

GEOLOGICAL CONDITIONS AFFECTING WATER-CONSERVATION

in the
FLORENTINE AND GORDON VALLEYS

INTRODUCTION

The geological investigation with which this report deals was carried out in connection with the work of the Hydro Electric Department in determining the feasibility of an economic hydro-electric scheme being evolved by turning the waters of the Gordon River into the Florentine and storing the combined waters in the valley of the latter. In order to carry this scheme into effect, the following undertakings would be necessary:-

- (a) Erection of a low dam on the Gordon at the entrance to the gorge.
- (b) The cutting of a canal from the Gordon to a branch of the Florentine River.
- (c) The erection of a dam in the lower reaches of the Florentine.

A report on the geological aspects of the scheme must therefore deal with the following points:-

- (1) The geological structure at the site of the Gordon dam.
- (2) The character of the country to be penetrated in cutting the Gordon-Florentine canal.
- (3) The geological structure in the lower reaches of the Florentine as affecting dam construction.
- (4) The "water tightness" of the Gordon Valley and that portion of the Florentine Valley which it is proposed to inundate.

These specific points cannot be dealt with without a knowledge of the general geology of the area. Accordingly the general geology will be concisely indicated, after which will follow a detailed discussion of the geological factors controlling the various phases of the conservation scheme.

GENERAL GEOLOGY OF THE AREA

(1) The Lithological Groups

The geology of the area is somewhat complex, there being several rock systems present. The accompanying geological map will serve to indicate what these rock systems are and their approximate distribution. It must be remembered, however, that the geological boundaries are only approximately indicated, this being due to the absence of detailed surveys. A study of this map, together with the cross-sections, will serve to present an accurate idea of the general geological structure of the area.

With the exception of the Pre-Cambrian mica schists and quartzites in the extreme west, the oldest rock series represented is the West Coast Range Conglomerate series. Outcrops of this are confined to the western and southern portions of the area, constituting The Thumbs and Mt. Wright on the west, and Tim Shea on the south. The Gordon at the head of the gorge

cuts through this rock series. The constituent rocks of this series are conglomerates of varying coarseness sandstones and quartzites, very hard and well cemented.

Overlying practically conformably the West Coast Range conglomerate series occurs a series of limestone beds. These are the Gordon River or Silurian limestones. The beds in this series range from a very pure bluish-grey limestone to a hard quartzite, but the calcareous beds predominate largely over the siliceous. The limestone is much fractured and is characterised by numerous caves and solution channels. This limestone constitutes the bed-rock of the Gordon and Florentine river valleys, and also that of the Junee River.

Conformably overlying the limestones occur the Silurian sandstone series. The typical rock type of this series is a white to yellowish-white sandstone. This series occurs on the Gordon and Tiger Ranges, and has been referred to in previous geological reports as "sandstone of unknown age". In these Tanges the limestone is seen at the foot succeeded as the slope is ascended by the sandstone series.

Overlying, with a marked unconformity, these Silurian limestone and sandstone series there occur the Permo-Carboniferous mudstones and grits which are themselves succeeded by Trias Jura sandstones. The Permo-Carboniferous mudstones contain narrow bands of a slippery clay and are, in general, soft and crumbly in character. The grits are harder, but these beds are associated with the argillaceous (mud-stone) members. The Trias-Jura sandstones vary in coarseness and consist mostly of silica. The Permo-Carboniferous beds occur in the Florentine Valley on the slopes of Mt. Misery, coming down to river level about 3 miles below the point where the Dawson Road crosses the river. About 2 miles further down stream, the Trias Jura sandstones are seen at the river level. In the south-eastern portion of the area on the slopes of Mt. Humboldt the Permo-Carboniferous beds are highly developed, and in this locality also they lie unconformably on the Silurian limestone series.

Lying generally at a higher level than any of the rock series so far described and intruding both the Permo-Carboniferous and Trias-Jura systems occurs the diabase - a rock type so well known in Tasmania. This rock caps Mts. Humboldt, Wherrett's Lookout, Misery and Wyld's Craig, and reaches the level of the Florentine River about 3 miles above its junction with the Derwent, the lowest 3 miles of the former stream being through a gorge cut into this hard rock.

The remaining rock types occurring in the area consist of sand, clay and gravel deposits of Pleistocene or Recent age. These occur in the river valleys. Those in the Gordon Valley are of both ages, but are shown in the geological map herewith as of the one age as, in general, their lithological characters are approximately identical. The deposits in this valley are of considerable extent. In the Florentine Valley the deposits are of Recent age and are of quite small extent being confined to a few remains of old river terraces.

(2) The Geological Structure and History

Of the various lithological groups described above the Pre-Cambrian mica-schists, the West Coast Range Conglomerate series, and the silurian limestone and sandstone series, are much folded and faulted and

these possess varying directions and amounts of dip.

Neither the Permo-Carboniferous nor the Trias-Jura series are folded, but may possess an inclination from the horizontal up to 30° . This inclination is the result of their being cut up by normal faults into many blocks which have been tilted against each other at various angles.

The Pleistocene and Recent gravels, sands and clays lie absolutely undisturbed in their original horizontal position on the denuded edges of the older rocks.

To explain the present relative positions of all of these lithological groups it is desirable to concisely indicate the succession of events which has brought about the present geological structure.

The first period of sedimentation was that of the Pre-Cambrian mica-schists which have been converted from their original sedimentary character by the folding and crushing movements which succeeded the sedimentary period.

On the denuded edges of these rocks the West Coast Range Conglomerate was laid down followed by the Silurian limestone and then the sandstone series in conformable succession. At the close of this period of sedimentation there occurred an intense compression whereby the West Coast Range Conglomerate, the Silurian limestone and sandstone series were folded along axes having a general north-westerly trend.

The completion of this folding was followed by a long period of denudation which removed in places the sandstone series and part of the limestone. On this eroded surface the Permo-Carboniferous beds were laid down followed in conformable succession by the Trias-Jura sandstones.

These latest horizontal sediments were intruded by the igneous rock diabase which solidified in the form of thick sills or irregularly transgressive masses. A period of denudation followed in which the sediments overlying the intruded diabase were removed and the diabase laid bare to the surface. It was probably at this stage that the warping by pivotal movement along fault planes brought about the difference in elevation of the Permo-Carboniferous and Trias-Jura sediments in the lower reaches of the Florentine River as compared with their elevation on the southern slopes of Mt. Humboldt.

The present cycle of denudation was the next event to ensue and is still in progress. A phase of this cycle was the appearance of mountain glaciers reaching down to parts of the Gordon Valley (Valley of Rasselas) and these were responsible for the glacio-fluviatile deposits which cover most of the plain in this valley. The present rivers have left in places terraces and alluvial deposits which are plentiful in the Gordon Valley, but only sporadically distributed in the valley of the Florentine which incidentally appears never to have been reached or touched by glaciers and is probably slightly younger than that of the Gordon.

The present cycle of denudation has carved out the present topography, but this action has to a considerable extent been modified by the influence of the

geological composition and structure. This influence has determined the outstanding features of Mt. Humboldt and Wyld's Craig capped by the resistant diabase, as well as the broad flat expanses of the Gordon and Florentine Valleys, the bed-rock of which is the easily eroded Silurian limestone.

THE GEOLOGICAL STRUCTURE AT THE SITE OF THE GORDON DAM

The site of the proposed dam at the head of the Gordon Gorge is located on the West Coast Range Conglomerate. The actual members of this series at this point are mainly quartzites and hard sandstones and dip eastwards at about 45° to 50° . The river bed consists of the hard rock in situ and there are practically no boulders at the point where the cataract begins. On the southern side of the gorge at this point, however, above water level there occurs a huge detached block measuring approximately 25 feet cube. This would probably have to be removed in dam construction.

The foundations are excellent for any size of concrete dam as the rock is strong and resistant, totally free from slippery bands, dips upstream at about 50° , and thus has the whole of this rock series behind it as a buttress. Concrete dam construction can be confidently proceeded with.

THE CHARACTER OF THE COUNTRY TO BE PENETRATED IN CUTTING THE GORDON-FLORENTINE CANAL

The canal it is proposed to cut in order to carry the impounded waters of the Gordon into the Florentine will run from the head of a small branch of the Huntley Creek across a button-grass plain to the head of a branch of the Florentine.

The plain at this locality consists of glacio-fluviatile deposits overlying limestone. The alluvial will be found to consist of quartzose pebbles of medium size, but the exact thickness to bed-rock at any point is at present unknown. The general character of the wash will be such as to render its removal by sluicing an undertaking which presents no difficulties. It will be necessary, however, before this work is decided upon to put a series of bores down along the line of the proposed cut to ascertain both the character and depth of the wash, and also whether the limestone bed-rock will be encountered in the cut. The evidence points, however, to the probability that the whole of the cut will be confined to wash.

THE GEOLOGICAL STRUCTURE IN THE LOWER REACHES OF THE FLORENTINE AS AFFECTING DAM CONSTRUCTION.

There are five locations which have been selected as possible dam sites in the lower reaches of the Florentine. Three of these were examined by Mr. Hartwell Conder and occur at from 4 to $4\frac{1}{2}$ miles below the Florentine farm-house. The remaining two sites have been more recently located as the result of the examination of the river further down its course in order to ascertain whether the diabase came down to river level as seemed probable on geological evidence. Actually there are a considerable number of dam sites in this locality which occurs about a quarter of a

mile below the debouch of Misery Creek, but as they are of two general types they may be grouped into two general sites.

In regard to the three upper sites, the present examination has definitely established the fact that the rock which would form the foundations of the proposed dams is of Permo-Carboniferous age, and consists of mudstones and argillaceous grits in which marine fossils of undoubted Permo-Carboniferous age are abundant. This age determination is of the utmost importance both in regard to questions of the safety of the dam foundations, and also in determining the water-tightness of the storage basin at its northern end. The uncertainty that resulted from the determination by Mr. Hartwell Conder of these beds as being of "undetermined age" is now definitely removed.

The three sites are numbered 1, 2, and 3 in succession going down-stream.

No. 1 Site: At the upper or No. 1 site the Permo-Carboniferous mudstones strike 315° making an angle of 50° with the length of the dam. The dip is down-stream and measures 23° which corresponds to an inclination down-stream at right angles to the dam wall of 15° . The beds exposed in the bar in the river at this point are rather hard cemented grits, but immediately above water level on the bank the normal mudstones are seen to contain thin beds about $\frac{1}{4}$ inch thick of a very slippery clay. The bores recently put down along the site show a varying thickness up to about 12 feet of sandy clay and clayey grit which for the most part represented the bed-rock decomposed in situ. Although it is apparent that bedrock is available at a very slight depth, yet the nature of that bedrock and the thin slippery clay beds combine to present very unsafe conditions for dam construction. The lubricating effect, resulting from the penetration of water under pressure into such mudstones and clay, would permit sliding to take place down-stream along the bedding planes inclined 15° in that direction when the load of the stored water began to take effect.

No. 2 Site: This site is 28 chains below No. 1. The direction of the dam bears 292° . The bedrock is of the same general lithological character as at site No. 1 and the bores recently put down show that a varying thickness of surface clay and grit overlies the bedrock to, in places, as much as 35 feet in thickness. The bedrock shows in the bed of the river, and it can be seen that at this point the strike is 322° and the dip upstream at 17° . This corresponds to a dip upstream at right angles to the dam of 8° .

The conditions, therefore, are suitable for the construction of either earth or rock-fill dams, but it is at least doubtful whether a concrete dam is feasible. The marked softening of the mudstones under the hydrostatic pressure would bring about a tendency to local deformation under the weight of the concrete structure to such an extent as to threaten local collapse in the dam. This site may therefore be regarded as suitable for an earthen or similar dam, but not for one of concrete.

No. 3 Site: This is 5 chains below No. 2 site. The bedrock here is also Permo-Carboniferous mudstone overlain by a thin mantle of surface detritus. The details of strike and dip are not as clear as in

the two previous cases, but there is undoubtedly a slight dip downstream. Whether this is of such a small amount as to allow of an earthen dam being constructed with a base sufficiently wide to ensure that no sliding could possibly occur, cannot be definitely stated. To answer this question would entail the sinking of trial pits about 20 feet in length at right angles to the length of the dam, sufficiently deep into the bedrock to enable the true dip to be observed. A concrete dam is certainly not desirable.

No. 4 Site: This site is intended to represent the first group of the dam sites in the lower more precipitous reaches of the river. This group is characterised by the occurrence of a bedrock of fine-grained to moderately coarse sandstone overlain in part by fragmental diabase detritus and a steeper slope of the sides of the gorge than further upstream, and includes cross-sections numbered 89 and 90.

The sandstone is of Trias-Jura age and has been dropped down to river level along a fault-plane running in a north-south direction and crossing the river at about the debouch of Misery Creek. The dip of these sandstone beds is upstream and amounts to 10°, in several cases, however, being quite horizontal. The lithological character of these rocks is well known and that they do not contain interbedded clay seams may be accepted in view of our knowledge of them in better known localities. They consist almost wholly of silica, and when crushed the coarser varieties would make excellent sand for concrete work.

The lithological character and structural features of the sites thus characterised, combine to present conditions favourable for the erection of concrete dams. The excavation needed to reach solid bedrock will not be excessive, and this bedrock when reached will most probably be of such a character as to uphold a properly designed concrete dam. It would be advisable, however, to put down several test bores in the sandstone at any actual site that may be decided upon to finally determine the exact character of the sandstone beds. These bores could be put down by a small hand-boring plant, preferably one of the "Acme" boring sets recently purchased by the Mines Department.

No. 5 Site: This site includes all those immediately below the No. 4 series, and are represented by sections Numbers 69, 75, 79, 82 and 86. In all of these sites the bedrock is solid diabase covered more or less with loose diabase boulders. The solidity of this rock mass presents excellent conditions for concrete dam construction. The bedrock outcrops over the greater part of the sites, and wherever detrital boulders and fragments of diabase occur they will not be in excessive amounts. Concrete dam construction may therefore be undertaken with absolute confidence at any of the section lines included under this general designation of No. 5 site.

THE "WATER TIGHTNESS" OF THE GORDON VALLEY AND THAT
PORTION OF THE FLORENTINE VALLEY WHICH IT IS PROPOSED
TO INUNDATE

Having dealt with the geological conditions of the proposed dam sites as affecting dam construction, it is now necessary to enquire into the effect of storing large volumes of water behind such dam walls in both the Gordon and Florentine River Valleys. This

enquiry must deal with the efficiency of these storage basins in respect of their capability of holding water without appreciable leakage.

In order to thoroughly examine this question the two cross-sections submitted herewith have been prepared and these will serve, in addition, to illustrate the following descriptions and conclusions.

The question of the "water-tightness" of the storage basins arises through the fact that the bedrock over the greater part of both storage areas is the Silurian limestone. This limestone, as explained in a preceding portion of this report is characterised by the presence of numerous intersecting caverns and fractures and carries a considerable underground water circulation. The possibility therefore clearly exists of the water impounded behind the dams flowing underground into other adjacent drainage systems and thus being lost to the proposed conservation scheme. It is obvious that if this loss is appreciable the feasibility of the scheme will be seriously threatened. As there are two basins in which water will be conserved, it is necessary to examine each separately from the above point of view.

Gordon Valley: The limestone in this storage basin is overlain very largely by more or less impervious alluvial material, but limestone outcrops in the river bed, and there is thus not a complete blanketing of the pervious rock. A certain amount of water must be expected to penetrate the circulation channels in the limestone.

What will be the destination of that leakage from the storage basin?

The answer to this question is seen by referring to the section on the line C D. This shows that there is no danger of leakage down the Gordon Gorge because the impervious West Coast Range Conglomerate forms a very efficient dam in that direction. The fact, however, indicated in that section that the water table (marked in red) passes under the Gordon Ridge and outcrops in the Florentine Valley 200 feet below the level of the Gordon, clearly demonstrates that whatever leakage happens it will find its way into the Florentine above the proposed dam.

The conservation scheme will not, therefore, be affected by any leakage from the Gordon storage basin.

Florentine Valley: In this storage basin, with the exception of a comparatively small area nearer the dam sites, the bedrock is the Silurian limestone which is exposed to the surface and has no blanketing alluvial whatsoever. The stored water, therefore, will have free access to the underground circulation over all of that area. The question arises therefore:

Is the limestone in this basin in a geological basin and thus disconnected with outcrops of the same rock series in other drainage areas, or is there a continuous bed of limestone making a potential circulation connection with such adjacent areas?

The sections along the lines AB and CD clearly show that the limestone in the Florentine Valley does not constitute a geological basin, but is connected

by means of a series of folds with the same limestone in both the Gordon and Junee Valleys. It has been shown above that the underground circulation is through limestone from the Gordon into the Florentine so no leakage is possible from the latter into the former. Section CD shows that the continuity of the limestone in the direction of the Derwent is completely broken by a series of faults which brings the impermeable Permo-Carboniferous mudstones against the limestone, and further northwards completely interposes the massive impermeable diabase. In any case the fact of no limestone outcrops occurring in the Derwent Valley and the diabase, Permo-Carboniferous and Trias-Jura rocks exclusively occurring there show that no leakage into that valley is possible.

When we come to Section AB, however, it is clear that there is a continuous run of limestone from the Florentine to the Junee outcrops and that the water table in that direction shows a net fall of about 200 feet. Realisation of this fact induces the following questions:-

- (1) Is there an underground circulation from the Florentine to the Junee, although the surface Florentine drainage flows northwards?
- (2) Even if there is no Florentine to Junee drainage at present will the raising of the water level 50 feet or more in the Florentine Valley bring about such a movement of the water?

In regard to question 1 although the water table has a net fall towards the Junee, yet it does not definitely follow that there will be an underground circulation from the Florentine to the Junee valley because an underground water-shed may exist. In view of the fact however, that the geological evidence available and which is pictured in Section AB demonstrates that such a watershed does not seem to exist, it seems highly probable that such a circulation is actually taking place at present. It is very difficult to prove this as no measurements are available and would be very difficult, indeed, to actually obtain in regard to the amount of water actually in the Florentine as compared with what is entering from the tributaries.

The only way to ascertain whether water from the Florentine valley actually reaches the Junee at present is to put a substance in the water of the Florentine Valley at some suitable spot, which could be recognised in very minute quantities at the Junee. Preferably this substance should be put into water in a cave, if such can be found, where water is as nearly stationary as possible. These caves should be searched for in the Florentine Valley at the foot of Mt. Humboldt near where section line AB crosses. A substance suitable for such tests is Fluorescein which has been extensively used for this purpose, and can be detected by simple chemical tests, or Ammonium Chloride may be used and tested for at the Junee by an electrolytic method which is continuous and automatic.

If these tests result in showing that there is even a very slight amount of water coming from the Florentine Valley to the Junee, it is clearly inadvisable to attempt to store water in the former valley, as whatever takes place now will be intensified enormously when the head is raised by 50 feet or more, and the outlet northwards completely blocked by the proposed

dam. It would most probably result that no water at all could be stored in the Florentine, but that the greater part of the Florentine drainage above the dam would be diverted to the Junee. This brings us to the second question which will be now discussed.

Unfortunately, although the detection at the Junee of the substance put into the water in the Florentine Valley would definitely prove an underground Florentine-Junee drainage, yet its non-detection does not demonstrate that such a drainage would not develop after the erection of a dam and the storage of water with a head at least 50 feet above the present water level in the Florentine Valley. The geological evidence is such however, as to indicate that under such conditions it is highly probable that the impounded waters will find their way underground to the Junee

CONCLUSION

Summarising the conclusions arrived at in the preceding pages, it may be stated that all of the various factors in the scheme, indicated at the opening of this report are satisfactory with the exception of the "water-tightness" of the Florentine storage area. The fact that a very considerable leakage into the Junee valley through the cavernous limestones will take place seems to be clearly indicated on the geological evidence. As this portion of the scheme is a vital one, it seems as if the whole project may have to be abandoned. Before arriving at that decision, however, it will be certainly advisable to carry out the tests with fluorescein or ammonium chloride as indicated above.

Concisely the conclusions are:-

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| A. GORDON VALLEY | - Dam Site: | Suitable |
| | Storage: | Leakage into Florentine Valley but above latter dam and therefore unimportant. |
| B. FLORENTINE VALLEY | Dam Site: | No. 1 - Unsuitable
No. 2 - Suitable for earth or rock-fill, but not concrete.
No. 3 - Probably unsuitable.
No. 4 -) Suitable for
No. 5 -) concrete or any type of dam. |
| | Storage: | No possible leakage into Derwent or Gordon. Leakage on a considerable scale into the Junee highly probable. |

The following plans are to accompany this report:

- (1) General Geological Map of the Gordon-Florentine-Junee area.
- (2) Vertical Section along the line A B
- (3) Vertical Section along the line C D.

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LAUNCESTON,
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