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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1964/53

DARWIN RIVER DAM SITE
SEISMIC SURVEY 1963

by

J.T.G. ANDREW

The information contained in this report has been obtained by the Department of National Development as part of the policy of the Commonwealth Government to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

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ILLUSTRATIONS

SUMMARY

This Record describes a seismic survey at the Darwin River dam site, associated saddles, and pondage areas, in 1963. The survey results suggest that the dam site with best foundation conditions is about 200 feet downstream from the present proposed site. At the first saddle the bedrock surface may be lower than the proposed water level of the dam. At the second saddle fresh bedrock is below sea level. Leakage may occur through both saddles. Either of the two pondage sites surveyed would be suitable.

Note: This Record supersedes Record No.1963/78 which was issued as a Progress Report on the survey.

1. INTRODUCTION

The Geological Branch of the Bureau of Mineral Resources, on behalf of the Commonwealth Department of Works, asked for a geophysical survey to be made at the Darwin River, NT. Work was done at a dam site, at two saddles, and at two pondage reservoir sites. An extra traverse was surveyed to determine whether the river follows a shear zone. The depth to bedrock and the seismic velocity in the bedrock were determined. The total length of seismic traverse surveyed was 11,000 feet.

The locations of the various sites surveyed are shown in Plate 1. Referring to the Australia 1:50,000 map series, the co-ordinates of the sites are as follows:

Site	Co-ordinates	Sheet No.
Dam	964638	5072-11 (Tumbling Waters)
First Saddle	950615	" " "
Second Saddle	950590	" " "
Upper pondage	963743	5072-1 (Middle Arm)
Lower pondage	955750	" " "

The survey was made between 19th and 29th March 1963. The gravity consisted of J.T.G. Andrew (party leader), J. Ashley (geophysicist), and C.J. Braybrook (geophysical assistant). W.A. Wiebenga (senior geophysicist) was with the party up to 25th March. The Department of Works provided field assistants; the topographic survey was made by the Water Resources Branch of the Northern Territory Administration.

2. METHODS AND EQUIPMENT

The seismic refraction technique known as the 'method of differences' (Dyson and Wiebenga, 1957) was used. The instrument used was an SIE 12-channel seismograph, with TIC geophones of natural frequency 20 c/s.

The geophone spacing was 50 ft for normal spreads. Spacings of 25, 15, and 10 ft were used for more-detailed spreads.

3. DARWIN RIVER DAM SITE

Geology

The geology of the area was investigated by Hays (1962). Subsequently the area was costeaned.

The dam site is at a gap in a ridge of quartzite trending north-north-east. The true strike is roughly at right angles to the river and ranges from 015 degrees to 025 degrees; the dip ranges from 40 degrees to 65 degrees in the west-north-west direction. The quartzite is not homogeneous; within the quartzite there are layers of phyllite that have been shown in the costeans to be considerably weathered. One small shear was mapped in the railway cutting and another is visible in the costean on the south bank of the river. Joints are developed in an easterly direction.

Plate 2 shows the geology of the dam site and the location of the seismic traverses.

Results

The velocities determined are interpreted in geological terms in Table 1.

TABLE 1

Seismic velocity (ft/sec)	Rock type
1500 - 2000	soil and mud
3000	saturated river mud
5000 - 9000	weathered to partly weathered phyllite and quartzite
10,000 - 15,500	slightly weathered to fresh quartzite and phyllite

Plate 3 shows the results of the seismic work on the dam site. These results show that along Traverses A and B, which are nearly parallel to the strike of the quartzite, the bedrock is shallower than along Traverses C, D, E, F, and G, which are across the strike. This is caused by weathered phyllite bands between layers of quartzite. For further explanation reference is made to the Appendix. The velocity along the strike at the top of the quartzite is 11,000 ft/sec, whereas across the strike the velocity is between 5000 and 8000 ft/sec.

Plates 4 shows the seismic velocities measured along the traverses and the shear zones. Two shear zones are indicated: one from F9 to C12, the other on the south bank only, passing between G5 and G7 and between C7 and C9.

On Traverse D there are indications of a low-velocity layer under the first high-velocity layer at both ends of the traverse (Plate 3). There is also a low-velocity layer indicated at depth near G2 and between B6 and B9 (see Appendix).

The bedrock appears to be shallow under the river; on Traverse A and B the depth of the bedrock decreases as the river is approached. Traverse J and the Meander traverse (Plate 5) were surveyed to investigate whether the river was formed on a shear zone. Along Traverse J, on which no depth was determined, the bedrock velocity is about 13,000 ft/sec; along the Meander traverse, on the extension of the line of the river, the velocity is 12,500 ft/sec. Both these velocities are high enough to suggest that there is no shear zone in the river bed.

Conclusions

The presence of the two shear zones and the greater depth to bedrock to the east suggest that foundations would be better for a dam immediately west of Traverse B than on Traverse A.

The greatest depth to bedrock recorded is 117 ft at F8.

The places where drilling information would be most informative would be at:

C8, D6½, and G6 to check the shear zones,

B6½, E8, and on the river bank between A9 and B9 to check for weaker material at depth.

From the engineers' point of view the traverses in the easterly direction give a better estimate of depth to sound foundation rock than the north-south traverses, as there may be a further weak layer below the depths determined on the north-south traverses whereas in the east-west direction the depths determined are to continuous solid material.

4. FIRST SADDLE SITE

Geology

The location of the site is shown in Plate 6.

The geology of this area has not been mapped in detail. The Precambrian is believed to be overlain by Cretaceous rocks, which include two highly permeable horizons (Wilson, 1963).

Results

The velocities determined are interpreted in geological terms in Table 2.

TABLE 2

Seismic velocity (ft/sec)	Rock type
1000 - 2000	Soil and clay
5000 - 8000	Weathered Precambrian or Cretaceous rock.
11,000 - 16,000	Slightly weathered to fresh Precambrian

The results are plotted in Plate 7. It is possible that velocities less than 11,000 ft/sec represent the Cretaceous sediments and the 11,000-ft/sec and higher velocities represent the Precambrian. If this is so the maximum depth to the Precambrian is 80 ft near I10. There may be a shear zone near H1.

Conclusions

It is possible that the Cretaceous sediments, including highly permeable horizons, may extend down to an R.L. of 100 ft, which is lower than the proposed water level of the dam. If this is the case the saddle will have to be sealed to prevent leakage.

It is suggested that holes should be drilled at H11, H1, and I10.

5. SECOND SADDLE SITE

Geology

The location of the site is shown in Plate 6.

The geology of this area has not been mapped in detail, but it is believed that Cretaceous sediments, including permeable horizons, overlie the Precambrian (Wilson, 1963).

Results

The seismic velocities determined are interpreted in geological terms in Table 3.

TABLE 3

Seismic velocity (ft/sec)	Rock type
1000 - 2000	soil, clay
4000 - 7200	weathered Cretaceous or Precambrian rock
10,000 - 16,000	Slightly weathered to fresh Precambrian bedrock

The results of the seismic traverses are shown in Plate 8. If the 4000 to 7000-ft/sec-velocity range includes only Cretaceous rocks, then the greatest depth to Precambrian bedrock is 200 ft at K40.

Conclusions

In this area the Cretaceous/Precambrian unconformity is probably near to sea level. If the Cretaceous is permeable, leakage may occur through this saddle. Holes should be drilled at K20 and K40 to determine whether the low-velocity material represents Cretaceous or Precambrian weathered rock.

6. PONDAGE RESERVOIR SITES

Geology

The sites are located on the Depot Creek Sandstone with flat bedding. In places the sandstone is silicified and it is also well jointed. Some of the joints are filled with sandstone breccia (Hays, 1962).

Results

The velocities obtained are interpreted in geological terms in Table 4.

TABLE 4

Seismic velocity (ft/sec)	Rock type
1500 - 3000	soil and clay to saturated clay
4000 - 6500	weathered sandstone
7000 - 8700	slightly weathered sandstone
10,000 - 13,000	quartzite or sandstone bedrock

At the pondage sites there was insufficient overlap of high velocities on the time/distance curves to enable depths to be calculated at every geophone. It was not practicable to repeat the work with shots farther away, so only the depths calculated from intercept times are shown. Thus the profiles indicate the general trend of the bedrock surface, but do not show details of variations in depth along the traverses.

Upper pondage site. The results of the seismic traverses are plotted on Plate 9. On the south-west side of the river the greatest calculated depth to sandstone is 36 ft at N10 and the least depth 26 ft at N1. On the north-east bank the greatest calculated depth to sandstone is 36 ft at N10 and the least depth 26 ft at N1. On the north-east bank the greatest calculated depth to sandstone is 65 ft at L1 and the least calculated depth is 18 ft at L11. There is also a higher-velocity layer indicated at 172-ft depth near L1.

Lower pondage site. The results of the seismic traverses are plotted on Plate 10. On the south bank of the river the greatest calculated depth to bedrock is 34 ft near R1.

On the north bank of the river the greatest calculated depth to bedrock is 59 ft at P1 and the greatest calculated depth to sandstone is 15 ft at P1.

Conclusions

At both pondage sites at depths of not more than 65 ft there is material strong enough for foundations for a small dam.

7. REFERENCES

DYSON, D.F. and WIEBENGA, W.A. 1957 Final report on geophysical investigations of underground water at Alice Spring, NT 1956. Bur. Min. Resour. Aust. Rec. 1957/89 (unpubl.)

HAYS, J. 1962 Darwin water supply investigation of supplementary sources. Bur. Min. Resour. Aust. Rec. 1962/165 (unpubl.)

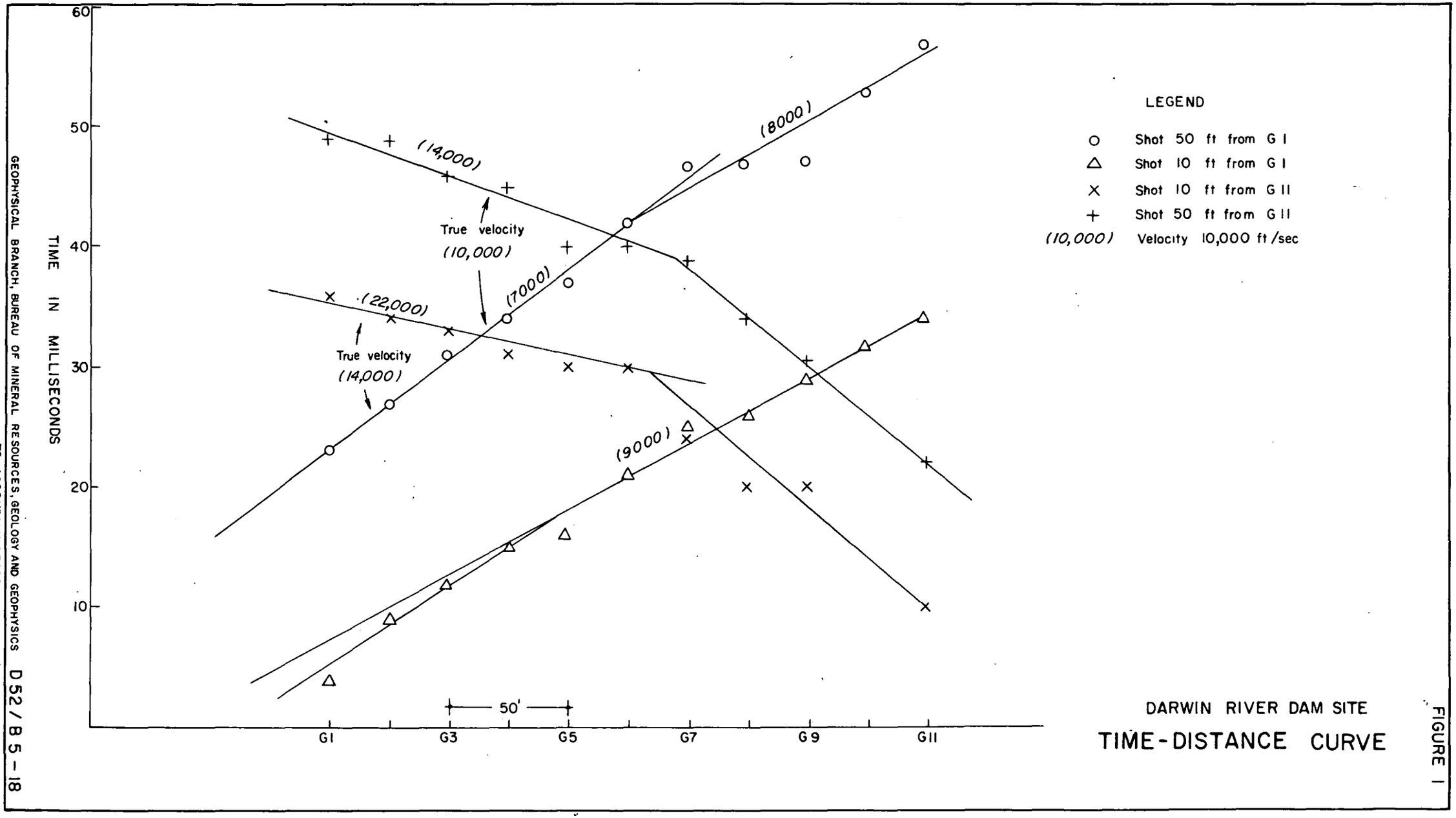
WILSON, H.M. 1963 Private communication.

APPENDIX

REVERSAL OF VELOCITY GRADIENT

On the east-west traverses at the Darwin River dam site, the time-distance curves show features as in Figure 1, where the velocity (22,000 ft/sec) measured with the short shot from the G11 end was higher than the velocity (14,000 ft/sec) measured with the long shot from the same end of the geophone spread. Theoretically a reversal of velocity gradient (i.e. a decrease of velocity with depth) cannot be detected by the seismic refraction method, as there will be no refracted wave returning to the surface from a boundary where high-velocity material overlies low-velocity material.

A lower velocity was detected from the long shot in this area because of the steep dip of the quartzite and phyllite; most of the energy from the short shot, which was fired on the quartzite, travelled through the high-velocity quartzite, whereas most of the energy from the long shot, presumably fired on the phyllite, travelled through a layer of low-velocity phyllite between two bands of quartzite. A series of different velocities can be obtained through the layers of quartzite and phyllite (see Figure 2 and interpretation of Traverse G on Plate 3).



DARWIN RIVER DAM SITE

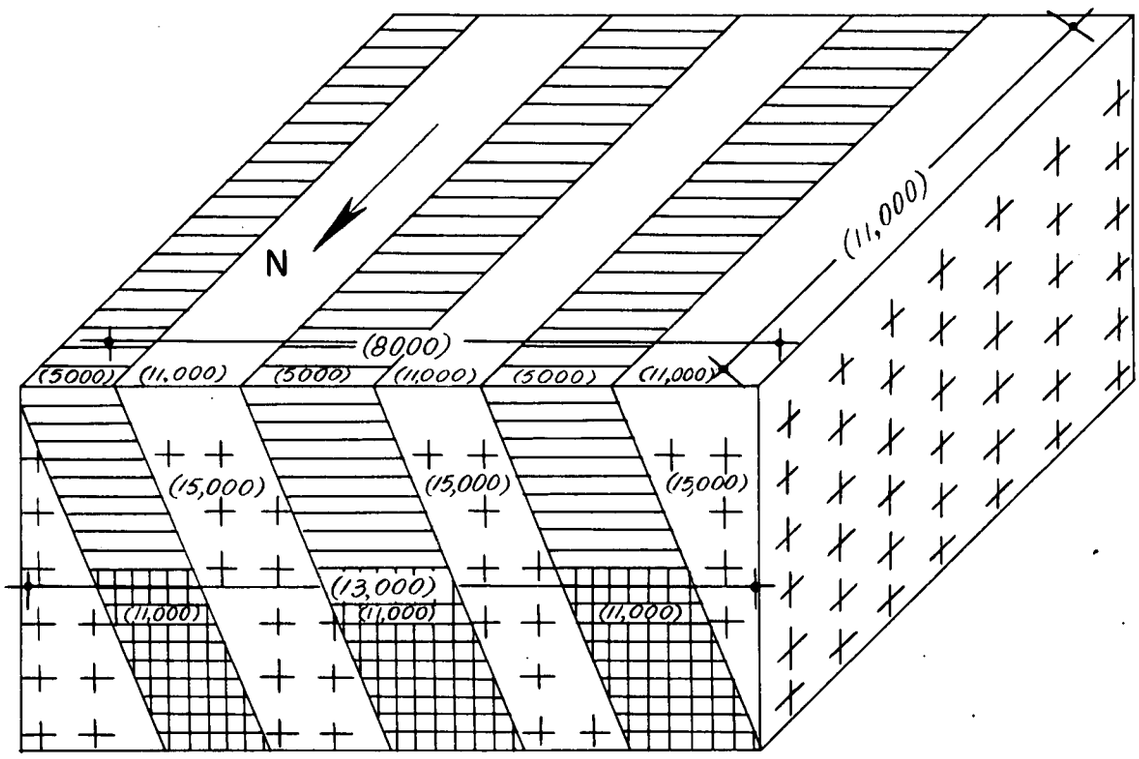
TIME-DISTANCE CURVE

FIGURE 1

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS D52/B5-18

TO ACCOMPANY RECORD No 1964/53

FIGURE 2



Weathered phyllite
Velocity 5000ft/sec

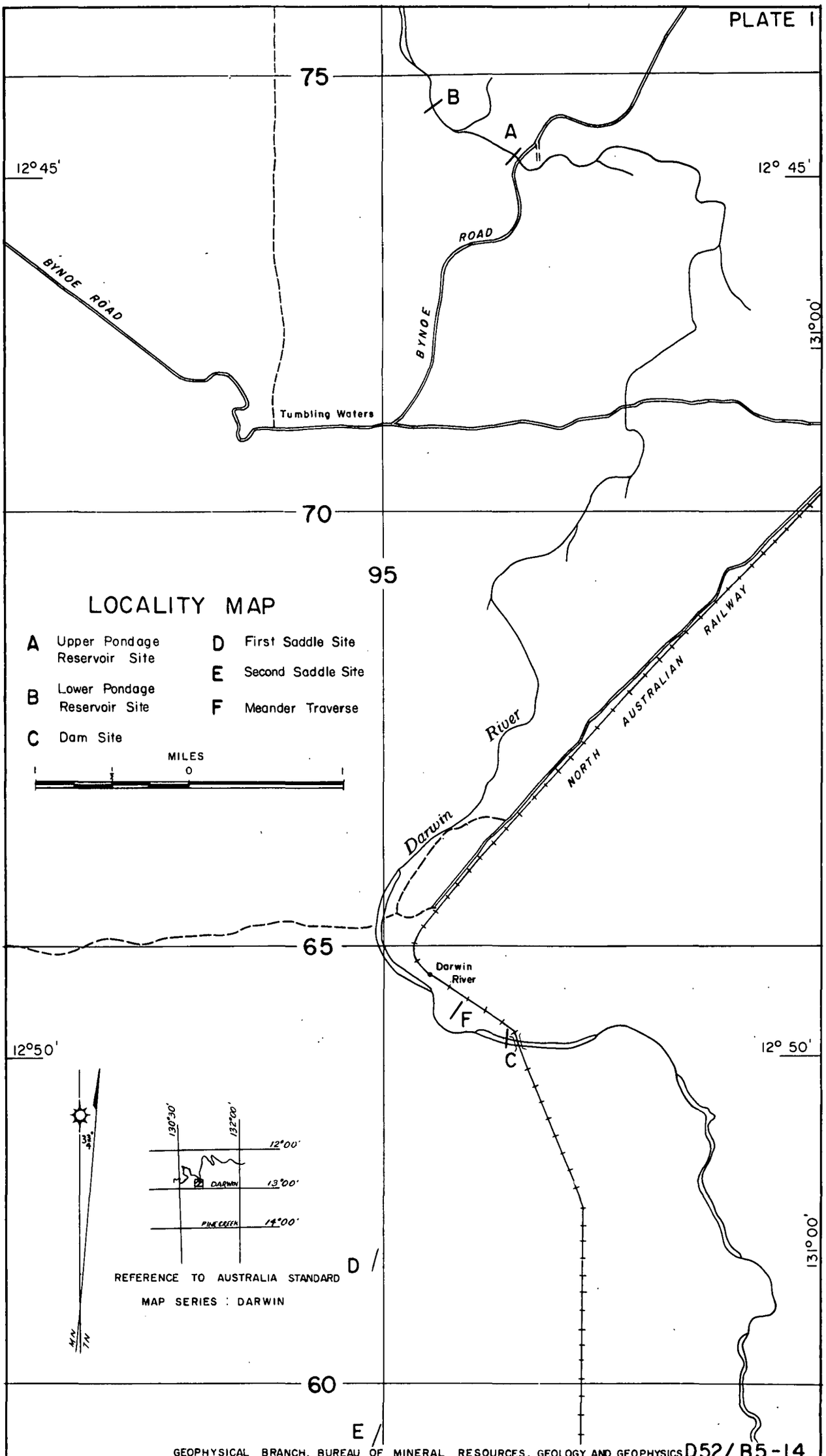
Slightly weathered quartzite
Velocity 11,000 ft/sec

Fresh phyllite
Velocity 11,000ft/sec

Fresh quartzite
Velocity 15,000 ft/sec

This diagram illustrates how the depths determined to the 13,000-ft/sec layer in the east-west direction, differ from those found to the 11,000-ft/sec layer in the north-south direction, at the Darwin River dam site. The velocities used in this diagram are arbitrary.

PLATE 1



GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS D52/B5-14

TO ACCOMPANY RECORD No 1964/53

DARWIN RIVER DAM SITE N/1963

TRAVERSE F
F1
F5
F10
F12
TRAVERSE B
B1
B5
B10
B15
TRAVERSE A
A1
A5
A8
A10
A15
RAILWAY CUTTING
QUARTZITE RUBBLE
TRAVERSE E
E1
E5
E7
E8
E10
E11
QUARTZITE BLOCKS AND RUBBLE
SPOIL FROM CUTTING
TRAVERSE H
H11
H1
TRAVERSE J
J3
J1
TRAVERSE G
G11
G10
G5
G1
DARWIN RIVER
TRAVERSE D
D1
D5
D10
D12
QUARTZITE BLOCKS AND RUBBLE
ALLUVIAL OR FERRICRETE FLATS
NORTH AUSTRALIAN RAILWAY
TRAVERSE C
C1
C5
C10
C12
B20
B21
A20
A21
QUARTZITE RUBBLE

LEGEND

LOWER PROTEROZOIC
- MASSON FORMATION
- ACACIA GAP MEMBER

- Suggested drill site
- Small fault or shear
- Quartzite
- Interbedded quartzite and slate
- Phyllitic slate
- Boundary of outcrop

DARWIN RIVER DAM SITE

GEOLOGICAL MAP AND SEISMIC TRAVERSES

GEOLOGY AFTER HAYS (1962)

50 25 0 50 100 150 FEET

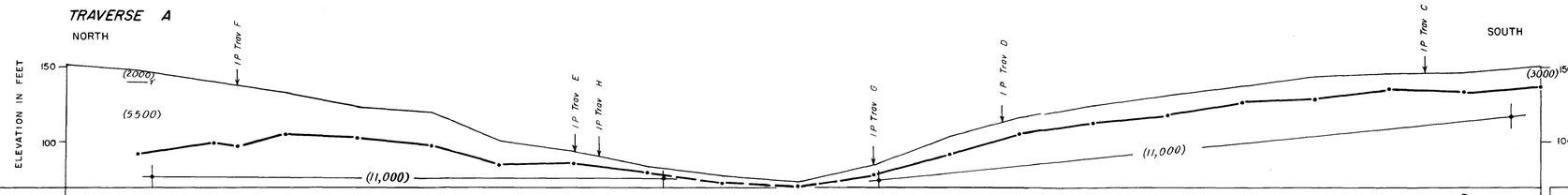
MN GN

TO ACCOMPANY RECORD No 1964/53

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS D 52/B5-4

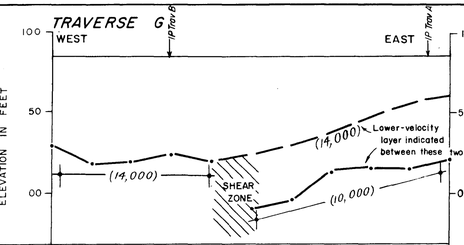
PLATE 3

TRAVERSE A



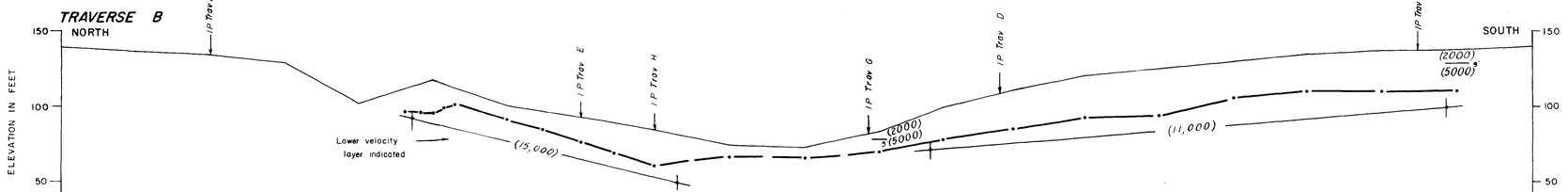
STATION NUMBER	1				5				10				15				20		21
STATION ELEVATION	152	148	142	134	125	120	100	95	86	76	73	84	103	116	125	132	139	143	146	148	149
DEPTH TO BEDROCK	55	40	41	26	19	20	15	9	11	10	7	7	12	10	12	12	9	13	9	14	12

TRAVERSE G



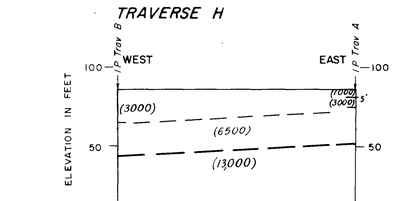
STATION NUMBER	11	10			5				1
STATION ELEVATION			85					83	
DEPTH TO BEDROCK	55	68	68	62	68	96	90	70	70	70	64

TRAVERSE B



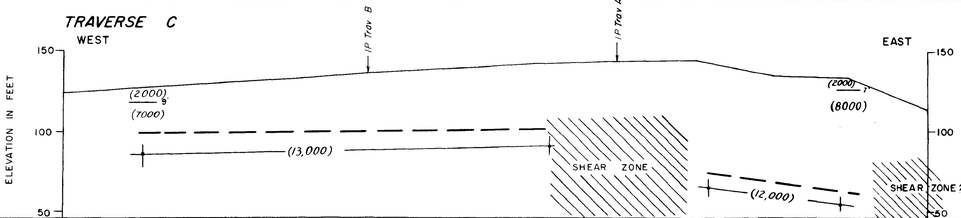
STATION NUMBER	1				5				10				15				20		21
STATION ELEVATION	139	131	134	128	103	119	100	94	86	74	73	85	101	113	121	126	131	135	138	139	142
DEPTH TO BEDROCK						16 18 22 16 11	9	13	16	20	25	16	27	15	21	27	25	32	23	23	29	27	27

TRAVERSE H



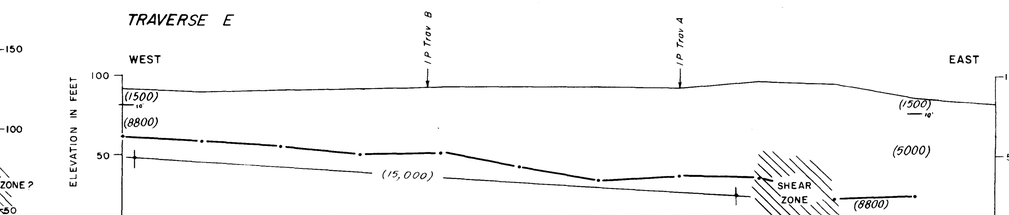
STATION NUMBER	11	10			5				1
STATION ELEVATION	86								
DEPTH TO BEDROCK	43			38				33	

TRAVERSE C



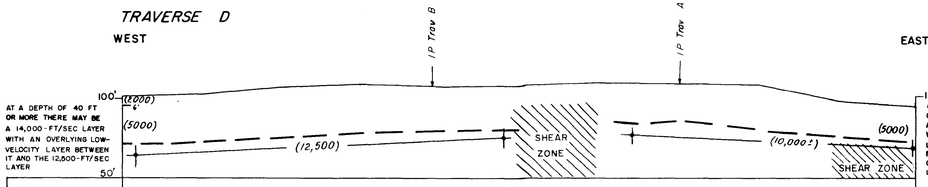
STATION NUMBER	1				5				10		12
STATION ELEVATION	124	127	131	135	139	142	145	147	147	139	127	118
DEPTH TO BEDROCK	33										78	

TRAVERSE E



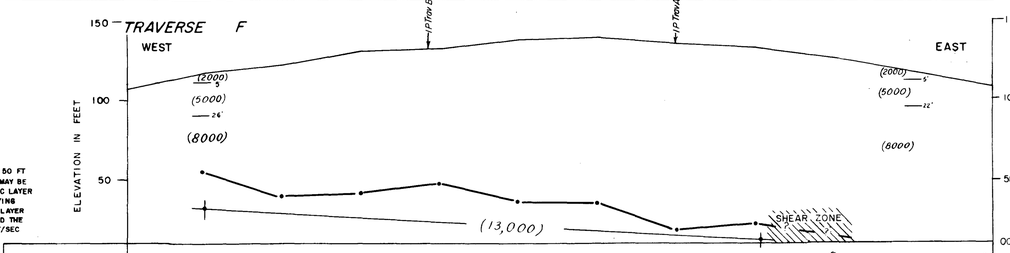
STATION NUMBER	1				5				10	11
STATION ELEVATION	91	91	92	93	94	96	95	95	99	97	88	85
DEPTH TO BEDROCK	31	31	36	41	41	50	58	54	63	71	63	

TRAVERSE D



STATION NUMBER	1				5				10	11
STATION ELEVATION	103	104	109	110	109	109	112	111	111	100	95
DEPTH TO BEDROCK	30					30	22				22

TRAVERSE F



STATION NUMBER	1				5				10		12
STATION ELEVATION	107	118	123	130	132	137	140	137	135	129	119	111
DEPTH TO BEDROCK		62	73	84	89	83	101	100	117	110		

LEGEND

(8000) Formation with seismic velocity of 8000 ft/sec

—7'— Depth to formation with different seismic velocity

IP Intersection point

Unweathered bedrock boundary

Levels refer to Darwin Town Datum

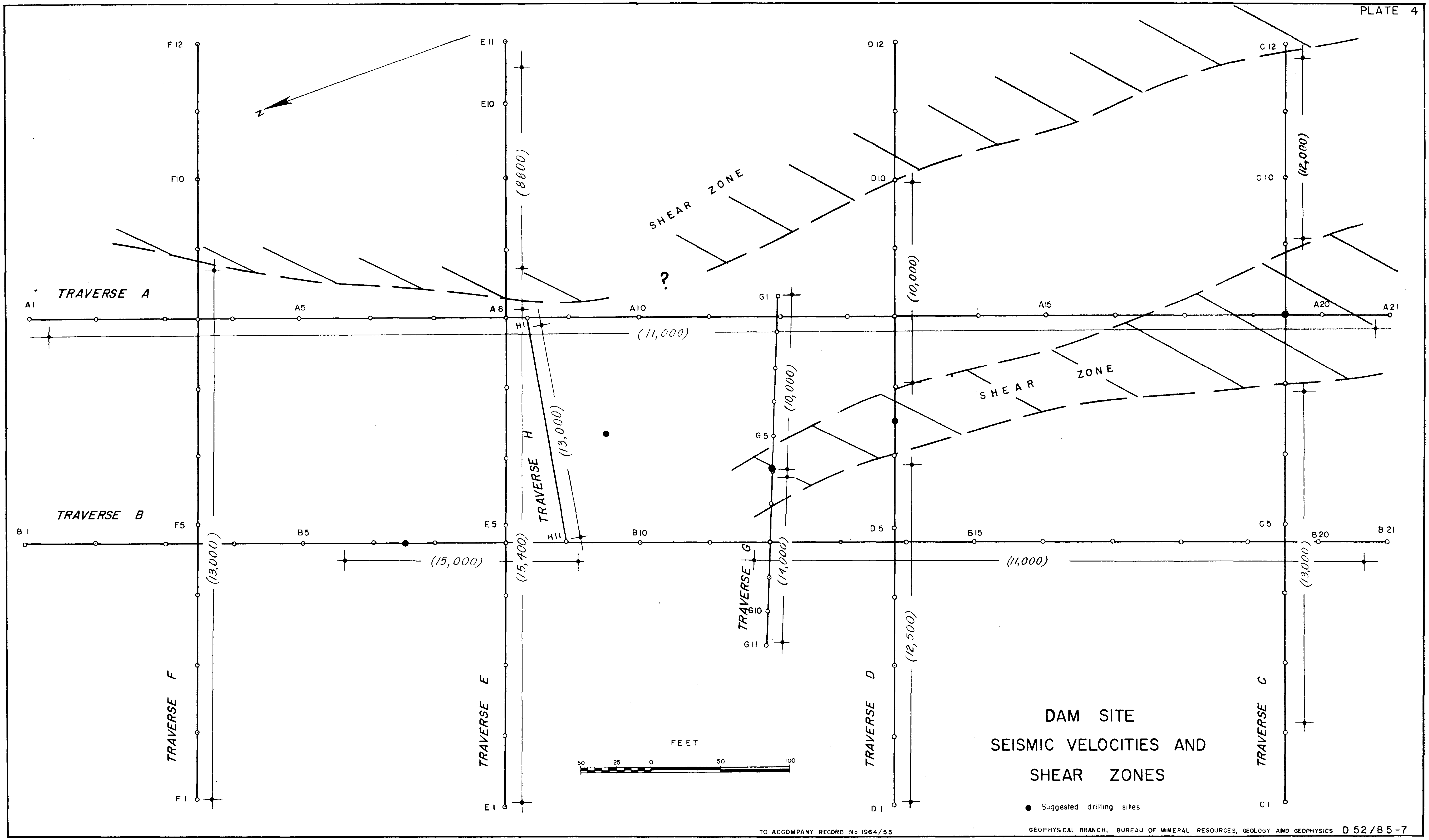
TRAVERSES A TO H
SEISMIC CROSS-SECTIONS

FEET
50 25 0 50 100 150

DARWIN RIVER DAMSITE NT 1963

TO ACCOMPANY RECORD No 1964/53

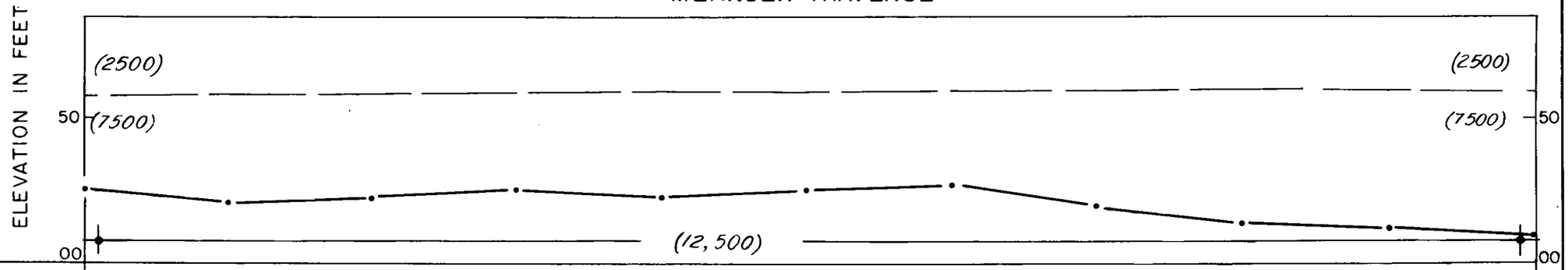
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS D52/B5-5



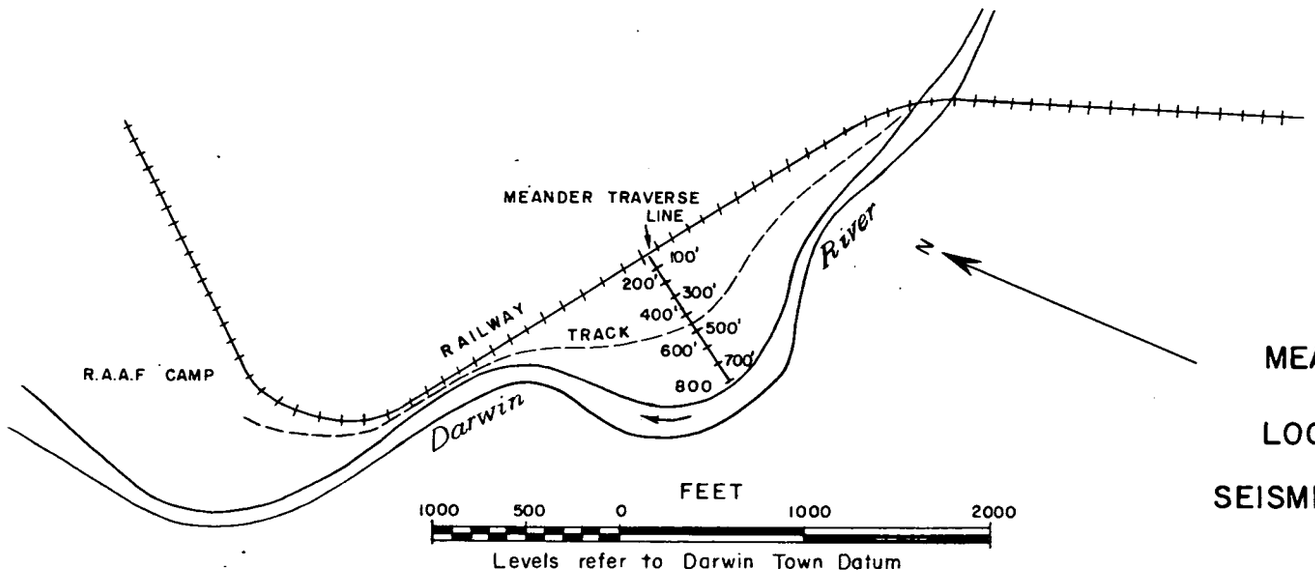
DARWIN RIVER DAM SITE NT 1963

DARWIN RIVER, NT, 1963

MEANDER TRAVERSE



STATION DISTANCE (FEET)	150	200	250	300	350	400	450	500	550	600	650
STATION ELEVATION		85		85		84		84		84	
DEPTH TO BEDROCK	58	64	62	60	62	60	59	66	71	73	75



MEANDER TRAVERSE

LOCALITY PLAN AND SEISMIC CROSS-SECTION

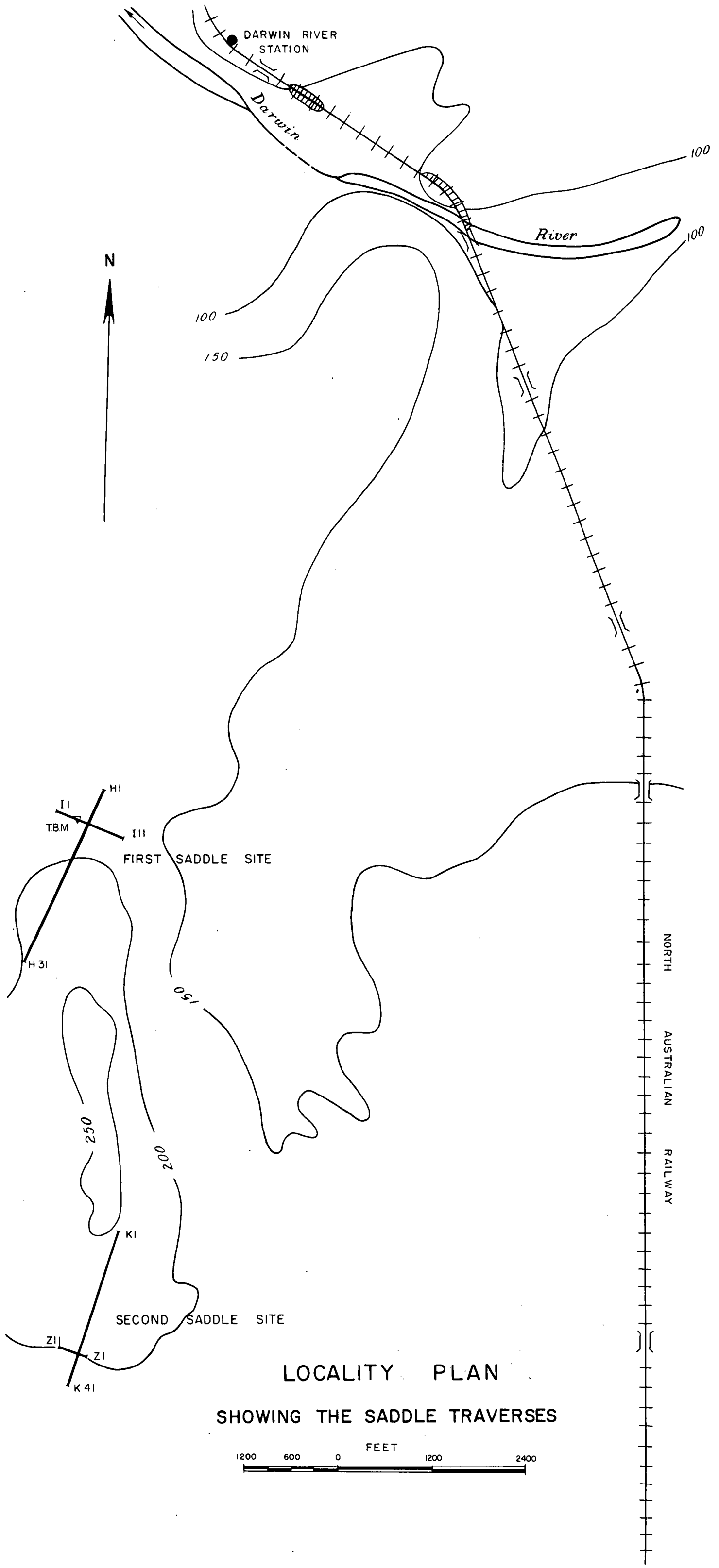
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

TO ACCOMPANY RECORD No 1964/53

D 52/B5-8

PLATE 5

PLATE 6



LOCALITY PLAN

SHOWING THE SADDLE TRAVERSES

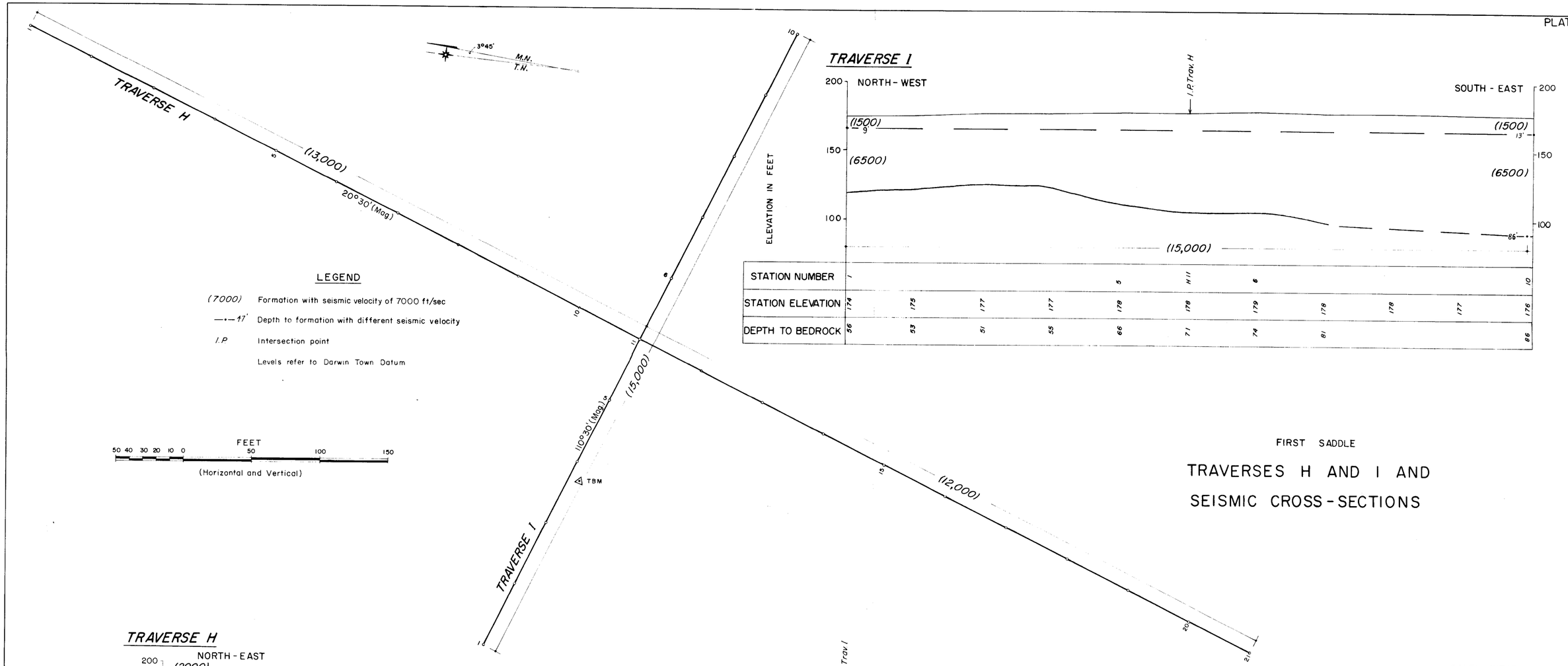
Based on Water Resources Branch Map W 430

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS D52/B5-9

TO ACCOMPANY RECORD No 1964/53

DARWIN RIVER, N.T. 1963

PLATE 7



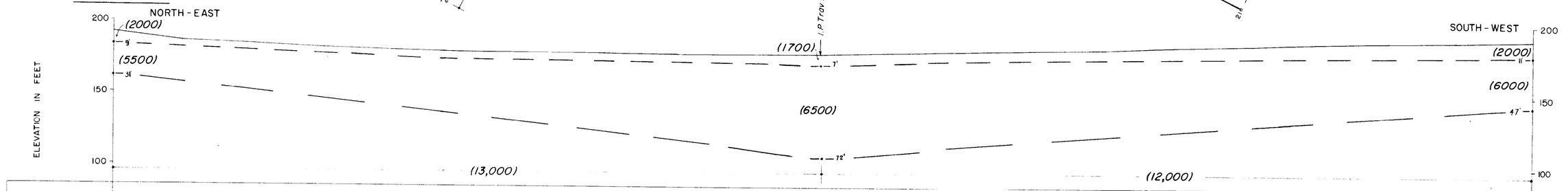
TRAVERSE I

STATION NUMBER	1				5	H11	6				10
STATION ELEVATION	174	175	177	177	178	178	179	178	178	177	176
DEPTH TO BEDROCK	56	53	51	55	66	71	74	81			86

FIRST SADDLE

TRAVERSES H AND I AND SEISMIC CROSS-SECTIONS

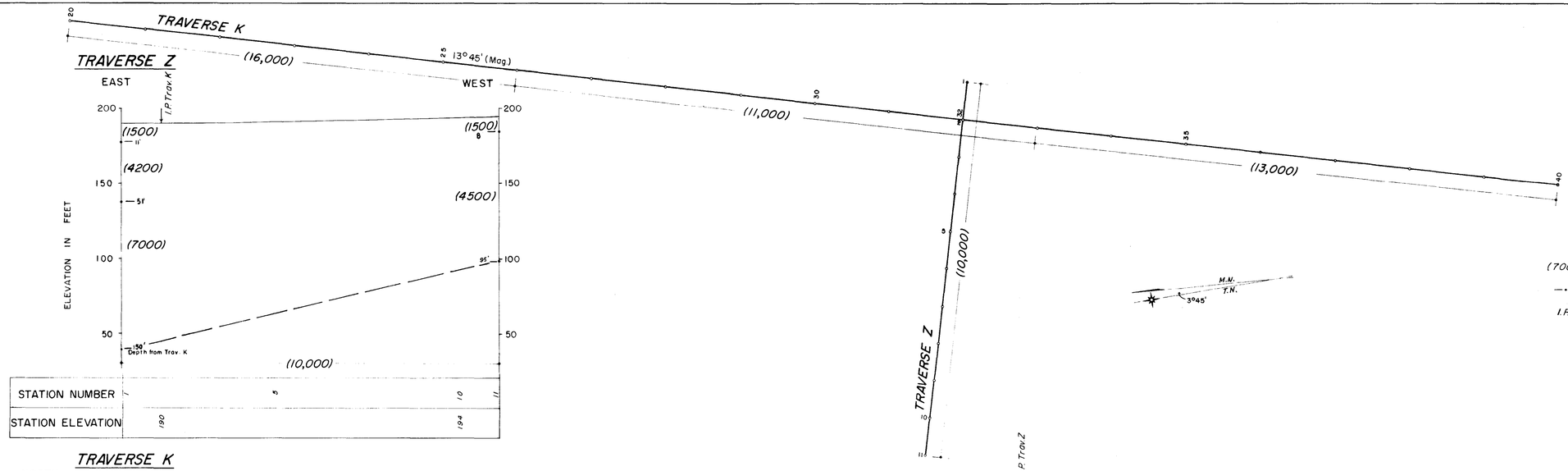
TRAVERSE H



STATION NUMBER	1				5				10						15					20	21
STATION ELEVATION	191	186	184	182	180	180	179	179	178	178	178	179	180	181	182	184	185	187	188	189	191

TO ACCOMPANY RECORD No 1964/53 Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B5-11

DARWIN RIVER DAM SITE, NT, 1963



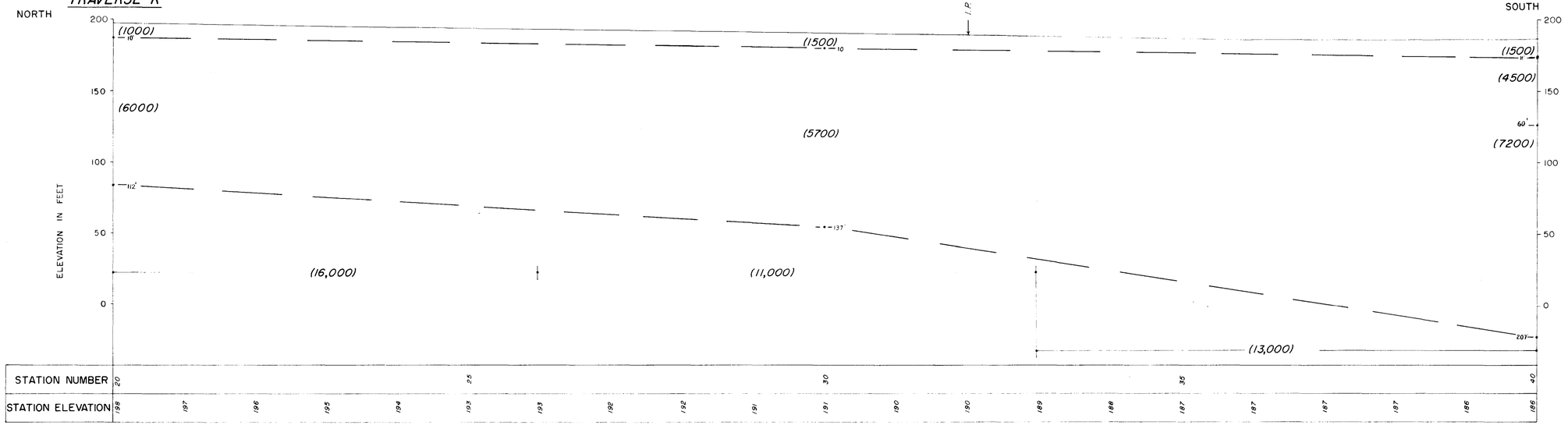
LEGEND

(7000) Formation with seismic velocity of 7000 ft/sec

—•—25' Depth to formation with different seismic velocity

I.P. Intersection point

Levels refer to Darwin Town Datum



SECOND SADDLE

TRAVERSES K AND Z AND SEISMIC CROSS – SECTIONS

FEET
50 40 30 20 10 0 50 100 150
(Horizontal and Vertical)

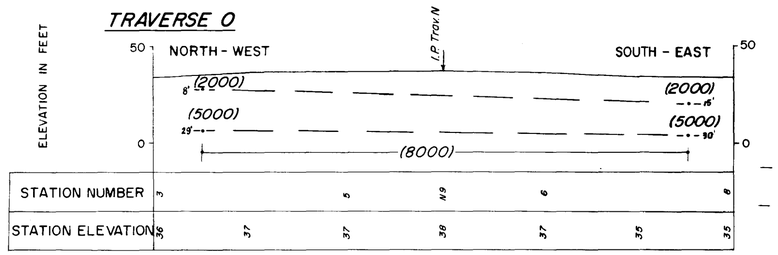
TO ACCOMPANY RECORD No. 1964 / 53

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B5-10

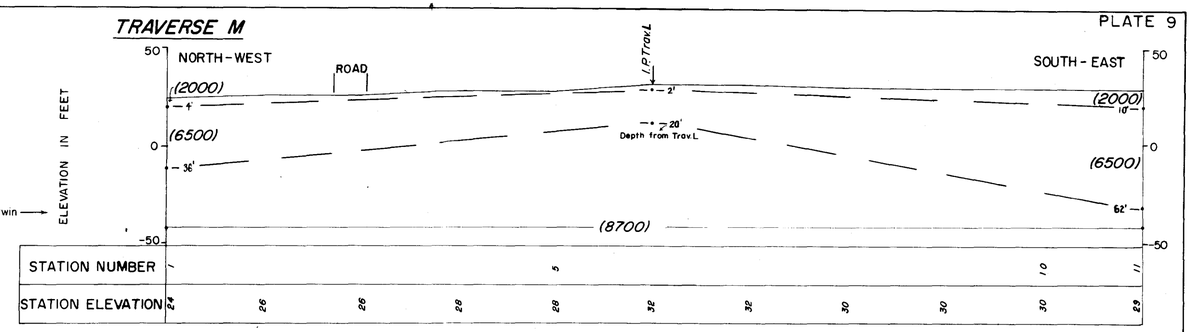
DARWIN HINTS DAM SITE, N.T., 1963

PLATE 9

TRAVERSE O



TRAVERSE M



LEGEND

(7000) Formation with seismic velocity of 7000 ft/sec

—•—18' Depth to formation with different seismic velocity

I.P. Intersection point

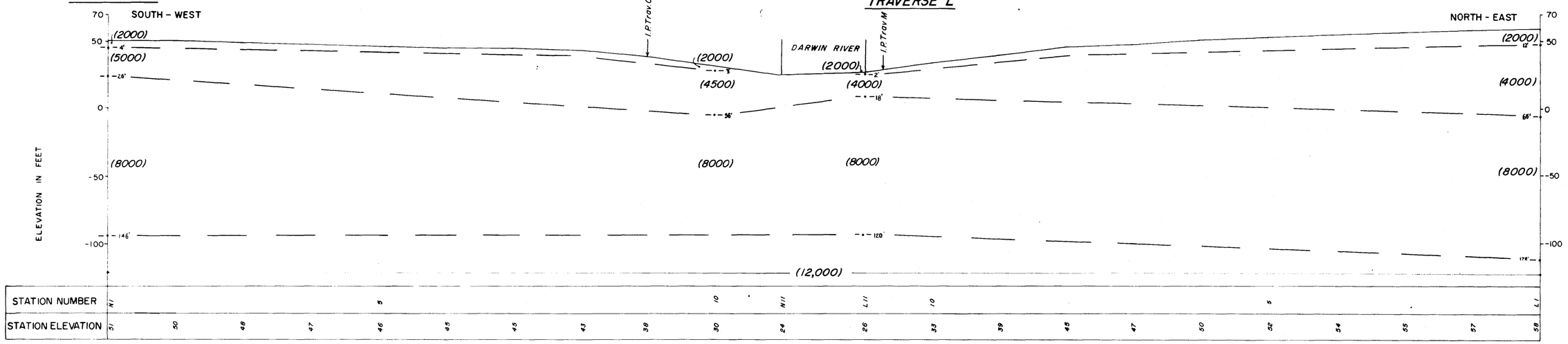
Levels refer to Darwin Town Datum

UPPER PONDAGE RESERVOIR SITE

TRAVERSES N, L, O, AND M AND SEISMIC CROSS - SECTIONS

FEET
50 40 30 20 10 0 50 100 150
(Horizontal and Vertical)

TRAVERSE N



TO ACCOMPANY RECORD No 1964/53

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B5-12

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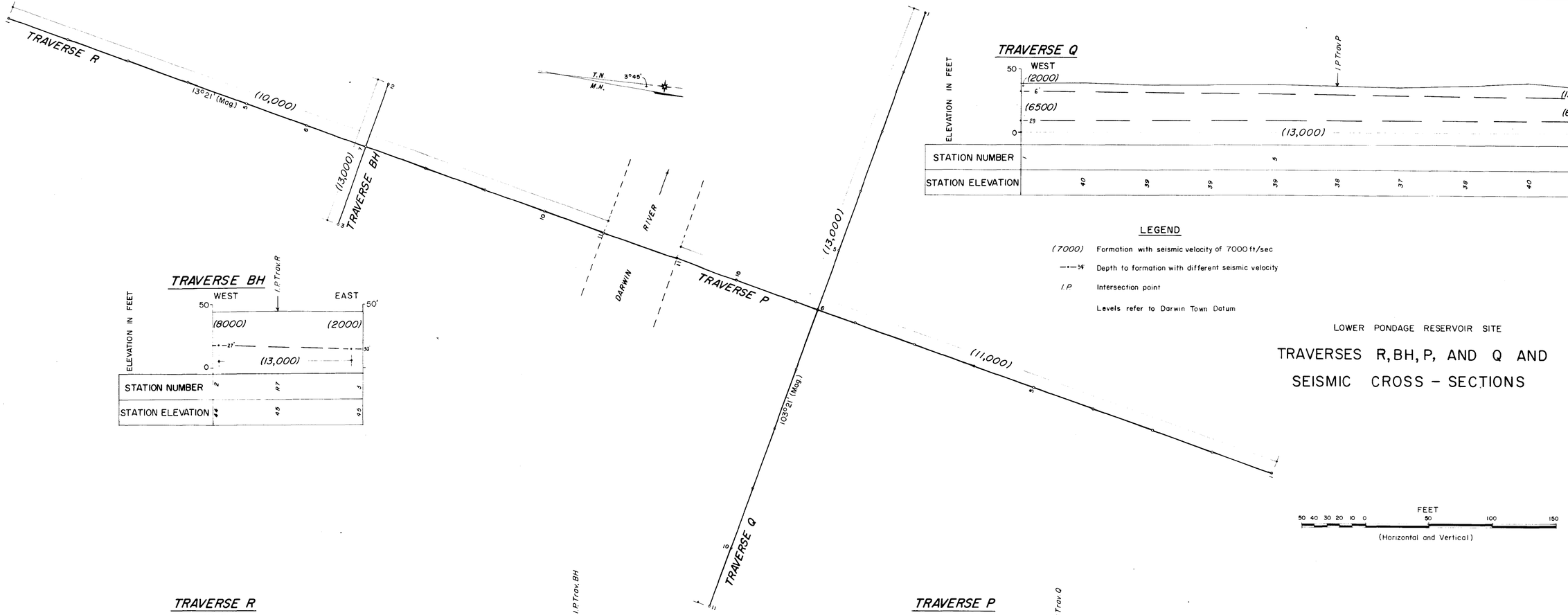
PLATE 10



LEGEND

(7000) Formation with seismic velocity of 7000 ft/sec

—•—•— Depth to formation with different seismic velocity

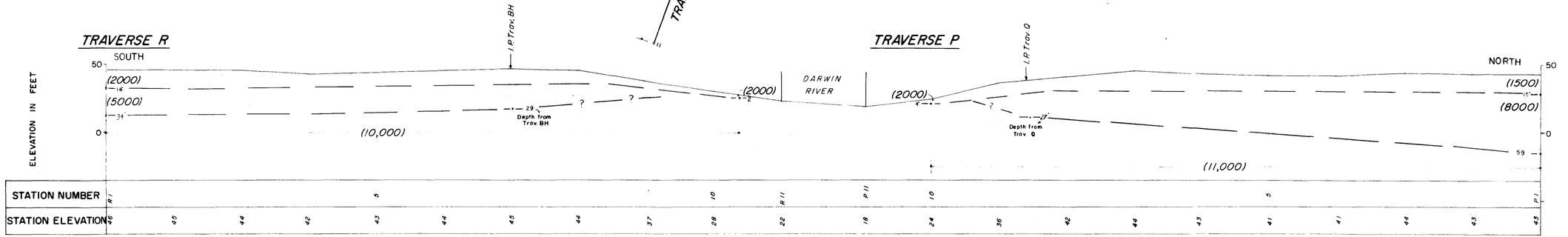
I.P Intersection point

Levels refer to Darwin Town Datum

LOWER PONDAGE RESERVOIR SITE

TRAVERSES R, BH, P, AND Q AND SEISMIC CROSS - SECTIONS

FEET
50 40 30 20 10 0 50 100 150
(Horizontal and Vertical)



TO ACCOMPANY RECORD No 1964/53

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics D52/B5-13

DARWIN RIVER DAM SITE, N.T. 1963