DEPARTMENT OF
NATIONAL RESOURCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1977/66

GEOPHYSICAL SURVEY OF WEIR SITES,
LAKE TUGGERANONG PROJECT, ACT, 1977

by

P.J. Hill

Record 1977/66

GEOPHYSICAL SURVEY OF WEIR SITES, LAKE TUGGERANONG PROJECT, ACT, 1977

by

P.J. Hill

CONTENTS

SUMMARY

The proposed sites of three weirs which are planned for construction as part of the Lake Tuggeranong project (ACT) were investigated by seismic refraction and magnetic profiling, to assess foundation conditions and ease of excavation within the pondage areas. With a geophone spacing of 2.5 m, 2220 m of seismic refraction coverage was obtained. Total geomagnetic intensity measurements were made at 5 m intervals along 1300 m of traverse.

The results indicated that depth to suitable foundations within the weathered acid volcanics was variable over all three sites, from the surface to more than 6 m. At least 2.5 m of overburden will have to be removed along sections of all alignments investigated.

1. INTRODUCTION

The construction of an artificial water feature, Lake Tuggeranong, is proposed by the National Capital Development Commission (NCDC) as part of the Tuggeranong town centre development in the ACT. The lake is to be formed by damming Tuggeranong Creek below its confluence with Village Creek; the dam, an embankment (and fixed-crest spillway), will also serve as a crossing point for the South Woden Arterial. The project is planned to proceed in stages: first, the development of water-quality control ponds on the feeder creeks; later, the construction of the main embankment.

Three proposed weirs - Tuggeranong Creek weir 1, Tuggeranong Creek weir 2 and Village Creek weir - will back up the creeks forming the water-quality control ponds. Each of these structures will be about 8 m high from foundation to footway, and will hold back a head of water about 2 m high.

In order that design and selection of alignments for the weirs proceed, the NCDC submitted a request to the Bureau of Mineral Resources, Geology and Geophysics (BMR) for subsurface information and advice on proposed site areas. A survey of the sites was subsequently carried out by BMR's Engineering Geophysics Group using seismic refraction and magnetic methods.

To assist with the geophysical work a number of traverse lines were surveyed (and pegged at 5-m intervals) at each of the proposed weir localities by the Australian Survey Office (Department of Administrative Services). Included in the surveying was an additional line about 300 m downstream of the Tuggeranong Creek weir 1 site, where a drilling program had been undertaken to investigate bridge foundations (Erindale Drive). The intention was to use the results of the drilling program to help interpret the geophysical results at the weir sites.

The location of the survey area is shown in Plate 1. Plate 2 is a large-scale plan of this area showing the general geology, surveyed lines, and positions of seismic spreads shot during the course of the investigation.

The bulk of the fieldwork was done part-time between April and June 1977. Additional seismic refraction spreads were shot at the Tuggeranong Creek weir 1 and Village Creek weir sites later in the year (October), following a request from NCDC. Traverse lines TW1, VC5, and VC6 were surveyed and pegged for this work.

The BMR personnel who participated in the geophysical investigation, and the equipment used, are outlined in the Appendix.

2. GEOLOGY

General mapping and engineering geological investigations of the area have been done by a number of BMR geologists, the more recent work by Vanden Broek (1974) and Goldsmith (1976). The geology shown in Plate 2 has been taken from Goldsmith's report.

The survey area is underlain by acid volcanic bedrock, consisting of Upper Silurian welded crystal tuff of rhyodacitic to dacitic composition. Bedrock is exposed at all three sites - mostly along the creek beds, but also on both banks - particularly on the knoll of the right bank - at the Tuggeranong Creek weir 2 site. In the exposures the rock is seen to be moderately to extremely weathered, with moderately spaced joints, many of which have been filled by quartz-epidote. Elsewhere on the sites the unconsolidated material overlying the weathered bedrock is composed of topsoil, clays, alluvium, and colluvium which are more than 2 m thick in places.

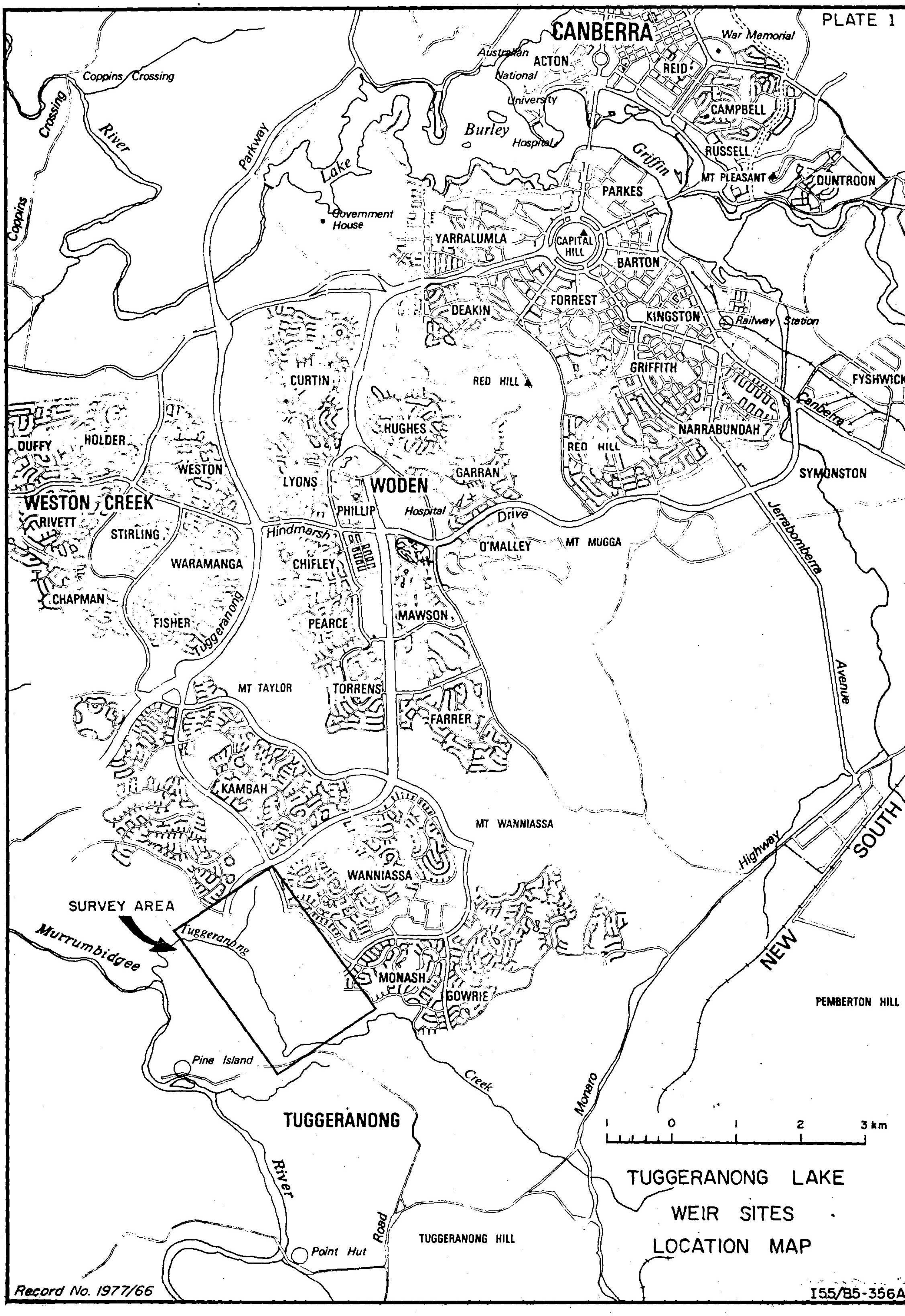
No direct evidence was found at the sites for the inferred fault that is thought to intersect the Village Creek weir and the Tuggeranong Creek weir 1 sites and just graze the Tuggeranong Creek weir 2 site (Plate 2); quite possibly it was concealed beneath the regolith cover. However, a prominent joint-set strikes parallel to the inferred fault at the Village Creek weir site.

3. SEISMIC REFRACTION SURVEY

Method of investigation

The seismic investigation of the subsurface was based on the routine shallow seismic refraction 'reciprocal method' as described by Hawkins (1961). The method assumes stratification of the seismic layers subparallel with the ground surface, and a monotonic increase of velocity with depth. In nature this is the most common situation.

PLATE 1



TUGGERANONG LAKE
WEIR SITES
LOCATION MAP

Record No. 1977/66

I55/B5-356A

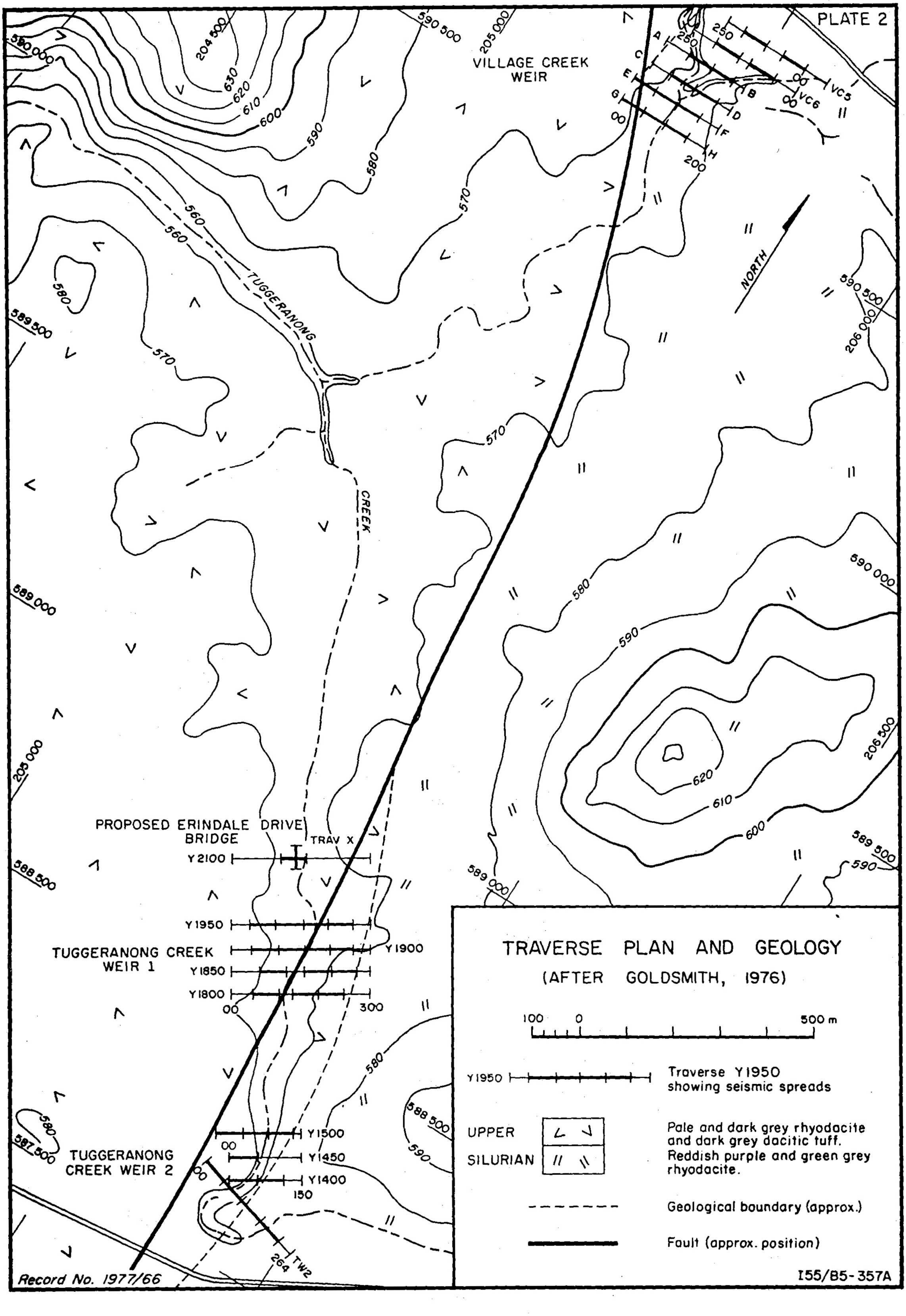


PLATE 2
VILLAGE CREEK
WEIR
TUGGERANONG
CREEK
NORTH
VC5
VC6
PROPOSED ERINDALE DRIVE
BRIDGE
TRAV X
Y 2100
Y 1950
TUGGERANONG CREEK
WEIR 1
Y 1900
Y 1850
Y 1800
TUGGERANONG
CREEK WEIR 2
Y 1500
Y 1450
Y 1400
TW2
TRAVERSE PLAN AND GEOLOGY
(AFTER GOLDSMITH, 1976)
100 0 500 m
Y 1950
Traverse Y1950
showing seismic spreads
UPPER
SILURIAN
Pale and dark grey rhyodacite
and dark grey dacitic tuff.
Reddish purple and green grey
rhyodacite.
Geological boundary (approx.)
Fault (approx. position)
Record No. 1977/66
I55/B5-357A

A 2.5-m geophone spacing was used during the survey; this gave a spread length of 55 m (later 57½ m, when the use of reciprocal geophones was discontinued) for the 24-channel equipment. For each spread, shots (consisting of gelignite and instantaneous detonators) were generally fired between geophones 12 and 13 (centre shot), 1¼ m off the ends (short shots), and one spread length plus 1¼ m (i.e., 56¼ or 58¾ m) off the ends (long shots). Where continuous traverses were possible, spreads were linked by having one common geophone position; in other words, the first geophone of one spread became the last geophone of the next spread.

Reciprocal geophones were used in conjunction with the long shots during the early part of the survey. Their use was discontinued for the October work, since it was considered that sufficient accuracy in delineating seismic bedrock could be achieved by determining reciprocal times from the short and long shot arrival times.

Survey results and their interpretation

The results of the seismic refraction investigation are presented in Plates 3-7 as cross-sections showing the calculated subsurface distribution of seismic velocities.

As a general guide, material with a seismic velocity less than 1200 m/s is rippable by the larger, more powerful tractors (e.g., D7 to D9), whereas material with seismic velocity in the range 1200-1500 m/s may or may not be rippable (Caterpillar Tractor Company, 1966).

From surface geological evidence and experience in areas of similar geology, interpretation of the various seismic velocity layers in terms of lithology is made as follows:

Seismic velocity (m/s)	Material
250-900	Topsoil, clay, alluvium, colluvium, extremely weathered tuff
900-1500	Highly weathered tuff
1500-3500	Moderately weathered tuff
3500-4500	Slightly weathered tuff
4500-5600	Fresh tuff

While the seismic results, according to the above interpretation, correlate well with the borehole logs (Erindale Drive bridge, Plate 3) for the near-surface layers there appears to be some discrepancy at depth. The fact that the log descriptions were based more on the ease or difficulty of drilling than rock condition, and that drilling only samples a very small section of the subsurface, could explain the apparent differences.

Moderately weathered to fresh tuff should provide adequate foundations for the proposed weirs. Some of the highly weathered tuff with seismic velocity down to 1200 m/s may be difficult to rip, and so may provide satisfactory foundations.

An inherent problem in deducing seismic velocities from time-distance curves is that of masked layers (see Merrick, Odins, & Greenhalgh, 1976). The depth of material with seismic velocity less than 1200 m/s should be known, since this material will prove unsuitable for the weir foundations and is expected to be readily removed by mechanical means. To delineate the possible minimum depth extent of such material, calculations were made to determine the top of a hypothetical blind zone of 1200 m/s velocity. These calculated depths have been incorporated in the normal (without including hidden layers) seismic cross-sections depicted in Plates 3-7.

The exposures at all three sites are moderately jointed. Effective recorded seismic velocity decreases both with intensity and width of joints within the rock medium.

The seismic results support the existence of the inferred fault transecting the Tuggeranong Creek weir 1 site. At the approximate position of the fault on lines Y1950, Y1900, Y1850, and Y1800 (Plate 2), the bedrock has a significantly lower velocity and/or is deeper (Plate 4). Depth to bedrock at the western ends of lines GH and EF (Village Creek weir site, Plate 6) also shows a marked increase, perhaps again reflecting the nearby fault.

After the seismic work was completed at the Tuggeranong Creek weir 1 site, Maunsell and Partners Pty Ltd (consultants to NCDC) had two trial pits excavated by backhoe along line Y1850. The geology as exposed in the pits is described below - from the logs of Maunsell's site engineer and the observations of D.C. Purcell (Engineering Geology Group, BMR).

Test pit No. 1 (ch. 95-105)

0-1 m fine sandy soil
1-2 m dark grey silty clay
2-3 m light brown and grey clayey sand
3-3.4 m (end of hole) extremely weathered tuff

At a depth of 2 m there was a considerable inflow of silty water from the dammed creek; a comparatively slow inflow of groundwater also occurred from the bottom of the pit.

Test pit No. 2 (ch. 180-190)

0-0.8 m soil
0.8-0.9 m red brown loam
0.9-1.7 m yellow brown gravelly sandy material
1.7-3.2 m highly to extremely weathered tuff
3.2 m (end of hole) at ch. 190 moderately weathered tuff
4.0 m (end of hole) at ch. 180 highly weathered tuff

The seismic refraction results correlate well with this data.

4. MAGNETIC MEASUREMENTS

Measurements of total geomagnetic intensity were made at 5-m intervals along the north-northeasterly traverses at the Erindale Drive bridge and Tuggeranong Creek weir 1 sites lines Y2100, Y1950, Y1900, Y1850, and Y1800). The sensor was maintained at a height of 2.5 m above the ground surface.

As can be seen in Plate 8, the magnetic profiles do show significant variations, with anomalies in the order of 150 nT. A comparison of the profiles with the seismic cross-sections shows that the magnetic 'highs' generally correlate with bedrock approaching the surface. The expected relative magnetic profiles along lines Y1950, Y1900, and Y1800, assuming that all the magnetic effect was coming from a magnetically homogeneous 'seismic' bedrock, were calculated using D. Hsu's (Marine Group, BMR) two-dimensional computer program. A value of 1000 x 10^{-6} cgs units for the magnetic susceptibility contrast gave the best fit.

The larger magnetic 'highs' remain unexplained, however. The shapes of these anomalies suggest that they originate near the top of the fresh bedrock or possibly within the weathered zone. Magnetic heterogeneity appears to be the most likely cause, and, though the seismic results do not clearly indicate this, there could be changes in the engineering properties of the rock associated with the magnetic variations. This can be definitely ascertained only by drilling or excavation.

Magnetic measurements were not made at the other weir sites because the results at the Erindale Drive bridge and Tuggeranong Creek weir 1 sites could not be interpreted without ambiguity.

5. CONCLUSIONS

The final siting of the wiers will be subject to such considerations as aesthetics and the incorporation of the weirs into the framework of surrounding urban development proposals, and not solely to the geology, which, however, is of fundamental importance. To satisfy the geological criteria, the weirs should be constructed on shallow sound foundations, preferably with an area immediately upstream consisting of poorly consolidated material that can readily be excavated, if necessary, to increase the area or depth of the storage ponds.

The seismic refraction work indicated variable depth to suitable foundations, ranging from the surface to in excess of 6 m. An approximate range of maximum depth to suitable foundations for each traverse is listed below:

	Approximate range of maximum depth to suitable foundations (m)
Tuggeranong Creek weir 1	
line Y1950	3-4
Y1900	4-6
Y1850	6-11
Y1800	6-7
Tuggeranong Creek weir 2	
line Y1500	3-5
Y1450	2.5-4
Y1400	2.5-5
TW2	2.5-4
Village Creek weir	
line AB	4-5
CD	4-5
EF	4-9
GH	2.5-4.5

Part of the upstream area of the Village Creek weir site (around lines VC5, VC6 and possibly AB and CD) will have to be excavated to provide adequate pondage. The seismic results suggest that surface material can be removed by mechanical means to at least an average depth of 3 m in this area.

The total geomagnetic intensity profiling produced results which correlate to some extent with depth to bedrock. However, the distorting effect of large anomalies, possibly produced by magnetic heterogeneities near the top of the bedrock or within the weathered zone, negated the possibility of making meaningful inferences about the subsurface.

6. REFERENCES

CATERPILLAR TRACTOR COMPANY, 1966 - HANDBOOK OF RIPPING: A GUIDE TO GREATER PROFITS, 3rd edition. Caterpillar Tractor Company, Peoria, Illinois.

GOLDSMITH, R.C.M., 1976 - Murrumbidgee Park Drive, Tuggeranong, A.C.T. geological investigation. Bureau of Mineral Resources, Australia, Record 1976/106 (unpublished).

HAWKINS, L.V., 1961 - The reciprocal method of routine shallow seismic refraction investigations. Geophysics, 26(6), 806-19.

MERRICK, N.P., ODINS, J.A., & GREENHALGH, S.A., 1976 - A solution to the problem of masked layers within a sequence of horizontal or dipping refractors. Water Resources Commission, Hydrogeological Report 1976/14.

VANDEN BROEK, P.H., 1974 - Engineering geology of Tuggeranong town centre, ACT. Bureau of Mineral Resources, Australia, Record 1974/184 (unpublished).

APPENDIX

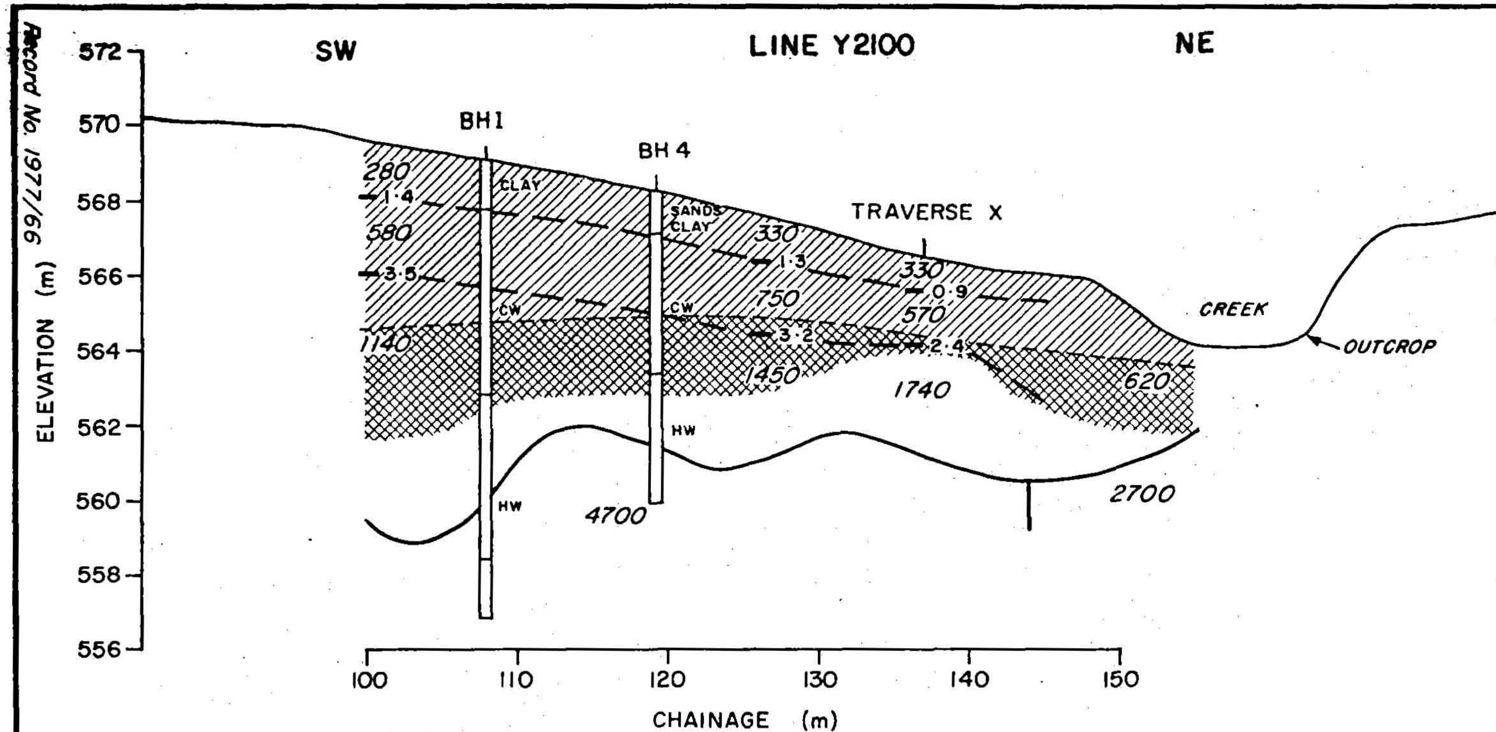
BMR personnel assisting with the fieldwork -

P.J. Hill (Party Leader)
D.G. Bennett
D.H. Francis
M. Preston-Stanley
L.W. Miller
D. Pownall
R. Tracey

Survey equipment -

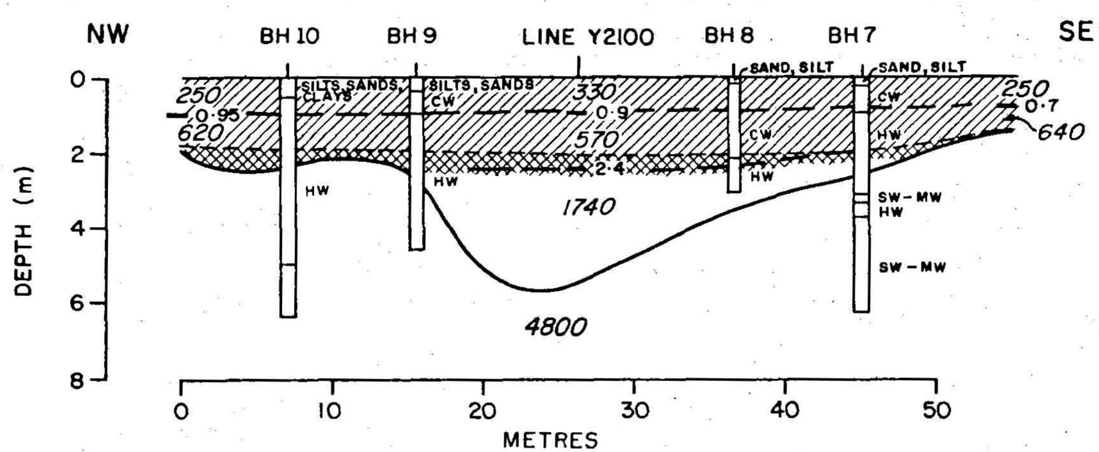
Seismic refraction:	24-channel SIE PSU-19 amplifier
	25-channel SIE PRO-11 oscillograph
	8 Hz GSC-20D geophones (with 1.8 kΩ shunt resistance to give 70% damping)
	Electro-Tech HV blaster (BC-8A)
	Pye Cambridge (FM 10DV) two-way radios
Magnetic:	Geometrics (G816) portable proton magnetometer
	Staff, 2.5 m long for the magnetometer head.
Vehicles:	International D1310 (four-wheel drive) recording truck
	Landrover shooting vehicle
	Valiant station sedan (general transport)

Record No. 1977/66



ERINDALE DRIVE BRIDGE SEISMIC CROSS-SECTIONS

TRAVERSE X (AT 90° TO LINE Y2100, INTERSECTING IT AT ch. 137m)



LEGEND

$\frac{V}{H} = 2{\cdot}5$

1450 Seismic velocity in metres/second

— 3·2 Depth of refractor in metres

Expected minimum depth of material unsuitable for good foundations (lower boundary has been taken as the upper surface of a 1200 m/s seismic blind zone of maximum thickness).

Marginal material – suitable foundations should be found within or below this zone. (Material with seismic velocity >1500 m/s should provide suitable foundations)

CW Completely weathered

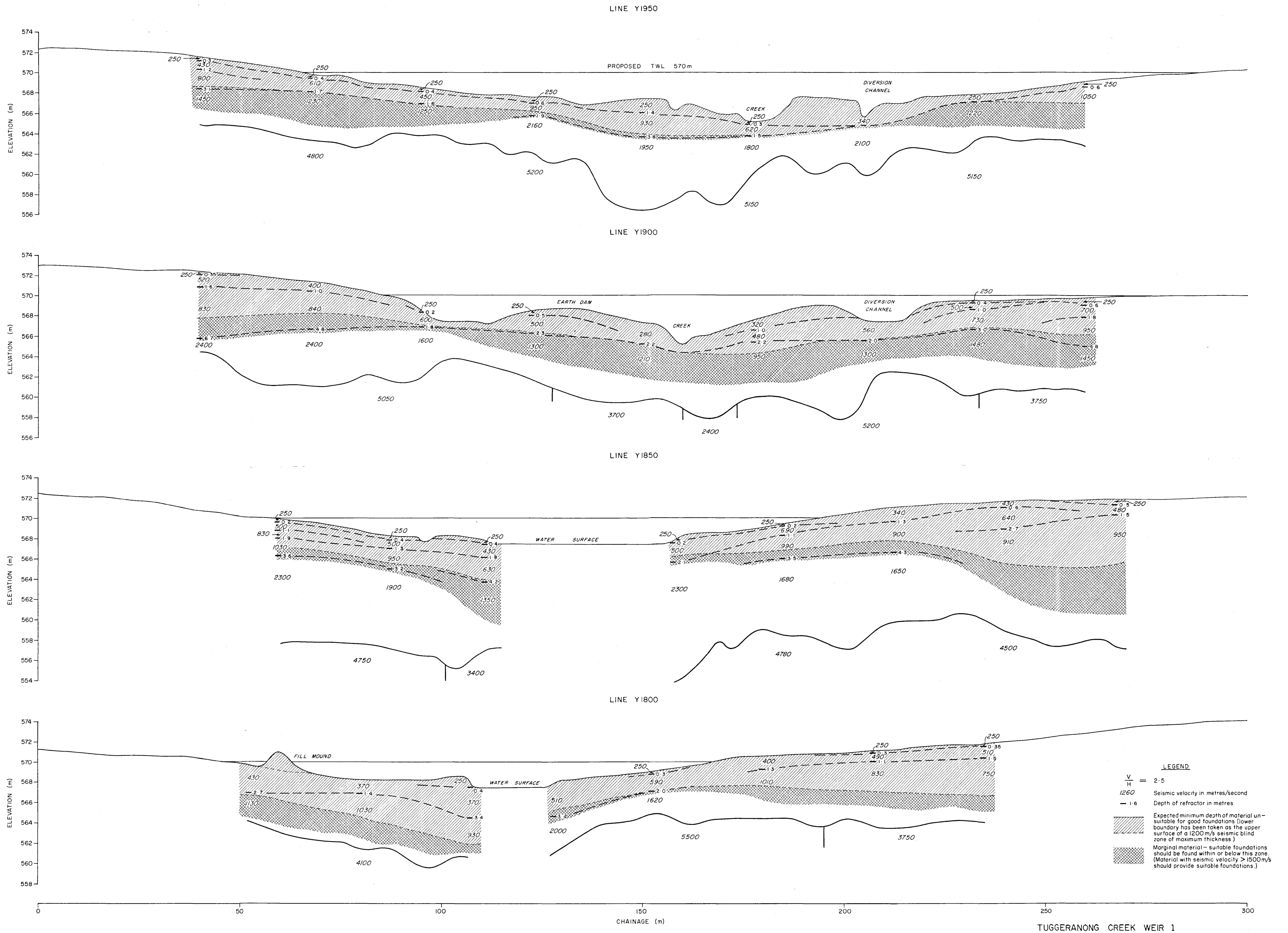
HW Highly weathered

MW Moderately weathered

SW Slightly weathered

I55/B5-358A

PLATE 3

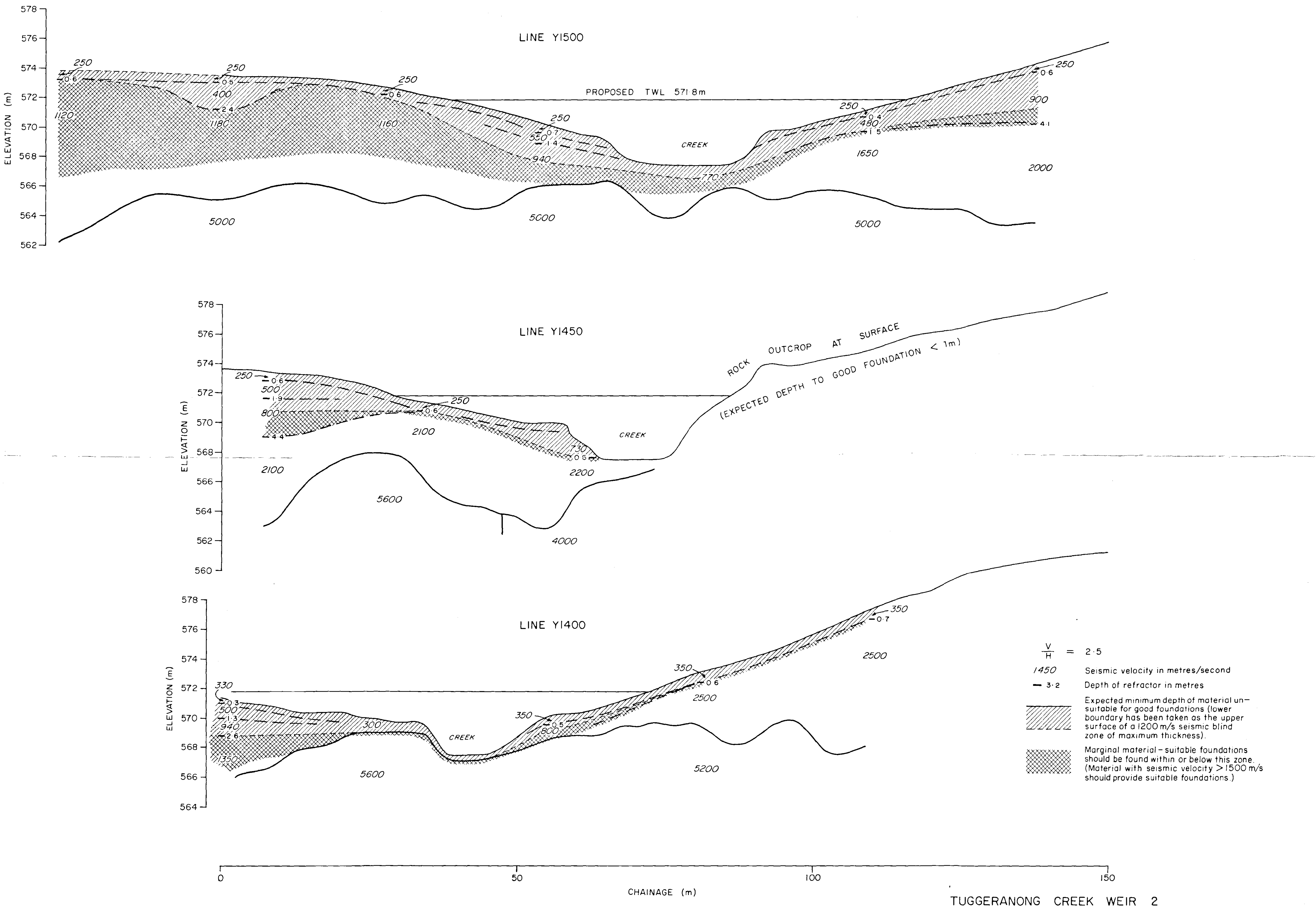


TUGGERANONG CREEK WEIR 1

SEISMIC CROSS-SECTIONS

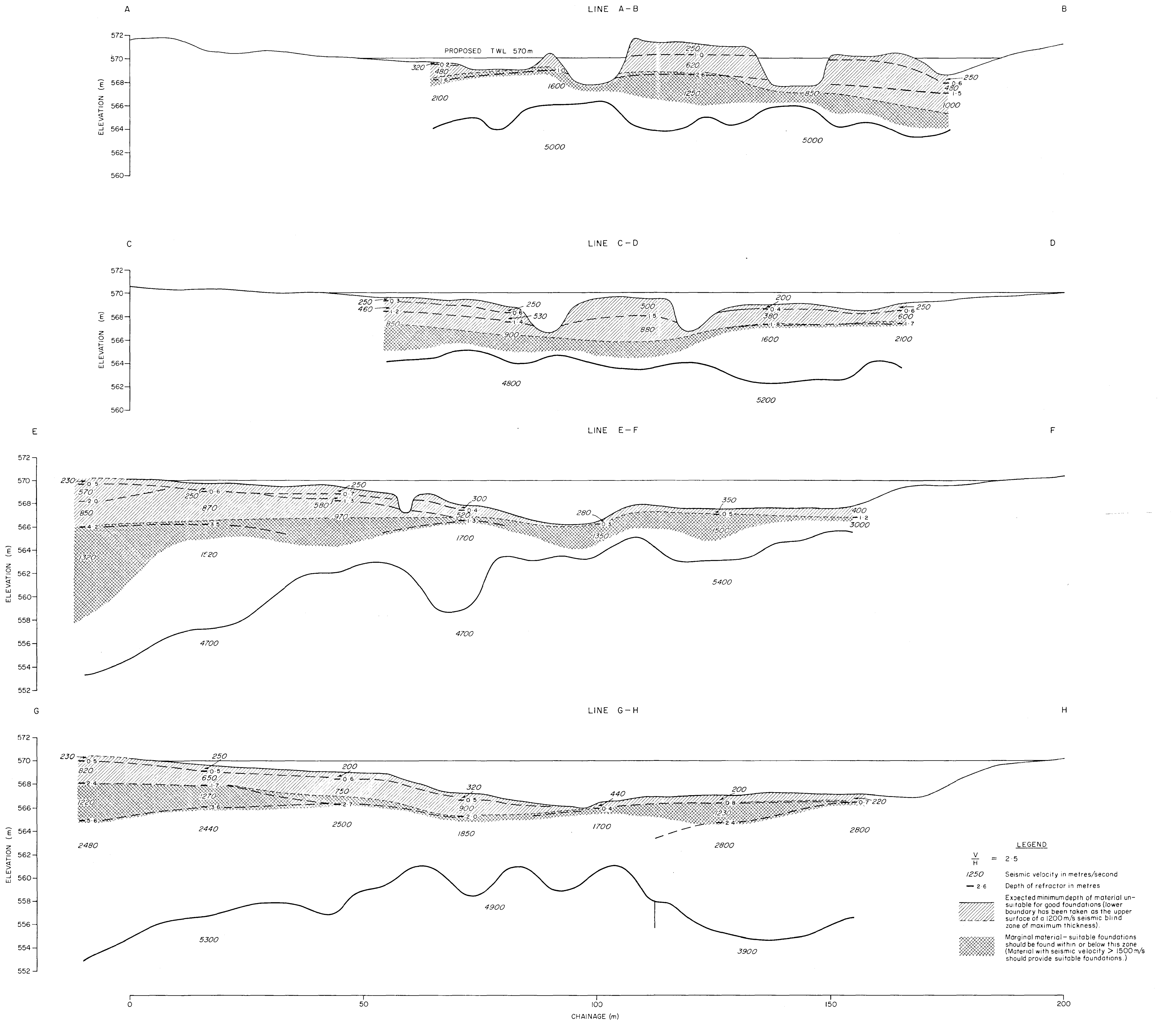
Record No. 1977/66

I55/B5-359



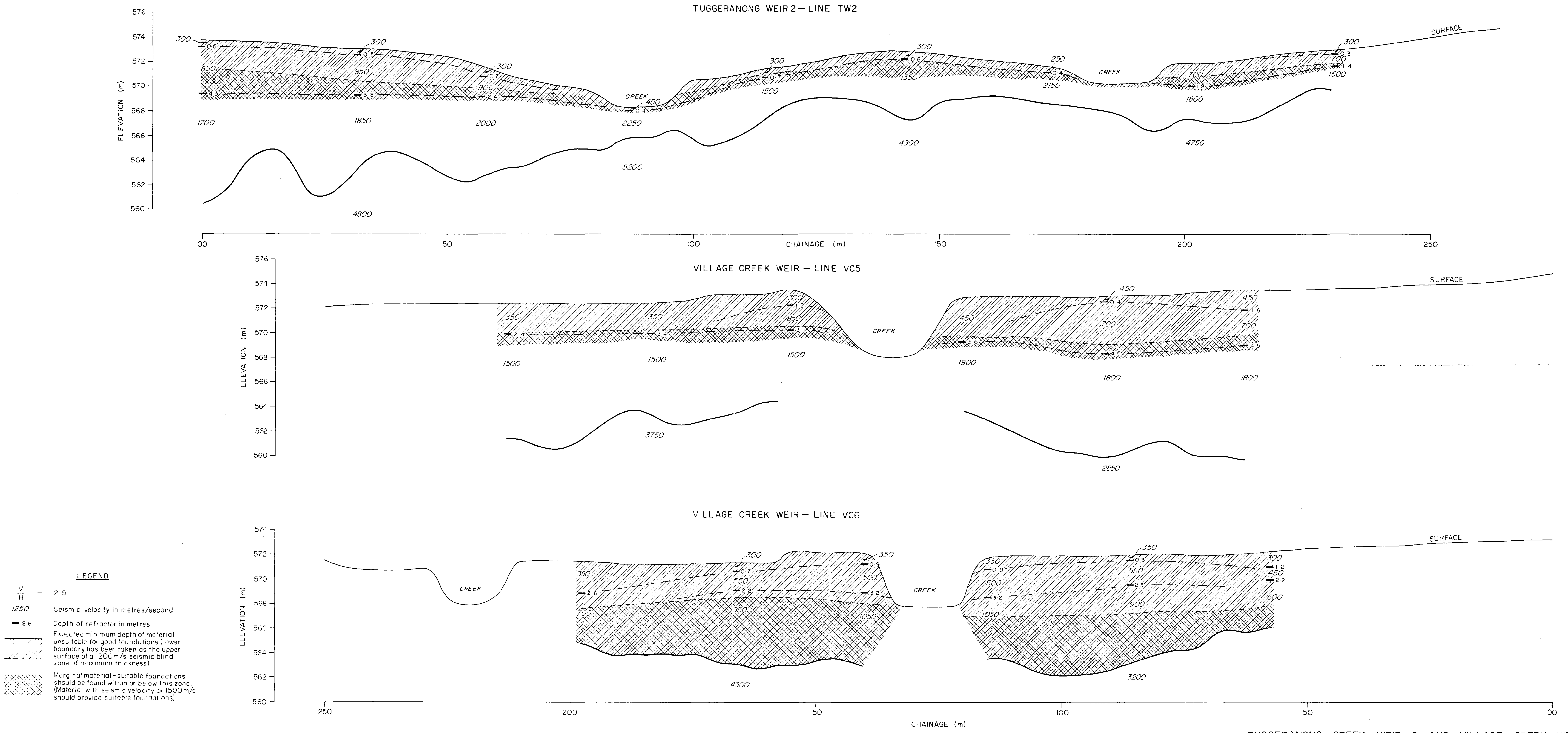
TUGGERANONG CREEK WEIR 2

SEISMIC CROSS-SECTIONS



VILLAGE CREEK WEIR

SEISMIC CROSS-SECTIONS



TUGGERANONG CREEK WEIR 2 AND VILLAGE CREEK WEIR

ADDITIONAL SEISMIC CROSS-SECTIONS

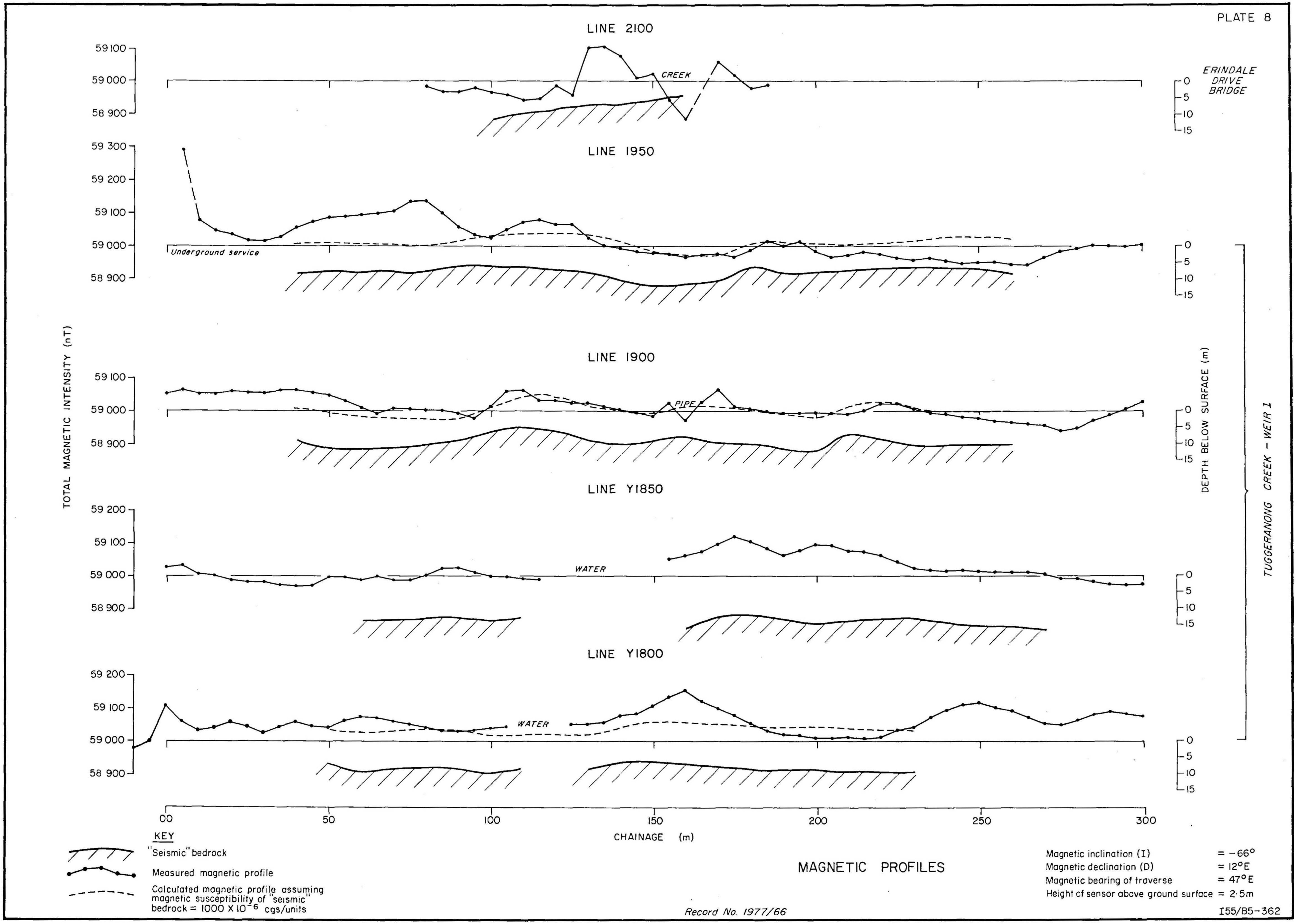


PLATE 8
LINE 2100
LINE 1950
LINE 1900
LINE Y1850
LINE Y1800
TOTAL MAGNETIC INTENSITY (nT)
59 300
59 200
59 100
59 000
58 900
CREEK
ERINDALE DRIVE BRIDGE
Underground service
PIPE
WATER
DEPTH BELOW SURFACE (m)
0
5
10
15
TUGGERANONG CREEK - WEIR 1
00
50
100
150
200
250
300
CHAINAGE (m)
KEY
"Seismic" bedrock
Measured magnetic profile
Calculated magnetic profile assuming magnetic susceptibility of "seismic" bedrock = 1000 X 10⁻⁶ cgs/units
MAGNETIC PROFILES
Magnetic inclination (I) = −66°
Magnetic declination (D) = 12°E
Magnetic bearing of traverse = 47°E
Height of sensor above ground surface = 2·5m
Record No. 1977/66
I55/B5-362