PROPOSED ACCESS ROAD
RIFLE RANGE ROAD TO MARIA POINT
SOUTHEAST TASMANIA

GEOTECHNICAL REPORT

Cover photo
View looking west across the western side of Mortimer Bay from near test pit A, July 30, 2014.

Refer to this report as
Cromer, W. C. (2014). *Geotechnical report for a proposed access road, Rifle Range Road to Maria Point, southeast Tasmania.* Unpublished report for Maria Point Pty Ltd by William C. Cromer Pty. Ltd., 14 August 2014; 84 pages.

Important Notes
New geotechnical information is contained in this report. The information may be useful to regulators and geotechnical practitioners. Dissemination of such knowledge ought to be encouraged by practitioners and regulators.

William C Cromer as author will upload this report to his website www.williamccromer.com as a freely downloadable file.

The local planning or building authority is encouraged to make this report (or a reference to it) available on-line.

William C Cromer Pty Ltd may submit hard or electronic copies of this report to Mineral Resources Tasmania to enhance the geotechnical database of Tasmania.

SUMMARY STATEMENT

Geotechnical risks associated with a proposed 1.2km long access road from Rifle Range Road to Maria Point in southeastern Tasmania range from Very Low to Very High.

In the short to medium term, all risks are able to be managed so that Very Low and Low risks remain Acceptable, and higher risks are reduced to and maintained at Low and Acceptable levels. Recommendations are made to achieve these aims. The longer term risks which will be difficult to manage relate to sea level rise, storm surge and shoreline recession.

1 INTRODUCTION

1.1 Background

An access road about 1.2km long is proposed by Maria Point Pty Ltd from the end of Rifle Range Road to land owned by the company at Maria Point. The proposed route from points A to B on Figure 1 traverses land in other ownership, over a narrow strip of ground called a "Reserved Road" on old survey plans (Attachment 3).

Clarence City Council, and the owners of the land in other ownership, have objected to the proposal. The matter is currently being considered by the Resource Management and Planning Appeal Tribunal (RMPAT) which, in a Direction to Parties (Attachment 1), has requested a geotechnical report of the proposed access route.

William C Cromer Pty Ltd (WCC) was commissioned by Maria Point Pty Ltd to conduct the geotechnical investigation and report.

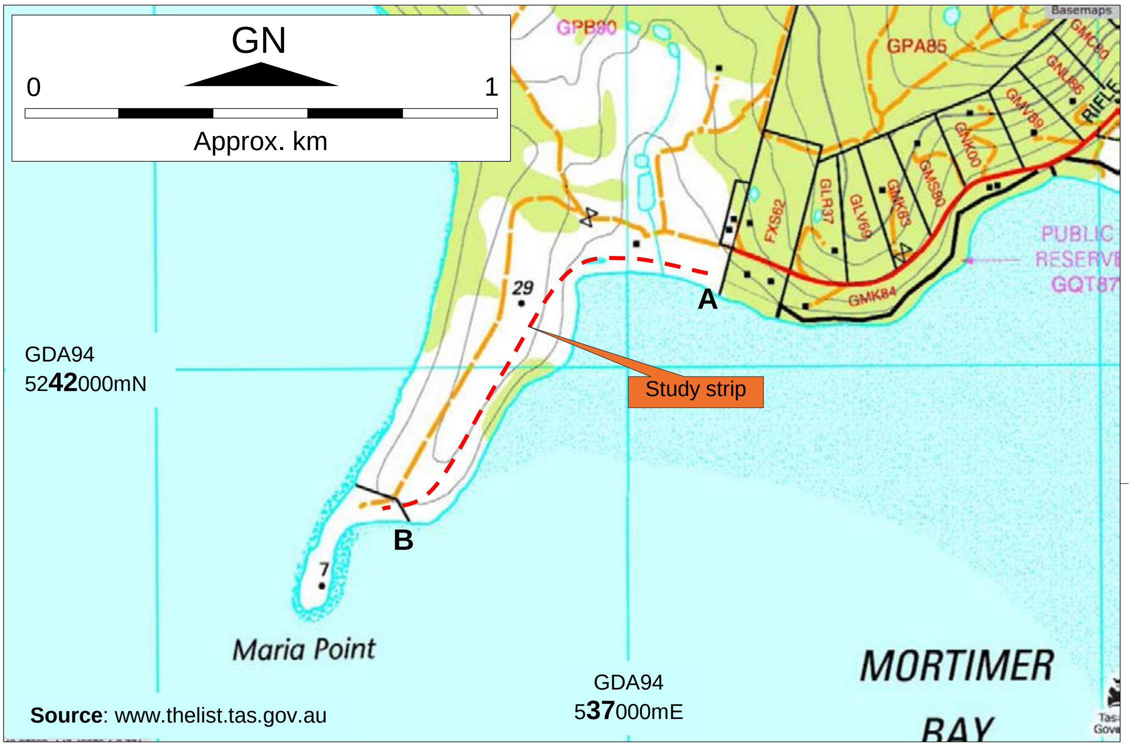

Figure 1 **Location map showing the route of the access road from A to B (called the "Study strip" in this report) proposed by Maria Point Pty Ltd**

1.2 Brief, guidelines and methodology

Brief

The RMPAT Brief in Attachment 3 is:

> "…to carry out a Geotechnical Investigation along the length of the proposed access across 742, 750 and 765 Rifle Range Road, and terminating at the Maria Point site in order to determine the soil conditions present. The investigation is to be carried out in accordance with Austroads "Guide to Road Design Part 7" Geotechnical Investigations [sic] and Design""

Guidelines

In addition to the Austroads guidelines[1], the present work is also in general accordance with AS1726 (1993) *Geotechnical site investigations*, and the series of Landslide Risk Management

[1] Paul, R. and Grove, R. (2008). Guide to Road Design Part 7: Geotechnical Investigation and Design. Austroads Incorporated, Austroads Project No. TP1158, March 200881 pages.

documents produced by the Australian Geomechanics Society in 2007[2], supported by Cromer (2014) [3].

Methodology
In this report, the narrow strip of ground corresponding more or less to the "Reserved Road" in Attachment 3 is called the "Study strip". Geotechnical investigations were not permitted outside this strip.

A preliminary site inspection along the study strip was conducted by WCC on 8 July in the company of engineer P. Holmes. Subsequently, the centreline of a 10m wide strip of land was surveyed and pegged out by Noel Leary & Associates.

The study strip was investigated on 30 and 31 July 2014, when 19 test pits dug by a 4.5t rubber-tracked excavator were logged, photographed and tested. Prior and subsequent office work included:

- a desk top review of geological and landslide hazard maps (Attachment 2), and
- compilation of all field data, and a Landslide Risk Management (LRM) assessment

Presentation of data
The test in the body of this report has been kept to a minimum. Evidence to support the findings of the report is presented in detail in the accompanying Attachments.

1.3 Access strip is considered in three sections

Geotechnically, the access strip can be divided into three sections (Sections 1, 2 and 3) as shown in Attachment 3.

- Section 1 is the low-lying strip behind the beach, between test pits A and E, comprising flat-lying ground underlain by beach sands and estuarine clays over bedrock,
- Section 2 is the undulating and locally steep ground near test pit E, rising to about test pit K, and comprising aeolian sands and colluvial deposits over bedrock, and
- Section 3 is the higher ground from about test pit K to test pit S, underlain by soil over shallow bedrock (and a strip of fill along the alignment of an abandoned access track to Maria Point).

[2] The five AGS documents are:
AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007b). Commentary on Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007d). Commentary on Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007e). The Australian Geoguides for Slope Management and Maintenance. Australian Geomechanics Vol 42 No 1 March 2007

[3] Cromer, W. C. (2014). *Building for landslide: Geotechnical guidance for regulators and practitioners using the Tasmanian Landslide Code*. Draft report for the Tasmanian Department of Premier and Cabinet by William C. Cromer Pty. Ltd., June 2014).

2 SITE DESCRIPTION

2.1 Topography, relief and drainage

Topography and relief

The study strip flanks low-lying land at or near sea level behind the beach at the western end of Mortimer Bay (Section 1). At the western end of the beach, the land rises fairly steeply to elevations around 20m (Section 2), and falls gradually in a southerly direction towards Maria Point (Section 3).

The land is almost flat in Section 1. In Section 2, slope angles are in the 12 – 28^0 range (Attachment 4). In Section 3, east-facing slopes east of the study strip range from about 20 – 25^0, but the access strip itself follows a break of slope along an abandoned track and is on gentler east-facing slopes in the 15 – 18^0 range.

Surface drainage (Attachment 6)

Section 1

An intermittent Class 3 or 4 watercourse crosses Section 1. Its passage across the study strip is ill-defined, with no obvious channel.

Section 2

It is reported that a seepage/spring line crosses Section 2, probably between test pits E and H. There was no obvious surface expression observed during the current investigations.

Section 3

No drainage lines were observed along Section 3.

2.2 Rainfall

Opossum Bay is the nearest relevant rainfall station to the property. Figures are available since 1925 (Table 1). Annual rain averages 541mm, which is fairly evenly distributed through the year[4].

Intensity-frequency-duration curves for the location (Figure 3) suggest that short-lived (a few minutes) rainfalls of up to about 30mm/hour has a one year recurrence interval. A similar intensity over 30 minutes has a recurrence interval of 10 years, and over 45 minutes a recurrence interval of 20 years.

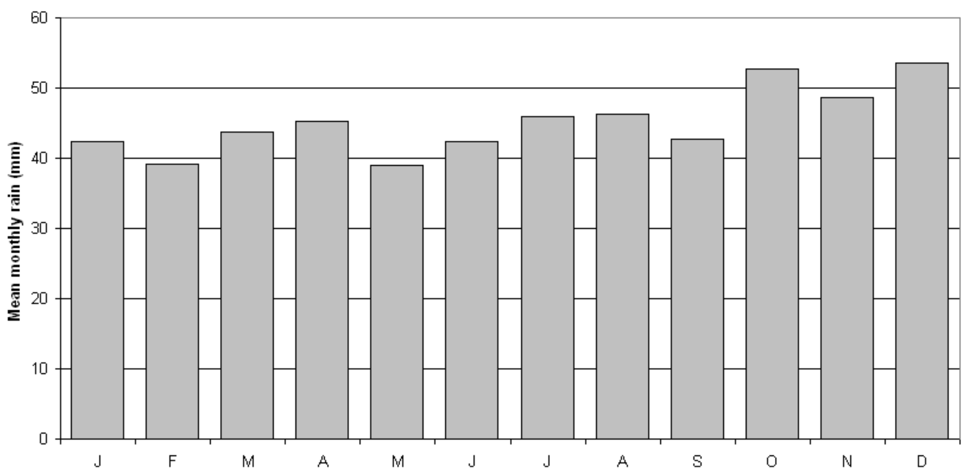

Figure 2: **Mean monthly rainfall for Opossum Bay (1925-present)**
Source : http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_stn_num=094048&p_startYear=

[4] Assuming a runoff coefficient of 0.7, for example, monthly runoff is 70kL/ha for each 10mm of rain.

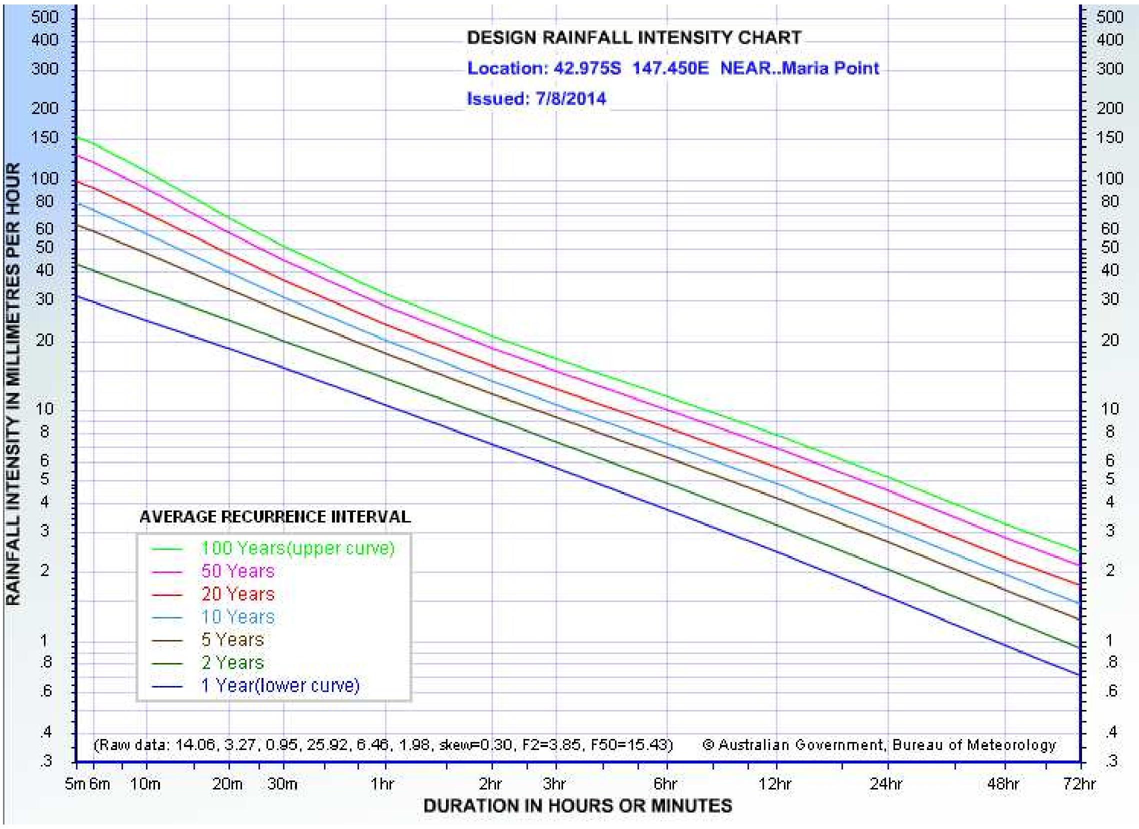

Figure 3: **Rainfall intensity-frequency-duration chart for Maria Point**
Source : http://www.bom.gov.au/water/designRainfalls/ifd-arr87/index.shtml

2.3 Geology

Published bedrock geology

The published geology[5] of the area (Attachment 2) shows that shallowly W to WSW-dipping Permian siltstone and sandstone of the Abels Bay Formation underlies Maria Point and the study strip described in this report. Low-lying ground behind the beach at the end of Rifle Range Road is underlain by undifferentiated Quaternary unconsolidated sediments.

Observed geology (Attachment 6)

The observed geology is in general accord with the published geology.

Quaternary colluvium (Attachment 6)

Material interpreted as colluvial in origin was exposed in several test pits (Attachments 5 and 6), where it typically consists of gravelly sand (GW), and clayey sand (SC, CL).

2.4 Soils and Fill

Soils (Attachments 4, 5 and 6)

Section 1 soils comprise uniform sandy profiles a metre or so thick, overlying siltstone bedrock or estuarine clay.

Section 2 soils are uniform profiles of aeolian sands over siltstone bedrock or beach shingle, or duplex profiles up to about 1.5m thick consisting of a dark-coloured topsoil sand over subsoil clay or gravelly clay, usually overlying colluvium.

[5] Calver, C. R. and Latinovic, M. (compilers) 2002. Digital Geological Atlas 1:25,000 Scale Series. Sheet 5224. Taroona. Mineral Resources Tasmania.

Section 3 soils are duplex profiles up to about 1m thick consisting of a dark-coloured topsoil silty sand over subsoil clay or gravelly clay, overlying siltstone bedrock.

Fill
No significant areas of fill were observed.

Bearing capacity of materials (Attachment 5)
Testing shows that surface materials along the study strip are of low strength, with DCP values (blows/l00mm) are often less than 2, and CBR (%) less than 3.

A range of higher DCP and CBR was recorded for subsurface clays, colluvium and aeolian sand, with DCP refusal on bedrock.

These strength testing results will be useful guides for pavement design for the access road.

Reactivity of materials
No subsurface materials were tested for reactivity[6].

Soil dispersion
Soils and colluvium are mostly non-dispersive. See Attachment 8. Tunnel erosion is not, and will not be, a significant problem along the proposed access road.

Soil infiltration capability
Refer to Attachment 7. Infiltration rates in the sandy topsoils along the route are expected to range up to about 30mm/hour depending on soil saturation and slope angle.

2.5 Groundwater (Attachment 6)

Groundwater in unconfined, fractured rock aquifers
Permanent groundwater is present under unconfined conditions in fractured bedrock types in the district. The groundwater is recharged by infiltrating rain and at intermediate scale discharges to Mortimer Bay.

Shallow groundwater in unconfined sediments
Sections 1 and 2
Shallow groundwater was observed in aeolian and beach sands in test pits B, C, D, E and G. No water table depths were recorded since water inflow was continuing when the pits were backfilled. Nevertheless, a permanent water table is expected to be present in these materials at depths close to mean sea level, and locally fluctuating with tides. Groundwater movement is expected to be very slow, and towards the coast.

3 LANDSLIDE RISK MANAGEMENT (LRM)

Attachment 8 is a LRM for Section 2 of the study strip, in general accordance with the Australian Geomechanics Society (AGS) *Landslide Risk Management* (2007).

4 GENERAL GEOTECHNICAL RISK ASSESSMENT

In Tables 1, 2 and 3, a range of geotechnical issues (including those addressed in the LRM in Attachment 8) has been canvassed for each of the three sections of the study strip. The likelihood of each issue has been assessed, its consequences to road construction are suggested, the level of risk associated with each is proposed, and where appropriate,

[6] Reactive materials contain clays which shrink and swell in volume when their moisture content decreases or increases respectively.

recommendations are made to treat (manage) the risk[7]. See Figure 1 for an explanation of terms used.

Rated risks range from Very Low to Very High:

- In Section 1, the highest risks relate to low strength (surface) materials, waterlogging/flooding and storm surge, and in the longer term, to sea level rise and shoreline recession.
- In Section 2, the highest risks relate to shallow-seated landsliding, low strength (surface) materials, localised waterlogging/flooding, and in the longer term, to shoreline recession.
- In Section 3, a high risk relates to low strength (surface) materials

In the short to medium term, all risks are able to be managed so that (a) Very Low and Low risks remain Acceptable, and (b) higher risks are reduced to and maintained at Low and Acceptable levels. The longer term risks which will be difficult to manage are mainly restricted to Section 1 and relate to sea level rise, storm surge and shoreline recession.

Recommendations are made to achieve these aims.

[7] It is up to stakeholders to decide whether any evaluated risk is acceptable or not. A rough guide might be to consider all Very low and Low geotechnical risks as acceptable and not requiring treatment, Moderate risks to be acceptable or tolerable and may require treatment, and High and Very high risks as tolerable or intolerable, and generally requiring treatment. Treatment is designed to reduce risks to acceptable or tolerable levels. It may include Accepting the risk, Avoiding the risk (ie abandoning the project), Reducing the likelihood of the hazard occurring (ie stabilisation measures to control triggering circumstances), Reducing the consequences (eg suitable construction design), Monitoring and warning systems (which might help reduce the consequences of the hazard), Transferring the risk (eg requiring another authority to accept the risk or compensate for the risk, such as insurance companies), and Postponing a decision (eg if there is insufficient certainty about the risk, it might be better to do further investigations).

5 CONCLUSIONS

From a geotechnical perspective, an access road along the survey strip presents manageable short to medium term risks.

6 RECOMMENDATIONS

From a geotechnical viewpoint, development of the access road should proceed subject to the recommendations listed in Table 1, 2 and 3. Some of these are described in more detail in Attachment 8. The good hillside construction practices described in Attachment 9 shall also be followed.

W. C. Cromer
Principal

This report is and must remain accompanied by the following Attachments

Attachment 1. RMPAT Direction to Parties including a Brief for a geotechnical report (1 page)
Attachment 2. Published geology and landslide hazard bands (1 page)
Attachment 3. Survey plans showing topography, surveyed peg locations, and test pits dug 30, 31 July 2014 (2 pages)
Attachment 4. Geotechnical fact map of southern part of study strip (2 pages)
Attachment 5. Engineering logs of test pits dug 30 and 31 July 2014 (20 pages)
Attachment 6. Site and test pit photographs (8, 30 and 31 July, 2014) (24 pages)
Attachment 7. Geology, soils, surface drainage ad groundwater (7 pages)
Attachment 8. Landslide Risk Management (9 pages)
Attachment 9. Examples of good and poor hillside engineering practices (3 pages)

Table 1 **SECTION 1: Summary of geotechnical issues, risks and consequences to access road development, and suggested risk treatment practices**

	Issue	Likelihood of occurrence	Consequences to development	Level of risk to development	Risk treatment
1	**Surface soil erosion**	Possible	Minor	Moderate	Control upslope surface runoff with table drains and culverts
2	**Tunnel erosion**	Unlikely	Minor	Low	As for issue 1
3	**Soil creep**	Rare	Minor	Very Low	No action required
4	**Shallow-seated landslide or debris slide**	Barely Credible	Medium	Very Low	No action required
5	**Rock/earth topples and falls**	Barely credible	Insignificant to Minor	Very low	No action required
6	**Deep-seated landslide (involving, eg boulder beds, talus, colluvium, bedrock etc); includes runout**	Barely Credible	Major	Very Low	No action required
7	**Foundation movement due to reactive or unstable soils**	Unlikely	Minor	Very Low	No action required
8	**Low strength materials (eg uncontrolled fill, soft soils)**	Almost Certain	Medium	Very High	Employ appropriate road construction techniques
9	**Vegetation removal**	Unlikely	Minor	Low	No action required
10	**Flooding or waterlogging**	Likely	Minor to Medium	Moderate to High	Employ appropriate road construction including drainage techniques
11	**Shore bank collapse**	Likely	Insignificant	Low	No action required
12	**Site contamination from previous activities**	Locally possible	Insignificant	Low	Visual inspection during site construction, and clean up as required.
13	**On-site domestic wastewater disposal**	Not applicable			
14	**Earthquake risk**	Almost certain (magnitude <5); Likely (magnitude>5)	Insignificant to Minor	Low to Moderate	Generally accept risk. A similar range of risks exists throughout Tasmania.
15	**Sea level rise**	Likely	Insignificant (short to medium term) to Major (long term)	Low (short to medium term) to Very High (long term)	Employ appropriate road construction including drainage techniques
16	**Storm surge**	Likely	Minor to Major	Low to Very High	Employ appropriate road construction including drainage techniques
17	**Shoreline recession**	Likely	Insignificant (short to medium term) to Major (long term)	Low (short to medium term) to Very High (long term)	Employ appropriate road construction including drainage techniques

1. **The assessments are unavoidably subjective to varying degrees.**
2. **See next page for an explanation of the terms used in this table.**
3. **Further reading: Australian Geomechanics Society Subcommittee (2007). Landslide Risk Management Aust. Geomechanics 42(1) March 2007, pp 1 – 219.**

Table 2 SECTION 2: Summary of geotechnical issues, risks and consequences to access road development, and suggested risk treatment practices

	Issue	Likelihood of occurrence	Consequences to development	Level of risk to development	Risk treatment
1	**Surface soil erosion**	Possible	Minor	Moderate	Control upslope surface runoff with table drains and culverts
2	**Tunnel erosion**	Unlikely	Minor	Low	As for issue 1
3	**Soil creep**	Unlikely	Minor	Low	No action required
4	**Shallow-seated landslide or debris slide**	Likely	Minor to Major	Moderate to Very High	Construct engineered, drained retaining walls to cope with lateral stresses; employ good hillside construction techniques (Attachment 9)
5	**Rock/earth topples and falls**	Barely credible	Insignificant to Minor	Very low	No action required
6	**Deep-seated landslide (involving, eg boulder beds, talus, colluvium, bedrock etc); includes runout**	Barely Credible	Major	Very Low	No action required
7	**Foundation movement due to reactive or unstable soils**	Unlikely	Minor	Very Low	No action required
8	**Low strength materials (eg uncontrolled fill, soft soils)**	Almost Certain	Medium	Very High	Employ appropriate road construction techniques
9	**Vegetation removal**	Likely	Insignificant	Low	No action required
10	**Flooding or waterlogging**	Locally Likely	Minor to Medium	Moderate to High	Employ appropriate road construction including drainage techniques
11	**Shore bank collapse**	Locally Likely	Insignificant	Low	No action required
12	**Site contamination from previous activities**	Locally possible	Insignificant	Low	Visual inspection during site construction, and clean up as required.
13	**On-site domestic wastewater disposal**	Not applicable			
14	**Earthquake risk**	Almost certain (magnitude <5); Likely (magnitude>5)	Insignificant to Minor	Low to Moderate	Generally accept risk. A similar range of risks exists throughout Tasmania.
15	**Sea level rise**	Likely	Insignificant	Low	Employ appropriate road construction including drainage techniques
16	**Storm surge**	Likely	Minor	Moderate	Employ appropriate road construction including drainage techniques
17	**Shoreline recession**	Likely	Insignificant (short to medium term) to Major (long term)	Low (short to medium term) to Very High (long term)	Employ appropriate road construction including drainage techniques

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Table 3 SECTION 3: Summary of geotechnical issues, risks and consequences to access road development, and suggested risk treatment practices

	Issue	Likelihood of occurrence	Consequences to development	Level of risk to development	Risk treatment
1	**Surface soil erosion**	Possible	Minor	Moderate	If stormwater runoff is concentrated by access formation, control it with table drains, culverts and retention/diffusing trenches
2	**Tunnel erosion**	Unlikely	Minor	Low	As for issue 1
3	**Soil creep**	Unlikely	Minor	Low	No action required
4	**Shallow-seated landslide or debris slide**	Unlikely	Minor to Medium	Low	No action required
5	**Rock/earth topples and falls**	Barely credible	Insignificant to Minor	Very low	No action required
6	**Deep-seated landslide (involving, eg boulder beds, talus, colluvium, bedrock etc); includes runout**	Barely Credible	Major	Very Low	No action required
7	**Foundation movement due to reactive or unstable soils**	Unlikely	Minor	Very Low	No action required
8	**Low strength materials (eg uncontrolled fill, soft soils)**	Almost Certain	Medium	Very High	Employ appropriate road construction techniques
9	**Vegetation removal**	Unlikely	Insignificant	Low	No action required
10	**Flooding or waterlogging**	Unlikely	Minor to Medium	Low	Employ appropriate road construction including drainage techniques
11	**Shore bank collapse**	Locally Likely	Insignificant	Low	No action required
12	**Site contamination from previous activities**	Locally possible	Insignificant	Low	Visual inspection during site construction, and clean up as required.
13	**On-site domestic wastewater disposal**	Not applicable			
14	**Earthquake risk**	Almost certain (magnitude <5); Likely (magnitude>5)	Insignificant to Minor	Low to Moderate	Generally accept risk. A similar range of risks exists throughout Tasmania.
15	**Sea level rise**	Likely	Insignificant	Low	No action required
16	**Storm surge**	Likely	Insignificant	Low	No action required
17	**Shoreline recession**	Likely	Insignificant	Low	No action required

1. **The assessments are unavoidably subjective to varying degrees.**
2. **See next page for an explanation of the terms used in this table.**
3. **Further reading: Australian Geomechanics Society Subcommittee (2007). Landslide Risk Management Aust. Geomechanics 42(1) March 2007, pp 1 – 219.**

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Figure 1 **Terminology used in geotechnical risk assessment.**
Source: AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

Attachment 1

(1 page)

RMPAT Directions to Parties including a Brief for a geotechnical report

RESOURCE MANAGEMENT AND PLANNING APPEAL TRIBUNAL

DIRECTION TO PARTIES

Date: 2 July 2014

File No: 20/14 P

Citation: Maria Point Pty Ltd v Clarence City Council

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1. Pursuant to the powers vested in it by Section 22(1) of the *Resource Management and Planning Appeal Tribunal Act 1993 (the 'Act')* the Tribunal directs the Applicant, Maria Point Pty Ltd to carry out a Geotechnical investigation along the length of the proposed access across 742, 750 and 765 Rifle Range Road, and terminating at the Maria Point site in order to determine the soil conditions present. The investigation is to be carried out in accordance with Austroads "Guide to Road Design Part 7 "Geotechnical Investigations and Design"; and

2. Prepare a concept drainage plan(s) based thereon.

3. The Appellant is to file and serve the geotechnical report and accompanying concept plans on each of the Respondents within 21 days.

4. Each of the Respondents will be afforded a further period of 14 days to file any further evidence in response thereto.

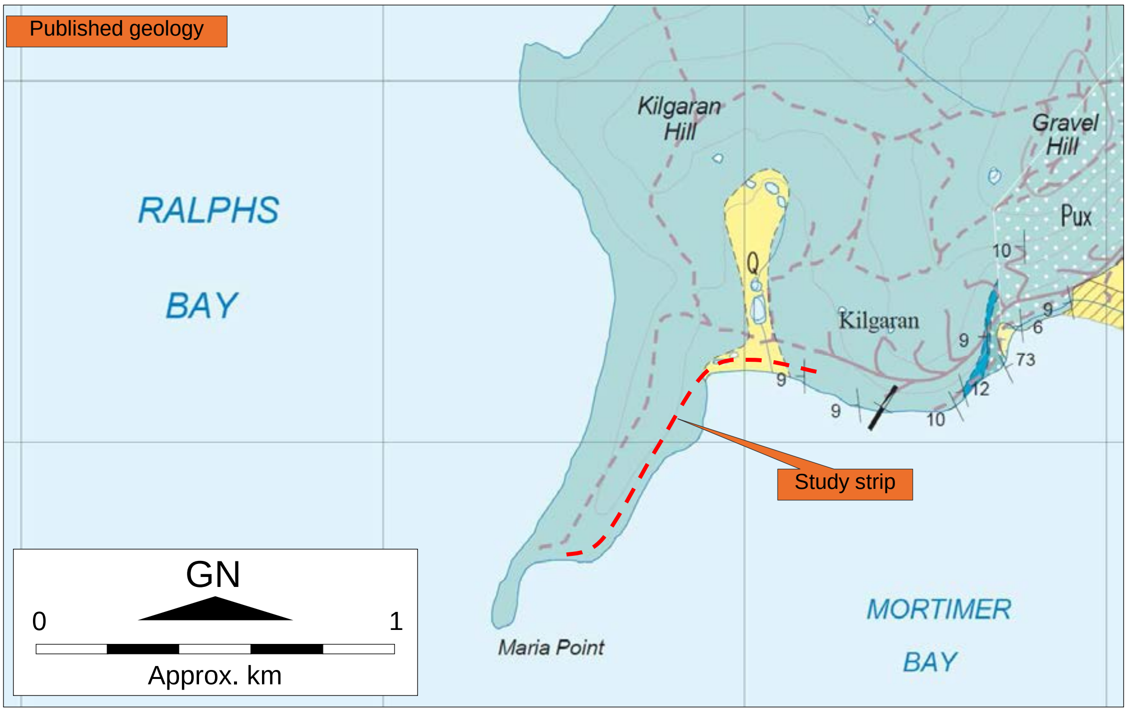
5. There shall be liberty to apply in relation to the timetable imposed by the Tribunal.

GP Geason
M E Ball
P Spratt

Attachment 2

(1 page)

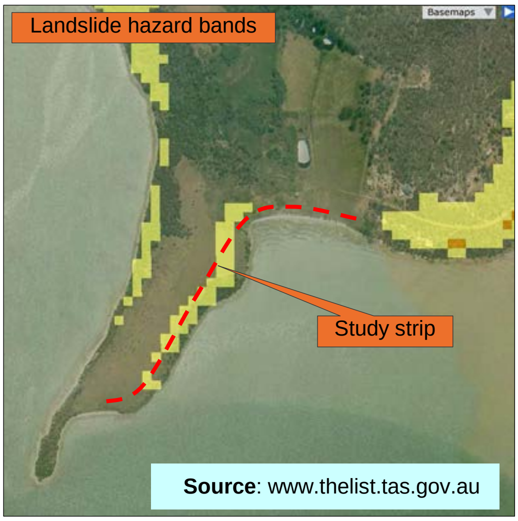
Published geology and landslide hazard bands



Source: Calver, C. R. and Latinovic, M. (compilers) 2002. Digital Geological Atlas 1:25,000 Scale Series. Sheet 5224. Taroona. Mineral Resources Tasmania.

Key to rock types

All shades of blue = Permian-age sedimentary rocks (symbol Pua = Abels Bay Formation – unfossiliferous, glaciomarine interbedded mudstone, siltstone, sandstone, pebbly sandstone); Yellow (symbol Q) = Quaternary-age undifferentiated, unconsolidated beach, aeolian and alluvial deposits.



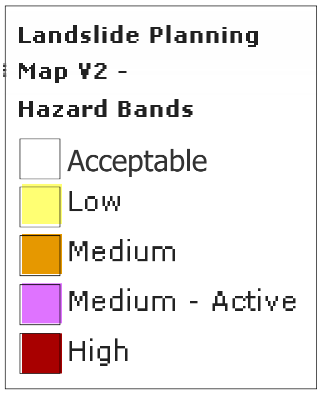
Acceptable band
A landslide is a rare event based on current understanding of the hazard, but it may occur in some exceptional circumstances.

Low band
The area may include landslide features but their activity is unknown, and they have been judged by MRT to rank of lesser risk than those in higher bands.

Medium band
The area has known landslide features, or is within a landslide susceptibility zone, or has legislated controls to limit disturbance of adjacent unstable areas.

Medium-active band
The area has known recently active landslide features.

High band
The site is within a declared Landslip A area.

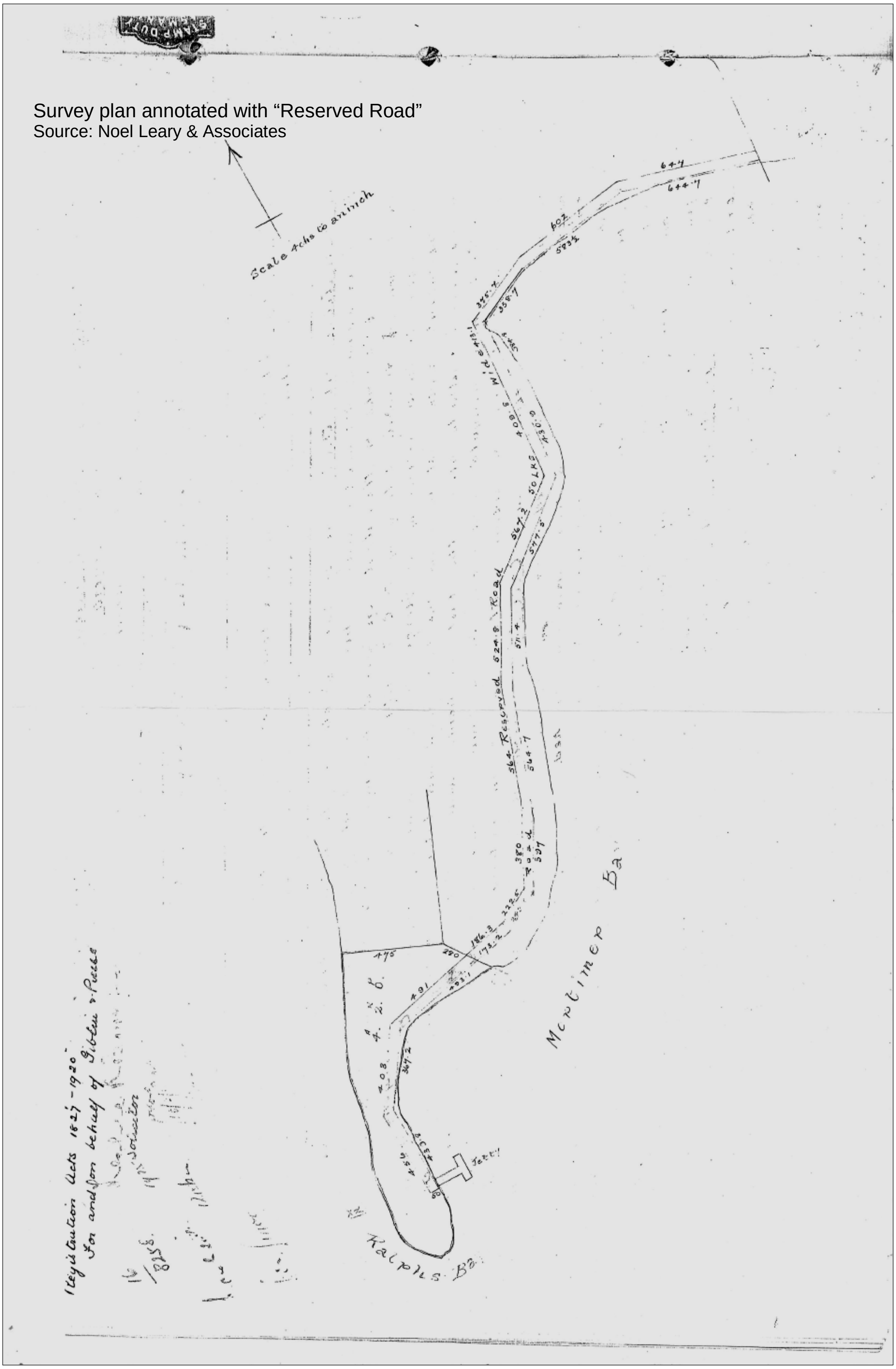


Attachment 3

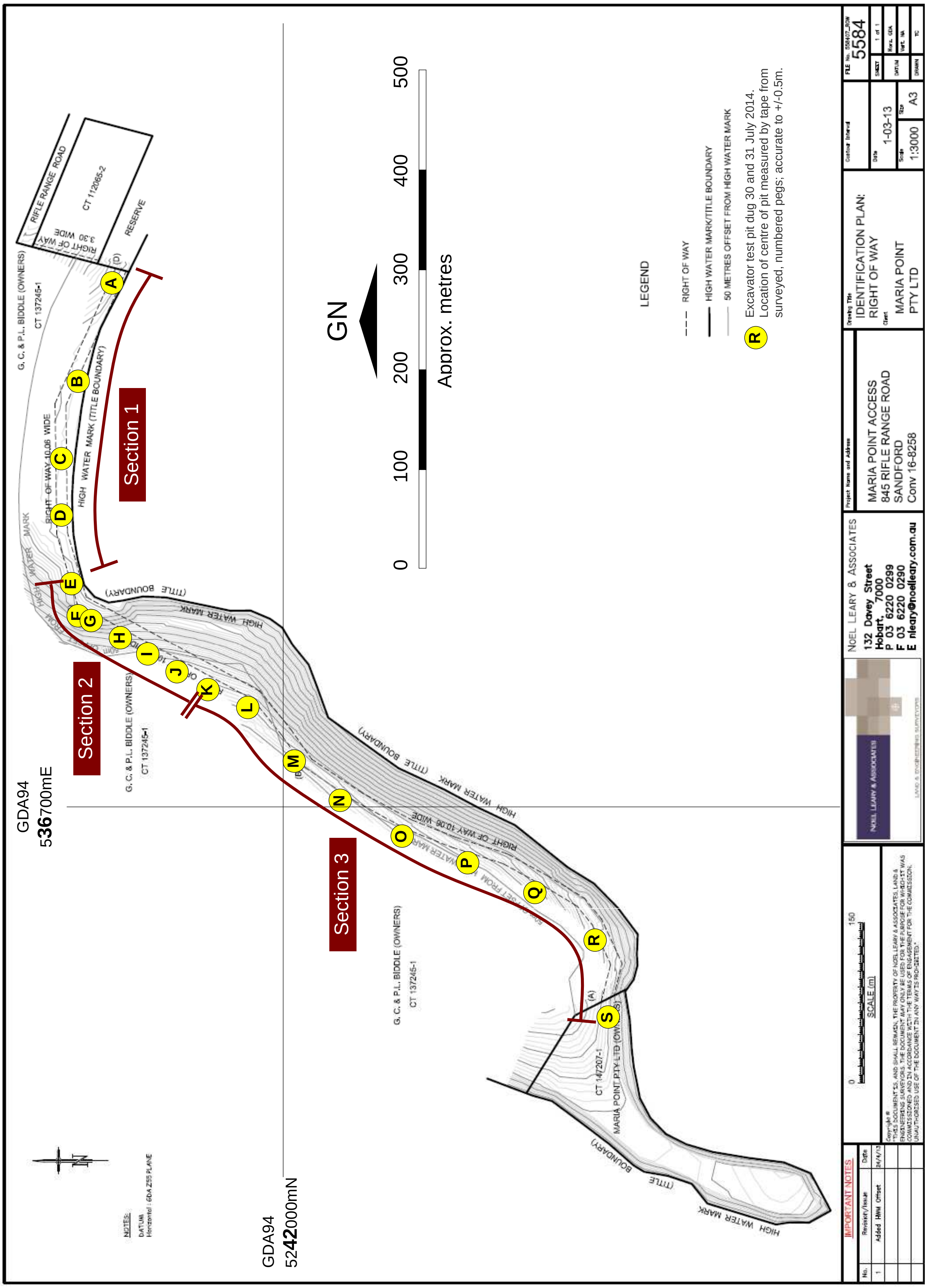
(3 pages)

Survey plans showing topography, surveyed peg locations, and test pits dug 30, 31 July 2014

Source for base plans: Noel Leary & Associates



Survey plan annotated with “Reserved Road”
Source: Noel Leary & Associates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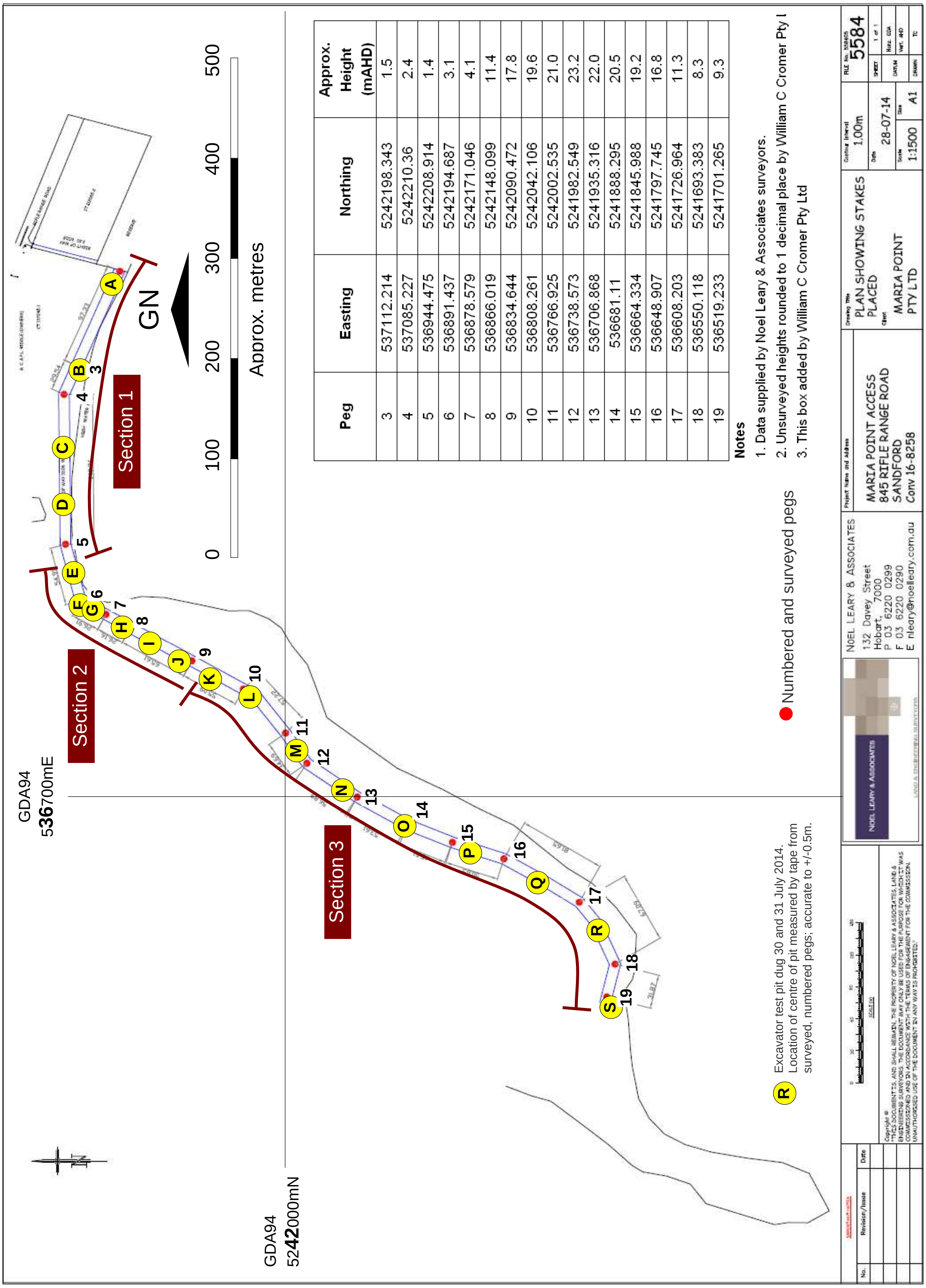
100
200
300
400
500
Approx. metres
LEGEND
RIGHT OF WAY
HIGH WATER MARK/TITLE BOUNDARY
50 METRES OFFSET FROM HIGH WATER MARK
Excavator test pit dug 30 and 31 July 2014.
Location of centre of pit measured by tape from
surveyed, numbered pegs; accurate to +/-0.5m.
RIFLE RANGE ROAD
CT 112665-2
RESERVE
G. C. & P.L. BIDDLE (OWNERS)
CT 137245-1
RIGHT OF WAY 10.06 WIDE
HIGH WATER MARK (TITLE BOUNDARY)
HIGH WATER MARK
(TITLE BOUNDARY)
MARIA POINT PTY LTD (OWNERS)
CT 147207-1
NOEL LEARY & ASSOCIATES
132 Davey Street
Hobart 7000
P 03 6220 0299
F 03 6220 0290
E nleary@noelleary.com.au
MARIA POINT ACCESS
845 RIFLE RANGE ROAD
SANDFORD
Conv 16-8258
IDENTIFICATION PLAN:
RIGHT OF WAY
MARIA POINT
PTY LTD
1-03-13
1:3000
A3
5584



Peg	Easting	Northing	Approx. Height (mAHD)
3	537112.214	5242198.343	1.5
4	537085.227	5242210.36	2.4
5	536944.475	5242208.914	1.4
6	536891.437	5242194.687	3.1
7	536878.579	5242171.046	4.1
8	536866.019	5242148.099	11.4
9	536834.644	5242090.472	17.8
10	536808.261	5242042.106	19.6
11	536766.925	5242002.535	21.0
12	536738.573	5241982.549	23.2
13	536706.868	5241935.316	22.0
14	536681.11	5241888.295	20.5
15	536664.334	5241845.988	19.2
16	536648.907	5241797.745	16.8
17	536608.203	5241726.964	11.3
18	536550.118	5241693.383	8.3
19	536519.233	5241701.265	9.3

Notes

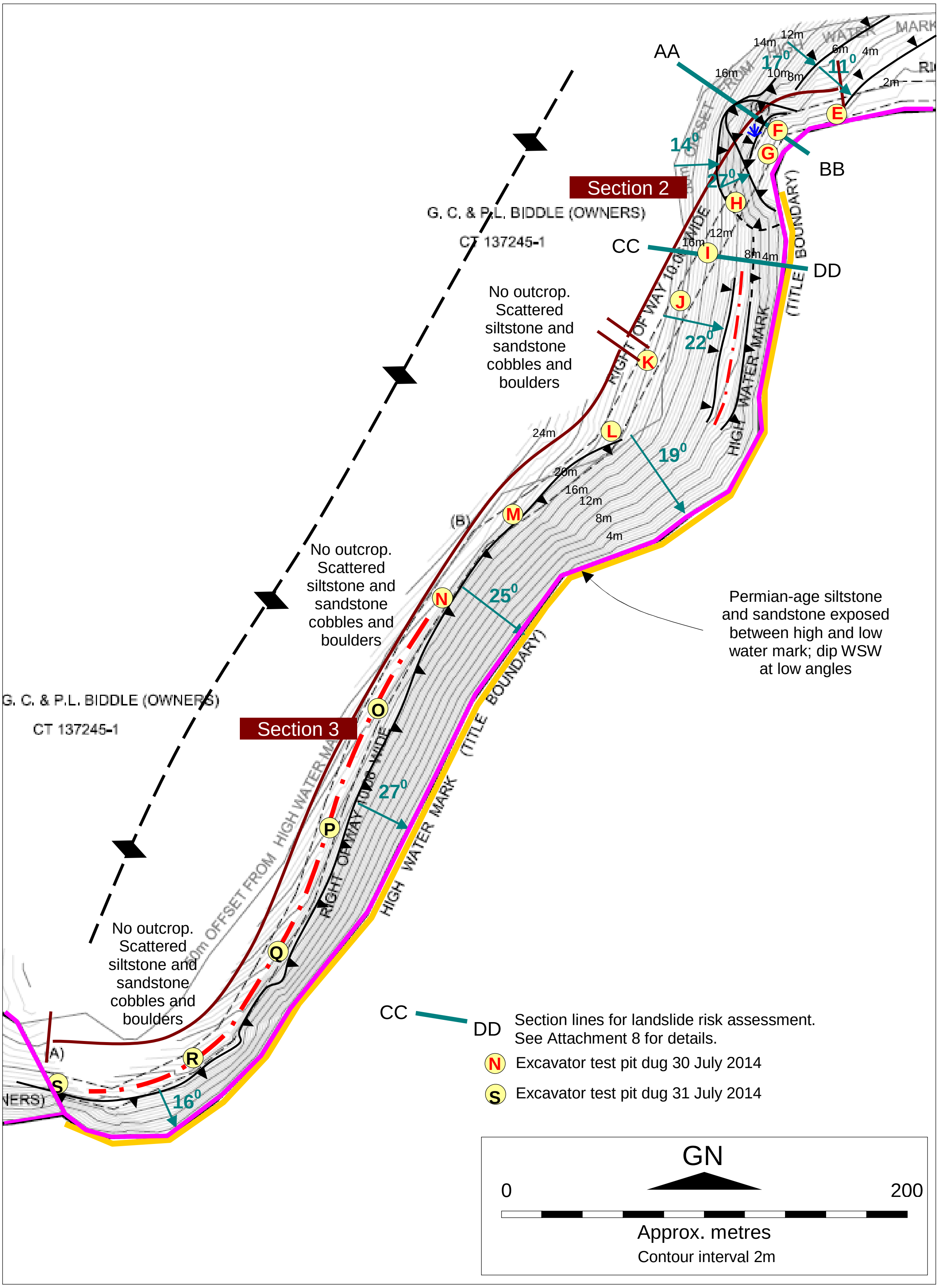
1. Data supplied by Noel Leary & Associates surveyors.
2. Unsurveyed heights rounded to 1 decimal place by William C Cromer Pty l
3. This box added by William C Cromer Pty Ltd

Attachment 4

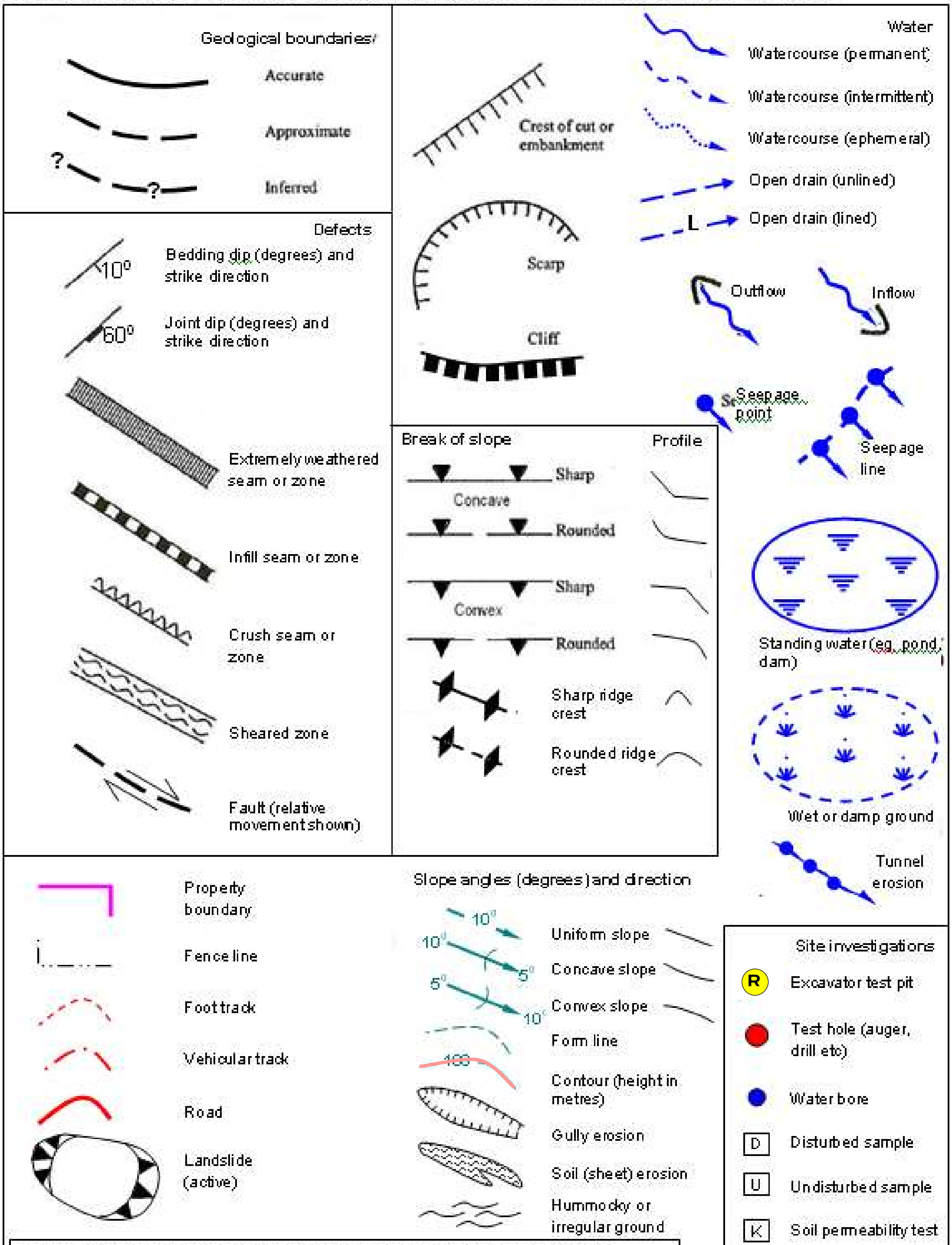
(2 pages)

Geotechnical fact map of southern part of study strip

Source for base plans: Noel Leary & Associates



Geological and geomorphological mapping symbols and terminology used in this report



Source: Adapted from AGS (2007c) Appendix E, after *Guide to Slope Risk Analysis* Version 3.1 November 2001, Roads and Traffic Authority of New South Wales, and Gardiner, V. and Dackombe, R. V. (1983). *Geomorphological Field Manual*. Allen & Unwin

Attachment 5

(20 pages including this page)

Engineering logs of test pits dug 30 and 31 July 2014

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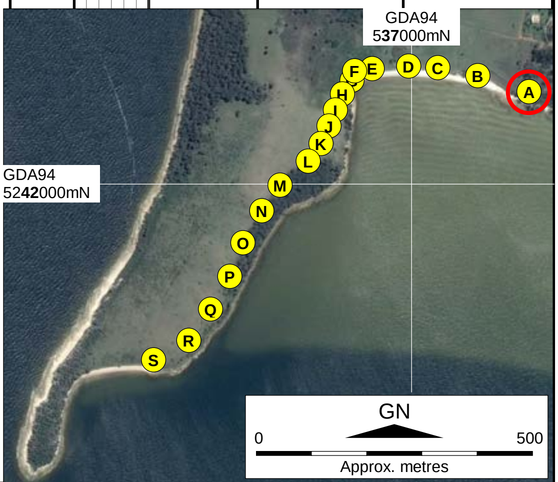
Excavation log

Pit A
Sheet 1 of 1

Project – Maria Point access driveway   Location

Coordinates	537198mE 5242160mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 1.5m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 0.7 Length 1.7 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Strength: Hand penetrometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrometer (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
		GNE				SP	Silty SAND: grey-black; some cream shell fragments	M	MD				Organic A horizon
				0.5		SP	Shelly SAND: cream with grey matrix; >80% shell fragments to 15mm;	M	L				Shell hash?
							SILTSTONE: olive green and brown; strongly fractured; moderately weathered; dip 5 deg SW						Bedrock
				1			Excavator refusal at 0.7m on Permian-age siltstone bedrock						
				1.5									
				2									
				2.5									
				3									
				3.5									



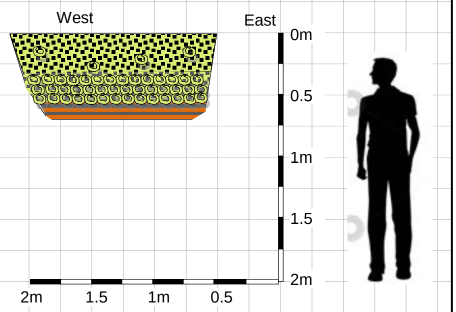
0.5m
V and H scale
0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS, SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit B Sheet 1 of 1

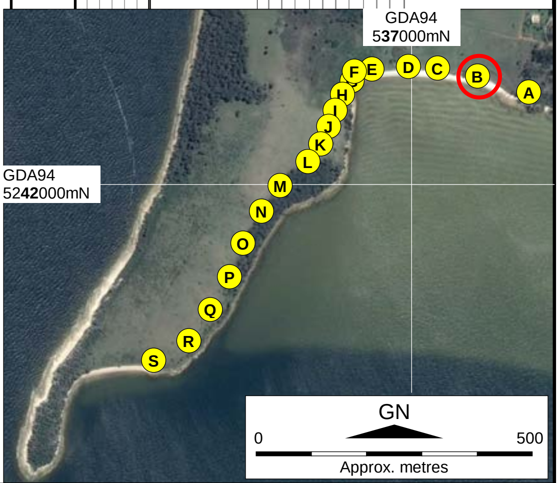
Project – Maria Point access driveway — Location

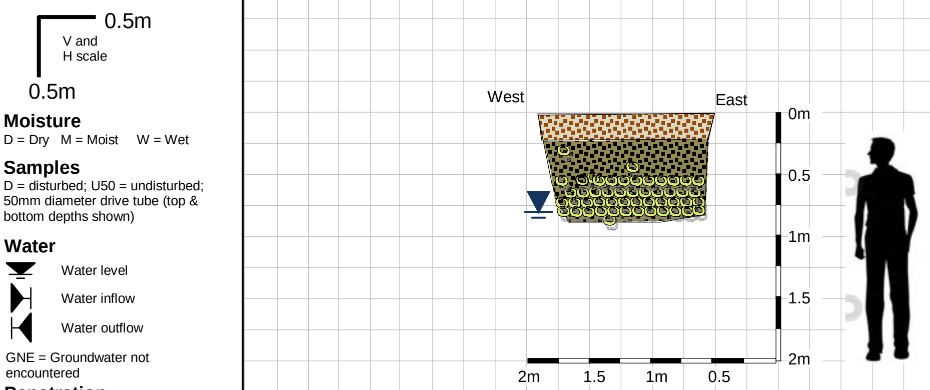
Coordinates	537131mE 5242192mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 2m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 0.9 Length 1.4 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Depth (m)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Structure, geology and interpretation
0–0.1	SP	SAND: beige; fine-med grained	D	L	Aeolian sand
0.1–0.5		Shelly SAND: dark grey; 20% shell fragments to 15mm		MD	Beach sand
0.5–0.65		Shelly SAND: dark grey; >80% shell fragments to 15mm	M-W	MD	Shell hash?
0.65–0.9		SILTSTONE: yellow brown; subhorizontal; mod fractured;			
0.9		Excavator refusal at 0.9m on Permian-age siltstone bedrock			Bedrock

Strength: Hand penetrometer (kPa) 25 50 100 200 400; Shear Vane (kPa); Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) 2 4 6 8 10 12 14 16 18 20 22. DCP refusal at 0.9m.

Columns: Penetration (1 2 3), Support, Water, Notes (Samples and tests), RL, Depth metres, Graphic log. Depth scale: 0.5, 1, 1.5, 2, 2.5, 3, 3.5.





Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit C
Sheet 1 of 1

Project – Maria Point access driveway **Location**

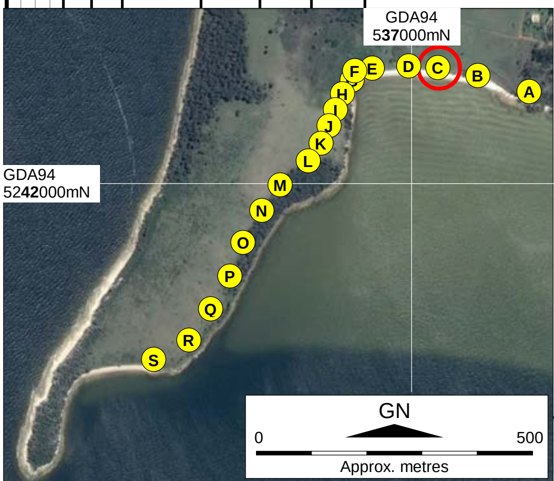
Coordinates	537060mE 5242210mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94			**Date logged**	30 July 2014
RL	Approx. 1.5m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.5 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

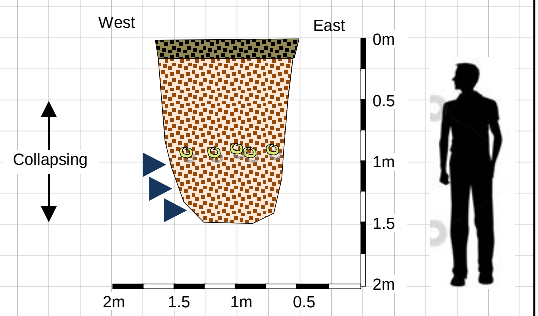
Depth (metres)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Structure, geology and interpretation
0–0.1	SP	SAND: dark grey; fine-med grained	D	L	Organic sand
0.1–1.5		SAND: beige; fine-med grained; shelly horizon near 0.9m	D; M (from ~0.45); M-W (from ~1.0); W (from ~1.1)	MD	Beach sand
1.5		End as required at 1.5m. Pit collapsing below 0.5m			

Water: water inflow at approx. 1.0–1.5m.

Strength columns: Hand penetrometer (kPa) 25 50 100 200 400; Shear Vane (kPa); Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) 2 4 6 8 10 12 14 16 18 20 22; Estimated in-situ CBR (%) 3 8 12 17 23 29 34 40 45 50.

Penetration 1 2 3; Support; Water; Notes – Samples and tests; RL; Graphic log.





Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS, SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit D
Sheet 1 of 1

Project – Maria Point access driveway — Location

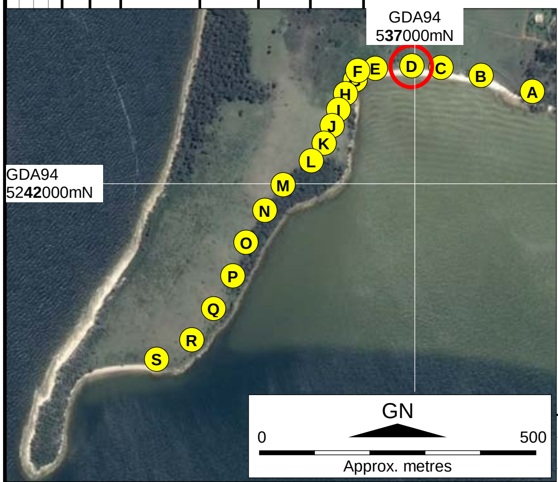
Coordinates	536998mE 5242214mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94			**Date logged**	30 July 2014
RL	Approx. 1.5m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.5 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

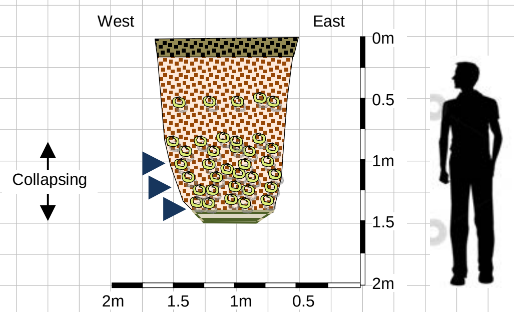
Depth (m)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Shear Vane (kPa)	Structure, geology and interpretation
0–0.1	SP	SAND: dark grey; fine-med grained	D	L		Organic sand
0.1–1.4	SP	SAND: beige; fine-med grained; shelly horizon near 0.5m; abundant shells below 0.8m; some thin lenses of black sand	D; M; M-W; W	MD		Beach sand
1.4–1.5	CH	Sandy CLAY: dark olive grey	M<>PL	St	100kPa@1.5m	Estuarine clay
		End as required at 1.5m. Pit collapsing below 0.8m				

Strength: Hand penetrometer (kPa) 25 50 100 200 300 400; Shear Vane (kPa); Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) 2 4 6 8 10 12 14 16 18 20 22

Estimated in-situ CBR (%) 3 8 12 17 23 29 34 40 45 50

Water: water inflow below approx. 0.8m





0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

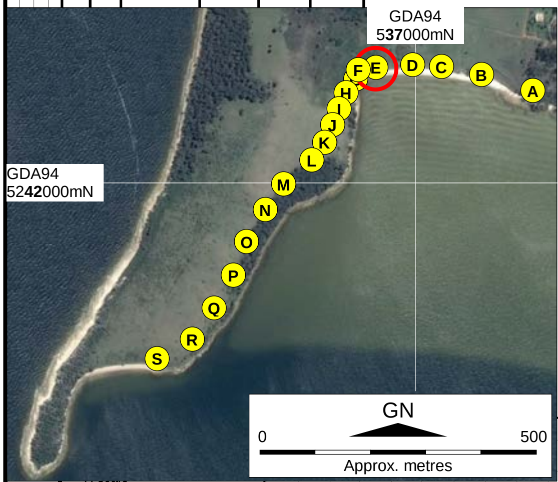
Pit E
Sheet 1 of 1

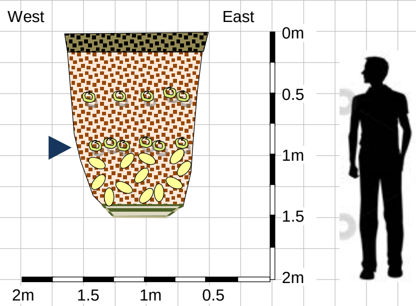
Project – Maria Point access driveway **Location**

Coordinates	536915mE 5242205mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 3m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.5 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Hand penetrometer (kPa)	Shear Vane (kPa)	Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm)	Structure, geology and interpretation
						SP	SAND: dark grey; fine-med grained	M	L-MD				Organic sand
				0.5		SP	SAND: beige; fine-med grained; shelly horizon near 0.5m and 0.9m; abundant sub-rounded to rounded quartzite pebbles to 50m below1m						Beach sand
		▶		1				M-W W	MD				
				1.5		CH	CLAY: olive green	M<>PL	St		112kPa@1.5m		Estuarine clay
							End as required at 1.5m.						

Strength — Hand penetrometer scale: 25 50 100 200 400. Dynamic cone penetrometer scale: 2 4 6 8 10 12 14 16 18 20 22. Estimated in-situ CBR (%): 3 8 12 17 23 29 34 40 45 50





0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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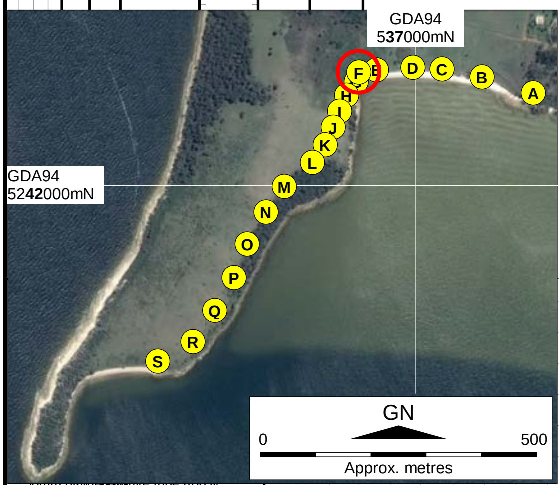
Excavation log

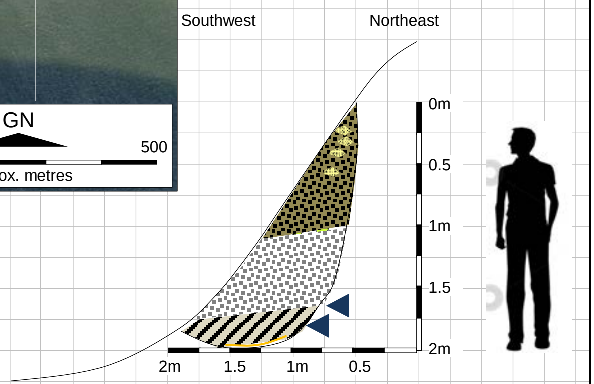
Pit F
Sheet 1 of 1

Project – Maria Point access driveway **Location**

Coordinates	536881mE 5242186mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 4m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 2.0 Length 1.5 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Strength: Hand penetr-ometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Dynamic cone penetrometer (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
				0–1.0		SP	SAND: dark grey; fine-med grained, with light grey sand patches in surface 0.4m; buried leaf at base	M	MD				Aeolian sand
				1.0		SP	SAND: grey; fine-med grained;						
				1.5			Sandy SILT: dark grey; rapid dilatancy	M-W					
		Water inflow				SP	SILTSTONE: yellowish grey brown; mod fractured; slightly weathered	W	S				
				2			Excavator refusal at 2.0m on Permian-age siltstone bedrock dipping c4-5 deg to 150 deg True						Bedrock





bottom depths shown)

Water
- Water level
- Water inflow
- Water outflow

GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS / SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

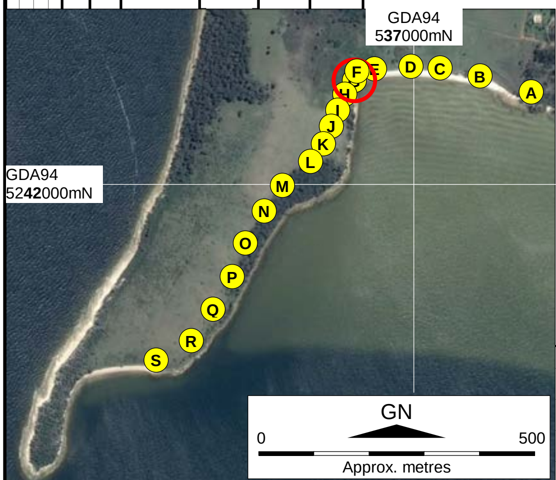
Pit G
Sheet 1 of 1

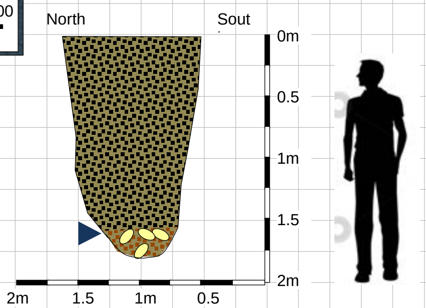
Project – Maria Point access driveway **Location**

Coordinates	536884mE 5242194mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94			**Date logged**	30 July 2014
RL	Approx. 3m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.8 Length 1.5 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL metres Depth	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Hand penetrometer (kPa) (25 50 100 200 400)	Shear Vane (kPa)	Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
				0 – 1.5		SP	SAND: dark grey to black; fine-med grained	M (M-W at 1.5)	MD				Aeolian sand
		Water inflow at ~1.6		1.6 – 1.8		SP	SAND: brown-grey; >50% rounded siltstone clasts to 75mm	W	L			Estimated in-situ CBR (%): -3 -8 -12 -17 -23 -29 -34 -40 -45 -50	Beach sand
				1.8			End as required at 1.8m in beach sand						

Depth scale: 0.5, 1, 1.5, 2





D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS
SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit H
Sheet 1 of 1

Project – Maria Point access driveway — Location

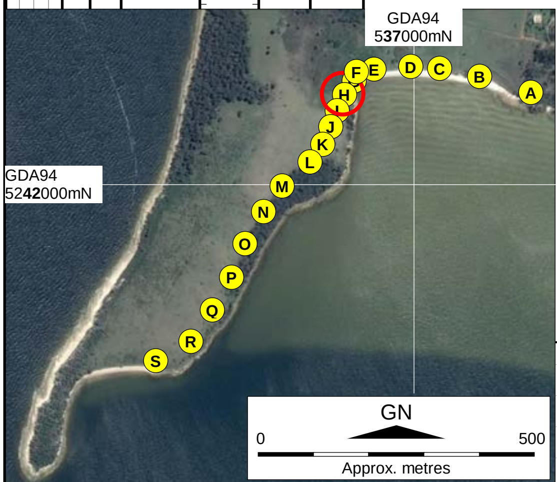
Coordinates	536879mE 5242174mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94			**Date logged**	30 July 2014
RL	Approx. 5m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.8 Length 1.5 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

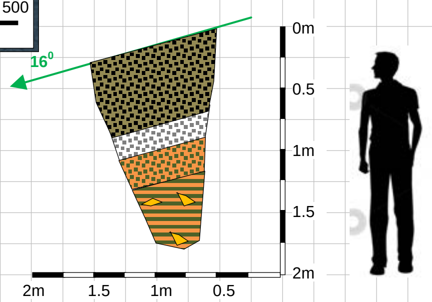
Depth (metres)	Water	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Structure, geology and interpretation
0–0.7	GNE	SP	Silty SAND: dark grey	D	MD	Aeolian sand
0.7–0.9		SP	Silty SAND: grey; hardsetting		D	Topsoil (A1 horizon)
0.9–1.2		SP	Silty SAND: olive brown; hardsetting; trace clay; nonplastic to low plasticity			Topsoil (A2 horizon)
1.2–1.8		CL	Sandy CLAY: olive brown; low plasticity; occasional angular siltstone fragments to 0.1m	M<PL	VSt-H	Subsoil (B horizon)
1.8			End as required (slow digging) at 1.8m in B soil horizon (over Permian-age siltstone bedrock?)			

Strength: Hand penetrometer (kPa) 25 50 100 200 400; Shear Vane (kPa); Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) 2 4 6 8 10 12 14 16 18 20 22

Estimated in-situ CBR (%): 3 8 12 17 23 29 34 40 45 50

Notes: Samples and tests





D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit I

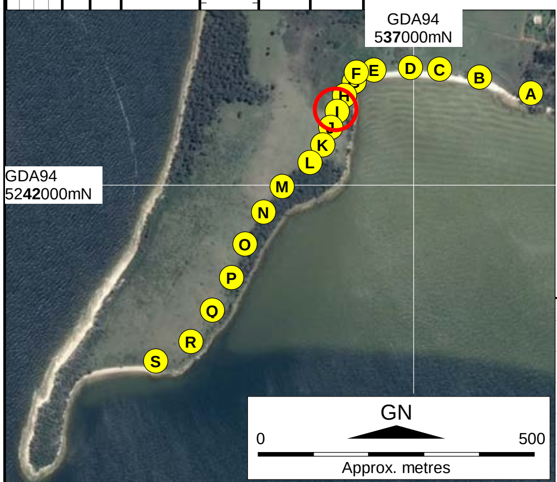
Sheet 1 of 1

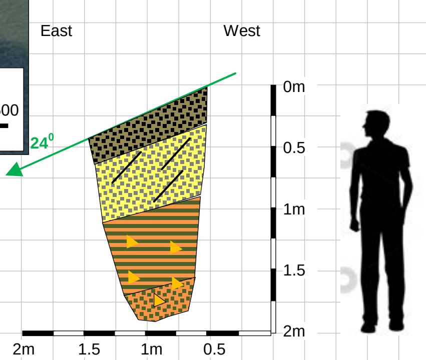
Project – Maria Point access driveway

Location

Coordinates	536867mE 5242156mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94			**Date logged**	30 July 2014
RL	Approx. 8m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 2.0 Length 1.5 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Strength: Hand penetrometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
		GNE		0–0.3		SP	SAND: dark grey	D-M	MD				Topsoil (A1 horizon)
				0.3–0.8 (0.5)		SP	Silty SAND: light yellowish grey; hardsetting	D	Fb-D				Topsoil (A2 horizon)
				0.8–1.6 (1, 1.5)		CL	Gravelly CLAY, CLAY: grey brown; mod to high plasticity; gravel is angular siltstone fragments; occasional clasts to 50mm	M<PL	VSt		DCP refusal on clasts	Estimated in-situ CBR (%): 3 8 12 17 23 29 34 40 45 50	Subsoil (B horizon)
				1.6–2.0 (2)		SP loc GW	Gravelly SAND: olive brown; trace clay; nonplastic to low plasticity	D-M	Fb-D-VD				Colluvium
							End as required at 2.0m in Quaternary colluvium (over Permian-age siltstone bedrock?)						





D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water

Water level

Water inflow

Water outflow

GNE = Groundwater not encountered

Penetration

1 2 3 4

No resistance

Refusal

Graphic log key

- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS / SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit J

Sheet 1 of 1

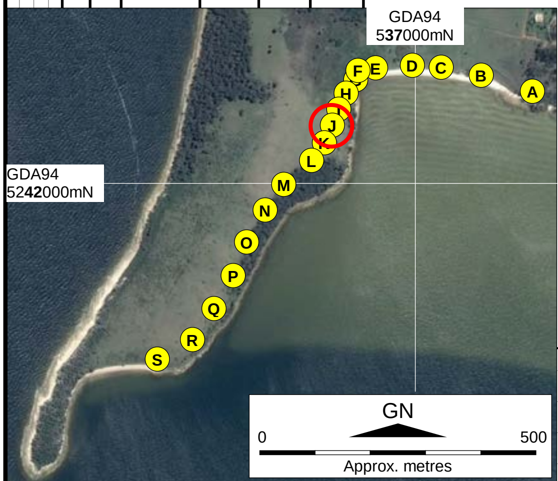
Project – Maria Point access driveway

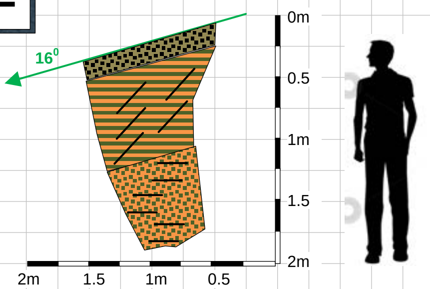
Location

Coordinates	536862mE 5242145mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 11m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.8 Length 1.5 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Hand penetrometer (kPa)	Shear Vane (kPa)	Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm)	Structure, geology and interpretation
		GNE		0–0.2		SP	Silty SAND: black	M	MD				Topsoil (A horizon)
				0.2–1.0		CH	Silty CLAY: olive brown; high plasticity; some sand increasing below 0.8m; gradational base	M<PL	VSt		108kPa@0.4 93kPa@0.6 176kPa@0.8 78kPa@1.0		Subsoil (B horizon)
				1.0–1.8		CL SP	Clayey SAND; locally silty SAND: olive brown; nonplastic to low plasticity near base	M	Fb-D				Extremely weathered bedrock (CB horizon)
				1.8			End as required at 1.8m (over Permian-age siltstone bedrock?)						

Depth scale: 0.5, 1, 1.5, 2. Hand penetrometer scale: 25, 50, 100, 200, 400. DCP scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22. Estimated in-situ CBR (%): 3, 8, 12, 17, 23, 29, 34, 40, 45, 50.





D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS
SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit K

Sheet 1 of 1

Project – Maria Point access driveway

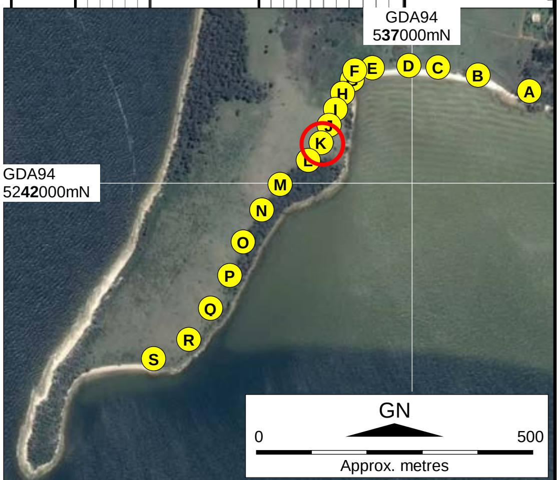
Location

Coordinates	536835mE 5242090mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 18m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 0.9 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

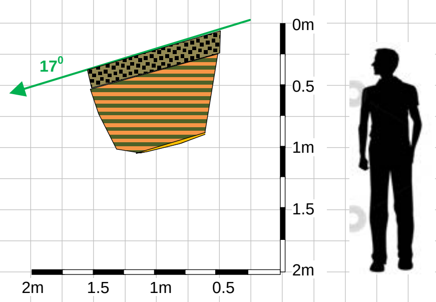
Penetration	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Strength: Hand penetrometer (kPa)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm)	Structure, geology and interpretation
		GNE		0–0.2		SP	Silty SAND: black; gradational base	M-W	L-MD		44kPa@0.2		Topsoil (A horizon)
				0.2–0.9		CH	CLAY: olive grey-brown; high plasticity; trace gravel and sand	M>PL	S-F		60kPa@0.4		Subsoil (B horizon)
								M<>PL	St-Vst		200kPa@0.6		
							SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; slightly weathered				130kPa@0.8		Siltstone bedrock
				0.9			Excavator refusal at 0.9m on Permian-age siltstone bedrock						

Depth scale: 0.5, 1, 1.5, 2, 2.5, 3, 3.5 m. Dynamic cone scale: 2 4 6 8 10 12 14 16 18 20 22. Hand penetrometer scale: 25 50 100 200 400.

Estimated in-situ CBR (%): 3 8 12 17 23 29 34 40 45 50



0.5m
V and H scale
0.5m



Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit L

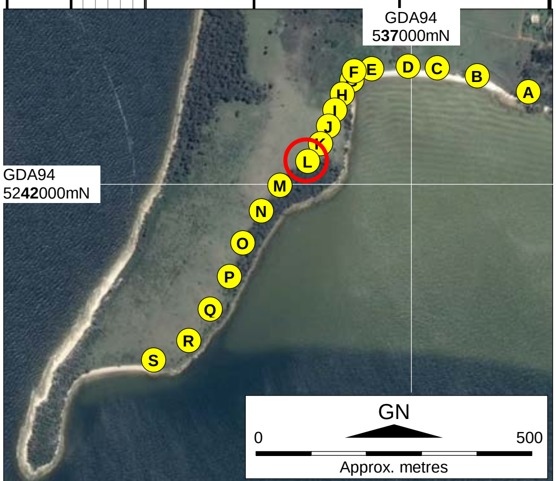
Sheet 1 of 1

Project – Maria Point access driveway

Location

Coordinates	536808mE 5242042mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 20m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 0.7 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth metres	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Strength: Hand penetrometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
		GNE				SP	Sandy SILT: dark grey;	M	Fb-F				Topsoil (A horizon)
						CH GC	CLAY: grey brown; high plasticity; some gravel and sand	M<>PL	VSt				Subsoil (B horizon)
				0.5			SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered						Siltstone bedrock
							Excavator refusal at 0.7m on Permian-age siltstone bedrock						
				1									
				1.5									
				2									
				2.5									
				3									
				3.5									



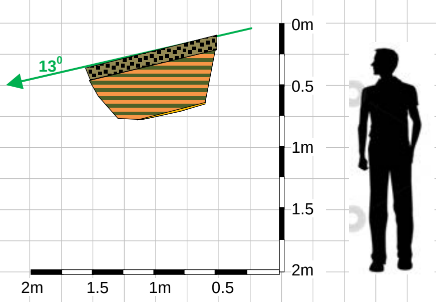
0.5m
V and H scale
0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

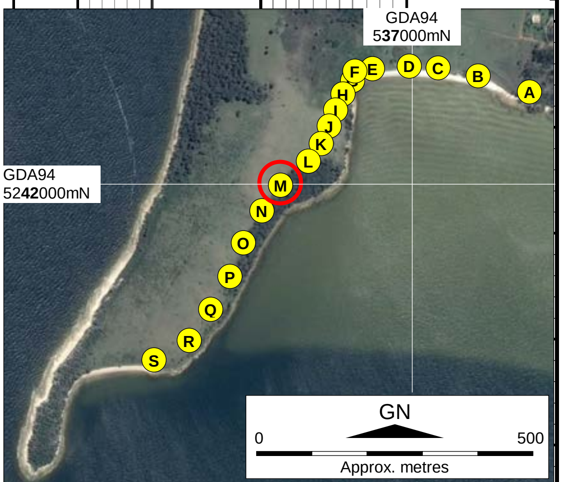
Pit M
Sheet 1 of 1

Project – Maria Point access driveway   Location

Coordinates	536766mE 5242001mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94			**Date logged**	30 July 2014
RL	Approx. 21m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m) Depth 1.0 Length 1.2 Width 0.6		**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Strength: Hand penetrometer (kPa)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm)	Structure, geology and interpretation
		GNE				SP	Sandy SILT: grey brown;	D	Fb				Topsoil (A1 horizon)
						GM	Silty GRAVEL: grey;	D	Fb-D		DCP refusal on pebble		Topsoil (A2 horizon)
				0.5		GC	Gravelly CLAY: brown; mod plasticity	M<>PL	VSt			Estimated in-situ CBR (%): 3, 8, 12, 17, 23, 29, 34, 40, 45, 50	Subsoil (B horizon)
							SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered						Siltstone bedrock
				1			Excavator refusal at 1.0m on stepped Permian-age siltstone bedrock						
				1.5									
				2									
				2.5									
				3									
				3.5									

Hand penetrometer scale: 25 50 100 200 400. DCP scale: 2 4 6 8 10 12 14 16 18 20 22.



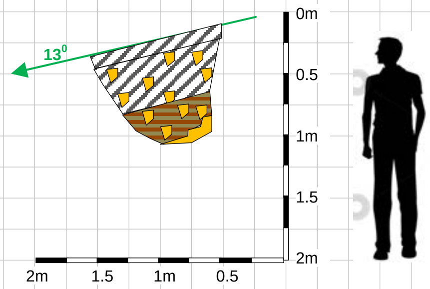
0.5m
V and H scale
0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit N

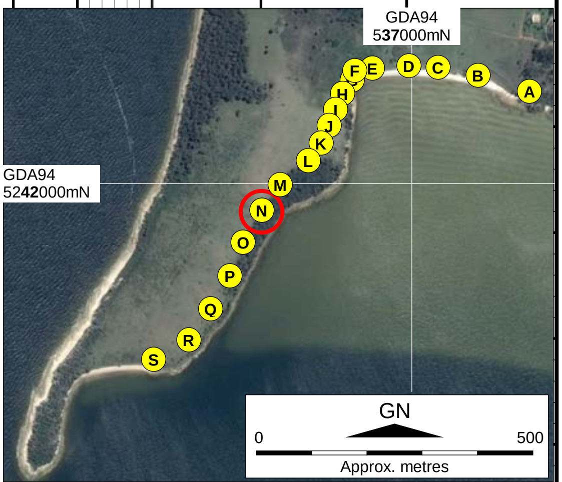
Sheet 1 of 1

Project – Maria Point access driveway

Location

Coordinates	536726mE 5242961mN	**Exposure type**	Excavator test pit	**Date dug**	30 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	30 July 2014
RL	Approx. 23m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.0 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth metres	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Strength: Hand penetrometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
		GNE				SP	Sandy SILT: grey brown;	D	Fb				Topsoil (A1 horizon)
						GM	Silty GRAVEL: grey;	D	Fb-D				Topsoil (A2 horizon)
				0.5									
						GC	Gravelly CLAY: brown; mod plasticity	M<>PL	VSt				
							SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered						Subsoil (B horizon)
				1									Siltstone bedrock
							Excavator refusal at 1.0m on stepped Permian-age siltstone bedrock						
				1.5									
				2									
				2.5									
				3									
				3.5									



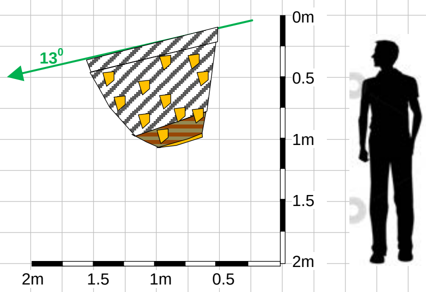
0.5m
V and H scale
0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS / SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit O

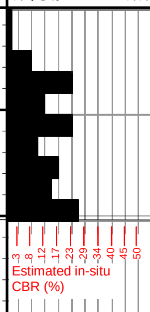
Sheet 1 of 1

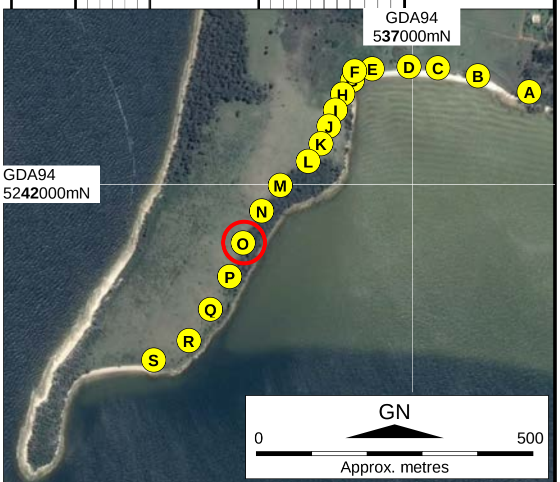
Project – Maria Point access driveway

Location

Coordinates	536698mE 5241906mN	**Exposure type**	Excavator test pit	**Date dug**	31 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	31 July 2014
RL	Approx. 21m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.0 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Strength: Hand penetrometer (kPa) (25 50 100 200 400)	Strength: Shear Vane (kPa)	Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) (2 4 6 8 10 12 14 16 18 20 22)	Structure, geology and interpretation
		GNE		0–0.5		SP	Silty gravelly SAND: black	M	MD				Fill? Topsoil (A1 horizon)
				0.5		GM	Silty GRAVEL: grey;	D	Fb-D				Topsoil (A2 horizon)
							Gravelly CLAY: brown; mod plasticity	M<>PL	VSt				Subsoil (B horizon)
						GC	SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered						Siltstone bedrock
				1			Excavator close to refusal at 1.0m on Permian-age siltstone bedrock; dip 3 deg to 180 deg True						
				1.5									
				2									
				2.5									
				3									
				3.5									





0.5m
V and H scale
0.5m

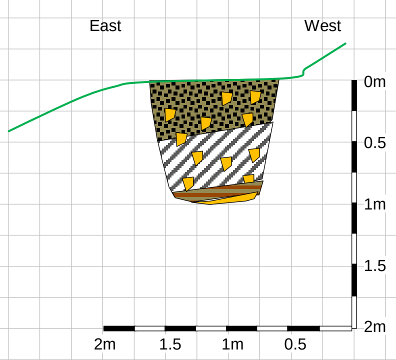
Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow

GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit P

Sheet 1 of 1

Project – Maria Point access driveway **Location**

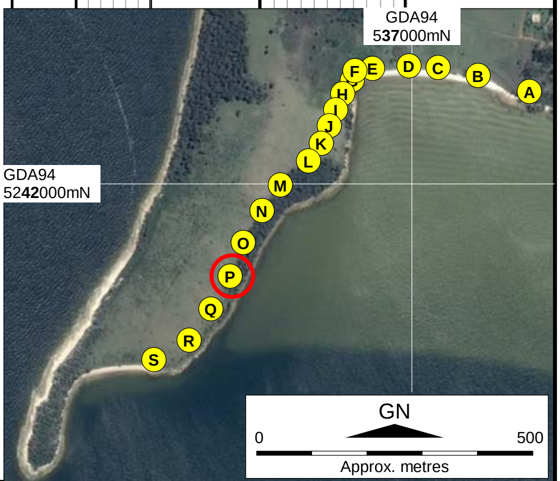
Coordinates	536664mE 5241846mN	**Exposure type**	Excavator test pit	**Date dug**	31 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	31 July 2014
RL	Approx. 19m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.2 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Depth (m)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Structure, geology and interpretation
0–0.5	SP	Silty gravelly SAND: black; trace glass	M	MD	Fill
0.5–1.2	GM	Gravelly SILT: light grey; some sand; nonplastic; occasional siltstone clasts to 0.3m; also, SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered	D	Fb-D	Siltstone bedrock
		End as required at 1.2m in Fill, with stepped siltstone bedrock exposed on upslope side of pit			

Water: GNE

Strength: Hand penetrometer (kPa) 25 50 100 200 400; Shear Vane (kPa); Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) 2 4 6 8 10 12 14 16 18 20 22

Estimated in-situ CBR (%) 3 8 12 17 23 29 34 40 45 50



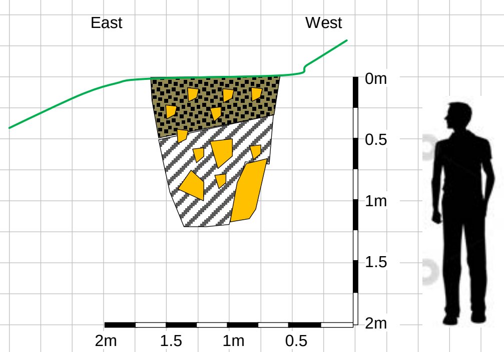
0.5m V and H scale 0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS, SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit Q Sheet 1 of 1

Project – Maria Point access driveway

Location

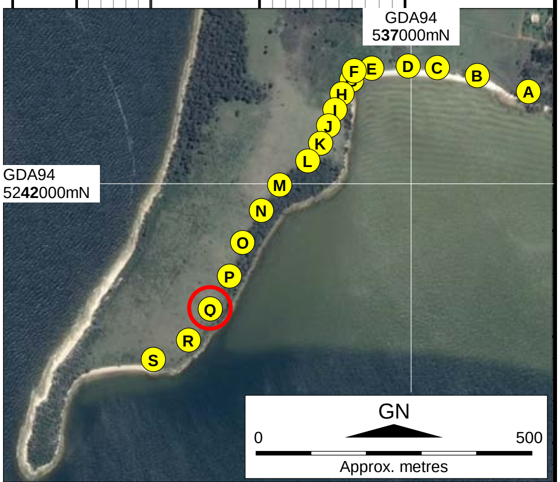
Coordinates	536648mE 5241788mN	**Exposure type**	Excavator test pit	**Date dug**	31 July 2014
Datum	GDA94			**Date logged**	31 July 2014
RL	Approx. 16m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.2 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Depth (m)	Water	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Structure, geology and interpretation
0 – 0.45	GNE	SP	Gravelly SILT: black; gradational base	M	MD	Fill
0.45 – 1.0		GM / GC	Gravelly SILT: light grey; some sand; with angular siltstone clasts to 0.15m	D	Fb-D	
1.0 – 1.2			Gravelly CLAY: olive brown; mod plasticity	M>PL	VSt	Subsoil (B horizon)
1.2			End as required at 1.2m close to Permian-age siltstone bedrock			

Strength: Hand penetrometer (kPa) 25 50 100 200 400; Shear Vane (kPa); Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm) 2 4 6 8 10 12 14 16 18 20 22

DCP refusal on clast

Estimated in-situ CBR (%) 3 8 12 17 23 29 34 40 45 50



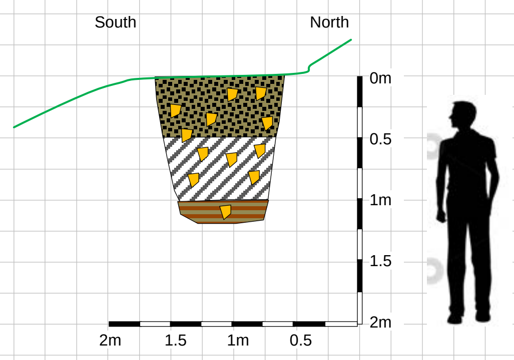
0.5m V and H scale 0.5m

Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal



Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit R

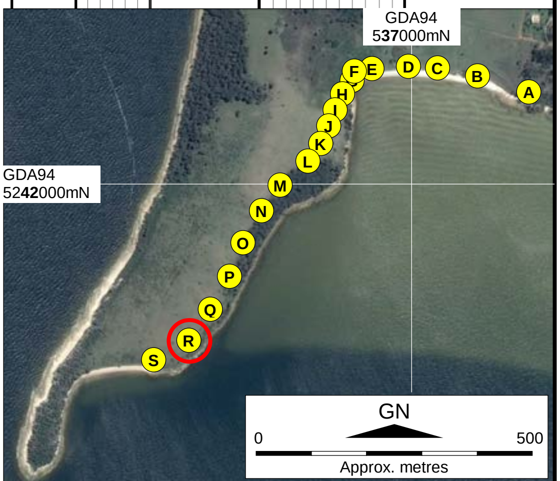
Sheet 1 of 1

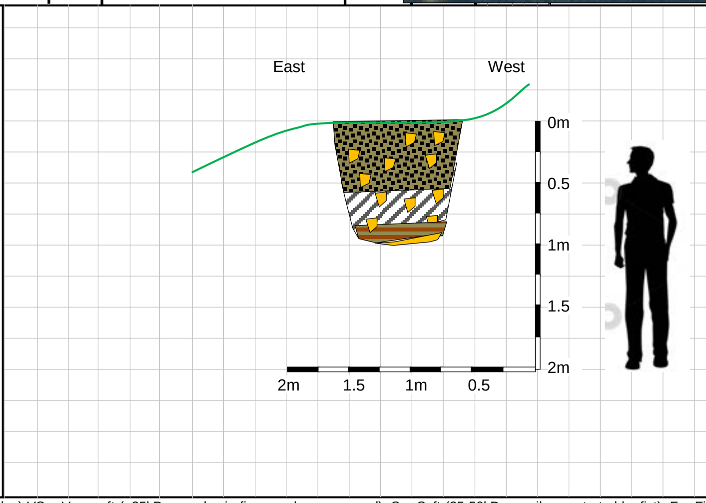
Project – Maria Point access driveway — Location

Coordinates	536608mE 5241728mN	**Exposure type**	Excavator test pit	**Date dug**	31 July 2014
Datum	GDA94	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Date logged**	31 July 2014
RL	Approx. 12m AHD			**Logged by**	W. C. Cromer
Dimensions (m)	Depth 1.0 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

Penetration	Support	Water	Notes (Samples and tests)	Depth (metres)	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency Density index	Hand penetrometer (kPa)	Shear Vane (kPa)	Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm)	Structure, geology and interpretation
		GNE		0–0.5	SP	Silty gravelly SAND: black; locally with small shell fragments	D-M	MD				Fill?
				0.5	GM	Gravelly SILT: light grey	D	Fb-D				
						Gravelly CLAY: olive brown; mod plasticity	M<PL	VSt				Subsoil (B horizon)
				–1	GC	SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered						Siltstone bedrock
				1		Excavator refusal at 1.0m on Permian-age siltstone bedrock						

Estimated in-situ CBR (%): 3 8 12 17 23 29 34 40 45 50





Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
CLAY (CH, CL)
SAND (SP)
SILT (SM)
GRAVEL (GP, GW)
COBBLES (63-200mm)
BOULDERS (>200mm)
SHELLS
SHELL FRAGMENTS
ROOTS
FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

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Excavation log

Pit S
Sheet 1 of 1

Project – Maria Point access driveway **Location**

Coordinates	536542mE 5241695mN	**Exposure type**	Excavator test pit	**Date dug**	31 July 2014
Datum	GDA94			**Date logged**	31 July 2014
RL	Approx. 8m AHD	**Equipment**	4.5t Komatsu with 0.45m GP bucket with 4 teeth	**Logged by**	W. C. Cromer
Dimensions (m)	Depth 0.9 Length 1.2 Width 0.6	**Operator**	Glen Edwards	**Checked by**	W. C. Cromer

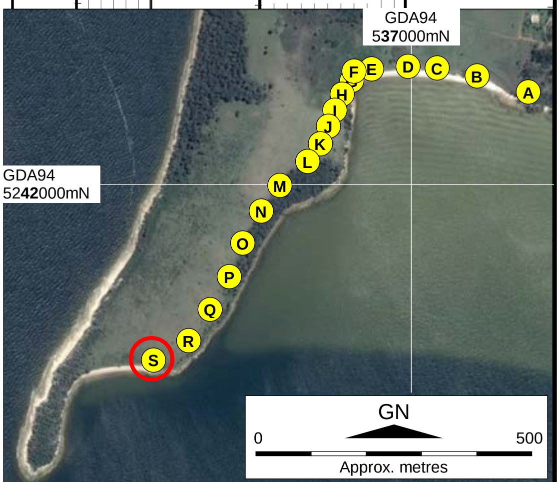
Penetration (1 2 3)	Support	Water	Notes (Samples and tests)	RL / Depth (metres)	Graphic log	USCS	Materials (Soil type, colour, plasticity or particle characteristics, secondary and minor components)	Moisture condition	Consistency / Density index	Strength: Hand penetrometer (kPa)	Strength: Shear Vane (kPa)	Strength: Dynamic cone penetrometer (9kg hammer falling 510mm) (Blows per 100mm)	Structure, geology and interpretation
		GNE		0–0.5		SP	Silty gravelly SAND: black; locally with small shell fragments	D-M	MD				Fill?
				0.5–0.9		SP	Silty SAND: yellow brown SILTSTONE: yellowish grey brown; subhorizontal; mod fractured; mod weathered	D	MD				CB horizon (weathered bedrock?) Siltstone bedrock
				1			Excavator refusal at 0.9m on Permian-age siltstone bedrock						

Hand penetrometer scale: 25 50 100 200 300 400

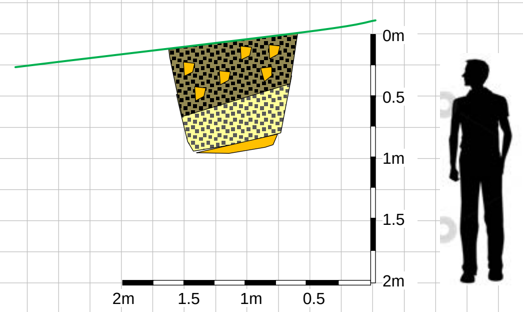
DCP scale: 2 4 6 8 10 12 14 16 18 20 22

Estimated in-situ CBR (%): 3 8 12 17 23 29 34 40 45 50

Depth scale (metres): 0.5, 1, 1.5, 2, 2.5, 3, 3.5



0.5m
V and H scale
0.5m



Moisture
D = Dry M = Moist W = Wet

Samples
D = disturbed; U50 = undisturbed; 50mm diameter drive tube (top & bottom depths shown)

Water
Water level
Water inflow
Water outflow
GNE = Groundwater not encountered

Penetration
1 2 3 4
No resistance
Refusal

Graphic log key
- CLAY (CH, CL)
- SAND (SP)
- SILT (SM)
- GRAVEL (GP, GW)
- COBBLES (63-200mm)
- BOULDERS (>200mm)
- SHELLS SHELL FRAGMENTS
- ROOTS
- FRACTURES

Consistency (silt, clay, sandy clay, silty clay) VS = Very soft (<25kPa; exudes in fingers when squeezed); S = Soft (25-50kPa; easily penetrated by fist); F = Firm (50-100kPa; easily penetrated by thumb); St = Stiff (100-200kPa; indented by thumb, penetrated with difficulty); VSt= Very Stiff (200-400kPa; easily penetrated by thumbnail); H = Hard (>400kPa; indented by thumbnail with difficulty); Fb = Friable (crumbles or powders when scraped by thumbnail)
Relative density (sand and gravel) VL = Very loose (ravelling); L = Loose (easy shovelling); MD = Medium dense (hard shovelling); D = Dense (picking); VD = Very dense (hard picking)

Attachment 6

(24 pages)

Site and test pit photographs (8, 30 and 31 July 2014)

The staff is graduated in 1m long white and yellow segments. The numbers on it are decimetres.

Plate 1 (above). View west across the western corner of Mortimer Bay towards test pit B.

Plate 2 (below). View west from near test pit A over a shore platform of Permian-age siltstones dipping WSW at about 8^0. The rocks form the bedrock of the Maria Point peninsula, and are generally slightly weathered, moderately fractured, and high strength.

Plate 3 (above). View east from near test pit D. The low-lying ground about 1m AHD is underlain by about 1 00150 1.5m of aeolian and beach sand overlying estuarine clay. The sands contain in-situ shell lenses and horizons, and a water table is present at about mean sea level.

Plate 4 (below). View east from near test pit E towards steeper ground composed of aeolian sand and silty sand probably locally up to 2 – 3m thick, overlying Permian-age siltstone bedrock. The yellow dashed line is the (very approximate) outline of a probable shallow translational landslide in aeolian sand and silty sand.

Plate 5 (above). View north towards test pits F and G. Siltstone bedrock was present in the base of test pit F at 2m, and beach shingle similar to that in the foreground was exposed in test pit G at 1.6m. The yellow dashed line is the (very approximate) northeastern limit of a probable shallow translational landslide in aeolian sand and silty sand. The dark-coloured silty sand soil is (a) probably moving downslope very slowly, and (b), is being removed at about the same rate by marine erosion.

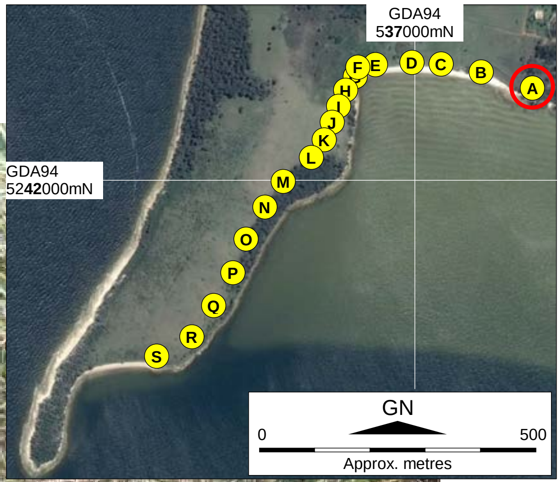
Plate 6 (below). View north from near test pit I.

Plate 7 (above). View N showing subhorizontal Permian-age siltstones and sandstones dipping WSW – a similar attitude to the same rocks exposed near test pit A.

Plate 8 (below). View NNE towards test pit J. The hillside shown here is composed of Quaternary-age colluvial deposits of silty gravelly clay and clayey sand up to about 2m thick overlying Permian-age siltstone.

Plates 9 (above) and 10 (below). Views SSW towards Maria Point, along an abandoned, formed access track, near test pits P and Q. Fill up to about 1.2m thick (in test pits P and Q) forms the outer eastern side of the track. The undisturbed ground comprises silty gravelly sand soils up to a metre thick, over subhorizontal Permian-age siltstone.


MARIA PT
PTY LTD
GEOTECHNICAL
30 JULY 14
PIT A


GDA94
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GDA94
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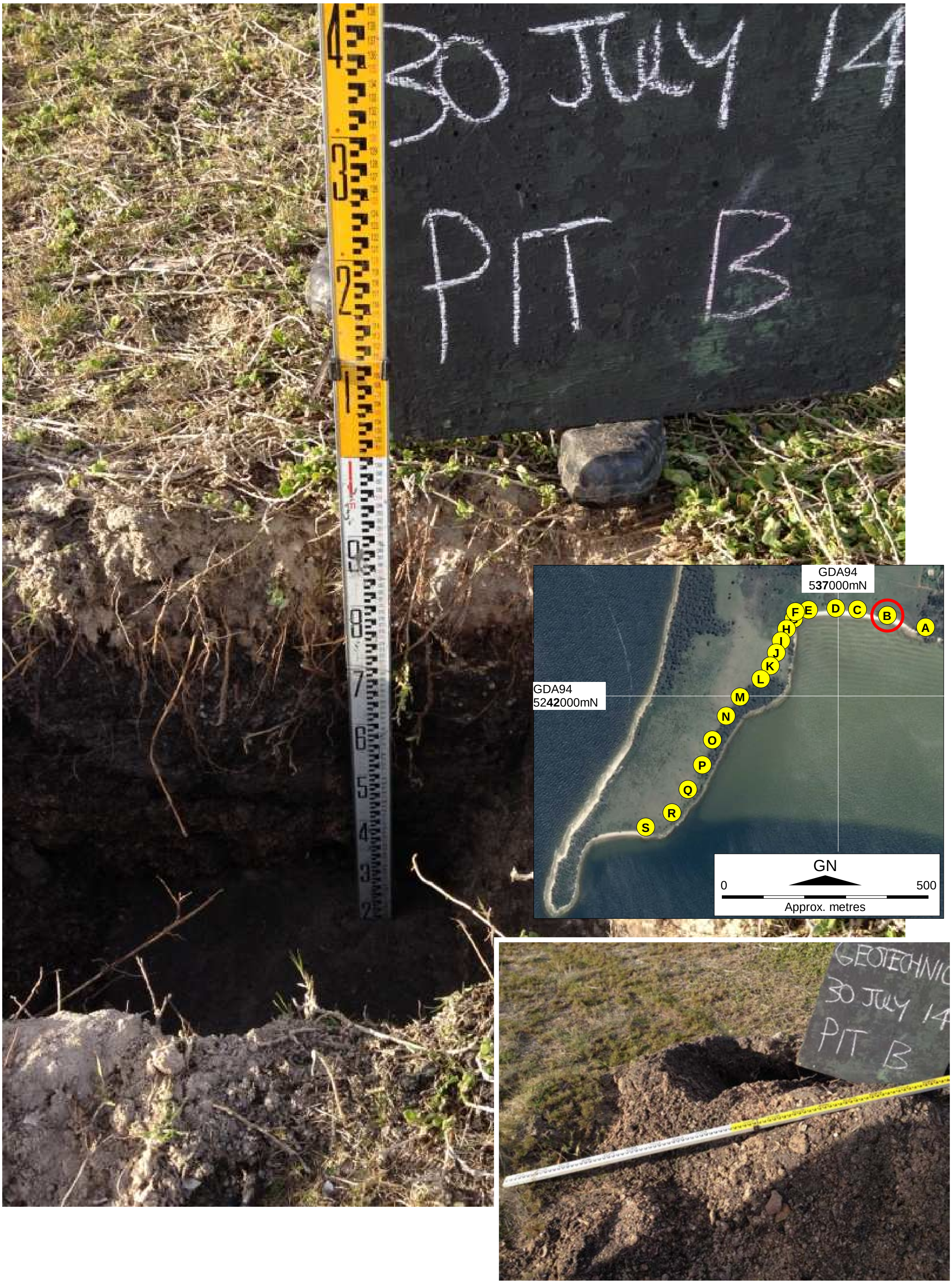
500
Approx. metres


MARIA PT
PTY LTD
GEOTECHNICAL


30 JULY 14
PIT B
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Approx. metres
30 JULY 14
PIT B


PTY LTD
GEOTECHNICAL
30 JULY 14
PIT C
GDA94
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GDA94
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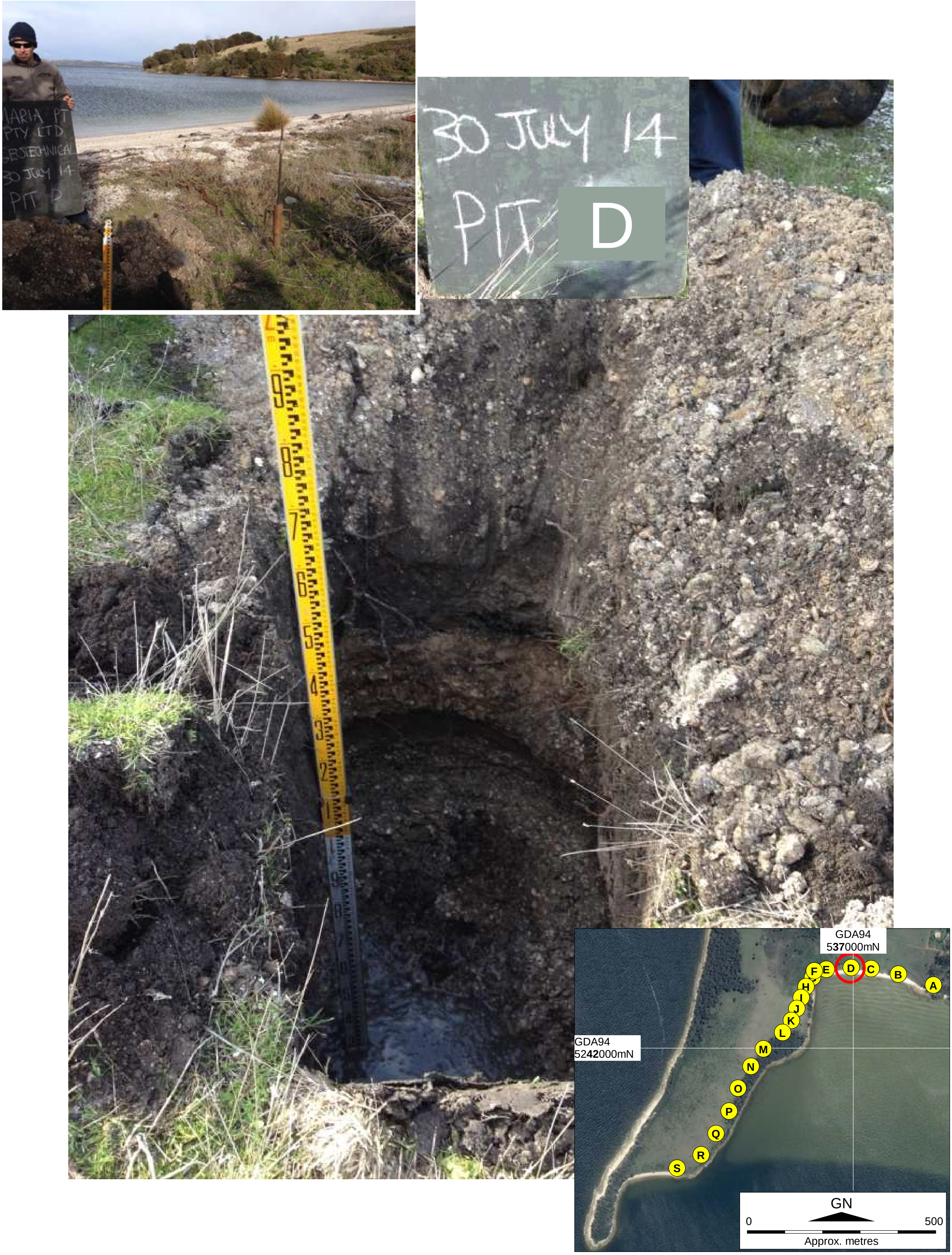
Approx. metres


30 JULY 14
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M
N
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Q
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GN
0
500
Approx. metres


30 JULY 14
PIT
E
PTY LTD
GEOTECHNICAL
30 JULY 14
GDA94
537000mN
GDA94
5242000mN
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B
C
D
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F
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I
J
K
L
M
N
O
P
Q
R
S
GN
0
500
Approx. metres


PTY LTD
GEOTECHNICAL
30 JULY 14
PIT F


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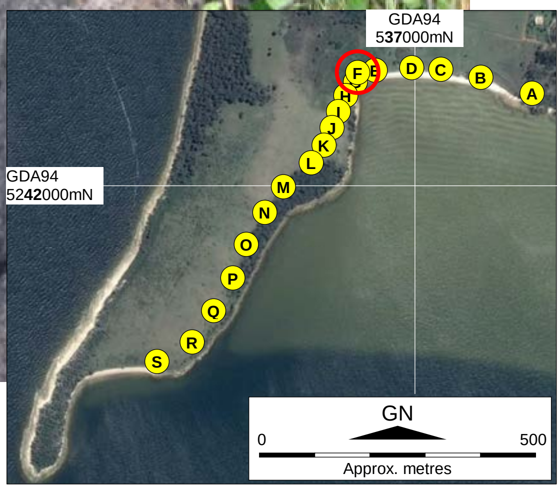
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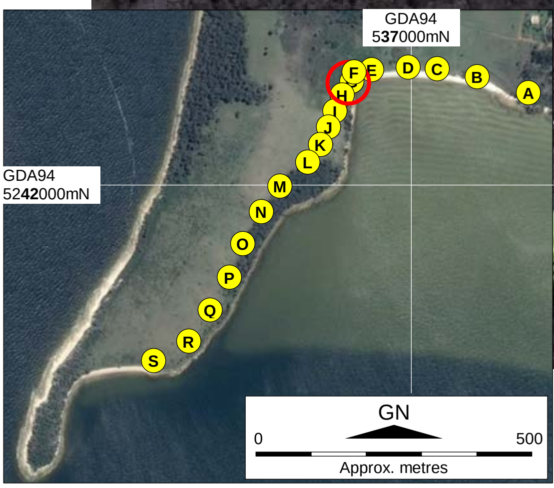
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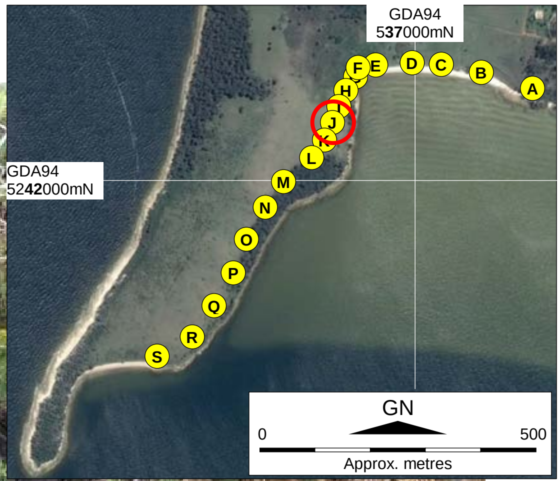
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Attachment 7

(7 pages)

Geology, soils, surface drainage and groundwater

7.1 Geology

Published geology

The published geology[8] of the area (Attachment 2) shows that shallowly W to WSW-dipping Permian siltstone and sandstone of the Abels Bay Formation underlies the western end of Mortimer Bay, including Maria Point, and the study strip described in this report.

Low-lying ground behind the beach at the end of Rifle Range Road is underlain by undifferentiated Quaternary unconsolidated beach, aeolian, estuarine and alluvial sediments.

Observed geology

Observations support the published geology.

Bedrock

Siltstone and fine-grained sandstone dipping at about 8^0 to the WSW is exposed on the shore platform near test pit A, and similar rocks crop out between high and low water mark on the eastern side of the Maria Point headland, from test pit H to S.

Siltstone bedrock was also exposed at an average depth of 1m (range 0.7 – 2m) in test pits A, B, F, K, L, M, N, O, P, R and S.

Quaternary sediments

Unconsolidated beach sand was encountered in test pits B, C, D and E. In pit B, the sand rested directly on siltstone bedrock. In pits D and E, it overlaid olive green clay interpreted as estuarine.

Aeolian sand, locally organic, was exposed in test pits F and G. In the latter, it rested on sandy beach shingle.

Quaternary colluvium

Material interpreted as colluvial in origin was exposed in test pits H, I and J (Attachments 5 and 6), where it typically consists of gravelly sand (GW), and clayey sand (SC, CL). The colluvium is nonplastic or of low plasticity, dry to moist, and friable and dense.

The colluvium is probably no more than a meter or two thick, overlying Permian sedimentary rocks.

7.2 Recent fill

In Section 3, the abandoned access track comprises fill up to about 1.2m thick along its outer edge (see the logs of test pits P, Q, and R in Attachment 5, and their photographs in Attachment 6).

No other instances of significant fill were observed.

7.3 Interpreted geological map and cross sections

Figure 8.4 in Attachment 8 presents conceptual cross sections across Section 2 of the study strip, which are consistent with site observations but which may need to be amended as more information becomes available.

[8] Calver, C. R. and Latinovic, M. (compilers) 2002. Digital Geological Atlas 1:25,000 Scale Series. Sheet 5224. Taroona. Mineral Resources Tasmania.

7.4 Soils

Soil texture and thickness

Section 1 soils comprise uniform sandy (SP) profiles a metre or so thick, overlying siltstone bedrock or estuarine clay (Attachments 5 and 6).

Section 2 soils at test pits E, F and G are uniform profiles of aeolian sands over siltstone bedrock or beach shingle. Test pits H, I and J exposed duplex profiles up to about 1.5m thick consisting of a dark-coloured topsoil sand (SP) over subsoil clay (CH) or gravelly clay (GW), usually overlying colluvium.

Section 3 soils, where undisturbed by former access track construction, are duplex profiles up to about 1m thick consisting of a dark-coloured topsoil silty sand (SP) over subsoil clay (CH) or gravelly clay (GW), overlying siltstone bedrock.

Soils along the study strip plot towards the sand apex of the sand – silt – clay soil clafficiation triangles in Figure 7.1.

Reactivity of materials

No subsurface materials were tested for reactivity[9].

Bearing capacity of materials

Undrained shear strength testing of materials in and next to most test pits was conducted by shear vane testing and dynamic cone penetrometer (DCP) profiling. Results are recorded on the test pit logs in Attachment 5, where the DCP profiles were also correlated with California Bearing Ratio (CBR) values (Tables 7.1 and 7.2). This testing has shown that surface materials along the study strip are of low strength, with DCP values (blows/l00mm) are often less than 2, and CBR (%) less than 3.

A range of DCP and CBR was recorded for subsurface clays, colluvium and aeolian sand, with DCP refusal on bedrock.

These strength testing results will be useful guides for pavement design for the access road.

Tunnel erosion and soil dispersion

No instances of tunnel erosion (suggestive of dispersive soils) were noted during site investigations.

Surface infiltration rates

Table 7.3 provides guidance on infiltration rates (from rainfall). All surface soils observed along the study strip (ie sand, silty sand), of loose to medium dense relative density.

In Section 1, infiltration rates are expected to be in the 20 – 30mm/hour range. On steeper ground in Sections 2 and 3, rates might be less than 10mm/hour.

For drainage design works, these infiltration rates might usefully be combined with the rainfall intensity-frequency-duration curves (Figure 3 in the body of the report).

Table 7.3 is also in general accord with application ("design loading") rates for absorption trenches and beds in Table L1 of AS/NZS1547:2012 *On-site domestic wastewater management*, and would be applicable to the design of diffusion/retention trenches which may be required along the proposed access road.

7.5 Surface drainage

Section 1

A Class 3 or 4 watercourse[10], with a catchment area of some 50ha and stream length of about 500m, crosses Section 1. The creek is probably intermittent, and has been dammed along its length in several places.

9 Reactive materials contain clays which shrink and swell in volume when their moisture content decreases or increases respectively.

Section 2

It is reported than a seepage/spring line crosses Section 2, probably between test pits E and H. There was no obvious surface expression observed during the current investigations. The catchment area is likely to be about a hectare.

Section 3

No drainage lines were observed along Section 3. Surface drainage is via diffuse runoff.

Table 7.1 Correlations between soil strength testing results and CBR values

Consistency	Field Test	Undrained Shear Strength c_u	Unconfined Compressive Strength q_u	Dynamic Cone Penetrometer blows/100 mm *	CPT Resistance MPa	CBR (%)	Estimated safe bearing capacity for shallow footings (kPa) (Factor of Safety = 2.5)
		Torvane (kPa)	Pocket Penetrometer (kPa) **				
Very soft	Easily penetrated >40 mm by thumb. Exudes between thumb and fingers when squeezed in hand.	<12	<25	<1	<0.2	<1	<25
Soft	Easily penetrated 10 mm by thumb. Moulded by light finger pressure	12 - 25	25 - 50	1	0.2 - 0.4		25 – 50
Firm	Impression by thumb with moderate effort. Moulded by strong finger pressure	25 - 50	50 - 100	1-2	0.4 - 0.8	1 – 3	50 – 100
Stiff	Slight impression by thumb cannot be moulded with finger.	50 - 100	100 - 200	2 -4	0.8 - 1.5	3 – 8	100 – 200
Very Stiff	Very tough. Readily indented by thumbnail.	100 - 200	200 - 400	4 - 8	1.5 - 3.0	8 – 17	200 – 400
Hard	Brittle. Indented with difficulty by thumbnail.	>200	>400	>8	>3.0	>17	>400

Table 7.2 Typical values for California Bearing Ratio (CBR)

Material	USC soil symbol	Description	CBR range (%)
Crushed stone	GW, GP, GM	Gravel, variably graded, silty	20 – 100
Coarse grained soils	GW	Gravel, well graded	40 – 80
	GP	Gravel, poorly graded	30 – 60
	GM	Gravel, silty	20 – 60
	GC	Gravel, clayey	20 – 40
	SW	Sand, well graded	20 – 40
	SP	Sand, poorly graded	10 – 40
	SM	Sand, silty	10 – 40
	SC	Sand clayey	5 – 20
Fine grained soils	ML	Silt, low plasticity	<=15
	CL	Clay, low plasticity	<=15
	OL	Organic silt, low plasticity	<=5
	MH	Silt, high plasticity	<=10
	CH	Clay, high plasticity	<-=15
	OH	Organic silt, high plasticity	<=5

[10] Watercourse classification in accordance with Table 8 of the Forest Practices Code (2000). See Forest Practices Board (2000). Class 1 watercourses are rivers, lakes, etc named on 1:100,000 topographic maps; Class 2 watercourses exclude Class 1 types and have catchments greater than 100ha; Class 3 watercourses have catchments between 50 and 100ha; Class 4 watercourses have catchments less than 50ha.

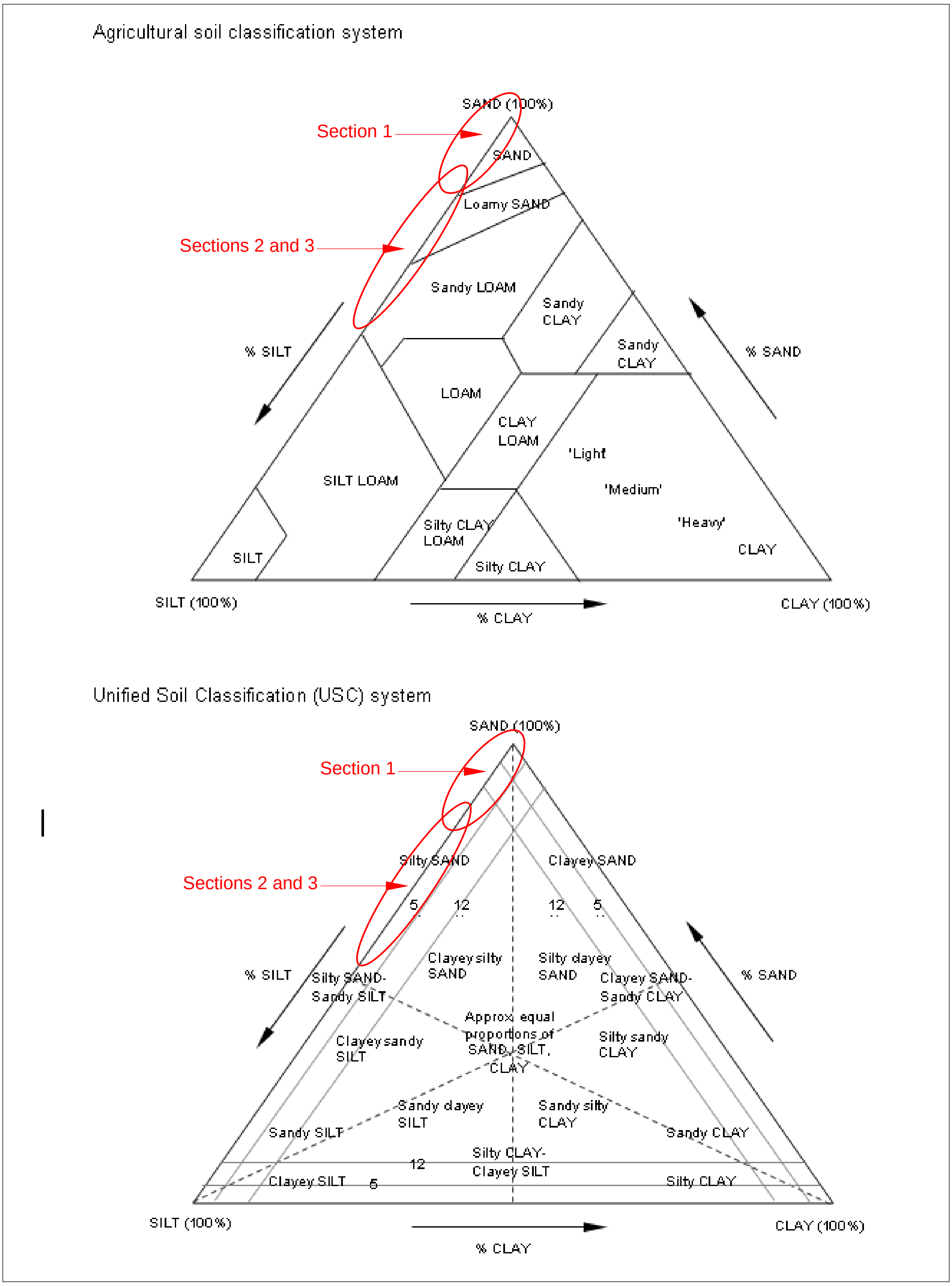

Figure 7.1 **Soils along the study strip are sand and silt dominated, plotting as SAND and loamy SAND in the agricultural system, and SAND and silty SAND in the USC system**

Table 7.3 **Soils along the study strip are sand and silt dominated (inside red border), and are expected to exhibit infiltration rates up to about 30mm/hour depending on slope angle.**

USC System	Agricultural class system	Slope angle (degrees) 0 – 3	3 – 5	5 – 7	7 – 9	>9
		Infiltration rate (mm/hour)				
SAND	Coarse Sand	32	25	19	13	8
SAND	Medium Sand	27	22	16	11	7
SAND	Fine Sand	24	19	14	10	6
SAND with some silt and clay	Loamy Sand	22	18	13	9	6
Clayey silty SAND and silty clayey SAND	Sandy Loam	19	15	11	8	5
Clayey silty SAND and silty clayey SAND	Fine Sandy Loam	16	13	10	6	4
Clayey silty SAND and silty clayey SAND	V. Fine Sandy Loam	15	12	9	6	4
SILT-SAND-CLAY in roughly equal proportions	Loam	14	11	8	6	4
Clayey sandy SILT, sandy clayey SILT and sandy SILT	Silt Loam	13	10	8	5	3
Silt	Silt	11	9	7	5	3
Sandy Clay	Sandy Clay	8	6	5	3	2
SILT-SAND-CLAY in roughly equal proportions	Clay Loam	6	5	4	3	2
Silty Clay	Silty Clay	5	4	3	2	1
Clay	Clay	3	3	2	1	1

Adapted from http://qcode.us/codes/sacramentocounty/view.php?topic=14-14_10-14_10_110&frames=on
USC = Unified Soil Classification

7.6 Groundwater

Groundwater in unconfined, fractured rock aquifers

Permanent groundwater is known to be present under unconfined conditions in fractured bedrock types in the district (Figure 7.2). The groundwater is recharged by infiltrating rain and at intermediate scale discharges to Mortimer Bay.

Shallow groundwater in unconfined sediments

Sections 1 and 2

Shallow groundwater was observed in aeolian and beach sands in test pits B, C, D, E and G. No water table depths were recorded since water inflow was continuing when the pits were backfilled. Nevertheless, a permanent water table is expected to be present in these materials at depths close to mean sea level, but fluctuating with tidal level immediately adjacent to the coast. Gradients are low, and groundwater flow rates correspondingly low and towards the coast.

Section 3

Shallow groundwater is not expected to be present, except in saturated soils above bedrock after rain.

7.7 Slope stability

Landslide risk

See Attachment 8 for a Landslide Risk Management assessment of Section 2 of the study strip.

Cut and fill batters for construction of the access road

Depending on engineering design, cut and fill along the access road is likely to be required in parts of Section 2 of the access road route. Inspection of the logs for pits H – K (Attachment 5) indicates that cuts of more than a metre or so will expose moderate to high plasticity subsoil clay.

Table 7.4 suggests that appropriate cut and fill batter angles for these subsoils will be in the 18 – 26^0 range (3:1 to 2:1 horizontal:vertical), but using drained, engineered retaining walls will partly or fully obviate the need for cut batters. For example, a wall which supports a clay subsoil but leaves exposed the coarser sand topsoil will permit the batter angle to be relaxed to about 34^0.

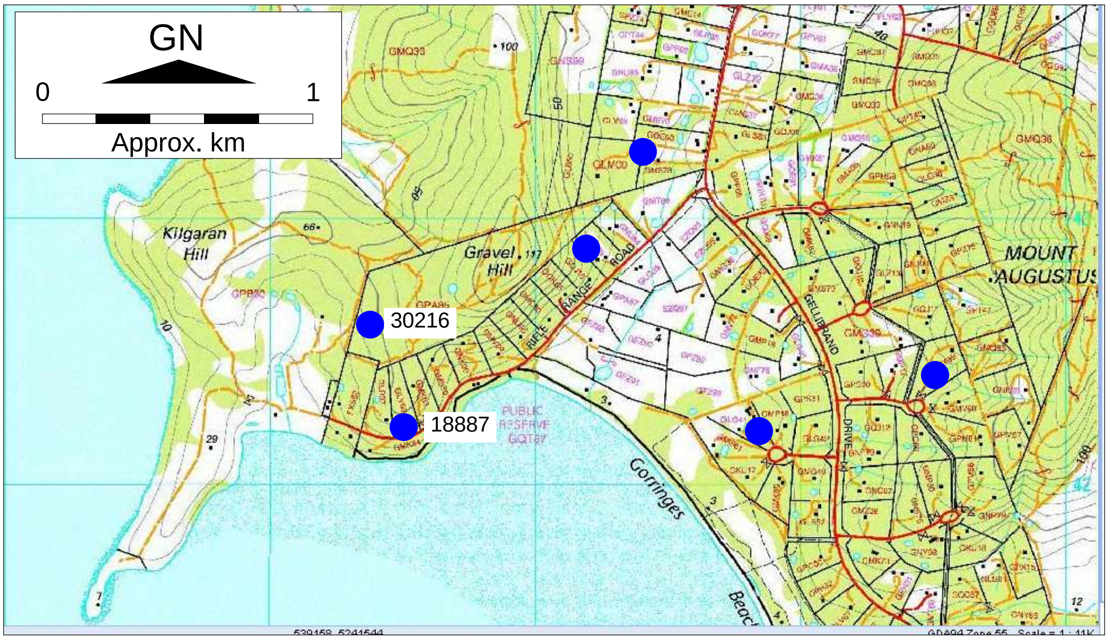

Figure 7.2 **Recorded water bores (blue circles) in the vicinity of the study strip. The two closest ones are bore 18887 (drilled 1985; 61m deep into Permian rocks; water table at 12m; initial yield 0.37L/sec), and bore 30216 (abandoned; drilled 91m into Permian rocks in 2003).**
Source: http://wrt.tas.gov.au/groundwater-info/

Table 7.4 **Cut and fill along parts of Section 2 of the proposed access road will expose moderate to high plasticity clay subsoils (bordered in red), which, if not supported by engineered, drained retaining walls, may require batter angles of18 – 26^{0} range (3:1 to 2:1 horizontal:vertical).**

	Slope ratio (Hor:Vert)	Slope angle (degrees)	Section
Most rock	1/4:1 to 1/2:1	76 to 63	
Very fractured rock	1:1 to 1.5:1	45 to 34	
Soils (very well cemented)	1/4:1 to 1/2:1	76 to 63	
Most in-place soils	3/4:1 to 1:1	53 to 45	
Loose coarse granular soils	1.5:1	34	
Heavy clay soils	2:1 to 3:1	26 to 18	
Soft clay-rich zones or wet seepage areas	2:1 to 3:1	26 to 18	
Fills of most soils	1.5:1 to 2:1	34 to 26	
Fills of hard angular rock	1.3:1	37	
Low cuts and fills (<2-3m high)	2:1 or flatter	26 or less	

Source: Slope Stabilization and Stability of Cuts and Fills
http://www.blm.gov/bmp/low%20volume%20engineering/M_Ch11_Slope_Stabilization.pdf

Attachment 8
(9 pages)
Landslide Risk Management

This Attachment addresses slope stability (landslide) issues for Section 2 of proposed access road (between test pits E and I), in accordance with Australian Geomechanics Society (AGS) Landslide Risk Management (2007)[11]. The process is depicted in Figure 8.1.

The main types of landslide movement are shown in Figure 8.2 and listed in Table 8.1.

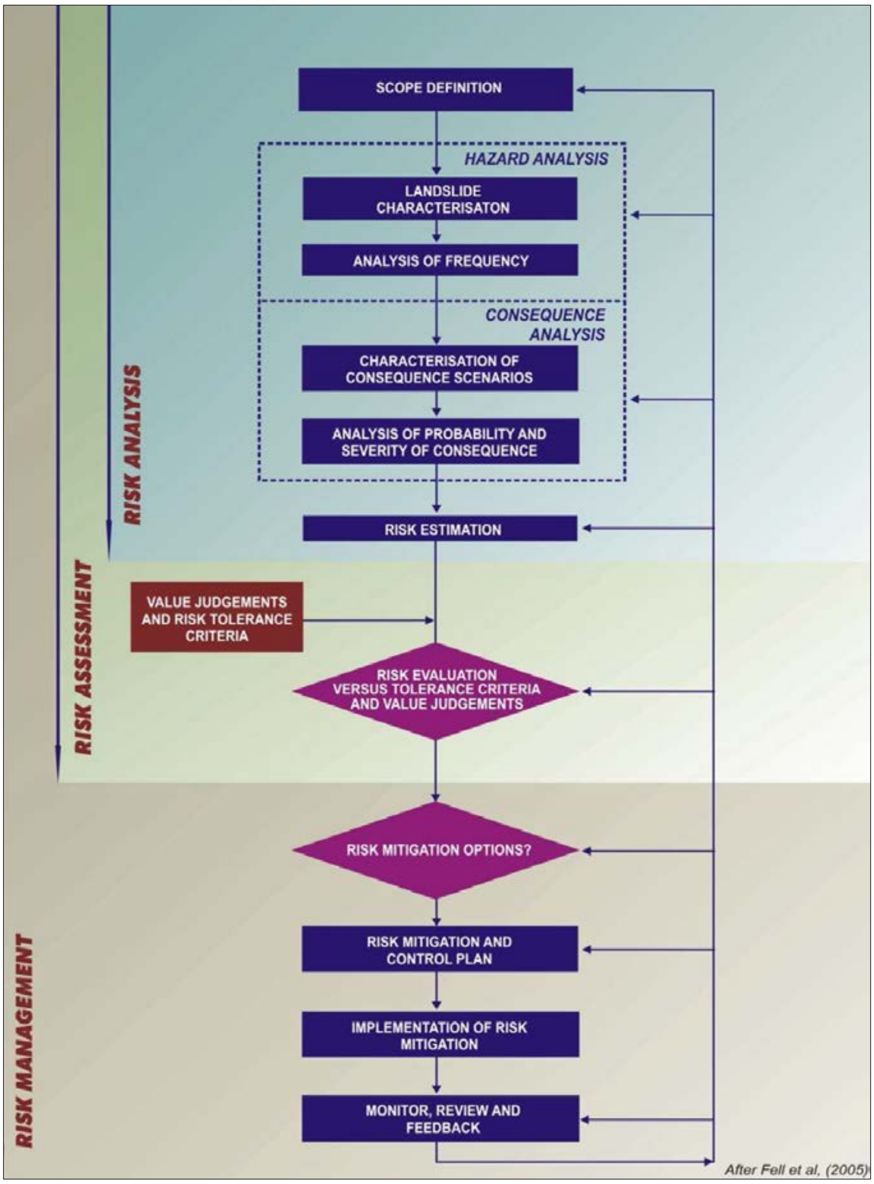

Figure 8.1. Framework for Landslide Risk Management
Source: Reproduced without amendment from AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007

[11] The five AGS documents are:
AGS (2007a). Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007b). Commentary on Guideline for Landslide Susceptibility, Hazard and Risk Zoning. Australian Geomechanics, Vol 42 No 1 March 2007
AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007d). Commentary on Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007
AGS (2007e). The Australian Geoguides for Slope Management and Maintenance. Australian Geomechanics Vol 42 No 1 March 2007

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

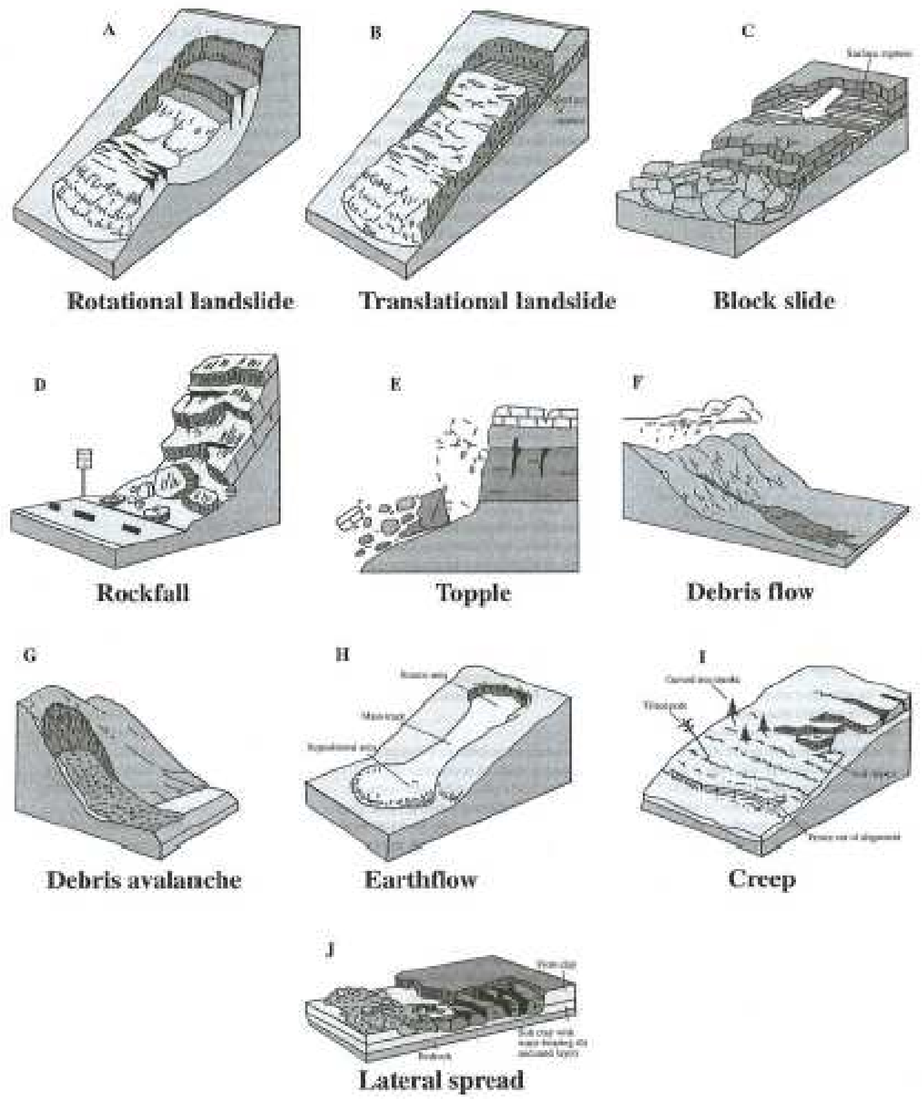

Figure B1: These schematics illustrate the major types of landslide movement.
(From US Geological Survey Fact Sheet 2004-3072, July 2004, with kind permission for reproduction.)

The nomenclature of a landslide can become more elaborate as more information about the movement becomes available. To build up the complete identification of the movement, descriptors are added in front of the two-term classification using a preferred sequence of terms. The suggested sequence provides a progressive narrowing of the focus of the descriptors, first by time and then by spatial location, beginning with a view of the whole landslide, continuing with parts of the movement and finally defining the materials involved. The recommended sequence, as shown in Table B2, describes activity (including state, distribution and style) followed by descriptions of all movements (including rate, water content, material and type). Definitions of the terms in Table B2 are given in Cruden & Varnes (1996).

Figure 8.2 **Main types of landslide movement**
Source: From Appendix B of AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

Table 8.1 Main types of landslide movement. Site investigations demonstrate that only earthslides and debris slides (bordered in red) are credible types of slope failures along the study strip.
Source: From Appendix B of AGS (2007c). Practice Notes Guidelines for Landslide Risk Management. Australian Geomechanics Vol 42 No 1 March 2007

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly Coarse	Predominantly Fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (Deep creep)	Debris flow (Soil creep)	Earth flow
COMPLEX	Combination of two or more principle types of movement			

LANDSLIDE RISK MANAGEMENT (LRM)

8.1 Preliminary

Field investigations demonstrate that of the landslide types listed in Table 8.1, only earthslides and debris slides are credible forms of actual or potential slope failure along the study strip. Further, these two types are considered not credible in Section 1, and unlikely in Section 3.

Accordingly, this LRM relates only to Section 2.

Desktop review of slope instability

Unpublished evidence

I am unaware of any unpublished reports referring to slope stability issues in the vicinity of Section 2, other than the Proof of Evidence provided by Pollington (2014)[12] which described a landslide in Section 2.

Published evidence

I am unaware of any published reports relating to slope stability issues in the vicinity of Section 2 (or indeed, in Sections 1 and 3 also).

More recently, landslide hazard band maps covering all of Tasmania have been released by the Department of Premier and Cabinet, using data provided by Mineral Resources Tasmania, and are available at www.thelist.tas.gov.au. The landslide hazard banding for the proposed access road, reproduced here in Attachment 2, shows Section 1 to lie within the Acceptable band[13], and Sections 2 and 3 to be mostly in the Low band.

Field evidence

Visual inspection, and test pit F, is inconclusive but topographically the feature in Section 2 identified by Pollington resembles a landslide[14]. Satellite imagery (Figure 8.3) suggests it may be two smaller features (SW and NE parts) which appear to have involved failure of aeolian

[12] Pollington, M. (2014. 742, 750, 765 & 845 Rifle Range Road, Sandford. Proof of Evidence to RMPAT (16 May 2014)

[13] Acceptable band: A landslide is a rare event based on current understanding of the hazard, but it may occur in some exceptional circumstances.
Low band: The area may include landslide features but their activity is unknown, and they have been judged by MRT to rank of lesser risk than those in higher bands.

[14] It has been suggested to me that the feature may be a borrow area for sand. Figure 8.3 shows what appears to be a near-horizontal track leading from the feature(s) towards the nearby waterhole and abandoned house, which is not inconsistent with this origin. But the borrowing operations might have been subsequent to landsliding. The site is thickly covered with and obscured by low vegetation, so it is not possible to visually distinguish between the two origins without more detailed geotechnical work (including geomorphological mapping and subsurface investigation). For the purposes of this report, the feature(s) is assumed to be landsliding, and assessed as such.

sand and silty sand on 20 – 28^0 slopes. Test pit F shows that the unconsolidated materials overlie siltstone bedrock.

Instability in sandy material on slope angles like these is somewhat unusual, but it is reported that seepage water, which may have promoted instability, is present. The northern and southern flanks are topographically ill-defined, but one or more short internal segments are steep-sided and appear to be head scarps. There is no well-defined toe at the base (test pit G exposed 1.5m of aeolian sand over beach shingle).

Silty sand exposed at the rear of the beach is currently being eroded by marine action.

Technically, the features are inferred to be small, slow-moving rotational, active[15] earthslides. They are collectively called Scenario 1 in the conceptual and schematic geological cross section in Figure 8.4.

Elsewhere in Section 2, there are no obvious signs of slope instability. Nevertheless, a credible form of failure – here termed Scenario 2 – involves colluvial materials over bedrock.

Site investigations
Site investigations relied on in this LRM are described in Attachments 3, 4, 5, 6 and 7 to this report.

Site plans and maps
Site plans and maps are included in several Attachments to this report.

8.2 Site sections (natural scale) and conceptual geological models

Figure 8.4 provides two natural-scale cross sections (conceptual models) through slopes in Section 2.

8.3 Hazard Analysis

Landslide characterisation
Figure 8.4 schematically shows potential forms or scenarios (red lines) of landslide movement in Section 2.

> **Scenario 1**
> Small-scale, slow moving rotational or translational earthslide in aeolian sand
>
> **Scenario 2**
> Small- to medium scale, slow moving translational earthslide or debris slide in colluvium

Frequency analysis
Table 8.2 (this Attachment) lists the subjective likelihood of occurrence of the landslide hazards shown in Figure 8.4 under post-development conditions, having due regard to the geotechnical investigations described in the present report. Terminology for measures of likelihood and consequences to property are explained in Figure 8.5.

8.4 Consequence analysis and qualitative risk to access road estimation – before and after treatment

Table 8.2 (this Attachment) is a consequence analysis and risk to property assessment for the two scenarios shown in Figure 8.4.

Before treatment, risks associated with Scenario 1 range from Low to Very High depending on the consequences. After treatment, risks reduce to Low. Low risks are generally regarded as Acceptable.

[15] An active landslide has moved since European occupation.

Risks associated with Scenario 2 are Low. No treatment is required to specifically address this risk.

8.5 Qualitative risk to life estimation – after development

Scenarios 1 and 2 present acceptably low risks to life. The highest risk is related to Scenario 1. Figure 8.6 is an event tree which assesses the risks to life for an occupant of a vehicle travelling the access road, and either being hit by the landslide, or hitting the landslide.

Table 8.2 Post-development frequency, consequence and risk assessment for Scenarios 1 and 2 shown in Figure 8.4

	After development, without treatment				After development, with treatment		
Scenarios in Figure 8.4	Likelihood	Consequences to access road	Risk to access road	Treatment	Likelihood	Consequences to property	Risk to property
1	Likely	Minor to Major	Moderate to Very High	Engineered drained retaining walls (manages Consequences)	Unlikely	Minor to Medium	Low
2	Unlikely	Minor to Medium	Low	None required (controlled drainage manages erosion risk)	Unlikely	Minor to Medium	Low

8.6 General comments on suggested risk mitigation actions in Section 2

Accepting the risk

Risks to the access road assessed as Low are Acceptable after treatment

Avoiding the risk

Avoiding the risk by not developing parts of the study strip is not feasible if the access drive is to be constructed.

Reducing the frequency of the risk

Reducing the frequency of the Scenario 1 risk is achieved by the recommended drainage and retaining wall controls.

Reducing the consequences of the risk

Reducing the consequences of the Scenario 1 risk is achieved by the recommended drainage and retaining wall controls.

Monitoring the risk

Unnecessary

Transferring or postponing the risk

Unnecessary

8.7 Suggested risk mitigation plan for Section 2

General comment

Development of the access road in Section 2 (and Section 3) should be in accordance with the examples of good hillside construction practices included here in Attachment 9.

Retaining walls

In Section 2, engineering design is required for cut and fill along the alignment of the access road, and for the appropriate design of drained retaining walls where required. Wall design should incorporate appropriate batter angles where needed, and adequate resistance to lateral forces on the hillside slopes, particularly between test pits F and I.

Low strength surface materials
Low-strength surface material shall be removed from the alignment before construction, and suitable fill, where used, shall be placed in a controlled manner. Clayey materials shall be avoided as fill.

Drainage controls
Between test pits E and G, appropriate culverting shall be employed at the low point in the access road to manage surface and shallow subsurface drainage, which should then discharge in pipework to the lower edge of the study strip. This same culvert could be sized and designed to collect runoff from the southern portion of Section 2[16].

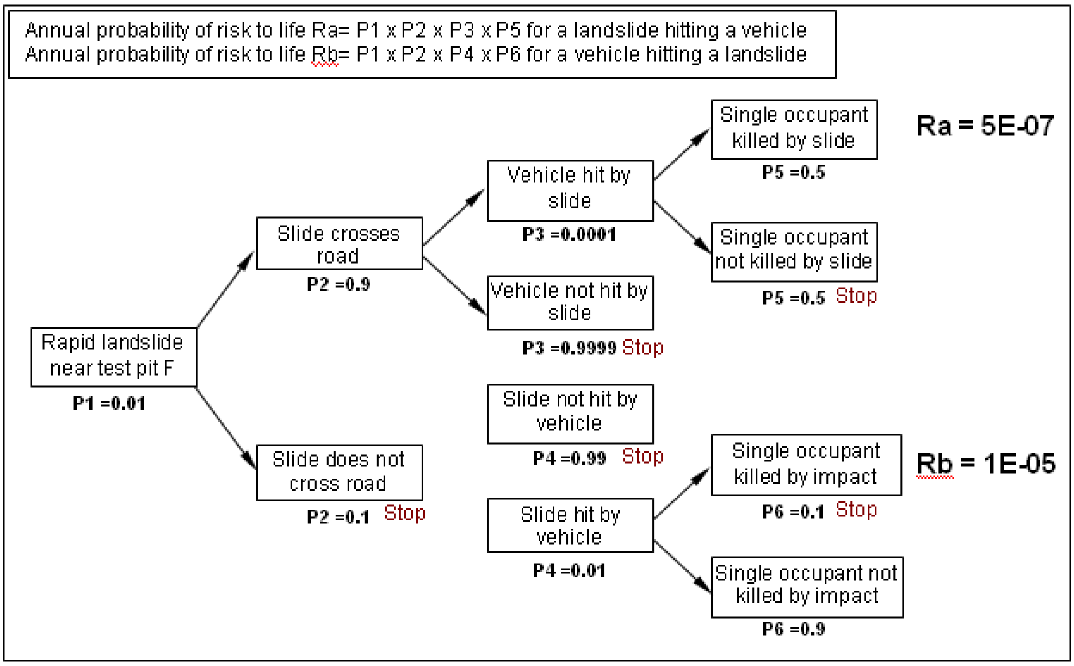

Figure 8.6 **Event tree for risk to life for an occupant of a vehicle travelling the access road and being hit by a rapid landslide (risk Ra) or hitting a landslide (risk Rb). The latter is the higher of the two, but both are acceptably low.**

[16] In Section 3, culverting shall collect diffuse upslope surface runoff, direct it under the access road, and retain and diffuse it again from absorption trenches. At each culvert, trenches on the lower side of the access road should be nominally 0.3m wide x 0.3m deep x 10m long, containing perforated pipework wrapped in geotextile and covered by durable aggregate, and backfilled with on-site topsoil. Other designs which satisfactorily achieve similar drainage control will be acceptable.

Figure 8.3 Historical satellite imagery of the landslide feature in the western corner of Mortimer Bay. The 2005 and 2011 images suggest it may be two smaller features. These images also show what appears to be a track leading from the northeasterly of the two features, towards the water hole and abandoned house. Source: Google Earth

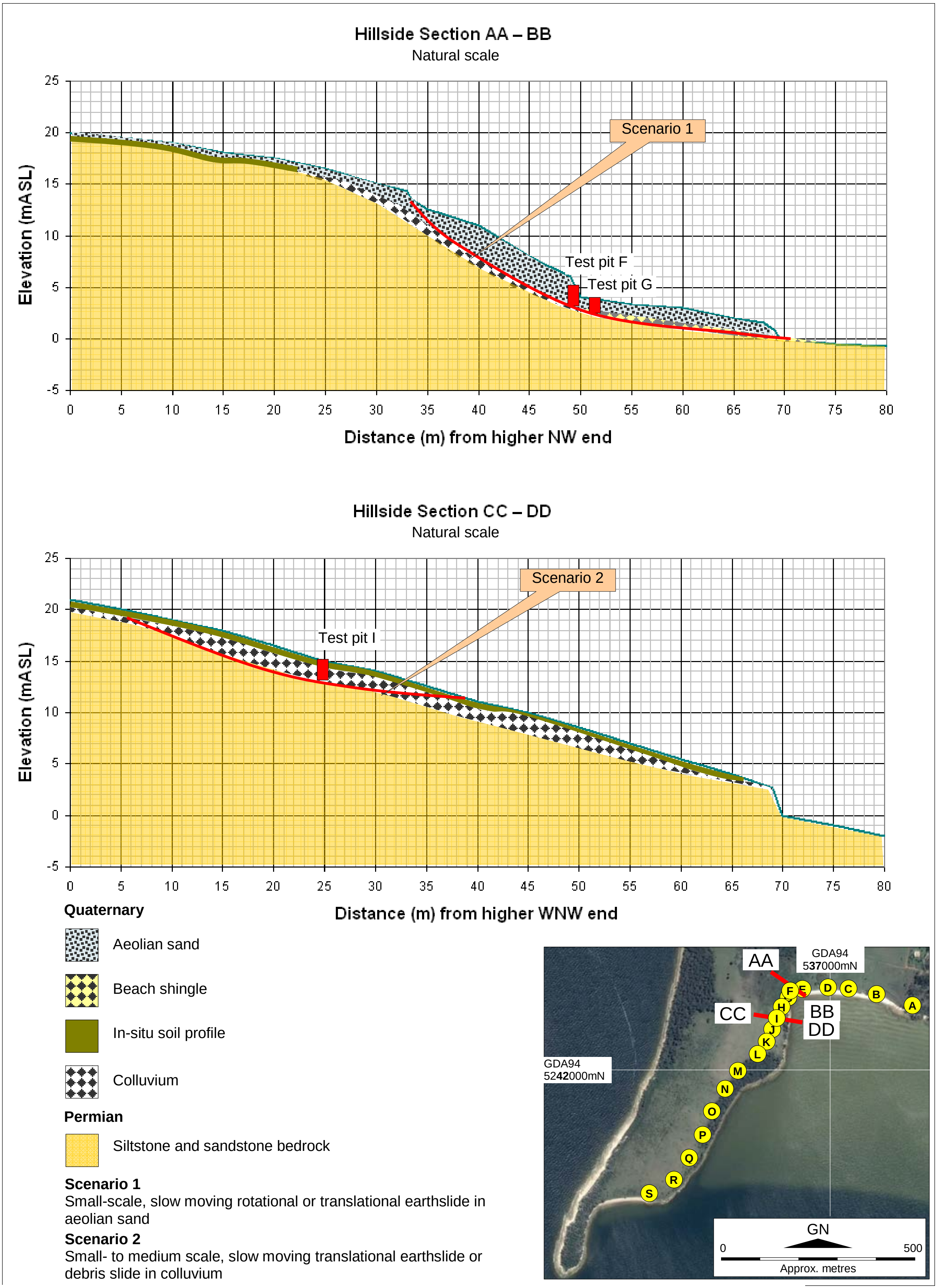

Figure 8.4 **Landslide scenarios in Section 2 for Landslide Risk Management**

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	$5x10^{-6}$	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

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Figure 8.5 Descriptive terminology for likelihood and consequences to property used in Table 8.2
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Attachment 9

(3 pages)

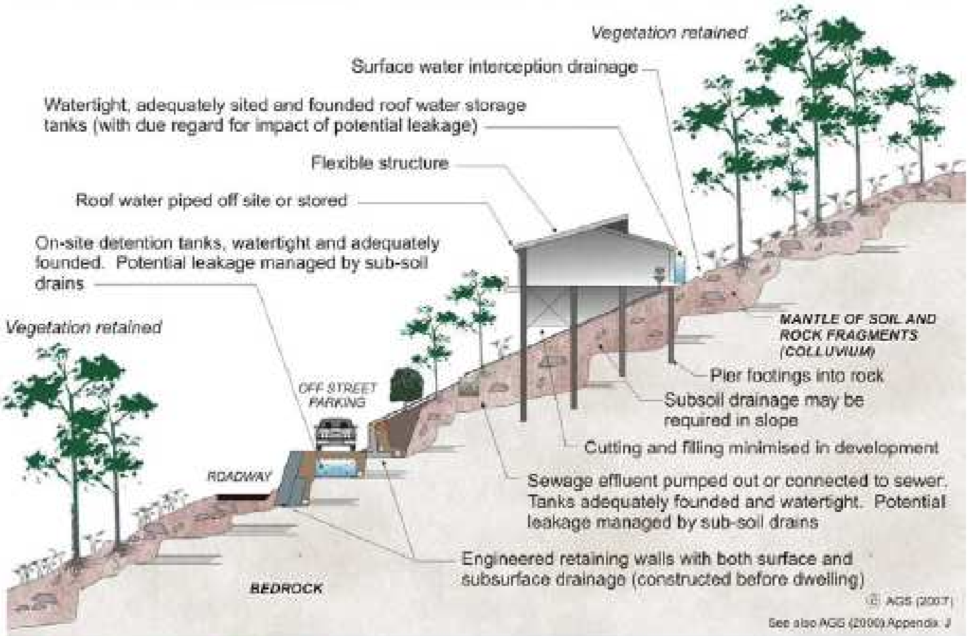
Examples of good and poor hillside engineering practices

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.

EXAMPLES OF GOOD HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

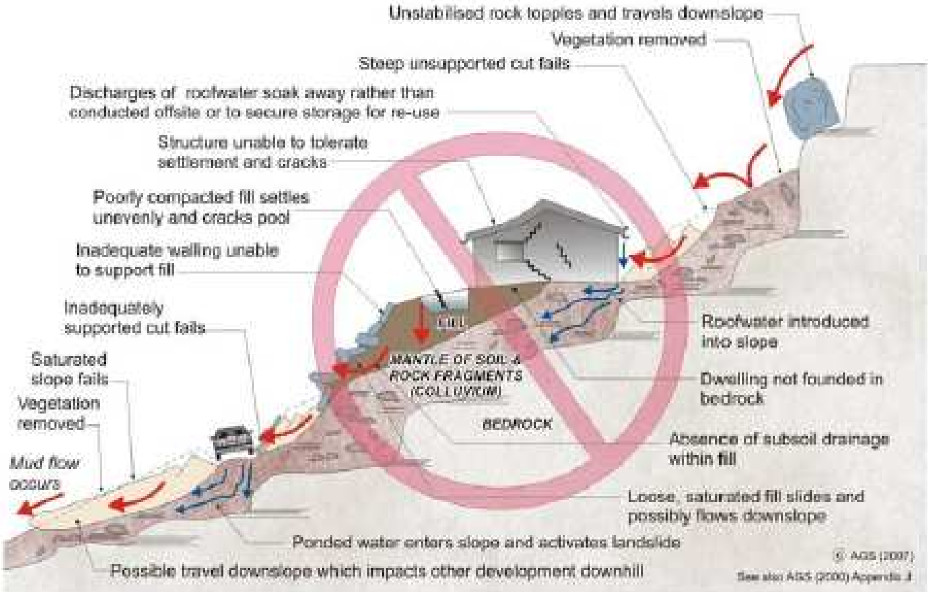
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	