DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL INVESTIGATIONS, MYPONGA DAM

CONSTRUCTION PHASE

Progress Report No. 2

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GEOLOGICAL INVESTIGATIONS,

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ABSTRACT

Further geological investigations at the dam site, particularly on the left bank, have delineated the width of limestone present and by means of an exploratory adit have shown that solution cavities are relatively rare. Cavities are of two types; major ones at the intersection of joints with each other or with minor faults; and minor ones confined to beds susceptible to weathering.

Deep weathering of certain beds is shown by the adit and by re-examination of diamond drill cores. Bedding plane faults may have contributed to the deep weathering.

Abundant jointing is confirmed.

Further exploration by diamond drilling and shaft sinking and more extensive grouting on the left bank is proposed.

INTRODUCTION

Since the previous report was forwarded the adit recommended by the Foundation and Grouting Committee has been completed and geologically mapped, and the limits of the "Brighton Limestone" have been defined more accurately by mapping on the surface. A water injection test on the cavity exposed in Blocks T and S has been completed and some further investigation into the depth and location of glacial deposits comprising the reservoir rim to the south of the damsite have been commenced.

The adit has revealed a number of lenticular pipe-like cavities, extensive alteration, chiefly due to weathering along certain beds in the limestone sequence, and a large number of joints. No cavity of the size of that exposed at the surface along the Block T fault was penetrated by the adit.

ENGINEERING GEOLOGY

Cavities

A number of cavities as revealed by the adit are shown on the plan 58-287. With one exception these possess considerable differences from the cavity revealed in the foundation excavation on Blocks T and S.

The cavities penetrated by the adit are practically confined to beds of weathered limestone and are all inclined down the dip of the beds, mostly in a direction normal to the strike, though some have irregular courses. They are pipe-like and lenticular with diameters varying from 2 to 6 inches. Some cavities extend beyond the limit of measurement (6 feet) and some are only a few inches in length. The cavities are definitely due to solution as shown by their pipe like form and the rough irregularly corrugated crusts of secondary calcite and dolomite deposited on their internal surfaces. Some have been partially filled with clay transported by water seeping down along the weathered rock layers. These cavities do not appear to be controlled by the intersection of joints of two different systems or by the intersection of a joint with a bedding plane. They are of relatively small dimensions and should be filled or isolated by an adequate grouting programme.

One other cavity of a different type was observed at a distance of 143 feet in from the portal, adjacent to a badly cracked and decomposed zone. This cavity extended in at least five feet from the east wall of the tunnel along the intersection of two joints or a joint and a bedding plane. It is bounded by roughly planar surfaces on which some secondary calcite has been deposited. The analogy with the surface cavity is obvious and it is possible that differential movement of blocks of rock, bounded by joint planes, along the fault or faults have actually partially formed this type of cavity. Subsequent solution of limestone by water travelling downwards to the permanent water table has no doubt enlarged them.

The adit was extended in to intersect the line of the fault projected downwards along its surface dip and it is possible that the fault was intersected between 140 and 148 feet in from the portal. The cavity described above is close to this point and may be connected through tortuous channels to that exposed in Blocks T and S though the adit was

designed to intersect the fault some 120 feet north-west of the surface cavity.

The water test conducted on the surface cavity showed that it is capable of discharging water at a rate in excess of 24,000 gallons an hour to the water table. Seepages from points a few feet above river bed level were observed to increase during the test and while this could be due to coincident increased seepage of meteoric waters it could also be due to formation of a "mound" in the water table. The evidence is too slender for proof one way or the other.

The water test does not prove that the cavity extends downwards at its surface dimensions to the water table as a flow at a rate of 24,000 g.p.h. could be dispersed by a small number of relatively narrow cracks and the cavity may pass into such cracks at depths. Conversely it may increase in dimensions with depth.

The evidence from the exploratory adit, while offering no definite proof, gives ground for hope that the larger cavities are confined to the intersection of joints and minor faults. Further evidence will be available when the whole of the south abutment is excavated to anticipated foundation levels. This excavation should be expedited as far as is possible.

A re-examination of diamond drill cores revealed that they show definite evidence of solution cavities in the limestone down to the deepest levels reached by the holes.

Lithology

The boundaries of the limestone on the left abutment have been re-mapped and are shown on plan 58-284.

It was possible to define the southern and northern boundaries with some accuracy due to good exposures in road cuttings and other excavations. The northern contact with the stratigraphically overlying phyllite and shales is quite sharp. The southern contact cannot be so easily decided as highly calcareous shales are interbedded with the limestone near its base. However for both stratigraphic and practical reasons the southern boundary of the limestone can be taken as the thin bed located some 330 feet due south of the southern abutment of the dam.

No limestone was observed south of this bed.

The horizontal width of the limestone, thus defined, on the surface is 550 feet. This is its most important dimension as it gives a limit to the zone that must be covered by the curtain grouting to ensure that no serious leakage will occur from the reservoir. In practice the curtain may need to be extended beyond the southern limits of the limestone to cope with the southerly extension at depth due to its steep southwards dip. This is discussed more fully in the section on remedial measures.

It was not possible to determine the boundaries of the limestone along the strike, both to east and west, so accurately owing to outcrop conditions. Westwards the limestone either lenses out, grades into shale or is cut off by some geological structural feature. Limestone was not mapped west of grid 8000E. Eastwards the limestone also appears to thin. It was not traced beyond the Myponga Valley as it maintains its thickness to this point and thus gives stored water access to the full width of the potential leakage zone.

The limestone is not lithologically uniform throughout. It consists principally of two types. Where perfectly fresh these are a dark blue-grey limestone and an argillaceous limestone with a sombre brownish, dark grey colour. Both types are laminated, the laminae consisting of dark grey to black shaly material and being inconspicuous in the unweathered rock. The argillaceous limestone appears to be more easily weathered and breaks down to a yellow brown clay. It has been previously described as a calcareous slate but is as fully susceptible, if not more so, to solution as the blue grey limestone. Most of the cavities found in the adit are in this type of limestone. To avoid confusion it will be referred to simply as limestone in this report. The cavity at the surface in Blocks T and S. is chiefly in blue-grey limestone.

Some attention has also been given to the occurrence of glacial deposits on the southeastern rim of the reservoir owing to the possibility of leakage through the rather narrow divide along the Myponga Beach road. This possibility was investigated by Miles and some drilling and gravimetric work was done, the conclusion being that leakage was unlikely. Retracing of the boundaries has now shown that Precambrian bedrock outcrops at a level

higher than full supply level of the reservoir on the south-western side of the divide south of where it is underlain by the thick glacial and fluvio-glacial deposits tested by percussion drilling in 1948. However there are geological grounds for suspecting that the deeper part of the old Permian glacial valley may be close to the Precambrian highland to the south and along the route of the Myponga-Yankalilla road.

Some further gravimetric work is in progress to check the original work and to give some more detail in the critical area. Drilling may be required to investigate the nature of the sediments and determine accurately the depth of bedrock. A recommendation will be made when the results of the gravity work are known.

Weathering

The adit has shown that weathering of certain beds in the limestone sequence extends to considerable depths. At 156 feet in from the portal or 75 feet vertically below the original surface a bed partially converted to clay over a true thickness of 2 feet was penetrated and drilling has indicated that weathering of similar severity occurs at depths down to 95 feet. The clay fortunately appears to be lenticular and in the adit many of the clay lenses grade into solid, though weathered, rock within the limits of the walls and back. The total proportion of badly weathered rock to sound rock exposed in the adit is 27% in the east wall, 24% in the west wall and 14% in the back, and this includes the zone 30 feet in from the surface which would normally be removed during excavation. The weathered rock seams have been shown to extend to depths well below the present anticipated foundation levels and their effect on foundation excavation and treatment must be considered.

If the masses of clay formed by weathering are lenticular and discontinuous, as is indicated by their occurrence in the adit, then they will be chiefly dangerous as a possible source of leakage, should water under pressure wash the clay out. This danger will be obviated if the lenses are confined by grout in all open cracks leading into and out of them.

On the other hand it seems quite possible that the presence of the clay seams will necessitate general excavation deeper than the assumed line of foundation excavation shown on drawing 56-303, but it may be that

only local excavation of individual clay seams will be required.

The removal of soil and badly weathered rock by sluicing already done on the left abutment has given a much clearer picture of the geology and the determination of final foundation levels would be assisted by completion of this operation.

Geological Structures

Surface mapping has confirmed the faulted nature of the dislocation along which the cavity in Blocks T and S occurs and has also delineated one other parallel fault to the north-west, within the area of the dam foundations. Both are minor dislocations and have caused little crushing of the rocks along their courses. Their main importance is in that they may form the locus of solution channels.

The fault L_1 projected downwards at its surface dip intersects the adit at a point 143' in from the portal. Immediately north of this point the adit penetrated a wide zone of cracked and broken rock, largely converted to clay and showing signs of shearing. It seems more than likely that this is due to the faulting or movement associated with the faulting, though no well defined fault plane, similar to that exposed in Blocks T and S, was observed in the adit. The area excavated to fresh rock in Blocks T and S is small and it is quite likely that larger zones of crushed and weathered rock. will be exposed down hill. This is yet another reason for expediting the excavation of the left bank.

The adit has confirmed the presence of extensive jointing and has shown that open cracks occur at depth along the joints. It is likely that open joints, as well as cavities, will extend at least down to the permanent water table and the curtain grout holes will have to be deepened beyond the limits shown on drawing 56-305.

A re-examination of the diamond drill cores shows that open joints persist to the greatest depths reached by the holes.

There also appears to have been rock movement along bedding planes which may have been minor readjustments between beds during the tight folding the rocks have undergone, or may have been due to faulting directed along the bedding planes. These would have been in the nature of minor thrust faults. The result has been to cause cracking and minor

crushing along certain bedding planes, thus allowing meteoric water easier access to the rocks.

This has been a major contributing cause to the formation of clay seams along certain beds and may have had a greater influence than the lithology of the beds. From the exposures in the tunnel more of the deep clay seams may be expected in Blocks R to M than from Block R outwards.

REMEDIAL MEASURES

Cavities

Treatment of the cavities depends on their size. In its upper section at least it is unlikely that the cavity in Blocks T and S could be filled with grout. It is thus important to explore its ramifications to see in what form it extends downwards. The shaft, a minimum depth of 30 feet, recommended in verbal discussion in committee has thus a twofold purpose, to enable proper treatment of that particular cavity and to explore it further.

As mentioned above the cavity might diminish to a series of relatively narrow cracks quite capable of dispersing the flow which was injected into it. Such cracks could be adequately filled with grout. On the other hand the cavity could enlarge downwards or narrow and then enlarge again. For this reason its form in the shaft must be very carefully examined. Should the cavities extend along fault L_1 a cut off trench may be required.

A final answer on the treatment of the cavities must await completion of excavation on the left abutment as well as completion of the exploratory shaft, as others of similar size may be disclosed along the fault L_1 and parallel faults.

The presence of open joints, as described above, will be an asset in treating the cavities as they will allow grout access to those cavities not penetrated by grout holes.

Grouting

Newly discovered factors which will influence the final design of the grouting programme are: the presence of cavities in the limestone

on the left abutment; deep weathering along possible minor thrust faults parallel to the bedding; extensive systems of joint cracks with a large aggregate leakage capacity; cracks along bedding planes on the right abutment; and the much greater thickness of limestone present in the left abutment.

The water test on the cavity C_1 has shown that leakage paths capable of taking a large flow occur down to the water table and that grouting to this depth must be considered. The leakage paths may be cavities or cracks along joints and faults. A re-examination of diamond drill cores in the light of knowledge gained from the adit and excavation has shown that they reveal evidence of weathering, and of open joint cracks and solution cavities in the limestone to levels below the present river bed level at the dam site.

The depth to which the grout holes should be drilled will be influenced by the ease of access of stored water to the leakage paths. Reservoir water will be in contact with the limestone sequence over its full width, and down to river bed level, in the north-south reach of the Myponga Valley upstream of the site. At the surface cavities and joint cracks are largely concealed by a clayey soil layer which will prevent direct access of stored water to most leakage paths, unless the soil and clay is washed into and through the cavities and cracks by water under pressure. Stored water will have direct access to cracks and cavities in the bed of the stream and in areas of outcrop. Other areas of rock may be exposed by under water landslides when the clay soils become submerged in the rising water.

The curtain grouting will also have to be extended south of the present intended limit to cover the potential leakage paths over the full width of the limestone. Again it will be a matter of judgement where the curtain should end and what should be the depth and spacing of the holes.

It is clear that the answers to several of the problems of grouting depend on the position of the permanent water table. This should be measured and some information should be obtained on the condition of the limestone at depth south of the southern abutment of the dam. Drilling is proposed, details of which are discussed in the succeeding section.

The proposed spacing, inclination and azimuth of the "B" grout holes should be satisfactory. Some holes may be required in special positions to ensure grouting of known cavities.

The presence of a large number of intersecting joints on the left abutment and open cracks along bedding planes in the right abutment will make satisfactory grouting under any pressure difficult. It is considered that it will be necessary to grout the "B" holes, at least, under cover of concrete. It may also be found necessary to grout some of the A pattern under cover to obtain a satisfactory result on the left abutment.

Excavation

Though the presence of highly weathered beds in the limestone sequence may require some general lowering of the proposed foundation level under Blocks Q to M, it is more likely that deeper excavation along the individual weathered beds will suffice.

In the main foundation area, below the river bed, the indications are that less than 6 feet of excavation will remove the loose rock. Weathering is confined to the vicinity of joint cracks and is slight.

On the right bank the diamond drill cores indicate that the depth of weathering is substantially less than on the left bank and a good foundation should be obtained at a shallower depth. The chief difficulty in excavation on the right bank will be due to slabs of rock splitting off along bedding planes beyond and below the line of the shot holes. It should be easier also to obtain a neat finish to the right bank excavation.

FUTURE EXPLORATION

Diamond drilling is proposed to determine the depth of the permanent water table and to obtain information as to the condition of the limestone beyond the limits of the dam. Four holes are required, details of which are as follows

Hole	Co-ordinates N	E	Approximate RL Collar	Bottom	Depth
WT1	9830	10110	768	610	160'
WT2	9640	10090	810	620	190'
WT3	9495	10090	825	625	200'
WT4	9340	10100	795	620	175'
				TOTAL	625'

Co-ordinates, reduced levels of collars and depths are approximate. only as the holes may have to be shifted to suit the terrain and excavation requirements. The reduced levels of the bottoms are fixed.

Holes should be drilled in NX size and provision made for periodic measurement of water levels. Provision should also be made for testing the holes with water under pressure after drilling.

As the holes will be required for water level measurements subsequent to the construction of the dam they must have permanent standpipes cemented in and adequate protection from damage.

The proposed exploratory shaft down the cavity has already been mentioned. Some further exploration may be required dependent on the features disclosed in the shaft. It is urged that excavation on the left bank be expedited as features such as minor faults, crush zones and other cavities which will require special treatment may occur under the present soil and weathered rock cover.

The gravity re-survey of the southern margin of the infilled glacial valley is in progress. Two to three percussion drill holes may be required in the divide near the Myponga-Yankalilla road to test for the presence of permeable beds in the glacigene sediments.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The current geological investigations on the left bank and the exploratory adit have shown that limestone or predominantly calcareous rocks extend 600 feet south of the river. The limestone sequence is heavily jointed and cut by a number of minor faults. It contains cavities due to solution which appear to be of two types. Minor solution has taken place along susceptible beds, the cavities being mainly of pipe like form

elongated down dip. This type should be adequately treated by grouting. The other type, as observed to date occurs at the intersection of major joints with each other or with minor fault surfaces. It constitutes a more serious defect as regards leakage and the larger ones will need to be excavated and back filled with concrete. There is some evidence that these cavities may be confined to the minor fault planes. A final conclusion as to their nature and occurrence cannot be reached until further exploration and excavation is completed.

Weathering has extended very deeply along certain beds in the limestone sequence. This may be due partly to a special chemical susceptibility to weathering and partly due to crushing along the beds caused by earth movements during folding or minor thrust faulting. The effect is due to compressive forces and is in the nature of shearing along the bedding planes and its result is to allow easier access for oxygen and carbon dioxide charged water percolating down to the permanent water table. Some deep excavation along narrow zones may be necessary because of this feature.

The presence of solution cavities and abundant joint cracks in the limestone will require grouting southwards beyond the present proposed limit on the left bank.

The limit of grouting to the south, the depth of the holes and their spacing azimuth and inclination are matters to be decided by the full committee. Discussions will be assisted by further information to be provided by the proposed drill holes.

In the limestone on the left bank within the foundations of the dam the azimuth and inclination of the "A" holes is considered suitable for effective grouting but it is advised that the holes should be carried at least down to the permanent water table.

In the phyllite on the left bank below the river bed and on the right bank present evidence indicates that the proposed azimuth inclination and depths of the "A" holes are satisfactory.

In the river bed weathered rock has been removed by erosion and little excavation will be required. On the right bank excavation will generally be less than the limits suggested and on the left bank deeper

along certain zones and possibly over wider areas of the foundations.

Recommendations

1. Curtain grouting over the full width of the limestone on the left bank of the river at the dam site is recommended, details to be decided later.

2. Grouting of the "A" curtain holes after placement of some concrete is recommended on geological grounds.

3. Below the dam foundations on the left bank it is recommended that the "A" holes be drilled to the permanent water table level.

4. Diamond drilling, details of which are given above, is recommended to determine the level of the permanent water table and to give some more information on the limestone.

5. The necessity for further exploration of the cavity on Blocks T and S, already recommended verbally, is confirmed.

6. Excavation of the left abutment should be pushed ahead vigorously as it may reveal features requiring special treatment and will certainly yield more information as to the extent and nature of the various geological features discussed in this report.

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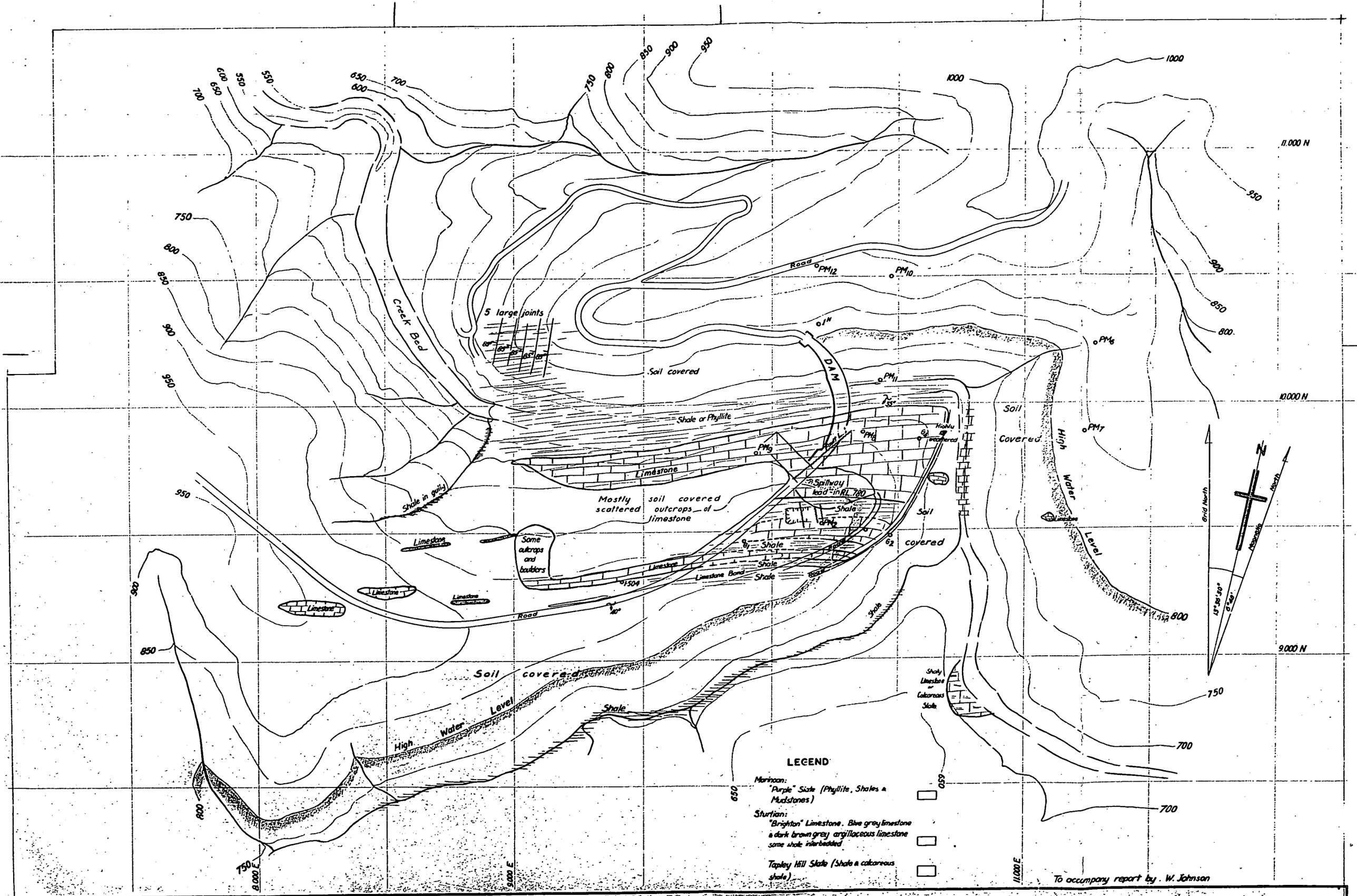
WJ:AGK
23/10/58



To accompany report by. W. Johnson

S.A. DEPARTMENT OF MINES

GEOLOGICAL INVESTIGATIONS MYPONGA DAM SITE
GEOLOGY OF THE DAM SITE & ENVIRONS

Req. No.	Approved	Passed		Scale: 1 inch to 200 ft.
D.M.			Drn.	58-284
Compiled from			Tcd. G.S.	Hc 4
	Director of Mines		Ckd. A.A.	Date 16-10-58
			Exd.	

Associated Drawing	No.	No.	Amendment	Exd.	Date

WEST WALL

℄ ADIT S.E. — N.W.

D.D.H. N° 6
Bng 305°53'
Dip 88°15'
Collar R.L. 737·82

EAST WALL

Weathered limestone, brown & yellow. Clays & mill bedded. Dip 35°-60°

Joints & fractures

MARINOAN — Phyllite & calcareous shale.

STURTIAN — Limestone & argillaceous limestone.

Slate or shale.

WT1 WT2 WT3 WT4

LIMESTONE SHALE LIMESTONE SHALE LIMESTONE

MYPONGA RIVER

Projection of stream bed from 'N' 3 meander W.S. of Dam.

800' 700' 600'

CROSS-SECTION OF LEFT ABUTMENT ALONG BASE LINE
LOOKING DOWNSTREAM
Scale: 80 feet to 1 inch

S.A. DEPARTMENT OF MINES

GEOLOGICAL INVESTIGATIONS MYPONGA DAM
EXPLORATION ADIT AND CROSS-SECTION OF LEFT ABUTMENT

Scale 10 feet to 1 inch (for both)

58-287