1961/95
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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1961-95

LOGAN RIVER 2.3M & 13.5M TIDAL BARRAGE SITES SEISMIC REFRACTION SURVEY, QUEENSLAND 1959

by

P. E. Mann

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ILLUSTRATIONS

ABSTRACT

The report describes the results of seismic refraction surveys at the 2.3M and 13.5M Logan River tidal barrage sites near Beenleigh, Queensland.

The maximum depth to bedrock at the 2.3M site is probably 130 ft at a point about 350 ft from the southern bank. The maximum depth to bedrock at the 13.5M site is about 80 ft, near the centre of the stream.

At each site, test drilling to check the seismic results is recommended before further development is planned.

INTRODUCTION

The Irrigation and Water Supply Commission of Queensland proposes damming the Logan River below the tidal limit, to provide water for irrigation of farms bordering the river. Two sites have been selected for investigation near Beenleigh; they are known as the 2.3 Mile and 13.5 Mile tidal barrage sites. The approximate co-ordinates of the centres of the sites are respectively 648561 and 635562 on the Brisbane sheet of the 4-mile military map series. Their locations are shown on Plate 1.

At the request of the Commission, the Bureau of Mineral Resources conducted a geophysical survey to determine the type of bedrock and the depth to unweathered bedrock at each barrage site. The seismic refraction method was used.

The Bureau party consisted of P.E. Mann, party leader, B. J. Bamber, geophysicist, and J. Pigott, geophysical assistant; four field assistants were supplied by the Commission. Field work at the two sites took place between the 18th and 27th August 1959.

Approximately 5500 ft of land traverse and nine water spreads were surveyed at the two sites. The Commission carried out the topographical surveying and provided additional transport, party supplies, and boats for the water-borne seismic work. A 30-ft fishing launch served as seismic recorder boat; a 15-ft fishing boat was used as shooter's boat for exploding the gelignite charges in water.

PART A : 2.3M LOGAN RIVER SITE

1. GEOLOGY

The site 2.3 miles from the mouth of the river is at a broad reach where the river is approximately 1000 ft wide. The right bank (looking down stream) rises steeply to a height of about 40 ft above the river level. On the left bank a low alluvial terrace approximately 500 ft wide separates the river from a gently sloping hillside.

Geological information of the tidal barrage site has been prepared by Dunlop (1959a). In the area there are Silurian rocks of the Neranleigh-Fernvale Group, and alluvium of Quaternary age.

Metamorphic rocks of the Neranleigh-Fernvale Group are exposed on both banks at the site. The principal rock type is a highly silicified greywacke with minor amounts of slate. The attitude of the beds is irregular; the dip varies from zero to 60 degrees. The variability is interpreted by Dunlop as resulting from faulting. Quartz veins of variable thickness, irregularly orientated and occasionally contorted, are common. Minor faults, joints, and fractures are iron stained.

The soil cover of sand, silt, and silicified greywacke fragments on the right bank overlies hill-wash material of sand and clay.

The alluvial material on the left bank consists of silty mud of high organic content, and sand.

2. METHODS AND EQUIPMENT

A general description of the seismic refraction method and the technique of the "method of differences" used for the land survey is given in a report on the Moogerah dam site, Queensland (Polak and Mann, 1959).

The equipment used was a "Midwestern" 12-channel portable seismograph designed for shallow reflection and refraction work.

On the land traverses, Midwestern geophones with a natural frequency of about 8 c/s were used to record the vertical motion of the ground.

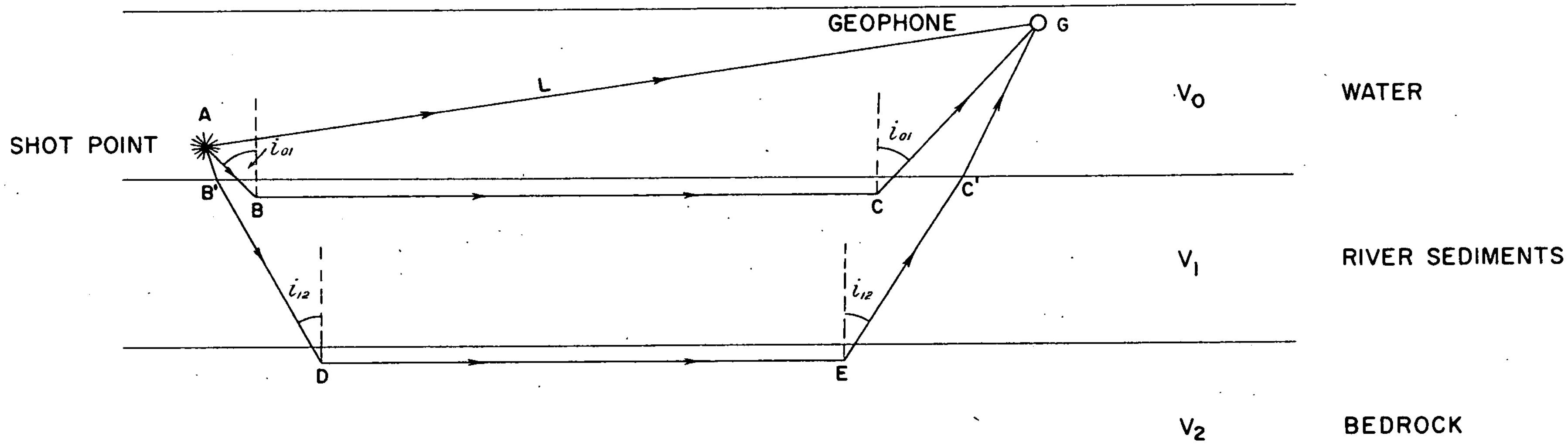
The following types of geophone spreads based on the "method of differences" were used:

(a) Normal spreads : the geophones were spaced 50 ft apart on the ground in a straight line, and shots were fired 50 and 200 ft beyond each end of, and in line with, the spread.

(b) Weathering Spread : The geophones were spaced 10 ft apart on the ground in a straight line, and shots were fired 10, 25, and 50 ft beyond each end of, and in line with, the spread.

On the water survey work the Midwestern recording equipment was used with underwater floating geophones manufactured by the Technical Instrument Co. of Houston, U.S.A. The natural frequency of the geophones is about 20 c/s. The recording equipment was mounted in a motor launch, and the geophone cable with 12 geophones attached 25 ft apart was floated behind the launch. Plastic buoys were attached to the geophone cable to float the line and suspend the geophones several feet below the water surface. The floating geophone spread was towed until the spread straddled the tidal barrage axis line, which was marked by a steel cable spanning the river.

The launch was anchored and shots were fired with the geophone spread held in position by the launch and the tide.



SEISMIC REFRACTION SURVEY AT THE 2·3 M. LOGAN RIVER
TIDAL BARRAGE SITE, NEAR BEENLEIGH, QUEENSLAND

RAY PATHS OF SIGNIFICANT SEISMIC WAVES

FIGURE 1

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G360-1-6
TO ACCOMPANY RECORD: No 1961-95

To locate the position of the geophone spread on the axis line, shots were fired at three surveyed points on the north bank. The points were termed the up-stream, broadside, and down-stream shot-points, and their positions are shown on Plate 2. At high tide shots fired at the three points were in water, and the arrival time of the water pulse was read from a seismogram. The distance of each geophone from the shot-points was obtained from the water wave velocity and the travel time of the water pulse. The intersection of arcs drawn about each shot-point gave the geophone positions. Two shot-points should theoretically be adequate to determine the distance, but it was found desirable to use three for improved accuracy, especially where the distance from the geophones was large.

The velocity of the water wave was determined on several spreads by firing a small charge suspended several feet below the water surface and in line with the spread. The average velocity of the water wave was 5000 ft/sec. At low tide, only the up-stream and down-stream shot-points were in water. However, the same method could be used, as it was found that the velocity in the mud was effectively the same as in water. The position of the geophone spread on the axis line is estimated as accurate within ± 20 ft.

To determine the depth to geological formations (refractors) to which a specific range of seismic velocities can be assigned, the seismic velocity of the overlying bed (or beds) must be known or measured. The computation technique used is called the "intercept method" (Dobrin, 1952, p220).

A small charge (generally 5 oz of AN60 gelignite) was weighted and lowered to the bottom of the river. The charge was approximately in line with, and within 50 to 200 ft of the end of, the geophone spread. The arrival times of those seismic waves which were reflected and refracted at different geological formations were measured from the seismograms.

For the three-layer case illustrated in Fig. 1, three different seismic waves are considered.

(a) The wave which travels from A directly through the water with a velocity $V_0 = 5000$ ft/sec.

(b) The wave which travels from A to B with velocity V_0 (water wave velocity) and then through the material constituting the river bed. The position of the point B is determined by the critical angle i_{01}. As this refracted wave travels along the river bed at velocity V_1 a part of it is continually refracted back at the critical angle i_{01}. The wave through point C reaches the geophone G.

(c) The wave which travels from A to B_1 with velocity V_0, from B_1 to D with velocity V_1, and through the bedrock with velocity V_2. A refracted wave from E travels through the river bed to C' with velocity V_1 and thence to G with velocity V_0.

In most cases in the present survey the velocity of the upper bed(s) could not be measured, and was estimated at 5500 ± 500 ft/sec.

The intercept time corresponding to the bedrock on the time-distance curve was corrected for the distance of the geophones above the river bottom to reduce "time depths" to the river bottom as datum. The correction applied was determined by one of two methods. The first method depends on the existence of a "bubble pulse", i.e. a seismic pulse generated by oscillations of the bubble gases resulting from the explosion (Ewing, Worzel, and Pekeris, 1948). The correction can be determined from the difference between the arrival times of the direct pulse and the bubble pulse at a given geophone.

In some instances, where the shot-point was not too distant from the geophone spread, the correction could be determined from the difference in arrival times of the direct pulse at successive geophones. In either case the assumption was made that the water was of the same depth underneath the whole geophone spread.

The time depth to a refractor may be up to 10 per cent in error, and the apparent velocity may be up to 15 per cent in error; hence the possible error in depth determination may be up to 25 per cent.

No corrections were applied for tidal variations in river level, which were considered small in comparison with other errors inherent in the seismic method.

3. RESULTS

Plate 2 shows the layout of traverses, and Plate 3 shows the interpretation of the seismic results as cross-sections giving the depth to bedrock. The depths to bedrock determined by floating geophone spreads are projected on to the tidal barrage axis line.

Right (Southern) Bank : Traverses A, AA, and X

On Traverses A and AA weathered and jointed bedrock of seismic velocity is close to the surface and crops out at X4. The depth to bedrock with a seismic velocity greater than 8000 ft/sec ranges from 49 ft at AA2 to 126 ft at A5. At A2 the seismic velocities of 2900, 7000, and 10,300 ft/sec are interpreted as water-saturated silt and clay, weathered jointed bedrock, and unweathered bedrock respectively.

On Traverse X near X10 seismic velocities of 1200, 4200, and 14,000 ft/sec are interpreted as soil, very weathered bedrock, and bedrock respectively. Between X10 and X4 the bedrock profile has been computed using the method of "continuous profiling" (Barthelmes, 1946). This method gives the shape of the refractor, but to determine the absolute depth, measurement by some other method, for example drilling, is required at one point on the traverse.

River Traverse : Stations X4 to X24

The depth to the highest velocity refractor interpreted as bedrock has been plotted as a smooth curve approximately through the points where a depth determination has been made.

The depth to bedrock probably has a maximum value of about 130± 30 ft, approximately 350 ft north of X4.

7000 to 8000 ft/sec

Left (Northern) Bank : Traverses B and X

On Traverse B the depth to bedrock decreases gradually from B2 to B22, being a minimum at B17 (9 ft) and a maximum at B6 (59 ft).

The seismic velocity of 3000 to 5600 ft/sec, for the formation overlying bedrock of velocity 9000 to 10,500 ft/sec, is characteristic of water-saturated porous unconsolidated alluvial material.

The seismic velocities of water-saturated sand and gravel are between 4000 and 5500 ft/sec, and those of silt and clay are between 3000 and 4000 ft/sec.

Near X37 seismic velocities of 1400, 3600, and 10,000 ft/sec are interpreted respectively as soil, very weathered bedrock, and bedrock.

Seismic Velocities

Table 1 shows the interpretation of the seismic velocities and rock type, based on available geological information.

TABLE 1

Seismic Velocity (ft/sec)	Rock Type
1400	Unconsolidated rock or dry soil.
2100	Water-saturated eluvial material.
3000 ±	Water-saturated fine silt and clay or silty clay.
3600-4200	Very weathered greywacke.
* 4000-5500	Water-saturated porous sands and gravels.
* 5000 ±	Water.
* 5000-6000	Ooze or mud and silt in river, usually rich in organic material.
7000-9000	Jointed, fractured, and slightly weathered greywacke.
10,000-14,000	Jointed to massive, unweathered greywacke.

* Greywacke at intermediate stages of weathering could also have velocities within this range. These velocities occur in the valley below the water table, and the interpretation given in Table 1 seems more probable. However, weathered bedrock could occur at a shallower depth than the recorded bedrock.

4. CONCLUSIONS

The seismic refraction survey shows that the depth to bedrock beneath the river sediments is large and probably has a maximum value of about 130 ± 30 ft approximately 350 ft north of station X4.

On the southern bank weathered jointed bedrock is close to the surface and crops out near X4.

To test the seismic results the following positions are recommended for test drilling : between X2 and X3 to check the structure of the left abutment, and about 350 ft north of X4 to check the maximum depth to bedrock in the river channel.

PART B : 13.5M LOGAN RIVER SITE

1. GEOLOGY

The site 13.5 miles from the mouth of the river is at a bend where the river is only about 200 ft wide. On the right (southern) bank of the river a narrow elevated alluvial terrace 12 ft wide separates the stream from the higher slopes. On the left (northern) bank, poorly developed terraces are present near the stream.

Geological information on the tidal barrage site has been prepared by Dunlop (1959b). Stratigraphical units present in the area are rocks of the Neranleigh-Fernvale Group of Silurian age and alluvium of Quarternary age.

Greywacke crops out on the right bank. The greywacke is hard, intensely jointed, and fractured rock. The soil cover on the right abutment consists of sand, silt, and numerous small angular particles of metamorphic rock. The surface material on the narrow alluvial terrace consists of fine sand and silt.

The surface material on the left bank consists of alluvium and eluvium derived from the Neranleigh-Fernvale Group. Fine sand, silt, and clay occur on the river terraces.

2. METHODS AND EQUIPMENT

The equipment used for land and water traverses was identical with that described in Part A of this report. Normal and weathering spreads described in Part A were used on the land traverses.

The method used to determine the depth to bedrock under the river differed somewhat from that described in Section 2 of Part A. The underwatdr geophone cable and geophones were weighted and lowered to the bed of the river, approximately along the axis line. One geophone placed at Station X8 on the left bank was used to enable the depth of geophones on the river bottom to be determined. Gelignite charges were detonated at only two surveyed shot-points, one up stream and the other down stream from the axis line. Because of the shorter distances involved a third shot-point was not necessary. The geophone positions were determined as in Section 2 of Part A, and they were found to be located within ± 20 ft of the axis line.

The seismic velocity of the river sediments was assumed to be 5500 ± 500 ft/sec.

3. RESULTS

Plate 4 shows the location of the traverses, and Plate 5 shows the seismic results plotted as cross-sections giving the depth to bedrock. On Traverse A the depth to unweathered bedrock of seismic velocity 10,000 to 16,500 ft/sec, is 41 ft near A15 and about 10 ft between A5 and A14. On Traverse X the depth averages about 20 ft.

On Traverse BB the depth to unweathered bedrock is about 25 ft, and on Traverse B the depth increases down stream from the axis line to 74 ft near B2.

On Traverse X, the depth to the highest-velocity refractor interpreted as bedrock has been plotted as a smooth curve approximately through the points where depth determinations have been made. A short portion of the bedrock profile is shown as a broken line to indicate that depths are computed from "time depths" which may be in error owing to the geometry of the seismic refractor. The depth to bedrock below the river bottom probably has a maximum value of about 80 ± 20 ft near the centre of the stream.

Table 2 shows the interpretation of the seismic velocities and rock type based on available geological information :

TABLE 2

Seismic Velocity (ft/sec)	Rock Type
1000–1400	Dry sand and silt.
1800–2700	Eluvium and very weathered greywacke.
5000 ±	Water.
5500 ± 500	Water-saturated river sediments, sand, silt, and mud.
5500 – 8000	Weathered to slightly weathered greywacke.
10,000 – 16,000	Strongly jointed and fractured greywacke.

4. CONCLUSIONS

The measured value of about 80 ft for the depth to bedrock beneath the river bottom should be tested by drilling before further development of the site is planned.

ACKNOWLEDGEMENTS

It is desired to acknowledge the assistance given to the party by the Senior Planning Engineer, (Mr. G. B. Symmonds), and other officers of the Commission.

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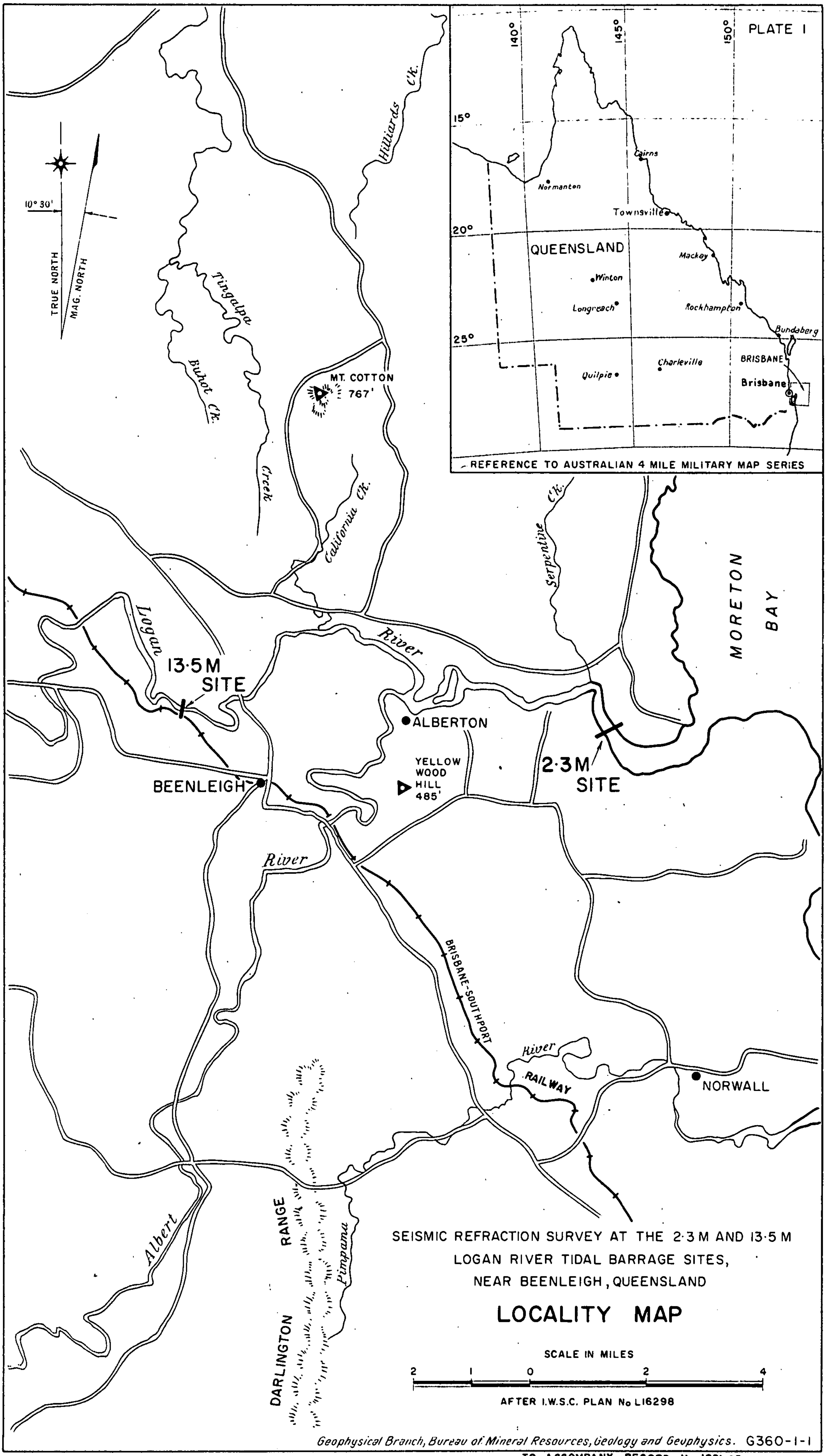
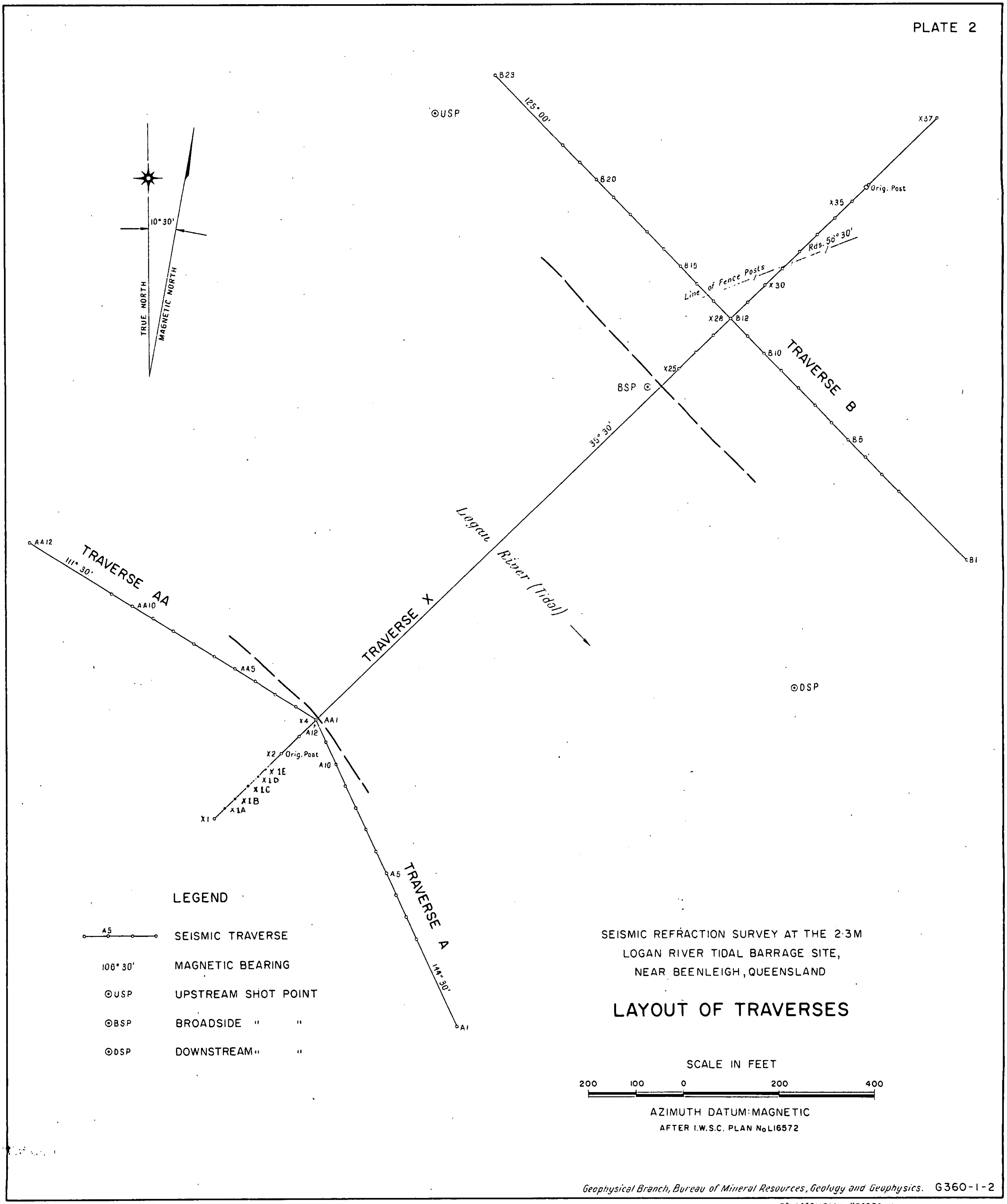


SEISMIC REFRACTION SURVEY AT THE 2·3 M AND 13·5 M LOGAN RIVER TIDAL BARRAGE SITES, NEAR BEENLEIGH, QUEENSLAND

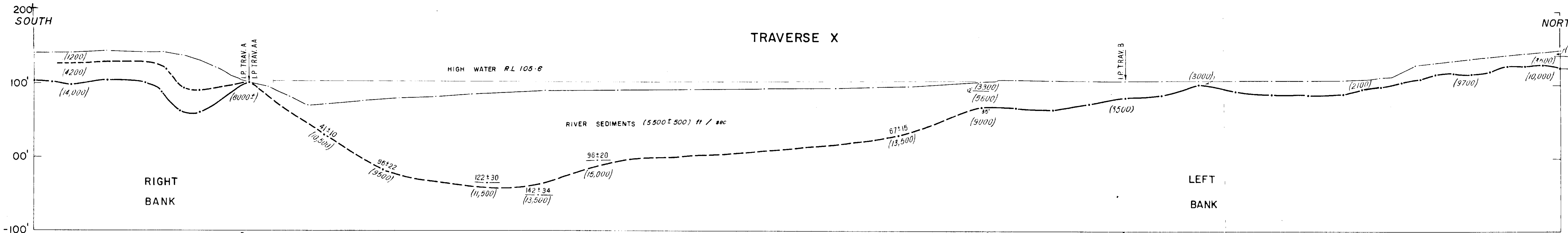
LOCALITY MAP

TO ACCOMPANY RECORD No 1961-95



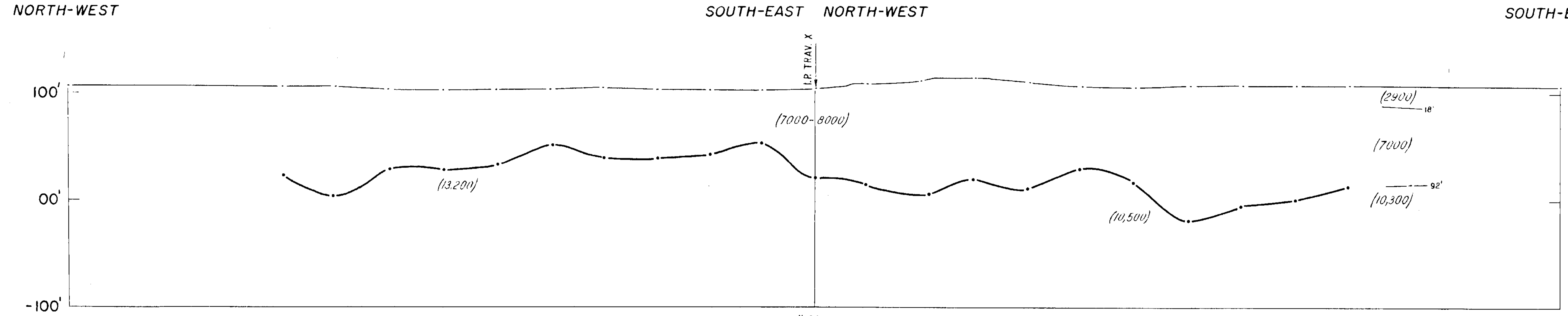
TO ACCOMPANY RECORD No 1961-95

TRAVERSE X



STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
1	142·0	38
1A	142·1	39
1B	142·8	44
1C	143·1	40
1D	142·9	42
1E	142·7	57
2	140·1	
3	123·2	
4=A12 =AA1	103·1	
24=No Peg	104·5	35
25	106·5	38
26	105·8	39
27	105·6	31
28=B12	105·4	23
29	105·3	20
30	105·4	6
31	105·5	15
32	105·4	19
33	105·7	21
34	106·2	20
35	109·8	13
		13
36	125·7	19
36A	129·5	15
36B	132·4	16
36C	134·9	21
36D	137·3	20
36E	139·2	15
36F	141·5	16
36G	143·2	18
37	144·9	21

TRAVERSE AA　　TRAVERSE A



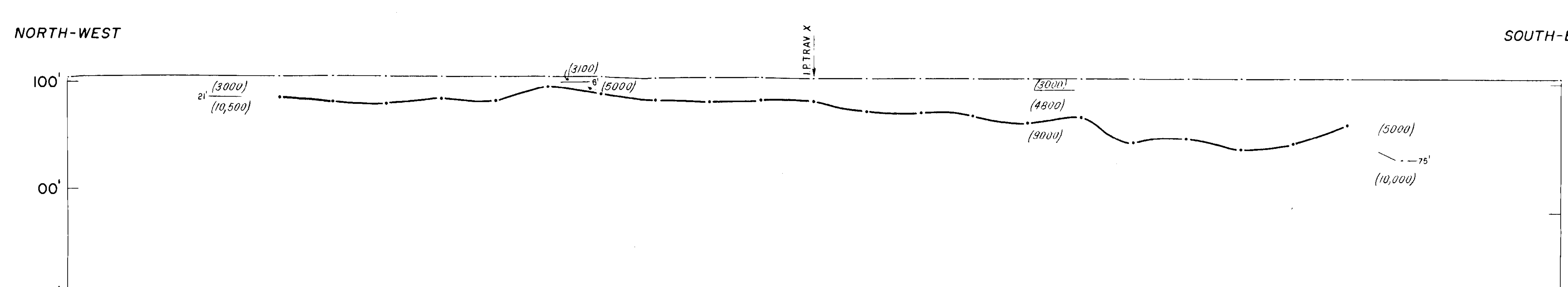
Traverse AA

STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
12	105·9	
11	106·9	84
10	106·7	102
9	104·3	75
8	103·9	75
7	103·9	70
6	104·4	52
5	105·6	66
4	103·9	66
3	103·5	60
2	102·8	49
1=X4=12	103·1	84

Traverse A

STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
11	108·1	94
10	110·2	105
9	113·6	94
8	109·2	98
7	105·9	77
6	105·1	88
5	106·9	126
4	107·1	112
3	107·5	105
2	107·3	94
1	106·9	

TRAVERSE B



STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
23	105·1	
22	106·5	20
21	105·7	25
20	106·0	27
19	105·9	22
18	105·8	23
17	105·7	9
16	105·8	17
15	105·2	21
14	105·8	23
13	105·6	22
12=X28	105·4	23
11	105·4	31
10	105·4	32
9	105·4	34
8	105·3	42
7	105·2	36
6	105·3	59
5	105·3	56
4	105·2	66
3	105·2	61
2	105·2	43
1	105·2	

LEGEND

(9000)	FORMATION WITH SEISMIC VELOCITY 9,000 ft./sec.
21'	DEPTH TO FORMATION WITH DIFFERENT SEISMIC VELOCITY.
96±22 / (9500)	DEPTH TO REFRACTOR OF 9500 ft/sec. AT 96 ft. BELOW RIVER BOTTOM. ESTIMATED MAXIMUM ERROR IN DEPTH: ±22 ft.

NOTE

LOCATION OF TRAVERSE ON AXIS LINE OBTAINED BY REFERENCE TO SURVEYED SHOT POINTS ON NORTH BANK OF RIVER. ESTIMATED MAXIMUM ERROR IN LOCATION OF TRAVERSE: ± 20 ft.

SEISMIC REFRACTION SURVEY AT THE 2·3M LOGAN RIVER TIDAL BARRAGE SITE, NEAR BEENLEIGH, QUEENSLAND

TRAVERSES A, AA, B AND X

SECTIONS

HORIZONTAL AND VERTICAL SCALES IN FEET

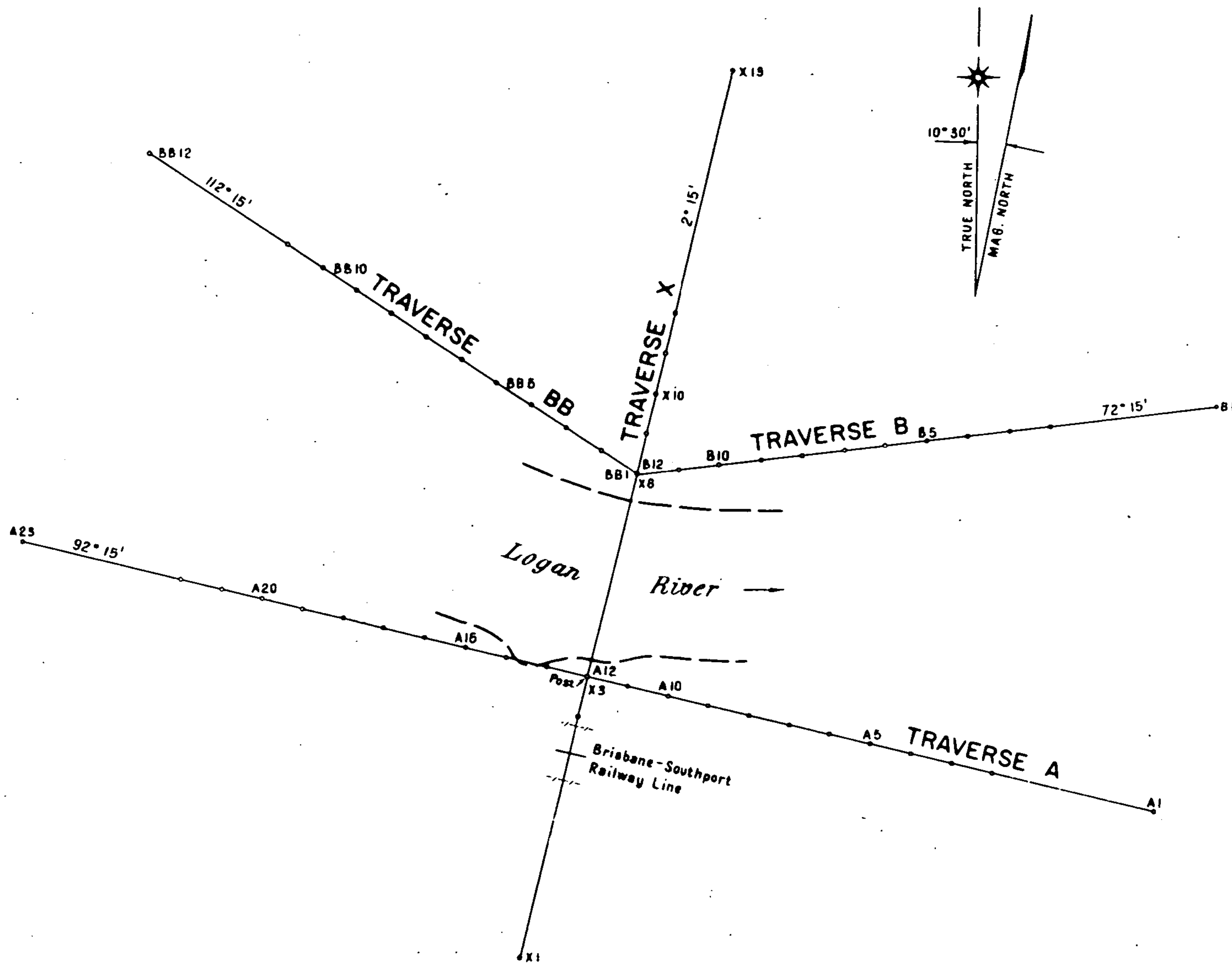
100 0 100 200 300 400

DEDUCT 100' TO EQUATE ELEVATION TO STATE DATUM.

AFTER I.W.S.C. PLAN No. L16572

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G360-1-5

TO ACCOMPANY RECORD No. 1961-95



LEGEND

A5 — SEISMIC TRAVERSE

92° 15' — MAGNETIC BEARING

SEISMIC REFRACTION SURVEY AT THE 13·5 M
LOGAN RIVER TIDAL BARRAGE SITE,
NEAR BEENLEIGH, QUEENSLAND

LAYOUT OF TRAVERSES

SCALE IN FEET

200 100 0 200 400

AZIMUTH DATUM: MAGNETIC

AFTER I.W.S.C. PLAN No L18572

PLATE 4

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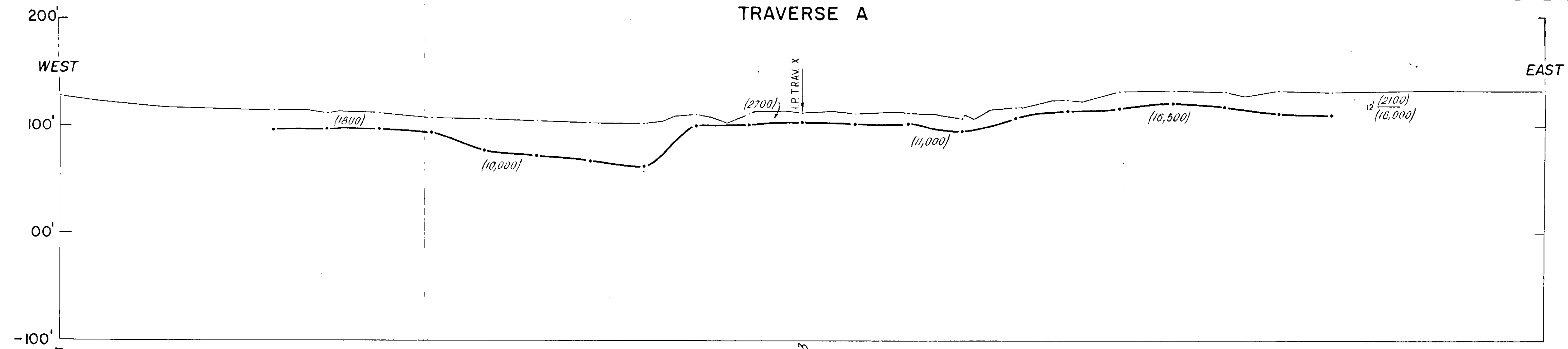
TO ACCOMPANY RECORD No 1961-95

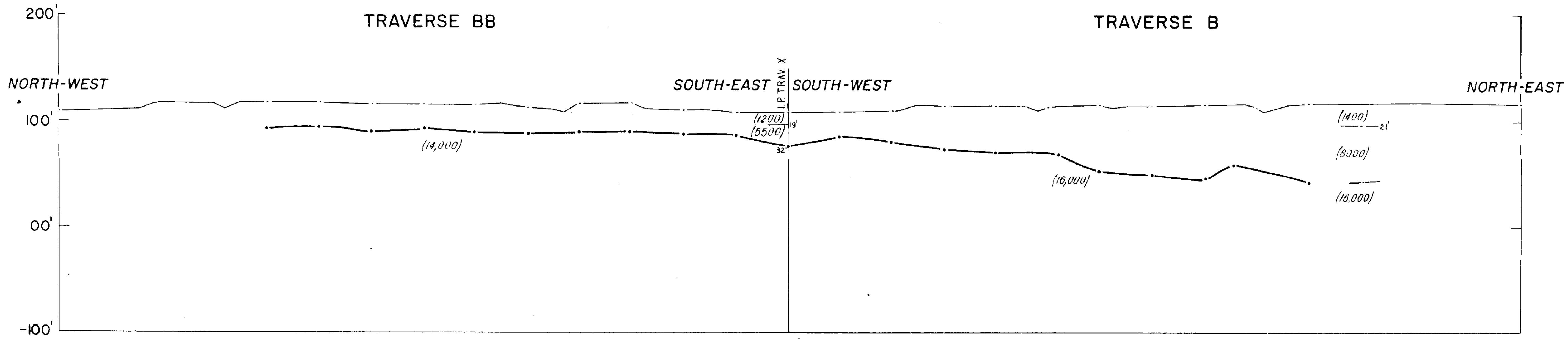
PLATE 5

TRAVERSE A



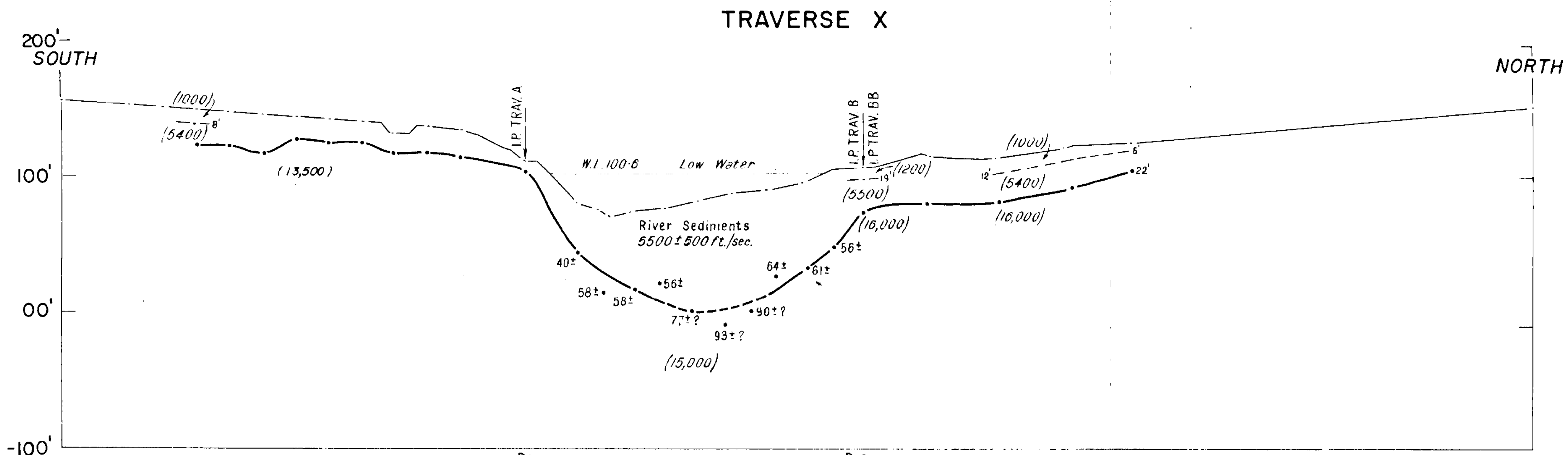
STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
23	126.5	
22	113.4	18
21	109.6	14
20	111.0	16
19	107.3	14
18	105.8	29
17	104.1	33
16	102.6	36
15	101.8	41
14	110.2	11
13	110.4	8
12=X3	111.4	8
11	103.4	10
10	109.5	9
9	105.2	12
8	115.0	9
7	122.5	11
6	130.0	14
5	131.4	12
4	130.0	14
3	130.8	21
2	130.1	21
1	130.5	

TRAVERSE BB / TRAVERSE B



STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
12	107.9	
11	117.4	25
10	116.9	23
9	115.4	25
8	114.9	23
7	114.8	26
6	111.5	25
5	116.1	27
4	116.3	27
3	108.9	23
2	107.4	22
1=X8=12	106.2	32
11	106.9	23
10	107.8	30
9	111.9	41
8	113.1	44
7	111.5	46
6	113.3	63
5	113.4	65
4	114.5	70
3	110.7	59
2	115.5	74
1	114.7	

TRAVERSE X



STATION NUMBER	STATION ELEVATION	DEPTH TO BEDROCK
1	154.3	
	148.4	25
	146.8	25
	144.9	28
	142.9	17
	141.2	17
	139.3	16
	131.3	15
	135.8	20
2	133.3	19
3=A12	111.4	8
8=B12=BB1	106.4	32
9	115.2	35
10	113.5	33
11	120.9	31
12	124.1	22
13	150.2	

LEGEND

(16,000) FORMATION WITH SEISMIC VELOCITY 16,000 ft./sec.

12' DEPTH TO FORMATION WITH DIFFERENT SEISMIC VELOCITY

SEISMIC REFRACTION SURVEY AT THE 13·5 M LOGAN RIVER TIDAL BARRAGE SITE, NEAR BEENLEIGH, QUEENSLAND

TRAVERSES A, B, BB AND X

SECTIONS

HORIZONTAL AND VERTICAL SCALES IN FEET

100 0 100 200 300 400

ELEVATION IN FEET ABOVE STATE DATUM

AFTER I.W.S.C. PLAN No. L16572

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