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Record 1971/60

GEOLOGICAL EVALUATION OF THE PROPOSED MUGGA SADDLE REFUSE DISPOSAL AREA, WODEN DISTRICT A.C.T.

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SUMMARY

The site for a proposed refuse disposal area at Mugga Saddle was mapped geologically and a subsurface investigation carried out. The results show that most of the area has insufficient soil* cover to allow the burial of large amounts of refuse. Where soil cover is sufficient, groundwater seepage would prevent economic working of the site. The proposed area is not suitable for refuse disposal and alternative sites are recommended.

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* The terms 'soil' and 'rock' are used in the engineering sense in this report. 'Soil is a natural aggregate of mineral grains that can be separated by such gentle mechanical means as agitation in water. Rock on the other hand is a natural aggregate of minerals connected by strong and permanent forces' (Terzaghi & Peck, 1969). Rock cannot normally be excavated by manual methods alone.

INTRODUCTION

In December 1970 the National Capital Development Commission requested the Bureau of Mineral Resources to report on the suitability of an area proposed for the disposal of refuse at Mugga Saddle, Woden District, A.C.T. The proposed site is located on the western side of Mugga Road, one and a half miles (2.5 kilometres)* from its intersection with Hindmarsh Drive (Fig. 1). The area lies downslope and to the south of Mugga Mugga Quarry.

The investigation was made in two stages: first, detailed surface geological mapping, and second, subsurface investigations including augering and seismic refraction. A base map for the investigation was compiled from a colour photo (Run 11, 9581, CAC/C14) and a topographic map (1:9,600) supplied by the National Capital Development Commission. The investigation was carried out between February and April 1971. Soil thicknesses throughout the area were estimated approximately during the course of the geological mapping. Hand-auger holes were sunk to test the depth to bedrock in areas where thin soil was expected. Subsequently several seismic traverses were carried out to test the thickness of soil in areas where thick cover was apparent. One power auger hole was sunk to test the reliability of the seismic work.

PHYSIOGRAPHY

The proposed refuse disposal area occupies a small valley flanked on the northeast and southwest sides by steep hills and on the southeast side by a low saddle. A major part of the drainage within the area occurs by seepage; surface drainage is to the north by a tributary of Yarralumla Creek which in turn flows into the Molonglo River. Erosion gullies expose bedrock in several places (Plate 1).

GENERAL GEOLOGY

Three rock units were mapped in the area; (a) Mugga Mugga Porphyry, (b) a sequence of bedded tuff, lava, shale, and siltstone (Deakin Volcanics), and (c) a toscanite welded tuff (Deakin Volcanics).

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* The Bureau commenced conversion to the metric system of measurements in 1970. British units are used in this Record but Metric equivalents are shown where appropriate: a table of conversion factors is given in Appendix 3.

Mugga Mugga Porphyry

Mugga Mugga Porphyry occurs in the northeastern part of the area (Plate 1). It is a dark mauve-grey colour and contains phenocrysts of plagioclase and quartz; it is a rhyodacite (Appendix 1, Thin section No. 71360014). The porphyry has, in many places, weathered to residual boulders that rest on jointed bedrock. Deep weathering does not usually occur because the cryptocrystalline groundmass of the porphyry is not very reactive to weathering processes. The porphyry weathers deeply in areas where it has been sheared; however, no shearing was detected within the areas mapped.

Bedded tuff, lava, shale and siltstone (Deakin Volcanics)

The sediments and associated volcanics have been mapped as a separate unit of the Deakin Volcanics. The unit occurs in the central portion of the proposed refuse disposal area and forms low outcrops almost level with the soil surface. Generally the rocks of the unit are fine-grained and yellow, purple, or green in colour. Some of the rhyodacite tuff is brecciated and silicified (Sample No. 71360015, Plate 1), possibly as a result of minor fault movement. An aphanitic rhyodacite flow (Sample No. 71360016, Plate 1) has been exposed in a trench just outside the area. A dip of 40° to the southwest was measured at an outcrop of purple bedded siltstone (Sample No. 71360017, Plate 1).

Toscanite welded tuff (Deakin Volcanics)

The toscanite, which occurs in the southwestern part of the proposed area (Plate 1), has been mapped as another unit of the Deakin Volcanics. It is a grey-green rock containing phenocrysts of quartz and plagioclase. It forms similar outcrops to the Mugga Mugga Porphyry but is distinguished from it because the plagioclase phenocrysts are labradorite (Appendix 1, Thin section No. 71360013) and the groundmass is finer grained. The groundmass is devitrified glass composed of quartz and orthoclase.

STRATIGRAPHY AND STRUCTURE

The rocks within the Canberra City area have been extensively studied by Öpik (1958) and others. The Deakin Volcanics, together with the Yarralumla Formation, form an Upper Silurian sequence of acid volcanics and sediments. Previously the Mugga Mugga Porphyry was considered to be intrusive into the Deakin Volcanics and Yarralumla Formation, but mapping within the area and petrographic evidence indicate that it could be a recrystallized welded tuff or lava flow. Petrographic evidence, such as the extremely fine grainsize of the groundmass (cryptocrystalline) and smooth outlines of the embayed phenocrysts, suggests that it may have been a flow (pers. comm., Miss B. Labonne, 1971). The Mugga Mugga Porphyry has no exposed contacts with other rocks in the area studied, but rocks quite close to the contact boundary show no signs of having undergone contact metamorphism. The porphyry is very uniform in appearance throughout the area and shows an apparent flow banding in the Blue Metal Industries Quarry a quarter of a mile (0.4 km) to the southeast. This flow banding dips at 20-30° to the southwest, and has a joint system developed at right angles to it that may have originated from contraction on cooling.

SUBSURFACE INVESTIGATIONS

HAND AUGERING

Hand auger holes (Plate 1) indicate that there is less than 4 feet of soil in the northeastern part of the area. Mugga Mugga Porphyry underlies the soil and is only slightly weathered. The augering also shows that the southern and western margins of the area do not have more than 6 feet of soil, and that the central part has a thick soil.

Hence it would only be practicable as far as soil thickness alone is concerned to use the central part of the area for refuse disposal.

SEISMIC TRAVERSES

Four seismic traverses (Plate 1) were carried out to ascertain depths to solid rock*, and the seismic velocities, of the soil and rock layers, in the central part of the area. Seismic cross-sections are shown in Figure 2, and Table 1 shows the correlation between seismic velocity ranges and corresponding layers. Definitions of terms used for weathering are given in Appendix 2.

Table 1. Correlation of seismic velocity with soil type or rock

Velocity range (ft/sec)	Layer
1100 - 1700	Topsoil, clay
2000 - 3300	Alluvial gravel, completely weathered rock
4800 - 5200	Highly weathered rock

*Solid rock is defined as rock that is either very difficult or too hard to rip.

POWER AUGERING

One power auger hole was put down along seismic traverse E-F (Plates 1) to correlate the soil layers with the seismic results. The auger intersected a foot of topsoil and 5 feet of orange-grey clay, before entering a fine alluvial sandy-gravel. The gravel is unconsolidated, and would be highly permeable since it contains no obvious clay. Highly weathered rock was encountered at 17 feet. Augered depths to gravel and rock (6 and 17 feet) corresponded closely with the seismic results (6 and 20 feet). Sub-artesian groundwater was struck at the top of the gravel layer.

ENGINEERING GEOLOGY

SOIL

Soil generally rests on highly weathered rock which retains sufficient strength and hardness to make it unrippable without expending considerable energy and time. Soil types are controlled by underlying rock types and topography as shown in Table 2.

TABLE 2. Relation of soil type to rock type and topography

	TYPE A	TYPE B	TYPE C
Description	Skeletal Soil	Hillside Colluvium	Alluvium
Occurrence	Developed on Mugga Mugga Porphyry	Developed on Toscanite welded tuff	Developed in the central basin area
Typical Vertical Section	Topsoil (1-3 feet thick)	Topsoil (1-2 feet thick)	Topsoil (1-3 feet thick)
	Slightly weathered rock	Orange-grey clay (1-4 feet thick)	Orange-grey clay (5-6 feet thick)
		Highly weathered rock	Alluvial sandy gravel (8-10 feet thick)
			Highly weathered rock

GROUNDWATER

The area tends to favour infiltration of water and a high proportion of rainfall on it drains by slow subsurface flow rather than surface run-off. Gravel below the clay horizon in the central part of the area forms a confined aquifer. Water was struck in the gravel (see 'Power augering') even though some weeks had passed since rain had fallen. Flow in the aquifer is probably maintained by leakage of pressure groundwater from joints in the underlying zone of near-surface weathering.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

(1) Three rock units have been distinguished within the proposed area.

(2) The northeastern part of the area is covered by no more than 4 feet of soil.

(3) The southern and western margins of the area are covered by no more than 6 feet of soil.

(4) The central part of the area has sufficient soil but groundwater flow would limit the use of the area for garbage disposal.

Therefore the proposed area is not suitable for the disposal of refuse using land fill methods.

RECOMMENDATIONS

Where sequences of volcanic rocks occur in the Canberra region, thick soils tend to develop on areas underlain by welded tuffs rather than porphyry; thicker soils develop where there is low relief. Where an area is not surrounded by steep hills water problems, of the type encountered in the area investigated, are less likely to be present. Alternative sites that may be suitable for refuse disposal are shown on Figure 3. It is suggested these areas be investigated if they are available, and suitable on other grounds, for garbage disposal.

REFERENCES

OPIK, A.A., 1958 - The geology of the Canberra City District. Bur. Miner. Resour. Aust. Bull. 32.

TERZAGHI, K., and PECK, R.B., 1967 - SOIL MECHANICS IN ENGINEERING PRACTICE. Wiley, N. York.

APPENDIX 1

PETROGRAPHIC DESCRIPTION OF ROCK TYPES

ROCK NAME: Toscanite welded tuff.

Registered No: 71360013 Co-ordinates: E33969 S18000

HAND SPECIMEN: Dark grey, fine grained porphyritic acid volcanic rock containing phenocrysts of quartz and feldspar.

THIN SECTION:

Optical estimate of constituents

Phenocrysts:	Approx. Percentage	Size Range (mm)	Average (mm)
Quartz	20	5.0 - 0.5	2.0
Plagioclase	10	1.0 - 0.2	0.5
Biotite	5	1.0 - 0.1	0.4
Opaques	minor	0.7 - 0.1	0.25

Groundmass: Devitrified volcanic glass much of which is potash feldspar.

Description

Quartz: Occurs as large rounded and thoroughly embayed phenocrysts and smaller more angular fragments showing straight extinction (unstrained).

Plagioclase: Typically twinned (carlsbad-albite twins) and zoned, anhedral-subhedral crystals. Composition varied from An_{55} (labradorite) to An_{35} (andesine).

Biotite: Biotite is completely altered to epidote, chlorite and opaques, but maintains its former outlines and ragged appearance.

COMMENTS: Rock consists of phenocrysts of quartz, plagioclase and biotite set in a very fine-grained groundmass of devitrified volcanic glass of acid composition. Rock is a toscanite welded tuff.

ROCK NAME: Mugga Mugga Porphyry

Registered No: 71360014 Co-ordinates: E34998 S15400

HAND SPECIMEN: Mauve-grey, prophyritic acid volcanic rock containing phenocrysts of quartz and plagioclase set in a dense glassy groundmass.

THIN SECTION:

Optical estimates of constituents

Phenocrysts:	Approx. Percentage	Size Range (mm)	Average (mm)
Quartz	15	3.0 - 0.3	1.5
Plagioclase	10	2.0 - 0.2	1.0
Biotite	5	1.0 - 0.1	0.5
Orthoclase	2		0.2

Groundmass: Consists of a cryptocrystalline aggregate which staining reveals consists mostly of potash feldspar and lesser amounts of quartz.

Accessories: Sphene, calcite, apatite, muscovite, epidote, carbonate.

Alteration: An infilling of carbonate and hematite occurs in the thin section; chlorite and sericite are extensive alteration products.

Description

Quartz: Occurs mostly as rounded and embayed phenocrysts, but smaller and more angular fragments also occur.

Plagioclase: Mostly twinned and occasionally zoned, ocurs as anhedral grains or aggregates of grains and is andesine (An_{35-40}).

Biotite: Completely altered to chlorite and iron oxide.

Orthoclase: Occurs as smaller grains (detected by staining) but most potash feldspar is restricted to the groundmass.

COMMENTS: This rock consists of phenocrysts of quartz, plagioclase, orthoclase and biotite set in a cryptocrystalline groundmass of quartz and orthoclase (staining). The nature of the groundmass suggests this rock may have been a lava flow but could have been a welded tuff.

ROCK NAME: Silicified rhyodacite tuff.

Registered No: 71360015 Co-ordinates: E34900 S16600

HAND SPECIMEN: Pale pink-white fine-grained aphanitic acid volcanic tuff which has been brecciated and silicified.

THIN SECTION:

Optical estimate of constituents

Crystals:	Approx. Percentage	Size Range (mm)	Average (mm)
Quartz	25	2.0 - 0.01	0.2

Groundmass: Cryptocrystalline devitrified volcanic glass probably consisting largely of potash feldspar.

Description

Quartz: Quartz occurs in two forms; initial primary quartz and secondary vein quartz.

Primary Quartz: Occurs as small crystal fragments fairly randomly distributed throughout the groundmass of the original tuff.

Secondary Quartz: Occurs in veins extensively dissecting the original tuff, veins have a mosaic texture with coarser grains in the centre of the vein (average 2 mm across) and markedly finer grained towards the margins. Quartz on the margins of the veins show undulose extinction.

COMMENTS: The texture of this rock is one that has undergone intense brecciation and silicification. The fracturing and silicification may be associated with a fault zone running through the area.

ROCK NAME: Rhyodacite

Registered No: 71360016 Co-ordinates: E35500 S17050

HAND SPECIMEN: Yellow-brown fine-grained tuff.

THIN SECTION:

Optical estimate of constituents

Crystals:	Approx. Percentage	Size Range (mm)	Average (mm)
Carbonate	8	0.75 - 0.25	0.5
Muscovite	minor		0.5
Quartz	minor	0.1 - 0.025	0.5
Biotite	minor	0.1 - 0.01	
Apatite	minor	0.5 - 0.01	
Zircon	minor		
Opaques	minor		

Groundmass: Cryptocrystalline devitrified volcanic glass and sericite, strongly iron stained.

Description

Calcite: Secondary, appears to have replaced a previously existing mineral.

Quartz: Angular scattered grains occur throughout the slide.

Biotite: Ragged and bent crystals, pleochroic pale grey to brown, flow elongated.

COMMENTS: The rock has been altered from its original state; however, the texture of the groundmass suggests that this rock could have originally been a very fine-grained flow-banded rhyodacite.

ROCK NAME: Quartz siltstone

Registered No: 71360017 Co-ordinates: E35850 S17350

HAND SPECIMEN: Purple-mauve fine-grained, bedded tuff.

THIN SECTION:

Optical estimate of constituents

Crystals:	Approx. Percentage	Size Range (mm)
Quartz	70	0.02 - 0.005
Muscovite	2	0.01 - 0.005
Biotite	2	0.01 - 0.005
Opaques	5	0.02 - 0.005

Accessories: Zircon, apatite and epidote.

Matrix: Appears to consist chiefly of sericite but may also contain devitrified glass.

Description

Quartz: Subangular to subrounded grains all approximately the same size. Grains are closely packed into a uniform aggregate, oblong grains are oriented parallel to micas, which also show a preferred orientation.

COMMENTS: This rock is a well sorted dominantly quartz siltstone.

APPENDIX 2

WEATHERING - DEFINITION OF TERMS

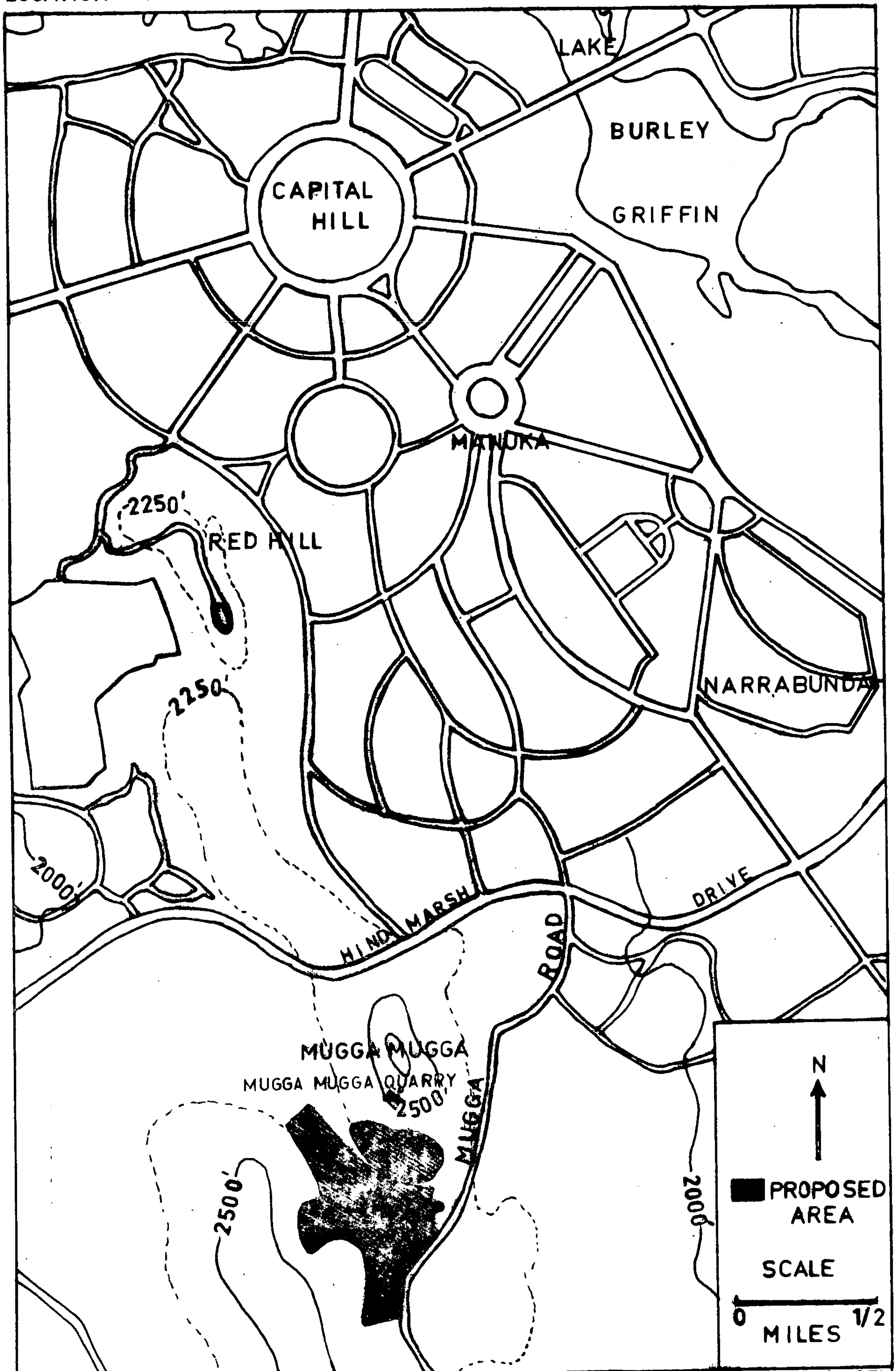
FRESH	Rock shows no discolouration or loss of strength.
SLIGHTLY WEATHERED	Rock is slightly discoloured but not noticeably weakened; a two-inch diameter drill core cannot usually be broken by hand across the rock fabric.
MODERATELY WEATHERED	Rock is discoloured and noticeably weakened, but a two-inch drill core cannot usually be broken by hand across the rock fabric; ripping by bulldozer not possible.
HIGHLY WEATHERED	Rock is usually discoloured and weakened to such an extent that a two-inch drill core can readily be broken by hand across the rock fabric. Wet strength generally lower than dry strength; ripping with bulldozer may be possible along joint planes.
COMPLETELY WEATHERED	Rock is discoloured and entirely broken down to an aggregate of particles that has the mechanical property of a soil; the original fabric of the rock is mostly preserved. The properties of the soil depend on the composition of the parent rock; easily ripped by a bulldozer.

CONVERSION FACTORS - BRITISH TO METRIC UNITS

Quantity	Imperial Unit	Metric Unit	Conversion Factors (Approximate): Imperial to Metric Units	Metric to Imperial Units
LENGTH	inch (in)	millimetre (mm) or centimetre (cm)	1 in = 25.4 mm	1 cm = 0.394 in
	foot (ft)	centimetre or metre (m)	1 ft = 30.5 cm	1 m = 3.28 ft
	yard (yd)	metre (m)	1 yd = 0.914 m	1 m = 1.00 yd
	mile	kilometre (km)	1 mile = 1.61 km	1 km = 0.021 mile
MASS	ounce (oz)	gram (g)	1 oz = 28.3 g	1 g = 0.0353 oz
	pound (lb)	gram (g) or kilogram (kg)	1 lb = 454 gm	1 kg = 2.20 lb
	ton	tonne (t)	1 ton = 1.02 tonne	1 tonne = 0.984 ton
AREA	square inch (in^2)	square centimetre (cm^2)	1 in^2 = 6.45 cm^2	1 cm^2 = 0.155 in^2
	square foot (ft^2)	square centimetre (cm^2) or square metre (m^2)	1 ft^2 = 929 cm^2	1 m^2 = 10.8 ft^2
	square yard (yd^2)	square metre (m^2)	1 yd^2 = 0.836 m^2	1 m^2 = 1.20 yd^2
	acre (ac)	hectare (ha)	1 ac = 0.405 ha	1 ha = 2.47 ac
VOLUME	cubic inch (in^3)	cubic centimetre (cm^3)	1 in^3 = 16.4 cm^3	1 cm^3 = 0.0610 in^3
	cubic foot (ft^3)	cubic decimetre (dm^3) or cubic metre (m^3)	1 ft^3 = 28.3 dm^3	1 m^3 = 35.3 ft^3
	cubic yard (yd^3)	cubic metre (m^3)	1 yd^3 = 0.765 m^3	1 m^3 = 1.31 yd^3
	bushel (bus)	cubic metre (m^3)	1 bus = 0.0364 m^3	1 m^3 = 27.5 bus
VOLUME (fluids)	fluid ounce (fl oz)	millilitre (ml)	1 fl oz = 28.4 ml	1 ml = 0.0352 fl oz
	pint (pt)	millilitre (ml) or litre (l)	1 pint = 568 ml	1 litre = 1.76 pint
	gallon (gal)	litre (l) or cubic metre (m^3)	1 gal = 4.55 litre	1 m^3 = 220 gallons
FORCE	pound-force (lbf)	newton (N)	1 lbf = 4.45 N	1 N = 0.225 lbf
PRESSURE	pound per square inch (psi)	kilopascal (kPa)	1 psi = 6.89 kPa	1 kPa = 0.145 psi
VELOCITY	mile per hour (mph)	kilometre per hour (km/h)	1 mph = 1.61 km/h	1 km/h = 0.621 mph
TEMPERATURE	Fahrenheit temp (°F)	Celsius temp (°C)	$°C = \frac{5}{9}(°F - 32)$	$°F = 9 \frac{x}{5} °C + 32$
DENSITY	pound per cubic inch (lb/in^3)	gram per cubic centimetre (g/cm^3) = tonne per cubic metre (t/m^3)	1 lb/in^3 = 27.7 t/m^3	1 t/m^3 = 0.0361 lb/in^3
	ton per cubic yard	tonne per cubic metre	1 ton/yd^3 = 1.33 t/m^3	1 t/m^3 = 0.752 ton/yd^3
ENERGY	British thermal unit (Btu)	kilojoule (kJ)	1 Btu = 1.06 kJ	1 kJ = 0.948 Btu
	therm	megajoule (MJ)	1 therm = 106 MJ	1 MJ = 9.48×10^{-3} therm
POWER	horsepower (hp)	kilowatt (kW)	1 hp = 0.746 kW	1 kW = 1.34 hp

REFERENCE: "Metric conversion for Australia". METRIC CONVERSION BOARD. Publ. Aust. Govt. Publ. Serv. Canberra. 1971.

LOCATION OF PROPOSED REFUSE DISPOSAL AREA. FIGURE 1



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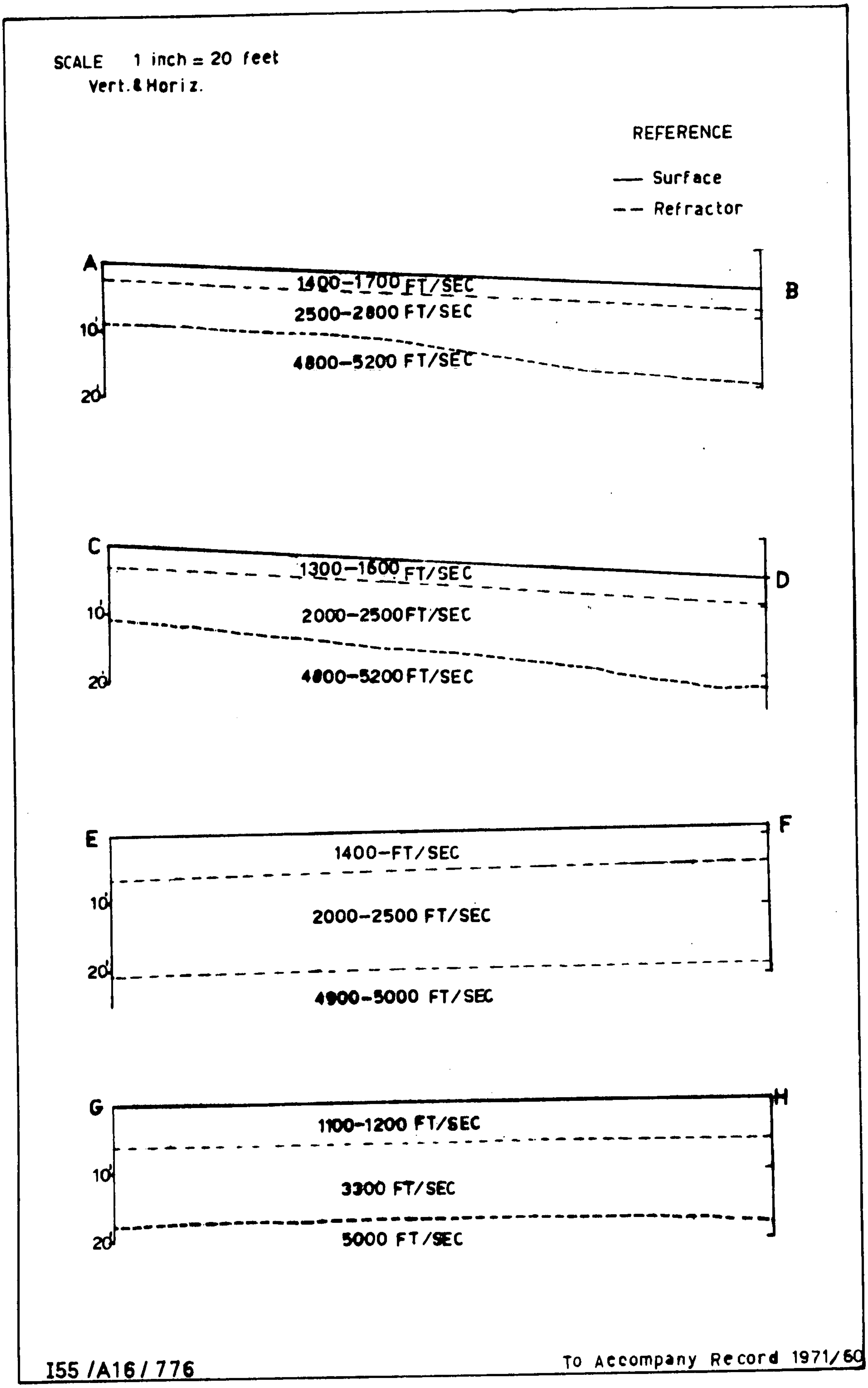
SEISMIC CROSS SECTIONS A-B, C-D, E-F AND G-H. FIGURE 2



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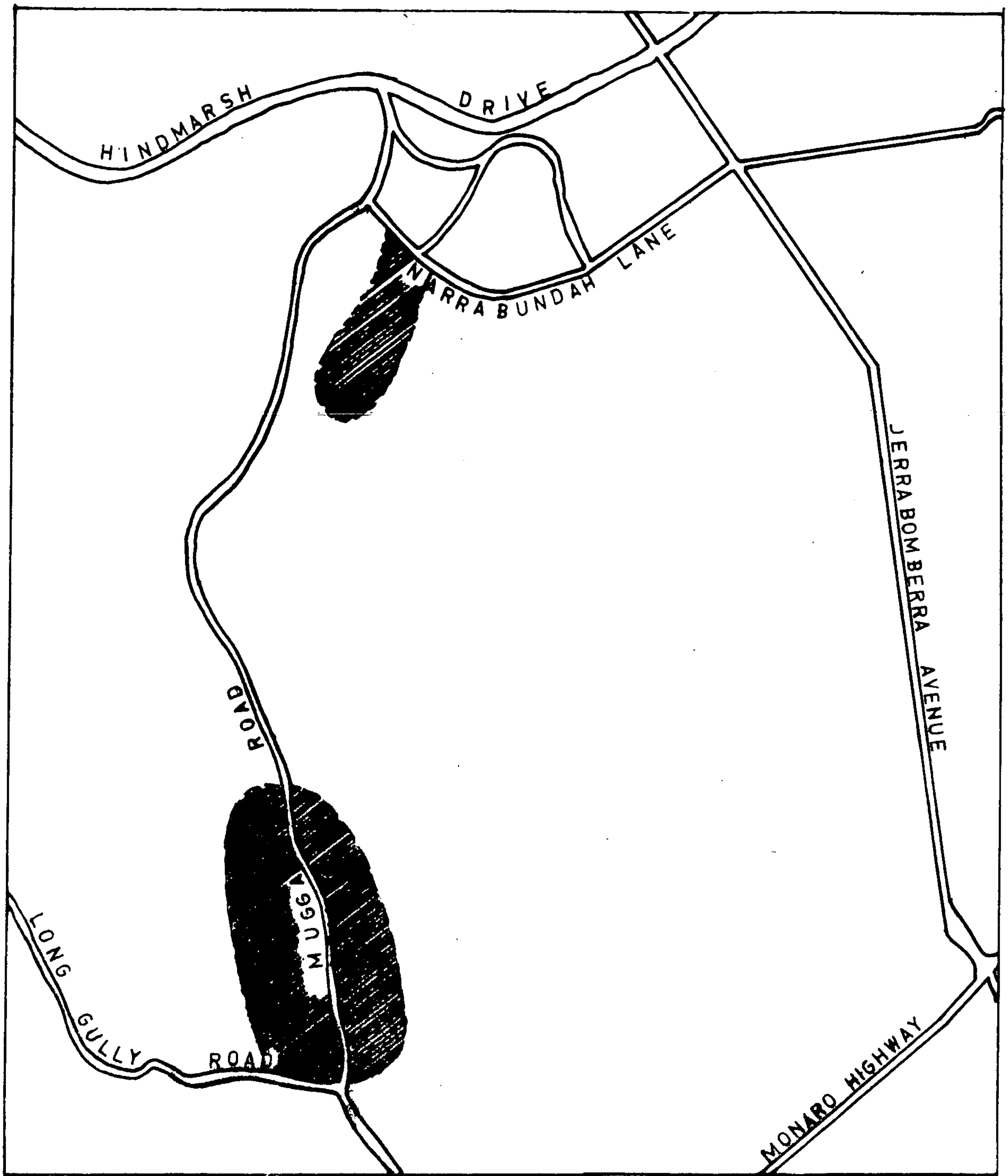
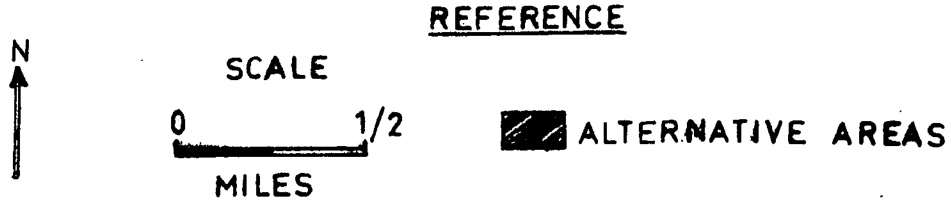
ALTERNATIVE SITES FOR A REFUSE DISPOSAL AREA FIGURE 3.



REFERENCE



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PROPOSED REFUSE DISPOSAL AREA, MUGGA SADDLE, A.C.T. GEOLOGICAL MAP. PLATE 1