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GEOPHYSICAL INVESTIGATIONS AT THE MACKINTOSH RIVER DAM SITE, TASMANIA

by

E. J. POLAK

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E. J. POLAK

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ABSTRACT

Details and results are given of seismic refraction, magnetic and resistivity surveys carried out in response to an application from the Hydro-Electric Commission of Tasmania to investigate a proposed dam site on the Mackintosh River, near Tullah.

The purposes of the surveys were to determine the depth to, and nature of, the bedrock and the nature of the overburden. The overburden consists of soil, scree, gravel and weathered rock, and is up to 90 feet thick. The bedrock consists of rocks of the Dundas Group.

Seismic velocities of 1,000 to 5,000 ft/sec. were recorded in the overburden and velocities of 8,000 to 18,000 ft/sec. in the bedrock.

It is estimated that the thickness of the overburden has been calculated with a maximum error of ± 25 per cent. There are no drill holes which could be used for control of the seismic calculations.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania proposes to construct a dam on the Mackintosh River about four miles above its junction with the Murchison River, near the township of Tullah. The dam will be part of the Pieman River scheme. The impounded water will flood the Sophia river valley, from where a tunnel will take the water into the Murchison River and then to Murchison power station (Plate 1).

The proposed site for the dam was chosen by the Commission from aerial maps, and is located near the northern spur of Mt.Farrell. In response to an application from the Commission, the Bureau of Mineral Resources carried out a geophysical survey of the site to determine the nature of the overburden and bedrock and the depth to bedrock.

The seismic refraction, magnetic and resistivity methods were applied. The survey was made in February, 1957, by a party consisting of E.J. Polak, geophysicist (Party Leader), and J. Kronenburg, geophysical assistant. The Commission provided additional assistants and carried out the topographical survey of the traverse lines.

2. GEOLOGY

The geology of the area is described by Ward (1908) and Bradley (1954,1956). A detailed geological examination of the site was carried out by Mather (1957), and his geological map is reproduced on Plate 2.

The investigated area is a wide valley covered with scree, river terrace material and sand. The southern abutment of the dam will rest on a steep cliff of Owen Conglomerate, and the northern abutment on a low ridge with outcrops of Dundas Group schists.

The Dundas Group rocks are of Cambrian age (Opik,1951), and consist of slates, cherts, shales, schists and graywacke. In the area of the proposed dam the bedding planes of the formations are nearly vertical. The strike of the bedding planes ranges between 10° and 53°, with an average of 35°. Some of the rocks weather very easily.

The Owen Conglomerate is part of the West Coast Range Conglomerate series and is of Cambro-Ordovician age (Opik,1951). The conglomerate is wholly quartzose in composition and contains pebbles (2 to 4 inches in diameter) of reef quartz and quartz schists. The matrix has been altered to quartzite material. The rock is strongly resistant to weathering. On traverse C, stations 1 and 2 (see Plate 2) may be located on Owen Conglomerate; otherwise the western boundary of the Owen Conglomerate is just outside the area covered by seismic traverses.

The river terrace material consists of sand and gravel.

The scree consists of Dundas Group rocks and angular blocks of Owen Conglomerate mixed with soil and sand from the river terrace.

The term "bedrock", as used in this report, refers to Dundas Group rocks, which have a seismic velocity ranging from 8,000 to 18,000 ft/sec. The term "overburden" refers to soil, scree, river gravel, river terrace material and possibly weathered Dundas Group rocks; the seismic velocity in the overburden ranges from 1,000 to 5,000ft/sec.

3. METHODS

The resistivity, seismic refraction and magnetic methods were applied:

A. Resistivity method.

Different rock types possess different electrical resistivity, as a result of variations in the lithology and physical properties of the rocks. Hard, non-porous, unweathered rocks generally have a high resistivity. Shearing and fracturing cause localised weathered zones which, because of the resultant increase in the water content and salinity, produce a decrease in resistivity. As a general rule it may be said that the resistivity of a rock is inversely proportional to its porosity and to the salt content of the pore solutions.

In the Wenner method of resistivity survey, which was used in the present investigations, four electrodes equally spaced in a straight line are moved as a whole along a traverse and readings are taken at consecutive stations. In the interpretation, absolute values of resistivity are not as important as sudden changes from high to low resistivity - such changes generally indicate a change in rock type.

The total length of resistivity traverses surveyed was 3,000 ft. A Megger Earth Tester was used.

B. Seismic method.

The seismic method of exploration depends on the contrast in the velocity of seismic waves through different rock formations. Hard, unweathered rocks have higher velocities than their weathered counterparts, while these in turn have higher velocities than soil and unconsolidated deposits.

The method of differences was used (Heiland, 1946) and the following types of spread were shot:

(i) Weathering spreads. These were used to obtain seismic wave velocities in, and the thickness of, near-surface layers. Geophone interval was 10 ft. and shot points were 5 ft. and 50 ft. from both ends of the spread.

(ii) Normal spreads. The geophone interval was 25 ft. or 50 ft. and shot points were 25 ft. and 250 ft. from both ends of the spread.

The equipment used in the seismic survey was a Century 12-channel refraction seismograph, model 506, with Technical Instrument Co. geophones of natural frequency about 20 cycles per second. The total length of seismic traverses surveyed was 10,300 ft.

C. Magnetic method.

Different rock types may have different magnetic susceptibilities, resulting in variations in the strength of the magnetic field measured at the surface. Magnetic measurements can, in some areas, indicate boundaries between different types of near-surface formations. At the Mackintosh dam site, however, the differences in magnetic susceptibility were so small that tests by this method yielded no useful information, and the results are therefore not included in this report. Sixty-five magnetic stations were occupied using a Watts vertical intensity variometer.

4. RESULTS

A. Resistivity Survey.

The results of the resistivity survey using an electrode spacing of 100 feet are shown as a resistivity contour map on Plate 2. The results are shown only for the left (south) bank of the river; a test traverse on the right bank of the river (traverse B-B') indicated that there were no significant anomalies on this bank.

The Owen Conglomerate has a low porosity, hence the resistivity is high. As shown on Plate 2, steep resistivity gradients were recorded along the south-eastern parts of traverses A-A', B-B' and C-C', the resistivity increasing towards the south-east.

As the overburden does not thin out towards the south-east and the interstitial water is everywhere equally fresh, the zone of steep gradients is interpreted as indicating the approximate boundary between the Dundas Group and the Owen Conglomerate.

B. Seismic Survey.

Plates 3 and 4 show the interpretation of the results of the seismic survey in the form of profiles indicating the thickness of the overburden. Lack of drilling data and the paucity of outcrops (these are confined to the river bed and to the ridge north of the area surveyed) make the assignment of velocities to any particular type of rock difficult.

Table 1 shows a tentative interpretation of velocities in terms of rock type.

TABLE 1.

	Rock type	Seismic velocity(ft/sec)	Young's Modulus (c.g.s.units)
Overburden	Soil	1,000	
	Scree River gravel Terrace material	2,000 - 3,500	
	River gravel (along H-H') or weathered Dundas Group rocks	3,500 - 5,000	
Bedrock	Unweathered Dundas Group rocks	8,000 -18,000	2.5×10^{11} to 8.4×10^{11}

A considerable difference was observed in the seismic velocities measured in two directions at right angles in the bedrock, indicating that the rocks of the Dundas Group are anisotropic. The velocity of propagation parallel to the bedding planes (as measured along traverses D-D', E-E', F-F' and H-H') is 20 to 30 per cent higher than that across the bedding planes. The velocities shown in Table 1 are those measured parallel to the bedding planes.

Plate 5 shows the contours of the surface of the bedrock, obtained from the seismic data.

The main features of the area, as indicated by the seismic survey, are:-

(i) On the left bank of the river, the thickness of the overburden increases away from the river; on the right bank, after an initial increase in thickness, the overburden thins out towards the Dundas Group outcrops on the ridge.

(ii) The lower boundary of two terraces is indicated by the bedrock contours.

(iii) The overburden has a maximum thickness of 90 ft. near station 80 on traverse A-A' on the right bank of the river.

(iv) Along traverses F-F' and H-H', which are approximately parallel to the strike of the bedding, the seismic velocities within the bedrock are lower between stations 147 and 150, 156 and 159, 163 and 167, 178 and 181, 191 and 194 than elsewhere along the traverses. This could be due to the presence of shear zones at the abovementioned places.

To calculate the approximate Young's Modulus values shown in Table 1, a density value of 2.7 was taken as an average for the rocks of the Dundas Group and a Poisson's ratio of 0.3 for rock of 8,000 ft/sec. velocity and 0.1 for rock of 18,000 ft/sec. velocity (Birch, Schairer and Spicer, 1950).

It is estimated (Wiebenga and Hawkins, 1954) that the thickness of the overburden has been calculated with an error of no more than ± 25 per cent. There are no drill holes at the site which could be used for control of the seismic calculations.

5. CONCLUSIONS

The geophysical survey provided information on the depth to bedrock at the dam site. The overburden consists of soil, scree, gravel, river terrace material and weathered rocks. The bedrock consists of rocks of the Dundas Group.

The seismic survey indicated that the thickness of the overburden is least along or close to traverse C-C' (see Plate 3).

The probable contact between the Owen Conglomerate and rocks of the Dundas Group was indicated by the resistivity survey.

6. REFERENCES

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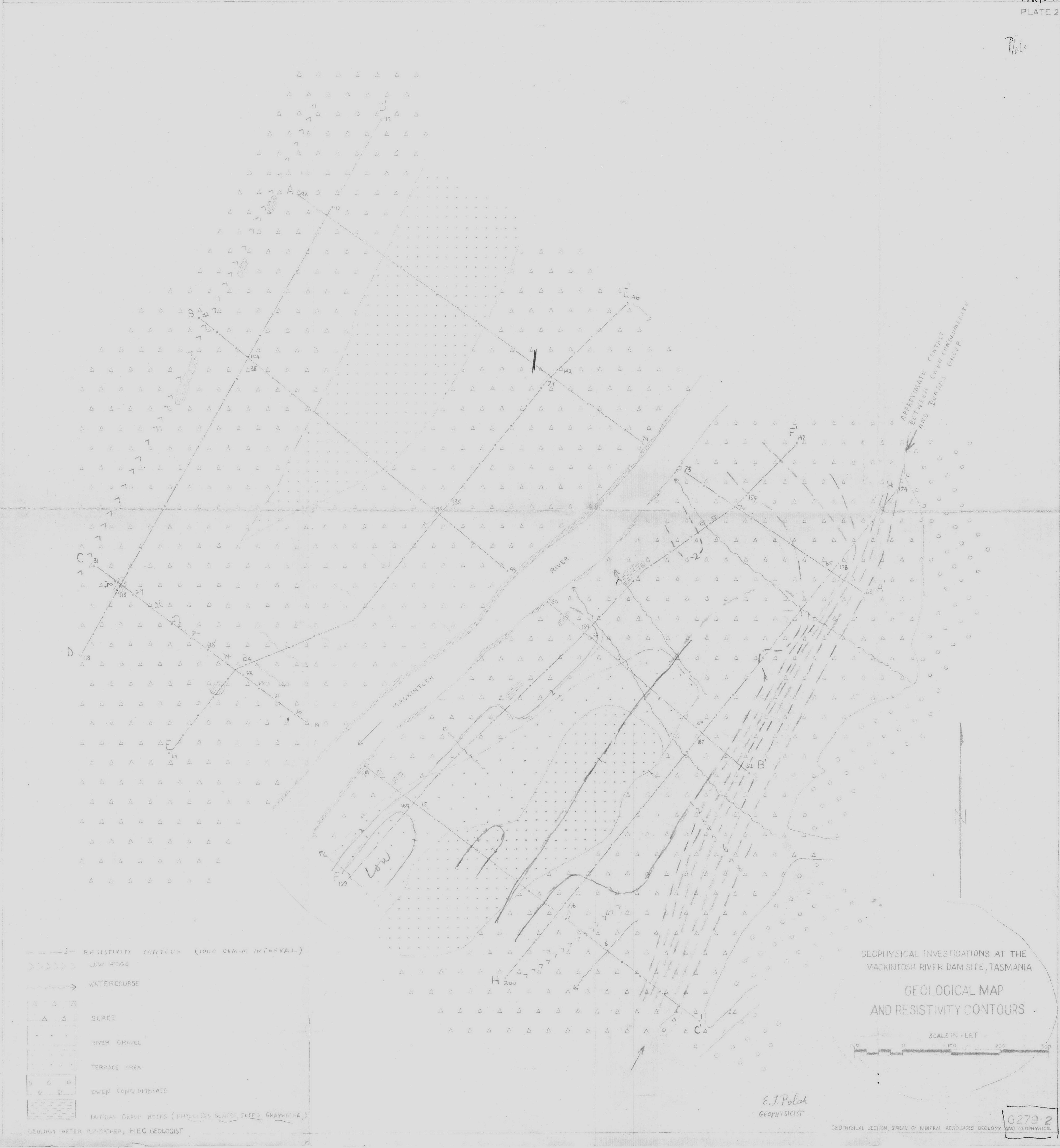
PLATE 1
LOCALITY MAP
INVESTIGATED AREA
EMU BAY RLY
PIEMAN RIVER
TULLAH
MACKINTOSH RIVER
MT FARRELL
MT BLACK
ROSEBERY
WILLIAMSFORD
MT MURCHISON
MURCHISON R.
SOPHIA R.
MILES
TASMANIA
MACKINTOSH
RIVER
SCALE IN FEET
100 0 100 200 300
LEGEND
TOPOGRAPHICAL CONTOURS, 10 FT INTERVALS
GEOPHYSICAL TRAVERSE WITH STATIONS
GEOPHYSICAL INVESTIGATIONS AT THE
MACKINTOSH RIVER DAM SITE, TASMANIA
TOPOGRAPHICAL CONTOURS AND GEOPHYSICAL TRAVERSES
G279-1
GEOPHYSICAL SECTION BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

Plate 1A
PLATE 2



GEOPHYSICAL INVESTIGATIONS AT THE MACKINTOSH RIVER DAM SITE, TASMANIA

GEOLOGICAL MAP AND RESISTIVITY CONTOURS

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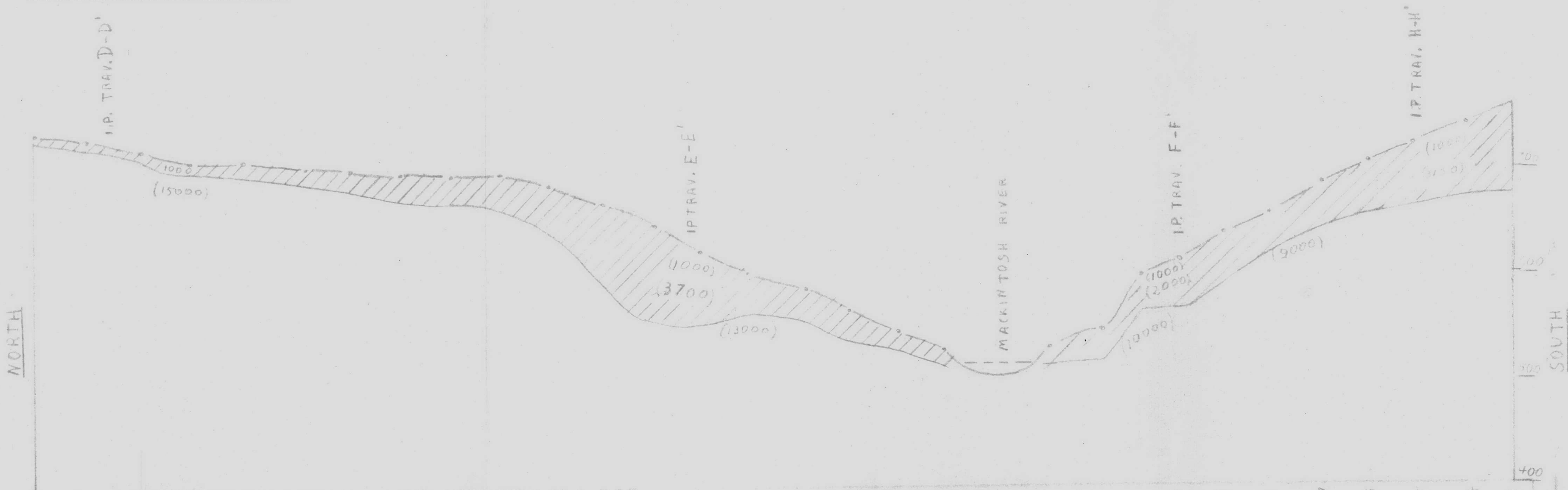
G279-2

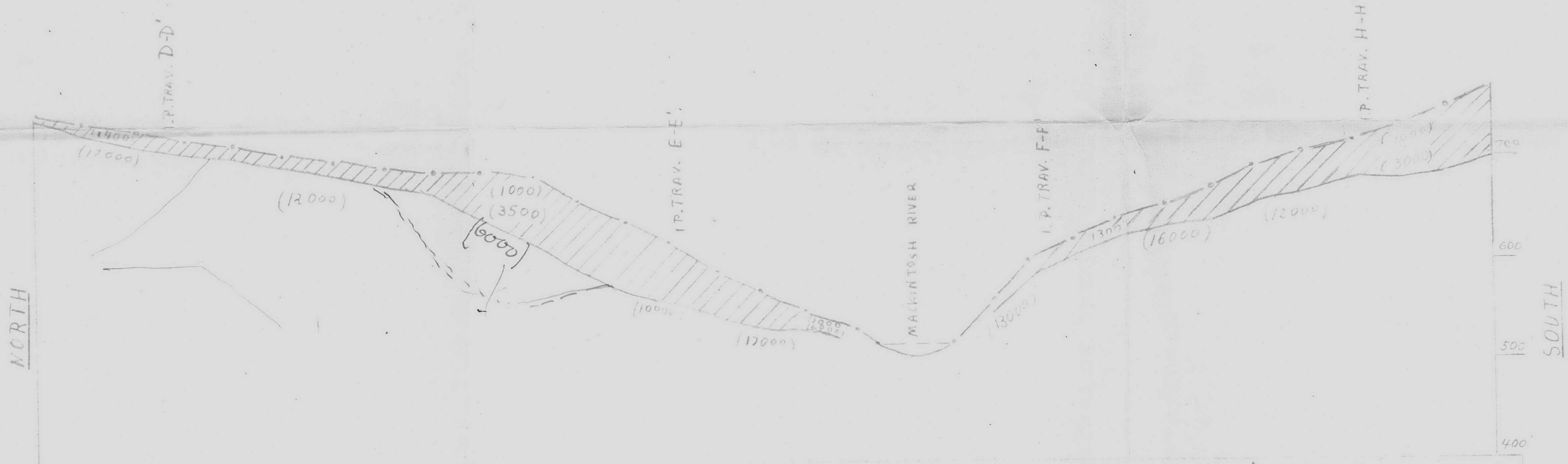
GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

TRAVERSE: A-A'



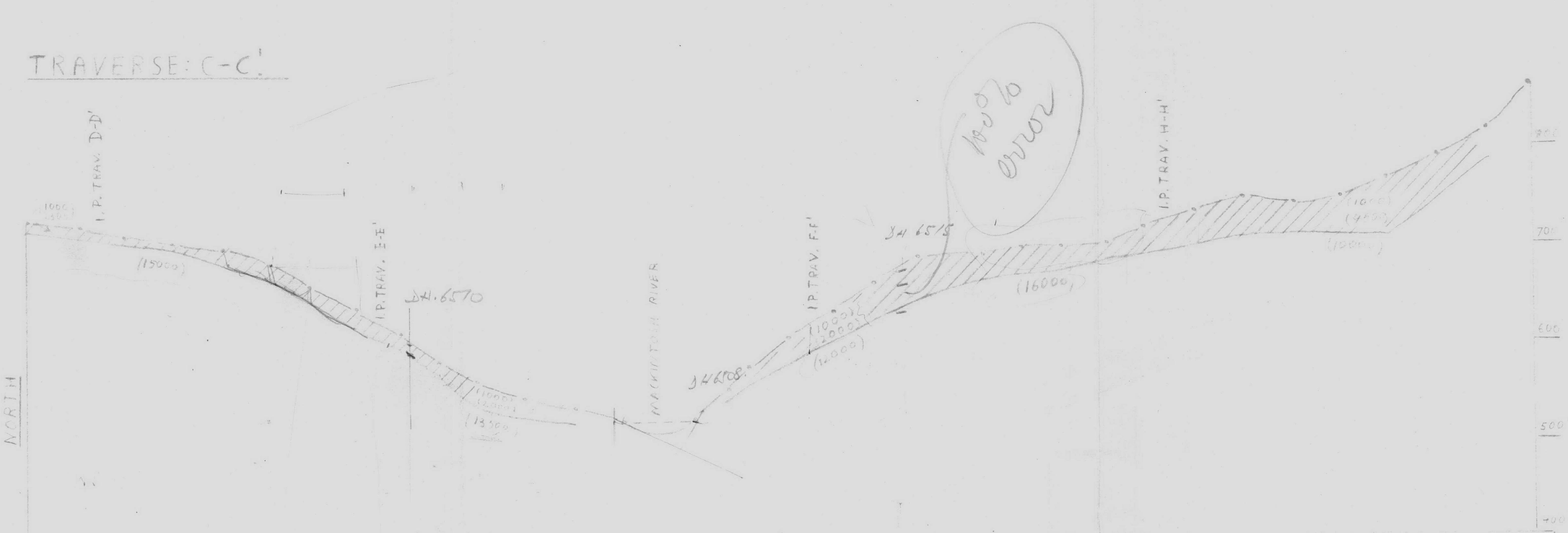
STATION NO.	92	91	90	89	88	87	86	85	84	83	82	81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63
SURFACE LEVEL	738	731	722	716	711	707	704	703	702	701	690	674	654	628	603	594	574	552	533	535	551	601	617	642	659	687	707	723	741	761
DEPTH TO BEDROCK	6	8	10	11	13	16	18	24	26	33	45	76	90	68	38	30	30	18	15	16	28	[illegible]	46	47	38	[illegible]	51	58	68	86

TRAVERSE: B-B'



STATION NO.	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
SURFACE LEVEL	757	745	736	728	721	712	705	695	691	692	683	664	643	621	594	573	552	533	520	569	599	620	639	654	672	694	707	716	732	750	771
DEPTH TO BEDROCK	5	14	17	17	16	12	14	17	23	46	66	67	67	60	45	36	18			12	[illegible]	20	20	22	35	40	[illegible]	[illegible]	54	56	70

TRAVERSE: C-C'



STATION No.	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	B,	6	5	4	3	2	1
SURFACE LEVEL	731	725	715	709	702	688	663	638	611	584	561	542	535	553	576	606	633	663	687	690	694	697	702	717	734	747	741	748	767	790	817	864
DEPTH TO BEDROCK	8	13	9	7	16	18	15	20	18	16	26	20	17	[illegible]	18	26	31	40	42	25	23	16	17	28	35	40	32	38	58	43	30	

LEGEND

OVERBURDEN

BEDROCK

(9000) SEISMIC VELOCITY IN FEET/SEC

I.P. INTERSECTION POINT

SCALE IN FEET

100 0 100 200 300

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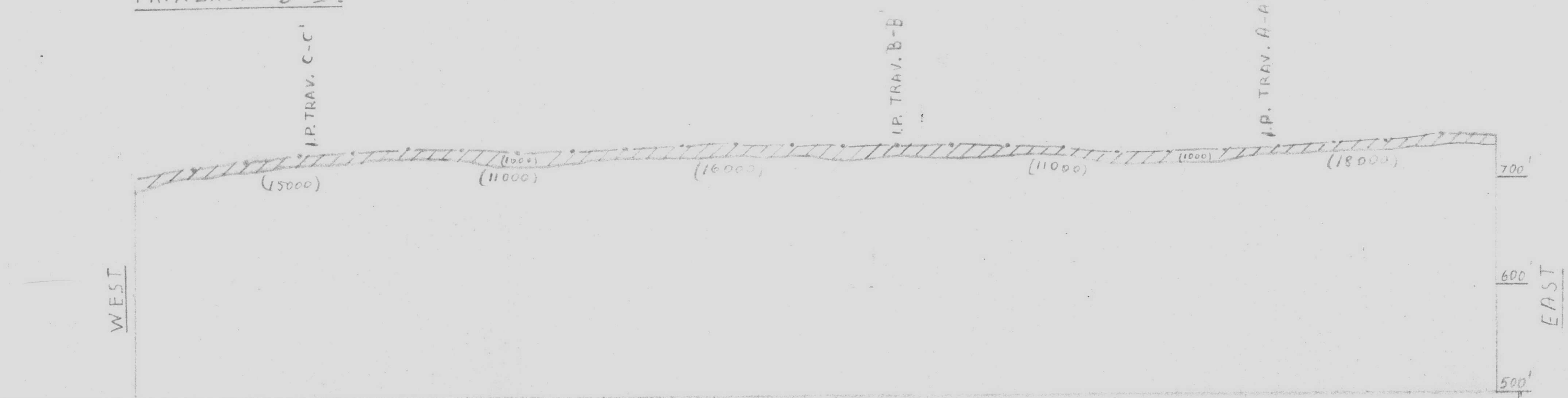
GEOPHYSICAL INVESTIGATIONS AT THE MACKINTOSH RIVER DAM SITE, TASMANIA

INTERPRETION OF SEISMIC TRAVERSES A-A', B-B' AND C-C'

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

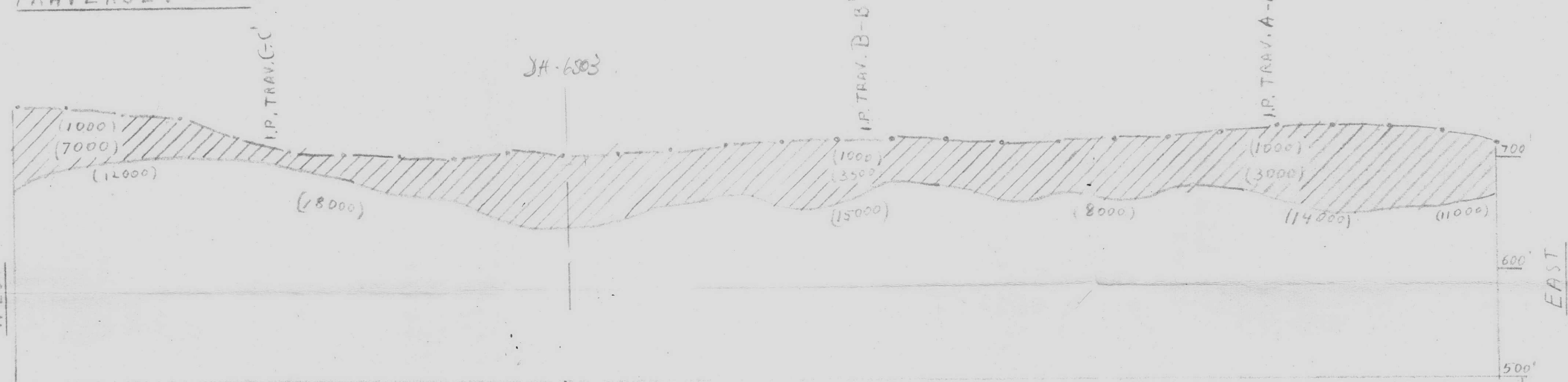
G279-3

TRAVERSE: D-D'



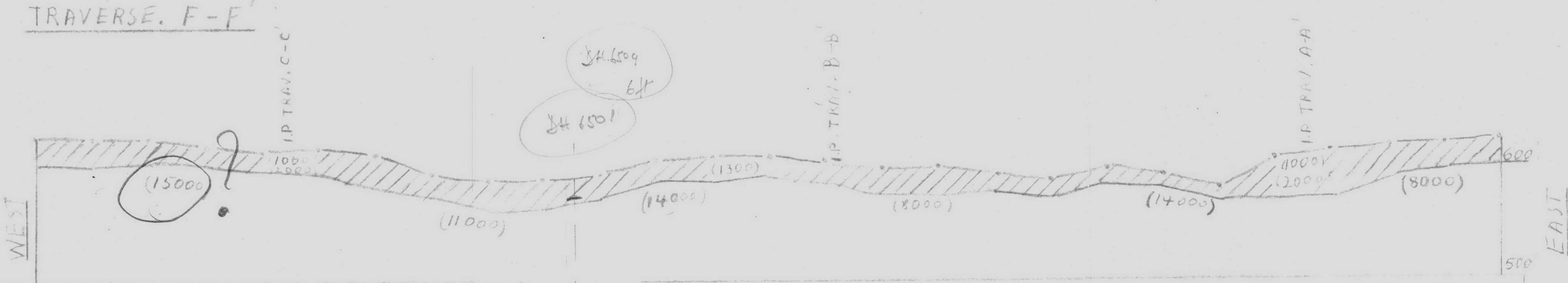
STATION No	SURFACE LEVEL	DEPTH TO BEDROCK
118	706	12
117	714	8
116	720	10
115	726	9
114	729	10
113	731	10
112	730	8
111	729	13
110	729	10
109	730	8
108	733	12
107	734	12
106	733	9
105	733	13
104	732	9
103	732	13
102	732	10
101	730	8
100	727	12
99	726	10
98	726	9
97	728	7
96	733	8
95	735	8
94	740	10
93	738	8

TRAVERSE. E-E'



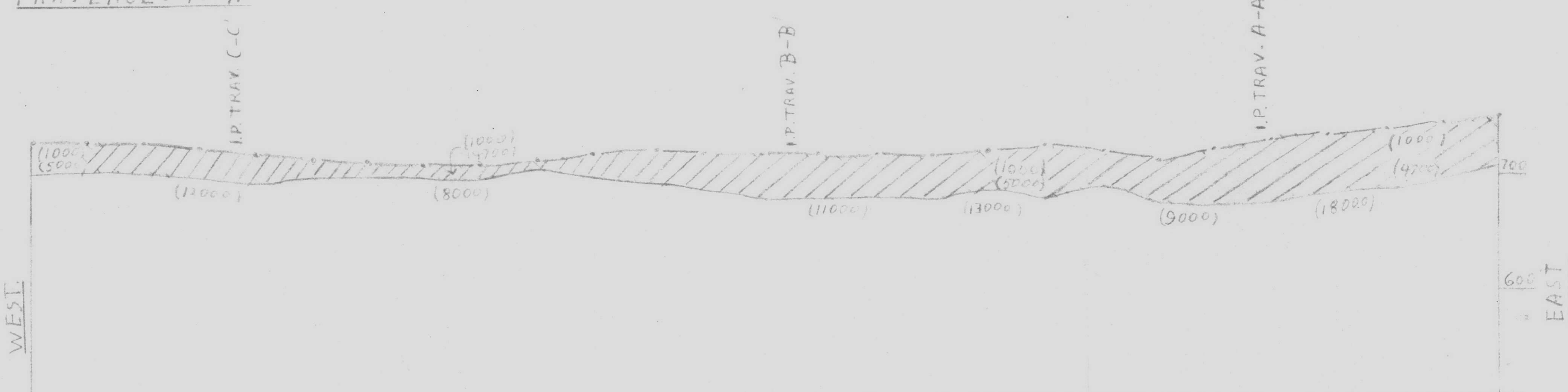
STATION No.	SURFACE LEVEL	DEPTH TO BEDROCK
119	652	74
120	651	56
121	647	42
122	642	34
123	626	20
124	612	14
125	609	21
126	606	34
127	604	38
128	610	63
129	607	65
130	609	60
131	612	50
132	614	46
133	619	60
134	620	59
135	620	37
136	620	42
137	619	53
138	617	47
139	618	56
140	620	49
141	625	50
142	629	68
143	630	80
144	628	75
145	625	68
146	614	46

TRAVERSE. F-F'



STATION No	SURFACE LEVEL	DEPTH TO BEDROCK
173	631	23
172	631	25
171	632	23
170	624	18
169	618	17
168	621	22
167	618	30
166	598	21
165	594	28
164	594	25
163	599	23
162	611	21
161	615	23
160	615	18
159	610	19
158	606	23
157	604	26
156	599	16
155	594	15
154	604	15
153	599	11
152	588	11
151	613	37
150	620	41
149	622	30
148	628	24
147	630	24

TRAVERSE. H-H'



STATION No	SURFACE LEVEL	DEPTH TO BEDROCK
200	733	31
199	733	30
198	731	29
197	723	26
196	722	27
195	718	19
194	714	18
193	711	15
192	711	12
191	715	11
190	721	26
189	724	32
188	721	35
187	721	41
186	720	43
185	720	40
184	719	43
183	723	35
182	728	50
181	721	35
180	714	43
179	725	55
178	731	58
177	738	52
176	743	56
175	748	54
174	754	46

LEGEND

OVERBURDEN

BEDROCK

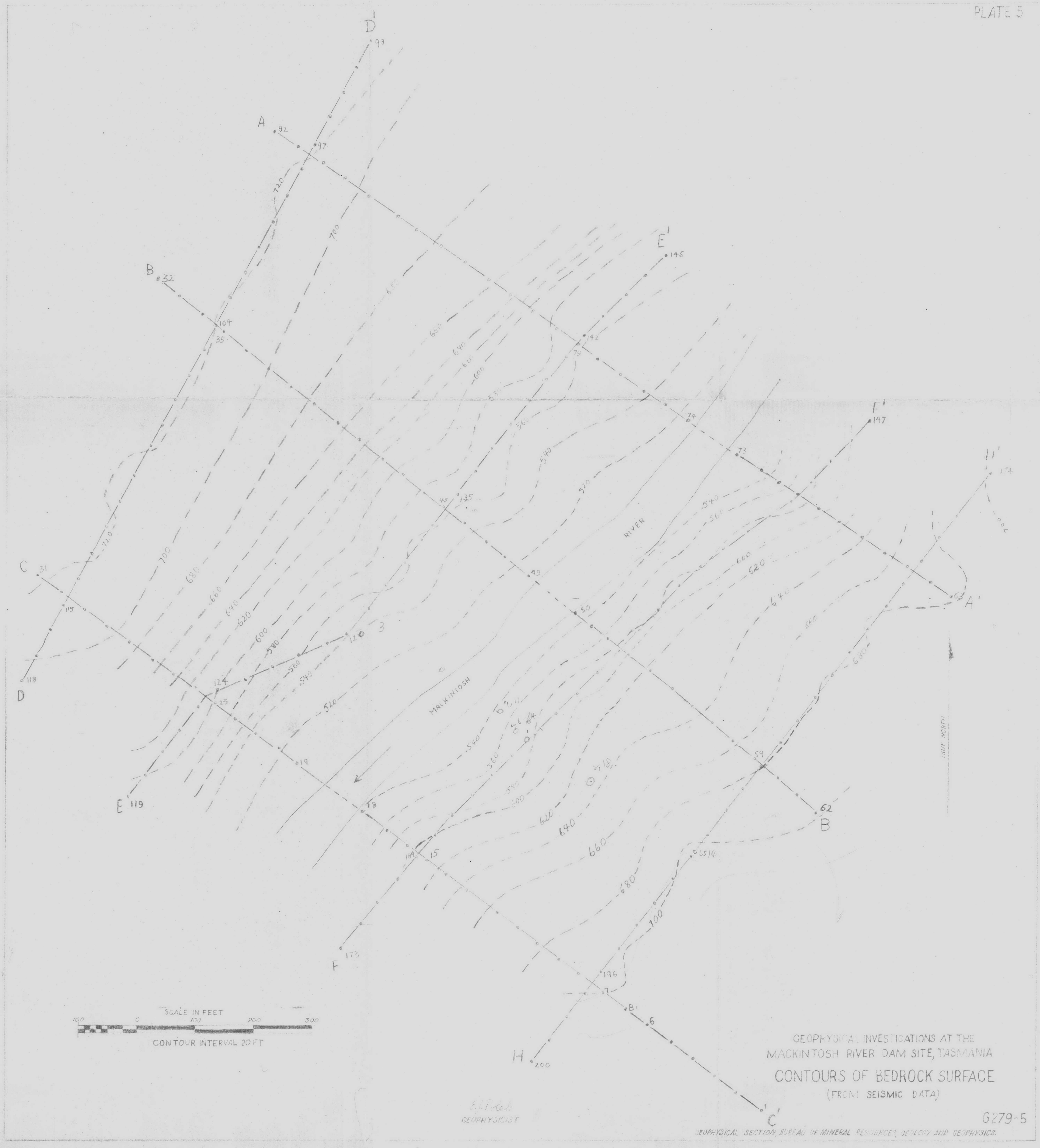
(9000) SEISMIC VELOCITY IN FT/SEC.

IP INTERSECTION POINT

SCALE IN FEET: 100 0 100 200 300

GEOPHYSICAL INVESTIGATIONS AT THE MACKINTOSH RIVER DAM SITE, TASMANIA

INTERPRETATION OF SEISMIC TRAVERSES D-D', E-E', F-F' AND H-H'



GEOPHYSICAL INVESTIGATIONS AT THE
MACKINTOSH RIVER DAM SITE, TASMANIA

CONTOURS OF BEDROCK SURFACE

(FROM SEISMIC DATA)

GEOPHYSICIST

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