DEPARTMENT OF MINES
SOUTH AUSTRALIA

SEISMIC INVESTIGATIONS AT MYPONGA

by

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SEISMIC INVESTIGATIONS AT MYPONGA

ABSTRACT

A seismic refraction survey was made to determine the depth to bedrock along a traverse line on the southeastern rim of the Myponga reservoir, beneath which a potential leakage path exists. A wellshoot was made of an existing drill hole near the traverse line to confirm the results of the line survey and to establish the geological nature of the seismic refractors detected. The survey is thought to have determined with reasonable accuracy the depth to bedrock. A gravity survey along the seismic traverse line is recommended to attempt to find why previous gravity surveys in the area have not detected the beds through which leakage could occur.

INTRODUCTION

During August and September 1959 a refraction seismic survey was made at Myponga, about 50 miles south of Adelaide in South Australia by the Geophysical Section of the South Australian Department of Mines. This survey was undertaken as part of the investigations being made by the Department of Mines into the water tightness of the Myponga reservoir at present under construction. A line refraction survey was made along a traverse line approximately 6000 feet in length which was located along a ridge forming portion of the rim of the reservoir storage, beneath which fluvio-glacial sands exist and form a potential leakage path through the rim. Four seismic refractors were detected underlying the area with velocities of 3500, 6500, 10000 and 15000 feet per second. A well shoot was made of an existing drill hole near the traverse line to confirm the results of the line survey and to establish the geological nature of the seismic refractors detected. Some correlation is possible between the seismic results and the subsurface geology as indicated by the borehole. In particular the lowest seismic refractor, with velocity 15,000 feet per second is indicated to be the bedrock in the area.

PREVIOUS INVESTIGATIONS

Extensive geological examinations have been made of the area as a potential reservoir site and also during the present phase of construction. The area forms the subject of Department of Mines Report DM 177/48 (unpublished) "Preliminary Report on the Geology of The Myponga Damsites and Reservoir Area" by K.R. Miles (1948) and the more immediate area of the seismic survey is discussed in W. Johnson's Department of Mines Report DM 63/58 "Geological Investigations - Myponga Dam, Construction Phase - Progress Report No. 3, Reservoir Water Tightness" (1958). A gravity survey was made of the reservoir site by the Commonwealth Bureau of Mineral Resources ("Report on Gravimetric Survey of Reservoir Site, Myponga, South Australia" by C.H. Zelman, Bureau of Mineral Resources Geology and Geophysics, Report No. 1948/42, Geophysical Report No. 4 (unpublished).

GEOLOGY AND GEOPHYSICS

The rock formations of the area consist of a series of hard Upper Precambrian sediments (slates, phyllites, limestone, sandstone and quartzite) crossed by an ancient glacial valley filled with Permian fluvioglacial clays and sands, some Tertiary marine deposits (limestone) and Pleistocene - Recent clays, sands and gravels. Miles (1948) recognised that the chief danger of leakage of stored water through the rim of the reservoir exists in the south-eastern rim where a comparatively narrow divide (the ridge along which the seismic traverse was made) separates the Myponga River valley from a topographically lower valley to the southwest. To investigate the possibility of permeable sediments filling an old valley of glacial origin leading through the divide, Miles recommended geophysical surveys and percussion drilling. The gravity survey made by the Bureau of Mineral Resources did not indicate the presence of any broad valley filled with unconsolidated sediments and from this work and the results of drilling it was concluded that there is negligible danger of leakage through the divide.

Johnson (1958) re-examined the geology of the area and from further investigation, including drilling, found that a permeable bed or series of beds extend beneath the rim of the reservoir and the present survey was undertaken in an endeavour to find the depth of bedrock in the area of the potential leakage path.

FIELD METHODS

A traverse line was located along the rim of the reservoir extending a distance of 6000 feet between outcrops of the Precambrian bedrock and crossing the potential leakage path through the reservoir rim. The line was surveyed and levelled by officers of the ~~Electricity~~ Engineering and Water Supply Department, pegs for geophone stations being located and levelled every 50 feet along the line. Shotholes located every 500 feet along the line were drilled to a depth of 20 feet where possible, using a Landrover mounted Proline rotary posthole digger. Considerable difficulties and delays were experienced in this work and the equipment in its present condition is not considered efficient or suitable for this work. A twelve channel Century portable refraction seismic recorder (on loan from the Bureau of Mineral Resources) was used to record the results. A lot of time was lost in making repairs and adjustments to this equipment. From each shotpoint short spreads were laid out adjacent to the shotpoint with detectors spaced $12\frac{1}{2}$, 25, $37\frac{1}{2}$, 50, 75, 100, 125, 150, 175, 200, 250, 300 feet from the shotpoint and small charges of a few ounces of Geophex located at the surface were exploded. The detector spread was then shifted further from the shotpoint using 50 foot separation of the detectors and larger charges of Geophex (up to 35 lbs.) were exploded in the drilled shotholes. Further spreads located at greater distances from the shotpoint were recorded until the seismic wave refracted from the bedrock was detected (where possible).

The wellshoot was made using a geophone lowered down the hole and small charges of a few ounces of Geophex located in shallow holes hand-augered near the top of the hole.

INTERPRETATION

Graphs were drawn of the refraction times (corrected to surface-to-surface times) against distance for each shotpoint. The corrections to the surface were made using the velocities in shallow section indicated by the short spreads near the shotpoints.

The refractors were located and their velocities determined from the apparent velocities recorded and the intercept times computed at each shotpoint. From these results a theoretical section was constructed for refractors of constant velocity. Theoretical time-distance curves were drawn for this interpreted section. The time-distance curves were then adjusted to the observed time-distance curves where the refractors show considerable relief until a satisfactory fit was obtained.

The results are presented in the form of a section showing the positions of the refractors and a time versus distance graph showing the time-distance curves computed from the sections (shown as lines) and the corrected times from the records (shown as points).

The section indicates five layers of rocks in the area

1. Low Velocity Layer of velocity 1000 feet per second 4 to 9 feet in thickness.
2. Layer of velocity 3500 feet per second usually about 50 feet in thickness but not present between 4000 and 4250 feet.
3. Layer of velocity 6500 feet per second and thickness varying from 50 feet at approx. 4700 feet to 250 feet at 3200 feet to 130 feet near the eastern end of the traverse line.
4. Layer of velocity 10,000 feet per second approximately 170 feet from the surface extending from the eastern end of the traverse to 2500 feet.
5. The lowest refractor of velocity 15,000 feet per second lying 80 feet from the surface at 4600 feet and deepening progressively to the east till at 500 feet it lies 390 feet from the surface. This refractor is considered to be bedrock.

It must be stressed that a number of unproven assumptions have been made in this interpretation. In particular, for a considerable distance at each end of the deepest refractor, the seismic velocity has been determined in one direction only as no reverse coverage is possible owing to the geometry of the refractor. In these areas the position of the refractor is correct only if its velocity is the same as that determined by reversed coverage in the central portion of the traverse.

This assumption is considered to be approximately correct. Also the beds have been assumed to be isotropic and this could easily introduce errors of from 10 to 15% in the interpreted depths.

As well as these sources of error considerable errors may also arise from the inherent inaccuracy of the method. In particular the presence of beds of low velocity underlying beds of higher velocity will cause gross errors in the depth estimates made by seismic refraction surveys. No such conditions were indicated by the well-shoot but they could occur in parts of the traverse.

Errors in timing also introduce considerable errors in depth. An error of 1 millisecond may cause inaccurate estimate of depth of over 10 feet.

For these reasons any real estimate of the accuracy of the survey cannot easily be made. The closeness with which the interpreted position of the deepest refractor corresponds with the true position of the bedrock indicates the validity of the large number of assumptions necessarily made in the interpretation of refraction seismic records.

However from the seismic results and the depths to bedrock shown by percussion drill holes in the area it would appear that the interpretation is reasonably accurate.

WELL-SHOOT

A theoretical time depth curve for the percussion drill hole shot (PDH 5) was constructed from the line refraction results and this curve was found to agree closely with the observed uphole times recorded. From an examination of the geological log of the hole it is apparent that the first refractor detected (with velocity 3500 feet per sec.) represents the base of the surface Low Velocity Layer, the second (with velocity 6500 feet per sec.) represents the change from the upper sands to clay while the third (with velocity 10,000 feet per sec.) represents no major change in geological conditions and the fourth (with velocity 15,000 feet per sec.) represents the bedrock.

CONCLUSIONS AND RECOMMENDATIONS

It is considered that the seismic refraction survey has determined with reasonable accuracy the depth to bedrock along the greater part of the seismic traverse and has also located three additional seismic refractors lying above the bedrock. It can also be concluded that, since the survey did not detect the bedrock at the eastern end of the traverse, it seems probable that bedrock dips quite steeply (at an angle greater than 15°) from the outcrops at the eastern end of the traverse line. It would be beyond the capacity of the method to detect bedrock in this position as it would not provide a fastest path to any point on the line of traverse. Similarly it cannot be assumed that the refractor with velocity 10000 feet per second does not extend further to the western end of the traverse than it was detected since it also would not provide a fastest path. If it does extend further west it would not cause any great error in the calculated depth to bedrock.

The area is not very suited to the seismic refraction method of survey as the contrast in velocity between bedrock (15000 feet per second) and overburden (10,000 feet per second) is not sufficiently large to indicate in great detail the relief of the bedrock surface. Only the broad outline of the bedrock position could be determined.

The drilling equipment used was inadequate for the efficient operation of this type of survey. Considerable time could be saved by using heavier drilling plant. Deeper shotholes would prevent the formation of craters which need to be filled in.

It is recommended that a gravity survey be made along the seismic traverse line in an endeavour to determine why the previous gravity survey did not indicate the presence of a broad valley of unconsolidated sediment. The results of this survey could provide data from which a new interpretation of the gravity results could be made to provide further information on the area.

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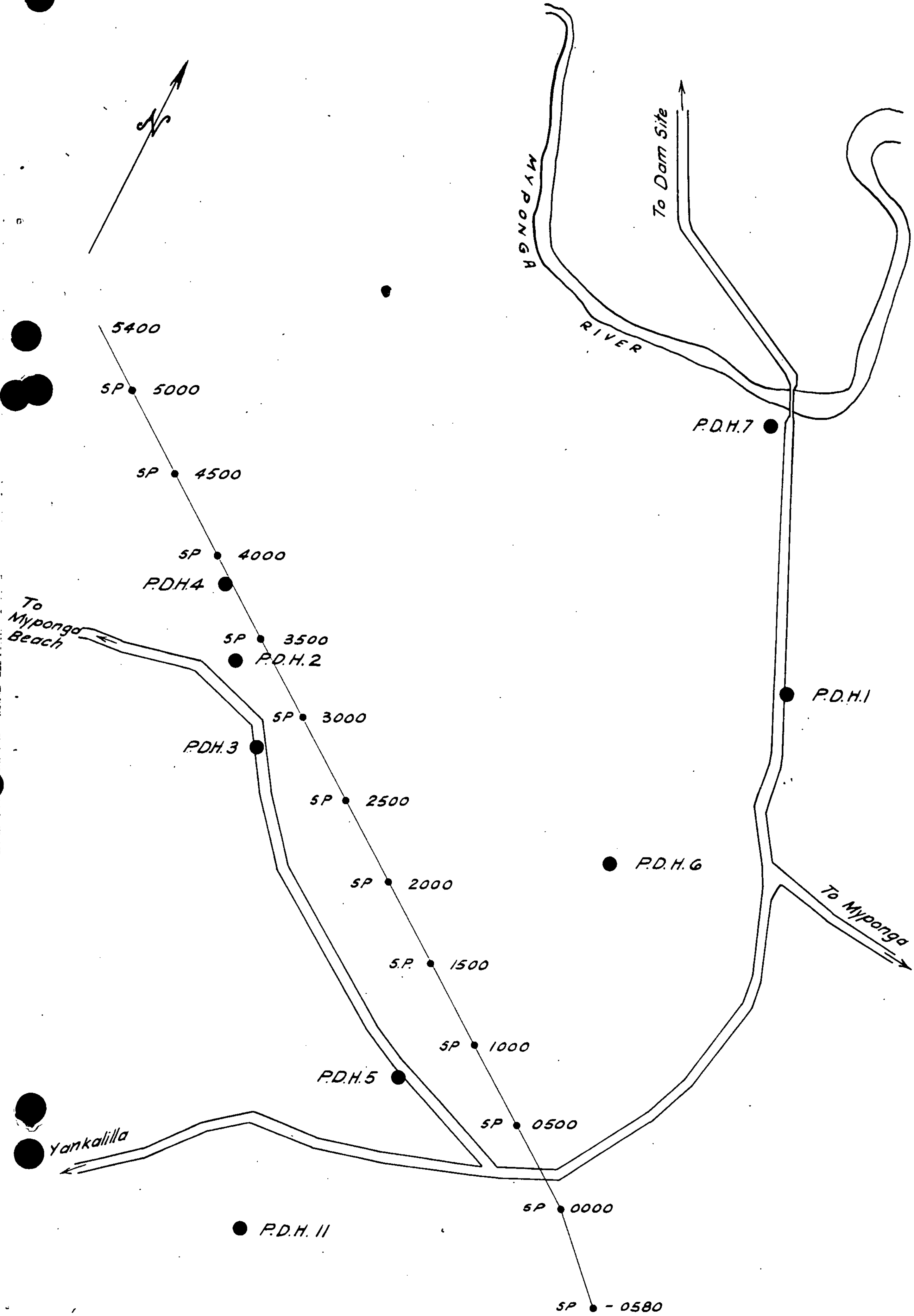
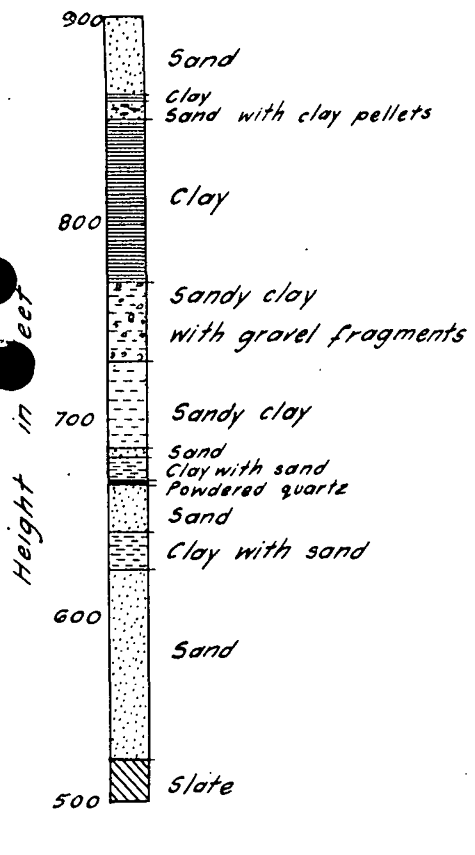
21/10/59.



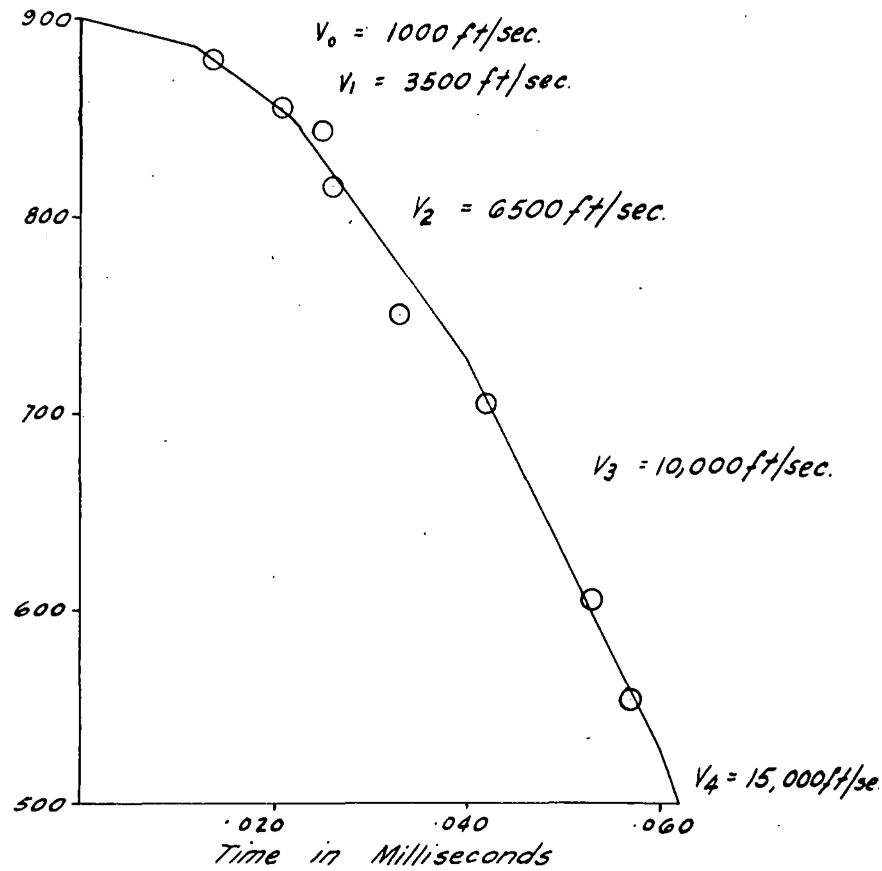
S.A. DEPARTMENT OF MINES

Approved	Passed	Drn.	MYPONGA SEISMIC TRAVERSE LOCATION OF SHOT POINTS AND PERCUSSION DRILL HOLES	D.M.	Scale 10 ch. to 1 inch
		Tcd. A.W.		Req.	S2273 Hc4
		Ckd.			
Director		Exd.			Date 21-10-59

200—8.59 2776



GEOLOGICAL SECTION



TIME DEPTH CURVE

UPHOLE TIMES COMPUTED FROM SEISMIC TRAVERSE SHOWN BY LINE.
OBSERVED TIMES SHOWN BY POINTS.

SCALE:- 100 FEET TO 1 INCH
0·020 SECONDS TO 1 INCH.

DATUM FOR HEIGHTS
L.W.O.S.T. PT. ADELAIDE = 100·0 FEET.

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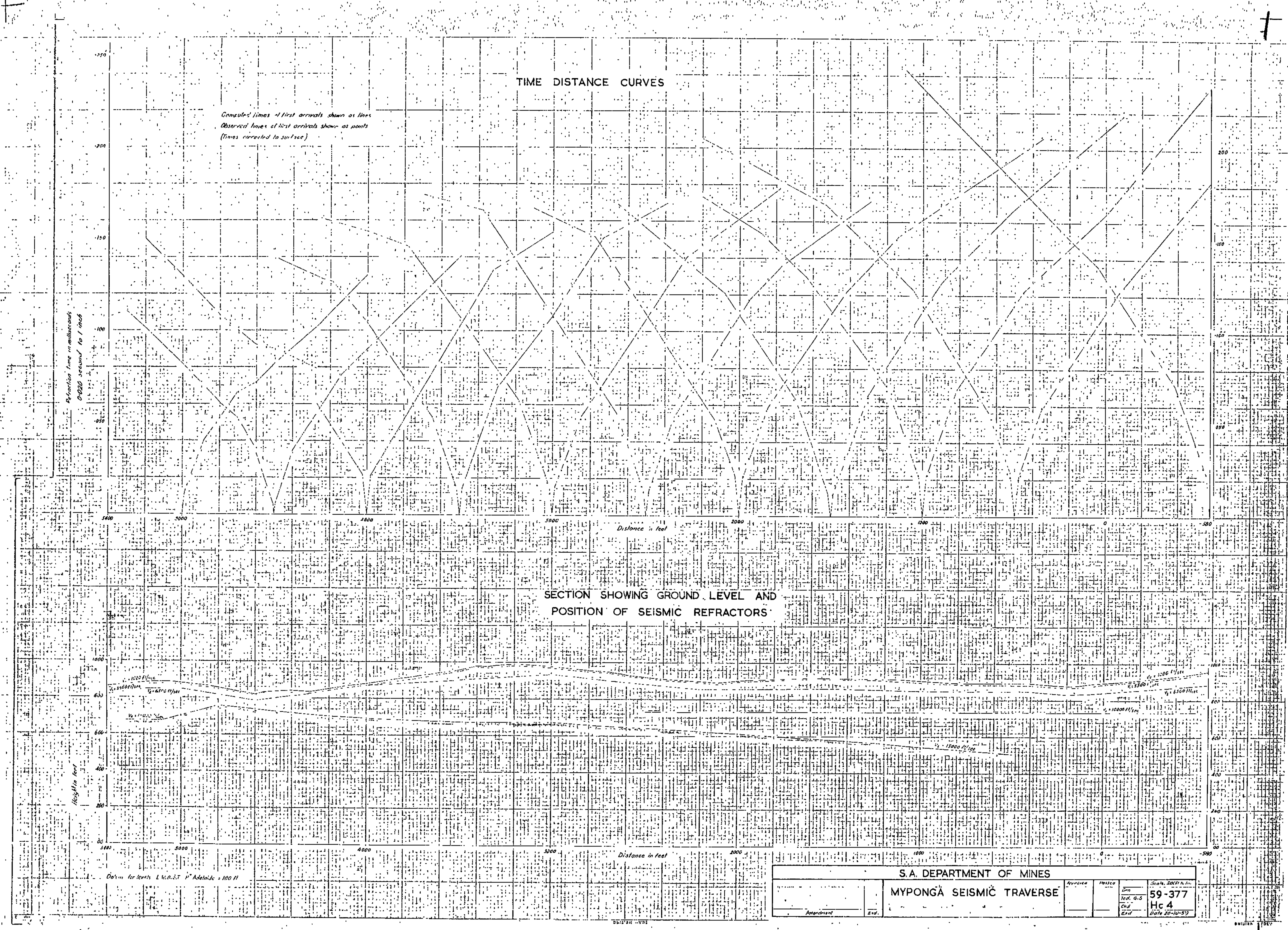
Approved	Passed	Drn.	MYPONGA SEISMIC SURVEY	D.M.	Scale
		Tcd. A.W.	WELLSHOOT OF P.D.H. 5.	Req.	S 2274 Hc4
		Ckd.			
Director		Exd.			Date 2/-10-59

200—8.59 2776



TIME DISTANCE CURVES
Computed times of first arrivals shown as lines
Observed times of first arrivals shown as points
(Times corrected to surface)
Refraction time in milliseconds
0.020 second to 1 inch
Distance in feet
SECTION SHOWING GROUND LEVEL AND
POSITION OF SEISMIC REFRACTORS
Height in feet
Distance in feet
Datum for levels L.W.O.S.T. P. Adelaide = 100 ft
S.A. DEPARTMENT OF MINES
MYPONGA SEISMIC TRAVERSE
Amendment
Scale, 200 ft to 1 in.
59-377
Hc 4
Date 20-10-59