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Record 1973/103

NOTES ON GEOLOGY AND ENGINEERING GEOLOGY,
BENDORA WATER MAIN, A.C.T.

by

G.A.M. Henderson

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SUMMARY

Geological investigations carried out both before and during construction of the Bendora water main have added to geological knowledge of the Lower Cotter valley. Of some interest to the stratigraphic interpretation is the discovery of a Silurian graptolite in strata conformably beneath the Tidbinbilla Quartzite whose inferred Silurian age has been based previously on structural relations only. Siliceous shale, containing Upper Ordovician graptolites and similar in lithology to the Acton Shale in the Canberra city area, was mapped at several localities.

A comparison of seismic refraction and augering results with observations of rock condition in the trench dug for the pipeline shows the varying degrees of reliability of each investigation method in a range of rock and overburden types. Some apparent anomalies in the seismic results are probably due to the nature of jointing.

INTRODUCTION

The Bendora water main, a 20 km long 60 inch (1.52 m) diameter gravity reticulation pipeline linking Bendora Dam and the Cotter pumping station, was constructed during 1966 and 1967 (for location see Fig. 1). The main provides for reticulation of water from Bendora and Corin Dams to the Canberra city reservoirs. Before the pipeline was laid, extensive geological, seismic refraction, and augering investigations were carried out to determine the condition of soil and rock along the proposed route of the trench which was to be excavated for the pipeline. The seismic survey was done by Industrial Geophysical Surveys Pty Ltd and the augering by Ground Test Australia Pty Ltd. D.E. Gardner of BMR carried out the geological investigation. During excavation of the trench for the pipeline G.A.M. Henderson recorded geological data including thickness and nature of soil, lithology and state of weathering of the underlying rock, and other information such as attitudes of bedding and faults. This report contains the geological data recorded in the trench and compares the data of engineering relevance with the data obtained from the feasibility investigations.

GEOLOGY

The geology of the Lower Cotter Valley area is described mainly in Noakes (1946 and 1948) and Malcolm (1954). Since then, further information has been obtained from investigations associated with Bendora Dam and other dam sites, and from the feasibility investigations for the pipeline (Gardner, 1965). The following notes outline the stratigraphy and structure of the area, and incorporate information from the mapping carried out along the trench dug for the pipeline and along nearby access tracks. Plate 1 shows the regional geology of the area.

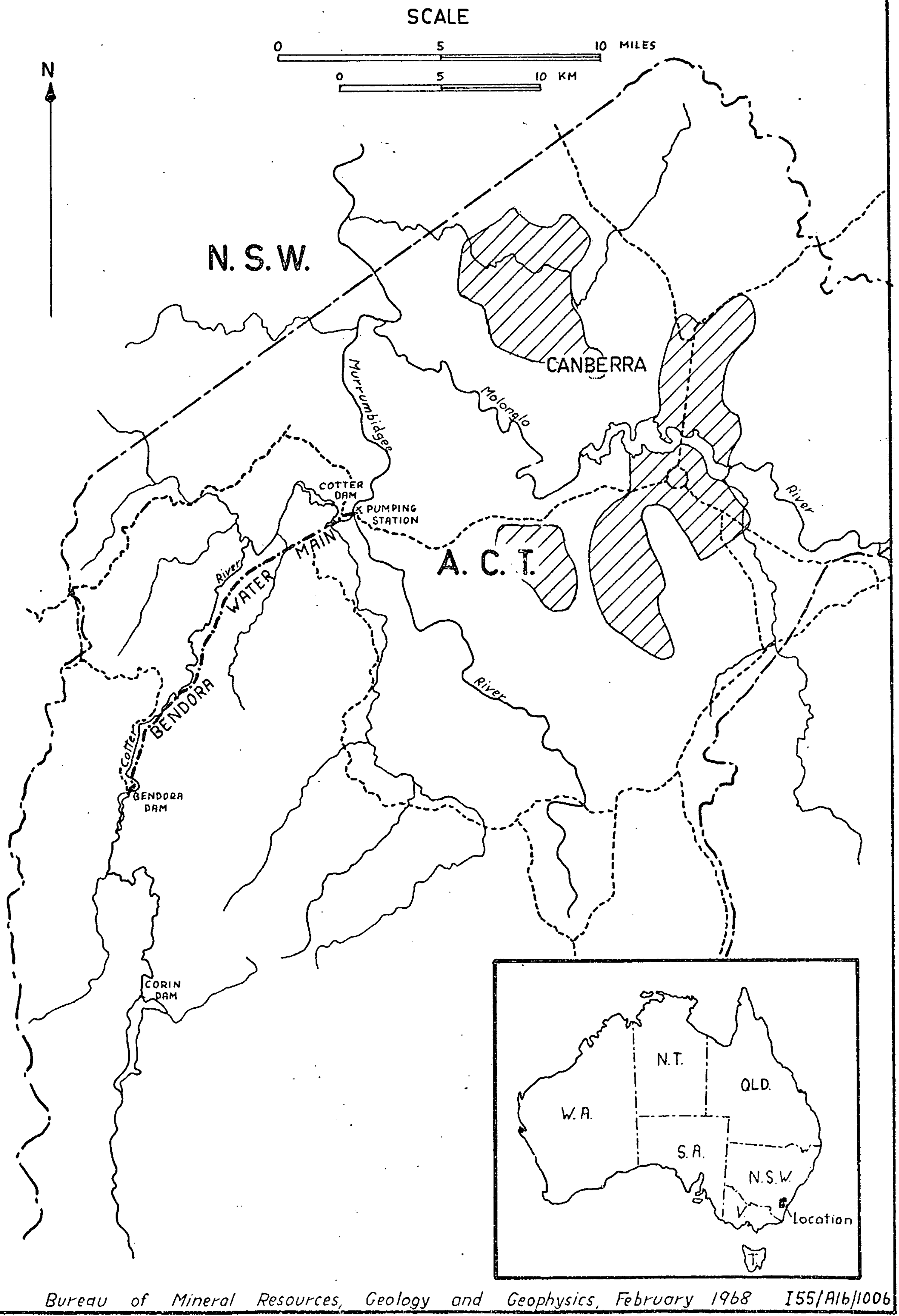
STRATIGRAPHY

Ordovician

Ordovician rocks belonging to two lithological associations are found in the area. The first association which is thought to be the older of the two, consists of phyllite and quartzite, and crops out along Bendora Dam road west of the Cotter Fault (Plate 2). It was not crossed by the pipeline. The second association crops out southeast of the Winslade Fault and comprises beds of sandstone and quartzite, siltstone, shale and mudstone, chert and siliceous shale. The beds were exposed in the pipeline trench between chainages 3 m4700 and 9 m5080 (Plates, 3, 4 & 5);

FIGURE 1

BENDORA WATER MAIN
LOCALITY MAP



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the lower part of the sequence consists mainly of interbedded sandstone and shale, but the upper part contains thick units of sandstone with units of shale; occasional beds of chert are found throughout the sequence. The siliceous shale is found at about the middle of the sequence and is similar in appearance to the Acton Shale described by Opik (1958) in the Canberra city area; it also contains Upper Ordovician graptolites similar to those in the Acton Shale.

The total thickness of the sequence southeast of the Winslade Fault is probably at least 1300 metres, although the complexity of folding and faulting limits the accuracy of estimates. It is not clear whether there are several beds of siliceous shale or only one which is repeated by folding and faulting. The exposures of siliceous shale range in thickness from 20 to 40 metres.

Silurian

Two sequences of Silurian rocks in the area were crossed by the pipeline. The first sequence, which was found at intervals between Bendora Dam and chainage 3m4040 (Plates 2 and 3), consists of the Tidbinbilla Quartzite (Noakes, 1946) and, at the northern end, a succession of siltstone and quartzite with silty laminae which appears to conformably underlie the Tidbinbilla Quartzite (shown as part of Tidbinbilla Quartzite on Plate 2). The contact between the succession of siltstone and quartzite with the Ordovician rocks farther north was not exposed in the trench, but an unconformity was inferred by Noakes as structural grounds. No fossils had previously been found in this sequence*, but during the mapping along the pipeline a fragment of a monograptus genus was found in the siltstone at chainage 3m1400 (see Plates 1 & 3), thus confirming Noakes' inferred Silurian age of the Tidbinbilla Quartzite. Although an early Upper Silurian age was assigned to the graptolite in Strusz (1971) a re-examination of the fossil has indicated that it could be a genus which is found earlier in the Silurian (D.L. Strusz, pers. comm.).

The second sequence of Silurian rocks crossed by the pipeline is part of the Uriarra Volcanics (Malcolm, 1954) and was exposed in the trench north of chainage 9m5080 (Plates 5 and 6). Malcolm regarded the unfossiliferous Uriarra Volcanics as Upper Silurian from lithological and structural data, and no evidence to contradict this conclusion was found along the pipeline trench. Most of the rock expoed along the pipeline

* Localities with queried Middle Silurian graptolites about 3 km to the north are shown on a field map of J. Barrie from mapping done in 1956 (see Plate 1). Although this area is shown as part of the Paddys River Volcanics on the Canberra 1:250 000 map the lithologies shown on his map suggest a correlation with the Tidbinbilla Quartzite and underlying siltstone and shale.

consists of massive porphyritic dacite except for three beds of ashstone or tuff between chainages 10m3800 and 11m3600 (Plate 6), and a probable rhyolite dyke at chainage 11m2000. The northernmost ashstone bed is approximately where Malcolm's Tarpaulin Ashstone Member is shown on this map; however the other beds are not indicated. In all exposures of the ashstone weathering was too severe to determine the attitude or thickness of the beds.

Intrusives

Granite and dacite intruding the sedimentary rocks were mapped along the pipeline. The granite is the Cow Flat Granite (Noakes, 1946) and was exposed between chainages 0m900 and 2m2940. Granite contacts with dacite and Tidbinbilla Quartzite were exposed between chainages 2m1000 and 2m2940 (Plates 2 and 8). Several exposures of porphyritic dacite, some definitely intrusive, were mapped between chainages 2m2940 and 5m1880. At chainage 2m2940 dacite and granite were seen in contact but the rocks were too weathered to give any indication of their age relations; this dacite appears to extend some distance to the north and is possibly related to the Paddys River Volcanics (see Plate 2). Although it is similar in appearance to the other dacites between chainages 2m2940 and 5m1880 no intrusive contact with sedimentary rocks was exposed and therefore it could possibly be extrusive.

STRUCTURE

Folding

All the sedimentary rocks are folded with varying degrees of complexity. The Ordovician rocks in the northern part mainly dip at moderate to steep angles to the west or northwest (Plates 4 and 5), but in the southern part (Plate 3) directions of dip are much more irregular. No regular fold system is apparent in the Ordovician rocks along the pipeline. The Tidbinbilla Quartzite and the beds conformably beneath it (Plates 2 and 3) show moderate to gentle dips and gentle folding. The regional dip of the quartzite is in a general westerly direction (Noakes, 1946) but dips in other directions were recorded along the pipeline, probably owing to the proximity of faults. Steep dips were seen close to the faulted contact between the quartzite and dacite at chainage 2m3640 (Plates 2 & 8). No bedding or folding was seen in the Uriarra Volcanics, although Malcolm's map shows the Tarpaulin Ashstone Member dipping at about 30 degrees to the west.

Faulting

Several major faults have been mapped in the lower Cotter Valley area but only one, the Winslade Fault, was crossed by the pipeline (at chainage 9m5080) where the fault delineates the contact between Ordovician sediments and the Uriarra Volcanics. The precise attitude of the fault could not be determined owing to weathering, but the general northeasterly strike was apparent from another exposure of the fault on a nearby track. Numerous other faults, mostly of unknown displacement, were seen along the pipeline and access tracks, and are shown on the plans and cross-sections. Faults probably account for some repetition of the beds of siliceous shale and chert which were mapped at various places along the pipeline and access tracks.

ENGINEERING GEOLOGY

A considerable amount of augering and seismic refraction work was done along the pipeline route before the trench for the pipe was dug. These investigations were carried out to determine the thickness of overburden and weathered rock, and to determine along which sections blasting in solid rock would be required. (Because of the steep and unstable slopes and also because of the effects of frost on the water flow in winter time, it had been decided at an early stage to bury the pipeline rather than lay it above ground). On plates 7 to 12 the results of the augering and seismic work have been plotted to compare them with the nature and condition of the soil and rock recorded along the pipeline trench. The following comments on the comparison of the investigation methods and the actual excavating conditions encountered are given.

1. Granite, dacite, and volcanic rocks were commonly deeply weathered and excavation along much of the route where those rocks occurred could be done without blasting.

2. In the sedimentary rocks, most of the rock below overburden was too hard to be excavated without blasting, but there were some short sections, generally with gentle slopes, where the rock was weathered sufficiently to be excavated by mechanical means.

3. In some places thick colluvial soil and scree enabled easy excavation, for example between chainage 5m2660 and 5m4100 (Plate 9). Thick alluvium, also easily excavated, was encountered in other places, for example between chainages 1m1840 and 1m2620 (Plate 7).

4. A generally fair to good correlation between augering, seismic and trench mapping data was obtained except in some sections of the granite. The anomalies in the granite were due to the nature of weathering; boulder cores of fresh or slightly weathered rock were present in highly to completely weathered rock. The rock varied greatly over very short distances, and the augering and seismic methods did not predict excavating conditions accurately in all places.

5. Where alluvium contained gravel or colluvium scree, seismic results ranged widely depending on the proportion of gravel or scree. Where the cobbles or blocks of scree were large, penetration of the auger was restricted although the material was unconsolidated and easily excavated.

6. Along much of the section of the pipeline where sedimentary rocks were encountered the seismic results tended to indicate slightly deeper overburden than that which was actually found. The augering however, was more accurate in predicting excavating conditions. The reason for the discrepancy in the seismic results is not certain but could have been due to open soil filled joints in hard rock immediately below the overburden. However, the open-jointed rock was commonly loose enough to be excavated without blasting.

7. In some places substantial variations in seismic velocity of rock were obtained where no noticeable difference in the degree of weathering was noted in the trench. This feature was not noted until after the trench was filled, and it was therefore not possible to observe whether the variations in seismic velocity were due to the pattern of jointing, which is the most likely explanation. For example, open joints crossing the trench line at right angles would give lower seismic velocities than if they were parallel to it. Or, alternatively, a closely spaced joint set crossing the trench in one place could give lower seismic velocities.

8. In areas where the trench crossed steep ridges and valleys underlain by sedimentary rocks the seismic velocity of the rock in any seismic layer tended to be less on the tops of the ridges than in the bottoms of the valleys. Possibly the rock is more open-jointed on the ridges although no noticeable difference was observed during the mapping. This feature is most apparent between chainages 6m1000 and 8m00.

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PLATE 1

GEOLOGY OF LOWER COTTER VALLEY

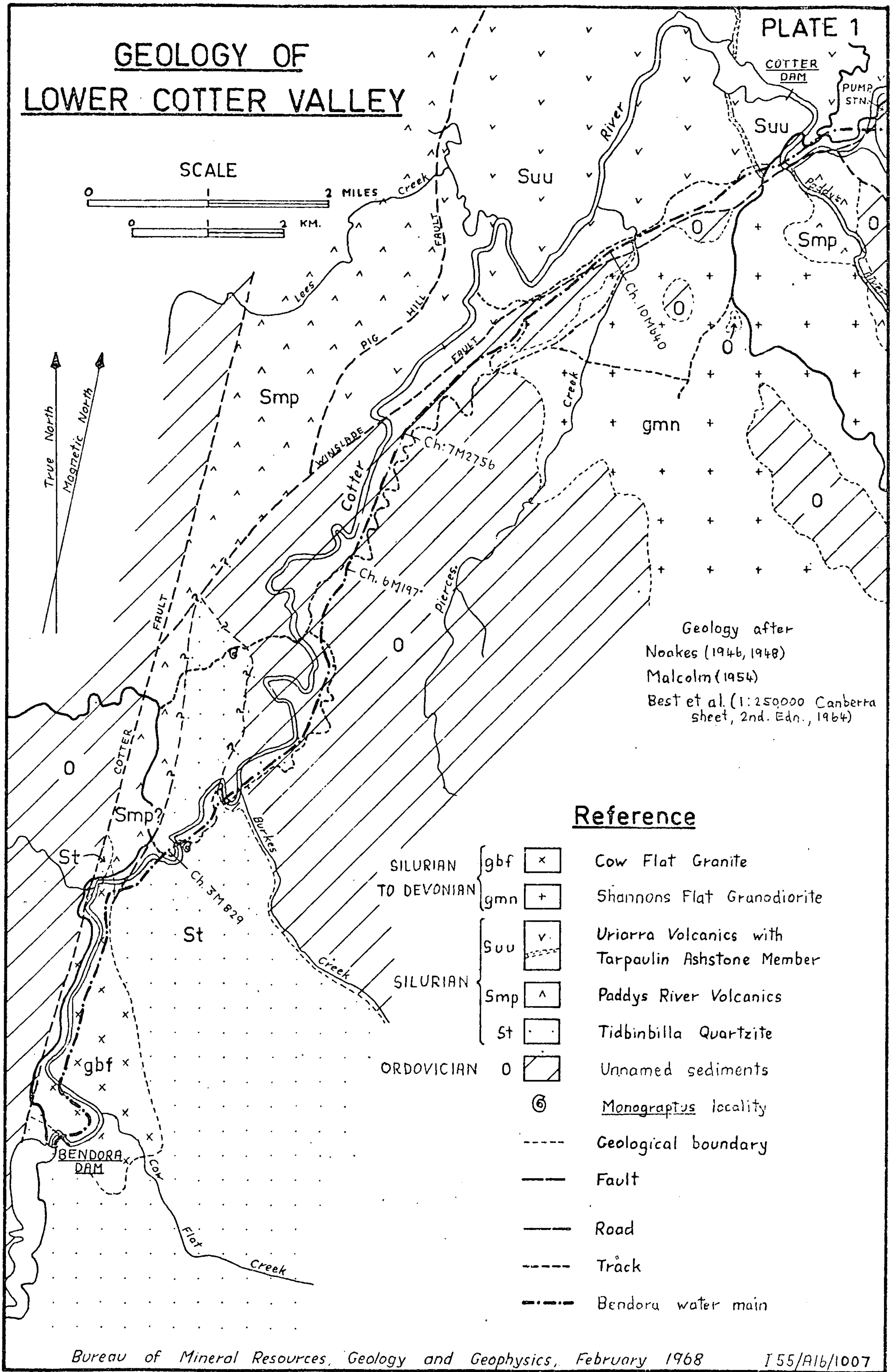

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PLATE 2

BENDORA WATER MAIN
CHAINAGE 0M00 TO 3M829
GEOLOGICAL DATA

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PLATE 3

BENDORA WATER MAIN
CHAINAGE 3M829 TO 6M197
GEOLOGICAL DATA

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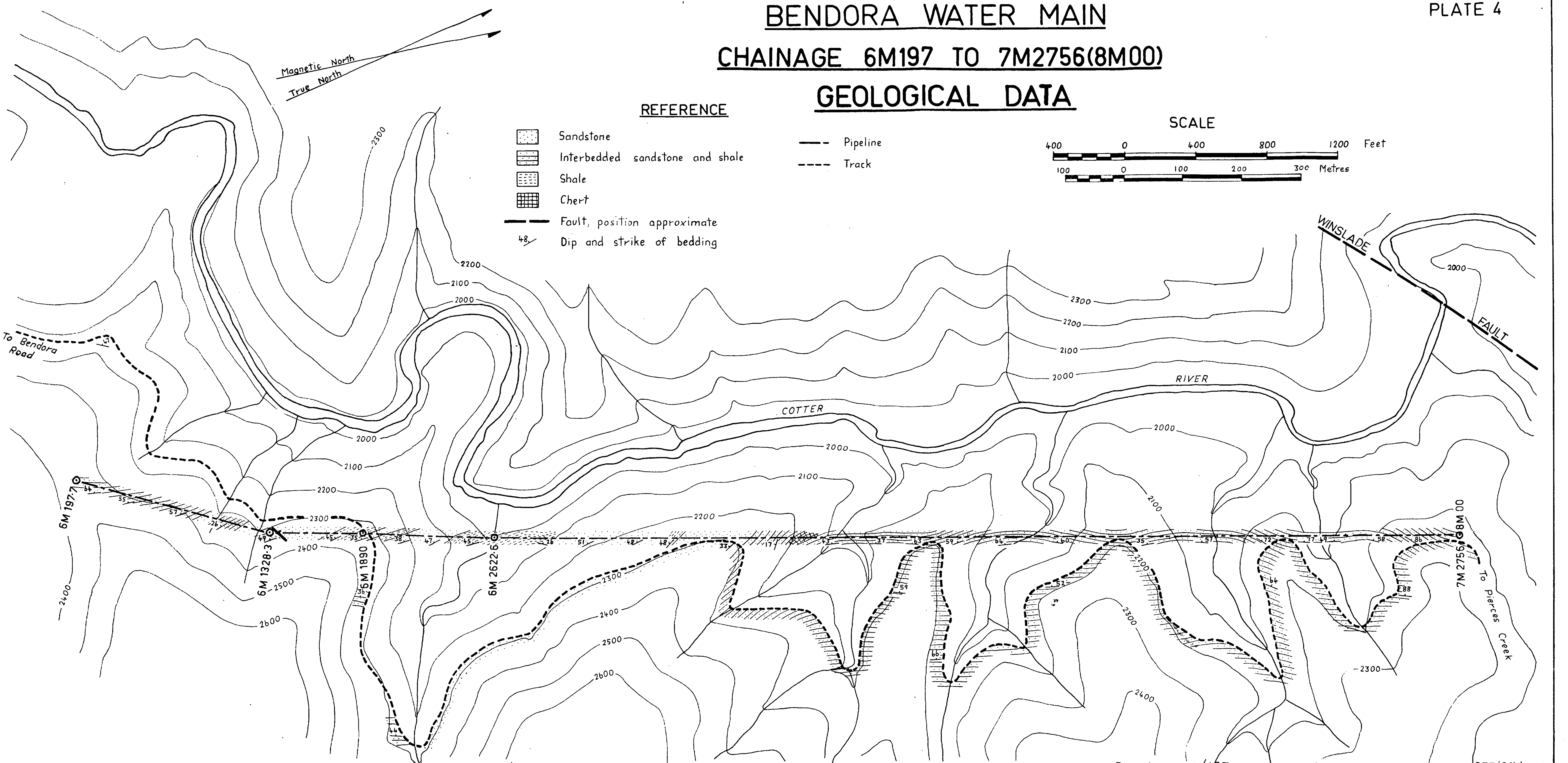
I55/A16/1009

PLATE 4

BENDORA WATER MAIN

CHAINAGE 6M197 TO 7M2756(8M00)

GEOLOGICAL DATA



Bureau of Mineral Resources, Geology and Geophysics, February 1968

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BENDORA WATER MAIN
CHAINAGE 8M00 TO 10M640
GEOLOGICAL DATA

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PLATE 6

BENDORA WATER MAIN CHAINAGE 10M640 TO 12M4228

GEOLOGICAL DATA

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PLATE 7

BENDORA WATER MAIN - CHAINAGE 0M00 TO 2M00
ENGINEERING GEOLOGY DATA

AUGERING AND SEISMIC SURVEY

AV. DEPTHS OF AUGER HOLES (feet)		2·0		1·5		10·0	7·0	2·0	5·5	9 0	9·0	10·0	1·0	6·0	1·7	1·0	10·0		10·0		2·0		4·0	9·0	2·8	5·0			1·5		1·0		5·0	1·5

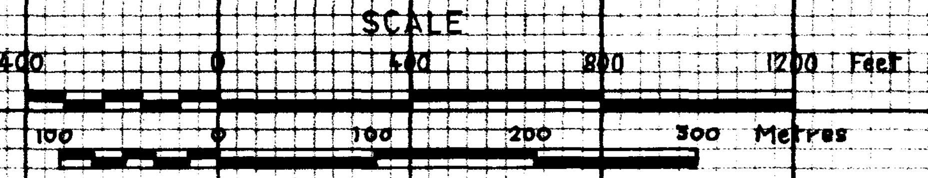
AV. SEISMIC VELOCITIES OF SOIL LAYER (ft./sec.)		1000	1100	1000	1200	1300	900		800		900		1300	1100	1300	1100	1800	1300		1000		1500		1400		800	1200	1200	1200	1100		700	1000
AV. DEPTHS TO 2ND. SEISMIC LAYER (feet)		8·0	3·3	3·7	1·0	3·6	2·7		3·8		2·5		4·0	9·7	5·0	3·0	9·0	3·0		3·5		5·0		4·8		3·7	3·0	3·3	3·3	1·3		11·0	2·0
AV. SEISMIC VELOCITIES OF 2ND LAYER (ft./sec.)		13400	5100	2000	5200	2500	2100		2300		1700		2900	8800	5500	4600	3800	2500		2700		12200		3400		3800	1700	2700	2300	2000		5800	2700
AV. DEPTHS TO 3RD. SEISMIC LAYER (feet)			22	15		15	15		24		15		30		29	23	28	22		21				21		13	15	20	14	21			11
AV. SEISMIC VELOCITIES OF 3RD. LAYER (ft./sec.)			17000	11000		5900	5300		10500		5500		7200		12800	128	13100	6400		6100				8100		9400	4000	8300	8000	9000			6700

INTERPRETIVE CROSS SECTION

TRENCH MAPPING

ROCK OR SOIL TYPE	Quartzite	River	Granite			Granitic soil and scree		Granite			Bridge	Granite		River	Granite and granitic soil					Coarse alluvial gravel	Granite and granitic soil			Very poorly sorted coarse alluvial gravel
DEPTH OF SOIL			Irregular - granitic soil grades into highly weathered rock			>6 feet	>2 feet	6	0-6	Irregular		Very irregular - floaters of fresh rock			Very irregular		Mostly >8 feet	Irregular		>8 feet	>8 feet	Irreg.	>8 feet	>8 feet
WEATHERING STATE OF ROCK	Slightly to moderately weathered		Moderately to highly weathered	Fresh to mod	Moderately to highly weath.				Fresh	Mod to highly weath.		Fresh to sl. weath.	Fresh to highly weathered		Mod. weath.	Moderately to completely weathered	Highly to completely weathered	Fresh	Slightly to mod. weath.		Compl. weath.	mod. weath.	Completely weathered	

CHAINAGE	0M00	202	671	996	1271	1465	2000	2286	2584	3000	3171	4000	4175	5000	1M00	1000	2000	2812	3000	4000	4073	4678	5000	2M00



Note: For reference see Plate 2

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PLATE 8

BENDORA WATER MAIN - CHAINAGE 2M00 TO 4M00

ENGINEERING GEOLOGY DATA

AUGERING AND SEISMIC SURVEY

AV. DEPTHS OF AUGER HOLE (feet)		7·0	4·8	5·0		1·5	3·5		10·0	11·0	3·3	1·3	1·5	3·0	1·5	1·3	1·0	2·0	2·0	2·0	1·0	2·0	2·7	1·8	7·7	1·4	1·2

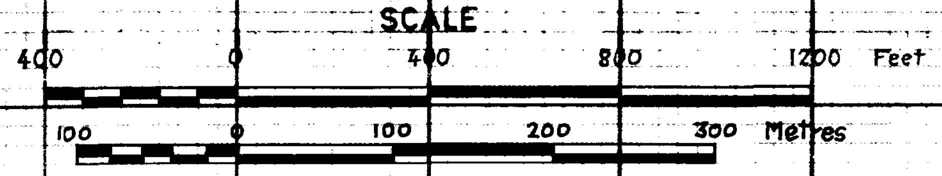
AV. SEISMIC VELOCITIES OF SOIL LAYER (ft/sec)	2100		1000	1100	1000	900	1100	1000	1100	1200	1800	1400	1400	1000	1300	1900	800	2000	1100	1200	1100	1700	900	1600	800	600	500	900	700	
AV. DEPTHS TO 2ND SEISMIC LAYER (feet)	3·0		5·1	0·6	1·5	2·0	2·3	3·3	1·8	1·0	4·0	3·4	2·0	4·0	2·6	3·0	4·3	3·0	4·0	6·0	3·4	7·7	4·0	3·0	4·2	3·0	3·5	6·5	3·4	
AV. SEISMIC VELOCITIES OF 2ND LAYER (ft/sec)	5900		4700	2600	4000	2900	2400	3000	3000	3400	6700	6000	4300	3500	6000	4100	4000	9400	4500	4400	2400	8900	4700	3200	4600	3600	3100	9700	4500	
AV. DEPTHS TO 3RD. SEISMIC LAYER (feet)			18	16	10	21	24	19	12	18			20				16			14	16		14	26	8	12	18		20	
AV. SEISMIC VELOCITIES OF 3RD. LAYER (ft/sec)			11400	8400	10000	7400	7100	6200	5200	12800			10100				8700			7700	5700		7400	8000	7100	5300	6900		8000	

INTERPRETIVE CROSS SECTION

TRENCH MAPPING

ROCK OR SOIL TYPE	Very poorly sorted coarse alluvial gravel	Soil & scree	Qzte	Soil & scree	Quartzite intruded by granite	Granite	Porphyry of dacitic composition		Qzte. & SiSt.	Quartzite	Bridge	Quartzite		River	Quartzite	Alluv. gravel	River	Sandstone and siltstone with irregular laminations		Soil & scree	S.S. & SiSt irreg. lams.	Bridge	Soil & scree	Sandstone & Siltstone irregular laminations	Soil & scree	Alluvial gravel	River	Sandstone	River
DEPTH OF SOIL	>8 feet		1-3 feet	>8 feet	Irregular	>8 feet	1-4 feet	>8 feet	1-2 feet			0-2 feet	2-3 feet		1-2 feet	>8 feet		2 ft	3-4 feet	3->10 feet	3-4 feet		>8 feet	3 feet	>8 feet			4 feet	
WEATHERING STATE OF ROCK			sl. weath		Qzte slightly weath Granite highly weath	Completely weathered	Slightly to mod. weathered	Highly weath.	Slightly to moderately weathered			Slightly to moderately weathered			Slightly weathered			Fresh	Slightly weathered		Slightly weathered			Slightly weathered				Slightly to mod. weathered	

CHAINAGE	2M00	819	1000	2000	2449	2786	3000	4000	4120	4813	5000	3M00	829	1000	1678	2000	2624	3000	3157	3810	4000	5000	5268



Note: For reference see Plates 2&3

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PLATE 9

BENDORA WATER MAIN - CHAINAGE 4M00 TO 6M00
ENGINEERING GEOLOGY DATA

AUGERING AND SEISMIC SURVEY

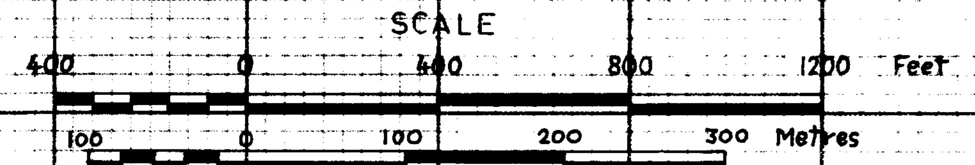
AV. DEPTHS OF AUGER HOLES (feet)	3·0	2·0	2·0	1·8		2·0	3·3	2·0	2·0	1·7	1·0	2·0	2·0	1·0	2·0	2·0	1·0	2·2	2·4	2·0	2·0		2	2·0	2·4	2·1

AV. SEISMIC VELOCITIES OF SOIL LAYER (ft./sec)	1000	1200	1400	1400		1400	900	800	900	2000	1400	2300	900	1300	1100	1300	1200	1300	1800	1100	1200	900		1400	1400	1000	1200	900	1600	1400	1000
AV. DEPTHS TO 2ND. SEISMIC LAYER (feet)	2·5	4·7	4·0	4·0		4·0	4·0	5·0	4·5	3·0	4·0	6·5	5·5	7·5	5·5	4·0	4·0	4·3	3·7	4·7	4·7	4·5		4·5	4·8	6·5	2·5	4·0	5·1	4·5	6·6
AV. SEISMIC VELOCITIES OF 2ND. LAYER (ft./sec)	3100	5300	5300	4800		5700	3900	7900	4700	4500	5900	5300	8000	5800	5000	3600	5900	5500	4600	5200	5300	7400		3600	4900	2600	3600	2400	4500	3800	3800
AV. DEPTHS TO 3RD. SEISMIC LAYER (feet)	13	47	45	49		40	32	24	29	39		51	45		62	37	38	37	41	30	30		18	13	47	43		31	32	28	32
AV. SEISMIC VELOCITIES OF 3RD. LAYER (ft./sec)	6500	11700	14600	10700		11400	8000	12300	12200	12700		14600	13200		18500	8900	11800	13700	10100	9500	13300		10200	6700	11300	11500		8800	10200	8000	12700

INTERPRETIVE CROSS SECTION

TRENCH MAPPING

ROCK OR SOIL TYPE	Sandstone	Sandstone and shale	Sandstone	Porphyry	Sandstone	Chert & sandstone	Sandstone	Sandstone and shale	Porphyry	Sandstone and shale	Shale	Siliceous shale	Sandst & shale	Shale	SSt & Sh.	Siliceous shale & sandstone	Porph.	Sandstone and shale	Silic. shale	Sandst & shale	Clay soil and scree (slopewash)	Shale	Sandst. & shale	S.St	Sandst. & shale
DEPTH OF SOIL	1-3 feet	1-3 feet	1-2 feet	1-4 feet	5- >10 feet	0-1 feet	0-2 feet	1-2 feet	1-4 feet	3-4 feet	1-4 feet	>8 feet	0-3 feet	4-6 feet	1-2 feet										
WEATHERING STATE OF ROCK	Moderately weathered	Slightly to mod. weath.	Mod. to highly weath	Slightly to mod weathered	Slightly weathered	Slightly to mod. weath.	Mod. to highly weath.	Moderately weathered	Slightly - mod weath.	Sl. w.	Slightly to moderately weathered	Mod. weath.	Sl. weath. below 10ft.	Sl. to mod. w.	Slightly to moderately weathered		Slightly weathered	Sl. to mod. w.	Slightly weathered						
CHAINIGE	4M00	1000	2000	2741	3000	3463	4000	4635	5000	5182	5M00	252	1000	1248	2000	2258	3000	4000	5000	5100	6M00				



Note: For reference see Plate 3

Bureau of Mineral Resources, Geology and Geophysics, February 1968

To accompany Record 1973/103

I55/A16/1015

PLATE 10

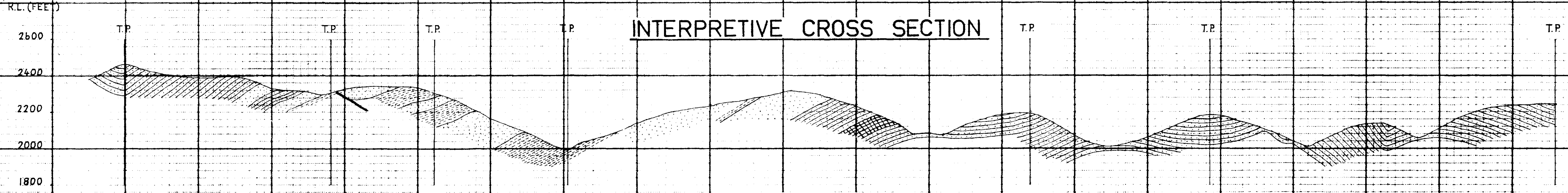
BENDORA WATER MAIN - CHAINAGE 6M00 TO 7M2756 (8M00)
ENGINEERING GEOLOGY DATA

AUGERING AND SEISMIC SURVEY

AV. DEPTHS OF AUGER HOLES (feet)	1·6	2·0	1·5	1·3	1·2	2·0	1·3	1·7	1·5	1·5	1·3	2·0	2·0	1·5	1·7	1·3

AV. SEISMIC VELOCITIES OF SOIL LAYER (ft./sec)	1200	1100	1100	-	2600	1700	2300	1900	1700	1500	1000	1700	1700		1500	2000	1200	1400	1700	1400	1600	1100	2700	2200	2000	1600
AV. DEPTHS TO 2ND. SEISMIC LAYER (feet)	5·0	4·5	3·7	0	5·5	3·5	5·0	5·5	14·0	6·0	4·0	3·8	5·0		4·0	6·3	9·5	4·5	4·0	4·7	4·7	4·0	8·5	5·5	4·5	4·0
AV. SEISMIC VELOCITIES OF 2ND. LAYER (ft./sec.)	5500	5400	3800	4200	5600	3400	4400	5700	8900	5700	2500	3600	5600		4000	8900	10100	4800	5000	4900	6800	6200	7400	5200	4200	5000
AV. DEPTHS TO 3RD. SEISMIC LAYER (feet)	34	34	35	34		31	32	19		39	26	28			26			12	36	33		31		32	15	33
AV. SEISMIC VELOCITIES OF 3RD. LAYER (ft./sec.)	12300	8900	10300	8800		9900	9100	9100		11600	12100	7200			10800			6800	11400	11300		11100		8000	5700	8200

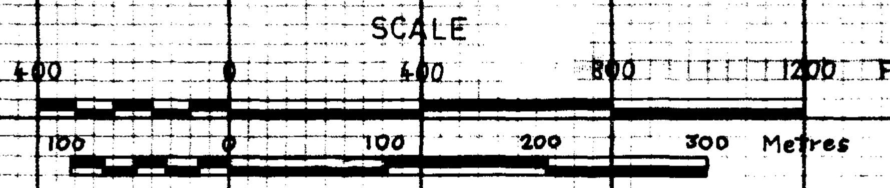
INTERPRETIVE CROSS SECTION



TRENCH MAPPING

ROCK OR SOIL TYPE	Sandstone and shale	Sandst.	Sandst & shale	Sandst	Shale	Sandstone	Shale	Sandst.	Shale	Sandstone	Shale	Scree	Sandstone	Scree	Shale	Sandstone	Sandst. & shale	Chert	Sandstone and shale	Sandstone and shale
DEPTH OF SOIL	1-3 feet								1-3 feet			>8	1-3 feet 3-7 ft.	>7		1-3 feet			1-3 feet	
WEATHERING STATE OF ROCK	Slightly to moderately weathered	Slightly weathered											Slightly to mod. weathered			Slightly to moderately weathered		Sl. weat	Moderately weathered	Moderately weathered

CHAINAGE: 6M00, 198, 1000, 1328, 1890, 2000, 2683, 3000, 4000, 5000, 5152, 7M00, 860, 1000, 2000, 2756 = 8M00



Note: ① For reference see Plate 4
② Folds shown in cross section are apparent only. They are due to changes of strike and changes in direction of pipeline.

Bureau of Mineral Resources, Geology and Geophysics, February 1968

To accompany Record 1973/103

I55/A16/106

PLATE 11

BENDORA WATER MAIN - CHAINAGE 8M00 TO 10M00

ENGINEERING GEOLOGY DATA

AUGERING AND SEISMIC SURVEY

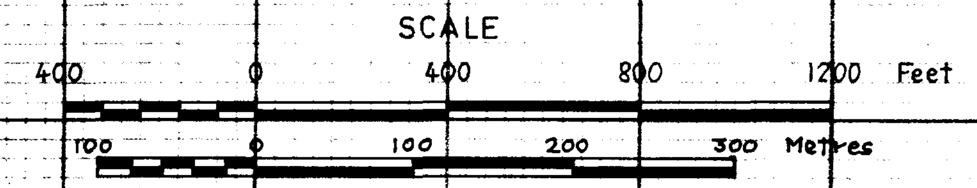
AV. DEPTHS OF AUGER HOLES (feet)	1·3	1·7	1·5	2·0	2·0	1·5	1·1	2·0	0·5	2·5	2·0		1·0	3·0	2·1	1·2	1·9	1·4	2·3	1·9

AV. SEISMIC VELOCITIES OF SOIL LAYER (ft/sec)		1300	-	2300	1500	1500		2000	1400	1200	1600	3000	-		1600	1700	1400	1600	2100	2300	1400	2000	1500	1400		1500		1000	
AV. DEPTHS TO 2ND. SEISMIC LAYER (feet)		4·0	0	2·8	4·0	4·5		5·0	5·0	5·0	5·0	5·0	0		2·8	6·5	1·5	4·0	3·7	7·5	4·5	4·5	4·3	4·0		4·3		5·0	
AV. SEISMIC VELOCITIES OF 2ND LAYER (ft/sec)		4500	6100	5100	4300	5000		5500	5900	10000	9000	5200	6000		3800	6700	3000	3400	4300	6500	4700	5300	4100	4100		4600		5900	
AV. DEPTHS TO 3RD. SEISMIC LAYER (feet)		31		18	20	28		27	50			24			35		44	9	39		39	36	33	44		37			
AV. SEISMIC VELOCITIES OF 3RD. LAYER (ft/sec)		12900		11200	8400	8000		10800	19500			7400			6300		12000	7700	15300		8400	11000	6600	13300		10300			

INTERPRETIVE CROSS SECTION

TRENCH MAPPING

ROCK OR SOIL TYPE	Sandstone and shale	Soil & scree	Siliceous shale, sandstone and shale	Sandst.	Shale	Sandst. & shale	Shale	Sandstone and shale	Silic. sh.	Shale & chert	Sandstone and shale	Sandst.	Sandstone & shale	Sandst.	Sandstone and shale	Sandst.	Scree	Sandstone and shale	Sandst.	Sandst. & shale	Siliceous shale	Siliceous shale and sandstone	Siliceous shale	Dacite
DEPTH OF SOIL	1-3 feet	>8 feet	1-3 feet	4-6 feet	1-3 feet	>8 feet	1-3 feet	3-5 feet																
WEATHERING STATE OF ROCK	Moderately weathered		Slightly to moderately weathered	Moderately weathered	Slightly to moderately weathered	Slightly weath.	Slightly to moderately weathered		Slightly to moderately weathered	Moderately weathered	Mod. to very weath.	Moderately weathered	Sl. to mod. weath	Very weath.										
CHAINAGE	8M00	1000	1331	1992	2000	3000	3758	4000	5000	5127	9M00	1000	1200	1580	2000	3000	4000	5000	10M00					



Note: ① For reference see Plate 5
② Except at Ch. 9M200 folds shown in cross section are apparent only. They are due to changes of strike and changes in direction of pipeline.

Bureau of Mineral Resources, Geology and Geophysics, February 1968

To accompany Record 1973/103

I55/A16/1017

PLATE 12

BENDORA WATER MAIN - CHAINAGE 10M00 TO 12M4228
ENGINEERING GEOLOGY DATA

AUGERING AND SEISMIC SURVEY

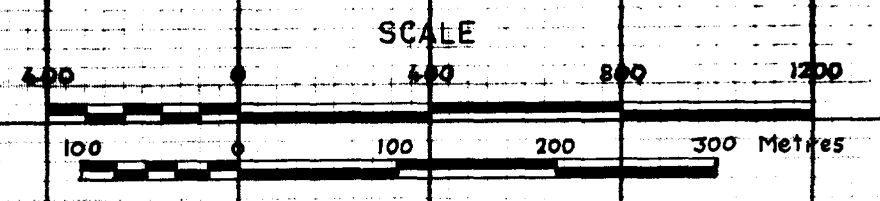
AV. DEPTHS OF AUGER HOLES (feet)	2·0	2·7	2·0		2·8	2·4	1·0	5·6	4·0	1·5	3·0	1·0	3·5	5·5	1·1		1·3	1·8	2·7	1·0		3·2	1·5		6·0	2·0	10·0	2·0	4·5	2·0	2·0	7·0	1·0	4·0	2·0	6·0	5·0	3·7			4·5
AV. SEISMIC VELOCITIES OF SOIL LAYER (ft/sec)		1300	2300		600	600	700		800		900		1300			1200		1200	1000	700	1300		1300	1300	1500	1100	1300	2500	3100	3300	1200	3100		1400	1900	1700	1600	2200	4900	1800	1700
AV. DEPTHS TO 2ND. SEISMIC LAYER (feet)		3·8	7·5		4·3	5·0	3·5		3·5		3·8		3·4			3·5		3·7	4·3	3·7	4·0		4·4	4·0	5·6	3·7	11·0	5·0	6·5	11·0	6·5	10·7		4·5	5·0	6·0	6·0	8·0	10·0	13·0	17·0
AV. SEISMIC VELOCITIES OF 2ND. LAYER (ft/sec.)		6800	6500		7300	12400	6100		6100		5300		5500			4900		5800	9700	6400	8500		8700	7900	8300	4900	6900	4000	7000	10500	8000	8700		3800	8200	7300	4700	12600	7300	8900	8100
AV. DEPTHS TO 3RD SEISMIC LAYER (feet)									17				11			15		19		20				11	23	12	52	26	36		30	42		27	29	28	38				
AV. SEISMIC VELOCITIES OF 3RD LAYER (ft/sec.)									9700				7400			11900		9800		10100				10700	?	18500	16000	10000	20000		15400	13900		11700	13400	12600	5200				

INTERPRETIVE CROSS SECTION

TRENCH MAPPING

ROCK OR SOIL TYPE	Dacite	Alluvial soil	Dacitic soil	Fine grained sandy tuff	Dacite	Fine gr. tuff	Dacite	Med. gr. tuff	Dacite	Fine gr tuff	Dacite	Alluv.	Alluvial soil and gravel	Alluvial soil	Dacite			Soil	Dacite	Soil	Dacite		Soil	Alluvial gravel & sand	Dacite
DEPTH OF SOIL	2-4 feet		>8 feet	2-4 feet					Very irregular	1-4 feet		>8 feet	>6 feet	>8 feet	1-4 feet	3-4 feet of alluvial gravel	1-5 feet	>8 feet	5-8 feet	>8 Feet	1-5 feet		>8 feet	>6 feet	1-4 feet
	Moderately to highly weathered		Completely weathered	Moderately to highly weathered	Moderately weathered				Slightly to highly weathered	Slightly to moderately weathered					Slightly to moderately weathered				Sl. weath.		Sl. weath.	Moderately weathered			Mod. to highly weath.

CHAINAGE 10M00 500 1000 2000 3000 4000 5000 11M00 1000 2000 2323 3000 3924 4000 5000 12M00 1000 2000 2585 3000 4000 4228



Note: For reference see Plate 6

Bureau of Mineral Resources, Geology and Geophysics, February 1968

To accompany Record 1973/103

I55/A1b/1018