Section 2: Engineering Geology

7R15-47-54

12. Further report on Deep Creek dam site

W.L. Matthews

PART 1. RESULTS OF AUGER DRILLING

Fourteen auger holes were drilled along the centreline of the proposed dam and 6 holes were drilled in the storage area. Water pressure tests were carried out in each hole but figures are only approximate due to the crude method used. Samples were collected from some of the holes and tested for possible dispersion of the clay in distilled water and water from Deep Creek.

DRILLING RESULTS

It was possible to case the auger holes as drilling proceeded and there could be some contamination by material falling from higher levels in the holes. There was often little or no sample return from the lower levels of the holes and the material that stuck to the augers was examined after their removal. See Figures 11, 12.

East Abutment (Holes 1, 2)

Material obtained from these holes consisted mainly of clay with some quartz and rock fragments. Quartzite and sandstone fragments were obtained from Hole 1 and some weathered igneous-like fragments from Hole 2. The material from these holes could be weathered, *in situ*, rock or transported material.

Flat between the East Abutment and the Hill (Holes 3, 4, 5)

Gravel and clay were struck in these holes. A gravel bed appears to occur fairly consistently at 2-4 m below the surface. Samples indicate that it is 0.3-1 m thick.

The material from the top part of each of these holes is almost certainly of Tertiary-Recent age but below c.4 m it could be weathered bedrock (*i.e.* Precambrian). Hole 5 appears to have entered fairly definite bedrock at c.6 m.

Hill in the middle of the Valley (Holes 6, 7, 8)

Sand, clayey sand, sandstone and quartzite fragments were encountered in these holes. This material could either be *in situ* weathered rock (quartzite) or Tertiary-Recent deposits derived from weathering of the quartzite. A small amount of clay is present throughout all of these holes.

Flat between the Hill and the West Abutment (Holes 9, 10, 11, 12)

Material from these holes consisted of clay, sandy clay and gravel. The material from the upper part of the holes is of Tertiary-Recent age, but the lower sections could be of *in situ* weathered rock. Holes 11 and 12 ended in material which could be bedrock. The section west of Deep Creek is very swampy and it was impossible to drill in this area.

West abutment (Holes 19, 20)

Clay, silty clay and gravelly clay were obtained from these holes. This material could either be weathered *in situ* rock or a Tertiary - Recent deposit.

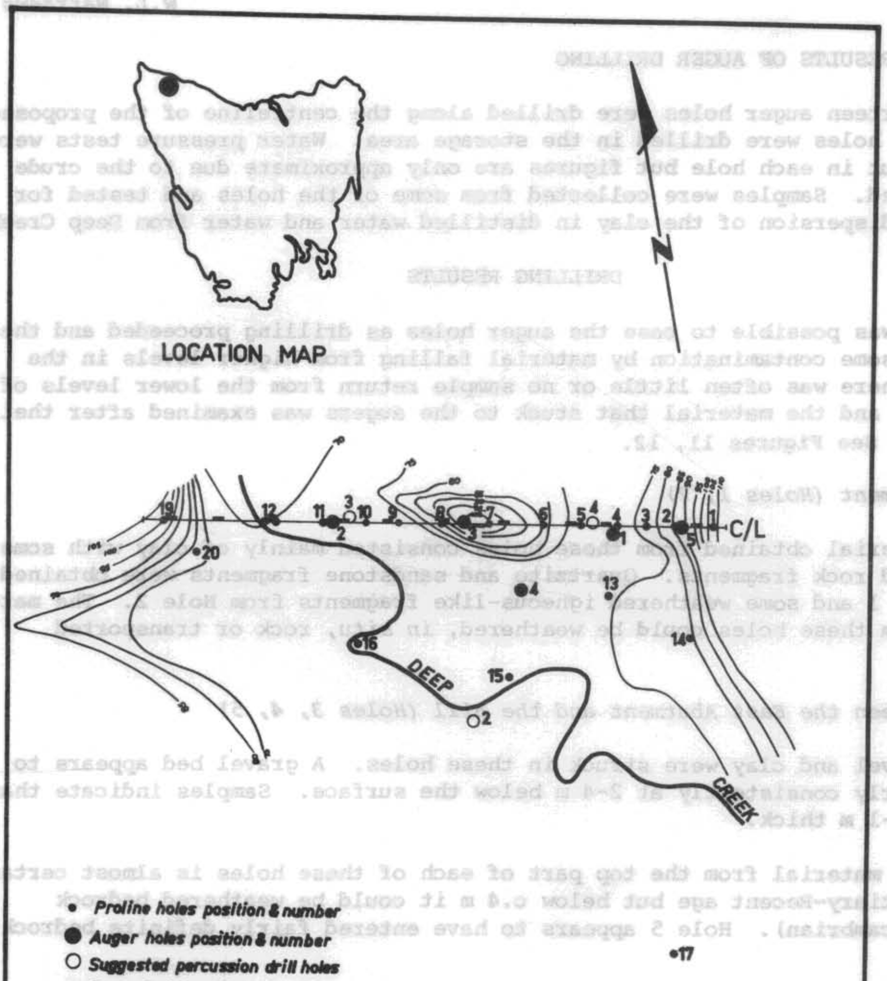
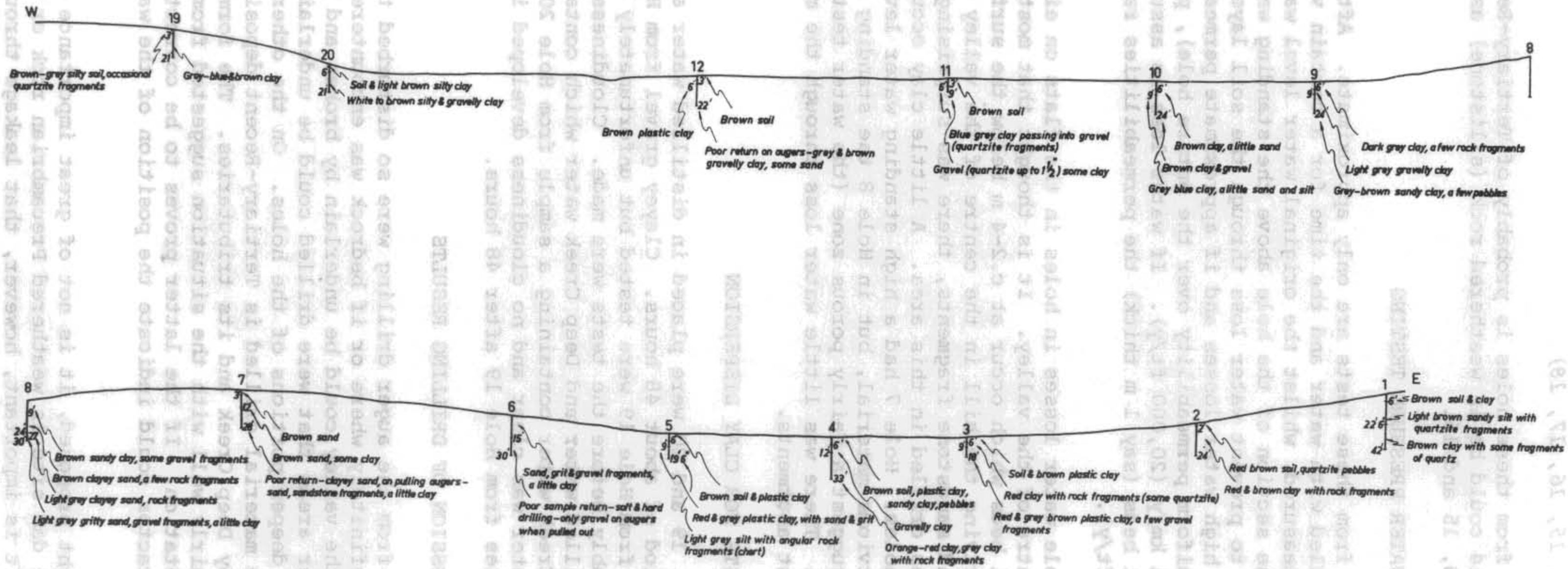


Figure 11. *Drilling and trenching, Deep Creek dam site.*

5 cm



SECTION ACROSS DAMSITE CENTRE-LINE DEEP CREEK

0 50 100 150 200 FT
0 20 40 60 M

Geologist W. L. Matthews

Figure 12.

5 cm

Storage Area (Holes 13, 14, 15, 16, 17, 18)

Much of the material from these holes is probably of Tertiary-Recent age although most of Hole 14 could be in weathered rock (siltstone) as could the lower parts of Holes 13, 15 and 16.

WATER PRESSURE TESTING

The figures obtained from these tests are only approximate. After drilling, each hole was filled with water and the time for a certain volume of water to disappear was measured, whilst the original water level was maintained. Where possible, the section of the hole above the standing water level was sealed with clay to prevent water loss through the soil layer. Some of the holes had very high water losses and if approximate permeabilities are calculated (assuming uniform permeability over the entire hole), permeabilities range up to c.6.1 km/y (20,000 ft/y). If water loss is assumed to occur through the gravel beds (say 1 m thick) the permeabilities range up to c.24.4 km/y (80,000 ft/y).

There were considerable water losses in holes in the flats on either side of the hill in the centre of the valley. It is thought that most of this loss is through gravel beds which occur at c.2-4 m below the surface. Although the material underlying the hill in the centre of the valley consists of sand, quartzite and sandstone fragments, there was surprisingly little water loss from holes drilled in this area. A little clay occurred in most sections of these holes. Hole 7 had a high standing water level which suggests fairly impervious material, but in Hole 8 the standing water level was low which could suggest a fairly porous zone (the water test did not support this, however). There was little water loss through the material underlying the east and west abutments.

TESTS FOR CLAY DISPERSION

Samples from Holes 8, 19 and 20 were placed in distilled water and Deep Creek water for a period of about 48 hours. Clayey gravel from Holes 8 and 20, and plastic clay from Hole 19 were tested but unfortunately the samples had dried considerably before the tests were made. Cloudiness had developed in both the distilled water and Deep Creek water which contained samples from Hole 8; Deep Creek water containing a sample from Hole 20 was cloudy but the distilled water was clear and no cloudiness developed in either water type containing samples from Hole 19 after 48 hours.

DISCUSSION OF DRILLING RESULTS

The samples obtained from the auger drilling were so disturbed that it is not possible to state definitely where or if bedrock was encountered. The hill in the middle of the valley could be underlain by broken and weathered quartzite and the other areas that were drilled could be underlain by weathered siltstone in the deeper portions of the holes. On the other hand, it is possible that all the material drilled is Tertiary-Recent deposits which are being dissected by Deep Creek and its tributaries. The former possibility would tie in fairly well with the situation suggested from the seismic survey and interpretation. If the latter proves to be correct, the 1,500 m/s (5,000 ft/s) refractor could indicate the position of the water table.

For a dam of the height proposed, it is not of great importance whether the material underlying the dam site is weathered Precambrian rock or Tertiary to Recent deposits. It is important, however, that leakage through the material is low and that it does not have properties which could cause the dam to fail. Several holes indicated that water loss could be great and there are suggestions from the samples tested that some of the clay will disperse when in contact with fairly pure water. The dispersion tests that have been made should not be taken as final and more sophisticated tests should be made (*e.g.* by the C.S.I.R.O. Soil Mechanics Section) to determine whether dispersion could be a problem or not.

The drilling did not determine whether or not dolomite underlies the storage area. In some holes, gravel prevented further drilling and in others, clay occurred to the greatest depths drilled. A surface layer of brown plastic clay about 2 m thick underlies most of the storage area and the flats along the centre line.

CONCLUSIONS AND RECOMMENDATIONS

(1) Leakage through near-surface gravels in the flats is a distinct possibility but a cut-off to the base of these gravels should reduce the amount of leakage considerably. Trenching with a back hoe is suggested so that gravel beds can be examined *in situ* and also to prove whether impervious material occurs underneath.

(2) Trenching is also suggested on both abutments and on the hill in the middle of the valley. These trenches should be tested for water loss and samples of the material excavated should be tested for possible clay dispersion.

Trenches in all areas need not be extensive laterally but should be 3-4.5 m deep if possible. Suggested positions are marked on the accompanying plan.

(3) The drilling has not established that dolomite is absent from the dam site and storage area. From regional mapping, it was thought that siltstone would underlie the storage area and that samples brought up by the auger drill would be easily recognisable. The geology suggests that dolomite is unlikely to occur but there is still some doubt. Sink holes have not been seen in any part of the dam site area which suggests that if it does occur, the development of solution cavities and channels has not been great. The surface clay layer which appears to cover most of the storage area should give some protection from leakage to possible dolomite beds underneath and also to gravel beds. However, it is suggested that two percussion holes to be drilled in the storage area to establish the underlying rock type. These holes could also be used to examine whether deeper gravel beds occur. If these holes prove inconclusive two more holes could be drilled along the centre line: one on each side of the hill in the centre of the valley.

The above investigations should prove whether there are any geological factors that would make the dam site unsuitable.

PART 2. RESULTS OF PERCUSSION DRILLING

Four holes were drilled in the dam site area to determine the nature of the Tertiary-Recent beds overlying the basement rocks and to establish the type of underlying bedrock. A drive pump was used to collect the samples from the upper sections of each hole and casing was driven as drilling proceeded to prevent contamination of lower samples by material falling from above. The logs of these holes are given below. The location of the drill holes is shown in Figure 11.

DISCUSSION OF DRILLING RESULTS

The drilling shows variable, and in some areas considerable, thicknesses of Tertiary-Recent material overlying bedrock. In Hole 1 this material consists of clay and clay with gravel fragments for most of the section. It is not known whether these fragments are isolated in the clay or whether they occur as thin beds of gravel separated by beds of clay. A fairly concentrated amount of gravel fragments occur from 1.5-3 m and from 4-7 m. There is also a gravel bed above the basement rock consisting of quartzite and chert fragments. This gravel has a fairly high permeability since the hole made quite a lot of water as this horizon was being drilled. The bedrock is dolomite.

Material from Holes 2, 3 and 4 is similar to Hole 1 in that there is a clay layer followed by a shallow zone with abundant sand and/or gravel. Gravel fragments are less common at lower levels except that a water-bearing gravel occurs on top of bedrock in Holes 2 and 3. A clay which is probably weathered Tertiary basalt occurs in Hole 2 from 11-12 m, in Hole 3 from 3-6 m and in Hole 4 from 6-20 m. The bedrock in Hole 2 consists of chert, in Hole 3 of quartzite and Hole 4 did not reach bedrock but ended in interbedded clay and gravel beds underlying the weathered basalt.

PROGRESS OF THE INVESTIGATIONS

After the geological and seismic surveys, it was thought possible that basement in the form of weathered or jointed rock would occur at relatively shallow depths. Auger drilling with a Proline rig was carried out to determine the nature of the superficial deposits and also to identify the bedrock. It was found that basement was deeper than expected. The shallow refraction obtained during the seismic survey was probably caused by the water table instead of weathered rock. Rather crude water loss tests were performed in each hole and some holes showed considerable water losses. From the material drilled, it appears that much of this was through sand and gravel zones at a depth of c.2-4 m below the surface. Relatively small water losses were observed in holes on each abutment and on the hill in the centre of the valley. Some clay dispersion was suggested in samples taken from holes in these areas.

It was recommended that further holes be drilled to determine more exactly the lithology of the superficial deposits (particularly the lower levels) and the nature of the bedrock in the dam site area.

This drilling showed that several different kinds of rock form the bedrock (including dolomite) and that there are other gravel zones in the sequence of superficial material, in particular on top of bedrock.

CONCLUSIONS

It is not possible to put a cut-off to the level of the bedrock, (up to 25 m) so that the material overlying bedrock must be relied upon to prevent leakage from the dam. Further investigations into the suitability of the area for a dam should be directed at examining these deposits. The section obtained in one borehole is unlikely to be representative of the whole storage area. In the flats along the dam centreline and nearby areas, the general near-surface sequence appears to be a clay layer of 1.5-2 m at the surface followed by zones with gravel and sand with clay from c.2-4 m under which there appears to be clay with pebbles (or thin gravel beds) which probably has a low permeability. It is unlikely that this sequence will continue over the whole storage area. It is possible that any of these materials could grade laterally into other rock types (*e.g.* clay beds into sand and gravel beds and vice versa). In fact there does appear to be more gravel in the holes drilled in the southern part of the storage area than the northern part. If gravel beds were to thicken in any direction and extend to the surface, considerable water loss could occur through gravels which were too deep to be affected by the cut-off (*e.g.* the gravel bed that has been struck on top of the bedrock in some areas). The presence of dolomite in the storage area raises the possibility of similar water losses along solution channels.

To ensure that appreciable leakage will not occur from the storage area, it must be shown that a clay bed of the necessary thickness extends over the whole storage area. At the moment the most likely possibility appears to be the surface clay, which in most areas drilled so far, is on average, 1.5-2 m thick but many more holes would be required to prove its continuity.

RECOMMENDATIONS

(1) The surface clay should be investigated to determine its lateral extent and consistency. This would require the drilling of a large number of holes on a grid system. They could be drilled with an auger type drill but would require careful filling in, to prevent any chance of leakage. The spacing could perhaps be increased if resistivity surveys are first conducted over the area but even so, assuming the storage area is about 810 ha (200 acres) in extent somewhere between 50 and 100 holes would probably be required. These holes need only be drilled to a maximum depth of about 3 m. Particular attention should be given to areas where basement rock is near the surface *e.g.* around the margin of the storage area and around the small hill about 400 m south of the centreline of the proposed dam.

(2) Further investigations should be carried out along the centreline.

(*a*) Trial pits 5 m deep should be dug at intervals along the centreline, (i) so that the shallower sand and gravel zones can be examined *in situ* (ii) to determine whether they were only cause of water loss from the Proline holes, and (iii) prove whether the cut-off through the zones of gravel and sand can be founded on impermeable material underneath. There might be gravel that extends deeper than it is economic to put a cut-off, or the weathered basalt could allow some water loss where it comes close to the surface. Once it is established that the surface clay extends over the storage area, a cut-off to the base of the sand and gravel zones will prevent water loss that seeps through the surface layer into these beds which appear to occur fairly consistently around the centreline and probably extends over wider areas.

(*b*) Samples from some of the holes on the abutments and the hill in the middle of the dam centreline were tested for dispersion of the clay. Preliminary tests indicated that some dispersion of the clay in the material occurred. Further more refined tests should be made to determine whether dispersion properties are widespread and if they are, whether they are important in the construction of the dam in this area.

(*c*) On both abutments and in the hill in the middle of the centreline, considerable thicknesses of clayey and sandy gravel were struck in the Proline drilling. Water tests in these holes suggested a low permeability but further tests should be performed to confirm this, preferably in larger holes or deep trenches.

(*d*) The results of (*b*) and (*c*) will indicate whether it will be necessary to face these areas with clay on the upstream face of the dam. There could be a great saving in costs if this is unnecessary. The clay, if laid would almost certainly need protection from wave action. Clay could not be obtained from storage area without risk of increasing leakage.

(*e*) The Department of Mines does not have equipment to do accurate measurements of permeabilities in unconsolidated sediments or facilities for measuring exchangeable sodium ratios (the measurement made to determine the possibility of clay dispersion). It is suggested that some organisation specialising in soil mechanics should supervise the further investigations along the centreline of the dam.

The Department of Mines could supervise the investigation into the lateral extent of the clay and could also perform any necessary resistivity work.

REFERENCE

MATTHEWS, W.L. 1971. Geology of a dam site on Deep Creek. *Tech.Rep.Dep.Mines Tasm.* 14:57-64.