

TR14-90-108
22. Patersonia dam site

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PART I. GEOLOGICAL SURVEY

The Launceston City Council is considering schemes whereby emergency supplies of water can be stored and then drawn in very dry periods. A site in the Patersonia district has been selected by the Council for investigation and if suitable a dam would be built across the Patersonia Rivulet about 220 yd below the bridge on the road from Nunamara to Patersonia. A storage capacity of something between 600 and 1200 million gallons is required and when an accurate survey is made, some idea of the size of the dam needed for this capacity will be known. At this stage the Council expect it to be at least 40 ft high with an upper limit of 70 ft. If suitable material can be obtained economically in the vicinity, a rock fill dam would be built but if no suitable material for this type of dam is available the dam will be earth fill.

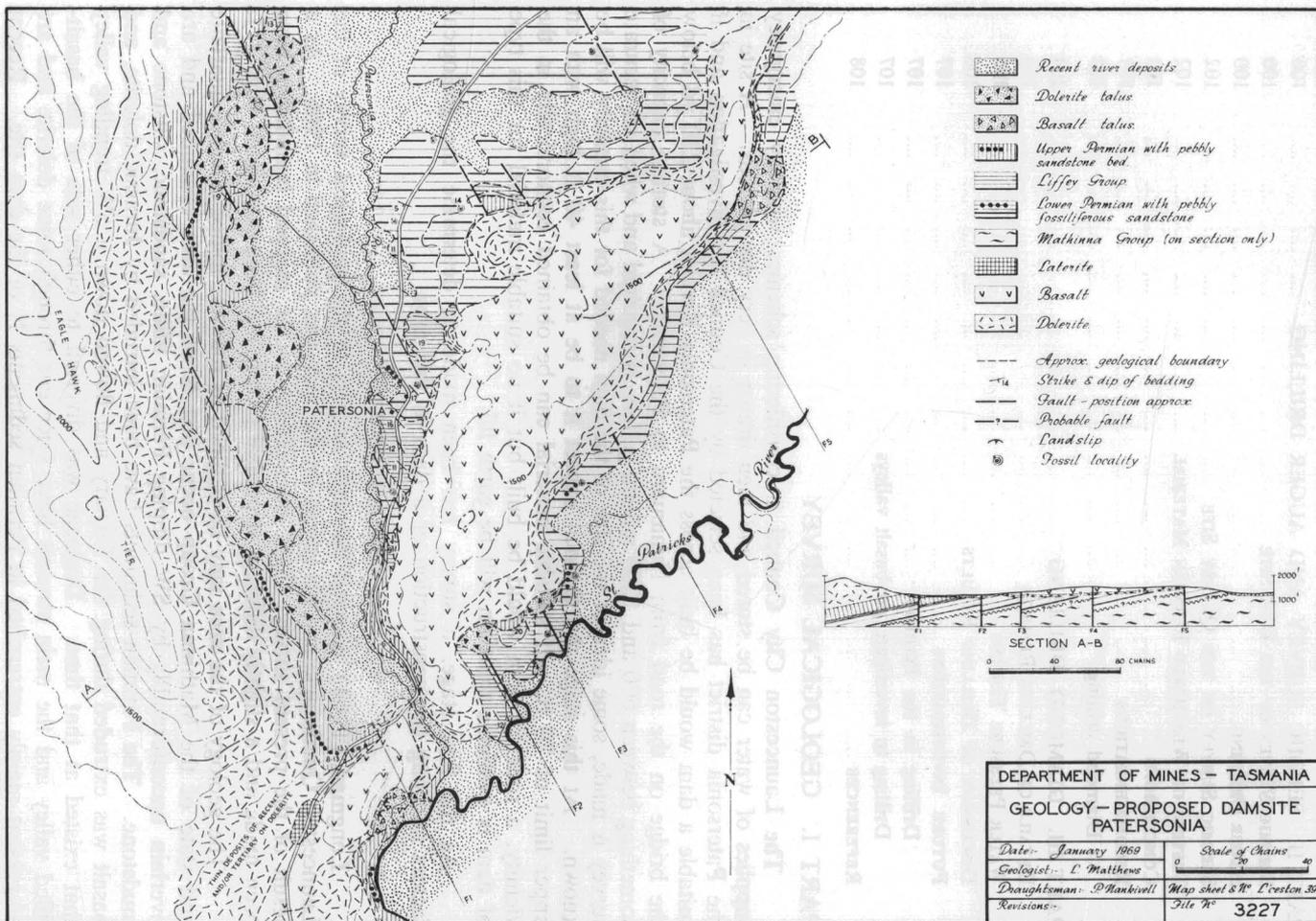
As the first stage, a survey has been made to determine the geological factors affecting the construction of a dam in this area.

GENERAL GEOLOGY

Longman (1964) mapped this area as part of the geological survey of the Launceston Quadrangle and his report on the area was published in 1966. As a result of the present survey, slight emendations to the mapped boundaries have been made and a slightly different structural picture has been postulated (fig. 27).

The geology of the area may be outlined as follows: folded Silurian quartzite and slate of the Mathinna Group occur just N of the area examined and are overlain unconformably by SW dipping Permian tillite, sandstone, siltstone and mudstone. The Permian sediments have been intruded by Jurassic dolerite, and basalt was extruded during the Tertiary and flowed down a SW trending valley that existed at that time. Drainage was diverted to either side of the basalt-filled valley and the main streams have since cut through some dolerite and are at present mainly entrenched in Permian sediments N of the dam site. Recent sediments occupy the floors of present day valleys, and talus, particularly that derived from dolerite, covers the underlying rocks on many of the slopes. Extensive faulting can best be seen from displacements in Permian rocks.

FIGURE 27



Permian

Longman (1966) divided the Permian in the Launceston Quadrangle into the following units:

Upper Permian	up to 650 ft
Liffey Group	100-150 ft
Lower Permian	130-725 ft

Longman mapped individual beds and sub-units in the Permian rocks in a number of localities some of which have been found in the area examined. The relatively poor exposure, except in road cuttings, and the low relief of the country where Permian rocks occur, precludes very precise mapping.

Lower Permian

The basal part of the Lower Permian is a tillite up to 150 ft thick (Longman, 1966) which crops out just N of the area examined. Overlying this is a dark grey, poorly bedded mudstone containing brachiopods and bryozoans towards the top of the sequence and also a few sandy beds. The mudstone weathers into small fragments with rounded surfaces. Longman records the thickness of this mudstone as 380 ft E of Lilydale and 300 ft N of Mt Barrow. In the Patersonia area it is probably of a similar thickness.

About 200 ft below the base of the Liffey Group there is a bed of richly fossiliferous siltstone (mainly with bryozoans) and at about 60 ft above it there is a pebbly sandstone bed again richly fossiliferous (with gastropods, brachiopods, bryozoans, etc.). This bed crops out in a number of places and between it and the Liffey Group are mudstone beds similar to those above the tillite.

Liffey Group

The Liffey Group is about 100 ft thick in the Patersonia district. The base, where exposed in St Patricks River, consists of about 1 foot of conglomerate, composed predominantly of quartz pebbles, followed by about 6 ft of grit and gritty sandstone. The uppermost part of the Liffey Group in the river section is a massive-bedded even-grained quartz sandstone overlying the grit and gritty sandstone. Exposures in the road cuttings do not always show the conglomerate at the base, but above the massively bedded sandstone is a section of thinly bedded feldspathic sandstone with abundant muscovite and carbonaceous matter on the bedding planes. A dark carbonaceous shale towards the top of the group usually contains a massive-bedded feldspathic sandstone with abundant worm casts at its top.

Upper Permian

The Upper Permian section is poorly exposed apart from an outcrop in a road cutting W of the bridge across Patersonia Rivulet. It consists mainly of blue-grey mudstone (which turns brown on weathering), containing various amounts of pebbles, sparse fossils and some sandstone bands. A dirty, pebbly sandstone band about 60 ft above the top of the Liffey Group contains *Conularia*. Another pebbly feldspathic sandstone bed 5-10 ft thick has been located in several places but its position within the sequence is uncertain. If there is a fault between the Liffey Group and this bed, it could be about 300 ft above the Liffey Group. If there is no fault it would be about 450 ft above the Liffey

Group. The full section of the Upper Permian does not occur in the Patersonia area because the top is intruded by dolerite. There appears to be at least 350 ft and possibly up to 500 ft of Upper Permian rocks beneath the dolerite contact.

Jurassic Dolerite

The dolerite is similar to that seen in other parts of the State. It is a dark grey, hard, medium-grained igneous rock which is resistant to weathering.

Apart from Eagle Hawk Tier, where there is a considerable thickness of dolerite, outcrops are few. Elsewhere, dolerite is mainly represented at the surface as boulders but it is likely that *in situ* dolerite occurs underneath. Except on Eagle Hawk Tier the dolerite appears to be a very thin, uneven sheet which has probably been eroded through in places, as indicated by its discontinuous nature on the plan. The whole dolerite sheet was probably continuous and was possibly as thick as that on Eagle Hawk Tier but erosion stripped most of it away before the basalt flow protected it. The irregularity could be produced by post-intrusive faulting: this aspect is discussed in the section on geological structure.

Tertiary Basalt

The basalt flowed down a Tertiary valley the course of which can be seen by referring to the map of the Launceston Quadrangle (Longman *et al.*, 1964). It was probably much more extensive than it is now, as it has been subject to erosion since Tertiary times. The basalt is a hard, almost black, fine-grained rock containing a variable number of vesicles and which is deeply weathered in places. Sediments (clay, sand and gravel) have been found underneath the basalt in such Tertiary valleys in other parts of the State. Although sediments underlying the basalt have not been seen in the Patersonia area, S of Eagle Hawk Tier, near the road, there are quartzite and conglomerate boulders near the contact of the dolerite and basalt.

Recent Sediments

Broad flats underlain by Recent sediments, consisting mainly of clay, silt and gravel, border existing streams. They are probably underlain by Permian sediments at varying depths in the vicinity of the dam site.

Dolerite and basalt talus cover large sections of some of the slopes.

West of the bridge over Patersonia Rivulet a small area of laterite of uncertain age occurs near the contact of the basalt and dolerite.

GEOLOGICAL STRUCTURE

Detailed structure is difficult to determine because of the relatively poor exposure, however some major faulting has been deduced, mainly from displacements of the Liffey Group. Five NW trending faults, marked F1, F2, F3, F4 and F5 (fig. 27, 28) have apparently moved about 120 to 300 ft. Small faults in road cuttings with similar trends, have been noted in a number of places and no doubt many obscured minor faults occur. F2, F3, F4 and F5 probably predate the dolerite intrusion, as they do not appear to displace the dolerite in some cases, and where there are changes in the level of the dolerite, it does not seem to be of the same order as the apparent fault displacement. Around F1 however, the level of the base of the dolerite changes quite sharply and this could be a post-intrusive fault. Disregarding questions of age, the area has been subject to widespread faulting.

The Permian sediments have a regular dip to the SW of 10°-15°, which is no doubt related to the faulting. The strike of the beds is parallel to the faults. The sections show the dolerite unaffected by faulting—only one of the two possible alternatives.

GEOLOGY AROUND THE DAM SITE

The dam would be built on dolerite, which occurs on both sides of the valley, providing its height did not exceed 50 ft, the level of the basalt/dolerite contact. There are Recent deposits of gravel, sand and silt of unknown depth in the stream bed. Upper Permian rocks probably underlie the Recent deposits although there could be some dolerite interposed. In the dolerite area the stream is confined in a narrow valley but the valley broadens N of the dam site where Permian sediments occur. Geophysical methods and/or drilling would determine whether dolerite or Permian sediments underlie the Recent deposits at the dam site. Upper Permian rocks underlie the dolerite just upstream on the E side and just downstream on the W side. Longman mapped Upper Permian sediments beneath the dolerite on both sides of the stream in the dam site area and his interpretation is probably correct, although no outcrops were found in this area during the present survey. The Permian sediments have of 10°-15° SW in the vicinity of the dam site and this direction of dip is roughly parallel to the axis of the dam.

Very little dolerite and basalt crop out in the vicinity of the dam site therefore there may be a considerable thickness of boulders and weathered rock before solid rock is reached. This would mean that fairly large quantities of material would have to be removed before bedrock was exposed during the construction of the dam.

It is unlikely that there is faulting along the stream channel, although the stream runs parallel to the main faults in the area. This alignment may be due to the prominent joint direction.

HYDROLOGY

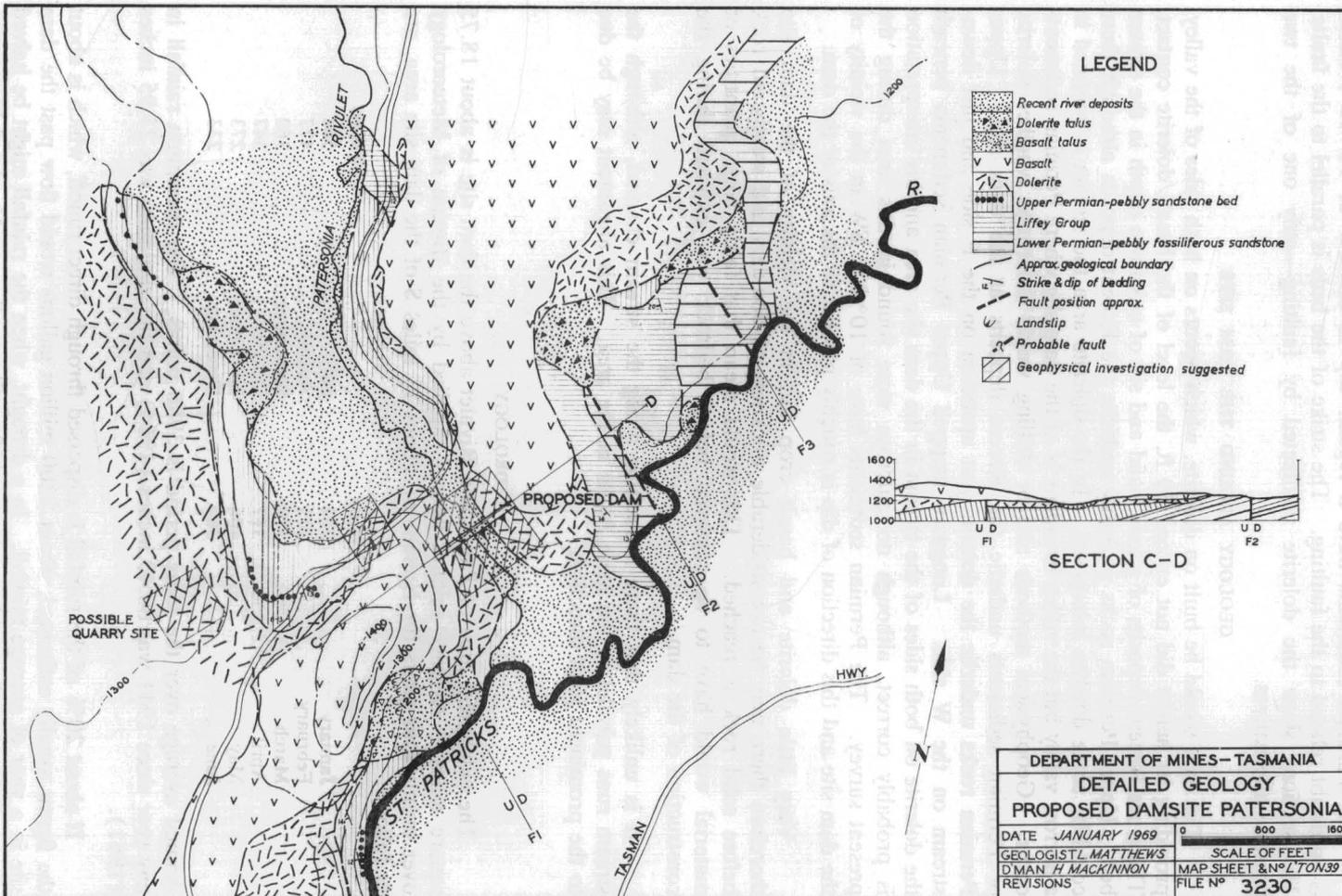
The catchment area of Patersonia Rivulet above the dam site is about 18.75 square miles. Average rainfall figures supplied by the Bureau of Meteorology over twenty-four years for Nunamara, about 1½ miles S of the dam site area, are as follows:

	<i>Points</i>		<i>Points</i>
January	224	July	568
February	233	August	477
March	178	September	360
April	317	October	347
May	406	November	273
June	369	December	233

Annual average over the same period is 3986 points. The maximum rainfall in any year since 1941 was 60.40 inches (1964) and the minimum was 23.95 inches (1961).

If about 20% of the rainfall is dispersed through direct runoff, which is about the figure usually estimated, about 2200 million gallons would flow past the dam site in a year of average rainfall. In a drought, when the rainfall might be halved the available runoff would be about 1100 million gallons. North of Nunamara

FIGURE 28



96

5 cm

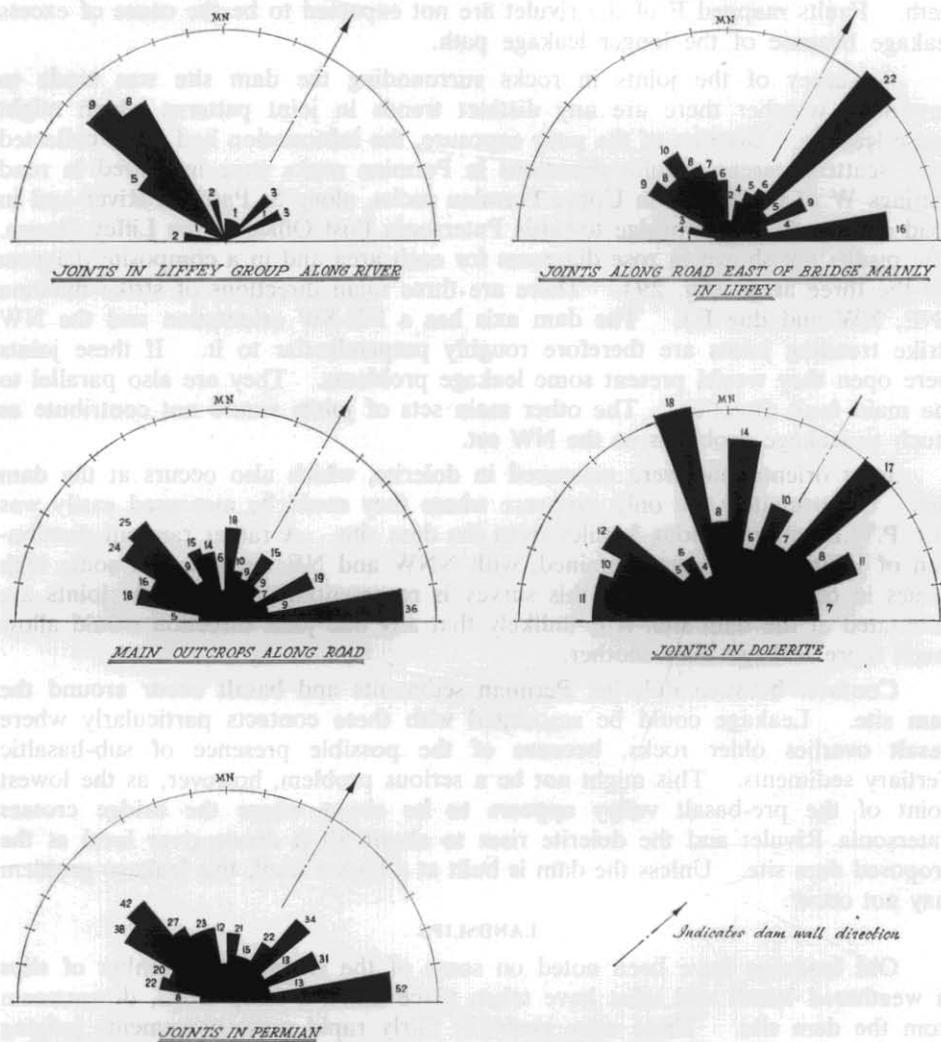


FIGURE 29. Rose diagrams of joint directions, Patersonia.

the average annual rainfall increases and at least part of the catchment area would be in the 50 to 60 inches per year rain belt. It could be expected from this that the desired quantities of water would be available.

If successive dry years were to occur and heavy drawing on the dam was necessary, loss of water through leakage would become important. There are a number of factors that could contribute to leakage. A series of NW-SE trending faults cut across the area and although none has been mapped as passing through the dam site itself, there may be other small faults which cannot be determined because of the poor exposure. It is not expected that much faulting later than the intrusion of the dolerite is present in the area because the base of the dolerite is at about the same level on either side of the dam site. The nearest probable

fault of any size is W of the rivulet and this would have a fairly short leakage path. Faults mapped E of the rivulet are not expected to be the cause of excess leakage because of the longer leakage path.

A survey of the joints in rocks surrounding the dam site was made to determine whether there are any distinct trends in joint patterns which might cause leakage. Because of the poor exposure, the information had to be collected from scattered areas. Joint directions in Permian rocks were measured in road cuttings W of the bridge in Upper Permian rocks, along St Patricks River and in road cuttings E of the bridge towards Patersonia Post Office in the Liffey Group. The results are shown in rose diagrams for each area and in a composite diagram for the three areas (fig. 29). There are three main directions of strike maxima (NE, NW and due E). The dam axis has a NE-SW orientation and the NW strike trending joints are therefore roughly perpendicular to it. If these joints were open they would present some leakage problems. They are also parallel to the main fault direction. The other main sets of joints would not contribute as much to leakage problems as the NW set.

Joint orientations were measured in dolerite, which also occurs at the dam site. Unfortunately the only exposure where they could be measured easily was in a P.W.D. quarry about 3 miles from the dam site. A rather random distribution of joint direction was obtained, with NNW and NE maxima and some high values in other directions. If this survey is representative of how the joints are orientated at the dam site, it is unlikely that any one joint direction would allow much more leakage than another.

Contacts between dolerite, Permian sediments and basalt occur around the dam site. Leakage could be associated with these contacts particularly where basalt overlies older rocks, because of the possible presence of sub-basaltic Tertiary sediments. This might not be a serious problem, however, as the lowest point of the pre-basalt valley appears to be about where the bridge crosses Patersonia Rivulet and the dolerite rises to about 50 ft above river level at the proposed dam site. Unless the dam is built at a higher level, this leakage problem may not occur.

LANDSLIPS

Old landslips have been noted on some of the slopes. A number of slips in weathered basalt and talus have taken place down a steep slope, downstream from the dam site. These were probably fairly rapid mass movements judging by the distance the material travelled and the nature of the slides.

On the E side of the Eagle Hawk Tier, there is a fairly large slip in weathered dolerite or dolerite talus in an area where the slope is low. The amount of movement on this slip is small and would have little effect had it occurred on a dam margin.

The slopes around the dam are not usually steep enough for the formation of large rapid moving slips. With the dam full of water, however, the water table will be raised in the surrounding area which may affect the stability of some of the talus. If the dam is to be built, a further examination should be made with this aspect in mind.

CONSTRUCTION MATERIALS

It is likely that both clay for the core and suitable rock fill could be obtained in the area. Clay could probably be found on the flats around the streams

upstream or downstream from the dam site. Drilling or the making of test pits will be necessary to prove this. The clay from these areas would need to be tested to determine its suitability for use in the core wall of a dam. Clay derived partly from Permian rocks was used in the construction of the Flagstaff Gully dam which subsequently failed. There are several possibilities for the supply of rock fill. The P.W.D. have a quarry a little over 3 miles from the dam site, near the highway to Launceston, but it might be too near the road for blasting operations. A suitable location for a quarry may be at the S end of Eagle Hawk Tier, where the land rises sharply and solid dolerite is close to the surface. Jointing is not very closely spaced and a lot of secondary blasting might be necessary. This may also be a problem at the P.W.D. quarry. A basalt hill W of the dam site may provide suitable rock fill material if it is not too deeply weathered.

CONCLUSIONS AND RECOMMENDATIONS

(1) From surface observations the building of the dam should present no insurmountable problems from a geological point of view.

(2) Calculations from rainfall figures and the catchment area suggest that water is available in the quantities required for storage.

(3) Materials of construction are probably available for a rock fill type dam, but this would have to be proved in the case of clay for the clay core, by drilling and sampling the flats around the streams. Geophysical work and some drilling would be required to find a suitable site for a quarry to supply the rock, unless an existing quarry could be used.

(4) Although the possibility of landslips on a scale likely to affect the safety of the dam appears remote, it is suggested that when the area which will be covered by water is determined, an examination of the margins be made with this aspect in mind.

(5) There are several factors which could contribute to leakage through the bedrock. These include the nature of the contacts between basalt, dolerite and Permian sediments, the joints in the Permian rocks that parallel the main faults and the faults themselves. Of those faults mapped the probable fault, F1, is the one that would allow most leakage. Smaller unmapped faults could also add to leakage problems. To estimate the amount of leakage and to determine whether any of these factors would cause a serious depletion of supply, water pressure testing in drill holes would be necessary. Resistivity surveys might locate faults more accurately than was possible from a surface survey.

(6) Because of the poor exposure some drilling around the dam site would be necessary to determine more precisely the geological structure and the nature of the rocks at depth.

(7) The slopes against which it is proposed to build the dam, are fairly deeply weathered and quite a lot of material might have to be moved before solid rock is found. Similarly the depth of Recent deposits in the stream channel is unknown. Seismic and/or resistivity surveys would probably indicate where solid rock occurs but this would need to be proved by drilling.

PART II. SEISMIC SURVEY AND AUGER DRILLING

SEISMIC SURVEY OF THE DAM SITE

Nineteen spreads, each with twelve geophones were fired from both ends. The lay-out of the spreads was in the form of three E-W traverses and three cross-spreads. The spreads along the centre line of the dam had a geophone spacing of 10 ft whilst all other spreads used a geophone spacing of 20 ft.

The results of this survey suggested that there were considerable depths of low seismic velocity material (about 1000-3000 ft/sec), underlying the slopes on either side of the rivulet (fig. 30). Depths of up to 30 ft of this material were indicated on each extremity of the centre line of the dam but thinning towards the creek to a depth of 4-8 ft. The bedrock underlying this low velocity material had a velocity of about 8000 ft/sec near the rivulet and decreased to about 6500 ft/sec away from the rivulet.

AUGER DRILLING

Following the discovery of the low seismic velocity zones it was apparent that the material underlying the abutments of the proposed dam was either very deeply weathered dolerite (as previously mapped) or else a soft sediment or talus. Auger holes were drilled to determine this. A number of holes were attempted but near-surface dolerite and basalt boulders (which would not affect the seismic velocities observed) prevented deeper drilling on many of the sites selected. However, three holes, one on the E side of the rivulet and two on the W bank were drilled to hard material at depth. Material that the auger drill was unable to penetrate would be expected to correspond with the 6000-8000 ft/sec material mentioned above. Each of these holes was sited about 30 ft above creek level. The hole on the E side was just N of the northernmost seismic traverse line and the two on the W of the creek were on either side of the middle traverse and about 105 ft apart (fig. 31). The following results were obtained:

Hole A

0- 2 ft	Brown clay and basalt boulders.
2- 3 ft	Grey-blue clay.
3- 7 ft	Blue-grey clay, some fairly hard siltstone fragments.
7- 9 ft	Sandy silt.
9-18 ft	Clay and some siltstone fragments.
18-22 ft	Brown sandy clay with a few small pebbles.
22 ft	Too hard to drill.

Hole B

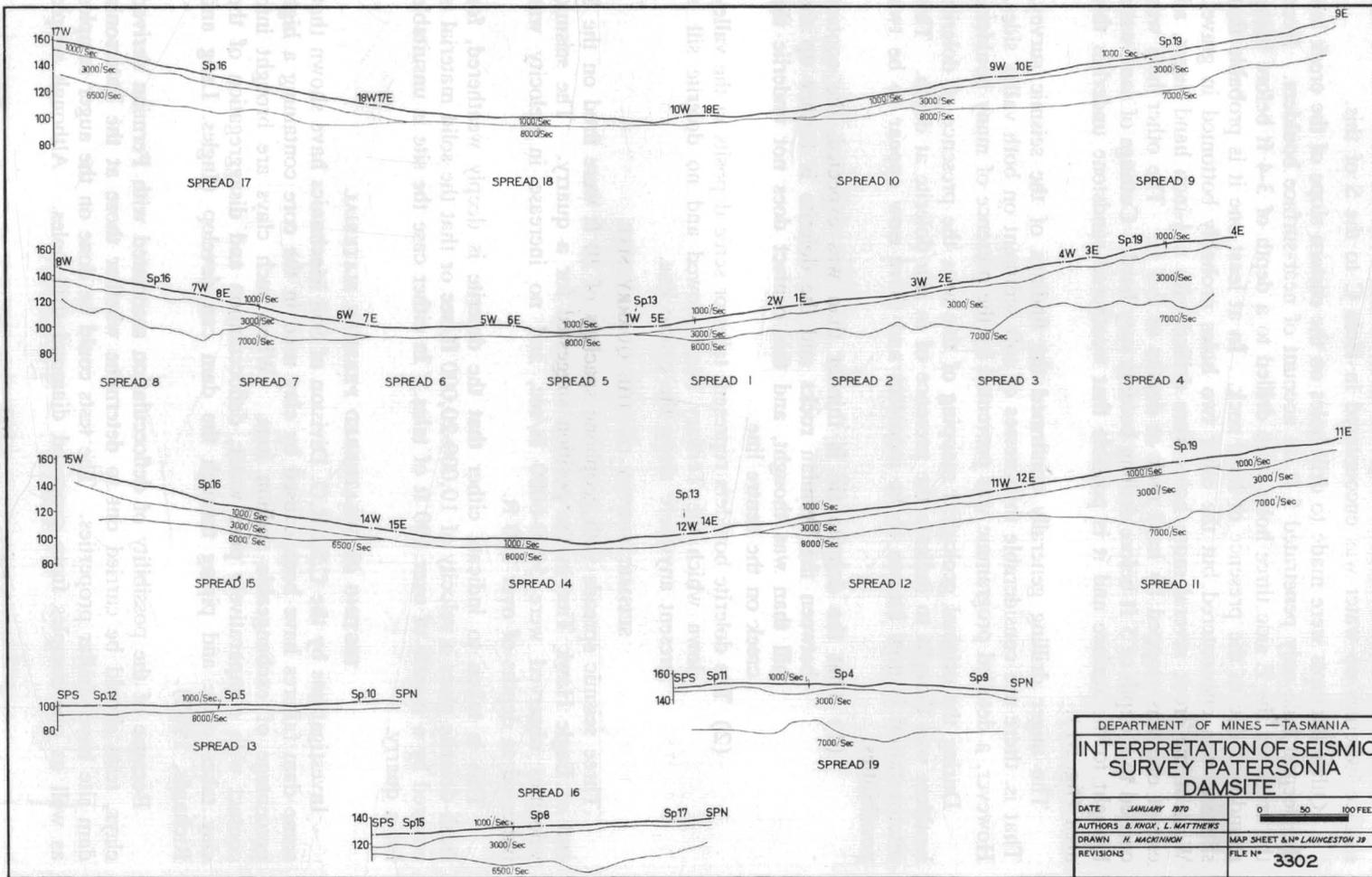
0- 3 ft	Dark grey-brown plastic clay.
3- 6 ft	Dark clay with a few pebbles.
6-18 ft	Light brown silty clay.
18-21 ft	Bluish sandy clay.
21-24 ft	Dark blue clayey material, with one thin sandstone bed.
24 ft	Too hard to drill.

Hole C

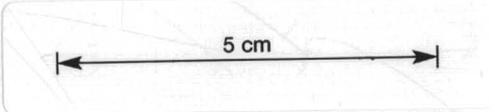
0- 3 ft	Dark brown plastic clay.
3- 6 ft	Clay and siltstone fragments.
6-18 ft	Light brown soft sandstone and siltstone fragments (in the section from 15-18 ft, some small fragments of dolerite were obtained possibly due to caving from the surface).
18-24 ft	Clay with some pebbles.
24 ft	Too hard to drill.

FIGURE 30

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DEPARTMENT OF MINES — TASMANIA	
INTERPRETATION OF SEISMIC SURVEY PATERSONIA DAMSITE	
DATE	JANUARY 1970
AUTHORS	B. ENOX, L. MATTHEWS
DRAWN	H. MACKINTOSH
REVISIONS	
MAP SHEET & NO.	LAUNGESTON J9
FILE NO.	3302



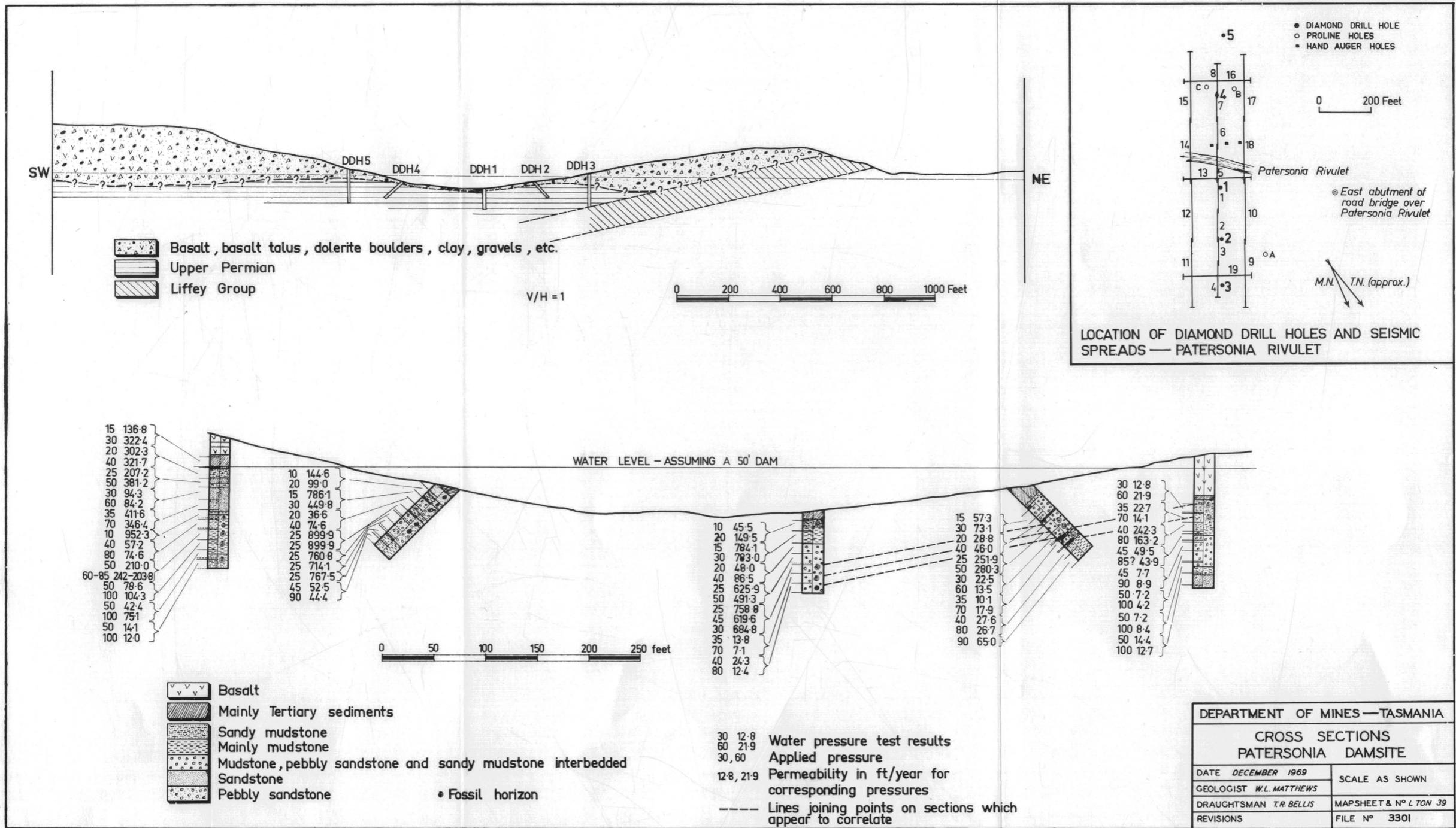
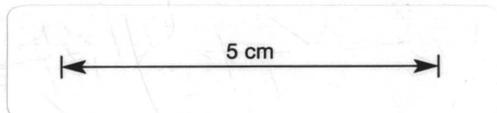


FIGURE 31

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Water was struck at shallow depth in Hole B and later the level rose to the surface, whereas no water was encountered in Hole C to the S of this.

Other attempts were made to drill holes on the eastern slope of the creek but the deepest hole only penetrated 5 ft on account of near-surface boulders. Near the creek on the E side three holes were drilled to a depth of 3-4 ft before being abandoned due to the presence of hard rock. In at least one it is probable that siltstone was encountered but the other two holes probably bottomed in gravel. West of the creek several more holes were drilled with a $\frac{1}{2}$ -inch hand auger, all except one was stopped by hard rock at depths of 2-3 ft. The other hole was carried to a depth of 5 ft before drilling became very hard. Cuttings of sand were brought to the surface and it is possible that weathered sandstone underlies this area (fig. 31).

The auger drilling generally confirmed the findings of the seismic survey. That is, there are considerable thicknesses of soft sediment on both valley sides. However, a detailed programme was prevented by the presence of many boulders.

During the original geological mapping of this area the presence of dolerite boulders was thought to indicate the presence of *in situ* dolerite at depth. This interpretation is now known to be incorrect and there now appear to be two possibilities:

- (1) That the dolerite sill is thinner than was expected, the contact between the Permian rocks and the dolerite is farther up the hill than was thought, and this contact does not underlie the creek on the centre line.
- (2) The dolerite boulders represent talus or scree deposits in the valley down which the Tertiary basalt flowed and no dolerite sill is present anywhere along the centre line.

SEISMIC SURVEY OF THE QUARRY SITE

Three seismic spreads with geophone spacings of 20 ft were fired on the S end of Eagle Hawk Tier in the position suggested for a quarry. The seismic velocities observed were 5000-6000 ft/sec, and no increase in velocity was indicated at depths of over 100 ft.

This is taken to indicate either that the dolerite is deeply weathered, for fresh dolerite gives a velocity of 10,000-20,000 ft/sec or that the solid material is covered by a mantle of over 100 ft of talus. In either case the site is unsuitable for a quarry.

TESTING OF WEATHERED PERMIAN MATERIAL

Investigations by the C.S.I.R.O. Division of Soil Mechanics have shown that some dam failures have been caused by clay used in the core containing a high percentage of exchangeable sodium ions. When such clays are brought into contact with comparatively pure water, deflocculation and disaggregation of the clay takes place and piping through the dam can develop (Ingles, Lang and Richards, 1968).

Because of the possibility of deflocculation associated with Permian derived clays, tests should be carried out to determine whether those at the Patersonia dam site have similar properties. The tests could be done on the auger samples as well as one samples from proposed diamond drill holes. Although simple

tests can be made as described by Reilly (1967) samples should also be submitted to the Soil Mechanics Division, C.S.I.R.O. where the physical and chemical nature of the material can best be studied.

CONCLUSIONS

The following conclusions can be drawn from the investigations:

- (1) Unweathered Permian siltstone and sandstone lies beneath the dam site, below creek level, and is at or below 24 ft in holes B and C and 22 ft in hole A. It is probable that the depth to this rock will be greater further up the hill on both sides. The unweathered rock appears to slope at a much gentler angle than the present surface, and the bedrock valley will be wider than the present surface.
- (2) The bedrock is overlain by weathered talus derived from Permian rocks and this is overlain in turn by dolerite and basalt boulders and by surface soil. This softer material forms the major part of the slopes along the centre line. It is possible that the weathered talus material is sensitive to deflocculation by fresh waters and tests are recommended.
- (3) The quarry site as the S end of Eagle Hawk Tier is unsuitable.

RECOMMENDATIONS

Diamond drilling

The initial problem to be solved is whether the soft material of the side slopes can be formed into the abutments of the dam. It is suggested that five diamond drill holes (NMLC) be drilled, with continuous coring, along the centre line and that these holes should be water pressure tested. Two of them should be placed, one on each abutment at least 10 ft above the proposed top water level, their aim being to determine (i) whether or not a dolerite sill exists along the centre line; (ii) what is the nature of the soft material that forms the slopes; and (iii) the nature, lithology, jointing and state of weathering and consolidation of the bedrock. These holes would total 120 ft each and should be vertical.

Two further holes should be placed half-way from top water level to the creek and should be inclined into the slope at 45° . These would again test the nature of the soft material and bedrock. The two holes would total 85 ft each. One vertical hole should be drilled at creek level to 80 ft, mainly to test bedrock.

These five holes will provide samples and information on rock types and will enable the decision to proceed to be made.

It is felt that the nature of the abutments is sufficiently important that this part of the investigation should be completed and reported on before further work is contemplated. Detailed recommendations for further work could then be given.

These would include investigation of possible spillway sites, detailed work on permeabilities of the soft and hard rocks, siting of a new quarry, and the investigation of the course of the pre-basalt valley which could form a leakage path.

PART III. DIAMOND DRILLING

DETAILS OF DRILLING RESULTS

The position of each drill hole is marked on Figure 31. Holes 1, 3 and 5 were drilled vertically, Holes 2 and 4 were inclined at 45° to the NE and SW respectively, along the axis of the dam.

Hole 1

The first 6-7 ft penetrated dolerite boulders with some clay. Below this level the drill entered Permian rocks which consisted of interbedded grey mudstone, sandy mudstone and minor sandstone bands with mica. Pebbles were noted at some horizons below about 30 ft. Fossils occurred at four main horizons and consisted mainly of bryozoans with some brachiopods in one zone. Calcite was common on joint planes, bedding planes and in the matrix of the coarser grained beds, throughout the Permian. Some thin, weathered zones were noted.

Hole 2

The top 15 ft 7 in consisted of dolerite boulders, quartz pebbles, sand and clay, the lower part consisting of clay with quartz pebbles which might be weathered Permian. Undoubted Permian rocks were entered at about 15 ft 7 in. As in Hole 1, these rocks consisted of mudstone, sandy mudstone and thin sandstone beds. The upper 39 ft of the core was limonite-stained; the lower boundary probably represents the lowest level of the water table. Pebbles and fossils occur at some horizons. Calcite was noted in the lower levels of the holes and a 9-inch limestone band occurred at about 72 ft 6 in.

Hole 3

This hole was commenced in basalt boulders and entered weathered, and broken unweathered basalt to about 38 ft. Recovery was poor around this depth but some grey and brown clay was obtained to 42 ft 4 in at which depth undoubted Permian sediments were penetrated. Again mudstone, sandy mudstone with subordinate sandstone beds were encountered which contained pebbles and fossils at some horizons to a depth of about 115 ft 8 in. Several limestone bands were noted and calcite was common on joints, bedding planes and in the matrix of the coarser grained beds. These rocks were limonite-stained to a depth of about 50 ft. At about 115 ft 8 in pebbly sandstone was encountered and continued to the bottom of the hole (127 ft 10 in). Abundant worm tracks characteristic of the Liffey Group occur in the bottom 6-7 ft of the core.

Hole 4

Dolerite boulders, occasional quartz pebbles and dark brown clay were encountered to a depth of 6 ft 6 in. Undoubted Permian rocks occur below this level to about 74 ft 8 in and consist of sandstone with subordinate sandy mudstone and mudstone. Pebbles were fairly common throughout and except for the bottom 8-10 ft the beds were fossiliferous. These rocks were stained with limonite to about 32 ft from the surface. Calcite and a little pyrite were noted in parts of this section. Some zones towards the bottom of this section were soft and broken. After 74 ft 8 in a 3-foot band of clay with many glide planes, was encountered above mudstone and sandy mudstone. A 2-inch pyrite nodule occurred towards the bottom of the hole.

Hole 5

Basalt boulders and weathered basalt were drilled to a depth of about 18 ft followed by a thin band of quartzite, gravelly clay, quartz gravel and dolerite boulders to about 31 ft 6 in where Permian rocks were encountered. To 73 ft 8 in in the Permian sediments consisted of unfossiliferous sandstone, sandy mudstone and mudstone beds. Pebbles and mica were fairly common throughout; most of the limonite staining ends at 52 ft but some joints are stained to 62 ft. After 73 ft 8 in richly fossiliferous beds of mudstone, sandy mudstone and limestone were drilled to the final depth of 129 ft. Slip surfaces were noted at several places in this interval as were occurrences of pyrite and lime-rich sections.

The Permian beds consist of interbedded mudstone, sandy mudstone, and dirty sandstone so that it has not been possible to correlate individual beds on lithology alone. However there are some thin zones which are richly fossiliferous and it has been possible to make correlations between the three holes on the E side of the rivulet on this basis. Measurements of bedding plane dip on core samples indicate an average dip of about $12\frac{1}{2}^{\circ}$. The dip direction cannot be determined from the core, but dips measured from outcrops surrounding the dam site area indicate that the regional dip is $12\frac{1}{2}^{\circ}$ SW and it seems likely that this is the dip direction of the Permian along the axis of the dam. This is confirmed by the correlations made between the drill holes.

Sandstone of the Liffey Group crops out E of Hole 3 (see geological map, fig. 28 and section fig. 31) and the top of the Liffey Group was struck in this hole. Examination of levels suggests that the Liffey Group dips from these surface outcrops to the bottom of Hole 3 at the regional dip with little or no displacement by faulting. If correlations between Holes 3 and 1 are correct, then there is little or no displacement between these holes.

Assuming a dip of $12\frac{1}{2}^{\circ}$ SW over the whole dam site area, the top Permian bed in Hole 1 would occur at about 50 ft below the bottom of Hole 4, so that unless there is a fault between these holes, equivalents of the beds in Hole 1 would not occur in Hole 4. The cores show a little lithological similarity. Assuming again a dip of $12\frac{1}{2}^{\circ}$ SW and no faults there should be a considerable overlap between the sequences in Holes 4 and 5. Although there are comparable thicknesses of richly fossiliferous beds in the two holes, the lithologies of these beds are markedly different. There are abundant slip surfaces in the cores from these holes and faulting has probably eliminated overlap between the respective sequences.

WATER PRESSURE TESTING

Testing of the upper sections of each hole was not possible with the equipment available, because of the loose nature of the material.

Fairly high permeabilities were calculated for certain sections in several of the holes. In Holes 1, 4 and 5, the pump used in the tests did not have the capacity for the recommended pressures to be reached in some sections. During the drilling of Hole 4 there was a section of the hole where there was no water return and in a section of Hole 5 only about 50% of the water returned to the surface. The larger water losses in Holes 4 and 5 are probably due to the presence of sandstone together with fracturing associated with faulting.

All holes finished in rocks which had comparatively low calculated permeabilities.

DISCUSSION OF DRILLING RESULTS

The diamond drilling, together with the auger drilling which was done previously, has shown that the geology of the area differs in some respect from that outlined in the original report (Part I). It was though originally that the dolerite boulders in the area were the result of the weathering of a sill intruding the Permian sediments. It has now been established fairly conclusively that these boulders (in the dam site area in particular) are pre-basalt talus deposits in the valley down which the basalt flowed.

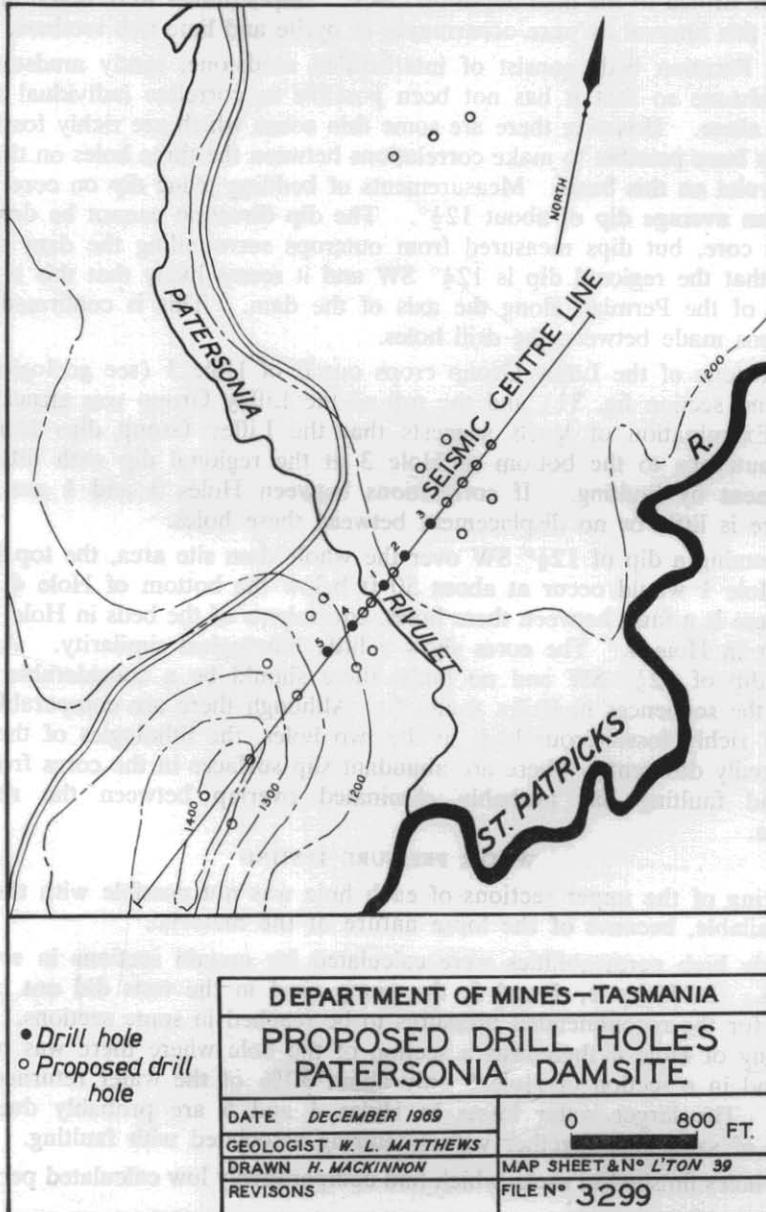
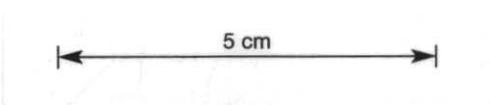


FIGURE 32



In the first interpretation, it was considered that the dam would be built against Permian sediments overlain by intruding dolerite and the investigation of the site as to its suitability as a dam site would be fairly straightforward. The drilling shows that other materials form part of the abutments because the pre-basalt valley extends to lower levels at points on the dam axis, than at first thought. To investigate the site completely will therefore require more drilling than was originally envisaged. This drilling would determine the extent and directions of the lows of the pre-basalt valleys and would also determine the permeability of the material filling these valleys.

FUTURE INVESTIGATIONS

The following work would be required to complete a feasibility study of the dam site (fig. 32).

Drilling in the Permian

The section between Holes 1 and 4 is incomplete and in order to determine whether faulting is present two holes, each 80-100 ft deep, are suggested; one vertical and one inclined at 45° SW along the axis of the dam.

Further investigation is required upstream and downstream of Holes 4 and 5 because of the presence of faulting in this area. Two holes upstream and two holes downstream from the centre line, all inclined at 45° SW are suggested. These should be deep enough (100-150 ft) so that definite correlations between boreholes can be made in this area.

Some fairly high water losses occurred in Hole 1 and a hole (say 80-100 ft deep) E of Hole 1 at 45° NE along the axis of the dam in order to determine the extent of this leakage is suggested.

If no faulting is found between Holes 1 and 4 these seven extra holes should be adequate for the investigation of this portion of the dam foundations. Water pressure testing would need to be carried out in all holes.

Drilling to investigate pre-basalt valleys

About eight holes would be required to determine the extent and permeability of material filling the pre-basalt valley on the E abutment (e.g., four or five holes along the axis, two holes N of the axis and one or two holes S of the axis of the dam). These holes would all need to be drilled into the underlying Permian sediments.

Leakage through material filling pre-basalt valleys is unlikely to be as great on the W side of the rivulet as on the E. However the lowest part of the old valley is upstream from the dam site and it appears to cross the axis of the dam SW of Hole 5. If the valley continues in the direction suggested by the distribution of the basalt (i.e., south-westerly), leakage would probably not be very important because of the long leakage path. If however the valley meanders, or there is a side valley towards the area where landslips were mapped originally, leakage in this area could become important if the material overlying the Permian is very permeable; four or six holes are suggested in this area and each should be extended into the Permian. It is possible that some *in situ* dolerite might be struck in this area.

There is a possibility that a valley was eroded into the Permian rocks around the fault E of the dam site (F2 on the original plan). Although the leakage path would be comparatively long two or three holes are suggested to test whether such a valley exists and whether significant leakage would occur.

Where significant leakages are found to occur from pressure testing, the possibility of grouting should be examined and trial grouting attempted where the country rock is suitable. It seems likely that some of the Permian will require grouting.

Apart from the above drilling requirements, investigations into finding suitable material for the construction of the dam would be required. A suitable quarry site would have to be found and it is expected that at least three or four diamond drill holes would be required to prove that sufficient material of the required quality is present. If the dam is to have a clay core, suitable material might be present in the dam site but shallow drilling and testing of the material would be necessary to prove this.

Some attention should be given to other possible problems such as clay seams in the Permian (e.g., the 3-foot seam in Hole 4 which might occupy a fault plane) and limestone in the Permian. Although most of the intersections of limestone are probably through nodules and lenticular deposits of limestone as in other areas, some of the limestone bands in Hole 5 were fossiliferous and could extend for some distance laterally. The possibility of solution of this limestone should be examined.

REFERENCES

- INGLES, O. G.; LANG, J. G.; RICHARDS, B. G. 1968. *Pre-equilibrium observations on the reconstructed Flagstaff Gully dam*. Division of Soil Mechanics, C.S.I.R.O.: Syndal.
- LONGMAN, M. J. 1966. One mile geological map series. K/55-7-39. Launceston. *Explan. Rep. geol. Surv. Tasm.*
- LONGMAN, M. J.; MATTHEWS, W. L.; ROWE, S. M. 1964. Geological atlas. 1 mile series. Zone 7 sheet No. 39 (8315S). Launceston. *Geol. Surv. Tasm.*
- REILLY, L. A. 1967. Chemistry aids farm dam construction. *Aqua* 18(11): 249-254.