary of Crown allotment 46A, Parish of Wondoomarook. The foundations for the machinery and the tail-races would be constructed in concrete, ample supplies of stone and sand being available near the site.

The turbines would be of the impulse type, arranged for direct coupling to three-phase alternators through horizontal shafts, and they would be provided with stream deflectors, needle valves, and the most modern automatic governing devices. Tail-water would be discharged into Wombat Creek, through which it would be returned to Seven Creeks. The first-mentioned has a sharp fall and its channel has been extensively eroded through the alluvial ground. The scour is sure to continue and would be somewhat hastened by a constant flow from a power station. The power house would not, however, be endangered by such erosion, though it would be desirable to acquire a strip of land along both banks of Wombat Creek, so that claims for damage by caving-in of the banks might be avoided.

The Power Stations in each of the three schemes would be similar in design, though the sizes of the buildings and machines would vary with the requirements. In each case there would be three turbines, of which two would be in daily use, with the third as stand-by. Drawing No. 5 shows a sketch of the general layout.

The following table indicates the machinery units that would be required in each scheme, also the net effective heads under which they would operate when the water in the Reservoir was low. The minimum heads would be those during full-load operation at which time the hydraulic losses would be greatest :—

Scheme.	Turbine Units.	Total Horse-power Installed.	Net Head in Feet.	
			Maximum.	Minimum.
A	3 of 1,000 brake horse-power	3,000	690	624
B	3 of 2,000 brake horse-power	6,000	705	613
C	3 of 600 brake horse-power	1,800	690	613

8. CAPITAL COST OF HYDRAULIC WORKS.

Estimates of the capital costs of hydraulic works and buildings in the three schemes under review are given below. They are based upon prices and rates of wages now ruling. Customs duties, at current rates, upon machinery of types that cannot as yet be manufactured in Australia have been included.

Estimate.—Capital Cost of Hydraulic Works.

Scheme A.

Concrete dam, including preparation of foundations and outlet works ..	£92,200
Acquirement of land for No. 1 Reservoir, road deviations, bridges, and culverts ; also fencing	10,500
Clearing of reservoir site, and removal of two farm buildings that would be submerged	2,800
Easements for pipe lines, bridges, trestles, &c.	1,200
18,200 feet of 26-in. wood piping, including syphons and structures ..	23,700
5,700 feet of 40-in. wood piping	11,300
Regulating basin at the saddle	3,000
Valves and surge pipes	1,200
Double line of steel and wood pressure piping, 21 inches and 18 inches diameter, with piers, anchorages, &c.	17,200
Power House foundations, tail-races, buildings, and crane	6,500
Three turbine units of 1,000 horse-power each, with accessories, complete ..	10,300
Acquirement of land on Wombat Creek for Power Station, road approaches, &c.	900
Staff quarters, office, and workshop	1,600
Use of plant during construction	2,000
Total for Scheme A	£184,400

The estimated cost of No. 2 Reservoir, as mentioned in paragraph 3, is £47,800. This is additional to the total of £184,400 given above, which includes only one Reservoir.

ESTIMATE.—CAPITAL COST OF HYDRAULIC WORKS.

Scheme B.

Concrete dam, including preparation of foundations and outlet works ..	£92,670
Acquirement of land for No. 1 Reservoir, road deviations, bridges, and culverts: also fencing	10,500
Clearing of Reservoir site, and removal of two farm buildings that would be submerged	2,800
Easements for pipe lines, bridges, trestles, &c.	1,200
24,100 feet of 51-in. wood piping, including syphons and structures ..	79,260
Valves and surge pipes	2,000
Double line of steel and wood pressure piping, 27 inches and 24 inches diameter, with piers, anchorages, &c.	21,900
Power House foundations, tail-race, buildings, and crane	7,500
Three turbine units of 2,000 horse-power each, with accessories, complete ..	17,250
Acquirement of land on Wombat Creek for Power Station, road approaches, &c.	1,000
Staff quarters, office, and workshop	1,600
Use of plant during construction	2,500
Total for Scheme B	£240,180

ESTIMATE.—CAPITAL COST OF HYDRAULIC WORKS.

Scheme C.

Diversion weir, in concrete, on Seven Creeks, and outlet works	£4,200
Acquirement of land above the diversion weir	300
20,320 feet of 24-in. diameter wood piping from the offtake to the saddle ..	22,280
Easements for pipe lines, trestles, &c.	1,300
Service basin at saddle	4,500
5,820 feet of 33-in. diameter wood piping between saddle and pipe-head ..	10,420
Pressure piping, in steel and wood, 21 inches and 18 inches diameter, with piers, anchorages, &c.	9,060
Power House, foundations, tail-race, buildings, and crane	4,300
Three turbine units of 600 horse-power each, with accessories, complete ..	9,900
Acquirement of land on Wombat Creek for Power Station, road approaches, &c.	900
Staff quarters, office, and workshop	1,500
Use of plant during construction	1,500
Total for Scheme C	£70,160

9. ANNUAL OPERATION, MAINTENANCE, AND CAPITAL CHARGES.

The totals of the annual charges for operation, maintenance, replacement, and interest that would have to be debited against the hydraulic sections of the several schemes are given below. Replacement charges have been based upon the duration of the probable useful lives of the hydraulic works and machines. Interest has been allowed for at the rate of £6 per centum on the estimated capital cost in each instance:—

Scheme A, with one Reservoir	=	£15,570
Scheme A, with two Reservoirs	=	£19,594
Scheme B	=	£20,118
Scheme C	=	£7,152

10. COST PER BRAKE HORSE-POWER PER ANNUM.

Based upon the figures given above, the average cost per brake horse-power per annum at the turbine shafts would be as under-

—	Average Brake Horse-power Obtainable Continuously.	Cost per Brake Horse-power per Annum.
		£ s. d.
Scheme A, with one Reservoir	590	26 7 10
Scheme A, with two Reservoirs	590	33 4 3
Scheme B, with one Reservoir	1,250	16 1 10
Scheme C, without storage	300	23 16 9

11. CONCLUSION.

When considering the schemes described above, the fact that they would have to be designed to operate under a low load factor, such as usually obtains in country districts, should not be overlooked. For example, most of the piping would, in order to provide water for the maximum daily load, have to be capable of discharging, for several consecutive hours, about four times the average flow through them. The same limitation applies to the sizes of the turbines required, as well as to other components of the scheme; for this reason, capital and operating costs at Strathbogie cannot be compared on even terms with those of other schemes that would be worked under more favorable conditions. For example, the Sugarloaf–Rubicon project would be interlinked with the Metropolitan system and energy from it could be delivered at a high load factor.

Referring, in order, to the possibilities at Strathbogie, it will be seen that Scheme A would be the only one which could be relied upon to furnish a continuous supply of power throughout a drought. To provide against all likely contingencies in respect to continuity, the investigation has shown that a second Reservoir would be required. If such were provided, the capital outlay on hydraulic works involved in Scheme A would, it is estimated, be £232,200, and the charges per brake horse-power per annum would be £33 4s. 3d. Making full allowance for the fact that the load factor would, as mentioned above, be a low one, the annual charges for energy at the turbine shafts do not compare favorably with those given for the Sugarloaf–Rubicon combination in our recent Report upon that scheme. It is likely, therefore, that the last-mentioned source of supply would be the cheaper for the northern areas, even after allowance is made for the cost of transmission from the Sugarloaf works. This, however, is a matter that will be dealt with by Mr. Harper in connexion with his Report upon the supply of electricity to the northern areas.

As to Scheme B, we regard it as one that would be capable of making available a considerable amount of energy in times of normal rainfall, though perhaps not in sufficient quantities to meet the requirements, at the end of a few years, of the northern areas as they have been forecasted by Mr. Harper. During severe droughts there would be a shortage of water and reliance would then have to be placed upon supplementary supplies of electric current from independent sources for the greater part of the demand. We consider that, in the case of Scheme B also, it will be found that energy for the northern districts could be provided at a cheaper rate from the Sugarloaf–Rubicon water-power scheme, and without rigid limitations as to the quantity obtainable. This is a scheme that might, we think, come up for consideration at some later date.

Scheme C would be unreliable in times of drought and appears to be on too small a scale to justify its adoption.

In either Scheme A or Scheme B, the time required for construction would be about two and a half years.

Generally, the principal difficulty with respect to water-power development at Strathbogie is the high capital cost of the works that would be required to develop the limited quantity of power obtainable. While the cost of energy from hydraulic works at Strathbogie would, notwithstanding the high initial outlay, be very much cheaper than any which might be developed by local steam stations, it appears to us that the Sugarloaf–Rubicon scheme possesses advantages that are lacking in those described above.

J. M. AND H. E. COANE,
Consulting Hydraulic Engineers.

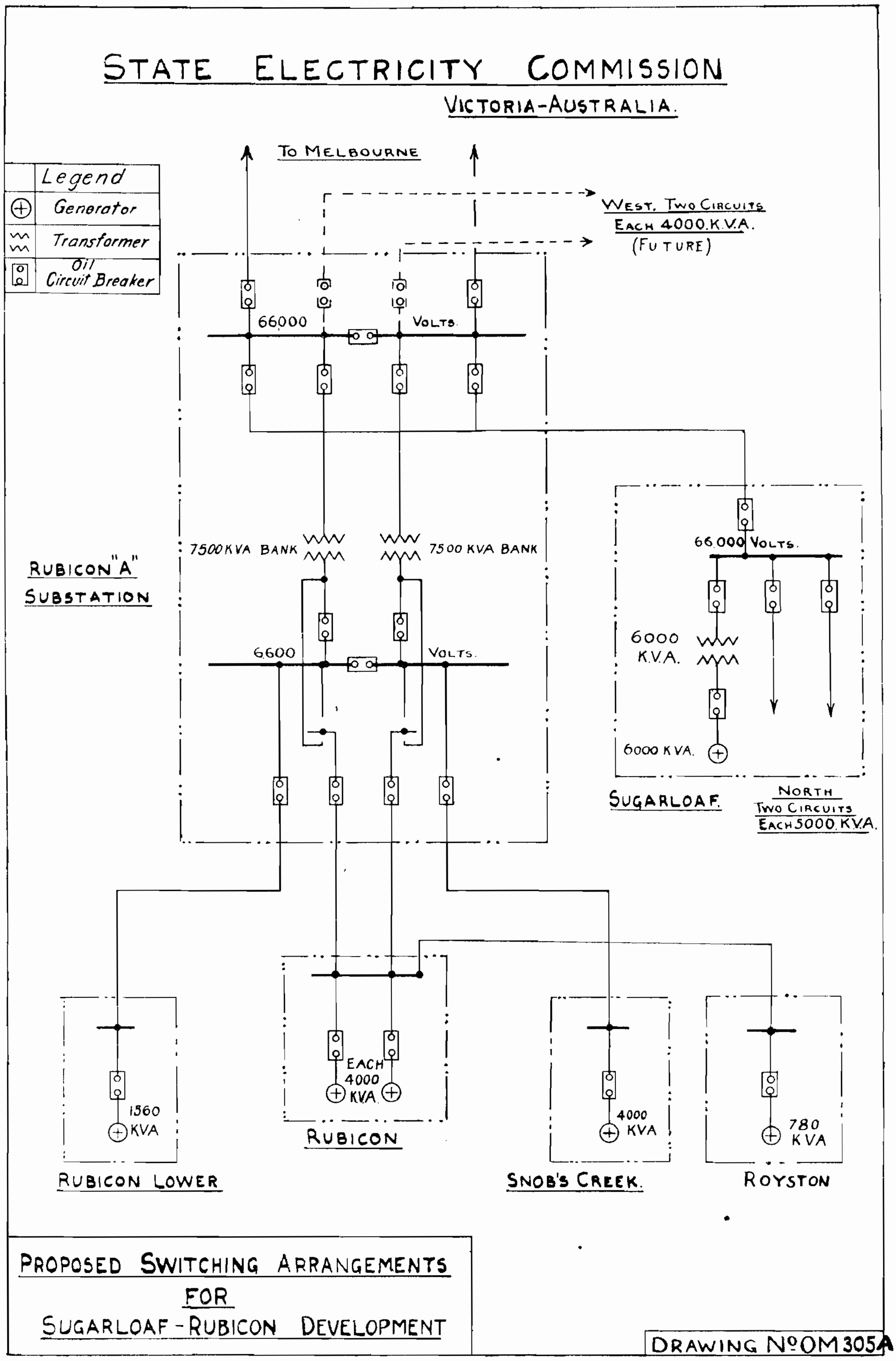
20th July, 1922.

DRAWINGS

TO ACCOMPANY

REPORT OF CHIEF ENGINEER.

10998.—5



STATE ELECTRICITY COMMISSION
VICTORIA-AUSTRALIA.
Legend
Generator
Transformer
Oil Circuit Breaker
TO MELBOURNE
WEST. TWO CIRCUITS
EACH 4000.K.V.A.
(FUTURE)
66000 VOLTS.
7500 KVA BANK
7500 KVA BANK
RUBICON "A"
SUBSTATION
6600 VOLTS.
66.000 VOLTS.
6000 K.V.A.
6000 KVA.
SUGARLOAF.
NORTH
TWO CIRCUITS
EACH 5000 KVA.
1560 KVA
EACH 4000 KVA
RUBICON
4000 KVA
780 KVA
RUBICON LOWER
SNOB'S CREEK.
ROYSTON
PROPOSED SWITCHING ARRANGEMENTS
FOR
SUGARLOAF - RUBICON DEVELOPMENT
DRAWING No. OM 305A

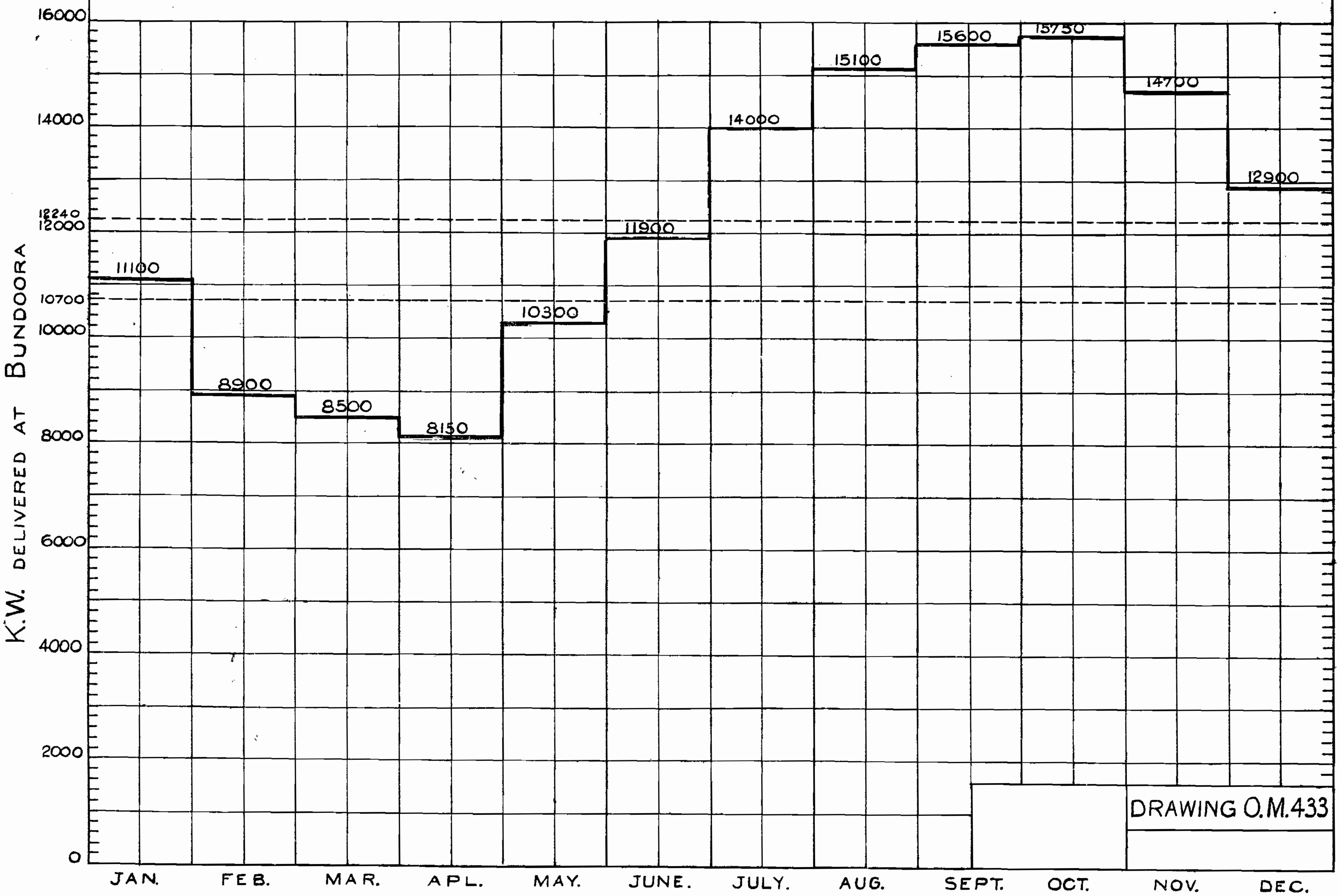
STATE ELECTRICITY COMMISSION
VICTORIA — AUST.

— SUGARLOAF RUBICON SCHEME —

CURVE SHOWS THE K.W. DELIVERED EACH MONTH TO BUNDOORA WHEN ALL PLANT IS AVAILABLE

12240 K.W. IS THE AVERAGE YEARLY K.W. WHICH WOULD BE DELIVERED TO BUNDOORA IF ALL PLANT WERE AVAILABLE

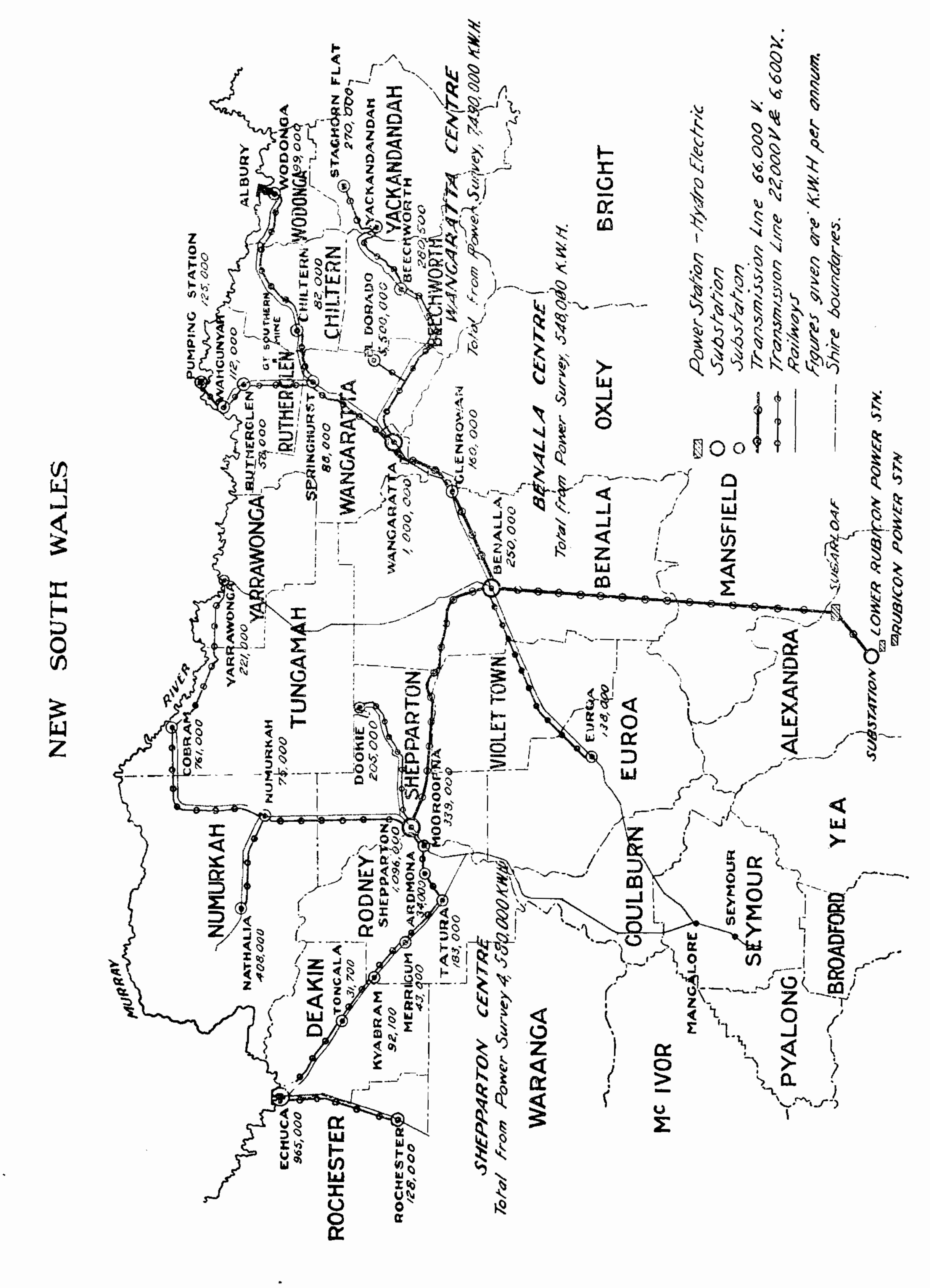
10700 K.W. IS THE AVERAGE YEARLY K.W. WHICH WOULD BE DELIVERED TO BUNDOORA ASSUMING 90% PLANT AVAILABILITY FACTOR AND MAKING A SMALL ADJUSTMENT FOR LOSSES.



DRAWING O.M.433

STATE ELECTRICITY COMMISSION

VICTORIA - AUST

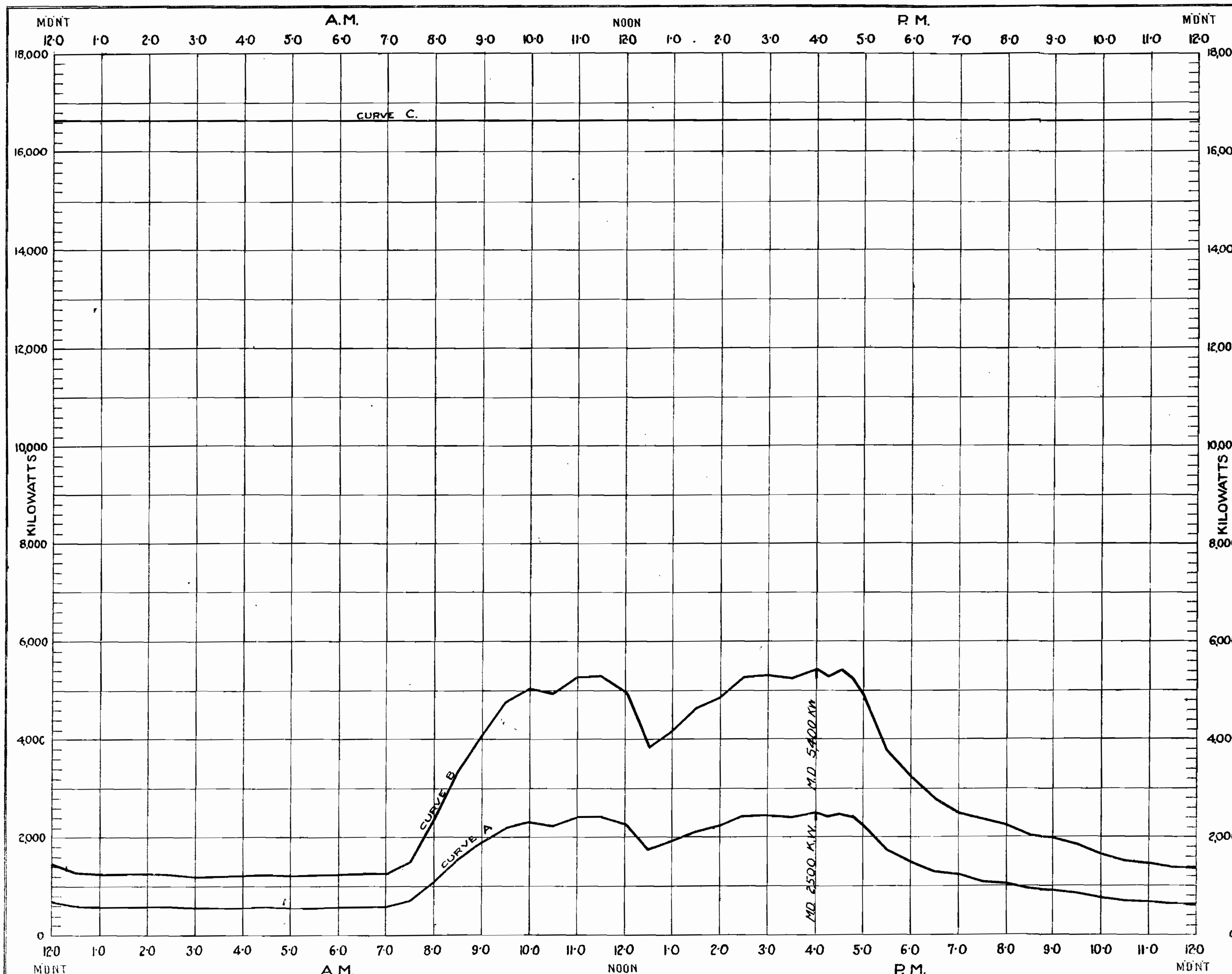


NORTH EASTERN VICTORIA

SHOWING TOWNS WHICH MAY BE SUPPLIED FROM SUGARLOAF-RUBICON SCHEME

SECTION No. OM. 18. DRAWING No. OM. 463.

STATE ELECTRICITY COMMISSION
VICTORIA - AUST.



SUGARLOAF - RUBICON SCHEME
CURVES SHOWING DISTRIBUTION OF LOAD AT SUGARLOAF 66,000 V. BUS UNDER MAX LOAD CONDITIONS

Curve "A" is the estimated daily load curve of N.E. district when M.D. for N.E at Sugarloaf is 2500 K.W.
Area between curves "C" and "A" shows estimated energy available for transmission to Melbourne when "A" is load curve for N.E.
Curve "B" is the estimated daily load curve of N.E. district when M.D. for N.E. at Sugarloaf is 5,400 K.W.
Area between curves "C" and "B" shows estimated energy available for transmission to Melbourne when "B" is load curve for N.E.

DRAWING No. OM. 481.

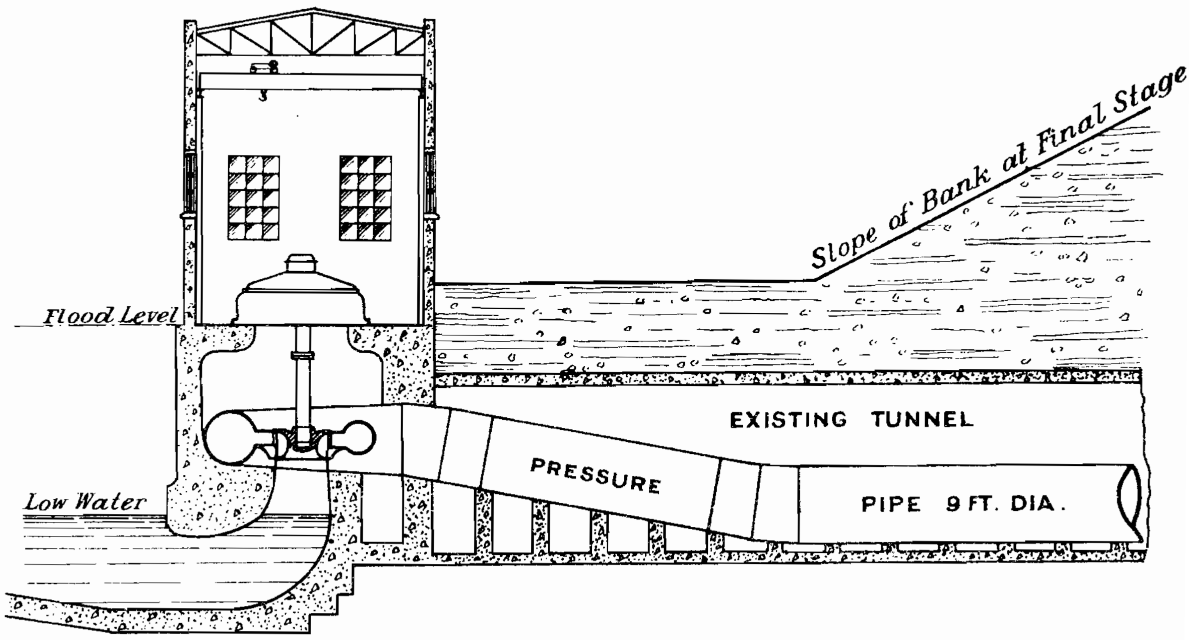
DRAWINGS

TO ACCOMPANY

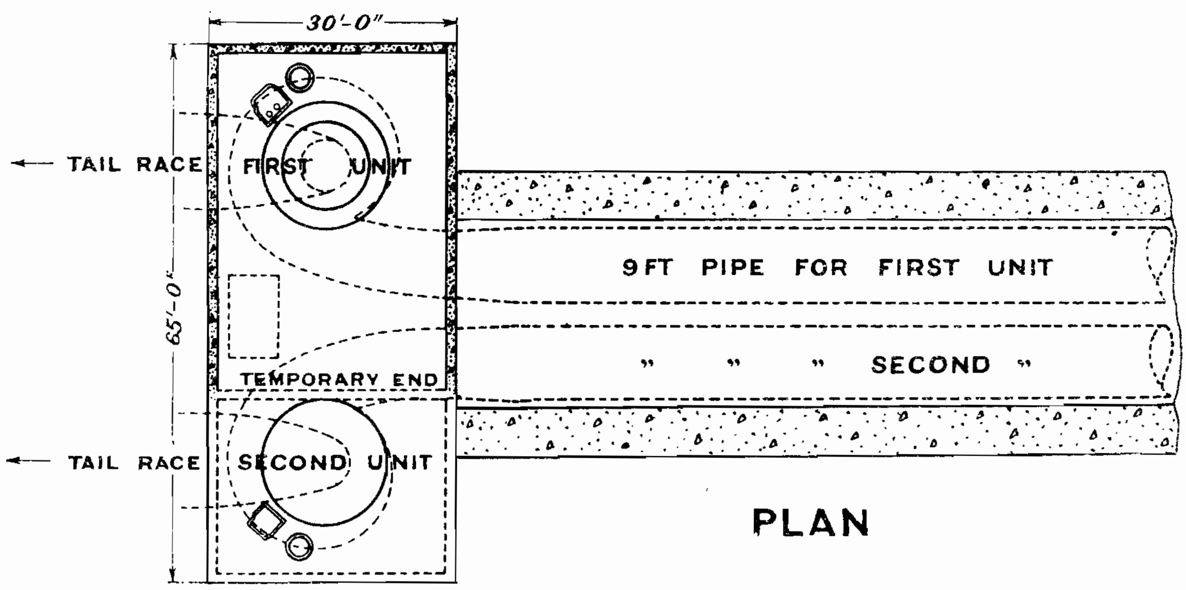
REPORT OF MESSRS. J. M. AND H. E. COANE

ON

SUGARLOAF-RUBICON SCHEME.



LONGITUDINAL SECTION



PLAN

STATE ELECTRICITY COMMISSION OF VICTORIA

SUGARLOAF - RUBICON
HYDRO-ELECTRIC SCHEME
SKETCH OF
SUGARLOAF POWER STATION

0' 20' 40' 60' 80' 100'

Scale of Feet

Jno. H. E. Coane

Consulting Hydraulic Engineers
May 2nd 1922

DRAWING No. 5.

STATE ELECTRICITY COMMISSION OF VICTORIA.

SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME.

DIAGRAM A.

Power Obtainable at Sugarloaf Dam.

Average for the 40 years, 1882–1921, assuming one unit of 7500 B.H.P. installed, F.S.L. of Reservoir, 823 ft.

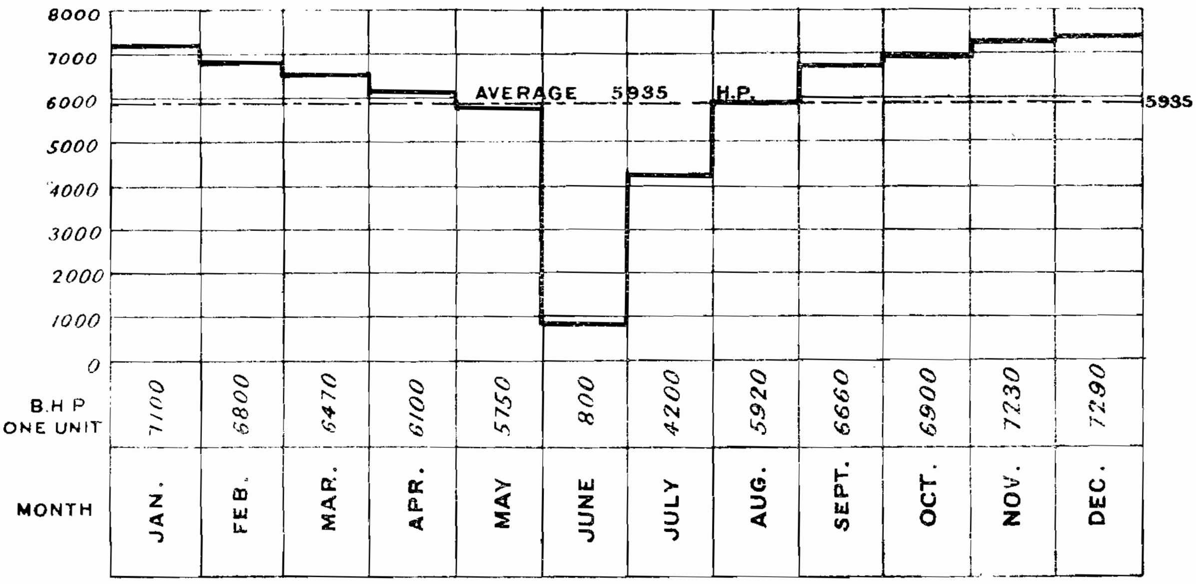
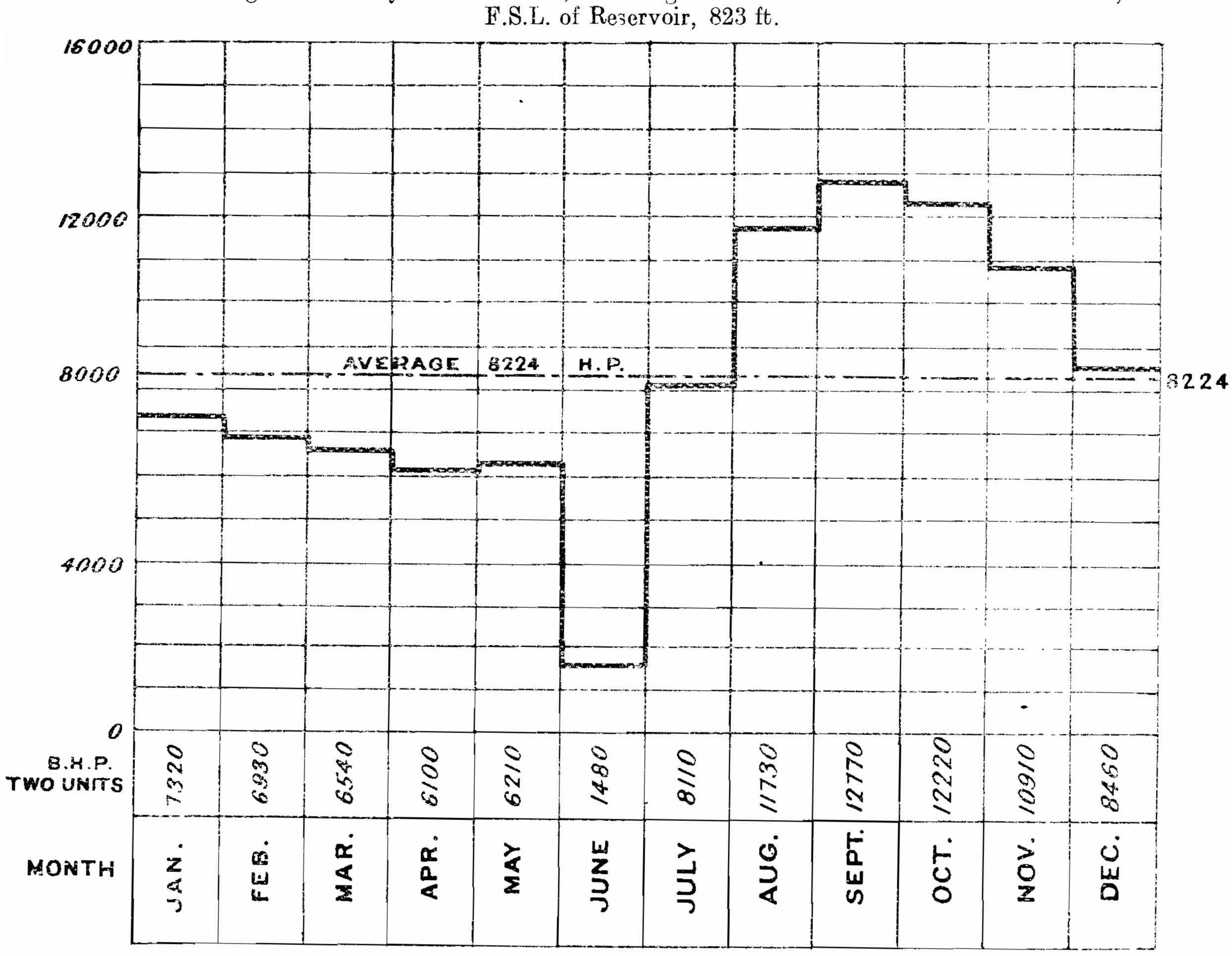


DIAGRAM B.

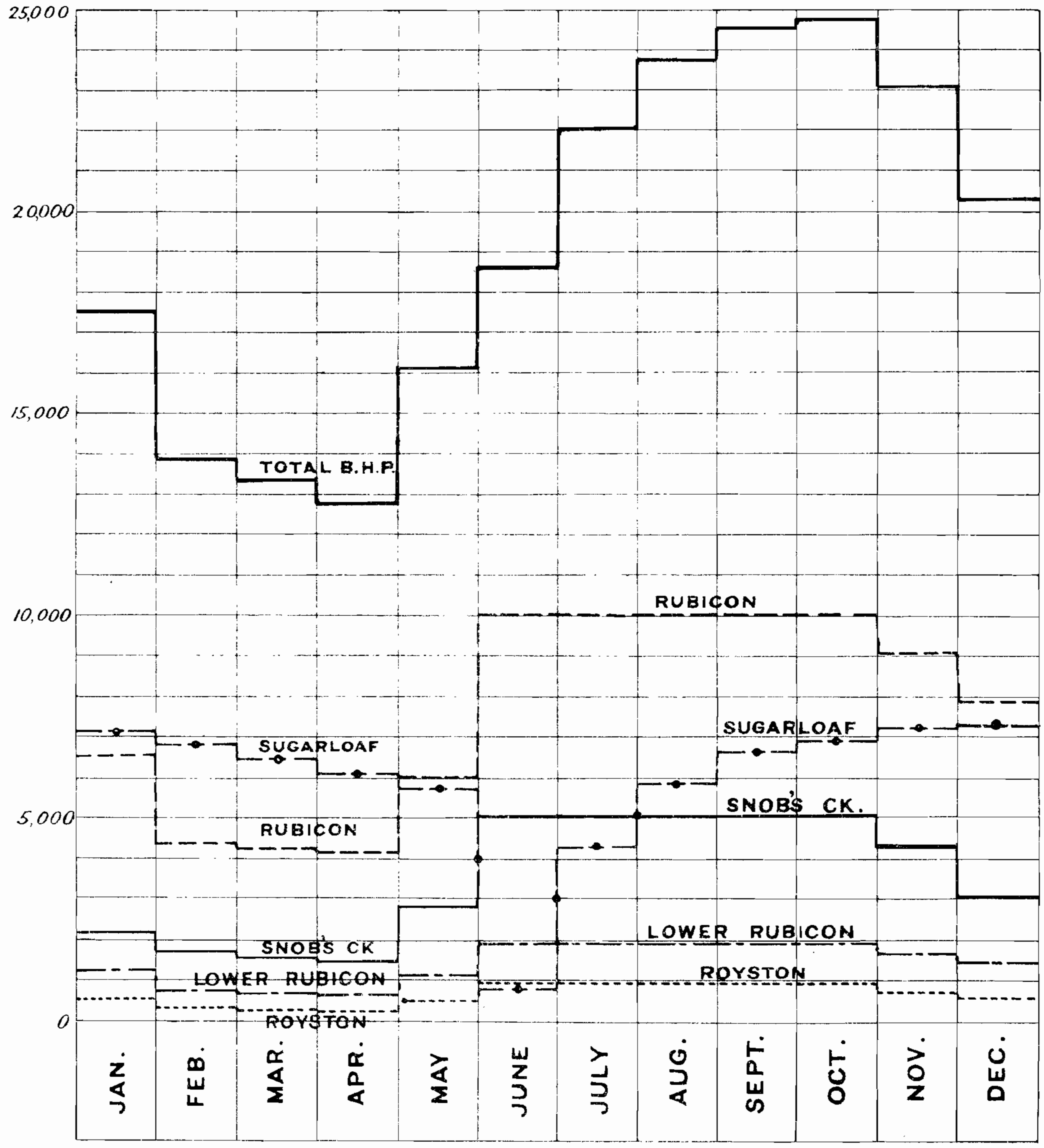
Power Obtainable at Sugarloaf Dam.

Average for the 40 years 1882–1921, assuming two units of 7500 B.H.P. each installed, F.S.L. of Reservoir, 823 ft.



J. M. & H. E. Coane,
Consulting Hydraulic Engineers,
2nd May, 1922.

DRAWING No. 6.



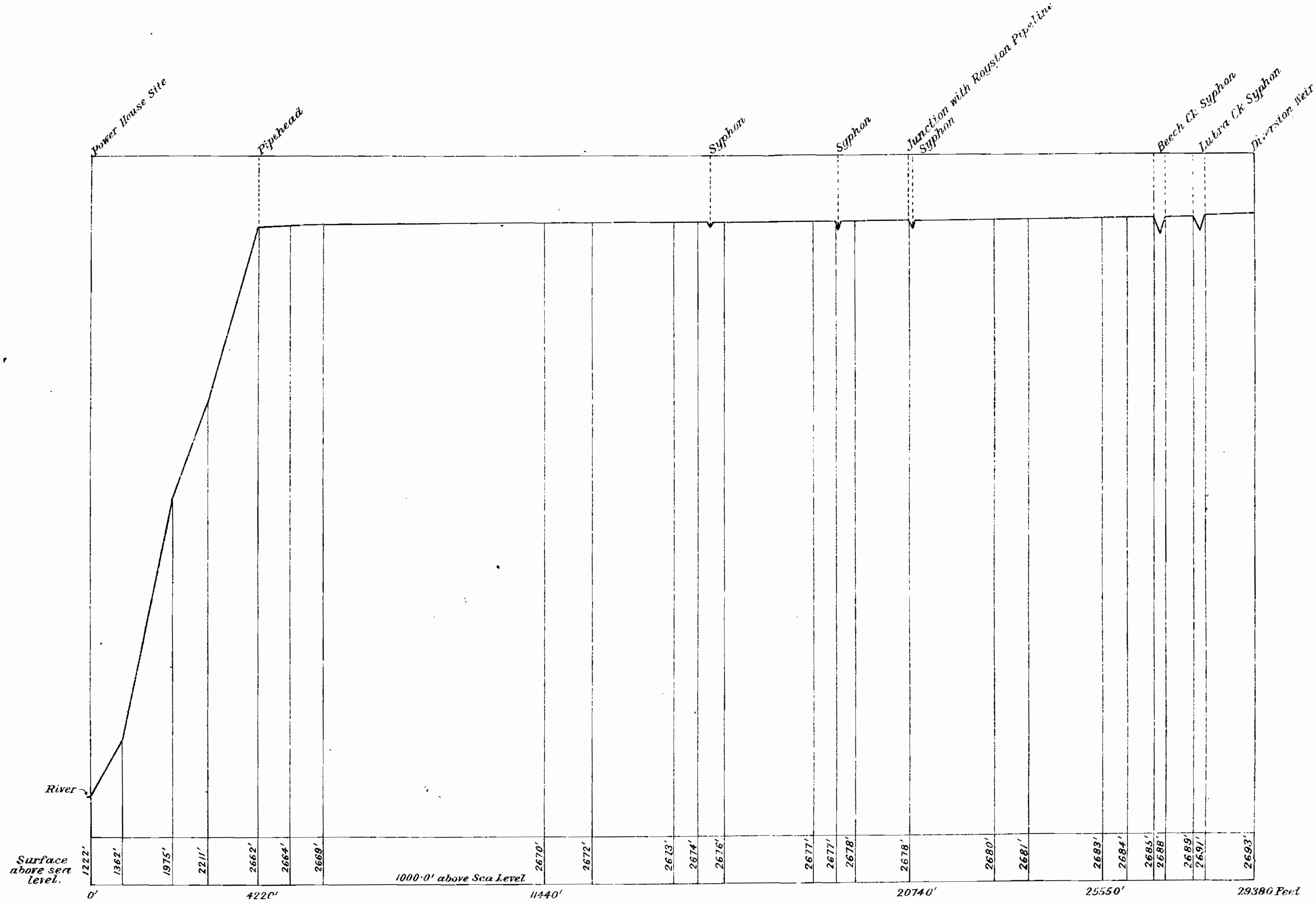
STATE ELECTRICITY COMMISSION OF VICTORIA.

SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME.

AVERAGE HORSE POWER OBTAINABLE FOR EACH MONTH OF THE YEAR AT ALL FIVE POWER STATIONS (ONE UNIT AT SUGARLOAF).

J. M. & H. E. COANE,
Consulting Hydraulic Engineers,
2nd May, 1922.

DRAWING No. 7.

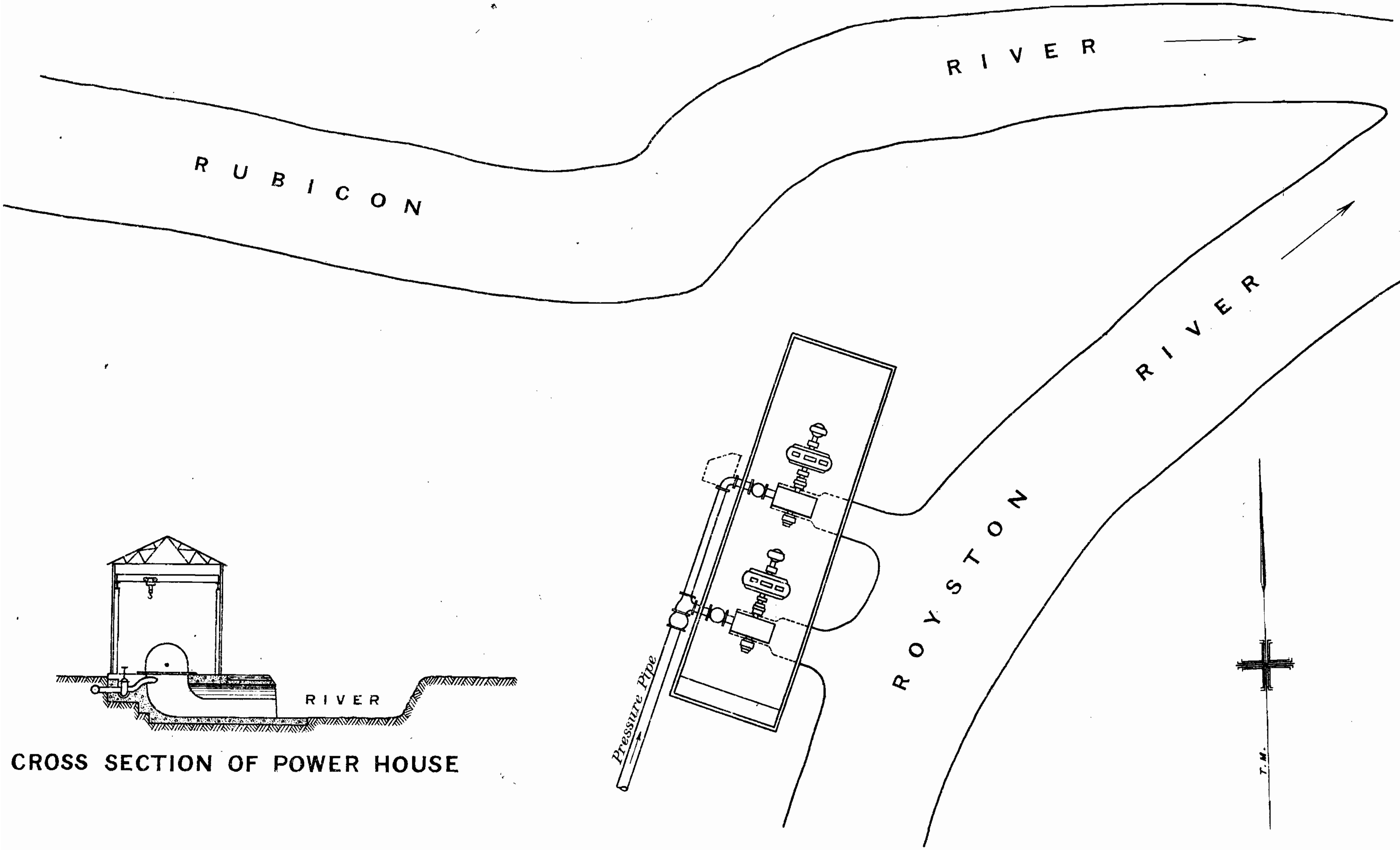


LONGITUDINAL SECTION
RUBICON RACE AND PIPELINE

[signature]
Consulting Hydraulic Engineers
May 2nd 1922.

STATE ELECTRICITY COMMISSION OF VICTORIA
SUGARLOAF - RUBICON
HYDRO-ELECTRIC SCHEME

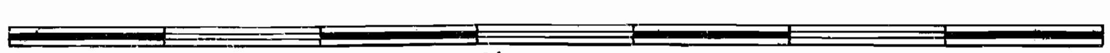
DRAWING NO.9.



CROSS SECTION OF POWER HOUSE

STATE ELECTRICITY COMMISSION OF VICTORIA

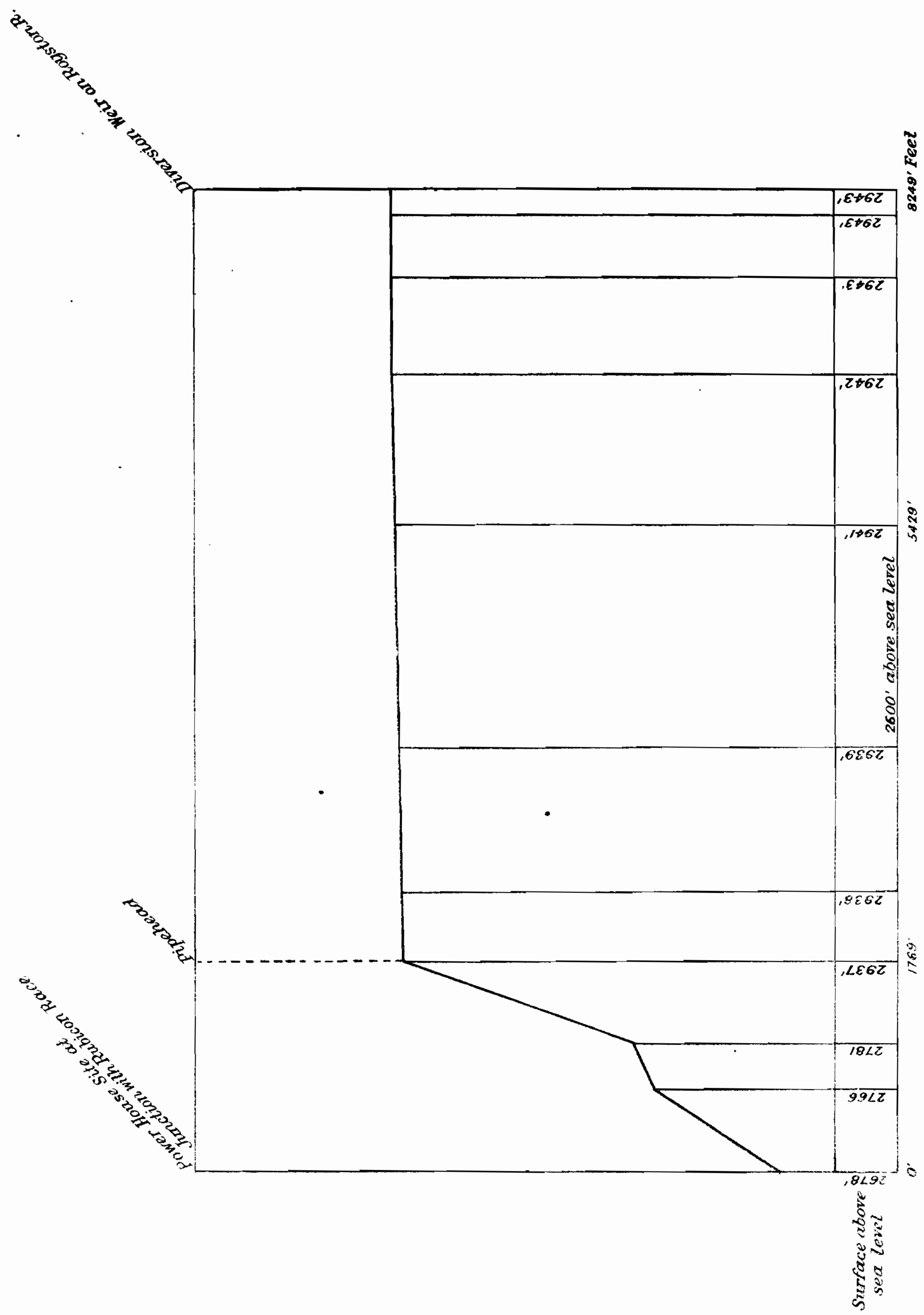
SUGARLOAF – RUBICON
HYDRO – ELECTRIC SCHEME
SKETCH OF RUBICON POWER STATION



Scale of Feet

Consulting Hydraulic Engineers
May 2nd 1922

DRAWING NO. 10.



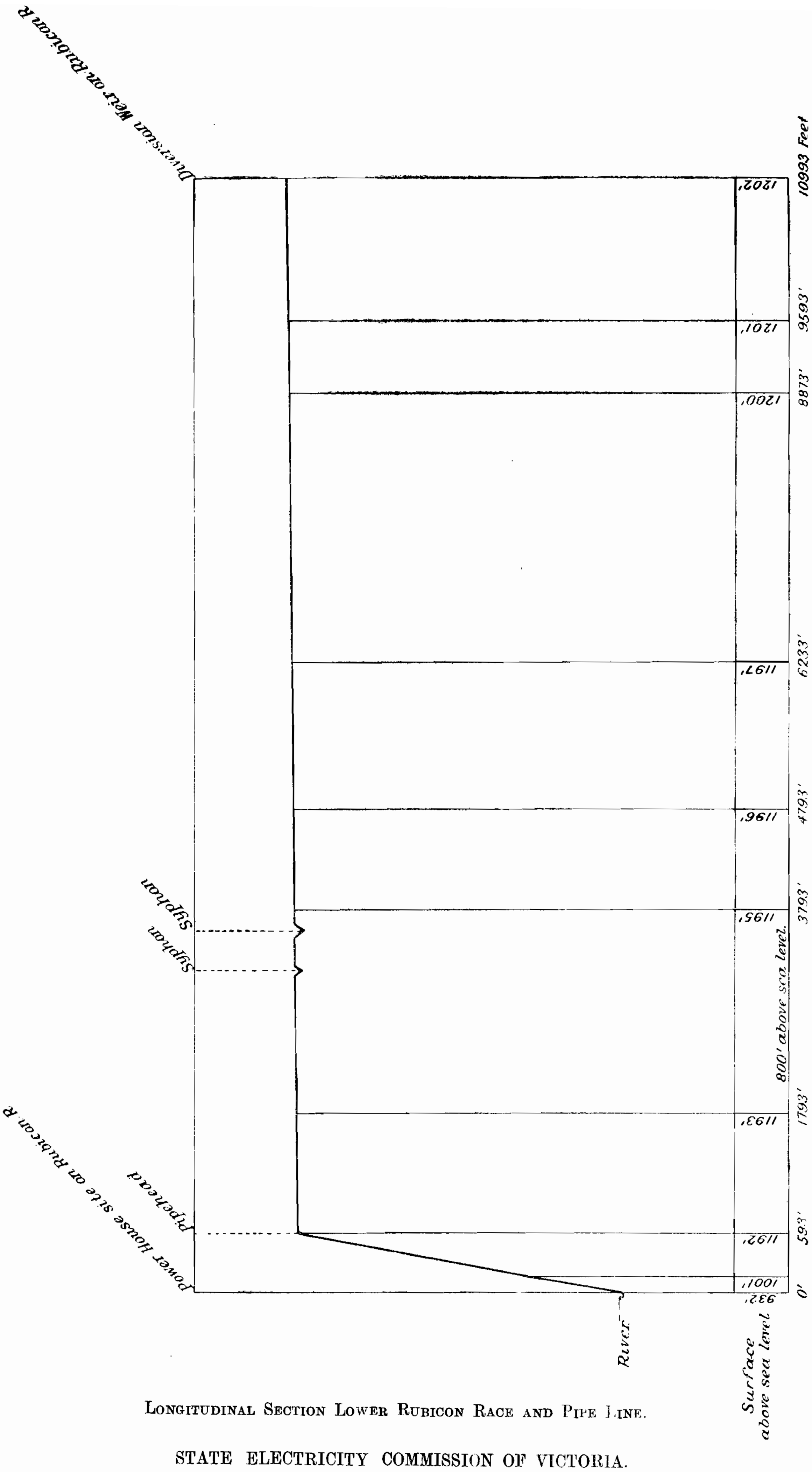
LONGITUDINAL SECTION, ROYSTON RACE AND PIPE LINE.

STATE ELECTRICITY COMMISSION OF VICTORIA.

SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME.

J. M. & H. E. COANE,
Consulting Hydraulic Engineers,
2nd May, 1922.

DRAWING No. 11.



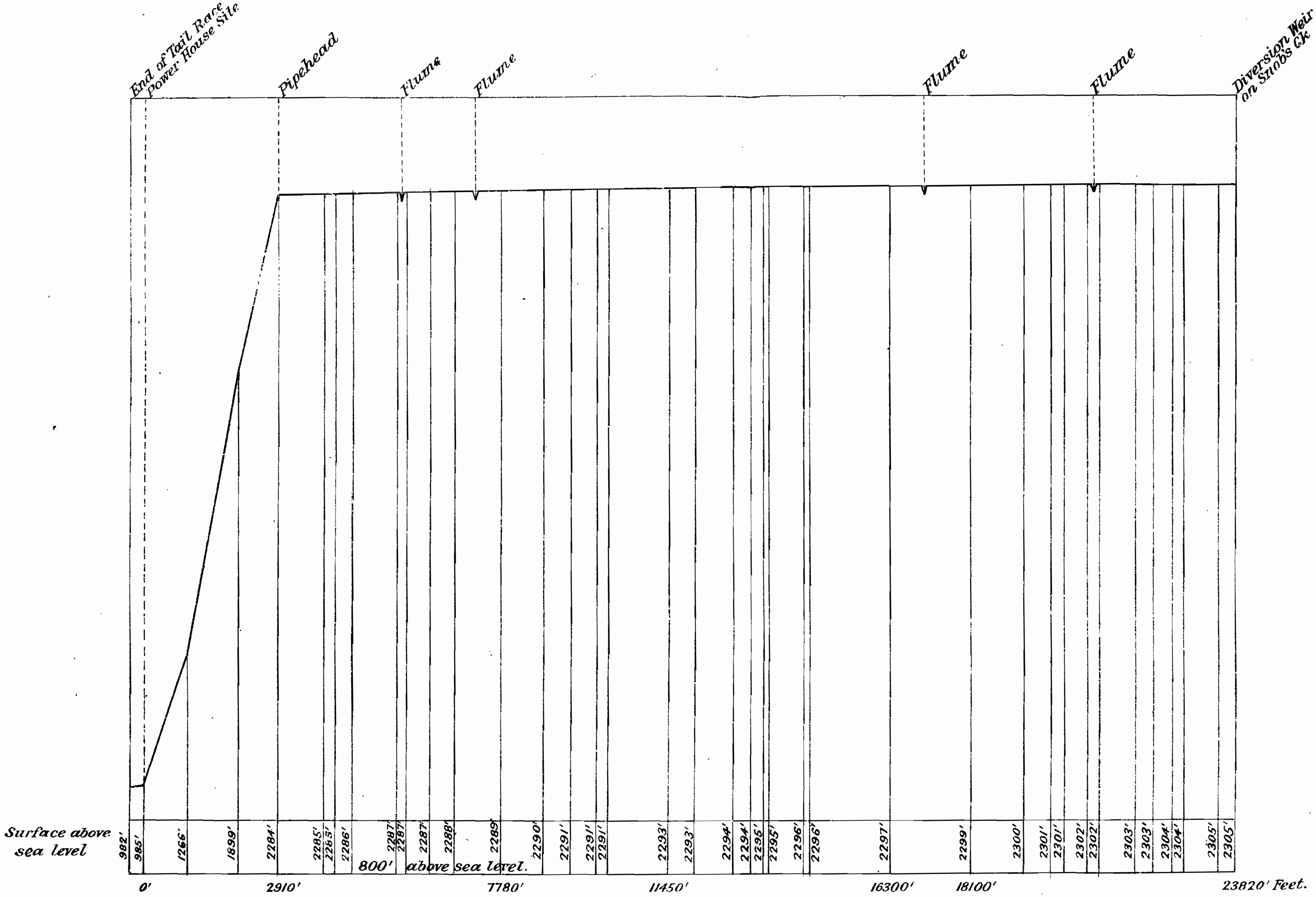
LONGITUDINAL SECTION LOWER RUBICON RACE AND PIPE LINE.

STATE ELECTRICITY COMMISSION OF VICTORIA.

SUGARLOAF-RUBICON HYDRO-ELECTRIC SCHEME.

DRAWING No. 12.

J. M. & H. E. COANE,
Consulting Hydraulic Engineers, May 2nd, 1922.



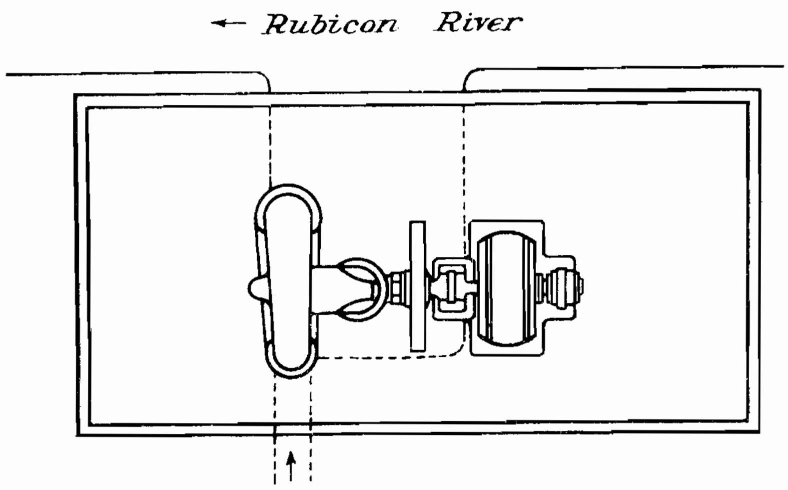
LONGITUDINAL SECTION
SNOB'S CREEK RACE AND PIPE LINE

STATE ELECTRICITY COMMISSION OF VICTORIA

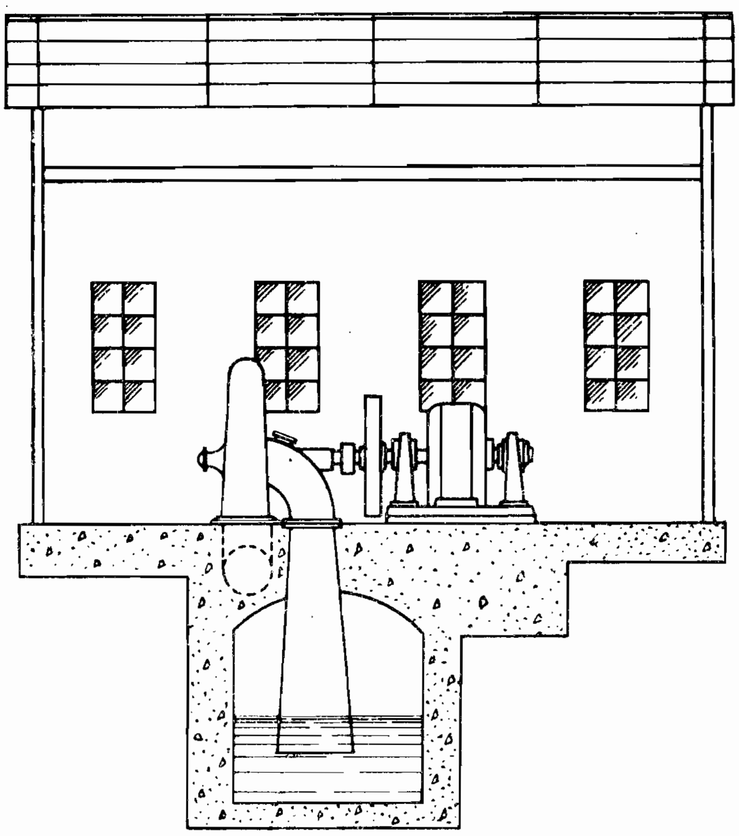
SUGARLOAF - RUBICON
HYDRO-ELECTRIC SCHEME

Jno. H. Coane [signature]
Consulting Hydraulic Engineers
May 2nd 1922

DRAWING NO. 13.

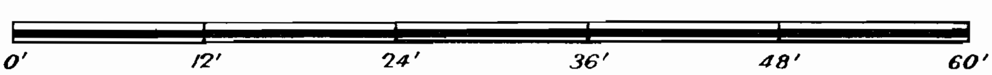


PLAN



SECTION

STATE ELECTRICITY COMMISSION OF VICTORIA
SUGARLOAF - RUBICON
HYDRO-ELECTRIC SCHEME
SKETCH OF
LOWER RUBICON POWER STATION



J. M. & H. E. COANE,
Consulting Hydraulic Engineers, 2nd May, 1922.

DRAWING No. 14.

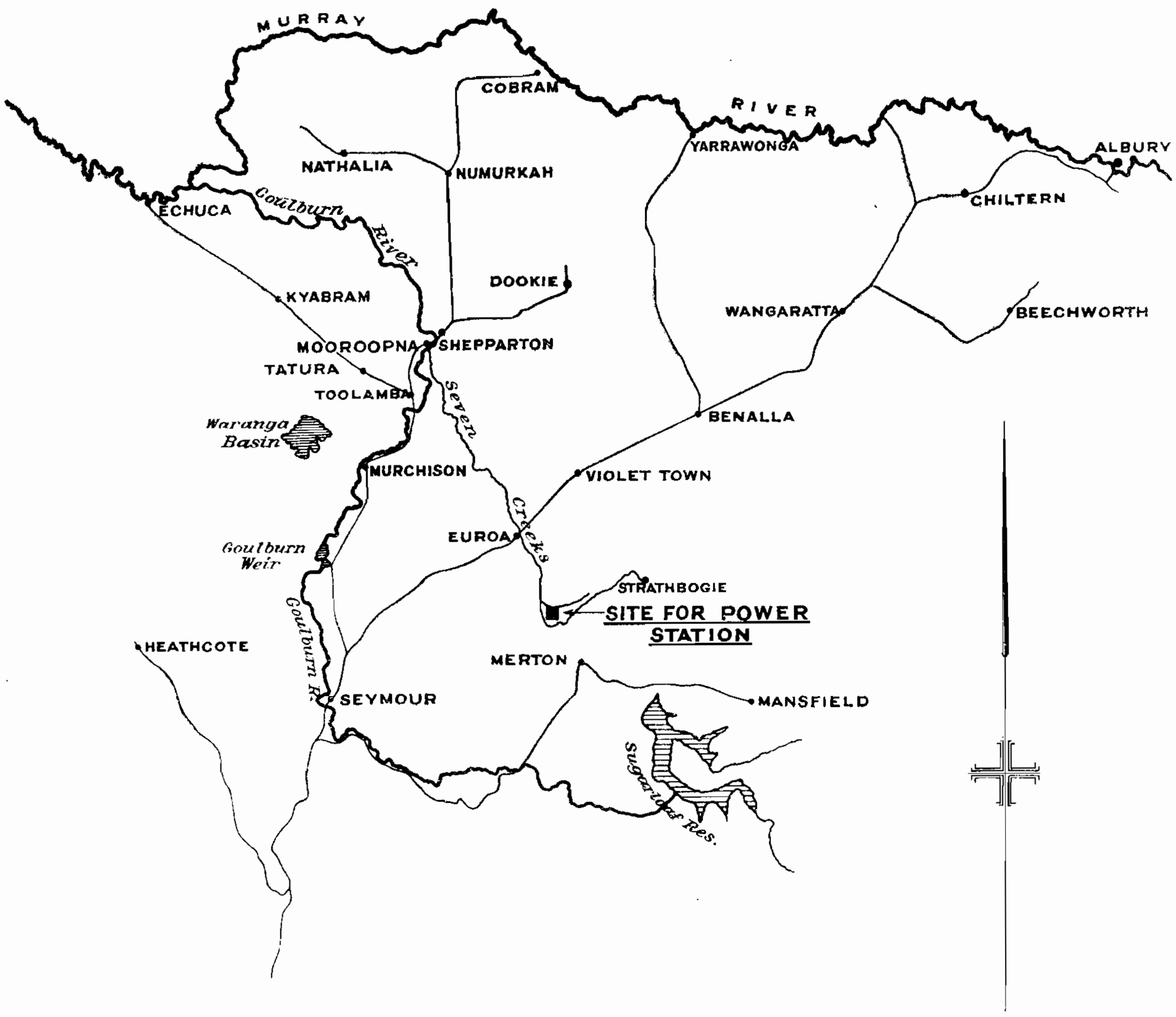
DRAWINGS

TO ACCOMPANY

REPORT OF MESSRS. J. M. AND H. E. COANE

ON

INVESTIGATIONS IN STRATHBOGIE DISTRICT.



STATE ELECTRICITY COMMISSION OF VICTORIA

HYDRO-ELECTRIC INVESTIGATION AT STRATHBOGIE

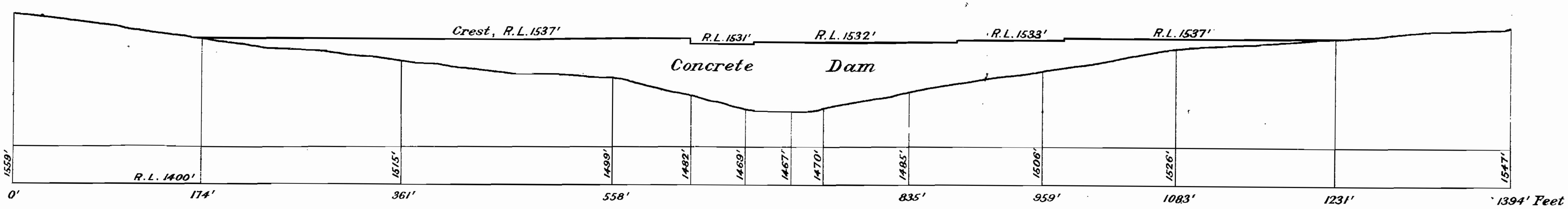
GENERAL PLAN

0 16 32 48 64 80

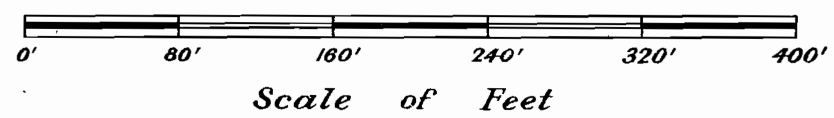
Scale of Miles

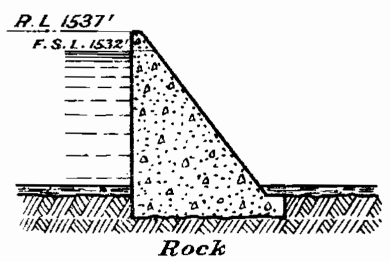
Consulting Hydraulic Engineers
August 1st 1922.

DRAWING No. 1.

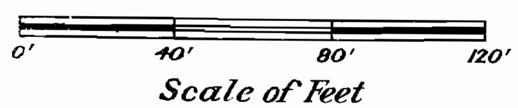


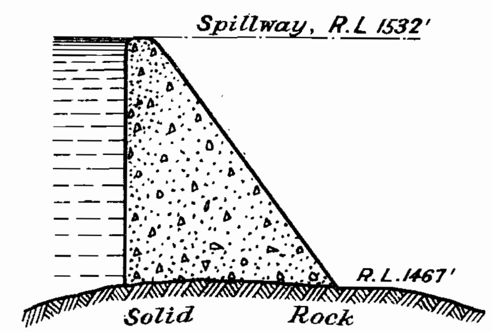
Longitudinal Section
PROPOSED DAM
AT
POLLY M^c QUINN'S
(Looking Upstream)



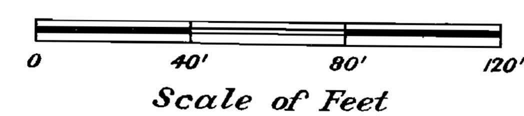


Cross Section
AT 558 FT





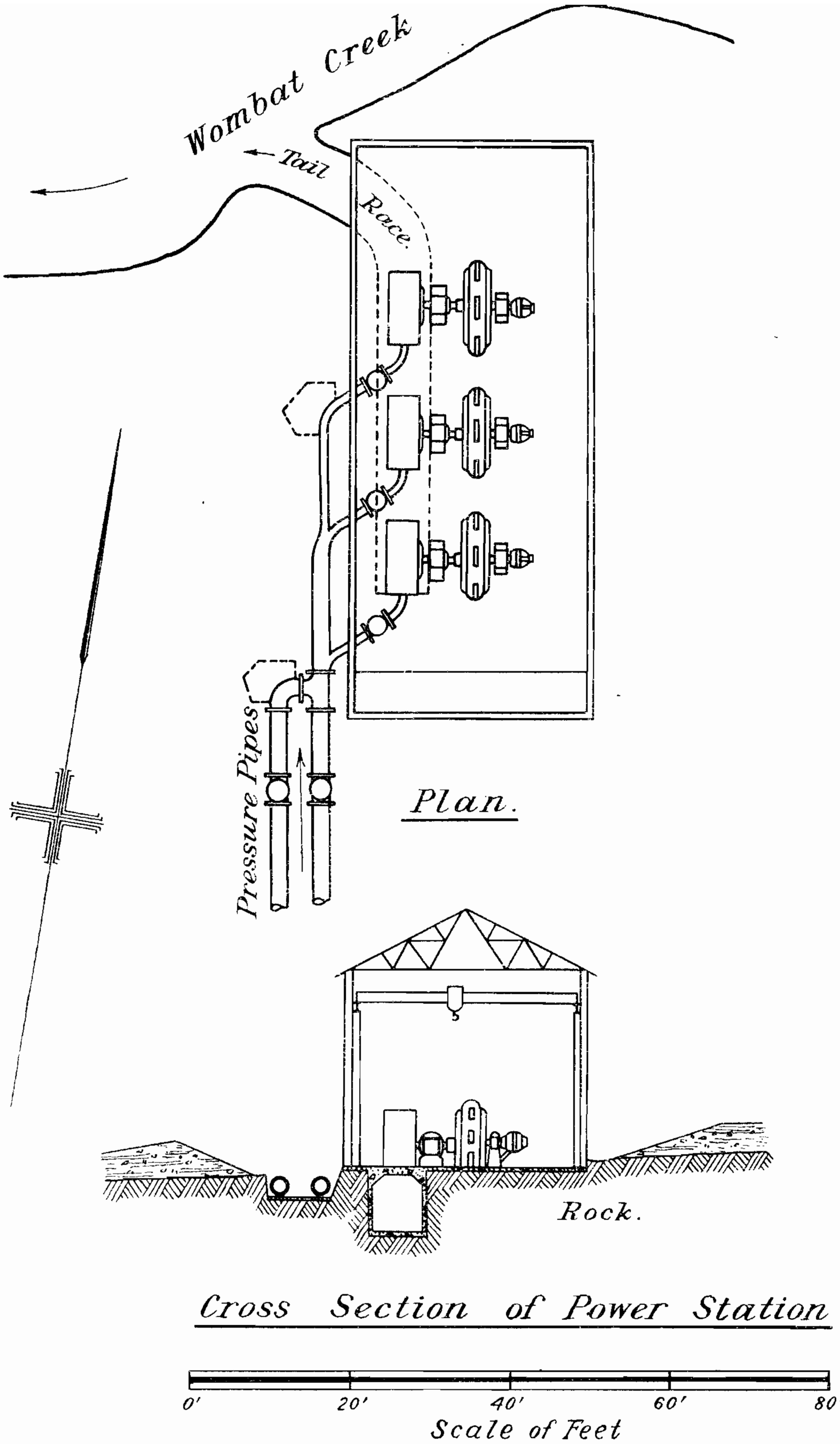
Cross Section
AT
DEEPEST PART



STATE ELECTRICITY COMMISSION OF VICTORIA
HYDRO-ELECTRIC INVESTIGATIONS
AT
STRATHBOGIE

[signature]
Consulting Hydraulic Engineers
August 1st 1922.

DRAWING NO 4



STATE ELECTRICITY COMMISSION OF VICTORIA.

HYDRO-ELECTRIC INVESTIGATIONS AT STRATHBOGIE.

POWER STATION ON WOMBAT CREEK.

SCHEME "B."

J. M. & H. E. COANE,
Consulting Hydraulic Engineers,
1st August, 1922.

DRAWING No. 5.

By Authority: ALBERT J MULLETT, Government Printer, Melbourne.