START

U.R. 1982/77

P. DAHLHAUS

U.R. 1982/77

ENGINEERING GEOLOGICAL INVESTIGATION OF PROPOSED CEMETERY SITE AT BUNDOORA

BY

P DAHLHAUS

UNPUBLISHED REPORT 1982/77

CONTENTS

ABSTRACT

An engineering geological investigation has been carried out on the proposed cemetery site at Bundoora.

A geological survey was made to assess the suitability of the site, followed by a geophysical survey to determine soil thickness over the cemetery area. Trial excavations were then carried out to provide a lithological correlation and reveal excavational problems.

The site is a marginal proposition for development as a cemetery as the soil cover is insufficient to allow the burial of two coffins in most areas. Alternative excavation techniques involving the use of heavier machinery and the possible creation of filled land would increase the area over which the required depths can be achieved.

INTRODUCTION

Following a request by the Health Commission of Victoria, Public Health Division, investigational works have been carried out at the site for a proposed cemetery at Bundoora, Victoria.

The area examined is south and west of the Plenty River and north of the Maroondah Aqueduct, and comprises the eastern section of the Janefield Colony.

A general reconnaissance survey was carried out to locate the proposed boundaries of the cemetery and to determine the geology of the rocks and soils of the area. This was followed by detailed geophysical work and trial excavations to determine the suitability of the site for burial purposes.

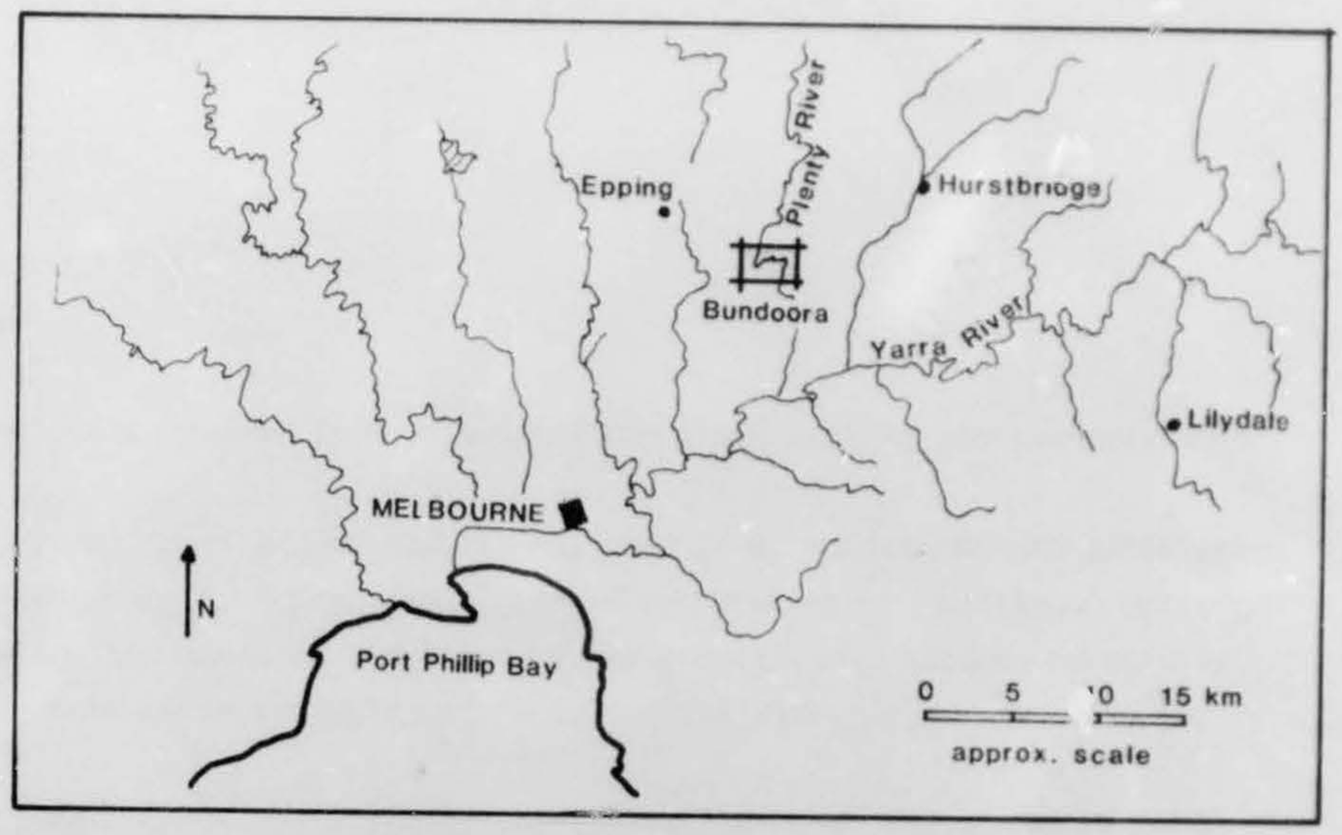
SITE LOCATION AND TERRAIN

The area is situated approximately 19 km N.N.E. of Melbourne in the Parish of Keelbundoora. It is bounded by the Plenty River to the north and east, the Maroondah Aqueduct to the south an an unnamed tributary to the west. (See Fig.1). The site covers approximately 97 ha of which 50 ha is cleared pasture-land, with the remainder being moderately to densely timbered.

The site is undulating with the hill crests being 105m above sea level, dropping 40 m to the Plenty River. Approximately 60% of the site (59 ha) is regarded as topographically suitable for the proposed cemetery, the remainder being considered too steep.

Good drainage is provided by the Plenty River and two minor intermittent tributaries. One of these tributaries forms the western boundary of the site, the other drains the centre of the area. This central drainage is provided by a subsurface concrete drain extending from the southern boundary of the site to the edge of the cleared area, where it feeds into the natural creek. The drain caters for the storm water drainage requirements of the adjacent residential area.

The details of the site are shown in Figs. 1 and 2.



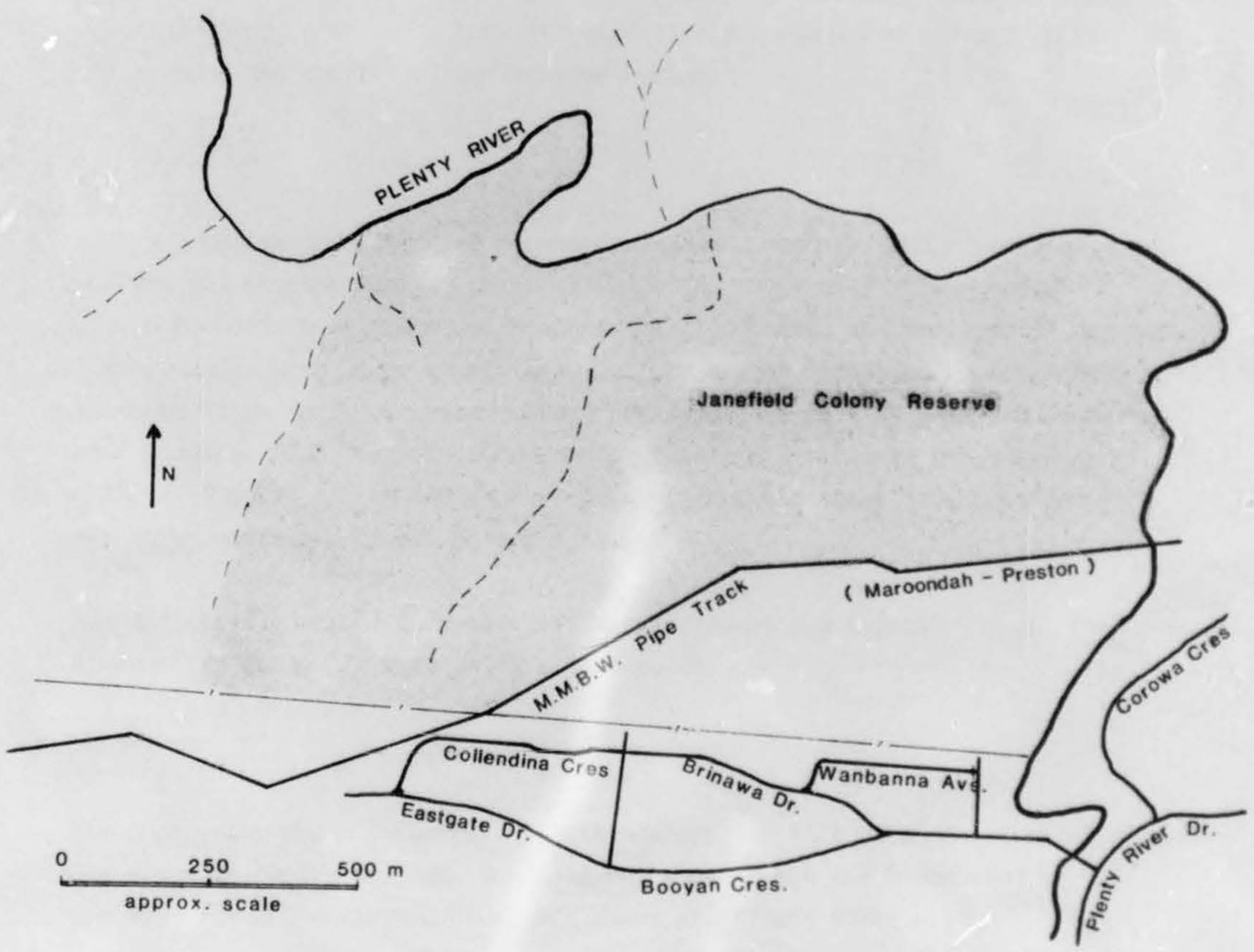


Fig. 1 LOCATION SKETCH PLAN

SITE GEOLOGY

Silurian

Residual soils derived from Silurian rocks cover most of the cemetery site.

Bedrock consists of bedded claystones, mudstones, siltstones and sandstones which are typically folded, well jointed and show minor faulting. Outcrops occur along the sides of the Plenty River and its tributaries, as well as in small patches in the west and centre of the site.

The derived subsoil is typically mottled yellow-brown and orange, moderately plastic, silty clay while the topsoil is generally brownish, friable, silty clays or clayey silts; both the subsoil and topsoil are classified as CL soils on the unified Classification system.

Tertiary

Tertiary sediments comprising cemented sands and gravels occur in the eastern and extreme western parts of the site. Typically, they consist of sub-rounded, poorly sorted, compact, mottled orange and red, medium grained, clayey sands, with minor quartz gravels. Layers of ironstone approximately 30 mm to 70 mm thick occur throughout the sands, as well as some iron cemented sand nodules. The Tertiary sands and gravels are visible in two small disused sand pits, one on the western boundary and the other just outside the south eastern boundary of the site.

Residual soils derived from the Tertiary sediments are typically thin dark brown silty sandy clays to silty clayey sands.

Quaternary

The Quaternary deposits comprise Pleistocene Newer Volcanics and river alluvium. The Newer Volcanics outcrop as basalt outliers to the north and east of the site forming a ridge of boulders above the Plenty River.

The river alluvium typically comprises sand, silt and gravel deposits along the incised meanders of the Plenty River.

The site geology is shown in Fig.2.

INVESTIGATION PROGRAME

Geophysical Survey

A Refraction Seismic Survey was carried out using a "Bison" model 1570B Signal Enhancement Seismograph. A total of 64 reversed seismic lines were surveyed to determine the depth of soil and weathering. The topography determined the location of traverses, as the Refraction Seismic method produces erroneous results over steep slopes. The optimum length of the seismic lines for efficient surveying was 30 m, thus producing spot-depths at 30 m intervals along the traverses. (Fig.2).

Trial Excavations

A total of 24 trial excavations were carried out using a Massey Ferguson 212 Backhoe, with 660 mm bucket. The backhoe and operator were supplied from the Fawkner Crematorium and Memorial Park. The excavations were carried out to determine the ease or otherwise of excavation and to examine any specific problems that may make the area unsuitable for burial purposes.

The test pits were located to determine the following two factors :-

. Correlation with the geophysical work.
. The nature of the areas either not covered by the geophysical survey or that of areas where the geophysical work produced meaningless results.

The test pit locations are shown in Figure 2.

RESULTS AND DISCUSSION

Geophysics

The refraction seismic survey gave meaningful results only in the area covered by the residual soils of the Silurian rocks. The Tertiary sands produced erratic results, probably due to the thinness of the soil cover and the presence of the ironstone bands.

Typical seismic profiles showed residual soils overlying weathered rock with a transition down to fresh rock. The range of seismic velocities were :

i) Soil - 360 m/s to 450 m/s;
ii) Weathered rock - 450 m/s to around 2000 m/s;
iii) Fresh rock - around 2000 m/s up to 3500 m/s.

Trial Excavation

Trial excavations on the seismic traverses indicated that the material not able to be excavated by the backhoe had seismic velocities in excess of 800 m/s. Correlation between lithologies and seismic profiles showed that the claystone/mudstone/siltstone beds had velocities of 1000 m/s to 1500 m/s while the sandstone beds had higher velocities. The calculated depths of material able to be excavated varied from 0.7 m to 5.0 m, with most of the results being less that 1.6 m.

The trial excavations showed that the ability of the backhoe to excavate the weathered material depended largely on the attitude of the beds. Excavations "across reef" (or at right angles to the strike), generally achieved a greater-than-calculated depth, with the backhoe excavating 200 mm to 300 mm deeper than expected from the seismic profiles, although with considerable difficulty. However, as the estimates cannot take into account the attitude of the beds (which is often unknown), the depths shown in Figure 2 refer to the depth of material with calculated seismic velocities greater than 800 m/s. From reverse seismic profiling at each location, these estimates are considered to be correct to within 0.2 metres.

Excavations in the north western region of the site proved the easiest because of the thickness of residual clay in the area, while those in the south western corner of the site achieved greater than average depth because of the extent of the weathering of Silurian sediments. The backhoe was generally unable to excavate to a satisfactory depth in the Tertiary sands with refusal occurring either on the ironstone bands or because of the density of the material.

Excavation logs are attached in Appendix I; and relevant locations are shown in Figure 2.

Discussion with the backhoe operator disclosed the following specific excavational problems that may be encountered in grave digging :

a) wall collapse between the grave being excavated and the adjacent existing grave;
b) fetid groundwater seepage into the excavation, from adjacent graves;
c) creation of a neat hole;

d) having to timber the sides of the excavation due to lack of cohesion of the soil;
e) having suitable machinery access.

With regard to the Bundoora site, the soil and weathered rock is considered cohesive enough to minimise the dangers of wall collapse within normal excavational practise. Timbering of the excavations would not be considered necessary.

The natural water table in the proposed cemetery site is at depth and would not constitute any problems. However, infiltration of surface water into existing graves could result in seepage into adjacent excavations (e.g. along the joint planes of the weathered rock), although the excellent surface drainage should minimise this problem under normal climatic conditions.

Problems with machinery access could be dealt with in the planning stages of the cemetery.

CONCLUSION

Based on the minimum requirements stipulated by the Health Commission for burial purposes (Fig.3), the site is a marginal proposition for cemetery development. Many of the trial excavations did not reach the required minimum depth for the burial of two coffins and some failed to achieve the minimum depth required for the burial of one coffin. The seismic work indicates that most of the site follows the same pattern.

Alternative excavation techniques such as jackhammering and blasting would increase the depth achieved, but at considerable added cost. Larger excavators would also increase the depths of the excavations, for example the large "Kato" backhoes' which can be fitted with compressed air operated rock breakers. However, with such machinery, access and cost would become formidable problems.

Another possible way of achieving greater depth would be to use excess grave-site backfill material as compacted landfill. Although the types of material would compact well with moderate compactive effort, some settlement can be expected with time and this may cause problems with the monumental works.

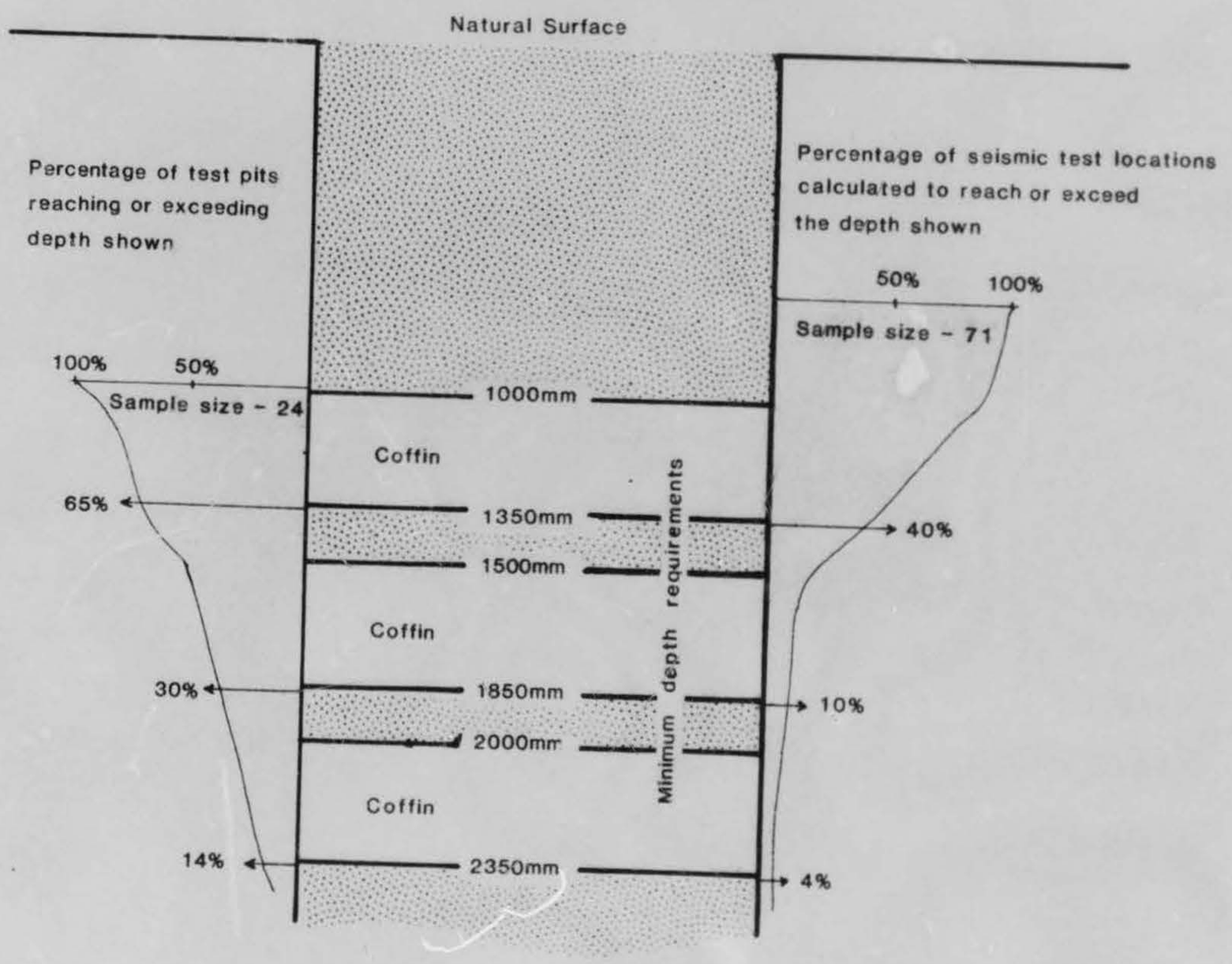


Fig. 3 Minimum Requirements for Burial

and percentage of test sites achieving the depths shown

APPENDIX I

EXCAVATION LOGS

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora

	One	Two	Three	Four
NUMBER	One	Two	Three	Four
LOCATION	S.W. Corner of site	S.W. region of site	Central S.W. of site	S.W. region of site
DEPTH mm				
200	Pale brown grey friable clayey SILT	Pale brown friable clayey SILT	Pale brown friable clayey SILT	Dark brownish grey, friable silty CLAY
400	Mottled orange-red-grey, stiff, moist silty CLAY	Yellow-brown, stiff to very stiff silty CLAY	Mottled orange-brown-red, stiff to very stiff, silty CLAY	Yellow brown very stiff silty CLAY
600				
800				Pinkish red, fine grained slightly weathered SANDSTONE
1000	Pale yellow extremely weathered MUDSTONE		Reddish brown extremely weathered MUDSTONE	Backhoe refusal.
1200		Greyish white, extremely weathered SILTSTONE.		
1400	Brownish red, moderately to highly weathered fine-grained SANDSTONE	Easily excavated by backhoe. Some clay filled joints throughout.	Pinkish red, fine grained slightly weathered SANDSTONE	
1600	Some clay interbeds at 1400 mm & 1650 mm		Very difficult to excavate	
1800				
2000	Slightly weathered SANDSTONE	Greyish white, moderately weathered SILTSTONE.	Backhoe refusal	
2200	Backhoe refused.	Excavated with moderate difficulty, well jointed.		
2400				
2600				
2800		Limit of backhoe - end of pit		
3000				
	LOGGED BY PdS	**DATE** 8-9-'82	**MACHINE** Massey Ferguson 212 Backhoe - 660 mm bucket	

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora

	Five	Six	Seven	Eight
NUMBER	Five	Six	Seven	Eight
LOCATION	N.W. region of site	NW region of site	N.W. region of site	Central North region of site
DEPTH mm				
200	Dark grey friable silty CLAY	Pale brown SILT, with minor gravel	Pale brown, dry, silty, medium grained SAND	Dark brown silty CLAY
400	Mottled orange-brown & red, stiff to very stiff, silty CLAY	Orange brown, very stiff, silty CLAY. Some angular, gravel size rock throughout.	Pale brown, moderately compact, well rounded, silty, sandy GRAVEL	Blocky, orange-brown, very stiff, silty, CLAY
600			Mottled grey, red & orange, well compacted, clayey SAND. Some well rounded quartz and quartzite gravel. Very diff. cult to excavate	Mottled orange-brown-red, stiff to very stiff, silty CLAY
800				
1000	Dark pinkish red fine grained SANDSTONE			Mottled pinkish-red & orange-brown extremely weathered MUDSTONE
1200	Backhoe refused	Orange brown extremely weathered MUDSTONE.	Backhoe refused	Dips 40°
1400				White, moderately weathered, well jointed SILTSTONE
1600		Greyish white moderately weathered MUDSTONE Joints heavily stained.		
1800				Backhoe refused.
2000		Dark pinkish red fine g... STONE		
2200		Backhoe refused.		
2400				
2600				
2800				
3000				
	LOGGED BY PCJ	**DATE** 8-9-'82	**MACHINE** Massey Ferguson Backhoe 212 - 660mm bucket.	

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora.

	Nine	Ten	Eleven	Twelve
NUMBER	Nine	Ten	Eleven	Twelve
LOCATION	North central region of site	N.W. region of site	Central western region of site	Central eastern region of site.
DEPTH mm				

Nine

- 0–200: Pale brown sandy silty CLAY
- 200–800: Yellow-brown, very stiff, silty CLAY
- 800–1800: Greyish-brown extremely weathered MUDSTONE
- 1800–2400: Brown, moderately weathered MUDSTONE. Many clay-filled joints throughout
- 2400–3000: Limit of Backhoe, end of pit

Ten

- 0–200: Pale brown, silty sandy ("Buckshot") GRAVEL
- 200–1800: Yellow-brown, very stiff silty CLAY
- 1800–2800: Yellow brown extremely weathered MUDSTONE
- 2800–3000: Yellow brown moderately weathered MUDSTONE. Many clay filled joints throughout
- End of excavation.

Eleven

- 0–200: Dark brown silty CLAY
- 200–1800: Orange brown, very stiff, silty CLAY
- 1800–3000: Yellow brown moderately weathered MUDSTONE. Many clay filled joints throughout.
- Backhoe refused.

Twelve

- 0–200: Dark brown, friable moist sandy, silty CLAY
- 200–1400: Mottled red-orange clayey SAND to sandy CLAY. Very dense and difficult to excavate
- 1400–1600: Greyish white, very stiff CLAY
- 1600–1800: Mottled red orange sandy CLAY. Difficult to excavate
- 1800–2000: Ironstone band
- 2000–2200: Mottled red-orange clayey SAND very dense
- Backhoe refused, ironstone

LOGGED BY PEJ

DATE 8-9-'82 (Nos 9-11) 9-9-'82 (No 12)

MACHINE Massey Ferguson 212 Backhoe - 660mm bucket.

EXCAVATION LOG

PROJECT Proposed Cemetery at Bundoora

	Thirteen	Fourteen	Fifteen	Sixteen
NUMBER				
LOCATION	Eastern region of site	Eastern region of site	Eastern region of site	North Eastern region of site
DEPTH mm				
200	Dark brown sandy CLAY	Pale brown silty SAND	Dark brown clayey SAND	Dark brown, blocky, silty CLAY
400	Pale brown, moderately compact medium grained, silty SAND	Large slabs of IRONSTONE throughout.	Pale brown, friable, moist, sandy CLAY to clayey SAND	Mottled yellow & brown, very stiff to hard, silty CLAY
600		Mottled red & orange, very dense, clayey SAND.		
800	Mottled red & orange, very dense, clayey SAND	Some discontinuous ironstone bands and iron cemented nodules.	Mottled red & orange, very dense, clayey SAND	Brownish white extremely weathered, well jointed MUDSTONE
1000	Backhoe refused	Very difficult to excavate.	Very difficult to excavate	Brownish white, moderately weathered MUDSTONE
1200				
1400				Backhoe refused.
1600		Backhoe refused	Backhoe refused	
1800				
2000				
2200				
2400				
2600				
2800				
3000				
	LOGGED BY PEJ	**DATE** 9-9-'82	**MACHINE** Massey Ferguson 212 Backhoe - 660mm Bucket.	

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora

	Seventeen	Eighteen	Nineteen	Twenty
NUMBER				
LOCATION	S.E. region of site	Central eastern region of site	central region of site	N.E. region of site.
DEPTH mm				

Seventeen (S.E. region of site)

200 — Dark brown slightly sandy silty CLAY

400 — Mottled brown-red & orange stiff, slightly sandy silty CLAY

600

800

1000 — Greyish white sandy CLAY to clayey fine grained SAND

1200

1400 — Ironstone

1600 — Mottled orange brown & red stiff sandy CLAY

1800

2000

2200

2400 — Backhoe refusal, Ironstone

2600

2800

3000

Eighteen (Central eastern region of site)

Dark brown to orange brown, friable, becomes stiff, silty CLAY with sub-angular COBBLES & BOULDERS. Very difficult to excavate

Greyish white moderately weathered SILTSTONE/MUDSTONE interbeds. Relatively easily excavated. becomes harder

Backhoe refused

Nineteen (central region of site)

Pale grey brown clayey SILT

Pale grey-orange, stiff, silty CLAY

Mottled red & orange very stiff silty CLAY

Pale brown, moderately weathered, fine grained SANDSTONE. Excavated "across reef" with difficulty.

Backhoe refused.

Twenty (N.E. region of site.)

Dark brown, blocky, hard, silty CLAY

Mottled orange & grey stiff to very stiff silty CLAY

Succession of vertically dipping brown MUDSTONE & SANDSTONE and greyish white SILTSTONE

Backhoe refused.

LOGGED BY PEB **DATE** 9-9-82 **MACHINE** Massey Ferguson 212 Backhoe - 660mm bucket

EXCAVATION LOG

PROJECT Proposed Cemetery at Bundoora.

	Twenty One	Twenty Two	Twenty Three	Twenty Four
NUMBER				
LOCATION	SE region of site	Central south region of site	Central south region of site	Central region of site
DEPTH mm				
200	Brown, blocky, silty CLAY	Dark brown, blocky, hard, silty CLAY	Pale brown, sandy silty CLAY	Dark brown silty CLAY
400	Mottled brown & grey very stiff silty CLAY	Mottled red & orange blocky very stiff silty CLAY	Mottled red & orange very stiff silty CLAY	Mottled red & orange, stiff to very stiff, silty CLAY
600				
800				Greyish white, extremely weathered, SILTSTONE
1000		Brown, moderately weathered, MUDSTONE. Excavated with difficulty along joints.	Pinkish brown moderately weathered MUDSTONE	Pale grey, moderately weathered MUDSTONE.
1200	Brownish grey, moderately weathered MUDSTONE			
1400	Backhoe refused	Backhoe refused	Backhoe refused	Brown, moderately weathered, fine grained SANDSTONE Excavated with much difficulty.
1600				
1800				
2000				Backhoe refused.
2200				
2400				
2600				
2800				
3000				
	LOGGED BY PET	**DATE** 9-9-'82	**MACHINE** Massey Ferguson 212 Backhoe - 660mm Bucket	

START

U.R. 1982/77

P. DAHLHAUS

U.R. 1982/77

ENGINEERING GEOLOGICAL INVESTIGATION OF PROPOSED CEMETERY SITE AT BUNDOORA

BY

P. DAHLHAUS

UNPUBLISHED REPORT 1982/77

CONTENTS

ABSTRACT

An engineering geological investigation has been carried out on the proposed cemetery site at Bundoora.

A geological survey was made to assess the suitability of the site, followed by a geophysical survey to determine soil thickness over the cemetery area. Trial excavations were then carried out to provide a lithological correlation and reveal excavational problems.

The site is a marginal proposition for development as a cemetery as the soil cover is insufficient to allow the burial of two coffins in most areas. Alternative excavation techniques involving the use of heavier machinery and the possible creation of filled land would increase the area over which the required depths can be achieved.

INTRODUCTION

Following a request by the Health Commission of Victoria, Public Health Division, investigational works have been carried out at the site for a proposed cemetery at Bundoora, Victoria.

The area examined is south and west of the Plenty River and north of the Maroondah Aqueduct, and comprises the eastern section of the Janefield Colony.

A general reconnaissance survey was carried out to locate the proposed boundaries of the cemetery and to determine the geology of the rocks and soils of the area. This was followed by detailed geophysical work and trial excavations to determine the suitability of the site for burial purposes.

SITE LOCATION AND TERRAIN

The area is situated approximately 19 km N.N.E. of Melbourne in the Parish of Keelbundoora. It is bounded by the Plenty River to the north and east, the Maroondah Aqueduct to the south an an unnamed tributary to the west. (See Fig.1). The site covers approximately 97 ha of which 50 ha is cleared pasture-land, with the remainder being moderately to densely timbered.

The site is undulating with the hill crests being 105m above sea level, dropping 40 m to the Plenty River. Approximately 60% of the site (59 ha) is regarded as topographically suitable for the proposed cemetery, the remainder being considered too steep.

Good drainage is provided by the Plenty River and two minor intermittent tributaries. One of these tributaries forms the western boundary of the site, the other drains the centre of the area. This central drainage is provided by a subsurface concrete drain extending from the southern boundary of the site to the edge of the cleared area, where it feeds into the natural creek. The drain caters for the storm water drainage requirements of the adjacent residential area.

The details of the site are shown in Figs. 1 and 2.

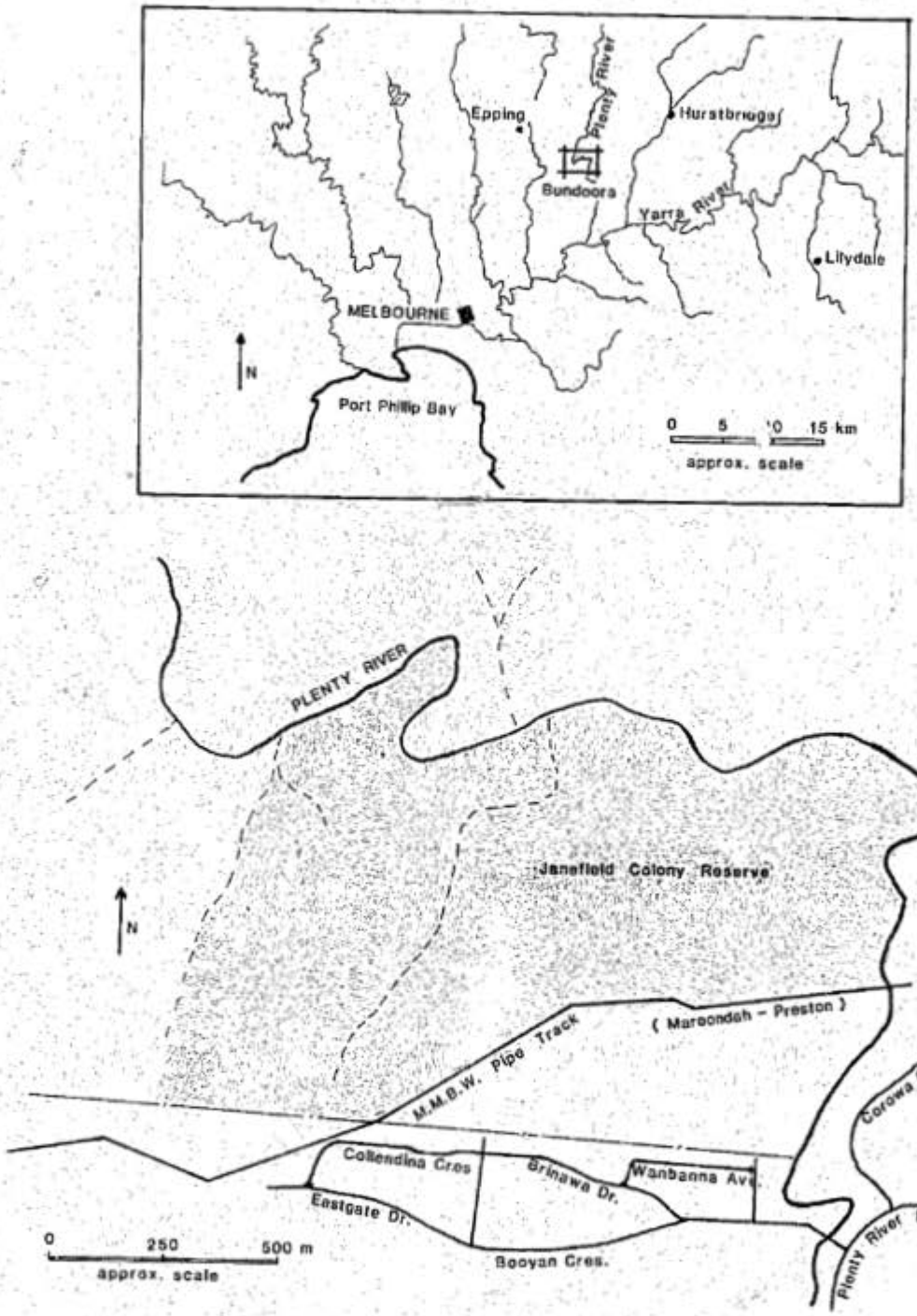


Fig. 1 LOCATION SKETCH PLAN

SITE GEOLOGY

Silurian

Residual soils derived from Silurian rocks cover most of the cemetery site.

Bedrock consists of bedded claystones, mudstones, siltstones and sandstones which are typically folded, well jointed and show minor faulting. Outcrops occur along the sides of the Plenty River and its tributaries, as well as in small patches in the west and centre of the site.

The derived subsoil is typically mottled yellow-brown and orange, moderately plastic, silty clay while the topsoil is generally brownish, friable, silty clays or clayey silts; both the subsoil and topsoil are classified as CL soils on the unified Classification system.

Tertiary

Tertiary sediments comprising cemented sands and gravels occur in the eastern and extreme western parts of the site. Typically, they consist of sub-rounded, poorly sorted, compact, mottled orange and red, medium grained, clayey sands, with minor quartz gravels. Layers of ironstone approximately 30 mm to 70 mm thick occur throughout the sands, as well as some iron cemented sand nodules. The Tertiary sands and gravels are visible in two small disused sand pits, one on the western boundary and the other just outside the south eastern boundary of the site.

Residual soils derived from the Tertiary sediments are typically thin dark brown silty sandy clays to silty clayey sands.

Quaternary

The Quaternary deposits comprise Pleistocene Newer Volcanics and river alluvium. The Newer Volcanics outcrop as basalt outliers to the north and east of the site forming a ridge of boulders above the Plenty River.

The river alluvium typically comprises sand, silt and gravel deposits along the incised meanders of the Plenty River.

The site geology is shown in Fig.2.

INVESTIGATION PROGRAME

Geophysical Survey

A Refraction Seismic Survey was carried out using a "Bison" model 1570B Signal Enhancement Seismograph. A total of 64 reversed seismic lines were surveyed to determine the depth of soil and weathering. The topography determined the location of traverses, as the Refraction Seismic method produces erroneous results over steep slopes. The optimum length of the seismic lines for efficient surveying was 30 m, thus producing spot-depths at 30 m intervals along the traverses. (Fig.2).

Trial Excavations

A total of 24 trial excavations were carried out using a Massey Perguson 212 Backhoe, with 660 mm bucket. The backhoe and operator were supplied from the Fawkner Crematorium and Memorial Park. The excavations were carried out to determine the ease or otherwise of excavation and to examine any specific problems that may make the area unsuitable for burial purposes.

The test pits were located to determine the following two factors :-

. Correlation with the geophysical work.
. The nature of the areas either not covered by the geophysical survey or that of areas where the geophysical work produced meaningless results.

The test pit locations are shown in Figure 2.

RESULTS AND DISCUSSION

Geophysics

The refraction seismic survey gave meaningful results only in the area covered by the residual soils of the Silurian rocks. The Tertiary sands produced erratic results, probably due to the thinness of the soil cover and the presence of the ironstone bands.

Typical seismic profiles showed residual soils overlying weathered rock with a transition down to fresh rock. The range of seismic velocities were :

i) Soil - 360 m/s to 450 m/s;
ii) Weathered rock - 450 m/s to around 2000 m/s;
iii) Fresh rock - around 2000 m/s up to 3500 m/s.

Trial Excavation

Trial excavations on the seismic traverses indicated that the material not able to be excavated by the backhoe had seismic velocities in excess of 800 m/s. Correlation between lithologies and seismic profiles showed that the claystone/mudstone/siltstone beds had velocities of 1000 m/s to 1500 m/s while the sandstone beds had higher velocities. The calculated depths of material able to be excavated varied from 0.7 m to 5.0 m, with most of the results being less that 1.6 m.

The trial excavations showed that the ability of the backhoe to excavate the weathered material depended largely on the attitude of the beds. Excavations "across reef" (or at right angles to the strike), generally achieved a greater-than-calculated depth, with the backhoe excavating 200 mm to 300 mm deeper than expected from the seismic profiles, although with considerable difficulty. However, as the estimates cannot take into account the attitude of the beds (which is often unknown), the depths shown in Figure 2 refer to the depth of material with calculated seismic velocities greater than 800 m/s. From reverse seismic profiling at each location, these estimates are considered to be correct to within 0.2 metres.

Excavations in the north western region of the site proved the easiest because of the thickness of residual clay in the area, while those in the south western corner of the site achieved greater than average depth because of the extent of the weathering of Silurian sediments. The backhoe was generally unable to excavate to a satisfactory depth in the Tertiary sands with refusal occurring either on the ironstone bands or because of the density of the material.

Excavation logs are attached in Appendix I; and relevant locations are shown in Figure 2.

Discussion with the backhoe operator disclosed the following specific excavational problems that may be encountered in grave digging :

a) wall collapse between the grave being excavated and the adjacent existing grave;
b) fetid groundwater seepage into the excavation, from adjacent graves;
c) creation of a neat hole;

d) having to timber the sides of the excavation due to lack of cohesion of the soil;
e) having suitable machinery access.

With regard to the Bundoora site, the soil and weathered rock is considered cohesive enough to minimise the dangers of wall collapse within normal excavational practise. Timbering of the excavations would not be considered necessary.

The natural water table in the proposed cemetery site is at depth and would not constitute any problems. However, infiltration of surface water into existing graves could result in seepage into adjacent excavations (e.g. along the joint planes of the weathered rock), although the excellent surface drainage should minimise this problem under normal climatic conditions.

Problems with machinery access could be dealt with in the planning stages of the cemetery.

CONCLUSION

Based on the minimum requirements stipulated by the Health Commission for burial purposes (Fig.3), the site is a marginal proposition for cemetery development. Many of the trial excavations did not reach the required minimum depth for the burial of two coffins and some failed to achieve the minimum depth required for the burial of one coffin. The seismic work indicates that most of the site follows the same pattern.

Alternative excavation techniques such as jackhammering and blasting would increase the depth achieved, but at considerable added cost. Larger excavators would also increase the depths of the excavations, for example the large "Kato" backhoes' which can be fitted with compressed air operated rock breakers. However, with such machinery, access and cost would become formidable problems.

Another possible way of achieving greater depth would be to use excess gravesite backfill material as compacted landfill. Although the types of material would compact well with moderate compactive effort, some settlement can be expected with time and this may cause problems with the monumental works.

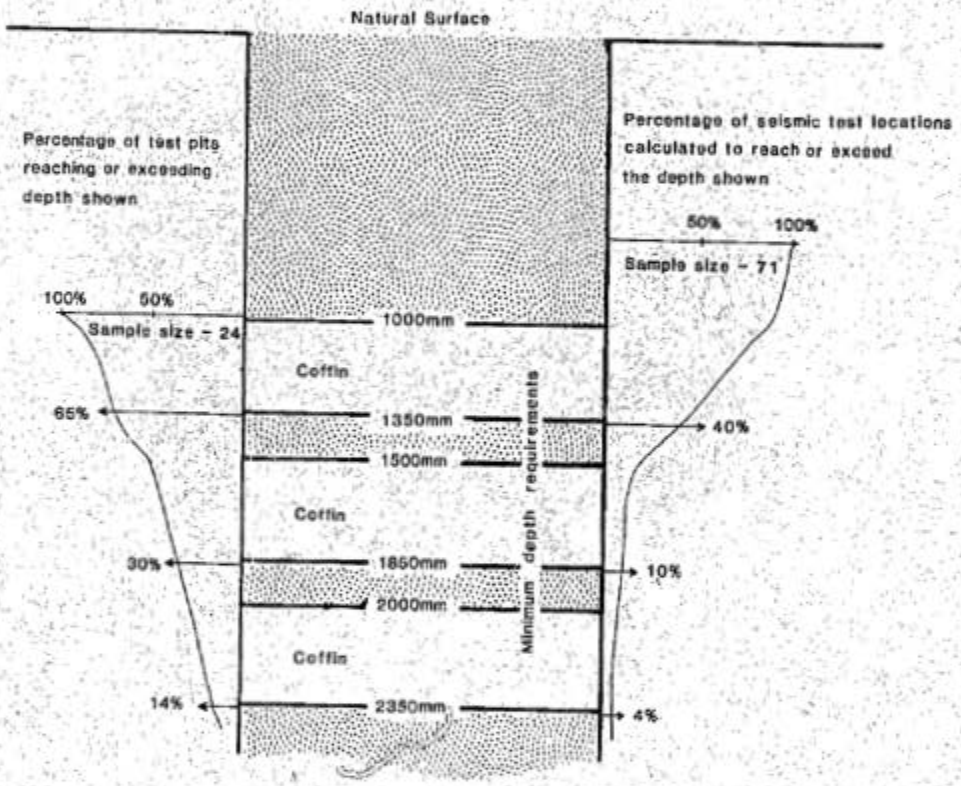


Fig. 3 Minimum Requirements for Burial

and percentage of test sites achieving the depths shown

APPENDIX I

EXCAVATION LOGS

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora

	One	Two	Three	Four
NUMBER	One	Two	Three	Four
LOCATION	S.W. Corner of site	S.W. region of site	Central S.W. of site	S.W. region of site
DEPTH mm				

One

- 0 – 200: Pale brown grey friable clayey SILT
- 200 – 800: Mottled orange-red-grey, stiff, moist silty CLAY
- 800 – 1000: Pale yellow extremely weathered MUDSTONE
- 1000 – 1200: Brownish red, moderately to highly weathered fine-grained SANDSTONE. Some clay interbeds at 1400 mm & 1650 mm
- 1200 – 2000: Slightly weathered SANDSTONE
- Backhoe refusal.

Two

- 0 – 800: Pale brown friable clayey SILT; Yellow-brown, stiff to very stiff silty CLAY
- 800 – 1200: Greyish white, extremely weathered SILTSTONE. Easily excavated by backhoe. Some clay-filled joints throughout.
- 1200 – 2000: Greyish white, moderately weathered SILTSTONE. Excavated with moderate difficulty, well jointed.
- Limit of backhoe - end of pit

Three

- 0 – 800: Pale brown friable clayey SILT; Mottled orange-brown-red, stiff to very stiff silty CLAY
- 800 – 1000: Reddish brown extremely weathered MUDSTONE
- 1000 – 1200: Pinkish red, fine grained slightly weathered SANDSTONE. Very difficult to excavate
- Backhoe refusal

Four

- 0 – 800: Dark brownish grey, friable silty CLAY; Yellow brown very stiff silty CLAY
- 800 – 1000: Pinkish red fine grained, slightly weathered SANDSTONE
- Backhoe refusal.

LOGGED BY [illegible]

DATE 8-9-'82

MACHINE Massey Ferguson 212 Backhoe - 660 mm bucket

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora

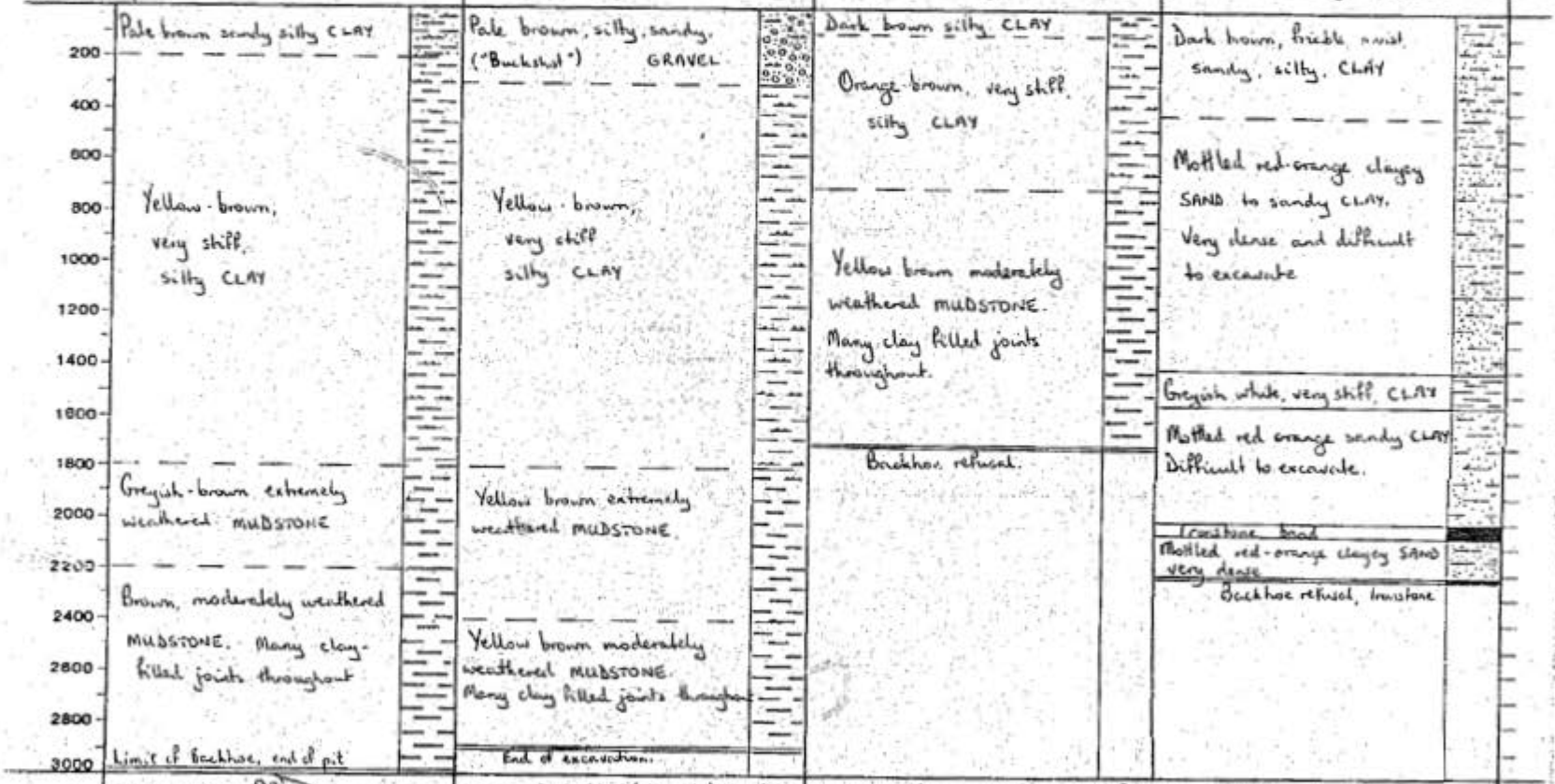
	Five	Six	Seven	Eight
NUMBER	Five	Six	Seven	Eight
LOCATION	N.W. region of site	NW region of site	N.W. region of site	Central/North region of site
DEPTH mm				
0	Dark grey friable silty CLAY	Pale brown SILT, with minor gravel	Pale brown, dry, silty, medium grained SAND	Dark brown silty CLAY
200	Mottled orange-brown & red, stiff to very stiff, silty CLAY	Orange brown, very stiff, silty CLAY. Some angular, gravel size rock throughout.	Pale brown, moderately compact, well rounded, silty, sandy GRAVEL	Blocky, orange-brown, very stiff, silty, CLAY
400			Mottled grey, red & orange, well compacted, clayey SAND. Some well rounded quartz and quartzite gravel. Very difficult to excavate	Mottled orange-brown-red, stiff to very stiff, silty CLAY
600				
800				
1000	Dark pinkish red fine grained SANDSTONE			Mottled pinkish-red & orange-brown extremely weathered MUDSTONE
1200	Backhoe refusal	Orange brown extremely weathered MUDSTONE.	Backhoe refusal	Dips 40°
1400				White, moderately weathered, well jointed, SILTSTONE
1600		Greyish white moderately weathered MUDSTONE. Joints heavily stained.		
1800				Backhoe refusal.
2000		Dark pinkish red fine gr... STONE		
2200		Backhoe refusal.		
2400				
2600				
2800				
3000				

LOGGED BY PEJ **DATE** 5·9·'82 **MACHINE** Massey Ferguson Backhoe 212 - 660mm bucket.

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora.

	Nine	Ten	Eleven	Twelve
NUMBER	Nine	Ten	Eleven	Twelve
LOCATION	North central region of site	N.-W. region of site	Central western region of site	Central eastern region of site.
DEPTH mm				



Nine

- 0–1800: Pale brown sandy silty CLAY; Yellow-brown, very stiff, silty CLAY
- 1800–2200: Greyish-brown extremely weathered MUDSTONE
- 2200–3000: Brown, moderately weathered MUDSTONE. Many clay-filled joints throughout
- 3000: Limit of backhoe, end of pit

Ten

- 0–1800: Pale brown, silty, sandy, ("Buckshot") GRAVEL; Yellow-brown, very stiff silty CLAY
- 1800–2600: Yellow brown extremely weathered MUDSTONE
- 2600–2800: Yellow brown moderately weathered MUDSTONE. Many clay filled joints throughout
- 2800: End of excavation.

Eleven

- 0–1600: Dark brown silty CLAY; Orange-brown, very stiff silty CLAY; Yellow brown moderately weathered MUDSTONE. Many clay filled joints throughout.
- 1600: Backhoe refused.

Twelve

- 0–1400: Dark brown, friable moist, sandy, silty, CLAY; Mottled red-orange clayey SAND to sandy CLAY. Very dense and difficult to excavate
- 1400–1600: Greyish white, very stiff, CLAY
- 1600–1800: Mottled red orange sandy CLAY Difficult to excavate.
- 1800–2200: Ironstone band; Mottled red-orange clayey SAND very dense
- 2200: Backhoe refused, Ironstone

LOGGED BY PRJ

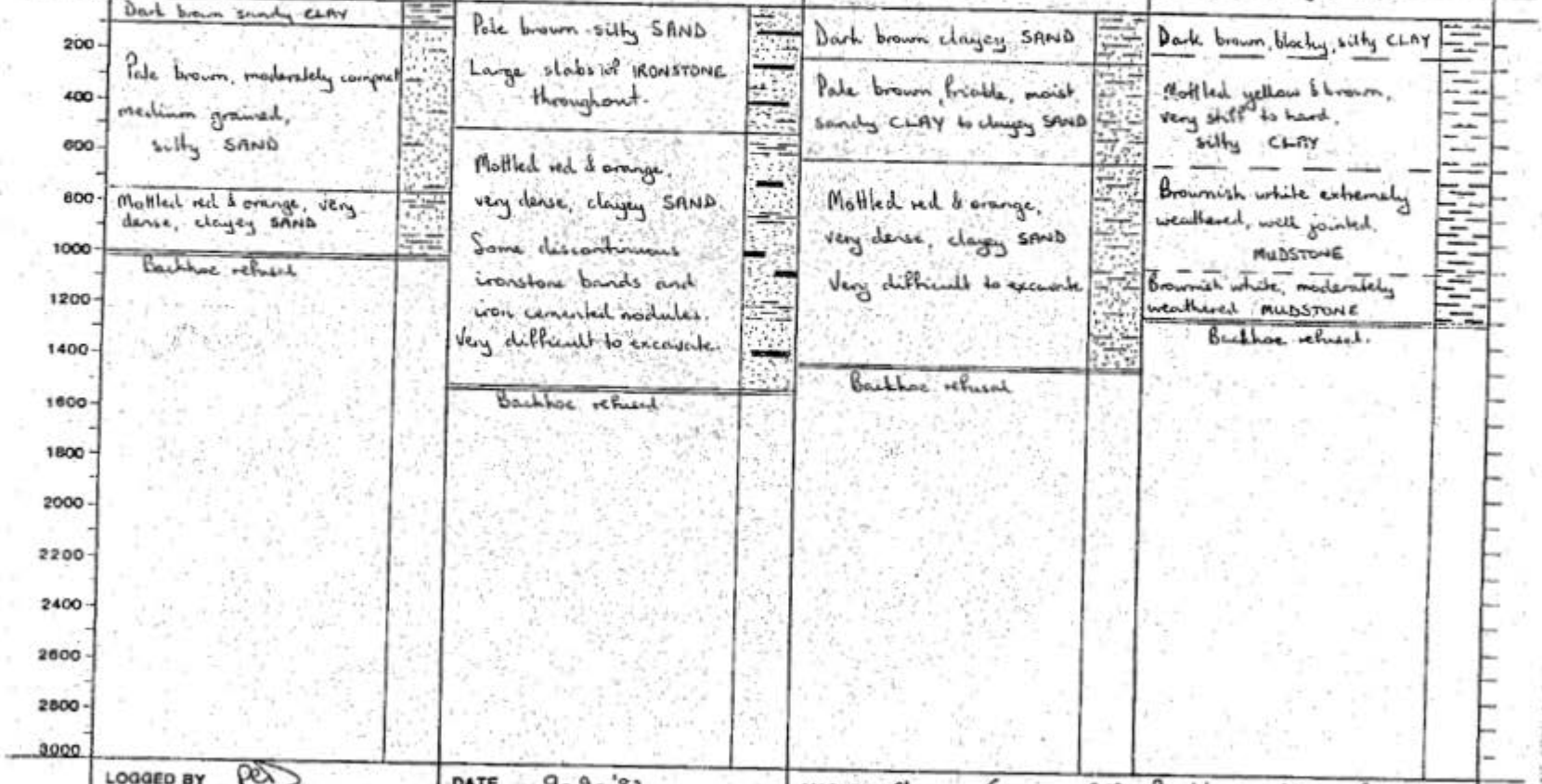
DATE 8-9-'82 (Nos. 9-11) 9-9-82 (No. 12)

MACHINE Massey Ferguson 212 Backhoe - 660mm bucket.

EXCAVATION LOG

PROJECT Proposed Cemetery at Bundoora

	Thirteen	Fourteen	Fifteen	Sixteen
NUMBER				
LOCATION	Eastern region of site	Eastern region of site	Eastern region of site	North Eastern region of site
DEPTH mm				



LOGGED BY PEJ

DATE 9-9-'82

MACHINE Massey Ferguson 212 Backhoe - 660mm Bucket.

EXCAVATION LOG

PROJECT Proposed cemetery at Bundoora

	Seventeen	Eighteen	Nineteen	Twenty
NUMBER				
LOCATION	S.E. region of site	Central western region of site	Central region of site	N.E. region of site
DEPTH mm				

Seventeen

- 0–200: Dark brown slightly sandy silty CLAY
- 200–1000: Mottled brown-red & orange stiff, slightly sandy silty CLAY
- 1000–1400: Greyish white sandy CLAY to clayey fine grained SAND
- 1400–1600: Ironstone
- 1600–2400: Mottled orange brown & red stiff sandy CLAY
- 2400–3000: Backhoe refusal, ironstone

Eighteen

- 0–2400: Dark brown to orange brown, friable, becomes stiff, silty CLAY with sub-angular COBBLES & BOULDERS. Very difficult to excavate.
- 0–2400: Greyish white, moderately weathered SILTSTONE/MUDSTONE interbeds. Relatively easily excavated. (~45°)
- 2400–3000: becomes harder
- 2400–3000: Backhoe refusal

Nineteen

- 0–200: Pale grey-brown clayey SILT
- 200–400: Pale grey-orange, stiff, silty CLAY
- 400–800: Mottled red & orange very stiff silty CLAY
- 800–1400: Pale brown, moderately weathered, fine grained SANDSTONE. Excavated "across reef" with difficulty.
- 1400–3000: Backhoe refusal.

Twenty

- 0–400: Dark brown, blocky, hard, silty CLAY
- 400–1000: Mottled orange & grey stiff to very stiff silty CLAY
- 1000–1400: Succession of vertically dipping brown MUDSTONE & SANDSTONE and greyish white SILTSTONE
- 1400–3000: Backhoe refusal.

LOGGED BY PCS

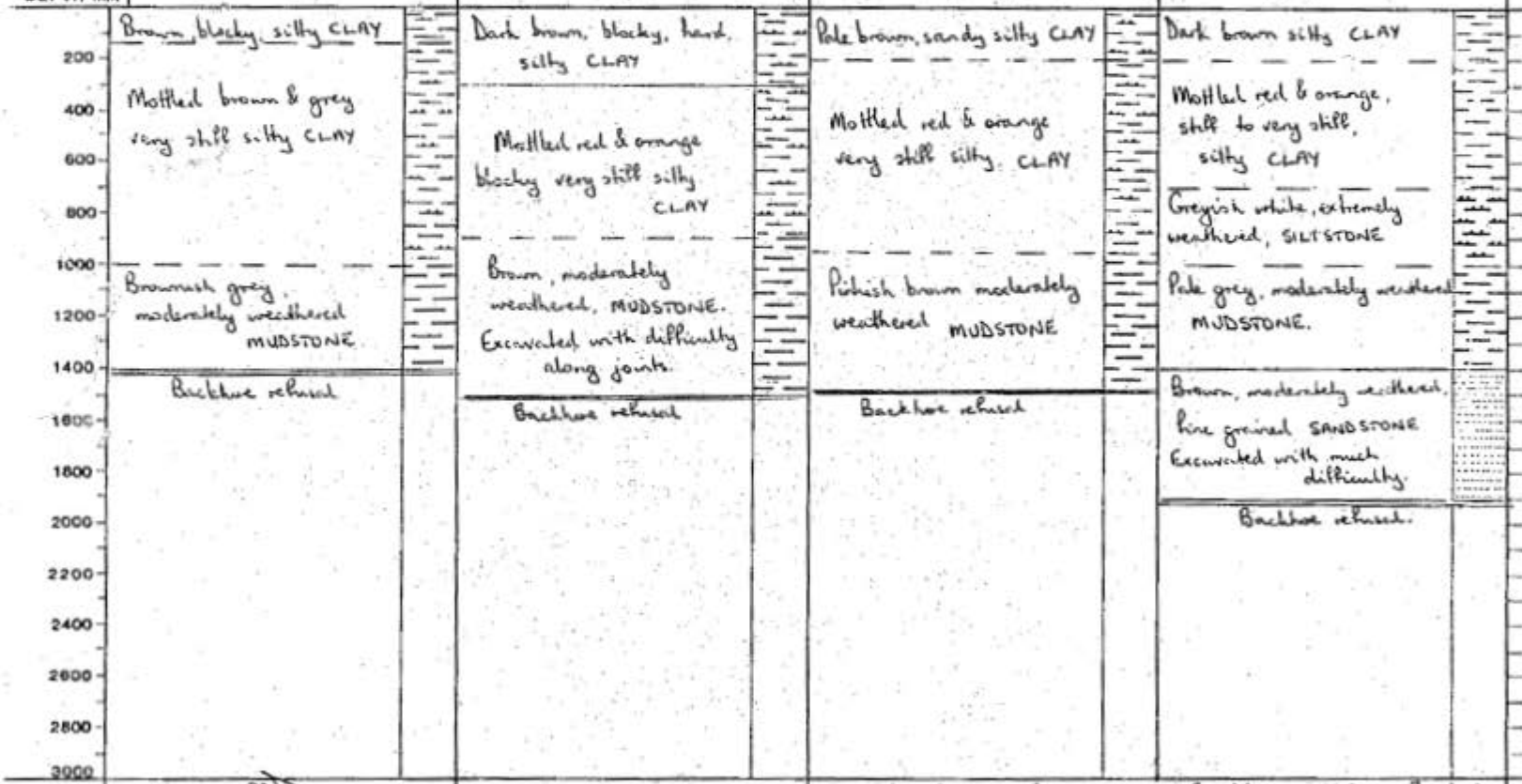
DATE 9-9-82

MACHINE Massey Ferguson 212 Backhoe - 660mm bucket

EXCAVATION LOG

PROJECT Proposed Cemetery at Bundoora.

	Twenty One	Twenty Two	Twenty Three	Twenty Four
NUMBER				
LOCATION	SE region of site	Central south region of site	Central south region of site	Central region of site
DEPTH mm				



LOGGED BY PEJ

DATE 9-9-'82

MACHINE Massey Ferguson 212 Backhoe - 660mm Bucket