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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1962/15

WALTERS MARSH DAM SITES SEISMIC REFRACTION SURVEY, TASMANIA 1961

by

E.J. Polak

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ILLUSTRATIONS

SUMMARY

This Record describes a seismic refraction survey at the Walters Marsh dam sites on the Mersey River, requested by the Hydro-Electric Commission of Tasmania.

The 'overburden' consists of large boulders of dolerite or quartzite with pebbles, gravel, sand, and clay. Seismic velocities in the overburden range between 3000 ft/sec on the slopes above the water-table, to 7000 ft/sec on dam site No. 1, where boulders up to 2 ft in diameter were proved by drilling. The 'bedrock' consists of quartzite with seismic velocities ranging from 10,000 ft/sec in a shear zone to 17,000 ft/sec for fresh solid quartzite. Young's modulus of the bedrock ranges between 4.2×10^6 and 6.5×10^6 lb/in.^{2}.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania proposes to construct a dam on the Mersey River, approximately 20 miles south of Mole Creek (approximate co-ordinates E.420 N.862 on the Devonport four-mile map). The dam will store water to be used in the power stations located in the lower reaches of the Mersey and Forth rivers (Polak and Duggin, 1961). Three possible dam sites were chosen for investigation.

The Commission requested the Bureau of Mineral Resources, Geology and Geophysics to assist with the investigation, the problem being the determination of the depth to bedrock and the nature of both the 'overburden' and the bedrock.

The seismic survey was carried out between 13th and 24th February 1961. The geophysical party consisted of E.J. Polak (party leader), D.J. Harwood (geophysicist) and J.P. Pigott (geophysical assistant). The Commission provided additional assistants and did the topographical surveying of traverse lines.

The total lengths of the surveyed traverses were:

Dam site No. 1	3650 ft
Dam site No. 2	4350 ft
Dam site No. 3	5050 ft
Total	13,050 ft

2. GEOLOGY

The geology of the area has been described by Spry (1958) and is illustrated on Plate 1. A detailed geological examination of the dam sites was made by Paterson (1959). His results are shown on Plates 2, 4, and 6. Four holes had been drilled on site No. 1 (see Plate 2).

The three dam sites are in a narrow valley of the Mersey River. The floor of the valley is filled in with fluvioglacial deposits containing boulders, pebbles, sand, silt, and clay. The boulders are predominantly of fresh dolerite, with a few of quartzite, both ranging up to two feet in diameter.

The bedrock in the valley consists of Precambrian quartzite, mica-quartzite, and mica schist of the Howell Group. The rocks are jointed, predominantly along the foliation. Drilling on site No. 1 indicated that some of the joints are open and filled in with clay or limonite. The beds are dipping steeply northwards.

As used in this Record, the term 'bedrock' refers to unweathered rock, including jointed rock, in the refractor with the highest recorded seismic velocity. The term 'overburden' refers to river gravel, clay, scree material, and completely or partly weathered rock, all with seismic velocity less than 9000 ft/sec.

3. METHODS AND EQUIPMENT

The seismic method of exploration depends on the contrast between the velocities of the seismic waves through different rock formations. Hard unweathered rocks have higher velocities than their weathered counterparts, and these in turn have higher velocities than unconsolidated deposits. A detailed description of the method has been given in previous reports to the Commission (e.g. Polak and Moss, 1959).

The 'method of differences' was used for traverses along the slope, but 'broadside spreads' were used on steep banks.

The equipment used in this survey was a Midwestern 12-channel reflection-refraction seismograph with T.I.C. geophones of natural frequency about 20 c/s. A three-component geophone was used to record longitudinal and transverse waves.

4. RESULTS

Seismic velocities

The seismic velocities recorded may be grouped as follows:

Low velocities in surface layer : 1000 to 2000 ft/sec. These velocities are recorded in dry, unconsolidated soil and sand, above the water table.

Medium-velocity layers: 3000 to 5000 ft/sec. On sites No. 2 and 3 the Commission geologist (Paterson, 1959) indicated river terrace material (see Plates 4 and 6). These velocities indicate sand, gravel, and clay of the river terrace material; the lower velocity may indicate a higher content of clay material. A velocity of 4000 ft/sec recorded on the slopes high above the water-level probably indicates very weathered rock.

Velocities 5000 to 7000 ft/sec: Drilling on site No. 1 indicates that the overburden there consists of large boulders (up to two feet in diameter) of fresh dolerite and quartzite. These rocks are characterized by very high velocities (15,000 to 18,000 ft/sec); therefore unconsolidated deposits consisting of large boulders will show fairly high seismic velocity, especially below the water-table where all the space between boulders is filled with water-saturated material. The velocity of 5000 to 7000 ft/sec is therefore interpreted as indicating fluvioglacial deposits containing a high proportion of large boulders. On Traverse H, site No. 3 (Plate 7), a velocity of 9000 ft/sec was recorded; this velocity has been interpreted as representing weathered bedrock. This conclusion has been reached because the bed shows seismic velocity anisotropy (the velocity measured along the strike was 9000 ft/sec, whereas the velocity recorded at right angles to the strike was only 7000 ft/sec), and because no velocity higher than 7000 ft/sec has been recorded on unconsolidated deposits in other parts of Tasmania.

High-velocity layers: 10,000 to 17,000 ft/sec. These velocities were recorded in the deepest refractor, therefore they represent the seismic velocities in the bedrock. The lower velocities represent the sheared and fractured material, and the higher velocities represent solid massive rock.

Anisotropy of seismic velocities was recorded at all three sites, the east-west velocity (in the direction of strike) being generally higher than the north-south velocity. The seismic velocities recorded in the bedrock are shown on Plates 2, 4, and 6.

Dynamic properties of rocks

If transverse seismic velocities are measured in addition to the longitudinal velocities, the dynamic properties of the rocks can be calculated (Polak & Moss, 1959). The following table shows the locations, velocity data, and elastic properties of the bedrock. The velocities were measured using a 3-component geophone.

Dam Site	Location	Longitudinal Velocity (ft/sec)	Young's modulus ($lb/in.^2$)	Poisson's ratio
2	D3	15,000	6.5×10^6	0.29
2	D29	12,000	4.2×10^6	0.28
3	J9	15,000	6.5×10^6	0.285
3	K9	14,000	5.7×10^6	0.285
3	L9	13,000	4.8×10^6	0.285

The results indicate:

(a) Poisson's ratio ranges between 0.28 and 0.29

(b) Young's modulus ranges between 4.2×10^6 and 6.5×10^6 $lb/in.^2$.

Both these values are higher than those calculated for the Martha Creek dam site (Polak and Duggin, 1961) which is approximately 7 miles down-stream.

Dam site No. 1

Plate 2 shows the detailed geology of the area and the locations of seismic traverses; Plate 3 shows the interpretation of the data in the form of seismic profiles.

Site No. 1 is located farthest up-stream. The valley here is very broad, but a knoll of solid rock in the centre would facilitate the construction. The present bed of the river is solid rock.

In the westerly part of the area the valley is filled with fluvioglacial deposits. The thickness of the unconsolidated rocks there reaches 133 ft in drill-hole 5707.

In a deep narrow channel, like the one on site No. 1, the first arrival refracted waves would come from the steep sides of the valley. Thus the vertical depth to the bottom of the valley would be considerably greater than the distance to the refractor calculated from the records. This applies on Traverse A, between stations 11 and 14.

The following table shows a comparison of drilling and seismic data.

DDH No.	Depth to Bedrock from drilling	Depth to Bedrock from seismic survey	Difference	Distance, DDH to seismic station.
5707	133 ft	65 ft	68 ft	20 ft
5706	57 ft	54 ft	3 ft	5 ft
5703	99 ft	73 ft	26 ft	10 ft

Seismic velocities recorded in the bedrock are shown on Plate 2. An area of low velocities, suggesting the presence of a shear zone, crosses the traverses approximately at C3, A12, and P10. The shear zone was presumably deeply eroded during the last glaciation.

Dam site No. 2

Plate 4 shows the detailed geology of the area and the location of seismic traverses. Plate 5 shows the interpretation of the data in the form of seismic profiles.

Site No. 2 is located approximately 1/3 of a mile down-stream from site No. 1. The river valley narrows here and it is covered with the river terrace. No drilling has been done on the site.

The seismic survey indicated that the river follows the centre of a U-shaped buried valley. The thickest overburden (about 92 ft) was indicated near D10, 50 ft west of the existing river. The velocities in the overburden are slightly lower than those at site No. 1, suggesting finer material.

An area of low velocities, suggesting the presence of a shear zone, crosses the traverses.

Dam site No. 3

Plate 6 shows the detailed geology of the area and the location of seismic traverses. Plate 7 shows the interpretation of the data in the form of seismic profiles.

Site No. 3 is located approximately ½ mile down-stream from site No. 2. The river flows along a steep valley filled with fluvioglacial deposits in clearly defined river terraces. No drilling has been done on this site.

The seismic survey indicated that the thickest overburden (81 ft) is near H17. The velocities in the overburden there are lower than on the upper sites, indicating finer material. At the base of the overburden a bed with a velocity of 9000 ft/sec suggests the presence of weathered bedrock.

As on sites No. 1 and 2, a low-velocity zone between H18 and H22 may suggest the presence of a shear zone with a northerly strike in the centre of the valley.

5. CONCLUSIONS

The geophysical survey provided information on the thickness of overburden and the nature of both overburden and bedrock.

On each site a low-velocity zone was recorded in the centre of the valley. This zone suggests a shear zone eroded by ice and water, leaving deep and narrow valleys.

The difference in seismic velocities of the overburden for different sites indicates that overburden on site No. 1 contains coarser material than the overburden on the two lower sites.

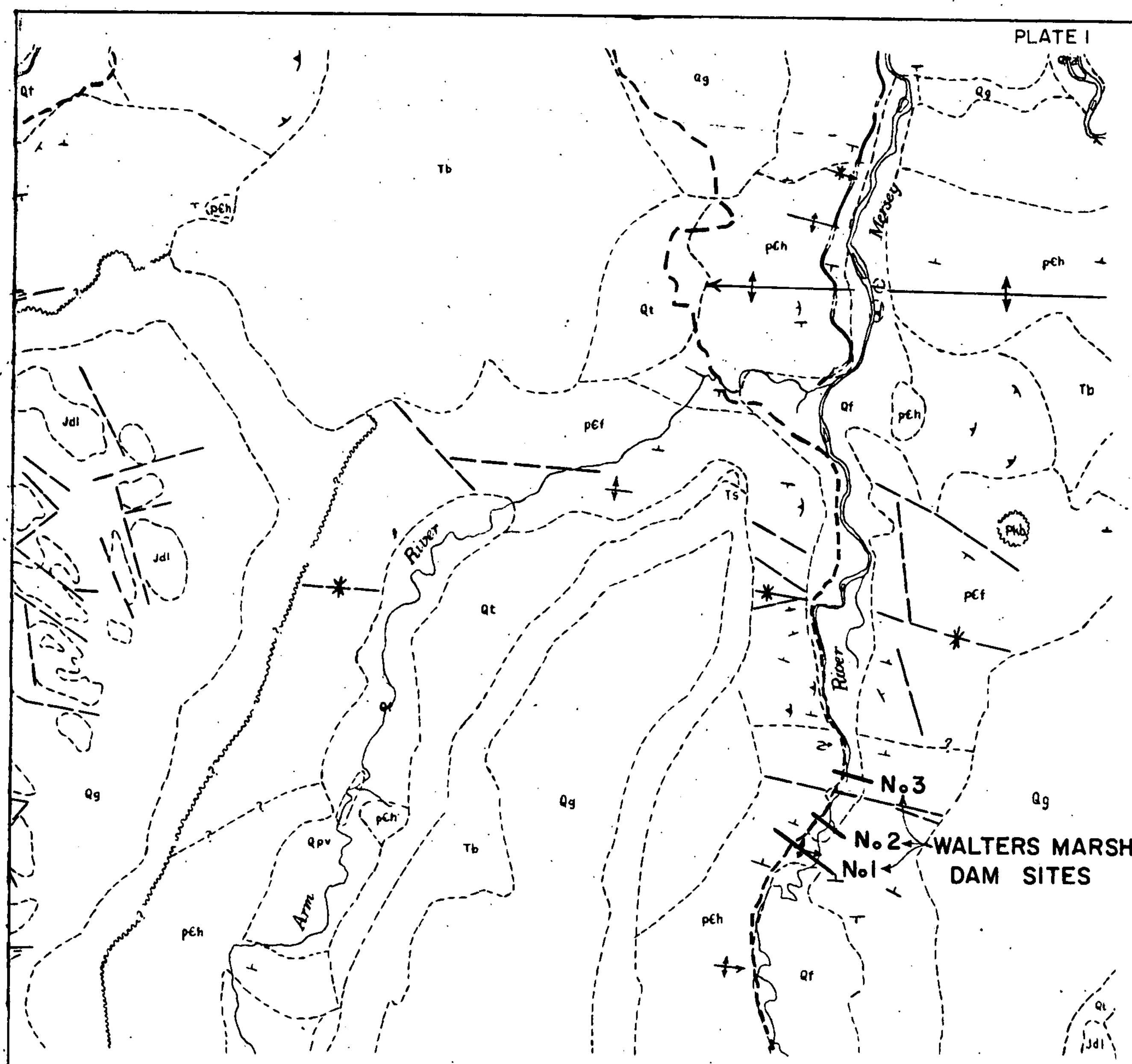
The value of Poisson's ratio for bedrock is about 0.28. Young's modulus ranges between about 4.2×10^6 and 6.5×10^6 lb/in.^{2}.

Considering that the seismic work suggests the presence of shear zones, further drilling is recommended at: Site No. 1, P10; Site No. 2, D16; and Site No. 3, H17 and H21.

6. REFERENCES

PATERSON, S.J.	1959	Unpublished maps, Hydro-Electric Commission, Tasmania.
POLAK, E.J. & DUGGIN, M.J.W.	1961	Mersey-Forth power scheme geophysical surveys, Tasmania 1960. Bur. Min. Resour. Aust. Rec. 1961/29.
POLAK, E.J. & MOSS, F.J.	1959	Geophysical survey at the Cluny dam site, Derwent River, Tasmania. Bur. Min. Resour. Aust. Rec. 1959/87.
SPRY, A.M.	1958	Precambrian rocks of Tasmania; Part 3 - Mersey-Forth area. Pap. Roy. Soc. Tasm. 92, 117-137.

PLATE I



LEGEND

ESTABLISHED BOUNDARY

UNCONFORMITY

GEOLOGICAL BOUNDARY (position approximate)

STRIKE AND DIP OF STRATA

TRANSCURRENT FAULT

DIRECTION OF PLUNGE OF LINEATION

LANDSLIPS SHOWING HEEL OF SLIP AND DIRECTION OF MOVEMENT

RECENT ALLUVIUM . . . . Qra

VARVED CLAYS . . . . Qpv

KANSAS CREEK BEDS . . . . Pkp

FLUVIOGLACIAL DEPOSITS, TILL and ALLUVIUM . . . . Qf

ROAD

STRIKE AND PLUNGE OF DRAGFOLDS

ANTICLINAL AXIS (position approximate)

ANTICLINAL AXIS

SYNCLINAL AXIS (position approximate)

SYNCLINAL AXIS

BASALT, SCREE MATERIAL and LANDSLIP DEBRIS

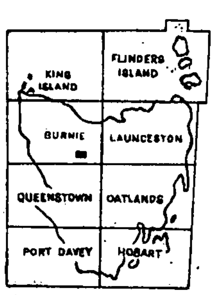
TILL, SCREE MATERIAL, MARSH DEPOSITS and GRAVELS

HOWELL GROUP . . . . PЄh's

TERTIARY BASALT . . . . Tb

JURASSIC DOLERITE . . . . Jdl

GEOLOGICAL MAPPING BY A.M. SPRY (1956).



REFERENCE TO AUSTRALIAN 4-MILE MAP SERIES.

WALTERS MARSH DAM SITES

MERSEY RIVER, TASMANIA 1961

GEOPHYSICAL SURVEY

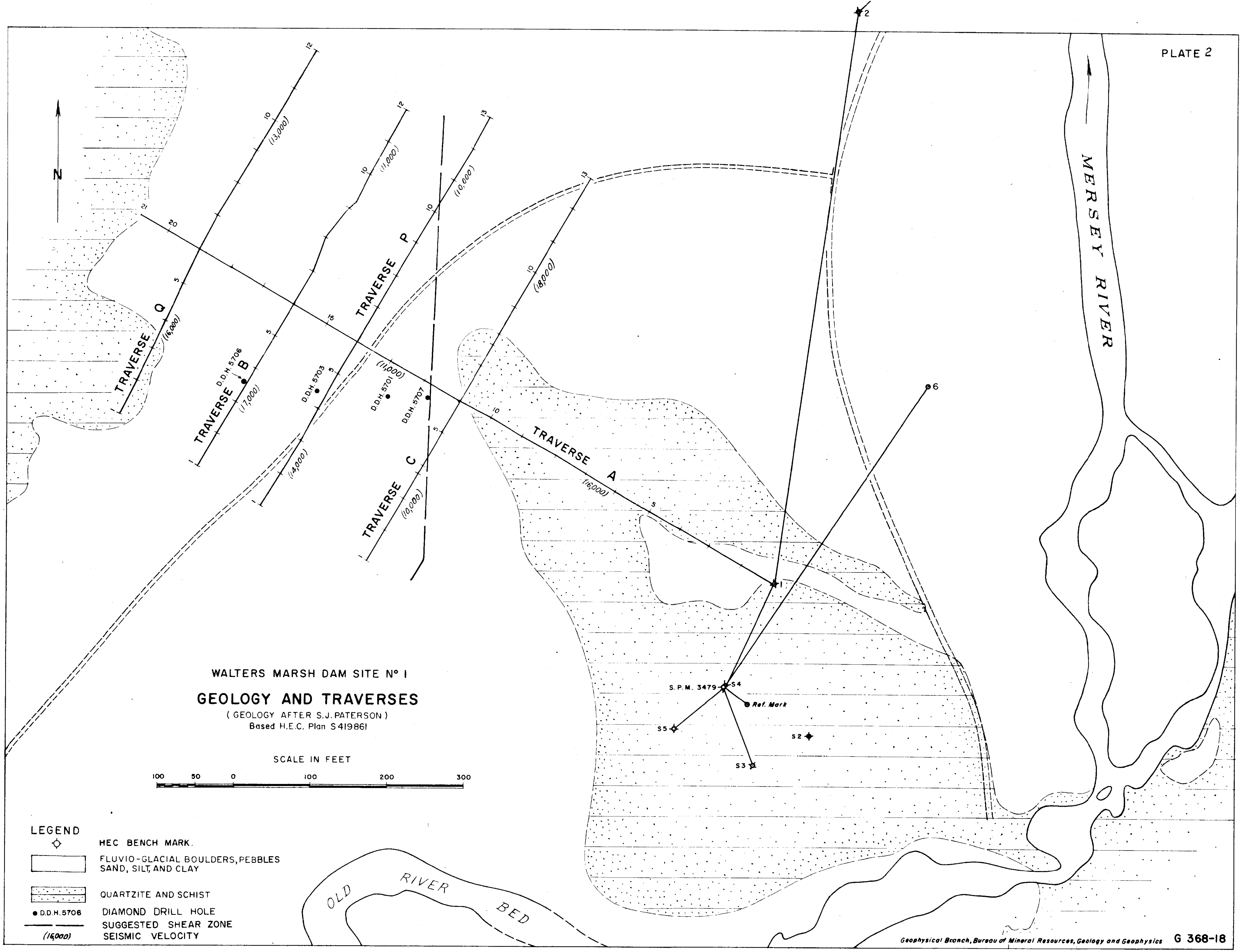
SCALE IN MILES

0 1 2 3

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS G368-33

TO ACCOMPANY RECORD No. 1962/15.

PLATE 2



WALTERS MARSH DAM SITE Nº I

GEOLOGY AND TRAVERSES

(GEOLOGY AFTER S.J. PATERSON)

Based H.E.C. Plan S 419861

SCALE IN FEET

100 50 0 100 200 300

LEGEND

HEC BENCH MARK.

FLUVIO-GLACIAL BOULDERS, PEBBLES SAND, SILT, AND CLAY

QUARTZITE AND SCHIST

● D.D.H. 5706 DIAMOND DRILL HOLE

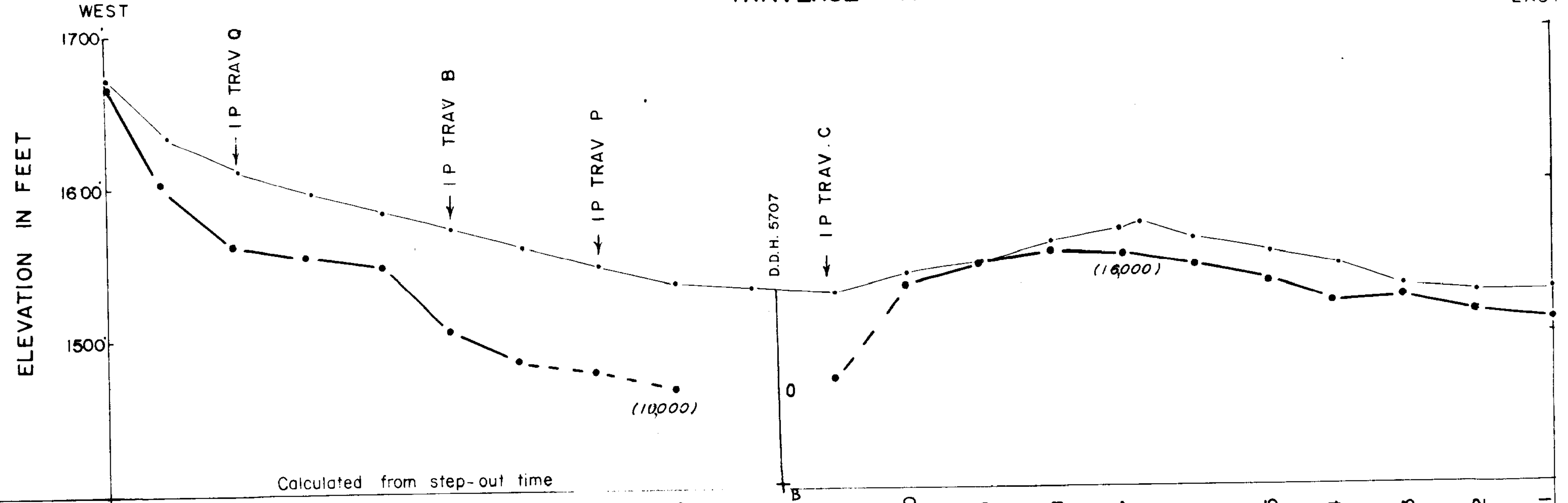
SUGGESTED SHEAR ZONE

(16,000) SEISMIC VELOCITY

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 368-18

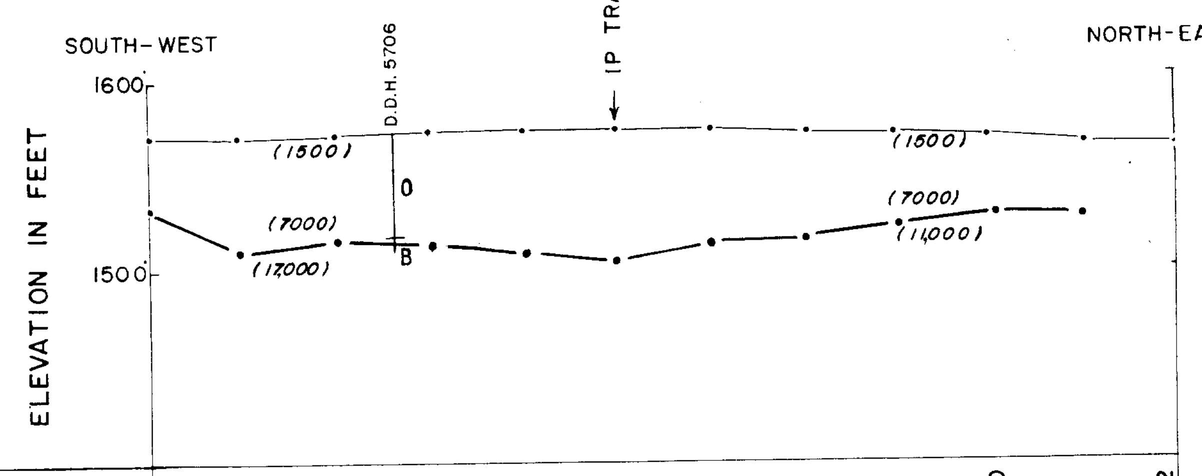
TO ACCOMPANY RECORD No. 1962/15.

TRAVERSE A



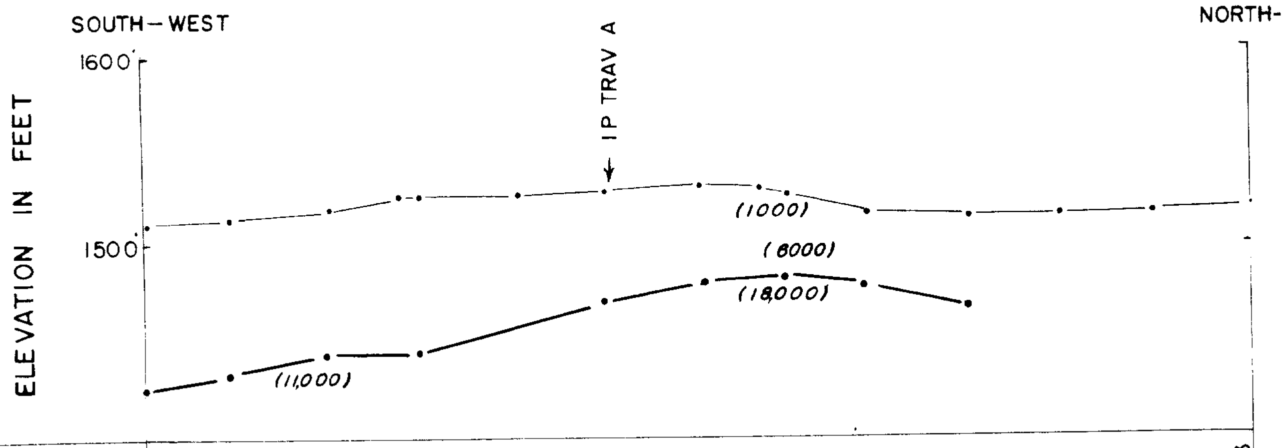
STATION NUMBER	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
STATION ELEVATION	1675	1636	1614	1599	1587	1575	1564	1548	1537	1533	1529	1541	1548	1561	1569	1562	1555	1546	1531	1527	1528
DEPTH TO BEDROCK	10	31	49	43	37	69	75	70	70	65	59	6	0	6	18	18	18	24	6	12	18

TRAVERSE B



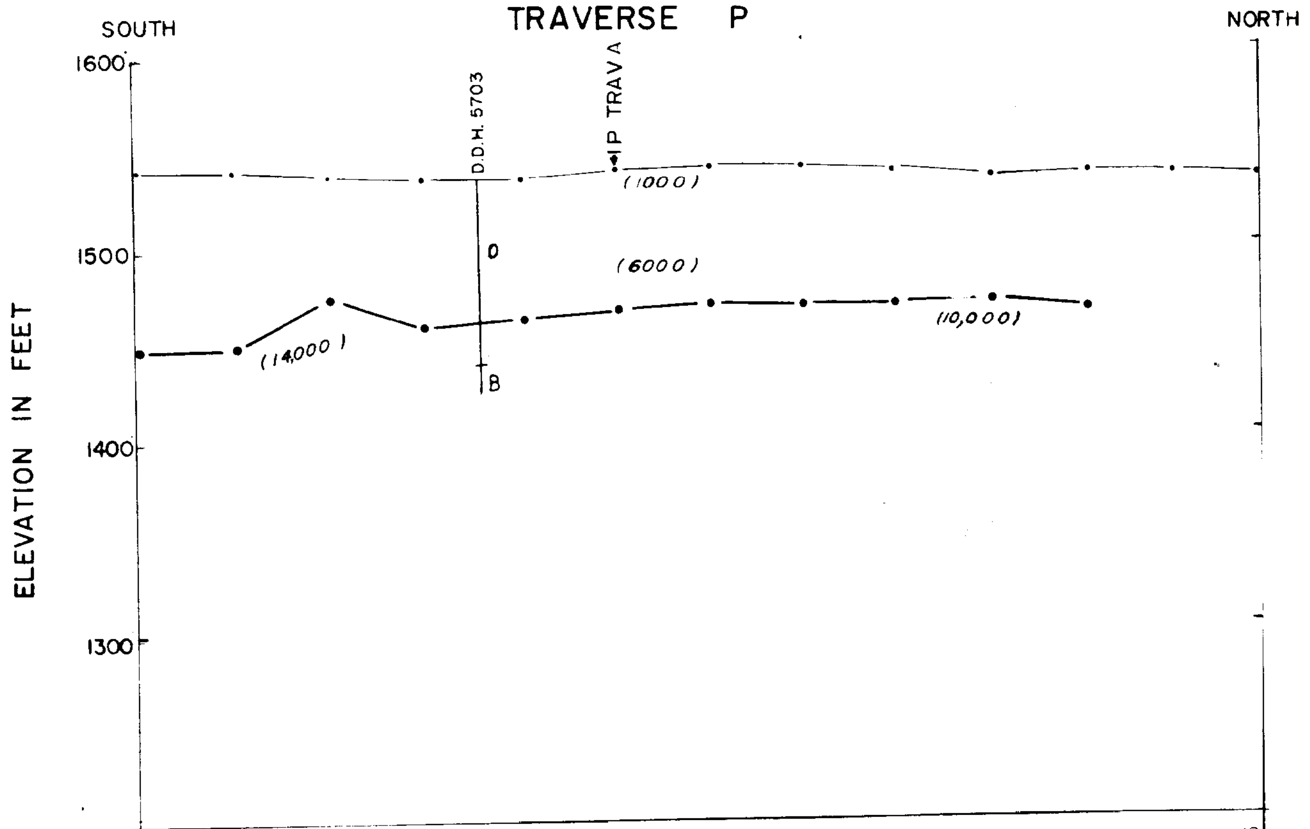
STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
STATION ELEVATION	1570	1571	1573	1573	1575	1575	1575	1572	1572	1569	1567	1565
DEPTH TO BEDROCK	34	56	53	56	62	68	56	54	47	37	37	

TRAVERSE C



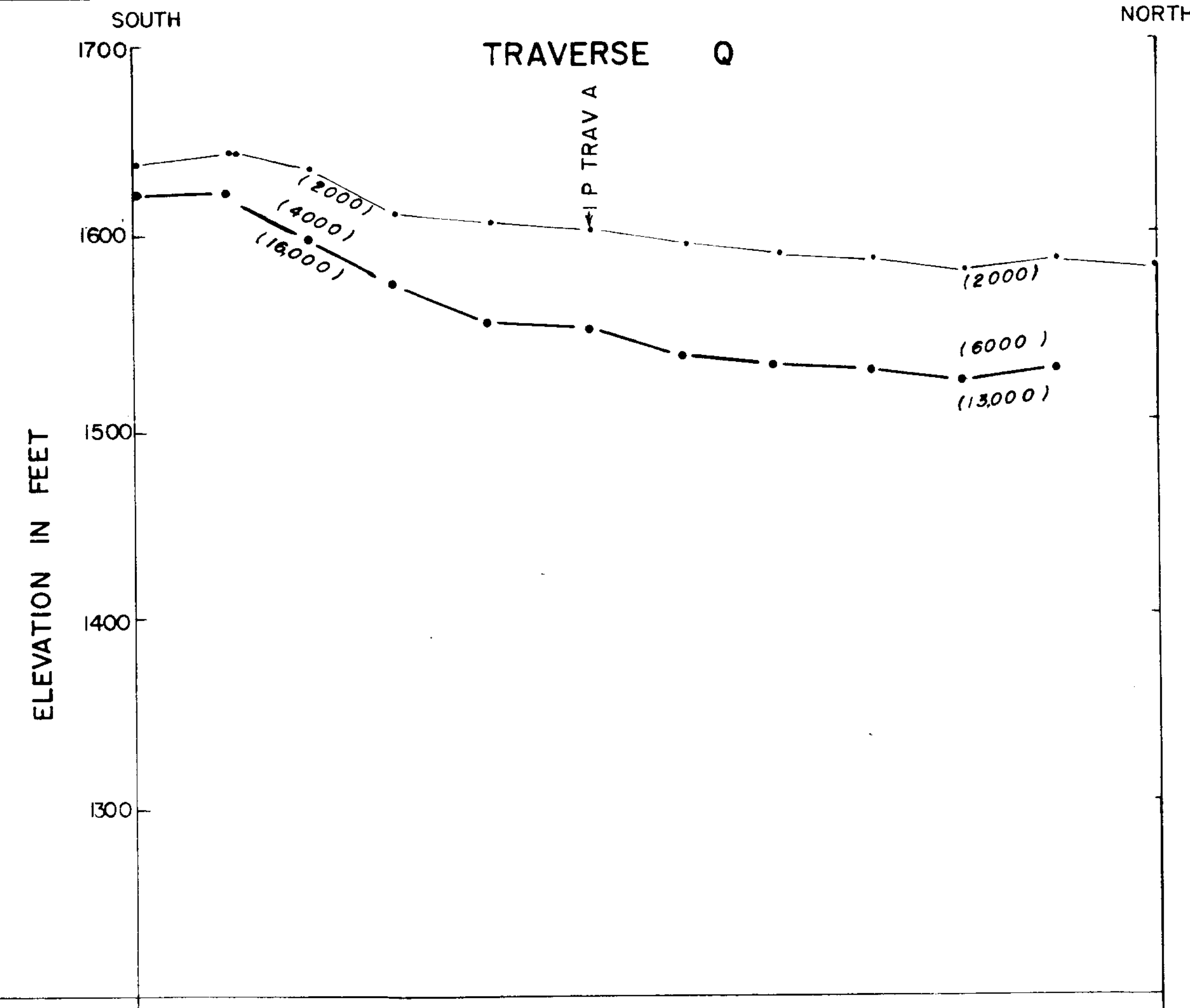
STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
STATION ELEVATION	1515	1515	1519	1527	1528	1529	1533	1527	1516	1515	1515	1517	1518
DEPTH TO BEDROCK	90	81	75	85		59	50	40	37	49			

TRAVERSE P



STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
STATION ELEVATION	1547	1547	1544	1543	1544	1548	1549	1550	1548	1545	1547	1547	1546
DEPTH TO BEDROCK	90	91	63	77	70	70	70	70	70	63	70		

TRAVERSE Q



STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
STATION ELEVATION	1648	1655 1655	1645	1622	1615	1614	1608	1602	1598	1592	1598	1593
DEPTH TO BEDROCK	19	22	34	37	53	49	59	59	56	59	56	

LEGEND

(11,000) FORMATION WITH SEISMIC VELOCITY 11,000 FT / SEC.

I P TRAV C INTERSECTION POINT

UNWEATHERED BEDROCK BOUNDARY

D.D.H. 5703 DIAMOND DRILL HOLE

O OVERBURDEN

B BEDROCK

DAM SITE No. 1

TRAVERSES A, B, C, P, AND Q

CROSS-SECTIONS

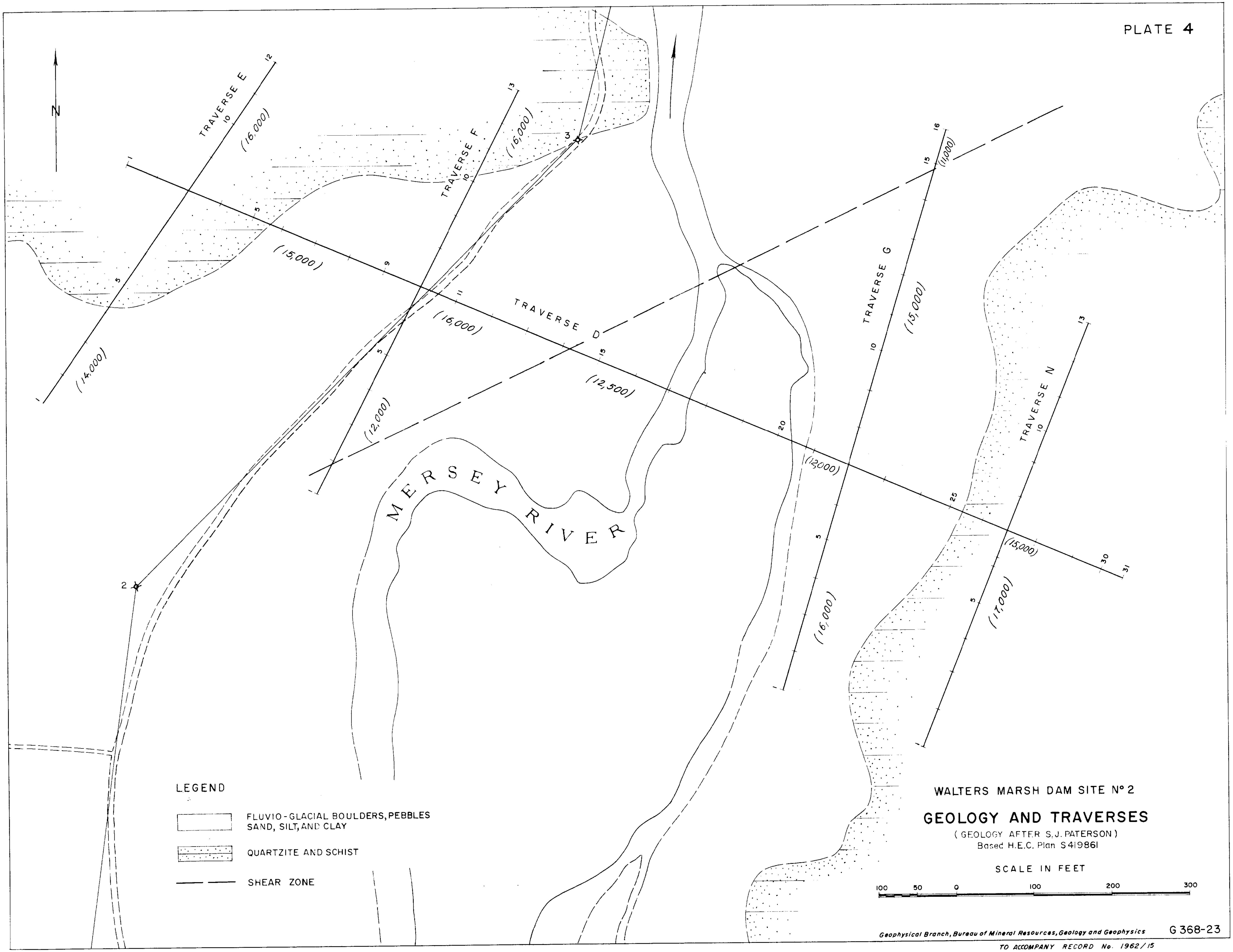
HORIZONTAL AND VERTICAL SCALES IN FEET

100 0 100 200 300

BASED ON HEC PLANS A8533 AND A8536

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS G 368-24
TO ACCOMPANY RECORD No 1962/13

WALTERS MARSH TAS 1961



WALTERS MARSH DAM SITE No 2

GEOLOGY AND TRAVERSES

(GEOLOGY AFTER S.J. PATERSON)
Based H.E.C. Plan S419861

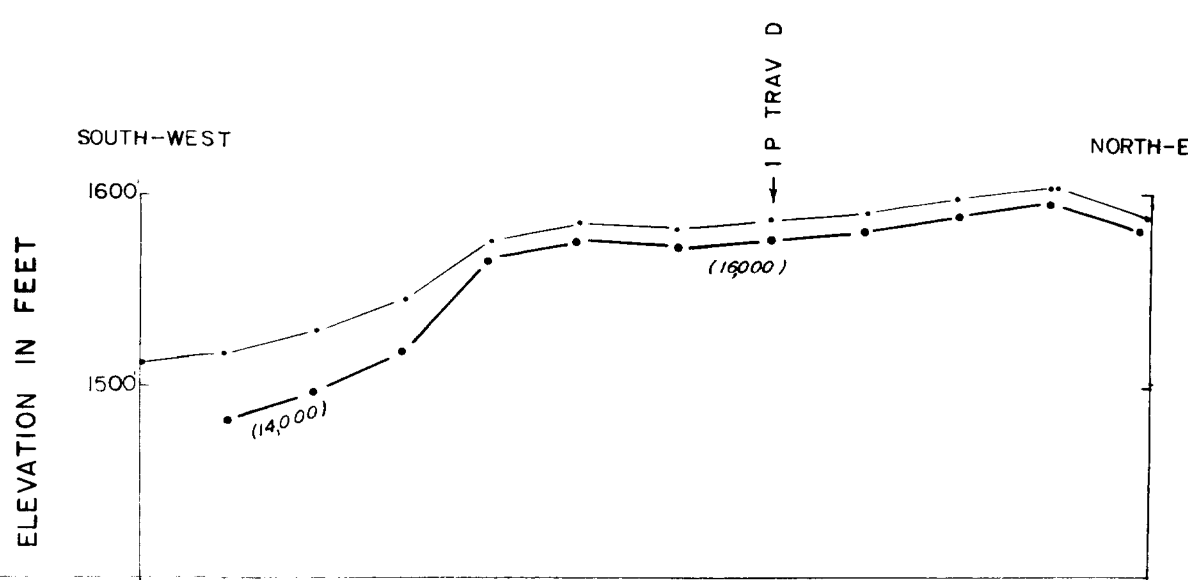
Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 368-23

TO ACCOMPANY RECORD No. 1962/15

WALTERS MARSH DAM SITE

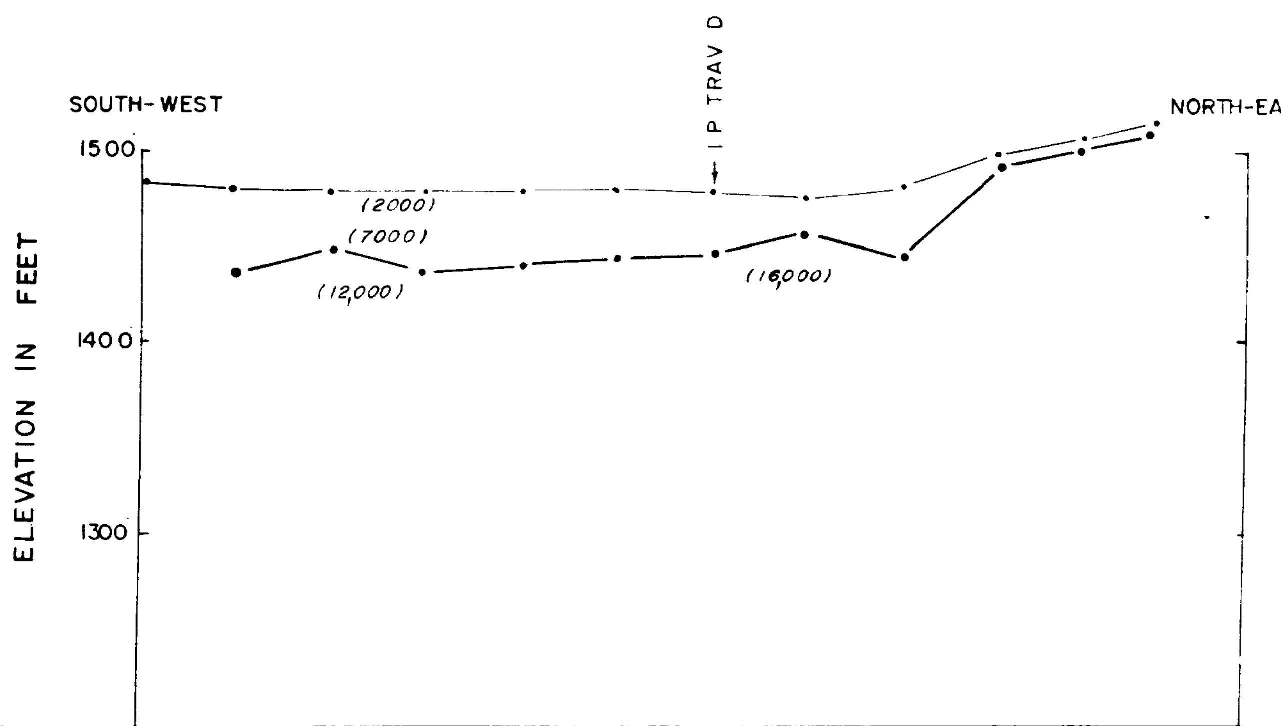
WALTERS MARSH DAM SITE. TAS.

TRAVERSE E



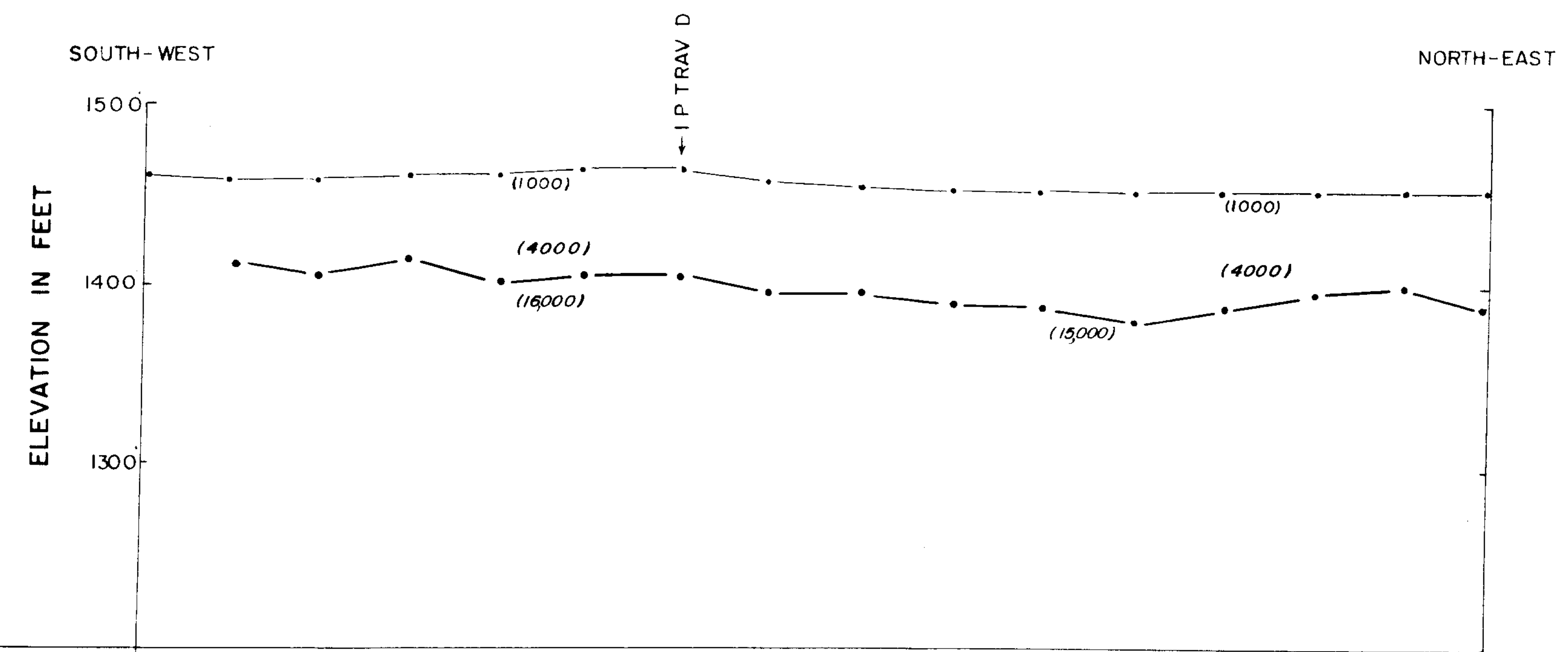
STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
STATION ELEVATION	1511	1516	1528	1545	1576	1587	1584	1588	1592	1600	1605 1605	1591
DEPTH TO BEDROCK		41	34	27	29	6	6	6	7	6	6	6

TRAVERSE F



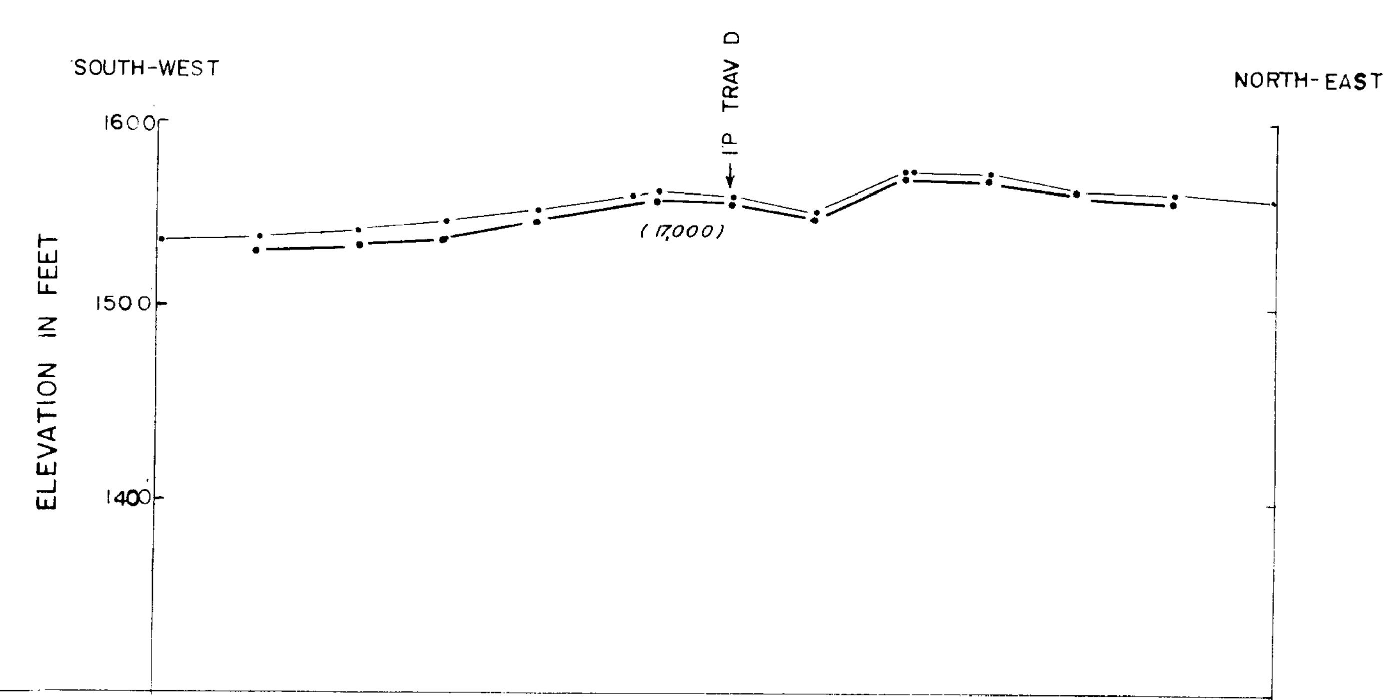
STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
STATION ELEVATION	1484	1482	1481	1481	1481	1481	1480	1477	1485	1498	1507	1516	1506
DEPTH TO BEDROCK		45	34	45	43	38	32	20	36	5	5	5	

TRAVERSE G



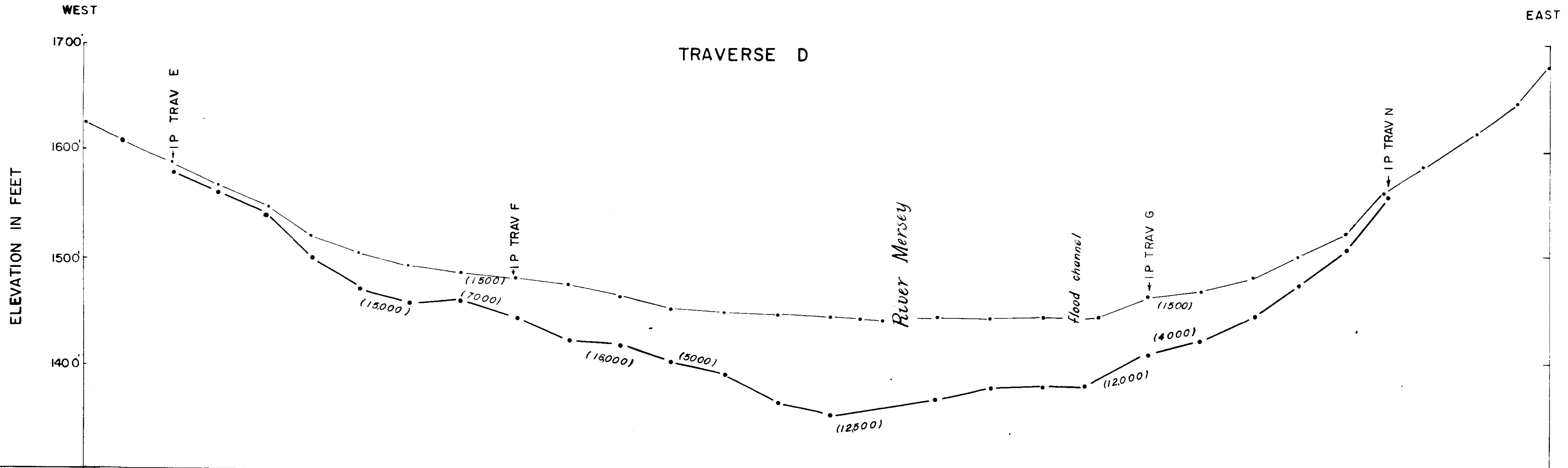
STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
STATION ELEVATION	1460	1456	1458	1459	1459	1462	1463	1458	1454	1453	1453	1453	1453	1452	1453	1452
DEPTH TO BEDROCK		45	50	43	57	58	58	60	58	60	64	72	64	56	54	64

TRAVERSE N



STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
STATION ELEVATION	1534	1537	1540	1546	1551	1558 1562	1561	1552	1573 1573	1574	1564	1563	1559
DEPTH TO BEDROCK		5	6	6	5	2	3	3	3	2	0	2	

TRAVERSE D



STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
STATION ELEVATION	1628	1608	1588	1567	1547	1519	1503	1490	1483	1480	1475	1463	1451	1447	1446	1444	1442 1439	1443	1443	1445	1443	1463	1468	1480	1501	1523	1561	1589	1618	1649	1683
DEPTH TO BEDROCK		7	7	7	6	20	32	34	25	36	52	45	49	56	81	92		78	68	65	65	58	43	32	27	15	4				

HORIZONTAL AND VERTICAL SCALES IN FEET

BASED ON HYDRO-ELECTRIC COMMISSION TAS. PLANS A8533 & A8534

DAM SITE No. 2

TRAVERSES E, F, G, N, AND D

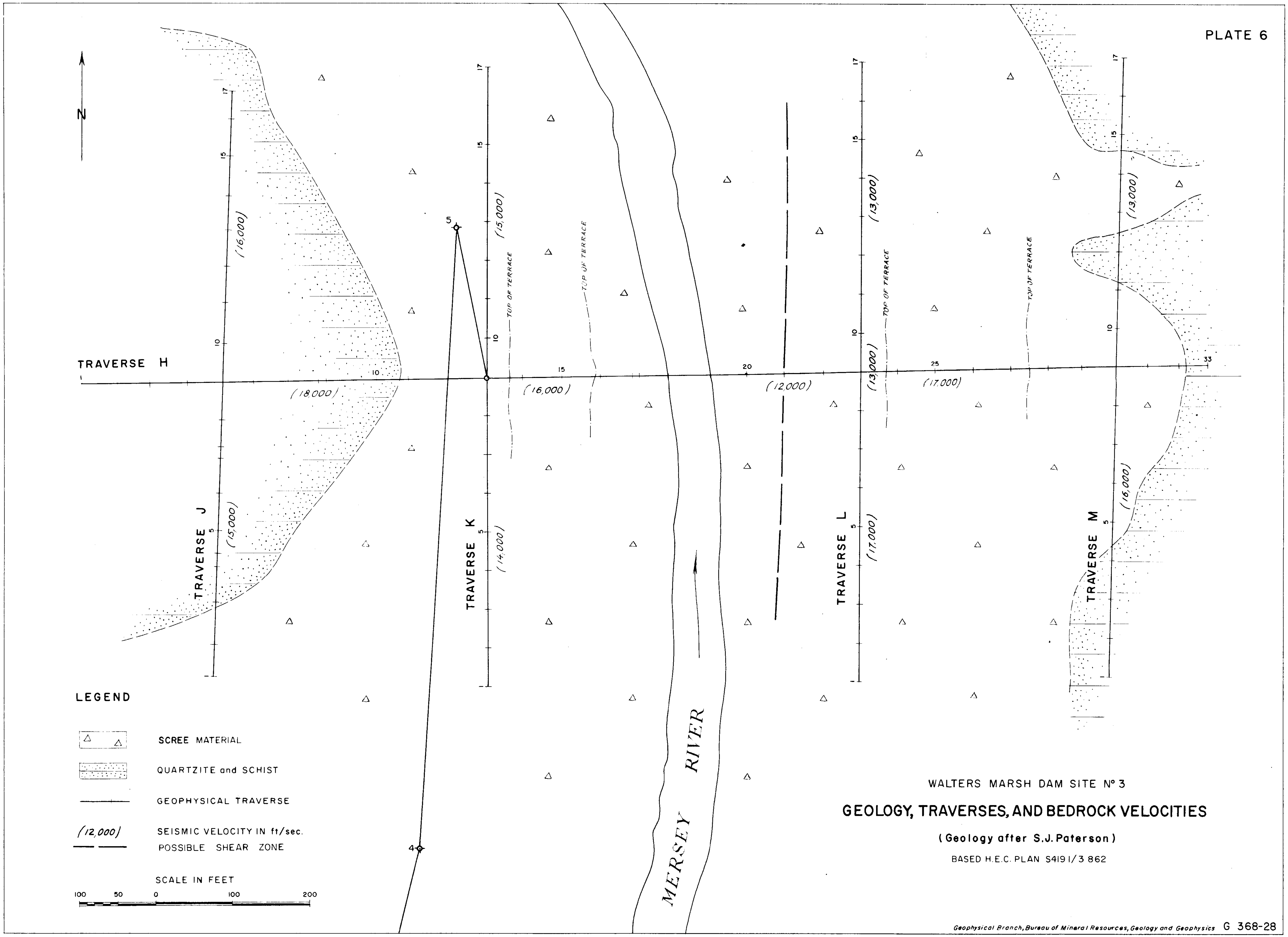
CROSS-SECTIONS

LEGEND

(10,000) FORMATION WITH SEISMIC VELOCITY 10,000 FT/SEC.

I.P.TRAV.D INTERSECTION POINT

UNWEATHERED BEDROCK BOUNDARY

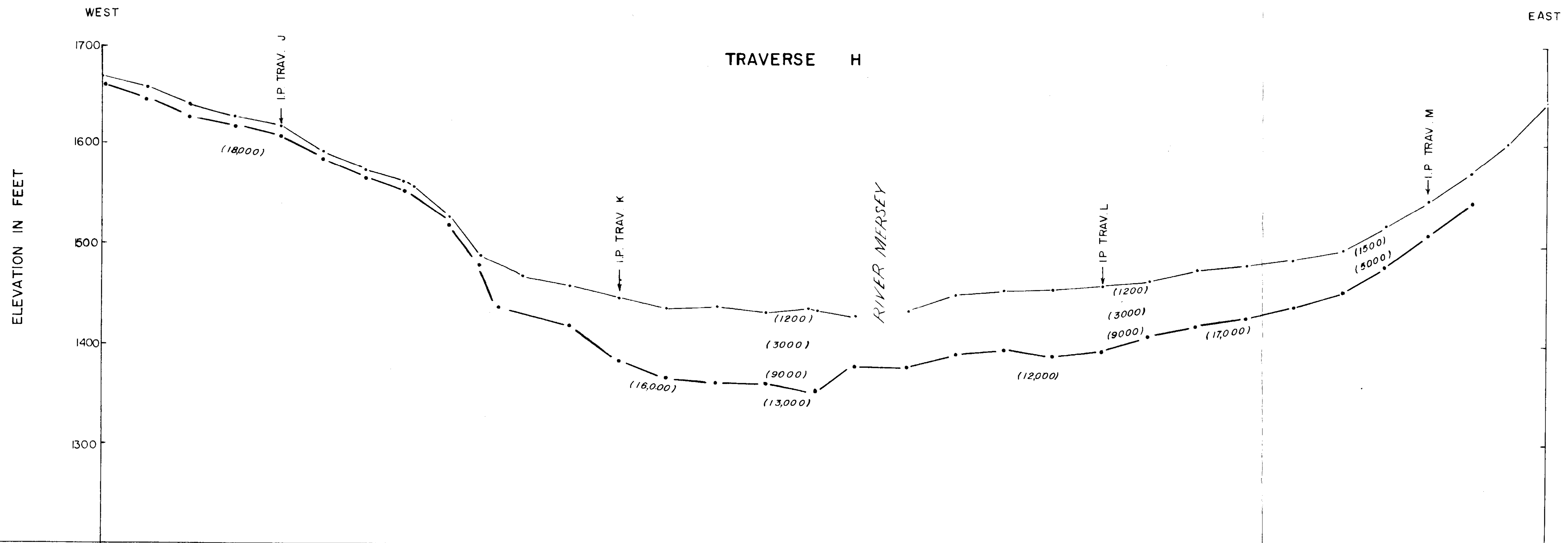


WALTERS MARSH DAM SITE Nº 3

GEOLOGY, TRAVERSES, AND BEDROCK VELOCITIES

(Geology after S.J. Paterson)

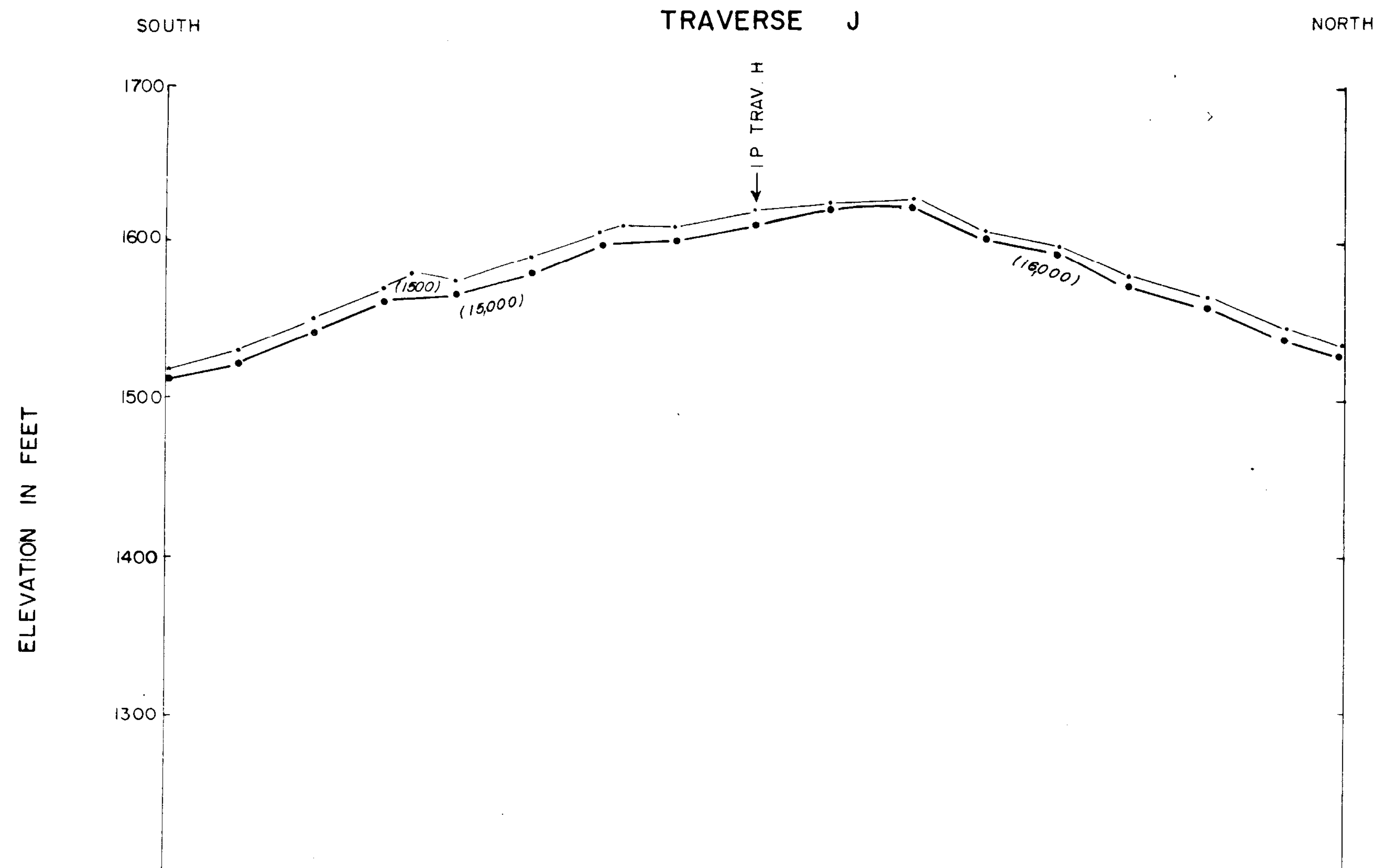
BASED H.E.C. PLAN S4191/3 862



TRAVERSE H

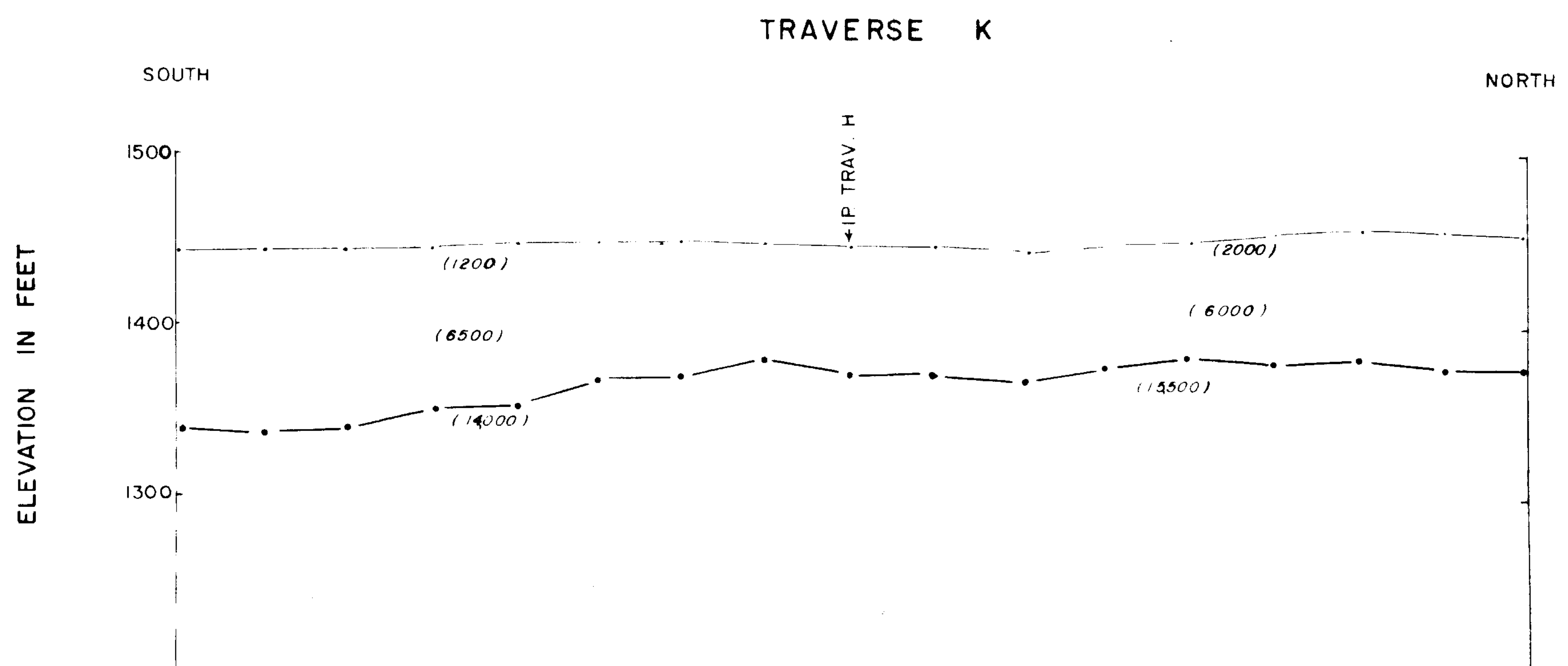
STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
STATION ELEVATION	1675	1659	1641	1630	1620	1594	1576	1564 1559	1529	1490	1469	1460	1449	1438	1440	1434	1438 1436
DEPTH TO BEDROCK	6	7	10	8	7	7	7	9	6	9	42	40	63	70	79	70	81

STATION NUMBER		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
STATION ELEVATION		1436	1453	1457	1459	1463	1468	1478	1483	1489	1498	1522	1549	1577	1606	1647
DEPTH TO BEDROCK	48	80	60	58	67	65	57	57	55	46	42	39	37	30		



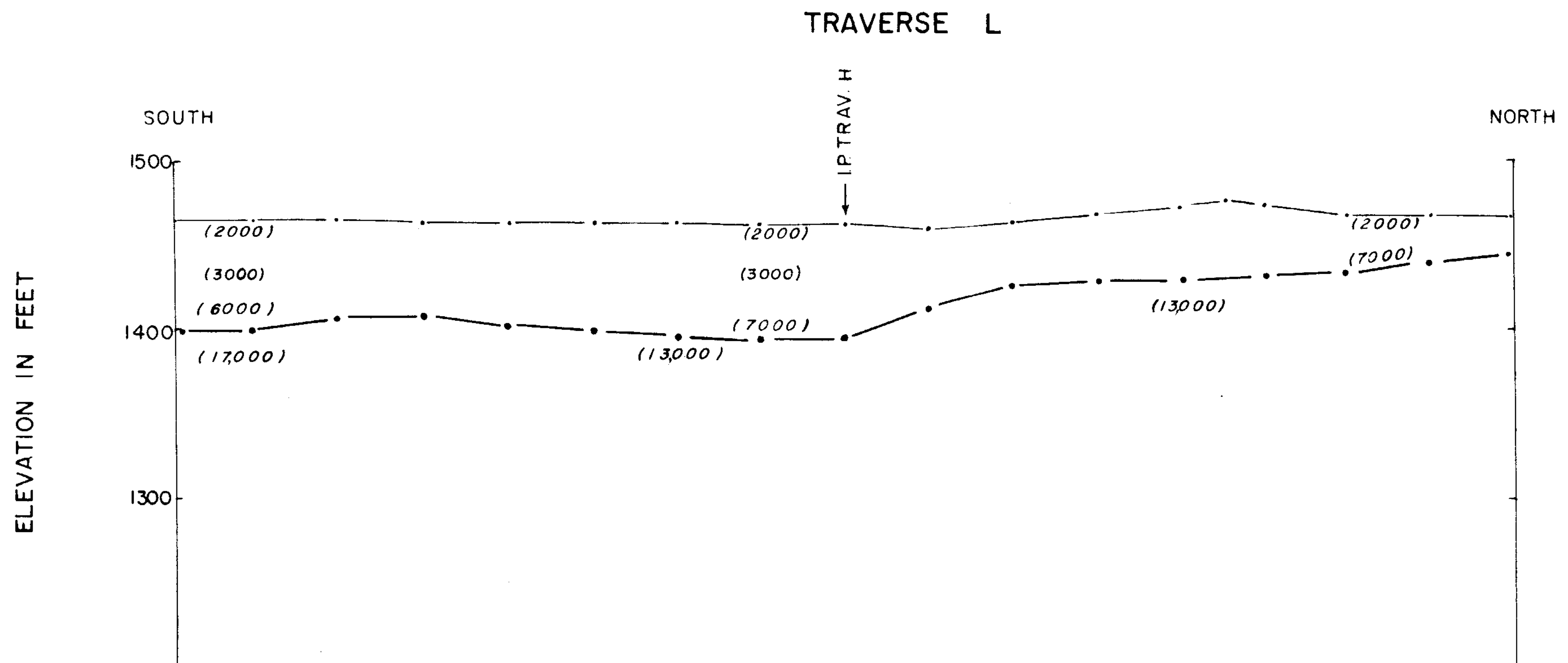
TRAVERSE J

STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
STATION ELEVATION	1519	1531	1551	1571 1580	1575	1590	1607 1610	1609	1620	1626	1629	1608	1599	1580	1566	1547	1535
DEPTH TO BEDROCK	9	9	9	8	7	8	7	6	6	5	4	3	2	4	5	5	6



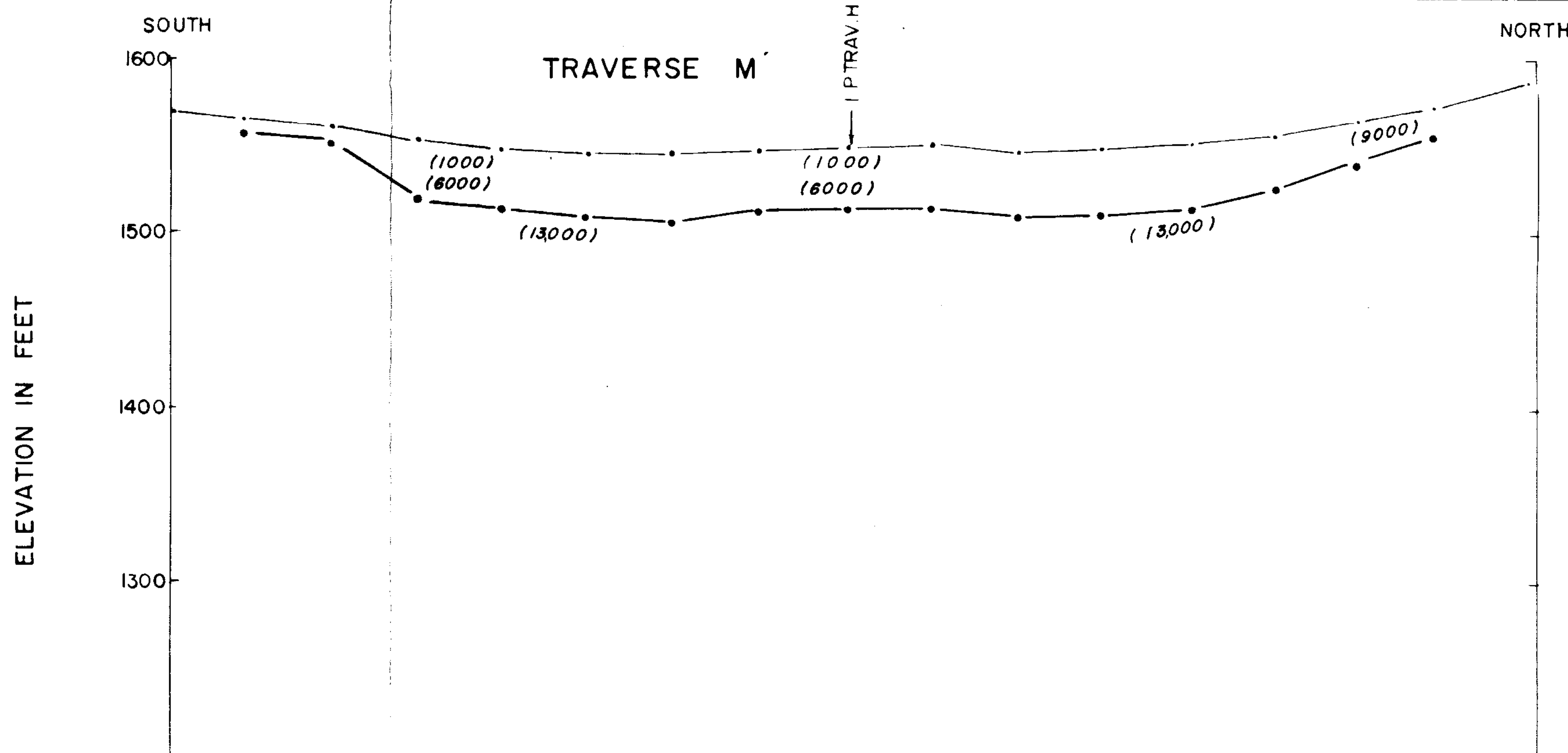
TRAVERSE K

STATION NUMBER	[illegible]	2	3	4	5	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12	13	14	15	16	17
STATION ELEVATION	447	1447	1446	1448	1450	1450	[illegible]	[illegible]	1449	1448	1445	448	1450	1454	1457	1456	1452
DEPTH TO BEDROCK	104	106	104	95	98	79	79	66	75	76	76	72	65	73	77	81	76



TRAVERSE L

STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
STATION ELEVATION	1466	1465	1465	1463	1463	1463	1463	1462	1463	1460	1465	1469	1474 1478	1475	1469	1468	1469
DEPTH TO BEDROCK	63	63	58	54	58	63	68	66	55	48	36	39	43	41	34	29	27



TRAVERSE M

STATION NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
STATION ELEVATION	1569	1566	1562	1554	1547	1546	1545	1547	1549	1551	1547	1549	1553	1555	1565	1571	1586
DEPTH TO BEDROCK		7	5	32	34	36	40	34	34	36	36	36	38	29	27	16	

LEGEND

(15,000) FORMATION WITH SEISMIC VELOCITY (15,000) FT / SEC.
I.P TRAV M INTERSECTION POINT
UNWEATHERED BEDROCK BOUNDARY

DAM SITE No.3

TRAVERSES H, J, K, L, M

CROSS-SECTIONS

HORIZONTAL AND VERTICAL SCALES IN FEET

100 0 100 200 300

BASED ON H.E.C OF TASMANIA PLANS No. A8535 AND 8536

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS G368-26
TO ACCOMPANY RECORD No. 1962/15