COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

5928/65

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS: 1957/32

SEISMIC SURVEY OF THE KINGS AVENUE BRIDGE SITE CANBERRA A.C.T.

14717/67

CONTENTS

ILLUSTRATIONS

ABSTRACT.

Results are given of a seismic refraction survey carried out by the Bureau of Mineral Resources at a proposed site for a new bridge across the Molonglo River at King's Avenue, Canberra. The objects of the survey were to determine the depth to bedrock and to obtain information on the nature of the bedrock from a study of observed seismic velocities.

Profiles are given showing the calculated depth to bedrock along the four traverses surveyed, and a plan of the surveyed area shows those portions of the traverses along which bedrock with low seismic velocity was indicated. Drilling results show these low-velocity zones to be weathered shale, partly fractured, sheared and faulted. In the area outside these zones, the bedrock has sufficiently high seismic velocity (9,500 to 16,000 ft/sec) to indicate satisfactory foundation rock.

The seismic velocities are used for a rough estimate of Young's Modulus values for the various rock types indicated.

No information was obtained on the formations in the river bed.

1. INTRODUCTION.

In response to a request from the Department of Works, Canberra, the Bureau of Mineral Resources carried out a seismic refraction survey of a proposed site for a new high-level bridge across the Molonglo River at King's Avenue. The position of the bridge is determined largely by the general plan of Canberra.

The objects of the seismic survey were to determine the depth to bedrock at the bridge site and to indicate the nature of the bedrock from observed seismic velocities. The survey was carried out during May, 1956.

Sixteen drill holes between 30 feet and 77 feet in depth were drilled close to the river before the geophysical survey was carried out. They are described in a geological report on the site by Gardner (1956).

A test to ascertain the applicability of the resistivity method to the determination of the depth and thickness of gravel beds in sections known from the drilling results showed that the beds were too thin for the method to be successful.

The topographical survey of the geophysical traverse lines was carried out by the Department of the Interior, Canberra, which also supplied traverse plans and sections.

The gelignite and storage facilities were supplied by the Department of Works, Canberra, which also provided four field assistants.

The geophysical party consisted of L.V.Hawkins, party leader, and J.P. Pigott, field assistant. W.A.Wiebenga, Senior Geophysicist, accompanied the party during the survey.

2. GEOLOGY.

The geology of the Canberra city district has been described by Opik (1955) and is shown on the geological and tectonic maps of Canberra (Opik, 1953a and 1953b).

The geophysical stations, with the exception of these on the western portion of Traverse A, are located on alluvium. On the western portion of Traverse A, the City Hill Shale is present under soil cover.

The St. John's Beds crop out a few hundred feet beyond the north-eastern end of Traverse C, and either these beds or the City Hill Shale may form the bedrock along Traverse C.

The City Hill Shale is a dark grey, calcareous shale with limestone bands and lenses and does not contain any volcanic material.

The St. John's Beds consist of volcanic rocks (tuffs and porphyries) interbedded with tuffaceous mudstones, sandstones, limestones, shales and tuffs, with limestone nodules. The St. John's Beds overlie the City Hill Shale but the contact is not exposed. Both formations are Lower to Middle Silurian in age.

The drilling results (Gardner 1956) show that close to the river very weathered shale underlies the alluvium and that a probable fault zone exists just north of the river.

The terms "overburden" (alluvium and weathered shale) and "bedrock", as used in this report, refer to rocks in which the seismic velocity is 5500 ft/sec. or less, and 6700 ft/sec or more, respectively.

3. METHOD AND EQUIPMENT

The seismic refraction "Method of Differences", which was used on this survey, is described in detail by Hawkins (1957). An explosive charge is used as a source of elastic waves which are refracted and reflected at seismic velocity discontinuities within the ground. The travel times of the first arrivals of the elastic waves from the shot point to a series of detectors (geophones) are recorded.

From the recorded travel times, the depth to bedrock may be computed. Also, by removing the effect of the overburden on the travel times the horizontal changes in the velocity in the bedrock may be reliably estimated.

A seismic velocity log of the drill hole near station B27 was taken to a depth of 28 feet, by detonating small charges at different depths in the drill hole. The results were used to assist in determining the velocity in the overburden.

The geophones were spaced at intervals of 40 feet and 10 feet.

A "Century Geophysical Corporation" 12- channel, portable refraction seismograph was used with "T.I.C." geophones of natural frequency 20 cycles per second.

4. RESULTS.

The location of the seismic traverses and the low velocity zones in the bedrock are shown on Plate 1.

The depth to bedrock, the velocity of compressional seismic waves in the bedrock, and the velocities in the overburden are shown on Plate 2.

Southern bank of river.

On the southern bank of the Molonglo River, traverse B and the eastern part of traverse A show a layer of alluvium in which the seismic velocity ranges from 1,200 ft/sec in clayey and sandy alluvium at the surface to 4,000 ft/sec in water-saturated sand and gravel at the base. The seismic results show the alluvium to be 20 to 30 feet thick. An intermediate layer with a seismic velocity of 5,500 ft/sec, referred to as weathered rock on Plate 2, underlies the alluvium and is shown by the drill logs to be weathered shale.

The bedrock has a seismic velocity of 10,000 to 10,800 ft/sec, except for a low-velocity zone of 6,800 to 7,000 ft/sec between stations B27 and B28 and from station A 10 to the end of traverse A (A13). The depth to bedrock in the low-velocity zone is between 71 and 91 feet.

The depth to the higher-velocity bedrock ranges from 70 feet (at B26) to 30 feet (at B33) on traverse B and from 67 feet (at A9) to 14 feet (at A3) on traverse A.

Northern bank of river.

North of the river, traverses C and D are on alluvium withseismic velocities similar to those recorded

on traverses A and B. No indication was obtained of the 5,500 ft/sec. intermediate-velocity layer which is present on the southern bank, but a low-velocity bedrock (6,000 to 6,700 ft/sec) occurs on traverse D and between stations C45 and the end of traverse C (C42). The depth to the low-velocity bedrock is between 22 and 31 feet. Between C46 and the other end of traverse C (C60) the velocity in the bedrock ranges between 9,500 ft/sec. and 16,000 ft/sec. and the thickness of the overburden is between 22 feet (at C46) and 59 feet (at C60).

The quality of the rock, for engineering considerations, can be roughly estimated from the recorded seismic compressional wave velocities with an estimated maximum error of ± 30 per cent (Hawkins, 1957). Table 1 gives the estimated Young's Modulus values for the various seismic velocities recorded.

Table 1.

	ROCK TYPE		SEISMIC WAVE VELOCITY (V) (FT/SEC)	YOUNG'S MODULUS (E) lbs/sq.in.	dynes/cm^2
burden	Alluvium	Sandy soil	1200	0.016×10^6	0.01×10^{11}
		Sand &gravel	4000	0.28×10^6	0.19×10^{11}
	Intermediate layer- very weathered shales		5500	0.59×10^6	0.41×10^{11}
	Sheared, weathered shales		6000 to 7000	0.73×10^6 to 1.1×10^6	0.5×10^{11} to 0.76×10^{11}
rock	Unweathered shales, sandstones or tuffs		9500 to 12000	2.1×10^6 to 3.7×10^6	1.5×10^{11} to 2.6×10^{11}
	Limestones or rhyolites		16000	7.0×10^6	4.8×10^{11}

The Young's Modulus values are calculated from the empirical formula :-

$$E = V^{2.34} \times 10^{-3} \text{ lb/sq. inch.}$$

Comparison with drilling results.

None of the drill holes penetrated the higher velocity (9,500 to 16,000 ft/sec) bedrock shown by the seismic results. The holes on the south bank of the river penetrated soft, plastic, non-coring weathered shale of 5,500 ft/sec. velocity, and those north of the river

penetrated mainly harder, non-plastic, weathered shale which was indicated by the seismic results to be bedrock of 6,700 to 7,000 ft/sec. velocity. The weathered shale is fractured and sheared in places.

Six drill holes are located near seismic stations and comparison between the depth to weathered shale determined by drilling and the depth to weathered rock determined seismically shows that at depths between 20 and 26 feet, the seismic determinations are about 23 per cent too large.

5. CONCLUSIONS.

Interpretation of the seismic velocities in terms of rock types is shown in Table 1. It seems likely from the drilling results that the weathered, low-velocity rock extends across the bed of the river between the two zones of low seismic velocity shown on Plate 1. These zones of low bedrock velocity (6000 to 7000 ft/sec) may be interpreted as sheared shale and possibly form a fault zone which has probably helped determine the present position of the river at King's Avenue.

Bedrock with a velocity of 9,500 ft/sec or higher probably has a Young's Modulus of 2.1 x 10^6 lbs/sq. in. or greater, and should be reasonably good foundation rock. The velocity range of 9500 ft/sec. to 12000 ft/sec. is consistent with that found in normal sedimentary rocks, and the velocity of 16000 ft/sec. could be due to either limestone or igneous rock (the porhyry of the St. John's Beds).

6. REFERENCES.

Gardner, D.E., 1956 - Supplementary geological report on King's Avenue bridge site. Bur. Min. Resour. Aust. (Internal Report.)

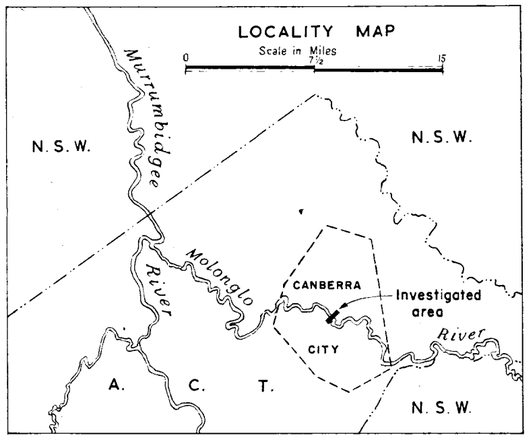
Hawkins, L.V., 1957 - Geophysical Survey of the Acton Weir site, Canberra, A.C.T. Bur. Min. Resour. Aust., Records 1957, No. 31.

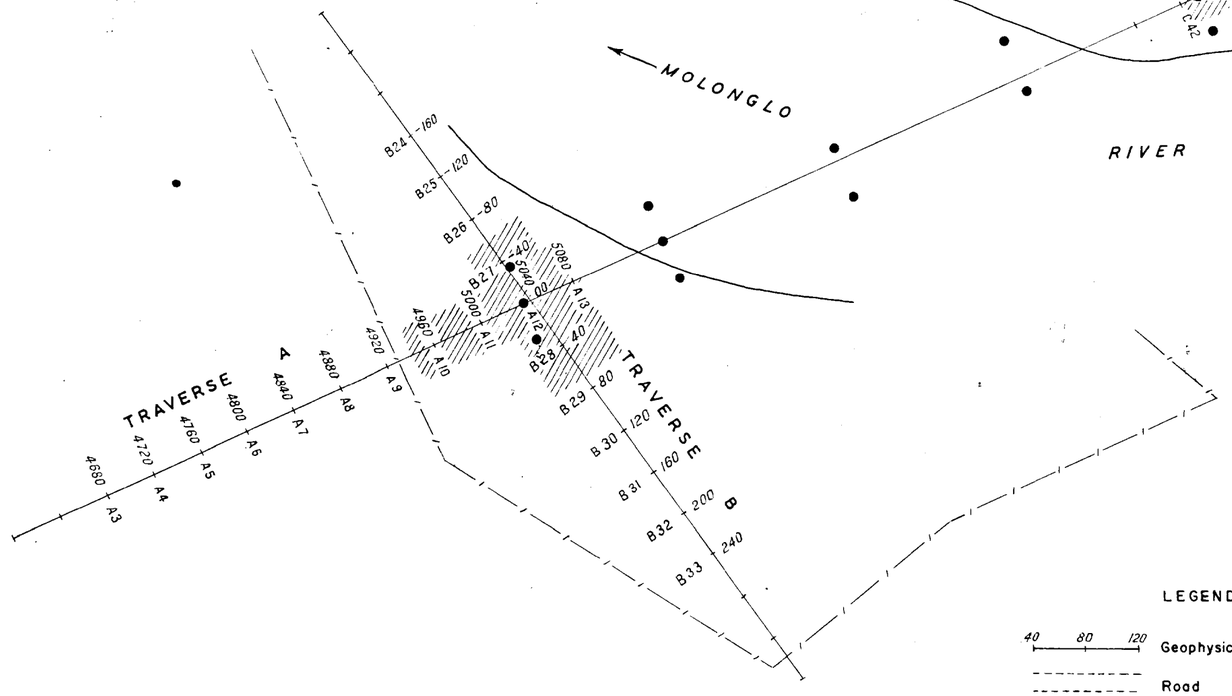
Opik, A.A., 1955 - The Geology of the Canberra City District. The Australian Capital Territory as a Region.

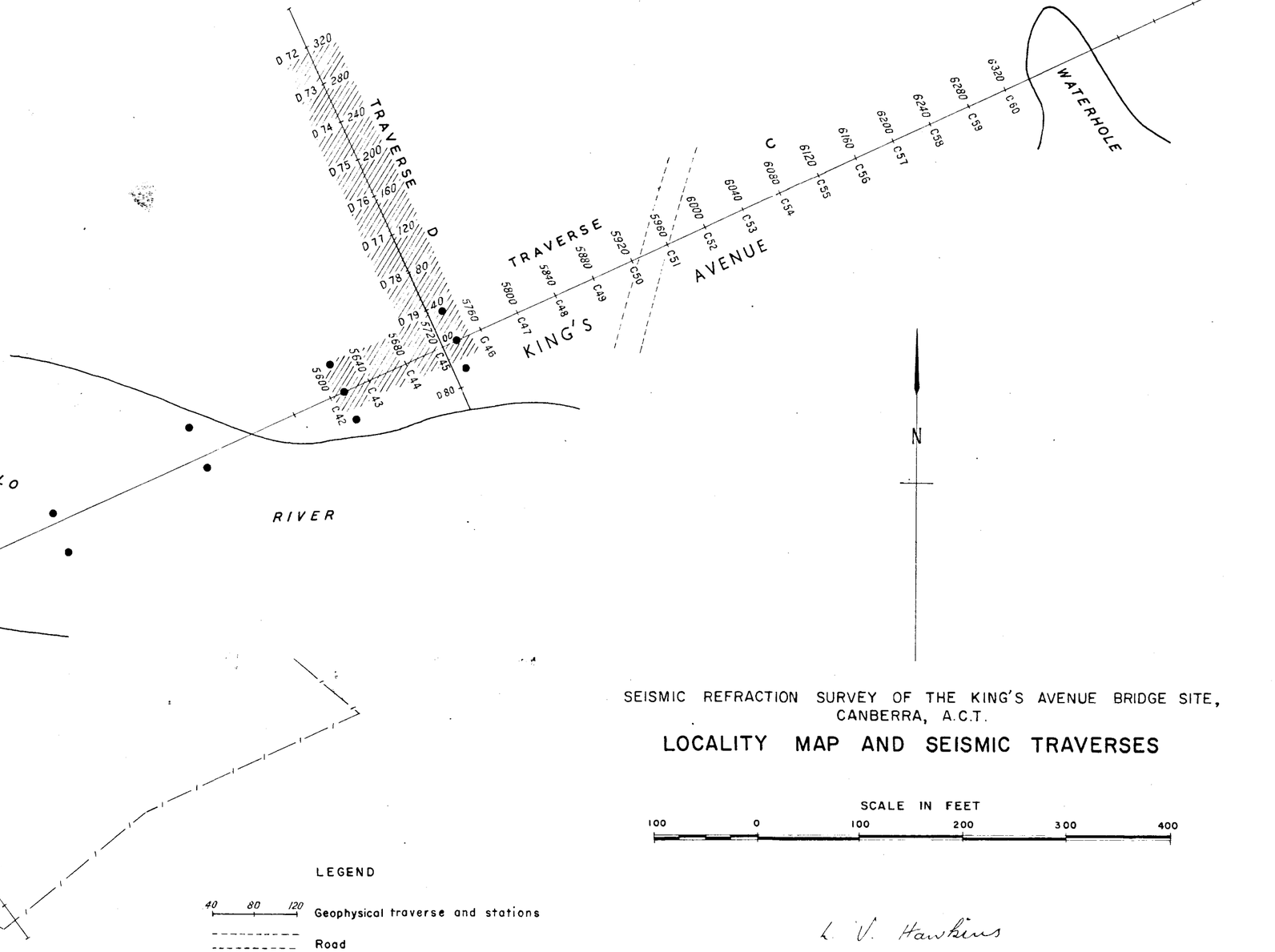
Opik, A.A., 1953a - Geological Map of Canberra. Bur. Min. Resour. Aust., A.C.T. G2-12.

Opik, A.A., 1953b - Tectonic Map of Canberra, Bur. Min. Resour. Aust., A.C.T. G2-13.

PLATE I







LEGEND

- Geophysical traverse and stations (40 80 120)
- Road
- Fence
- Low velocity zone in bedrock (Possible fault or shear)
- Drill hole

SEISMIC REFRACTION SURVEY OF THE KING'S AVENUE BRIDGE SITE, CANBERRA, A.C.T.

LOCALITY MAP AND SEISMIC TRAVERSES

SCALE IN FEET

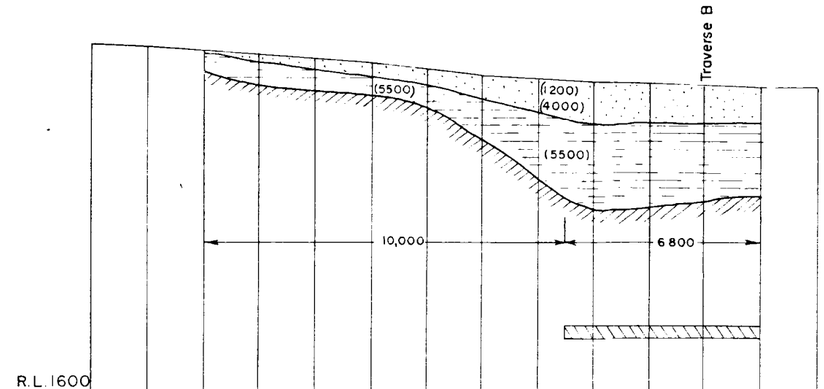
100 0 100 200 300 400

L. V. Hawkins

GEOPHYSICIST

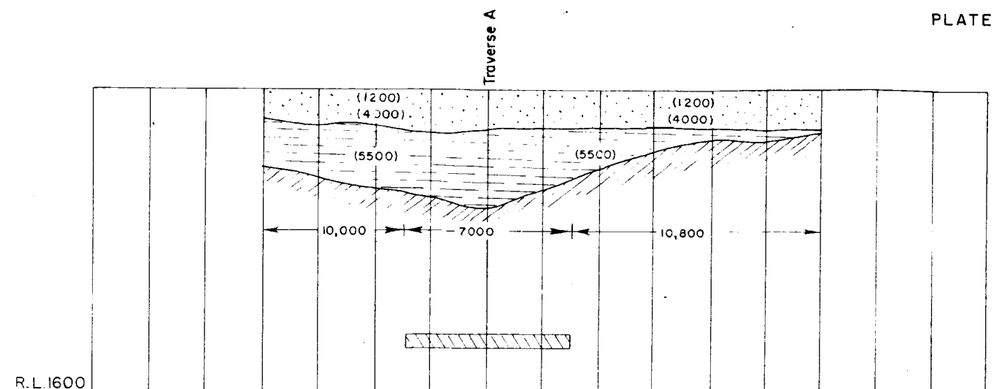
Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. I55/B5-8

(Ex G263-1)



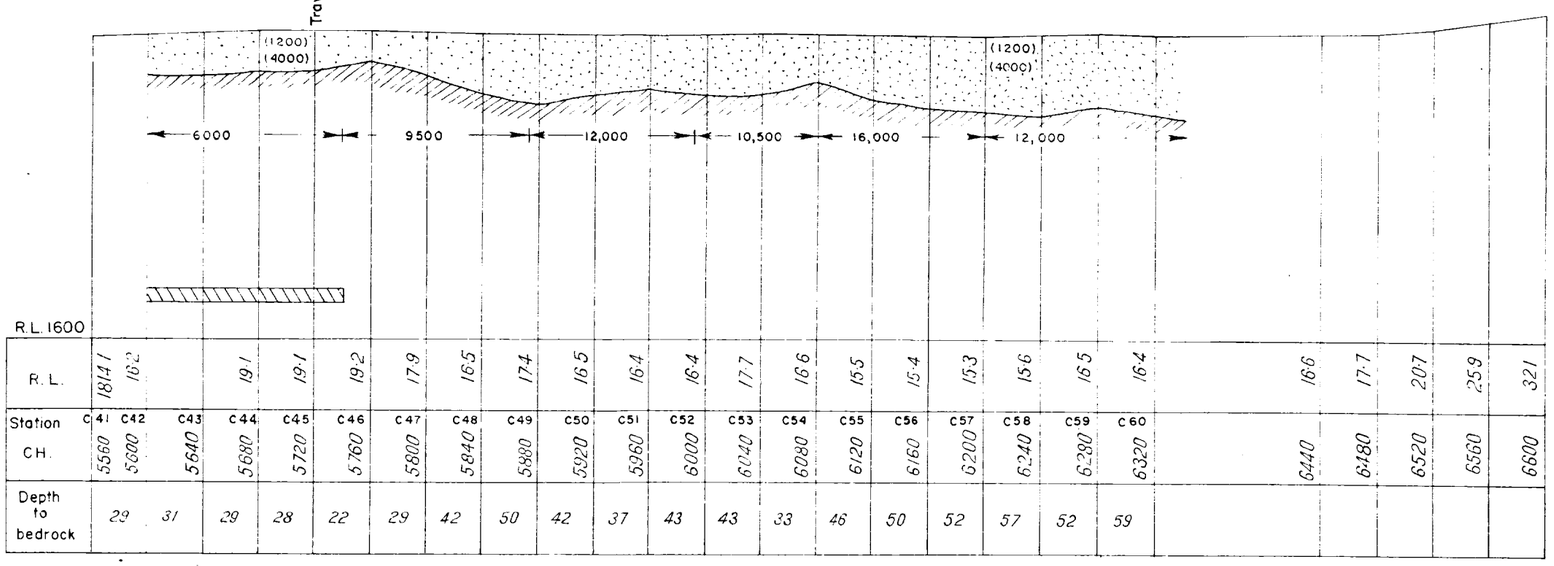
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
R.L. 1600	R.L.	1846·1	44·2	42·4	38·9	35·9	32·5	29·0	25·3	22·3	20·3	19·6	17·4	15·9	15·8
	Station CH.	4600	4640	4680	4720	4760	4800	4840	4880	4920	4960	5000	5040	5080	5120
	Thickness of alluvium			4	6	8	9	12	17	23	30	29	27	25	
	Depth to bedrock			14	23	22	23	29	48	67	91	90	85	76	

TRAVERSE A



		B21	B22	B23	B24	B25	B26	B27	A12	B28	B29	B30	B31	B32	B33	B34	B35	B36
R.L. 1600	R.L.	1818·1	18·0	17·4	17·4	17·1	17·2	17·5	17·4	17·2	17·4	17·4	17·4	17·9	18·1	17·5	16·8	17·9
	Station CH	280	240	200	160	120	80	40	00	40	80	120	160	200	240	280	320	360
	Thickness of alluvium				20	25	23	29	27	27	27	27	27	27	27			
	Depth to bedrock				54	62	70	76	84	71	57	44	34	37	30			

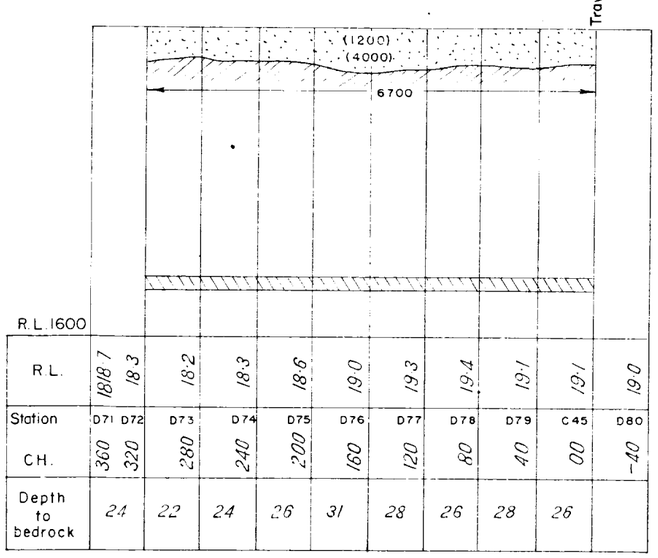
TRAVERSE B



		C41	C42	C43	C44	C45	C46	C47	C48	C49	C50	C51	C52	C53	C54	C55	C56	C57	C58	C59	C60
R.L. 1600	R.L.	1814·1	16·2		19·1	19·1	19·2	17·9	16·5	17·4	16·5	16·4	16·4	17·7	16·6	15·5	15·4	15·3	15·6	16·5	16·4
	Station CH.	5560	5600	5640	5680	5720	5760	5800	5840	5880	5920	5960	6000	6040	6080	6120	6160	6200	6240	6280	6320
	Depth to bedrock	29	31	29	28	22	29	42	50	42	37	43	43	33	46	50	52	57	52	59	

R.L. 1600	R.L.	16·6	17·7	20·7	25·9	32·1
	Station CH.	6440	6480	6520	6560	6600
	Depth to bedrock					

TRAVERSE C



		D71	D72	D73	D74	D75	D76	D77	D78	D79	C45	D80
R.L. 1600	R.L.	1818·7	18·3	18·2	18·3	18·6	19·0	19·3	19·4	19·1	19·1	19·0
	Station CH.	360	320	280	240	200	160	120	80	40	00	-40
	Depth to bedrock	24	22	24	26	31	28	26	28	26		

TRAVERSE D

LEGEND

- Alluvium } Overburden
- Weathered rock } Overburden
- Bedrock
- Low velocity zone in bedrock (Possible fault or shear)
- 5500 Seismic velocity

L. V. Hawkins

GEOPHYSICIST

SEISMIC REFRACTION SURVEY OF THE KING'S AVENUE BRIDGE SITE
CANBERRA, A.C.T.

WEATHERED AND UNWEATHERED ROCK PROFILES

SCALE IN FEET

100 0 100 200 300

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics I55/B5-9

(Ex G263-2)