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GEOTECHNICAL INVESTIGATION OF STABILITY OF GULLY BETWEEN THE EYRIE & POINT NEPEAN ROAD, MCCRAE

For

MORNINGTON PENINSULA SHIRE COUNCIL

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GEOTECHNICAL INVESTIGATION OF STABILITY OF GULLY

BETWEEN THE EYRIE and POINT NEPEAN ROAD, MCRAE

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GEOTECHNICAL INVESTIGATION OF STABILITY OF GULLY

BETWEEN THE EYRIE and POINT NEPEAN ROAD, MCRAE

1 INTRODUCTION

At the request of Mr Christopher Lyne of the Mornington Peninsula Shire Council in a letter dated 10th April 2007 and confirmed in an email dated 24th April 2007 (Order Number 052601), a limited geotechnical investigation was undertaken to determine the stability of the existing banks of the gully between The Eyrie and Point Nepean Road, McCrae and to recommend remedial actions to stabilise the banks of the gully.

Increased runoff in recent years has resulted in erosion of the gully bed and subsequent instability of the surrounding steep gully banks and the walking path. The rock lining of the lower part of the bed of the gully has had only limited benefit and de-stabilisation of the sides of the gully has still occurred. The instability has resulted in the collapse of a walking path and subsequent closure of the walking path.

The Council has provided two options with regard to stabilizing the gully. The first being to pipe and backfill the entire length of the gully, the second being to pipe and fill the upper part of the gully from The Eyrie down to the top of the existing rock beaching.

2 SCOPE OF THE INVESTIGATION

The proposed approach of the investigation is as follows:

- Drilling of deep boreholes in properties on either side of the gully as well as at the head and toe of the gully
- Installation of piezometers in the deep boreholes
- Drilling shallow hand auger boreholes along the base of the gully
- Geotechnical laboratory testing
- Analysis of slope stability of the gully banks
- Assessing the possible remediation works for the site

3 SITE DESCRIPTION & OBSERVATIONS

The gully falls from the top to the bottom of the escarpment that is between The Eyrie and Point Nepean Road. The gully falls approximately 40m over a length of approximately 180m with a grade of approximately 1V:4.5H. A walking track follows the gully from top to bottom. The location of the walking track and gully is indicated on the plate below.

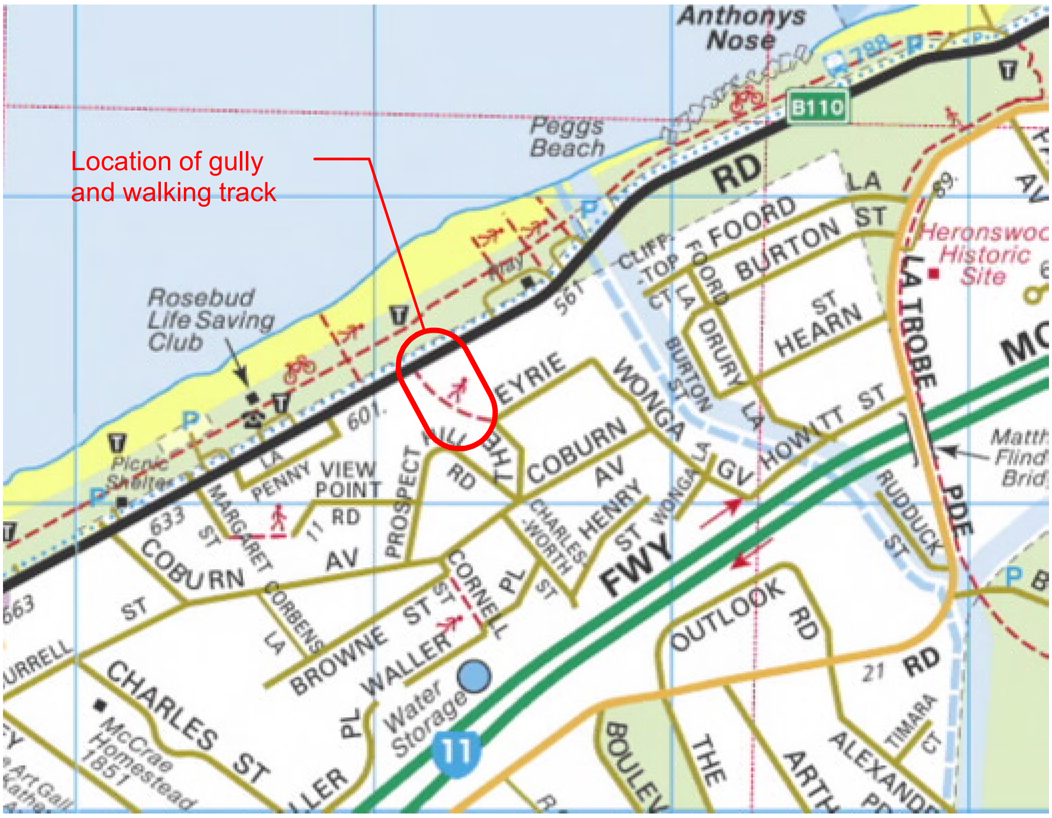
Location of gully and walking track

Plate 3.A: Location of Site Investigation

The gully is deep and narrow with a general depth in the order of 10-20m. The banks are generally covered with trees, shrubs and a grass cover. However, in the steeper sections the banks are often void of vegetation. At the base of the gully the ground levels off and has a slight slope to the beach. The figures on the following pages show the gully progressively from the top of the escarpment to the bottom of the escarpment.

The areas to the north and south of the gully above the escarpment are relatively flat compared to the gully and have a slight to gradual slope towards the escarpment.

The top of the gully in the vicinity of The Eyrie down to where the sewer pipe crosses the gully is relatively shallow (in the order of 5 – 7 metres) and has a flatter slope, relative to further down the gully, in the order of 3V:5H. (Plate 3.B).

The bed and banks of the gully in this area are well vegetated with plants such as wandering dew. There are also several medium sized trees within the gully that are potentially stabilizing the gully, although they are leaning as can be seen in the plate.

The upper part of this section gully has been landscaped by the local residents with some sections being lined with plastic sheeting.

The water course in this area appears to run in an incised channel at the base of the gully, although at the time of the investigation the water course was not running. The channel is incised up to 1.0m below the general base of the gully.

This section of the gully appears relatively stable with the exception of some possible soil creep in the upper soils.

Plate 3.B: Upstream view in vicinity of Section D-D'

Downstream of the sewer pipe the gully significantly deepens to greater than 10m depth and the base of the gully widens to several metres. The grade of the gully also significantly increases. (Plate 3.C) The gully banks also have a slope of approximately 1V:1H. Significant erosion of the toe slope banks is occurring in this section resulting in the banks being undermined (Plate 3.D) and resultant collapses are occurring. In addition the walking path has been undermined in areas. This required the construction of a boardwalk. The boardwalk has subsequently collapsed. (Plate 3.E)

Plate 3.C: Downstream view looking towards Section C-C'

Plate 3.D: Undermined bank between sewer pipe and Section C-C'

Plate 3.E: Collapsed Boardwalk in vicinity of Section C-C'

The banks of the gully are well vegetated with trees and a general groundcover. However there are numerous trees that are leaning or have fallen. (Plate 3.F)

Plate 3.F: View from south side of gully looking down towards Section B-B'

In the vicinity of Section B-B' the base of the gully begins to broaden and the slopes of the banks decrease to approximately 4V:5H. (Plate 3.G) The rock beaching starts in this area. Leaning trees in this area indicate that creep movement is occurring.

Plate 3.G: Upstream view between Sections A-A' and B-B' showing rock beaching

Below Section A-A' the gully begins to flatten out and the banks merge with the escarpment. At Point Nepean Road the grade becomes almost flat with a slight slope down towards the beach. (Plate 3.H)

At Point Nepean Road the watercourse has a right angle bend to the south and joins the street drainage. The street drain often becomes blocked with soil washed down from the gully. (Plate 3.I) This, in combination with high water flow during significant storm events, can result in overflow of the drainage channel and water flow over the road.

Plate 3.H: Upstream view from Point Nepean Road

Plate 3.I: Blocked street drainage on Point Nepean Road

4 SITE GEOLOGY

The geological map of the area (SORRENTO Sheet, 1:63,360), indicates that the site is underlain by sands and clays weathered from the underlying Devonian Age granodiorite. The limit of the granodiorite geological unit is characterized on the map by an escarpment and at the base of the escarpment Quaternary Age coastal beach deposits are indicated.

The fieldwork was consistent with the published geology.

5 GEOMORPHOLOGY

The passage from a broad and open valley to a steep- sided gully with steeper gradient as the coast is approached, i.e. rejuvenation, is common with the water courses entering Port Phillip Bay south of Frankston. It relates to movement on the Selwyn Fault and its effects on the granitic intrusions present in the area. The gully under study typifies this. It is believed that the gully is essentially a natural feature pre-dating European settlement although there are gullies in the nearby vicinity that were excavated as part of previous mining operations. (Keble, 1950)

The removal of trees, particularly in the upper reaches of the stream, increasing house construction, more roads and paving and changed vegetation in the vicinity of the gully have combined to reduce the infiltration of rain and increase both the amount and rapidity of run-off. This has led to increased flow and velocity of the stream, especially after heavy rainfall.

The sandy terrain through which the watercourse flows is easily eroded and the changes indicated above have resulted in deepening of the valley and lateral erosion on an increased scale.

The upper reaches of the gully are being depleted by erosion of the floor and sides of the gully and subsequent eroded sands are accumulating at the base and the lower reaches of the gully near Point Nepean Road.

6 FIELDWORK

The fieldwork was conducted over the period of 21st – 24th May 2007 with a further site visit on 27th June 2007.

Four boreholes (BH01-BH04) were drilled to a depth of between 10 and 20m using a Fox truck mounted drilling rig in properties on either side of the gully as well as at the head and toe of the gully. Undisturbed samples and Standard Penetrometer tests (SPT's) were taken in the boreholes. The location of the boreholes was very limited due to access difficulties to the properties surrounding the gully.

Upon completion of the drilling, Casagrande piezometers were installed in all four boreholes to allow the groundwater depth to be measured.

In addition, seven hand auger holes (BH05-BH11) were drilled to depths of between 1.0 and 1.5m along the base of the gully. Disturbed samples were taken from each of the boreholes. In addition, Dynamic Cone Penetrometer (DCP) testing was conducted adjacent to all seven hand auger holes to determine the in-situ CBR of the subgrade soils in accordance with AS1289 6.3.2 *Testing of Soils for Engineering Purposes.*

The locations of the boreholes are shown on the Site Plan, Figure No. 1, Appendix A. The records of the boreholes are appended as Figure Nos. 2 – 14, Appendix A, together with the Unified Classification System as Figure No. 15.

The piezometers were read on 24th May 2007 and 27th June 2007.

The fieldwork was carried out by an experienced geotechnical engineer, who supervised the drilling and in-situ testing, logged the ground encountered, conducted the sampling and installed the piezometers.

7 LABORATORY TESTING

A limited laboratory testing program was undertaken in our NATA accredited soils laboratory and consisted of the following:

- Atterberg Limits
- Particle Size Distributions
- Percentage Passing 75µm Sieve
- Emerson Class Determinations

The test records are included in Appendix B

8 RESULTS OF THE INVESTIGATION

8.1 GROUND STRATIGRAPHY

The soil profile encountered across the site was typical of those weathered from granite and granodiorite comprising predominantly silty and clayey sands (SM-SC).

The upper soil profile generally consisted of a medium to coarse grained silty SAND (SM) in a medium dense to dense, dry to moist condition that extended to approximately 4-5m depth.

Below the upper soil profile there were interbedded layers of silty SAND (SM) and clayey SAND (SC) of variable thickness extending to the full borehole depth of 20m. Some of the layers were cemented and in BH02 at a depth of 7.8-11.1m there was a Sandy CLAY (CI) layer.

The sands were generally medium to coarse grained and in a dense to very dense condition.

There appeared to be little correlation between the levels of the clay layers in the boreholes in the three deep boreholes drilled above the escarpment.

8.2 GROUNDWATER

The details of the piezometers are indicated in the following table:

Table 8.1: Details of the piezometers

Borehole No.	Casagrande Tip Depth (m)	Depth to top of gravel packing (m)	Depth to top of Bentonite Seal (m)	Lithology of Aquifer	Groundwater Depth (m)	
					24/5/07	27/6/07
BH01	20.2 - 20.5	19.0	15.0	Clayey SAND, fine to medium grained	7.15	7.40
BH02	20.2 - 20.5	17.0	12.0	Clayey SAND, medium grained	16.95	20.40
BH03	10.2 - 10.5	7.5	6.0	Silty SAND, fine to medium grained	NIL	9.49
BH04	10.2 - 10.5	6.5	4.5	Silty SAND, medium to coarse grained	1.10	1.04

8.3 LABORATORY TESTING

The results of the laboratory and field tests are summarized on the following page. The testing indicates that the sands are well graded and are dispersive.

Table 8.2: Results of Laboratory Testing

BH No.	Depth (m)	Soil Description	Liquid Limit (%)	Plasticity Index (%)	Percent. Passing 425µm (%)	Percent. Passing 75µm (%)	Percent. Passing 2µm (%)	Emerson Class
BH01	7.5 – 7.9	Silty SAND brown, well graded, clayey	21	2	71	36		
BH01	13.5 – 13.95	Clayey SAND grey-brown, silty				42		
BH02	9.0 – 9.4	Silty CLAY brown, sandy	45	28	87	69	33	
BH02	13.5 – 13.95	Clayey SAND grey-brown, silty				22		
BH03	4.5 – 4.95	Clayey SAND grey-brown, well graded	29	18	70	43		
BH06	0.7	Clayey SAND grey, orange-brown, silty						2 – Highly Dispersive
BH07	1.2	Sandy CLAY / Clayey SAND grey						3 – Moderately Dispersive
BH09	0.7	Clayey SAND, brown, silty						5 – Slightly Dispersive
Note: Distilled water was used in Emerson test.								

9 FAILURE MECHANISMS

The slope failures on the site can be typified by a three stage process which appears to be occurring in combination with mass wasting of the slope.

The first stage is the erosion of the more readily erodible layers of sands leaving in place the less erodible layers. This can result in very steep slopes, undermined areas, overhangs and caves being created where a lower layer is eroded and an upper layer remains in place. This process is currently occurring at several locations as indicated on Figure 1, Appendix A.

The second stage is the collapse of the upper layer when the toe erosion has occurred in the lower layer resulting in a significant overhang and loss of support for the upper layer. This results in a steep section that extends up the slope.

The third stage is a deeper circular or translational failure that occurs due to the steeper slope, which results in the slope returning to its natural angle of repose. It is possible that the third stage can occur directly after the first stage where erosion results in a steep lower slope.

After the third stage had occurred the process can start again resulting in a gradual widening and deepening of the gully.

10 SLOPE STABILITY

A slope stability model was created using the computer program XSLOPE, developed by the University of Sydney. This program uses the simplified Bishop Method Slices to analyse the slope stability for arcuate failures and the Morgenstern-Price method for non-uniform slope failure surfaces.

The slope stability model was developed by incorporation of the borehole logs, the laboratory test results and the correlation with the onsite observations.

The values were then calibrated against the existing conditions.

10.1 SELECTION OF THE SHEAR STRENGTH PARAMETERS

The design parameters were based on the results of the SPT testing of the sands, and correlations developed Stark et al (2005) for the sandy clay based on the Atterberg Limits and clay fraction. The design parameters adopted for the analysis are shown in the table below. The imported fill material layer was incorporated into the remediation works analysis as discussed in Section 10.3.

Table 10.1: Adopted Shear Strength Parameters

Soil Description	Effective Cohesion (kPa)	Effective Shear Angle (degrees)	Density (kN/m^3)
Imported Clay FILL	5.0	30.0	19.0
Upper Dense SANDS	2.0	38.0	19.0
Upper Very Dense SANDS	5.0	41.0	20.0
Sandy CLAYS	12.0	30.0	18.0
Lower Dense SANDS	3.0	38.0	19.0

The phreatic surface was adopted using the results from the piezometer and the water in the gully bed.

10.2 MODEL CALIBRATION

The adopted parameters were calibrated against four different cross sections along the gully. The locations of the sections are shown on the Site Plan, Figure No. 1.

The results of the back analysis are shown in the following table and are shown graphically in Figures 1-4, Appendix C.

Table 10.2: Summary of Results of Model Calibration

Section No.	Minimum Factor of Safety	
	Southern Batter	Northern Batter
1	1.38	1.49
2	1.05	1.23
3	1.00	1.22
4	1.71	1.81

It should be noted that the presence of the sandy clays only on the left side of the analysis, as indicated by the clays only being present in BH02, generally resulted in lower factors of safety for the southern batter slip circles.

A reasonable correlation was developed between the onsite observations and the computer model.

10.3 SOLUTION ANALYSIS

A slope is considered to be unstable if it has a factor of safety of less than 1.0, marginally stable if it has a factor of safety between 1.0 and 1.3 and stable if it has a factor of safety of greater than 1.3, but for most engineering applications, a factor of safety is at least 1.5.

Three of the four sections (Sections 1 to 3) that were analysed in the model calibration were found to have factors of safety in both the southern and northern directions that were in the range of 1.00 to 1.49. i.e. marginally stable.

One method that can be used to increase the factor of safety of gully slopes to be stable, i.e. greater than 1.5, is to pipe the gully and partially backfill the gully to a point where a factor of safety of 1.5 is achieved.

Figures 5-7 of Appendix C show the filling required for Sections 1 to 3 in order for a factor of safety of 1.5 to be achieved.

A lower factor of safety of between 1.25 and 1.35 can be adopted for these stabilisation measures. A relative increase in the factor of safety should be adopted rather than an absolute value. However adoption of the factor of safety of between 1.25 – 1.35 will increase the risk of future instability still occurring. The stabilisation works to date have been designed using the normally acceptable factor of safety of 1.5.

It should be noted that due to the depth of the gully and the steep slopes on the side of the gully a considerable depth of filling is required.

11 CONCLUSIONS AND REMEDIATION WORKS

The geotechnical investigation has found that instability of the gully banks is occurring as a result of erosion of the toe of the banks and the floor of the gully, further resulting in failures within the banks. At this stage, minimal rectification work has occurred within the gully with the exception of the rock beaching in the lower part of the gully. The beaching is considered to be insufficient to prevent failures in this area as the sides of the gully in the area of the beaching is very steep with a low factor of safety. In addition, it is considered that although the beaching is providing protection against deepening of the gully, it is providing minimal protection against erosion of the toe of the sides of the gully.

The Council has resolved to at least partially pipe the gully to resist further erosion combined with the placement of fill around and above the pipeline to improve the stability of the gully banks. We agree with this approach and recommend that the gully be piped from the exposed sewer pipe at the upper end to the lower extremity of the gully as discussed below.

A lower factor of safety against a slope failure can be adopted resulting in a reduced fill depth, provided that the Council is prepared to accept a higher risk of potential failure in the future. However, any works must reduce the slope of the gully banks to an acceptable batter to prevent or reduce the gully side slopes and consequential erosion to an acceptable level and allow stabilisation with planting. In any event, this will require a significant depth of fill to be placed in the base of the gully.

It is recommended that the remediation of the gully be carried out by the piping of the gully from the location where the sewer pipe crosses the gully at the top to the lower extremity of the gully. It is not recommended that the piping cease at the top of the rock beaching as the slopes below this point are only marginally stable. Stabilising fill in the base of the gully will be required to ensure the stability of the gully banks. The recommended approximate zone of the stabilization works is indicated on Figure 1, Appendix D.

We understand that there will be times when the pipe capacity is exceeded during high intensity storm events, but these should be infrequent and not greater than a 1 in 5 year event. This may result in a short, high velocity flow along the base of the new valley floor. As this flow is expected to be very infrequent and of short duration (<24 hours), and provided that the valley is well vegetated and grassed, minimal erosion should occur provided the imported fill is not readily eroded or dispersive.

It is recommended that the velocity dissipation structure near Point Nepean Road incorporate a sand and waste trap.

11.1 BACKFILL DEPTHS AROUND THE PIPE

While placing of the pipe in the base of the gully will inhibit the deepening of the erosion of the gully bed, it will not address the issues of instability of the gully banks. This can be achieved by the placement of engineered fill above and around the pipe and up the slopes of the gully. The depth of the fill will vary along the gully, but is in the order of 3.0 – 6.0m between Sections A & C. The extent of the filled area is shown on Figure 1, Appendix D.

11.2 PIPE STRESSES

Analysis of the slope indicates that the existing slope and fill may impose a lateral stress of 50 kPa or 8Z, whichever is deeper, on the pipe. An overburden stress, as a result of the fill, of up to 20.Z + S (kPa) will also apply, where Z is the depth below the ground surface and S is the ground surface surcharge in kPa. The stresses will increase depending on the slope of the fill and can be determined using the elastic solution in Poulos and Davis (1974)

An appropriate factor of safety or loading factor of at least 1.5 should be applied to both the lateral and overburden stresses.

11.3 CONSTRUCTION OF THE PIPELINE

It is recommended that the watercourse be pumped or diverted around the works area during the construction. The pipe mostly follows the bed of the gully and cutting into the gully banks should be avoided or minimized. The exposed, loose, alluvial silty sand and saturated soft clayey silt in the bed of the gully should be removed to expose the clayey sands. Once the base is established, the selected fill should be placed and compacted and the pipe then be placed.

11.4 BACKFILL AROUND THE PIPE

While a free – draining backfill is commonly used around a pipe, it is not recommended that this type of fill be used. The silty sand is very prone to erosion and will potentially undermine the bed of the pipe. It is recommended that the backfill be either a sandy clay or impermeable backfill. The backfill should be non-dispersive and be readily compacted. The difficulty of using this type of backfill is the need to place, shape and mould around the pipe to achieve adequate compaction and avoid a gap at the interface between the pipe and the fill. Furthermore, it reduces the soil modulus used in the design of the pipeline. Alternative approaches could be considered, provided that any migration of water along the underside of the pipe will not result in erosion of the bed or side support of the pipe. The proposed use of 14mm screenings could be considered provided that the screenings are entirely wrapped in a geotextile and measures are taken to avoid rapid flow of water through the screenings. A reduction to 6 – 10mm screenings would be preferable. The designer needs to consider carefully the backfill around the pipe to avoid the following:

- ☐ Erosion of the sand underlying the gravel backfill
- ☐ Excess pore water pressure under the pipe resulting in buoyancy of the pipe or uplift pressures of the surfacing material
- ☐ Prevention of high velocity flows through the backfill and erosion of the backfill by the construction of intermittent concrete cut-off collars.

The contractor should be aware of the need to use handheld compaction equipment and small compactors in the immediate vicinity of the pipe and to ensure that there are no gaps or voids between the pipe and the backfill. The fill around the pipe should be adequately compacted as discussed below.

11.5 GENERAL IMPORTED BACKFILL

It is recommended that the imported fill be either a sandy clay or clayey sand. Testing of the proposed backfill needs to be undertaken to ensure that the shear strength meets the requirements of the fill. This fill should be non-putrescible, non-dispersive and uncontaminated. The imported fill should meet the requirement of ‘Fill’ in EPA Bulletin 448.3, *Classification of Wastes,* May 2007. The selection and placement of the fill should be carried out in accordance with Australian Standard 3798 – 1996 *Guidelines on earthworks for commercial and residential developments.* It is recommended that the fill be placed in near horizontal layers not exceeding 200mm in thickness and be compacted to at least 96% Standard Dry Density ratio within ± 2% of the Optimum Moisture Content in accordance with Australian Standard 1289 *Testing of Soils for Engineering Purposes.* Care needs to be taken in the compaction of the fill around the pipe to avoid over –stressing the pipe. It is recommended that rubber-ringed jointed pipes be used in preference to butt-jointed pipes.

The proposed general backfill should be submitted by the contractor to the Shire for assessment as part of the tender approval. It is recommended that the testing of the compaction of the fill be carried out in accordance with Level 2, Appendix B, AS3798 – 1996.

Insitu density testing and compaction testing of the placement of the filling should be carried out by an experienced geotechnical testing authority that is NATA accredited for the particular tests. The insitu density testing should be carried out in accordance with Australian Standard 1289 5.8.1, 2.1.1, 5.1.1, 5.1.2, or 5.7.1. One Hilf compaction or Standard compaction test is required per density test. One-point density tests are not recommended as an alternative. Nuclear gauge moisture content determinations are not acceptable.

Verification is required that the clay is being placed in 150 - 200mm thick layers, as specified, and there is no lamination between clay layers.

It is recommended that the insitu density testing be carried out at a rate of at least 1 insitu density per 300 m^3 (Placed) or one test per layer; whichever is greater for the general backfill and one test per 100 m^3 for the material backfilled in the immediate vicinity of the pipe. It is important to ensure that the moisture content of the clay fill being placed is within the specified tolerances and the compaction is being achieved.

11.6 CONSTRUCTION LIMITATIONS

To avoid destabilising the gully banks, it is recommended that the contractor be restricted to the excavation of not more than 10m of gully bed at one time, prior to backfilling the exposed pipe section.

Limitations may need to be imposed on the type of compaction equipment to be used to backfill the gully. It is recommended that the fill be compacted with a non-vibrating sheepsfoot or tamping roller.

It is considered that the properties that have been affected by the gully bank instability may be additionally affected by the placement of the fill. The use of compaction equipment may result in further movement occurring during construction.

11.7 VEGETATION REMOVAL AND REPLACEMENT

It is recommended that the removal of vegetation be minimised. Any unsafe trees such as leaning trees should be removed, but grubbing of the stump should not be carried out.

A landscape consultant should be engaged to advise on the replacement of the removed vegetation with fast growing, deeply rooted trees that will inhibit mass wastage of the sand banks together with suitable ground covers. The use of erosion control biodegradable mats may be required until the trees are established. The trees should be planted on the gully banks, as well as the crest.

11.8 RESIDENTS RESPONSIBILITY

It is important to emphasise to the residents that they have a responsibility to maintain the vegetation in their property and prevent runoff from their properties causing erosion. The residents (or Council) need to ensure that the stormwater runoff from their properties is properly connected to the stormwater system.

It is recommended that the residents be referred to the appended 'Guidelines for Hillside Construction' from Australian Geomechanics, May 2002. See Appendix E.

The dumping of rubbish and tree cuttings onto the sides of the creek banks must be stopped.

11.9 STORMWATER COLLECTION

It is recommended that all of the dwellings and out buildings be connected to the stormwater pipe system that is directly connected to the gully pipe. This should be carried out by the contractor as part of the works and not be left to the residents.

Any surface runoff from the properties should be collected within a low flow channel above the pipeline and introduced into the pipe at suitable intervals.

To prevent erosion of the exposed slope and further mass wasting, it is recommended that any surface runoff be collected via a concrete spoon drain to the crest of the gully bank and be conducted via a pipe to the pipeline.

12 LIMITATIONS OF THE REPORT

The purpose of this report is to provide a geotechnical assessment of the site examined. The information provided herein will reduce the exposure to risks, but no geotechnical assessment can eliminate them. Nonetheless, even a rigorous assessment may fail to detect all of the geotechnical conditions on a site. Site variations may have occurred in areas not investigated or sampled.

This geotechnical report should not be used when the nature of the proposed site usage changes, when the size, layout, or location of the development is modified, when the site ownership changes nor should it be applied to a nearby area.

This site geotechnical assessment identifies actual subsurface conditions where the samples were taken and at the time they were taken. Our NATA accredited laboratory carried out the soil tests. Geotechnical engineers interpreted the laboratory and field results, and other data. The engineers then rendered an opinion about the overall subsurface conditions, the nature, soil type, the extent of the soil layers, and their likely impact on the proposed development with a discussion of the implications considered likely. The actual conditions may differ from the inferred conditions, as no person (no matter how qualified) or even the most detailed subsurface investigation can predict with confidence what may be hidden by soil or water or may have altered with time. Often the interface between different geotechnical areas may be more abrupt or gradual than anticipated. The actual conditions in an area may differ from those predicted.

Site assessments are limited by time, and natural processes such as erosion, or mankind altering the ground conditions, including the site levels or filled areas, may affect a site assessment.

This geotechnical assessment is prepared in response to a client's specific requirements. No person other than the client should apply the report without first conferring with Lane Piper Pty Ltd.

Costly problems can occur if the report is misinterpreted. To avoid these problems, Lane Piper Pty Ltd should be retained to work with the appropriate design professionals and to review the adequacy of their plans and specifications relative to the geotechnical matters.

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Finally, geotechnical reports are based extensively on opinion and judgment and are less exact than other sciences. The report may contain a number of explanatory clauses or limitations on the results to inform the client about the restrictions of the report. These clauses are not meant to be exculpatory clauses to foist liability onto another person, but to identify where Lane Piper's and the client's responsibilities start and finish. Their use is to clarify where individual responsibilities lie and to allow the individual to take appropriate actions.

We trust this meets your requirements, but should you have any further queries, please do not hesitate to contact us.

13 REFERENCES

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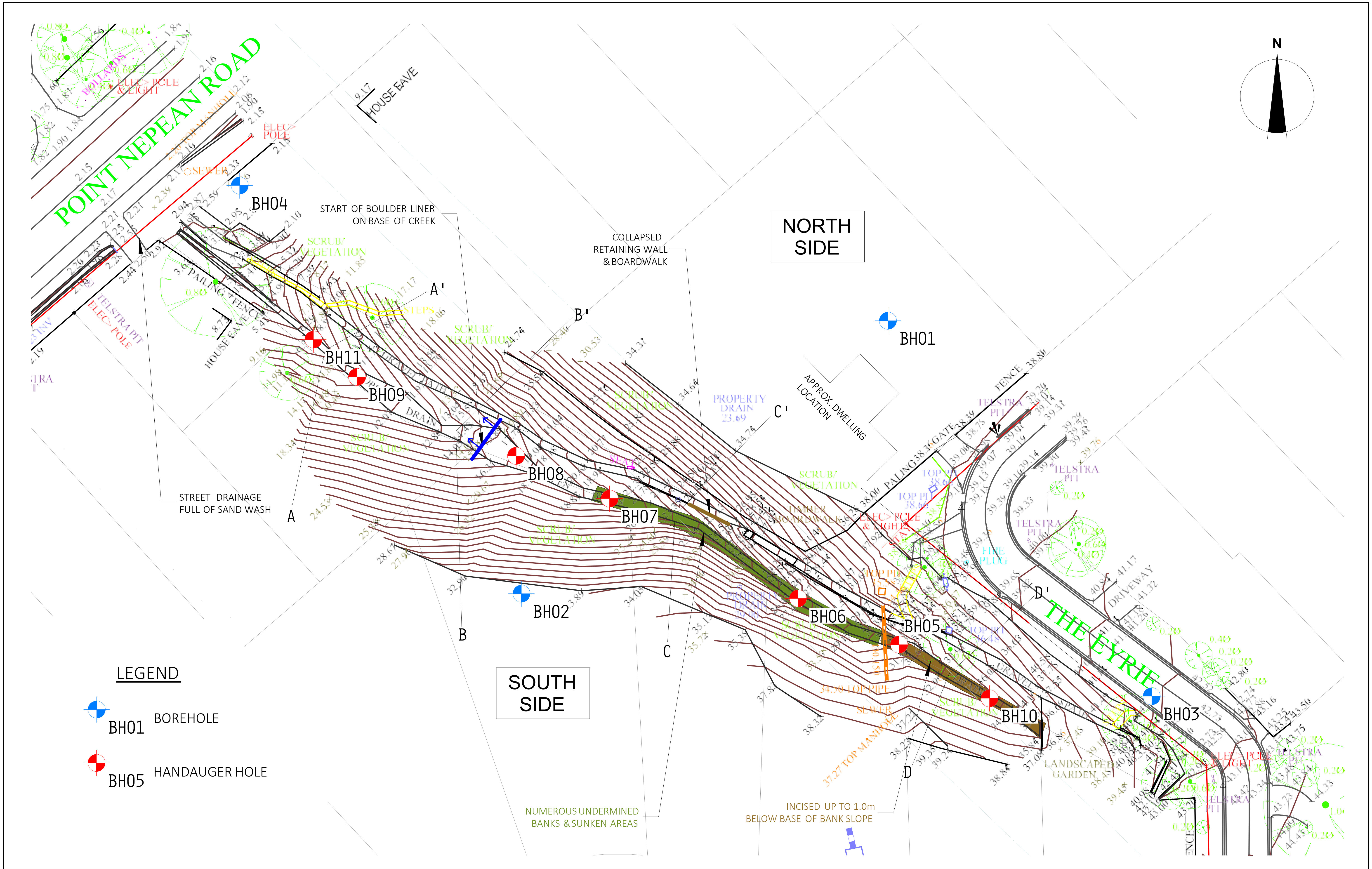
APPENDIX A

Site Plan
Records of the Boreholes
Unified Classification System



PROJECT PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN POINT NEPEAN ROAD & THE EYRIE, McCRAE

LANE PIPER PTY LTD
A.C.N. 120 109 935
LanePiper
Geotechnical and Environmental Engineers
Hydrogeologists and Environmental Scientists
BLDG 2, 154 HIGHBURY RD BURWOOD, VICTORIA, 3125
TELEPHONE [03] 9888 0100 FAX [03] 9808 3511

TITLE SITE PLAN

REF: P:\Projects 207118_207150\207141\Plans & Drawings

SCALE (A3) 1:500	DATE 3 SEP 2007		
DRAWN OBB	JOB NO. 207141		
MEL REF: 159:B9	REV. NO. 1	FIG. NO. 1	

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE & POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

BOREHOLE NO.: 01
DATE DRILLED: 21/5/07
DRILLING METHOD: SOLID AUGER/WASHBORE
INCLINATION: VERTICAL
PAGE 1 OF 2
LOGGED BY: DBS

DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	DEPTH (m)	SAMPLE GRAPHIC	SAMPLE TYPE	RESULT	REMARKS
0.0	Silty SAND (SM) fine grained, grey, medium dense to dense, moist Becoming light grey, dry at 0.3m		0.0				
1.0	Silty SAND (SM) medium to coarse grained, grey, brown, medium dense to dense, dry to moist, slightly clayey in zones, cemented in zones		1.0				
				□	SPT (25)		10 12 13
			2.0				
2.7	Silty SAND (SM) medium to coarse grained, grey, brown, medium dense, moist, trace fine gravel, clayey, well graded Becoming dense below 3.5m		3.0	□	SPT (15)		4 7 8
			4.0				
				□	SPT (44)		16 20 24
	Becoming very dense below 5.0m		5.0				
			6.0	□	SPT (>50)		Washbore from 6.0m 11 25 for 100mm
	Becoming dense below 6.5m						
			7.0				
				□	SPT (41)		15 21 20
			8.0				
	Becoming very dense below 8.2m						
			9.0	□	SPT (>50)		14 25 for 120mm
			10.0				
				□	SPT (>50)		18 25 for 130mm
			11.0				
	Becoming dense at 11.3m						
			12.0	□	SPT (34)		11 15 19

GROUNDWATER
Not Encountered

■ RECOVERY
□ NO RECOVERY
□ SPT DRIVE

FIGURE NO. 2

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE & POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

BOREHOLE NO.: 01
DATE DRILLED: 21/5/07
DRILLING METHOD: SOLID AUGER/WASHBORE
INCLINATION: VERTICAL
PAGE 2 OF 2
LOGGED BY: DBS

DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	DEPTH (m)	SAMPLE GRAPHIC	SAMPLE TYPE	RESULT	REMARKS
	Becoming medium dense at 13.0m		13.0				
				□	SPT (20)		7 9 11
13.8	Clayey SAND (SC) medium to coarse grained, brown, orange, red, medium dense, moist , thin zones of sandy CLAY		14.0				
			15.0	■	U64		
			16.0				
16.4	Clayey SAND (SC) fine to medium grained, grey, brown, medium dense, moist			□	SPT (24)		8 12 12
			17.0				
			18.0	□	U64		
			19.0				
	Gravel band at 19.2m			□	SPT (37)		18 19 18
			20.0				
	End of borehole #01 at 20.0m A 25mm diameter PVC piezometer was installed to 20.5m / 0.3m casagrande tip / Gravel screen from 19.0m to 20.5m / Bentonite seal from 15.0m to 19.0m. The borehole was then backfilled to the surface and a flush gatic cover was installed.		21.0				
			22.0				
			23.0				
			24.0				
			25.0				

GROUNDWATER
Not Encountered

■ RECOVERY
□ NO RECOVERY
□ SPT DRIVE

FIGURE NO. 3

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE & POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

BOREHOLE NO.: 02
DATE DRILLED: 22/5/07
DRILLING METHOD: SOLID AUGER/WASHBORE
INCLINATION: VERTICAL
PAGE 1 OF 2
LOGGED BY: DBS

DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	DEPTH (m)	SAMPLE GRAPHIC	SAMPLE TYPE	RESULT	REMARKS
0.0	Sandy SILT (ML) low plasticity, highly fissured, dark grey, dark brown, stiff, moist		0.0				
0.3	Silty SAND (SM) fine grained, grey, brown, medium dense, dry to moist Becoming moist at 2.0m Slightly clayey at 2.5m		1.0 2.0		SPT (18)		5 8 10
2.8	Clayey SAND (SC) fine grained, grey, brown, medium dense, moist		3.0		SPT (17)		5 8 9
4.0	Silty SAND (SM) medium to coarse grained, light grey, light brown, medium dense to dense, moist, clayey in zones, cemented in zones		4.0 5.0		SPT (30)		11 16 14
6.1	Sandy CLAY (CI) medium plasticity, moderately fissured, light grey, very stiff, moist		6.0		SPT (32)		Washbore from 6.0m 10 16 16
6.4	Clayey SAND (SC) coarse grained, grey, brown, dense, moist		7.0		SPT (>50)		12 22 25 for 120mm
7.8	Silty CLAY (CI) medium plasticity, moderately fissured, grey, brown, yellow, very stiff, moist, sandy		8.0 9.0 10.0 11.0		U64 U64	pp=320 pp=420	
11.1	Clayey SAND (SC) medium grained, grey, brown, yellow, medium dense, moist		12.0		SPT (23)		8 11 12

GROUNDWATER
Not Encountered

■ RECOVERY
□ NO RECOVERY
□ SPT DRIVE

FIGURE NO. 4

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE & POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

BOREHOLE NO.: 02
DATE DRILLED: 22/5/07
DRILLING METHOD: SOLID AUGER/WASHBORE
INCLINATION: VERTICAL
PAGE 2 **OF** 2
LOGGED BY: DBS

DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	DEPTH (m)	SAMPLE GRAPHIC	SAMPLE TYPE	RESULT	REMARKS
	Becoming dense at 12.8m	▨	13.0				
		▨	14.0	□	SPT (39)		14 18 21
		▨	15.0				
		▨	16.0				
		▨	17.0	□	SPT (41)		10 16 25
		▨	18.0				
18.2	GRANITE (CW) brown, grey, yellow, very low strength, abundant mica	▨		□	SPT (49)		23 22 27
18.8	Clayey SAND (SC) medium grained, grey, brown, orange, dense to very dense, moist	▨	19.0				
		▨	20.0	□	SPT (50)		13 20 30
	End of borehole #02 at 20.0m A 25mm diameter PVC piezometer was installed to 20.5m / 0.3m casagrande tip / Sand screen from 17.0m to 20.5m / Bentonite seal from 12.0m to 17.0m. The borehole was then backfilled to the surface and a flush gatic cover was installed.		21.0				
			22.0				
			23.0				
			24.0				
			25.0				

GROUNDWATER
Not Encountered

■ RECOVERY
□ NO RECOVERY
□ SPT DRIVE

FIGURE NO. 5

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE & POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

BOREHOLE NO.: 03
DATE DRILLED: 23/5/07
DRILLING METHOD: SOLID AUGER
INCLINATION: VERTICAL
PAGE 1 OF 1
LOGGED BY: DBS

DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	DEPTH (m)	SAMPLE GRAPHIC	SAMPLE TYPE	RESULT	REMARKS
0.0	ASPHALT - 50mm		0.0				
0.05	FILL Silty SAND (SM) fine grained, light grey, dry, medium dense, minimal coarse material						
0.8	Clayey SAND (SC) fine to medium grained, brown, grey, very dense, moist, cemented, well graded		1.0				
				□	SPT (>50)		11 25 for 135mm
	Becoming dense below 2.0m		2.0				
			3.0	□	SPT (33)		12 17 16
	Becoming very dense below 3.7m		4.0				
				□	SPT (>50)		15 25 25 for 120mm
	Brown-orange below 5.0m		5.0				
	Becoming grey-brown and silty at 5.8m		6.0	□	SPT (>50)		13 25 for 140mm
			7.0				
				□	SPT (50)		16 21 29
7.9	Silty SAND (SM) fine to medium grained, grey, brown, very dense, moist		8.0				
			9.0	□	SPT (>50)		25 for 135mm
	End of borehole #03 at 10.0m A 25mm diameter PVC piezometer was installed to 10.5m / 0.3m casagrande tip / Sand screen from 7.5m to 10.5m / Bentonite seal from 6.0m to 7.5m. The borehole was then backfilled to the surface and a flush gatic cover was installed.		10.0				
			11.0				
			12.0				

GROUNDWATER
Not Encountered

■ RECOVERY
□ NO RECOVERY
□ SPT DRIVE

FIGURE NO. 6

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE & POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

BOREHOLE NO.: 04
DATE DRILLED: 22/5/07
DRILLING METHOD: SOLID AUGER/WASHBORE
INCLINATION: VERTICAL
PAGE 1 OF 1
LOGGED BY: DBS

DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	DEPTH (m)	SAMPLE GRAPHIC	SAMPLE TYPE	RESULT	REMARKS
0.0	FILL Silty SAND (SM) fine to medium grained, brown, grey, very loose, dry to moist, includes minor brick pieces and rubble		0.0 1.0				
1.8	Silty SAND (SM) fine to medium grained, grey, medium dense, saturated, clayey		2.0 3.0 4.0		SPT (2) SPT (19)		1 1 1 10 11 18
4.2	Clayey SAND (SC) fine to medium grained, light grey, medium dense, saturated Very clayey in zones		5.0 6.0		SPT (21) U64	pp>600	Washbore from 4.5m 5 9 12
6.5	Silty SAND (SM) medium to coarse grained, brown, grey, dense to very dense, saturated		7.0		SPT (49)		16 28 21
7.8	Clayey SAND (SC) fine to medium grained, light grey, dense, saturated.		8.0				
8.0	Silty SAND (SM) coarse grained, brown, grey, very dense, saturated. Gravelly at 8.1m						
8.3	Clayey SAND (SC) coarse grained, grey, brown, very dense, saturated Becoming fine to medium grained at 9.1m		9.0		SPT (>50)		17 21 25 for 130mm
9.5	Silty SAND (SM) medium to coarse grained, brown, grey, very dense, saturated, some fine gravels. Slightly clayey at 9.9m		10.0				
	End of borehole #03 at 10.3m A 25mm diameter PVC piezometer was installed to 10.5m / 0.3m casagrande tip / Sand screen from 6.5m to 10.5m / Bentonite seal from 6.5m to 4.5m. The borehole was then backfilled to the surface and a flush gatic cover was installed.		11.0 12.0				

GROUNDWATER
Not Encountered

■ RECOVERY
☐ NO RECOVERY
☐ SPT DRIVE

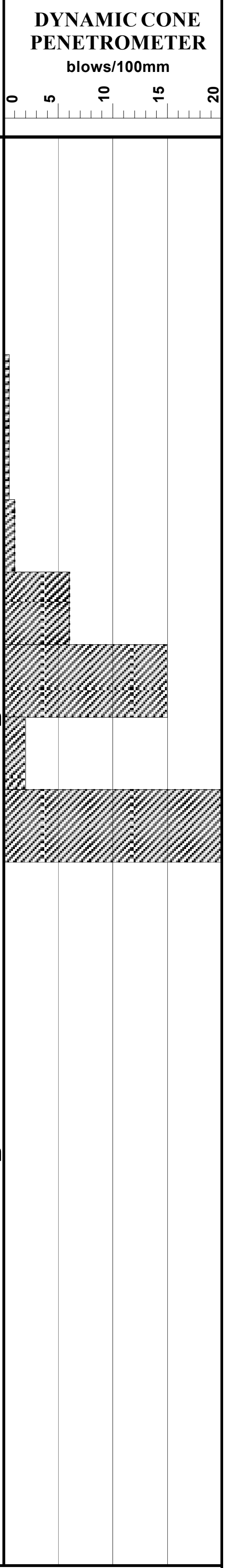
FIGURE NO. 7

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):
PAGE 1 OF 1

HANDAUGER NO.: 05
DATE EXCAVATED : 22/5/07
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	DEPTH (m)	SAMPLES
0.0	FILL. Clayey SILT (ML) low plasticity, grey, brown, soft, very moist		0.0 0.5	D / 0.8-0.9m
0.9	Gravelly SILT (ML) low plasticity, grey, brown, firm, wet		1.0	
1.3	Silty SAND (SM) medium to coarse grained, brown, grey, medium dense, wet		1.5	D / 1.4-1.5m
	End of handauger #05 at 1.5m.			



KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Water at 0.9m depth

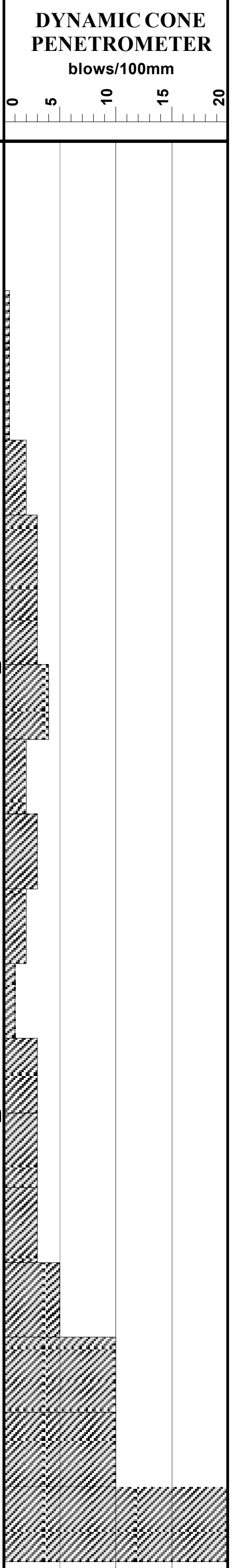
DCP test conducted in accordance with AS 1289 6.3.3

FIGURE NO. 8

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
HANDAUGER NO.: 06
LOCATION: McCRAE
DATE EXCAVATED : 22/5/07
JOB NO.: 207141
GROUND SURFACE (RL):
PAGE 1 OF 1
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	DEPTH (m)	SAMPLES
0.0	FILL. Clayey SILT (ML) dark grey, dark brown, firm, moist	░	0.0 0.5	
0.7	Clayey SAND (SC) fine to medium grained, grey, brown, medium dense, very moist	▨	1.0	D / 0.7-0.8m
1.3	Silty SAND (SM) medium to coarse grained, grey, brown, medium dense, very moist	▨	1.5	D / 1.3-1.4m
	End of handauger #06 at 1.5m.			



KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Water at 0.7m depth

DCP test conducted in accordance with AS 1289 6.3.3

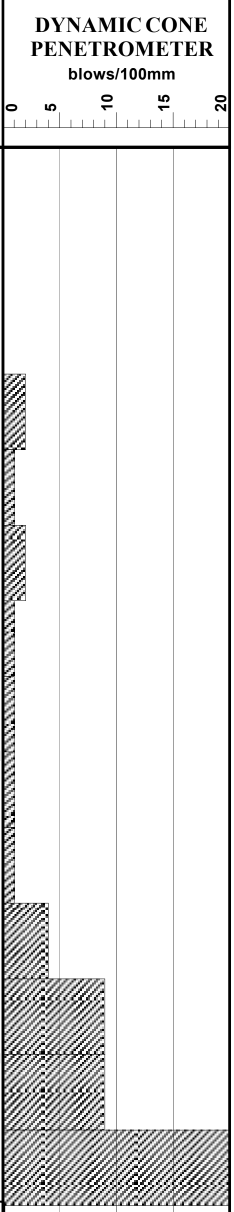
FIGURE NO. 9

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):
PAGE 1 OF 1

HANDAUGER NO.: 07
DATE EXCAVATED : 22/5/07
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	SAMPLES
0.0	FILL. Clayey SILT (ML) low plasticity, dark grey, soft, very moist		
0.8	Sandy SILT (ML) low plasticity, brown, grey, fine grained sand, firm, wet		D / 0.8-0.9m
1.0	Silty SAND (SM) low plasticity, coarse grained, brown, grey, wet, medium dense		
1.2	Sandy CLAY (CI) medium plasticity, moderate fissuring, grey, stiff, moist		D / 1.2-1.3m pp=220
1.4	Gravelly SAND (SP) coarse grained, brown, grey, yellow, medium dense, very moist		D / 1.4-1.45m
	End of handauger #07 at 1.45m.		
	Refusal on gravel/ rock.		



KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Water at 0.8m depth

DCP test conducted in accordance with AS 1289 6.3.3

FIGURE NO.10

LANE PIPER PTY LTD

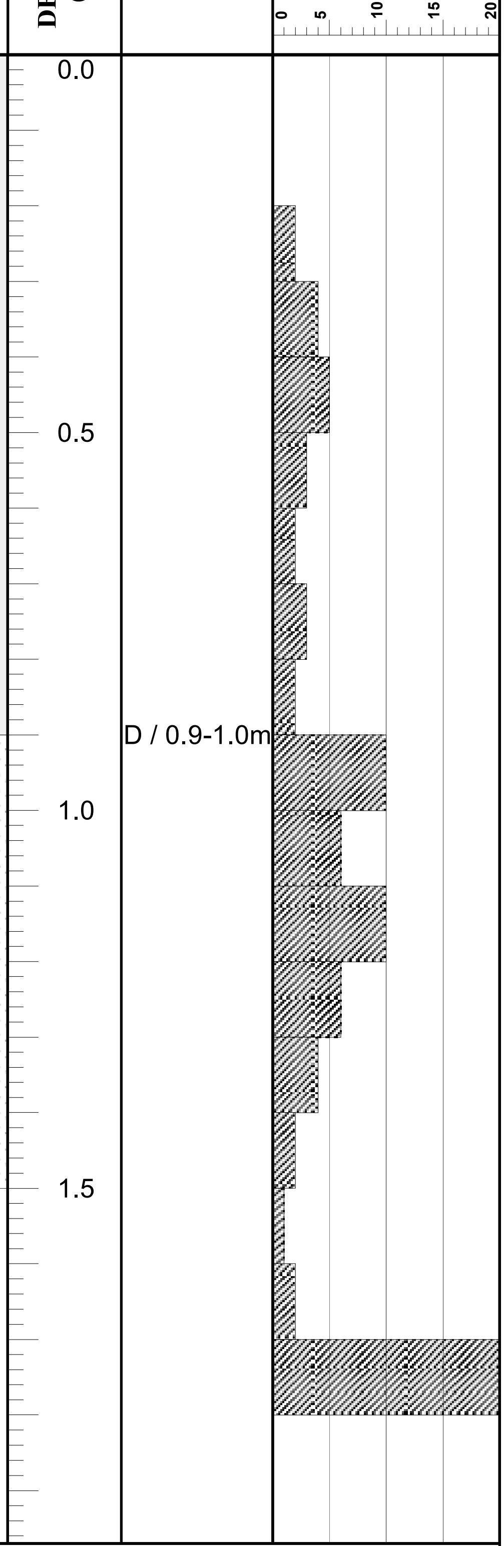
PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):

PAGE 1 OF 1

HANDAUGER NO.: 08
DATE EXCAVATED : 22/5/07
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	SAMPLES
0.0	FILL. Clayey SILT (ML) low plasticity, dark grey, soft, very moist		
0.9	Silty SAND (SM) medium to coarse grained, brown, grey, medium dense, wet		D / 0.9-1.0m
	End of handauger #08 at 1.5m		

DYNAMIC CONE PENETROMETER
blows/100mm



KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Water at 0.9m depth

DCP test conducted in accordance with AS 1289 6.3.3

FIGURE NO.11

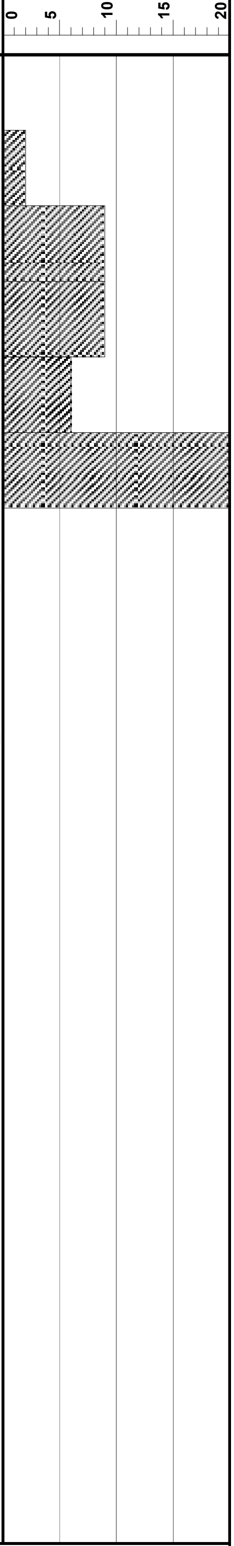
LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):
PAGE 1 OF 1

HANDAUGER NO.: 09
DATE EXCAVATED : 22/5/07
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	DEPTH (m)	SAMPLES
0.0	FILL. Clayey SILT (ML) low plasticity, dark grey, soft, very moist	░	0.0	
0.4	Clayey SAND (SC) low plasticity, brown, orange, medium dense, moist,	▨		D / 0.4-0.5m
		▨	0.5	
	becoming grey at 0.7m	▨		D / 0.7-0.8m
0.9	Sandy GRAVEL (GP) grey, brown, fine grained, dense, moist	○		D / 0.9-1.0m
			1.0	
	End of handauger #09 at 1.0m. Refusal on gravels.			
			1.5	

DYNAMIC CONE PENETROMETER
blows/100mm



KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Not Encountered

DCP test conducted in accordance with AS 1289 6.3.3

FIGURE NO.12

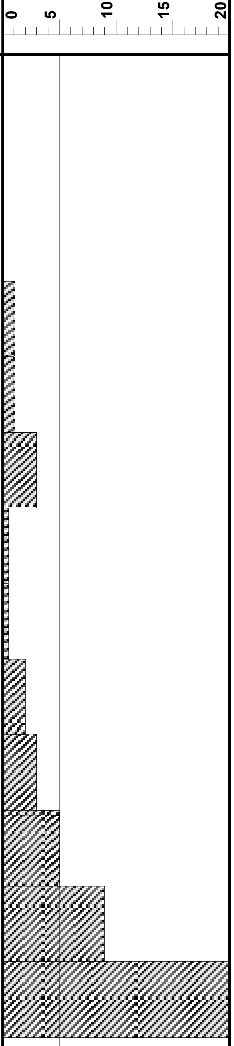
LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
LOCATION: McCRAE
JOB NO.: 207141
GROUND SURFACE (RL):
PAGE 1 OF 1

HANDAUGER NO.: 10
DATE EXCAVATED : 22/5/07
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	DEPTH (m)	SAMPLES
0.0	FILL. Clayey SILT (ML) low plastiicty, dark grey, soft, very moist		0.0	
0.3	Clayey SAND (SC) grey, brown, fine to medium grained, medium dense, moist	▨		D / 0.3-0.4m
			0.5	
0.9	Silty SAND (SM) / Sandy SILT (ML) fine grained, grey, medium dense, very moist, clayey			D / 0.9-1.0m
			1.0	
1.1	Silty SAND (SM) medium coarse grained, grey, medium dense, very moist			
			1.5	
	End of handauger #10 at 1.5m.			

DYNAMIC CONE PENETROMETER
blows/100mm



KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Water at 0.9m depth

DCP test conducted in accordance with AS 1289 6.3.3

FIGURE NO.13

LANE PIPER PTY LTD

PROJECT: GI GULLY STABILISATION
THE EYRIE AND POINT NEPEAN ROAD
HANDAUGER NO.: 11
LOCATION: McCRAE
DATE EXCAVATED : 22/5/07
JOB NO.: 207141
GROUND SURFACE (RL):
PAGE 1 OF 1
LOGGED BY: DBS

DEPTH (m)	DESCRIPTION OF STRATA	LEGEND	DEPTH (m)	SAMPLES	DYNAMIC CONE PENETROMETER blows/100mm 0 5 10 15 20
0.0	FILL. Clayey SILT (ML) low plasticity, dark grey, soft, very moist	░	0.0 0.5		
	End of handauger #11 at 1.0m. Refusal on boulder in fill		1.0 1.5		

KEY
D = DISTURBED SAMPLE
U = UNDISTURBED TUBE SAMPLE
pp = POCKET PENETROMETER (kPa)

GROUNDWATER
Not Encountered

DCP test conducted in accordance with AS 1289 6.3.3

FIGURE NO.14

Lane Piper Pty Ltd

UNIFIED CLASSIFICATION SYSTEM

(in accordance with AS1726 – 1993)

PARTICLE SIZES

TERM	SIZE (mm)
BOULDER	>200
COBBLE	60 to 200
GRAVEL	
Coarse	20 to 60
Medium	6 to 20
Fine	2 to 6
SAND	
Coarse	0.6 to 2
Medium	0.2 to 0.6
Fine	0.06 to 0.2
SILT	0.002 to 0.06
CLAY	< 0.002

COHESIVE SOILS

TERM	UNDRAINED SHEAR STRENGTH (kPa)
Very Soft	0 to 12.5
Soft	12.5 to 25
Firm	25 to 50
Stiff	50 to 100
Very Stiff	100 to 200
Hard	≥ 200

COHESIONLESS SOILS

TERM	'N' (SPT) VALUE (blows / 300mm)	RELATIVE DENSITY (%)	ANGLE SHEAR RESISTANCE (degrees)
Very Loose	0 to 4	< 15	25 to 30
Loose	4 to 10	15 to 35	27 to 32
Medium Dense	10 to 30	35 to 65	30 to 35
Dense	30 to 50	65 to 85	35 to 40
Very Dense	> 50	≥ 85	38 to 43

STRUCTURE

TERM	SIZE OF BLOCKS (mm)
Blocky	> 60
Cloddy	20 to 60
Nutty	6 to 20
Granular	0.6 to 6
Prismatic	Stated
Shattered	< 10

SAMPLES

U = undisturbed tube sample
D = disturbed sample
SPT(*9*) = standard penetrometer test (*blows per 300 mm*)
(63.5 kg hammer dropped 760mm)
BS = bulk sample
C = contamination jar sample
V = head space vial sample

INDEX PROPERTIES

ρ = bulk density (t/m^3)
DD = dry density (t/m^3)
mc = natural moisture content (%)
LL = Liquid Limit (%)
PL = Plastic Limit (%)
PI = Plastic Index (%)
LS = Linear Shrinkage (%)

GROUNDWATER

GW = Groundwater depth (m) or level (RL)

IDENTIFICATION OF SOILS

□ **FILL**

COARSE GRAINED SOILS

Coarse-grained soils (<50% fines)	Gravels 50% >2.36mm	▨	**GW**	Well graded gravels and gravel-sand mixtures, little or no fines
		▨	**GP**	Poorly graded gravels and gravel-sand mixtures, little or no fines
		▨	**GM**	Silty gravels and gravel-sand-clay mixtures
		▨	**GC**	Clayey gravels, gravel-sand-clay mixture
	Sands 50% <2.36mm	□	**SW**	Well graded sands and gravelly sands, little or no fines
		□	**SP**	Poorly graded sands and gravelly sands, little or no fines
		▨	**SM**	Silty sand, sandy silt mixture
		□	**SC**	Clayey sands, sandy clay mixtures

FINE GRAINED SOILS

Fine-grained soils (>50% fines)	Silts & Clays LL< 50	□	**ML**	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
		□	**CL** **CI**	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		▨	**OL**	Organic silts and organic silty clays of low plasticity
	Silts & Clays LL> 50	□	**MH**	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		□	**CH**	Inorganic clays of high plasticity
		▨	**OH**	Organic clays of medium to high plasticity
HighlyOrganic Soils		▨	**Pt**	Peat muck and other highly organic soils

FIELD TESTS

W = Field permeability
P = Pressuremeter test
R = Refusal
pp = Pocket penetrometer (kPa)
ID = Insitu density test

APPENDIX B

Geotechnical Laboratory Testing Results

LANE PIPER PTY LTD

154 Highbury Road, Burwood 3125 NATA Accreditation No. 3145

ATTERBERG LIMITS & UNIFIED CLASSIFICATION

These tests were carried out in accordance with Australian Standard 1289, 3.1.2 (One-Point Method), 3.2.1, 3.3.1, and 2.1.1.
The test was carried out only on the part of the soil finer than 0.425mm

PROJECT: GI STABILISATION OF GULLY

JOB/DOC No.: 207141/3

OPERATOR: GDH

LOCATION: McCRAE

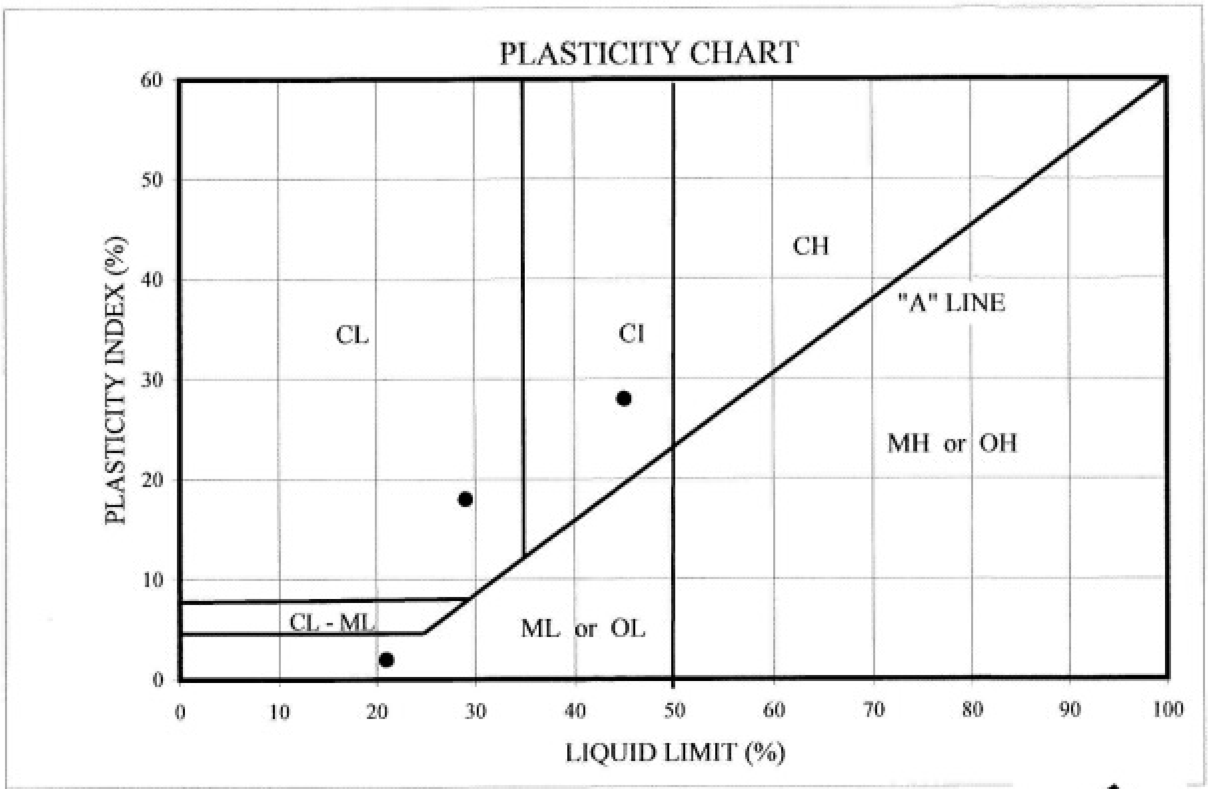
DATE: 5/06/2007

CLIENT: MORNINGTON PENINSULA SHIRE

ISSUE DATE: 3/09/2007

SAMPLE No.			
TESTPIT/BOREHOLE	BH1	BH2	BH3
DEPTH (M)	7.5-7.9	9.0-9.4	4.5-4.95
PREPARATION METHOD	AIR DRIED DRY SIEVED	AIR DRIED DRY SIEVED	AIR DRIED DRY SIEVED
SAMPLE DESCRIPTION	silty SAND brown, well graded	silty CLAY brown sandy	clayey SAND grey-brown well-graded
SAMPLING METHOD	AS1289.1.2.1.6.5.3	AS1289.1.2.1.6.5.3	AS1289.1.2.1.6.5.3
GROUP SYMBOL	SM	CI	SC
LIQUID LIMIT (%)	21	45	29
PLASTIC LIMIT (%)	19	17	11
PLASTICITY INDEX (%)	2	28	18

Plasticity Chart for classification of fine grained soil - Table A1 AS1726 - 1993



COMMENTS: Irrelevant & Sensitive

Test authorized by: Graham Hodgson
Laboratory Manager

WORLD RECOGNISED ACCREDITATION

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Figure No. 1.

LANE PIPER PTY LTD

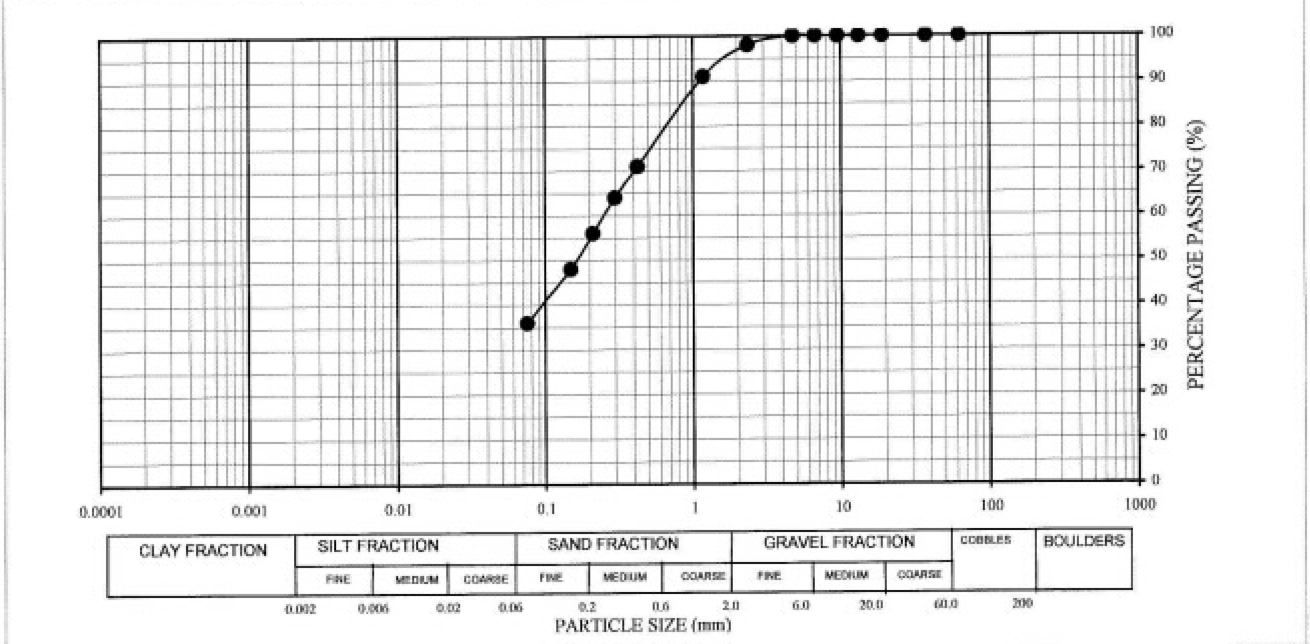
154 Highbury Road, Burwood 3125 NATA Accreditation No. 3145

DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF A SOIL STANDARD METHOD OF ANALYSIS BY SIEVING

This test was carried out in accordance with Australian Standard 1289.3.6.1

PROJECT: GI STABILISATION OF GULLY
JOB/DOC. No.: 207141/4
LOCATION: McCRAE
DATE: 3/06/2007
CLIENT: MORNINGTON PENINSULA SHIRE
ISSUE DATE: 3/09/2007
SAMPLE SOURCE: BH1 7.5-7.95m
OPERATOR: GDH
SAMPLE DESCRIPT.: clayey SAND brown, well graded
SAMPLING METHOD: AS1289.1.2.1.6.5.3
TOTAL DRY MASS OF SAMPLE: 145.8 grams

SIEVE APERTURE (MM)	PERCENTAGE PASSING OF TOTAL	SIEVE APERTURE (Micron)	PERCENTAGE PASSING OF TOTAL
63	100	1180	91
37.5	100	600	79
19	100	425	71
13.2	100	300	64
9.5	100	212	56
6.7	100	150	48
4.75	100	75	36
2.36	98		



REMARKS:

Irrelevant & Sensitive

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SIEVE.XLS LABSHEET
REV: 4/07

Figure No. 2.

LANE PIPER PTY LTD

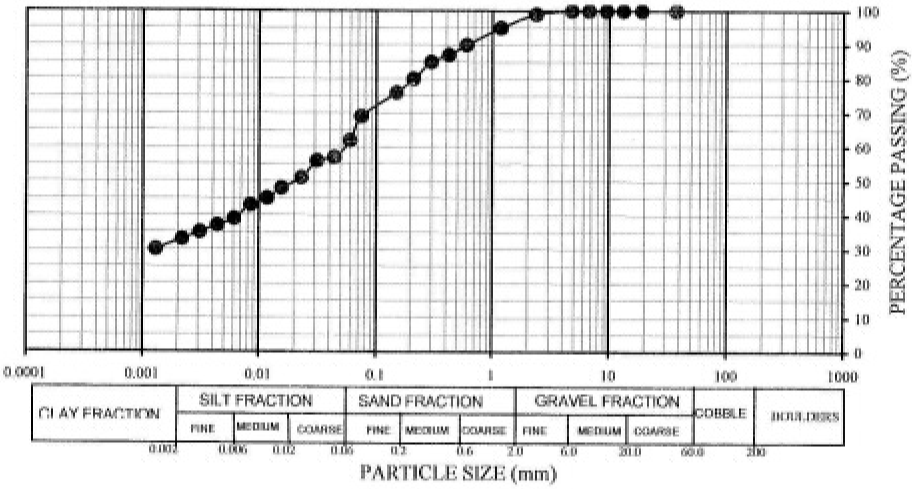
154 Highbury Road, Burwood 3125 NATA Accreditation No. 3145

DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF A SOIL
ANALYSIS BY SIEVING AND HYDROMETER (SUBSIDIARY METHOD)

This test was carried out in accordance with Australian Standard 1289 Method 3.6.2

PROJECT: GI STABILISTATION OF GULLY **JOB/DOC. No.:** 207141/6
LOCATION: McCRAE **DATE:** 4/06/2007
CLIENT: MORNINGTON PENINSULA SHIRE **ISSUE DATE:** 20/07/2007
SAMPLE SOURCE: BH2 9.0-9.4m **OPERATOR:** GDH
SAMPLE DESCRIPTION: silty CLAY brown sandy
SAMPLING METHOD: AS1289.1.2.1.6.5.
TOTAL DRY MASS : 541.3 grams
PRETREATMENT LOSS: NIL %
DISPERSION METHOD: Sodium Hexametaphosphate **HYDROMETER TYPE:** B5916

SIEVE APERTURE (MM)	PERCENTAGE PASSING OF TOTAL	PARTICLE SIZE (Micron)	PERCENTAGE PASSING OF TOTAL
37.5	100	60	62
19	100	44.2	57
13.2	100	31.5	56
9.5	100	23.3	51
6.7	100	15.7	48
4.75	100	11.8	45
2.36	99	8.5	43
1.18	95	6.1	39
0.6	90	4.4	37
0.425	87	3.1	35
0.3	85	2.2	33
0.212	80	1.3	30
0.15	76		
0.075	69		



REMARKS: Irrelevant & Sensitive

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Test authorised by: Graham Hodgson
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Figure No. 3 .

LANE PIPER PTY LTD

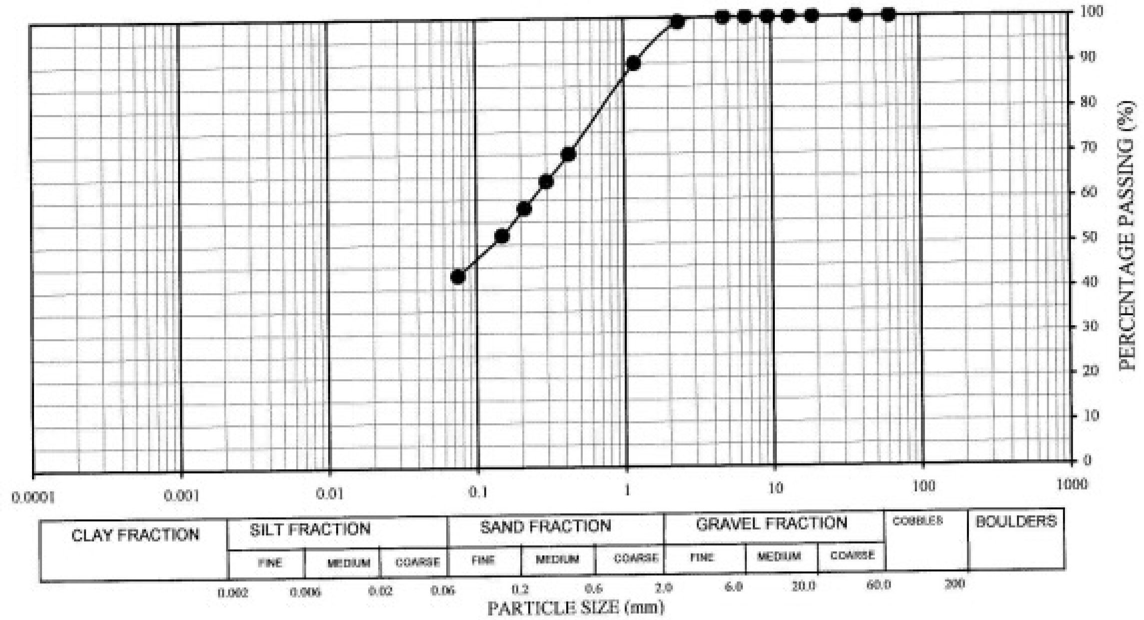
154 Highbury Road, Burwood 3125 NATA Accreditation No. 3145

DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF A SOIL STANDARD METHOD OF ANALYSIS BY SIEVING

This test was carried out in accordance with Australian Standard 1289.3.6.1

PROJECT: GI STABILISATION OF GULLY
JOB/DOC. No.: 207141/5
LOCATION: McCRAE
DATE: 4/06/2007
CLIENT: MORNINGTON PENINSULA SHIRE
ISSUE DATE: 3/09/2007
SAMPLE SOURCE: BH3 4.5-4.95m
OPERATOR: GDH
SAMPLE DESCRIPT.: clayey SAND grey-brown, well graded
SAMPLING METHOD: AS1289.1.2.1.6.5.3
TOTAL DRY MASS OF SAMPLE: 166.3 grams

SIEVE APERTURE (MM)	PERCENTAGE PASSING OF TOTAL	SIEVE APERTURE (Micron)	PERCENTAGE PASSING OF TOTAL
63	100	1180	90
37.5	100	600	77
19	100	425	70
13.2	100	300	64
9.5	100	212	58
6.7	100	150	52
4.75	100	75	43
2.36	99		



REMARKS:

Irrelevant & Sensitive

Test authorized by: Graham Hodgson
Laboratory Manager

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Figure No. 4.

LANE PIPER PTY LTD

154 Highbury Road, Burwood 3125

Determination of the Percent Passing a 75µm Sieve

PROJECT: GI STABILISATION OF GULLY

JOB/DOC. No.: 207141/1

LOCATION: McCRAE

DATE: 31/5/07

CLIENT: MORNINGTON PENINSULA SHIRE

ISSUE DATE: 1/06/07

SAMPLING METHOD: AS1289.1.2.1.6.5.3

OPERATOR: GDH

SAMPLE DESCRIPTIONS

Test No.	Sample Location	Depth (m)	Sample Description
1	BH1	13.5-13.95	clayey SAND grey-brown silty
2	BH2	13.5-13.95	clayey SAND grey-brown silty

PERCENTAGE PASSING

TEST No.	TOTAL DRY MASS (g)	% PASSING 75µm SIEVE
1	547.60	42
2	275.9	22

REMARKS:

Irrelevant & Sensitive

1/6/07

Test authorized by: Graham Hodgson
Laboratory Manager

Figure No. 5.

LANE PIPER PTY LTD

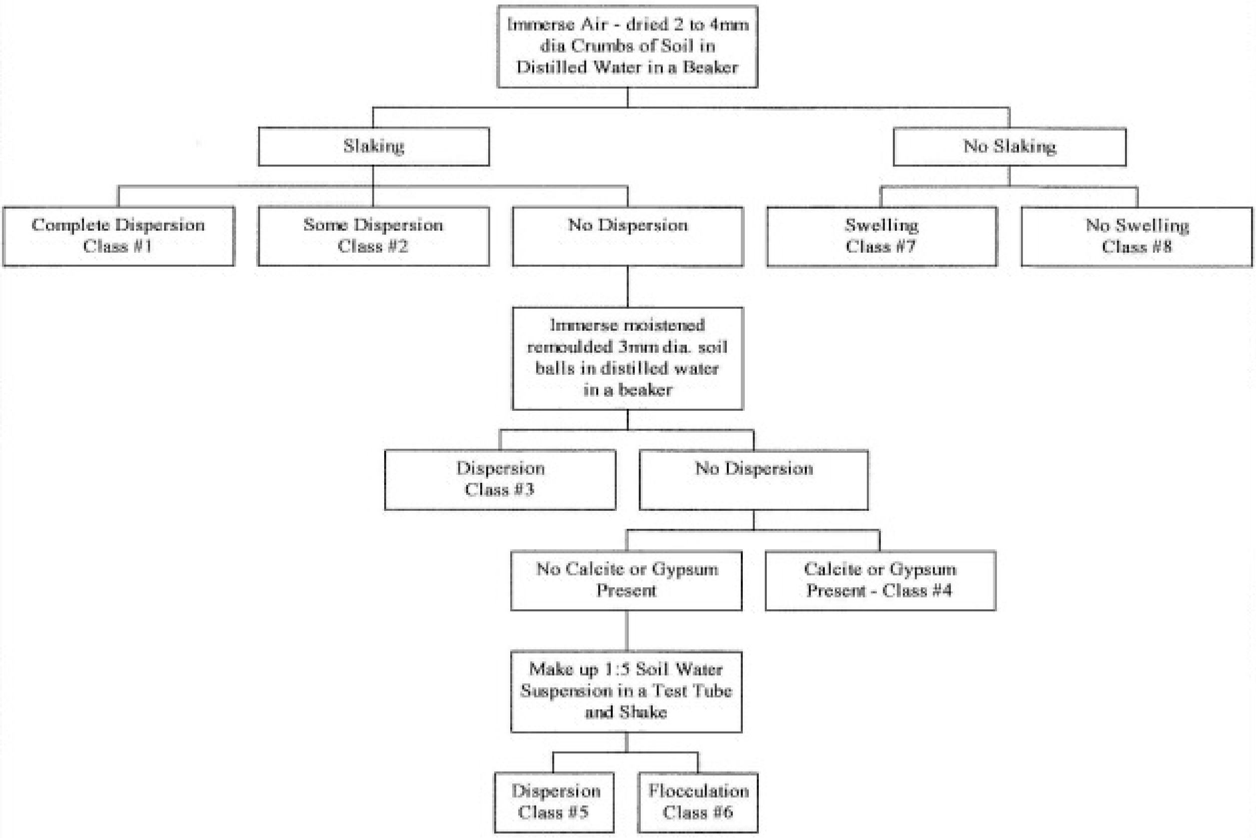
154 Highbury Road, Burwood 3125 NATA Accreditation No. 3145

DETERMINATION OF EMERSON CLASS NUMBER OF A SOIL

These tests were carried out in accordance with Australian Standard 1289 Method 3.8.1.

PROJECT: GI STABILISATION OF GULLY
LOCATION: McCRAE
CLIENT: MORNINGTON PENINSULA SHIRE
SAMPLE SOURCE: BOREHOLES
SAMPLING METHOD: AS1289 1.2.1.6.5.3

JOB/DOC. No.: 207141/2
DATE OF SAMPLING: 23/5/07
DATE OF TESTING: 31/5/07
ISSUE DATE: 1/6/07
OPERATOR: GDH



Test No.	Testpit No.	Depth (m)	Sample Description	Emerson Class No.	Description
1	HA9	0.7	Clayey SAND brown silty	5	Slightly Dispersive
2	HA6	0.7	Clayey SAND grey, orange-brown silty	2	Highly Dispersive
3	HA7	1.2	Sandy CLAY /clayey SAND grey	3	Moderately Dispersive

WATER USED FOR TESTING: DISTILLED

TEMPERATURE OF THE WATER: 17°C

COMMENTS:

Irrelevant & Sensitive 1/6/07

Test authorized by: Graham Hodgson
Laboratory Manager

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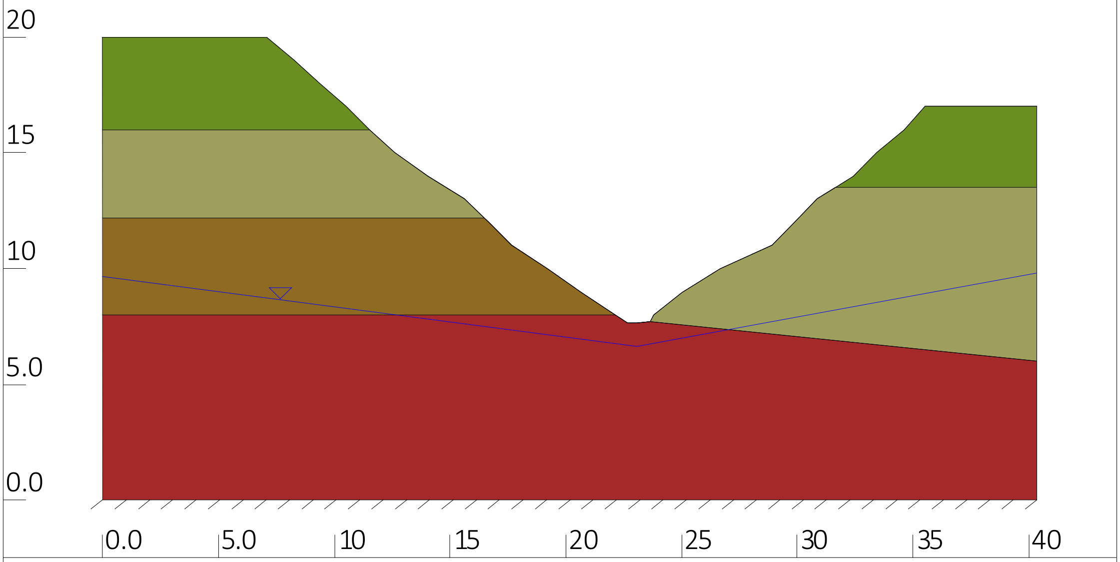
Figure No. 6.

APPENDIX C

Model Calibration XSLOPE Outputs
Solution Analysis XSLOPE Outputs

SOIL PROPERTIES

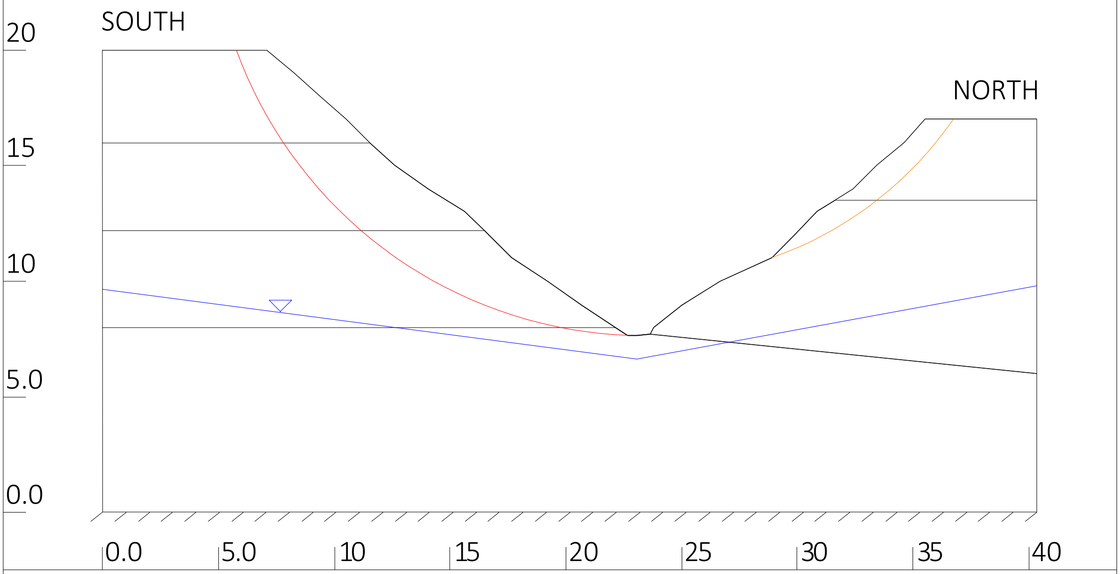
Layer	Cohesion	Phi	Gamma
🟧	5.0	30.0	19.0
🟩	2.0	38.0	19.0
▨	5.0	41.0	20.0
🟫	12.0	30.0	18.0
🟥	3.0	38.0	19.0



207141- McCrae- SectionA-A' - Backanalysis

CRITICAL CIRCLES

Circle	x0	y0	Radius	FoS
Southern	23.17	26.35	18.71	1.38
Northern	23.59	26.08	15.98	1.49



207141- McCrae- SectionA-A' - Backanalysis

TITLE **XSLOPE OUTPUT**

SCALE (A4) **SHOWN** | JOB NO **207141**

DRAWN **DBS** | DATE **3 SEP 2007**

REV. **0** | FIG. **1**

REF: 207141XSlope Results

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN. POINT NEPEAN ROAD & THE EYRIE, McCRAE**

LanePiper

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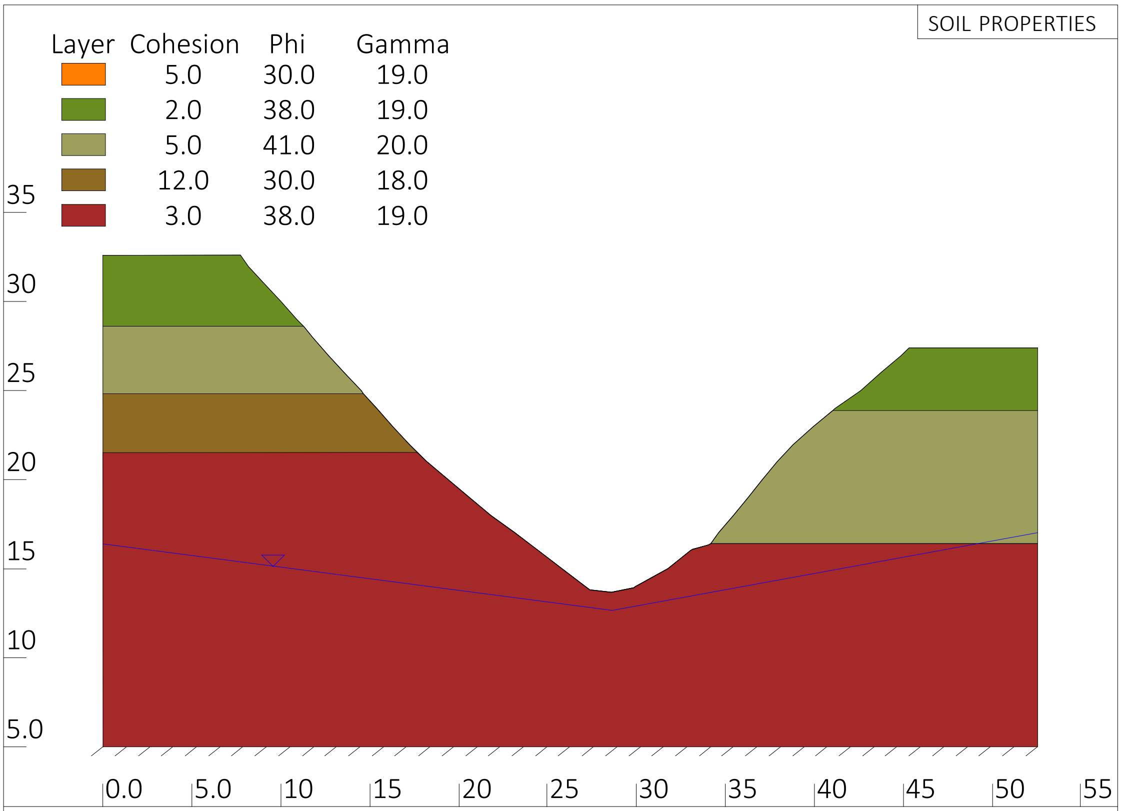
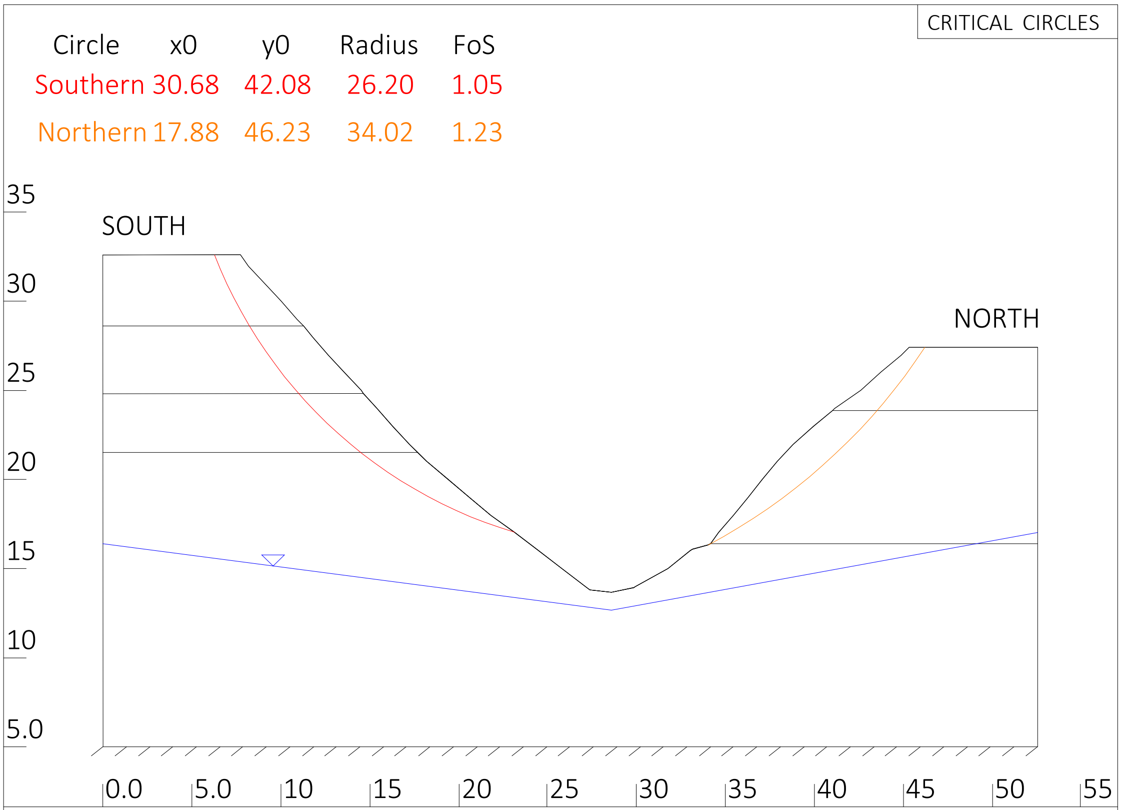
TELEPHONE [03] 9888 0100 FAX [03] 9808 3511



Layer	Cohesion	Phi	Gamma
🟧	5.0	30.0	19.0
🟩	2.0	38.0	19.0
🟩	5.0	41.0	20.0
🟫	12.0	30.0	18.0
🟥	3.0	38.0	19.0

207141- McCrae- SectionB-B' - Backanalysis



Circle	x0	y0	Radius	FoS
Southern	30.68	42.08	26.20	1.05
Northern	17.88	46.23	34.02	1.23

207141- McCrae- SectionB-B' - Backanalysis

TITLE	**XSLOPE OUTPUT**		
SCALE (A4)	**SHOWN**	JOB NO	**207141**
DRAWN	**DBS**	DATE	**3 SEP 2007**
		REV. **0**	FIG. **2**

REF: 207141XSlope Results

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN. POINT NEPEAN ROAD & THE EYRIE, McCRAE**

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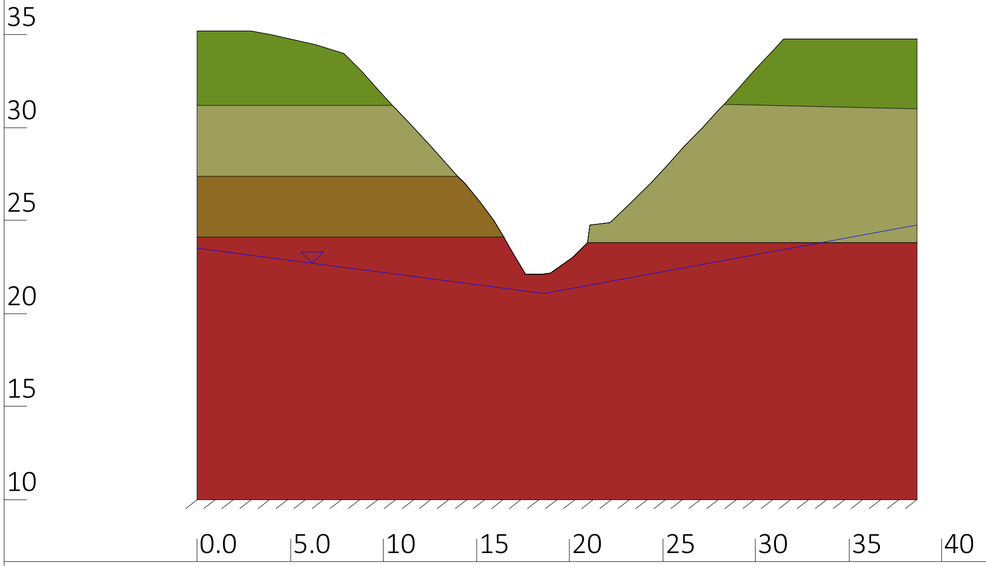
SOIL PROPERTIES

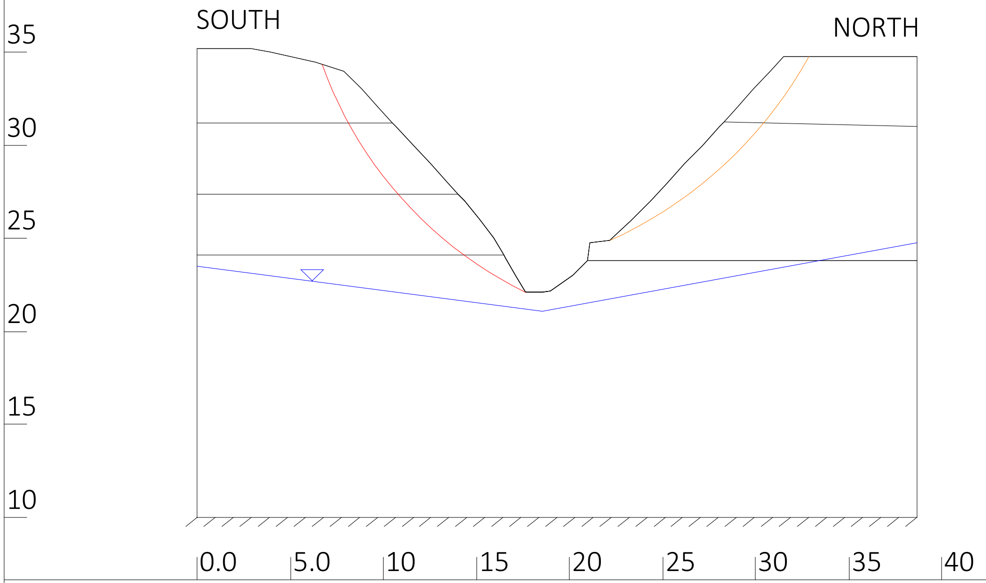
Layer	Cohesion	Phi	Gamma
🟧	5.0	30.0	19.0
🟩	2.0	38.0	19.0
🟩	5.0	41.0	20.0
🟫	12.0	30.0	18.0
🟥	3.0	38.0	19.0



207141- McCrae- SectionC-C' - Backanalysis

CRITICAL CIRCLES

Circle	x0	y0	Radius	FoS
Southern	27.35	41.75	21.93	1.00
Northern	12.34	46.30	23.54	1.22



207141- McCrae- SectionC-C' - Backanalysis

TITLE **XSLOPE OUTPUT**

SCALE (A4) **SHOWN** JOB NO **207141**

DRAWN **DBS** DATE **3 SEP 2007**

REV. **0** FIG. **3**

REF: 207141XSlope Results

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT**
BTN. POINT NEPEAN ROAD &
THE EYRIE, McCRAE

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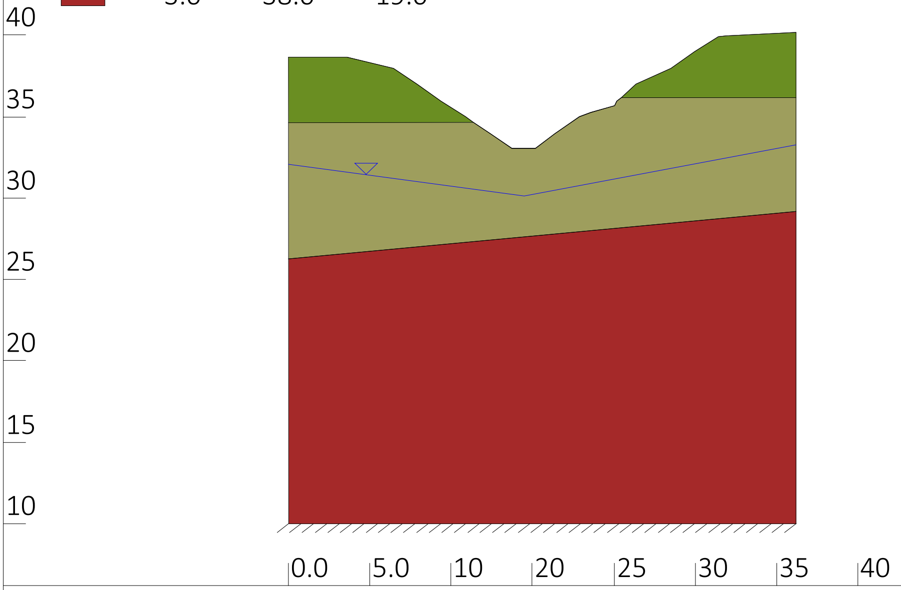
SOIL PROPERTIES

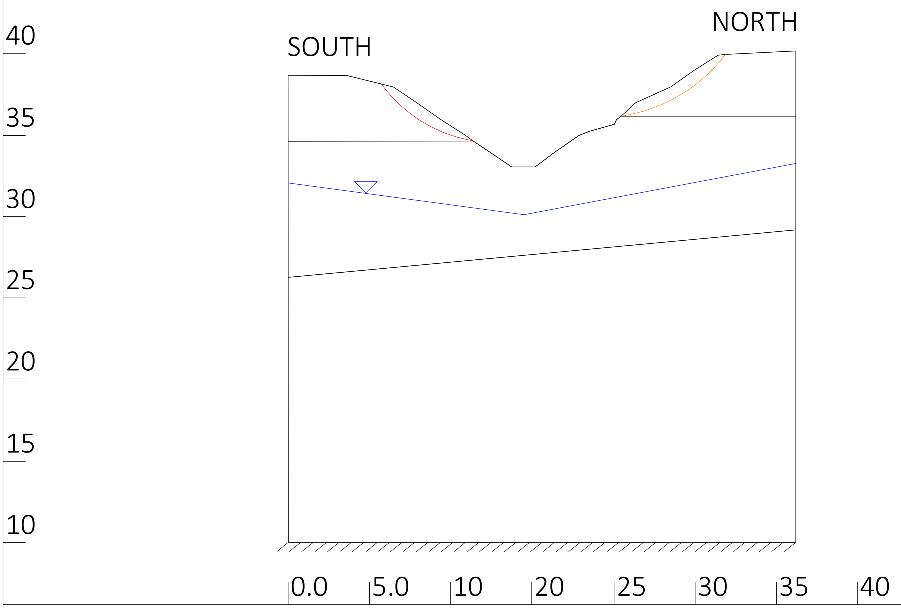
Layer	Cohesion	Phi	Gamma
🟧	5.0	30.0	19.0
🟩	2.0	38.0	19.0
🟨	5.0	41.0	20.0
🟫	12.0	30.0	18.0
🟥	3.0	38.0	19.0



207141- McCrae- SectionD-D' - Backanalysis

CRITICAL CIRCLES

Circle	x0	y0	Radius	FoS
Southern	12.87	43.42	8.87	1.71
Northern	18.95	46.11	10.02	1.81



207141- McCrae- SectionD-D' - Backanalysis

TITLE **XSLOPE OUTPUT**

SCALE (A4) **SHOWN** JOB NO **207141**

DRAWN **DBS** DATE **3 SEP 2007**

REV. **0** FIG. **4**

REF: 207141XSlope Results

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN. POINT NEPEAN ROAD & THE EYRIE, McCRAE**

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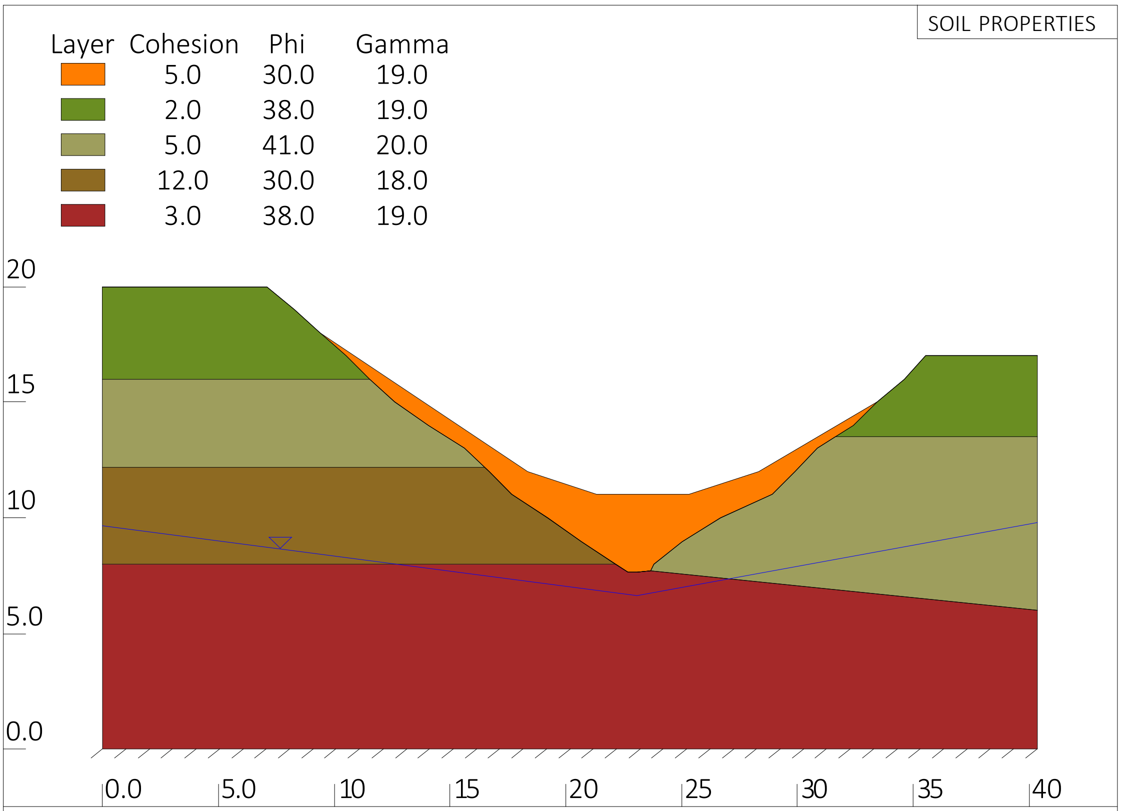
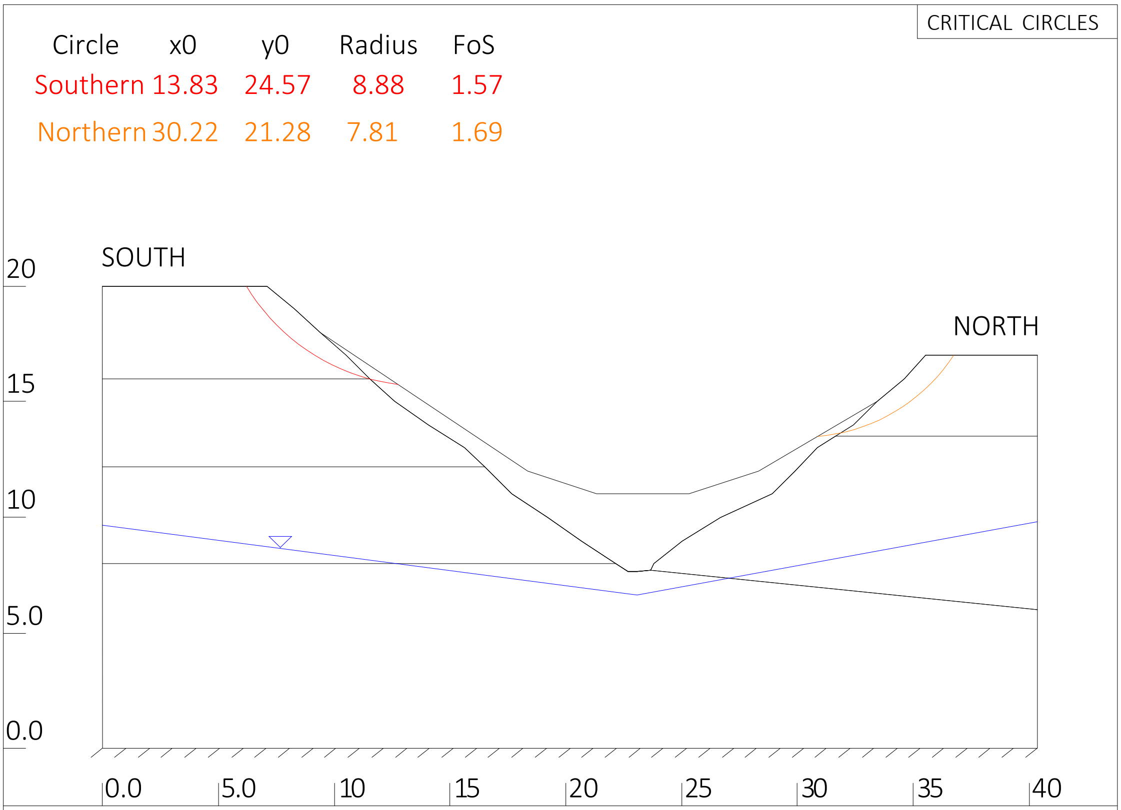


207141- McCrae- SectionA-A' - Solution



207141- McCrae- SectionA-A' - Solution

TITLE **XSLOPE OUTPUT**

SCALE (A4) **SHOWN**

JOB NO **207141**

DRAWN **DBS**

DATE **3 SEP 2007**

REV. **0**

FIG. **5**

REF: 207141XSlope Results

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN. POINT NEPEAN ROAD & THE EYRIE, McCRAE**

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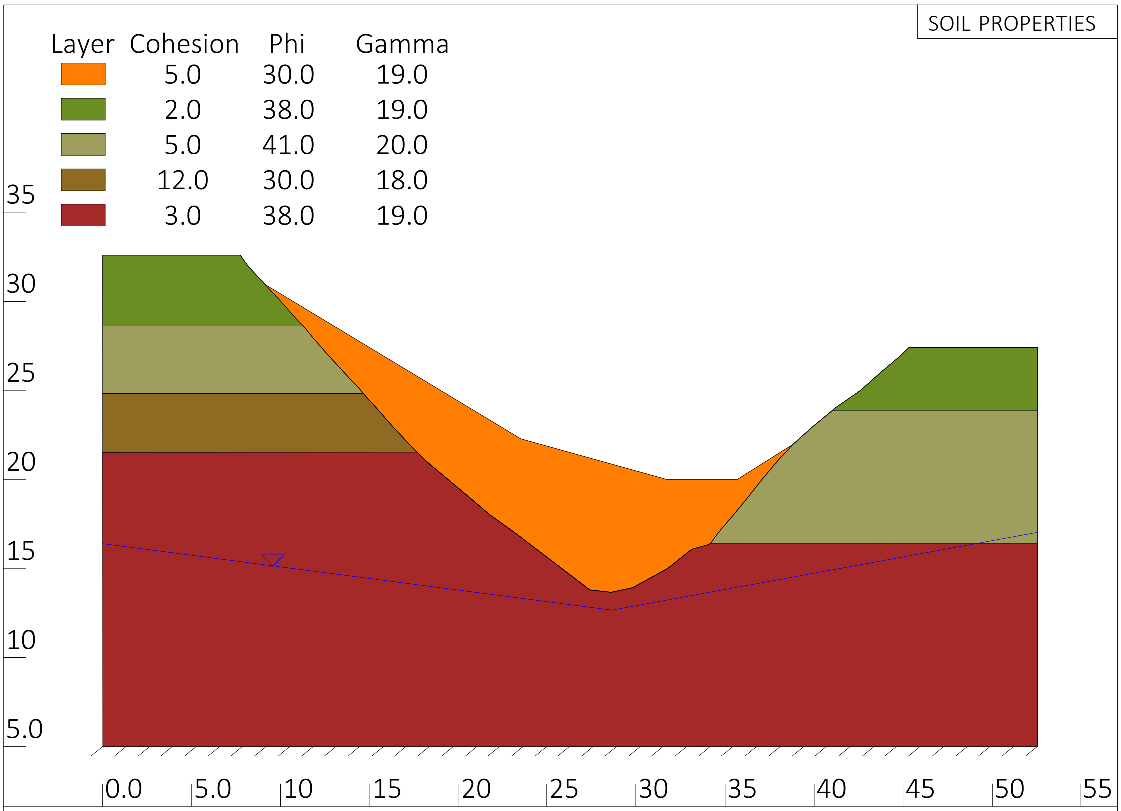
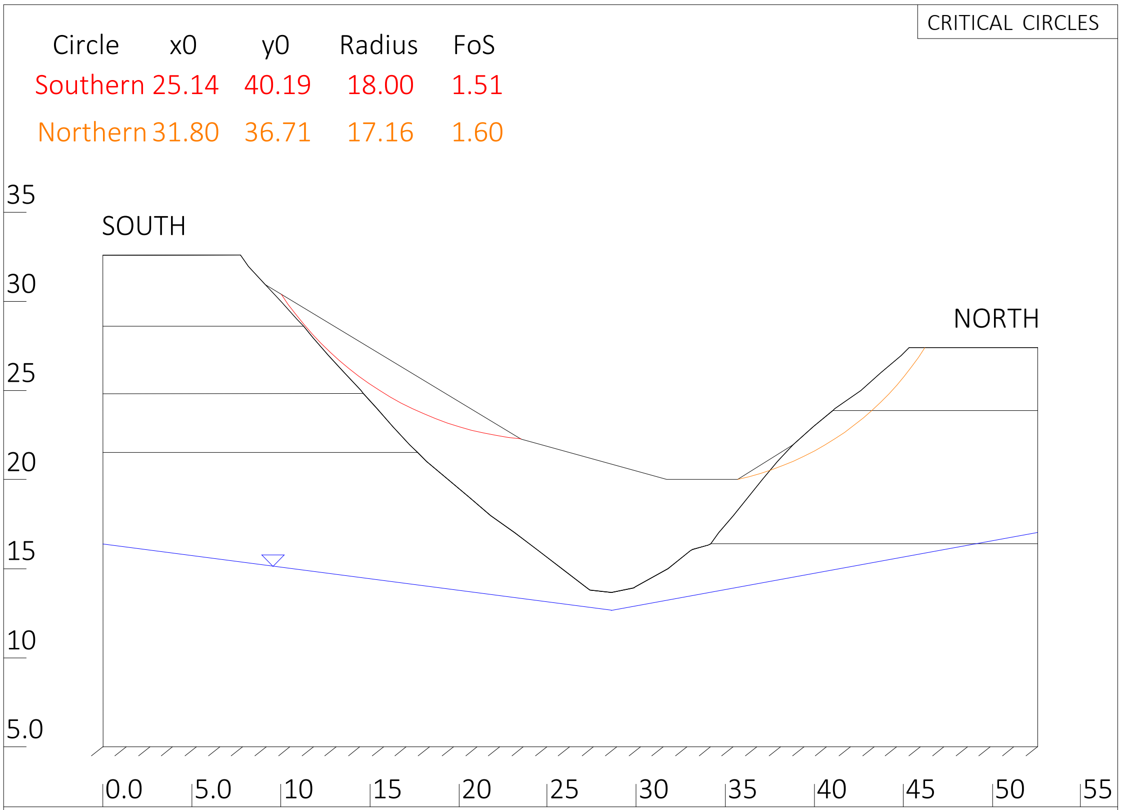


Layer	Cohesion	Phi	Gamma
🟧	5.0	30.0	19.0
🟩	2.0	38.0	19.0
🟩	5.0	41.0	20.0
🟫	12.0	30.0	18.0
🟥	3.0	38.0	19.0

207141- McCrae- SectionB-B' - Solution



Circle	x0	y0	Radius	FoS
Southern	25.14	40.19	18.00	1.51
Northern	31.80	36.71	17.16	1.60

207141- McCrae- SectionB-B' - Solution

TITLE	**XSLOPE OUTPUT**		
SCALE (A4)	**SHOWN**	JOB NO	**207141**
DRAWN	**DBS**	DATE	**3 SEP 2007**
		REV. **0**	FIG. **6**
REF: 207141XSlope Results			

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN. POINT NEPEAN ROAD & THE EYRIE, McCRAE**

LanePiper

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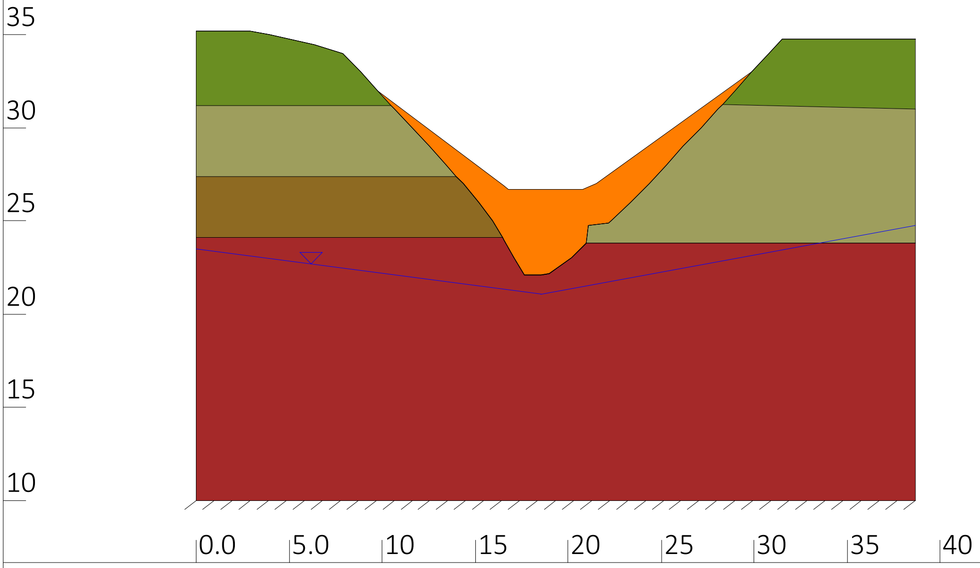
SOIL PROPERTIES

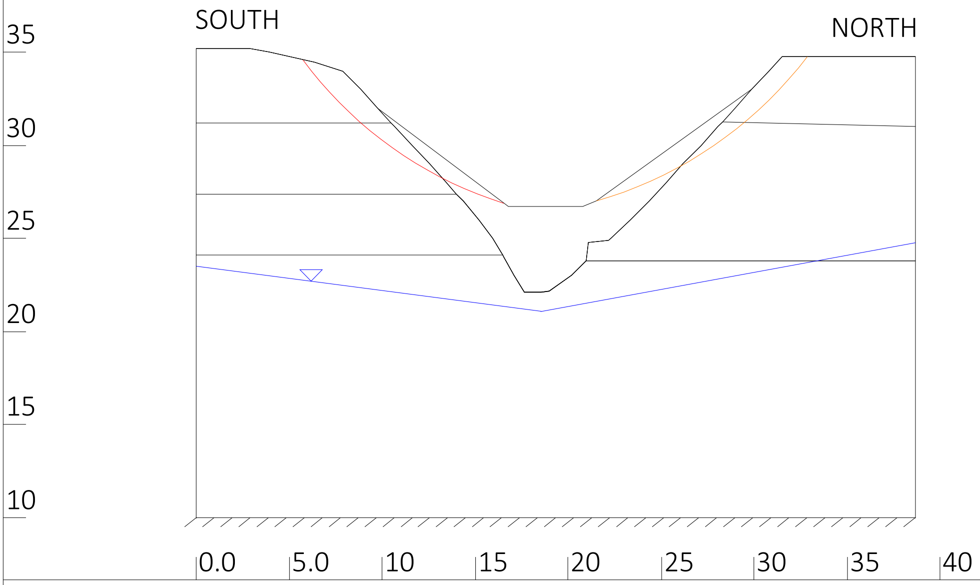
Layer	Cohesion	Phi	Gamma
🟧	5.0	30.0	19.0
🟩	2.0	38.0	19.0
🟩	5.0	41.0	20.0
🟫	12.0	30.0	18.0
🟥	3.0	38.0	19.0



207141- McCrae- SectionC-C' - Solution

CRITICAL CIRCLES

Circle	x0	y0	Radius	FoS
Southern	23.00	47.36	21.46	1.51
Northern	15.33	48.37	22.20	1.52



207141- McCrae- SectionC-C' - Solution

TITLE	**XSLOPE OUTPUT**		
SCALE (A4)	**SHOWN**	JOB NO	**207141**
DRAWN	**DBS**	DATE	**3 SEP 2007**
		REV. **0**	FIG. **7**
REF: 207141XSlope Results			

PROJECT **PIPING AND STABILISATION OF DRAINAGE EASEMENT BTN. POINT NEPEAN ROAD & THE EYRIE, McCRAE**

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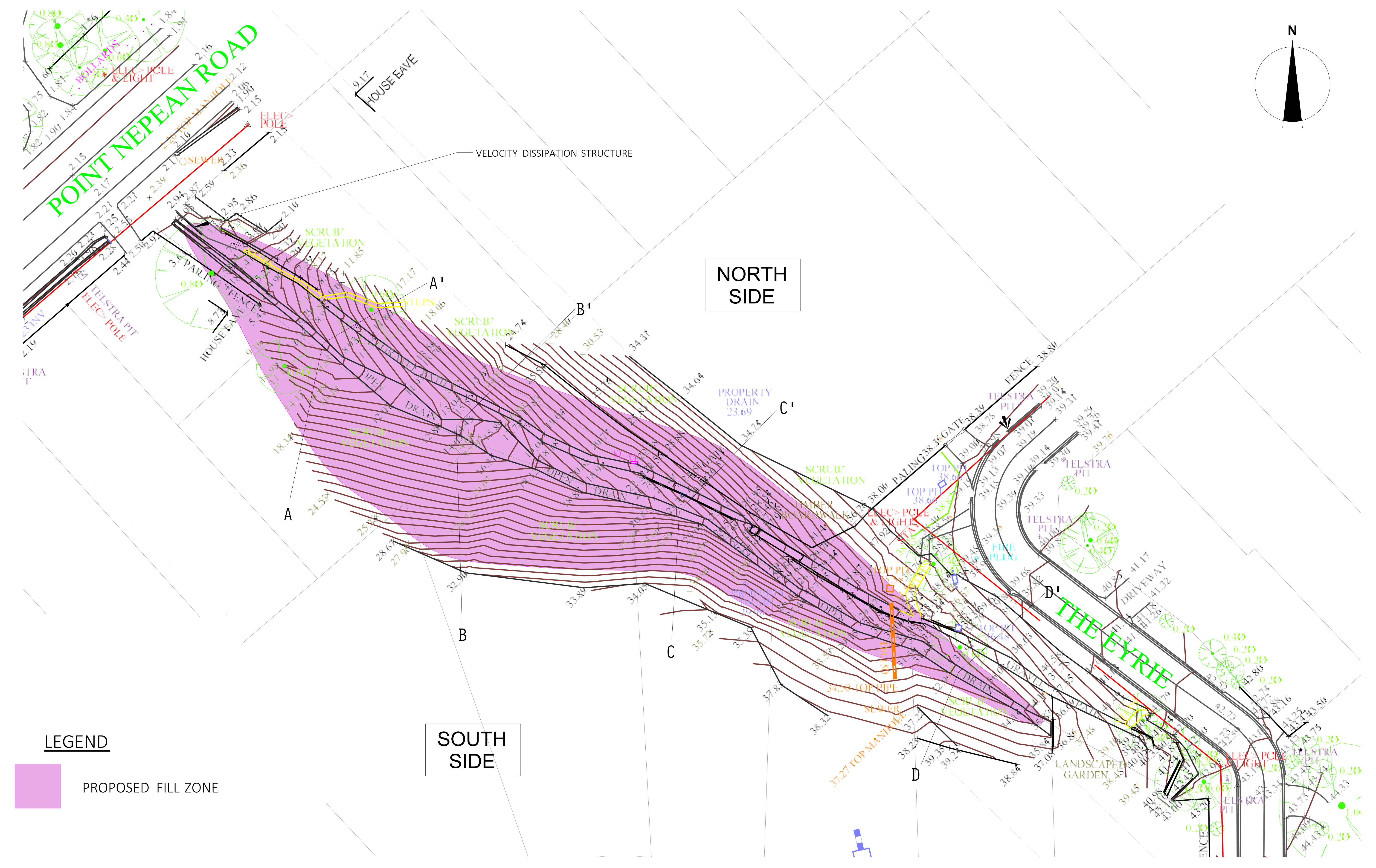
APPENDIX D

Area of Fill Placement Plan



PROJECT PIPING AND STABILISATION OF
DRAINAGE EASEMENT
BTN POINT NEPEAN ROAD
& THE EYRIE, McCRAE

LanePiper

LANE PIPER PTY LTD
A.C.N. 120 109 935
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TITLE
FILL PLACEMENT PLAN

REF: P:\Projects 207118_207150\207141\Plans & Drawings

SCALE (A3) 1:500
DATE 3 SEP 2007
DRAWN DBS
JOB NO. 207141
MEL REF: 159:B9
REV. NO. 0
FIG. NO. 1

APPENDIX E

Guidelines for Hillside Construction

APPENDIX J

SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant 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.	Indiscriminant 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.	

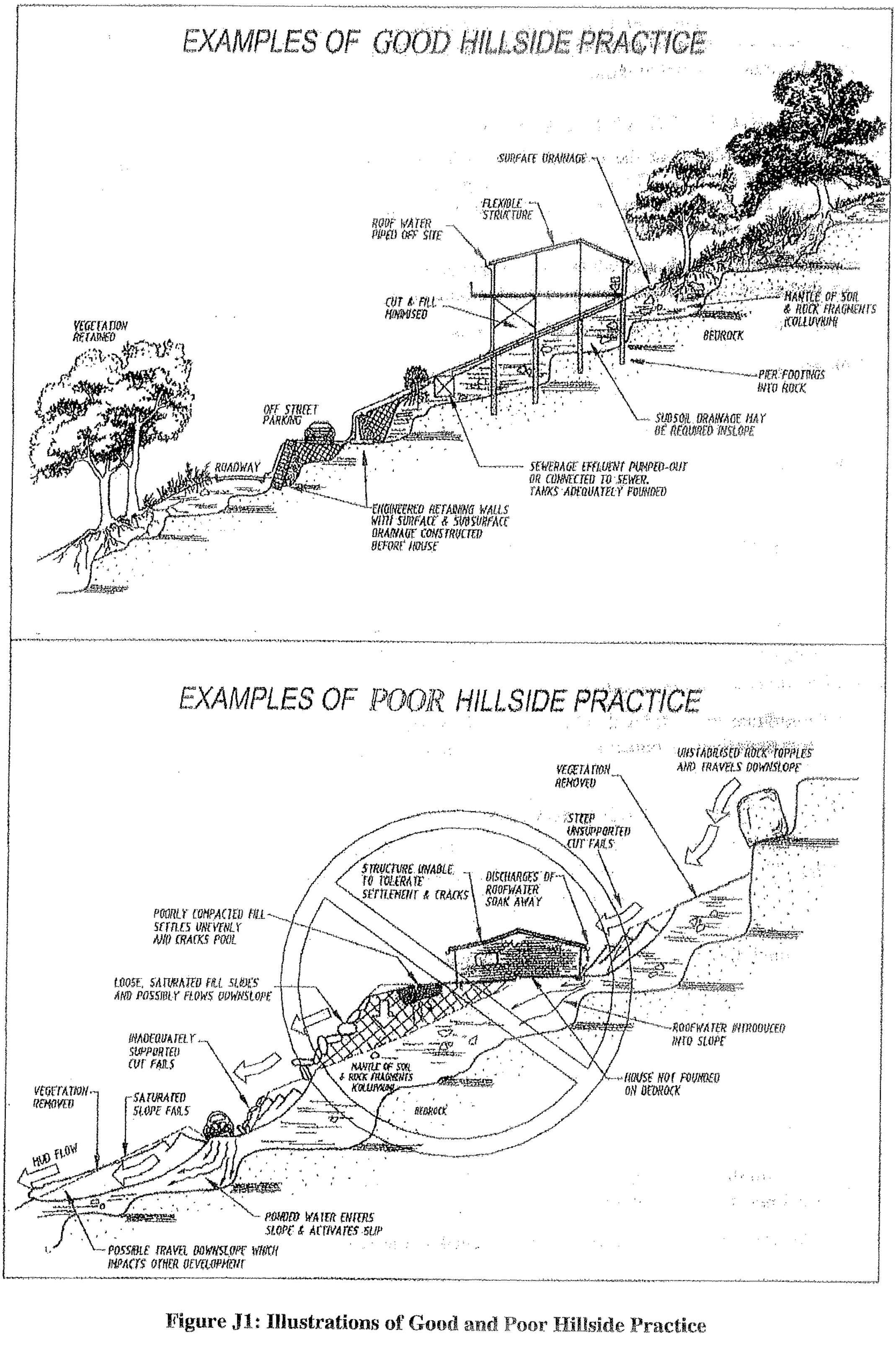

Figure J1: Illustrations of Good and Poor Hillside Practice