PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL

Approval no: DEV2017/844

Date: 25 October 2017

Queensland Government

JOB NO. GE12/005 FEBRUARY, 2012

PACIFIC INTERNATIONAL DEVELOPMENT CORPORATION

BROAD GEOTECHNICAL ASSESSMENT

FOR RESIDENTIAL SUBDIVISION

NEIGHBOURHOOD NH1 TO NH10

SECTOR 1 TO SECTOR 3 - PRECINCT 1

FLINDERS DEVELOPMENT

UNDULLAH STATION, UNDULLAH

FLINDERS

MORRISON GEOTECHNIC

TABLE OF CONTENTS

MORRISON GEOTECHNIC PTY LTD
www.morrisongeo.com.au

■ **BRISBANE**
Unit 1 / 35 Limestone Street
PO Box 3063
Darra Qld 4076
P: 07 3279 0900
F: 07 3279 0955
brisbanelab@
morrisongeo.com.au

■ **GOLD COAST**
Unit 5 / 36 Lawrence Drive
PO Box 2011
Nerang Qld 4211
P: 07 5596 1599
F: 07 5527 2027
goldcoastlab@
morrisongeo.com.au

■ **CABOOLTURE**
Unit 3 / 42 Aerodrome Road
Caboolture Qld 4510
P: 07 5499 0755
F: 07 5428 2498
caboolturelab@
morrisongeo.com.au

■ **SUNSHINE COAST**
Unit 4 / 81 Wises Road
Maroochydore Qld 4558
P: 07 5443 9522
F: 07 5479 1633
maroochydorelab@
morrisongeo.com.au

MORRISON GEOTECHNIC
ABN 51 009 878 899
RPEUQ 2241

Gold Coast Office
Job No. GE12/005
Ref: 15139
Author: Leigh Bexley

9th February, 2012

Pacific International Development Corporation Pty Ltd
C/-Mortons Urban Solutions
P O Box 2484
Southport Qld 4215

ATTENTION: MR MATTHEW MCLAREN **FAX NO. 55 711 088**
Email: mattmc@urbansolutions.net.au

Dear Sir

RE: BROAD GEOTECHNICAL ASSESSMENT FOR RESIDENTIAL SUBDIVISION NEIGHBOURHOOD NH1 TO NH10, SECTOR 1 TO 3, PRECINCT 1 - FLINDERS DEVELOPMENT, UNDULLAH STATION, UNDULLAH

1.0 INTRODUCTION

This report presents the results of a broad geotechnical assessment carried out for a proposed residential subdivision at the Flinders Development, Precinct 1 Development Site (Neighbourhood NH1 to NH10), Undullah. It aims at identifying major development constraints associated with the proposed residential development as well as dividing the site into Landform Units based on the topography. An established level of safety hazard has also been assigned to each Landform Unit, in accordance with the Australian Geomechanics Society (AGS) 'Practice Note Guidelines for Landslide Risk Management' Vol 42 No1 March 2007. The work was commissioned by the Client, Pacific International Development Corporation Pty Ltd.

From the information provided in a brief by Mr Matthew McLaren of Mortons Urban Solutions, the Client, Pacific International Development Corporation, is proposing to subdivide the Precinct 1 development site (NH1 to NH10) into numerous Lots as part of a residential development. The residential Lots are expected to be located at least 50m from the main creek corridors throughout the development site. The proposed development will also involve the construction of a primary and high school, town centre, active recreational areas, roads and parklands. No information with regards to the Lot layout or the proposed earthworks has been provided at this stage.

Based on the results of the fieldwork, our report contains the following:-

- Broad division of the site into identified Landform Units based on a combination of topography, surface features and slope stability.
- Broad assessment of subsurface profile in each identified Landform Unit, based on borehole drilling.
- Broad slope stability assessment of each identified Landform Unit.
- Identification of the more significant geotechnical constraints or issues which would impact on the proposed development such as unstable areas, soft compressible soils, groundwater issues, etc. and the appropriate geotechnical measures that would need to be undertaken to overcome these constraints.
- Drainage issues and impacts for development.
- Broad recommendations for filling and excavations, including compaction standards for fill material and foundation preparation, particularly in areas where there are significant constraints such as unstable areas, drainage features or steep topography.
- Advice on temporary and permanent batters.
- Broad recommendations for residential development at the site.
- The suitability and feasibility of the proposed development based on existing geotechnical conditions of the site.

Individual site classifications in accordance with AS2870 “Residential Slabs and Footings” for each residential Lot are excluded from the scope of work. Detailed investigation for house site design, infrastructure and services design as well as a surface and groundwater hydrology study are also excluded from the scope.

2.0 METHODOLOGY

A desk study of the available aerial photos, contour maps, geological survey maps, Lot Layout plans and our recent reports associated with the site was carried out to gain an understanding of the site geology, surface topography, proposed development area and major site features such as unstable areas, drainage features, seepage zones and sloping terrain.

Following this desk study, a walk over survey of the site was carried out by an Engineering Geologist from our Gold Coast office to identify the main geological and surface features, which would impact on the planning and design of the project. This included identifying major site features such as drainage features, rock outcrop, seepage zones and signs of any unstable areas and visible recent past instability such as slips, slumps, hummocks, backscarps and scree debris fans. Twenty (20) boreholes (BH1 to BH20) were drilled using a utility mounted Jacro 200 drilling rig to assess the underlying geology and typical rock depths for the slope stability assessment.

The subsurface conditions encountered in the boreholes were logged by a Senior Engineering Geologist from our Gold Coast office. All boreholes were located using a hand held GPS and superimposed onto a contour plan. Pocket penetrometer assessments of q_u for the encountered clay soils within the boreholes were also carried out at regular depth intervals.

Site photographs are contained in Appendix A to this report. The borehole logs are presented in Appendix B whilst the Guidelines for Hillside Engineering are presented in Appendix C. A Landform Unit Map showing the identified Landform Units and locations of the boreholes is attached to this report. A Reference Plan as well as a Slope Analysis Plan is also attached to this report.

3.0 SITE DESCRIPTION

The Precinct 1 development area (Neighbourhood NH1 to NH10) is located approximately 10km west of Jimboomba and 18km north west of Beaudesert. It is approximately 4.5km long north to south and ranges between 1km and 3km in width, east to west. Surface levels at the site range between approximately RL30.0m in the far southern portion of the site (NA2) and RL160m on the ridge line in the far northern portion of the site (H1).

The Precinct 1 development area typically comprises undulating, mild sloping terrain which is evident throughout most of the site, particularly within the southern and central portions of the site. This undulating terrain comprises mild slopes typically ranging between 5^{o} and 15^{o} in slope gradient which grades into moderate and steep sloping terrain in the elevated areas in the far northern and far western portions of the site. The moderate sloping terrain comprises slopes typically ranging between 15^{o} and 25^{o} whilst the steep sloping terrain which is evident within the elevated, localised areas throughout the site, typically ranges between 25^{o} and 35^{o} in slope gradient. There are also numerous hill crests and ridge lines throughout the entire site which typically align in a north to south lineation. These crest and ridges comprise slope gradients of less than 5^{o} and are typically flanked by mild sloping terrain in the lower central and southern portions of the site whilst in the elevated, northern and western portions of the site the crest and ridges are typically flanked by moderate and steep sloping terrain. There are also several alluvial plains and terraces adjacent to the creeks, particularly within the flatter, lower terrain to the south. These alluvial plains adjacent to the creeks typically comprise slope angles of less than 5^{o}.

The site is drained by Undullah Creek which borders the south western portion of the site, and Woollaman Creek which borders the southern portion of the site. There are also two ephemeral creeks within the eastern portion of the site which border the NH1 and NH2 development areas. Numerous drainage gullies as well as drainage swales are evident throughout the site and also form part of the drainage features at the site. These numerous drainage gullies and drainage swales direct surface and subsurface water flows into the main creeks and offsite to the south. The proposed development is expected to be located at least 50m from the main creeks. The proposed development is also expected to avoid most drainage gullies and swales, however, several of the smaller drainage features are expected to be filled as part of the proposed development.

The main creeks aligning the south western and southern boundaries of the site generally range between approximately 10m and 20m in width and range up to approximately 10.0m in height. The ephemeral creeks adjacent to NH1 and NH2 development areas typically range between 5m and 15m in width and range up to 5m in height. The banks of the creeks are generally densely vegetated limiting access to most areas. This vegetation includes mature trees which appear to have been present for a considerable period of time and have given the banks added stability. There are however, numerous areas with steep vertical banks which have been significantly eroded and undercut causing trees to slant and some sections of the banks to collapse. These areas are predominantly located on the outer bends of the creek banks where there is a slight meander and the flow velocity is greatest. The lineal sections of the creeks typically display only localised areas of erosion whilst the inner bends of the creeks are relatively flat with no major erosion only deposition evident. The smaller drainage features also display evidence of instability, particularly in areas where vegetation is limited. This instability is typically evident in the form of erosion and slumping or slipping of the banks. In the flatter sections of the drainage features, sink holes caused by tunnel erosion is often evident.

The main creeks to the west (Undullah Creek) and south (Woollaman Creek) are currently flowing whilst the smaller ephemeral creeks adjacent to NH1 and NH2 development areas are not flowing but contain ponded water at several locations within the creek beds, particularly in areas where bedrock is exposed within the base of the creek bed. It is expected that in areas where the base of the creekbeds are typically flat and comprise sand, groundwater may possibly be flowing. The direction of the water discharge is generally to the south.

The flat, alluvial plains adjacent to the creek banks and larger drainage features throughout the site typically display no major evidence of instability at the surface and did not encounter any groundwater within the boreholes drilled at these locations. It should be noted that groundwater associated with the creeks may possibly be encountered within localised areas within these flat alluvial plains adjacent to the creeks and larger drainage features. This would have to be confirmed in a surface and groundwater hydrology study of the site.

In the lower central and southern portions of the Precinct 1 site, where the surface topography is mild or flat, there are several dams. These dams are typically located within the drainage features and are expected to be filled as part of the proposed development.

For the purpose of this investigation, the Site has been divided into five distinct Landform Units which are shown on the attached Landform Unit Map and described below. It must be noted that the interpreted locations and boundaries shown on the attached Landform Unit Map are intended to differentiate broadly between the Landform Units on a large scale. On this basis, each Landform Unit shown on the attached Landform Unit Map can be expected to contain topography or characteristics belonging to other units. A summary of the geotechnical constraints or issues which would impact on the future development at the site is presented in Section 6.0 of this report.

3.1 Crest and Ridges

This Landform Unit is only minor but is evident throughout the site typically aligning in a north south lineation. It is characterised by being elevated terrain with surface gradients of less than 5^{o}. This Landform is typically flanked by the Mild Sloping Topography Landform Unit but is flanked by the Moderate to Steep Topography Landform Unit in localised areas to the far north and west. The soil profile is shallow in this Landform with bedrock typically encountered at depths of less than 1.0m below the existing ground surface. This Landform typically supports a sparse covering of native bush vegetation and contains no major evidence of instability.

3.2 Gentle Sloping Topography

This Landform Unit is located in localised areas adjacent to the creeks. It is characterised by being low lying terrain with gentle surface gradients of less than 5^{o}. It typically forms an alluvial plain with planar slopes which has been created by the deposition of sediment associated with the historical movement of the creek as well as erosion from the upslope terrain. The soil profile is deeper in this Landform with bedrock typically encountered at depths ranging between 2m and 5m below the existing ground surface. This Landform has mostly been cleared of vegetation and supports grass with localised areas of native bush vegetation. This Landform exhibits no major signs of instability. Drilling did not encounter groundwater in these areas but there may be localised areas where groundwater is present.

3.3 Mild Sloping Topography

This Landform Unit is the predominant Landform at the site and is evident flanking most of the Crest and Ridges Landform. It is characterised by surface gradients typically ranging between 5^{o} and 15^{o} and typically forms a convex or planar slope. The soil profile is shallow in this Landform with bedrock typically encountered at depths of less than 1m below the existing ground surface.

This Landform has mostly been cleared of vegetation and typically supports a sparse to moderate covering of native bush vegetation. This Landform exhibits no major evidence of instability.

3.4 Moderate to Steep Sloping Topography

This small Landform Unit is typically located within the elevated portions of the site to the far north and west and generally flanks the Crest and Ridges Landform Unit. It is also evident in localised areas adjacent to the creeks where the historical movement of the creek has cut into the toe of the slope and steepened the terrain. It is characterised by being planar and concave slopes with surface gradients typically ranging between 15^{o} and 30^{o} but slightly steeper in localised areas. No boreholes were drilled in this Landform Unit due to inaccessibility, however soil profiles are expected to be relatively shallow.

This Landform appears to display evidence of historical instability in the form of debris slides, slumping and possibly slips, particularly near the heads of the steeper gullies. There also appears to be recent minor instability in the form of creep movement at the surface. There are also numerous boulders strewn across the surface within this Landform Unit.

This Landform currently supports moderate bush vegetation with a covering of grass.

3.5 Drainage Features

This Landform Unit is typically located within the Mild Sloping Topography Landform. It is typically characterised by being highly eroded drainage features which collect surface and subsurface water from the surrounding areas and redirect this water into the creeks. These drainage features exhibit significant erosion which has instigated slipping and slumping within the banks, particularly in areas where there is no or limited vegetation evident. These highly eroded areas comprise steep banks which have been undercut as well as several sink holes created by tunnel erosion. Several of these drainage features contain ponded water, particularly where bedrock is evident within the base whilst several dams are also evident within the lower portions of the drainage features. Subsurface water is also likely to be encountered in these Landforms as there are several sink holes caused by tunnel erosion particularly within the flatter portions or near the heads of the drainage features.

This Landform Unit typically supports a moderate cover of native bush vegetation within the drainage features as well as along the banks.

In areas where these drainage features are expected to encroach or impact on the proposed development, the drainage features will need to be filled as part of the proposed earthworks. Recommendations for filling in these areas are described in Section 8.0 of this report.

4.0 SUBSURFACE CONDITIONS

The regional geology of the area forms part of the Marburg Formation which was formed in the Early Jurassic Geological Time Period. It comprises lithic or feldspathic, labile to sublabile sandstone, siltstone, shale and coal. The local geology within the Precinct 1 development area typically comprises sandstone bedrock with some interbedded siltstone layers overlain by residual soils, slopewash soils and flood plain and river terrace deposits of quaternary origin (Ipswich 1:100 000 Geological Series, Sheet 9442).

Based on field mapping and results of borehole drilling within the Precinct 1 development area, the subsurface conditions typically comprise silty sand and clayey sand at the surface which is underlain by residual sandy clay and sandstone bedrock with minor occurrences of interbedded siltstone. Adjacent to the creeks and within the larger drainage features, alluvial sandy soils typically overlie the residual clay soils at depth. The sandstone appears to be massive but does exhibit slight bedding in some areas. The bedding within the sandstone tends to dip at shallow angles typically ranging between 10^{o} and 40^{o} towards the east.

A summary of the subsurface conditions encountered in the boreholes are presented in the following subsections.

4.1 Crest and Ridges (Boreholes BH1, BH7, BH9, BH13 and BH20)

Topsoil: Comprising moist, loose and medium dense, silty sand, extending to depths ranging between 0.1m and 0.15m, underlain by

Slopewash Soil: Comprising moist, medium dense and dense, silty sand in borehole BH20 only and moist, firm and stiff, silty clay and sandy clay of high plasticity in boreholes BH1 and BH9 only, extending to depths ranging between 0.25m and 0.45m, underlain by

Residual Soil: Comprising moist, stiff to hard, silty clay and sandy clay of typically medium and high plasticity but becoming low and low to medium plasticity with depth, extending to depths ranging between 0.5m and 1.4m, underlain by

Bedrock: Encountered at depths of ranging between 0.5m and 1.4m and comprising extremely low to low strength, extremely weathered, sandstone, extending to depths in excess of 1.7m and 3.2m.

Boreholes BH1, BH7, BH9, BH13 and BH20 were terminated at maximum TC refusal depths ranging between 1.7m and 3.2m. No groundwater was encountered in any of the boreholes during this investigation.

4.2 Gentle Sloping Topography (Boreholes BH3, BH15 and BH19)

Topsoil: Comprising moist, firm, silty sandy clay of high plasticity in BH19 and moist, loose, silty sand and clayey sand at the surface of BH3 and BH15, extending to depths ranging between 0.1m and 0.3m, underlain by

Alluvial Soil: Comprising moist, stiff to hard, silty clay and sandy clay of typically medium to high plasticity, extending to depths ranging between 2.0m and 5.8m, underlain by

Residual Soil: Comprising moist, very stiff to hard, sandy clay of low to medium plasticity in borehole BH3 and BH15 and moist, very stiff, silty sandy clay of high plasticity in borehole BH19 only, extending to a depth of 2.4m in borehole BH15 only and to depths in excess of 4.5m and 7.2m in boreholes BH19 and BH3, respectively, underlain by

Bedrock: Encountered in borehole BH15 only at a depth of 2.4m and comprising very low strength, extremely weathered, sandstone, extending to a depth in excess of 3.0m.

Borehole BH3, BH15 and BH19 were terminated at depths of 7.5m, 3.0m and 4.5m, respectively. Groundwater was encountered in borehole BH3 only at a depth of 7.2m

4.3 Mild Sloping Topography (Boreholes BH4, BH6, BH8, BH10 to BH12, BH16 and BH18)

Topsoil: Comprising moist, typically loose, silty sand at the surface, extending to depths ranging between 0.05m and 0.1m, underlain by

Slopewash Comprising moist, stiff, sandy clay of medium to high plasticity in BH6 and BH8 and moist and wet, loose and medium dense to dense, silty sand extending to depths ranging between 0.25m and 0.7m, underlain by

Residual Soil Comprising moist, stiff to hard, sandy clay of low to high plasticity, extending to depths ranging between 0.7m and 3.2m, underlain by

Bedrock Encountered at depths ranging between 0.7m and 3.2m, comprising extremely low strength to low strength, extremely weathered, sandstone, extending to depths ranging between 1.3m and 4.5m

Boreholes BH4, BH6, BH8, BH10 and BH11 were terminated at maximum TC refusal depths ranging between 1.3m and 2.3m. Boreholes BH12, BH16 and BH18 were terminated at depths ranging between 1.5m and 4.5m. No groundwater was encountered in any of the boreholes during this investigation.

4.4 Moderate to Steep Sloping Topography

No boreholes were drilled in this Landform Unit due to inaccessibility problems for the drill rig, however soil profiles are expected to be relatively shallow.

4.5 Drainage Features (Boreholes BH2, BH5 and BH17)

Topsoil: Comprising moist and moist to wet, very loose and loose, silty sand and clayey sand, extending to depths ranging between 0.1m to 0.25m, underlain by

Alluvial Soil Comprising moist to wet, firm to very stiff, silty clay and sandy clay of low to high plasticity with interbedded layers of moist, medium dense and dense silty sand and clayey sand, extending to depths ranging between 0.85m and 6.5m, underlain by

Residual Soil Comprising moist, very stiff to hard, sandy clay of low to medium plasticity, extending to depths ranging between 1.55m and 7.1m, underlain by

Bedrock Encountered at depths ranging between 1.55m and 7.1m, comprising extremely low strength to very low strength, extremely weathered, sandstone, extending to depths ranging between 3.0m and 7.5m

Boreholes BH2, BH5 and BH17 were terminated at depths of 7.5m, 6.0m and 3.0m, respectively. No groundwater was encountered in any of the boreholes during this investigation.

5.0 STABILITY ASSESSMENT

Most of the site displays no evidence of recent past slope instability involving large-scale movements of significant quantities of soil or rock in a short duration event such as slips, slumps, debris slides or a landslide. There are however localised areas where slope instability is evident. These localised areas include the Drainage Features Landform and the Moderate to Steep Sloping Topography Landform which display instability in the form of minor slumping, creep movement and erosion. Piping or tunnel erosion also appears to be evident within the heads and flatter areas of the drainage features as well as within minor drainage lines within the sloping terrain.

Erosion is the main form of instability at the site. It is evident throughout the site but is more prominent within the drainage features where there is a concentration of surface water. This erosion is relatively severe and has cut deep washouts and rills ranging up to 2m deep and 10m in width into the base of several drainage features which are continually regressing, particularly within the lower sections of the drainage features where there is no or limited vegetation to stabilise the banks. This erosion has also undercut the banks of the drainage features in numerous areas causing slipping and slumping within the banks and toppling of trees. Piping or tunnel erosion also appears to be evident within the heads and flatter areas of the drainage features as well as within minor drainage lines within the sloping terrain. This piping or tunnel erosion is occurring approximately 1.0m below the surface in the flatter, larger drainage features and approximately 0.3m below the surface within the minor drainage lines within the sloping terrain. Tunnel erosion may also possibly be occurring in the flatter areas adjacent to the creeks where bedrock is exposed in the base of the creeks and there are possibly weaker, more permeable, alluvial sandy soils adjacent to the creek. The erosion evident throughout the remainder of the site is relatively minor with most instability typically limited to areas where there is no or limited vegetation and the soil is exposed.

It is anticipated that several smaller drainage features are expected to be filled in areas where residential development is proposed which may initiate minor instability issues within these areas. Modification of these drainage features for residential development is acceptable providing drainage is maintained. Recommendations regarding removal of the unstable areas and the implementation of drainage provisions is described in Sections 7.0 and 8.0 of this report.

The Gentle Sloping Topography which form flat alluvial plains adjacent to the creeks are generally considered to be stable as they typically display no major evidence of instability. The ground surface is typically flat with no hummocky ground or surface irregularities evident. There was also no evidence of weak soils or groundwater which would impact on the proposed development in these areas. This Landform Unit is however prone to erosion and problems possibly associated with flooding during extreme rainfall events. This Landform may possibly need to be raised above the Council regulated flood levels if development is proposed in this Landform Unit.

Evidence of instability also appears to be evident within the Moderate to Steep Sloping Topography within the far northern and western portions of the site. This instability is evident in the form of slumping and possibly small debris slides. The presence of localised areas displaying an uneven ground surface with several rocky mounds indicates that some surface movement has occurred. There also appears to be recent minor instability in the form of creep movement at the surface of the Moderate to Steep Sloping Topography which is evident by the presence of slanted trees. There are also numerous boulders strewn across the surface within this area.

The risk of slope movement in the form of deep seated failures through the rockmass below the soil cover is considered to be low. This is due to the mild surface gradients, typically shallow depths to bedrock, favourable geology and no evidence of groundwater within the sloping terrain.

Most of the site appears to be geotechnically stable at present with respect to slope stability. The main constraints or irregularities which would impact on the proposed development are typically limited to the Drainage Features and the Moderate to Steep Sloping Topography Landforms. Drainage is critical in these areas with respect to the residential development and must be addressed to minimise the potential for instability.

5.1 Generalised Slope Stability Assessment

A generalised slope stability assessment of each Landform Unit was carried out in accordance with the Australian Geomechanics Society (AGS) 'Practice Note Guidelines for Landslide Risk Management' Vol 42 No1 March 2007. It must be noted that the boundaries between Landform Units are gradational and not abrupt. On this basis it should be expected that the Hazard Rating zones may encroach upon one another. Detailed small scale assessments of localised areas would be required to refine the stability zones on a Lot by Lot basis. Lot by Lot assessments are not expected to produce risk rating classifications significantly different to the broad scale assessments carried out for this study.

Calculations used in the generalised slope stability assessment have been based on the following factors:-

- Ground surface slope angle
- Slope shape
- Geology
- Depth of soil cover and soil type (eg. colluvium, residual)
- Presence of erosion features, surface irregularities or existing instability
- Seepage and drainage conditions as assessed during the walkover survey carried out for this study

The results of the generalised slope stability assessment for each Landform Unit is presented in Table 1.

Table 1 – Level of Hazard Risk to Property

Landform Unit	Likelihood of Instability Event	Consequences to Property	Hazard Risk Rating
Crests and Ridges	Rare	Minor	Very Low
Gentle Sloping Topography	Unlikely	Minor	Low
Mild Sloping Topography	Unlikely	Medium	Low
Moderate to Steep Sloping Topography	Possible	Medium to Major	Moderate to High
Drainage Features	Likely	Major	Very High

The Landform Units and associated Hazard Risk Ratings are shown on the attached Landform Unit Map.

It should be noted that if the recommendations stated in this report are followed, areas which have been assigned hazard risk ratings of 'Moderate' or worse can be reduced to a Level of 'Low' or better. The above hazard risk ratings are reliant on the surface and groundwater hydrology study identifying all hydrological issues which may impact on the stability of the proposed development including piping or tunnel erosion and recommendations being implemented to address these surface and groundwater hydrological issues which may be occurring at the site.

5.2 Implications of Hazard Risk

The implications of hazard risk ratings are presented in the Australian Geomechanics Society (AGS) 'Practice Note Guidelines for Landslide Risk Management' Vol 42 No1 March 2007 and reproduced in Table 2.

Table 2 – Risk Level Implications (AGS)

Hazard Rating	Implications
VH (Very High Hazard)	Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low.
H (High Hazard)	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels.
M (Moderate Hazard)	Tolerable provided treatment plan is implemented to maintain or reduce risk. May be accepted. May require investigation and planning of treatment options.
L (Low Hazard)	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL (Very Low Hazard)	Accepted. Managed by normal slope maintenance procedures.

6.0 GEOTECHNICAL CONSTRAINTS OR ISSUES FOR DEVELOPMENT

Most of the site is assessed to be geotechnically stable at present with respect to slope stability. Most of the site exhibits no major signs of slope instability due to the typically mild surface gradients, mostly shallow depths to bedrock and favourable geology. There are, however, several geotechnical constraints which have the potential to impact on the proposed residential development if not addressed. These constraints include:-

- Existing and Recent Past Instability.
- Moderate to Steep Sloping Terrain.
- Active Drainage Features.

A summary of the existing geotechnical issues are presented in the following subsections:-

6.1 Existing and Recent Past Instability

As described in Section 5.0 above, most of the site displays no major evidence of recent past slope instability involving large-scale movements of significant quantities of soil or rock in a short duration event. The main form of instability evident at the site is erosion which is evident within the drainage features and on a smaller scale throughout the remainder of the site where there is no or limited vegetation and the soil is exposed. There is also evidence of instability in the form of hummocky topography, slumping and possible minor debris slides in the Moderate to Steep Sloping Topography. Several sink holes from piping or tunnel erosion have also been identified within and adjacent to the creeks and drainage features throughout the site which indicates the presence of groundwater flows below the surface. This existing and recent past instability is expected to impact on localised areas of the proposed development unless these unstable areas are removed and drainage improved where residential development is proposed. Recommendations to remove unstable areas and improve drainage are described in Sections 7.0 and 8.0 of this report

6.2 Moderate to Steep Sloping Terrain

Moderate to steep sloping terrain is evident at the far northern and western portions of the site flanking the ridge lines as well as in localised areas adjacent to the creeks where the historical movement of the creek has cut into the toe of the slope and steepened the terrain. It comprises surface gradients typically ranging between 15^{o} and 30^{o} with some localised steeper areas. There is also evidence of instability at the surface within the moderate to steep sloping terrain in the form of slumping and creep movement. The presence of localised areas displaying an uneven ground surface with several rocky mounds also indicates that some surface movement has occurred possibly in the form of small debris slides. This poses significant geotechnical constraints for development. This may include incorporating slope sensitive design for development in this area, possibly in conjunction with cutting and filling operations as well as the construction of retaining walls to reduce the risk of slope instability within this area to a tolerable level. Areas displaying instability will also need to be removed and the area stabilised prior to development.

Slope sensitive residential design and construction, which minimises earthworks, should be adopted for all Lots located on slopes with a surface gradient of greater than 15^{o}. Slope sensitive design for housing includes conventional pole houses, concrete framed houses with suspended floors which overly the natural contours and split level on-grade raft slab floors and/or suspended floors. All footings should found in competent soils or weathered rock below the soils which are suspect to downslope creep movement, and the structural design should ensure stiffness in the downslope direction eg. strip footings, slab beams or bearers aligned up and down the slope.

6.3 Active Drainage Features

There are several active drainage features evident at the site, which are expected to align through the proposed Lots. These drainage features may pose a significant threat to the proposed Lot development as they are expected to transmit significant surface water flows during rainfall events as well as the possibility of groundwater flows. There is also evidence of instability within these drainage features. Most development is expected to avoid these drainage features however there are likely to be several Lots proposed in these active drainage features.

If the drainage features are to be filled or Lots are to be located within the drainage features, consideration must be given to the interception and diversion of surface water flows or realigning the drainage lines. Recommendations for the removal of these unstable areas and the provision of drainage, are described in Section 7.0 and 8.0 of this report.

7.0 DRAINAGE ISSUES AND IMPACTS FOR DEVELOPMENT

Properly designed and constructed and maintained surface and subsurface drainage is critical for the long term performance of the site in terms of slope stability and preventing, slips, soil creep, subsidence and erosion. Minimising the ingress of surface and subsurface water into sloping terrain and fill platforms is of significant importance as saturation of these materials can result in creep movements, erosion, slips and landslides. Controlling groundwater within the development area is also critical in terms of the long term slope stability of the site.

No information has been supplied with respect to the proposed earthworks however it is expected that several drainage features will be filled. Adequate drainage provisions must therefore be implemented at the base of these drainage features prior to the placement of fill. Surface contour drains must also be installed to intercept and divert sheet flows of surface water from the typically planar slopes.

The following drainage recommendations must be implemented to reduce the risk of slope instability and ensure the long term performance of the site:-

- After removal of all wet and unstable materials within the drainage features which are to be filled, the exposed soil should be benched and battered to appropriate angles (described Section 9.0) and subsurface drains installed where groundwater is evident. These drains should form a permanent herringbone shaped drainage scheme with slotted pvc pipes lined with geofabric and backfilled with gravel. More detailed geotechnical investigation would be required within the drainage features to make an accurate assessment of the drainage requirements and the areas which require these provisions.

- In areas where the roads traverse drainage features the installation of conduits such as pipes and culverts at the base of the fills may be required. In these areas weak soils and high water flows can be expected requiring appropriate design considerations.

- Lined surface contour drains must be constructed upslope of each Lot to intercept and divert surface water flows into the stormwater system. This will reduce infiltration into the slopes and the potential for soil creep and erosion. For some Lots the road drainage system will be adequate.

- Subsurface drains should be installed above all modified drainage features and along both sides of all on-grade road formations and cuttings.

- Consideration should be given to backfilling all service trenches with drainage gravel in 'wet' areas so that these trenches can also act as subsoil drains to generally lower the groundwater and transmit seepages to the creeks. This would most likely be limited to localised areas within the alluvial plains where groundwater may possibly be evident.

- Drainage must be implemented behind the crest of all cut and fill batters as well as behind retaining walls to reduce surface water flow over or into structural fills.

- Drainage filter rock (footing to surface) is to be provided behind all retaining walls with a seepage pipe outlet to nominated gully pits.

- Drainage filters are to be separated from the insitu soils or fill using the appropriate geofabric.

- All Lot runoff and roof water must be discharged into stormwater systems via a system of pipe conduits or lined drains to minimise water infiltration into the slopes. Alternatively roof water can be discharged into water tanks for storage.

After stripping the unstable soils to expose the competent soils in areas to be filled, the foundation should be inspected to assess the requirements, if any, for subsoil trench drains. These may be required to maintain low groundwater conditions in areas of groundwater or surface water concentrations.

It should be noted that positive drainage must be maintained at all times to maintain the long term performance of the site in terms of slope stability and preventing, slips, soil creep and erosion.

8.0 RECOMMENDATIONS FOR FILLING AND EXCAVATIONS

It is anticipated that the proposed earthworks will most likely involve filling within the lower portions of the site and cutting within the upper portions of the site, which will reduce the slope gradients at the site and therefore generally reduce the risk of slope instability. However, the walkover survey of the site and the results of borehole drilling indicate that significant earthworks and remediation works will be required prior to the placement of fill material. This includes removing all unsuitable material such as weak wet soils or areas displaying instability and implementing appropriate drainage prior to the placement of fill.

Broad recommendations for filling and excavations are as follows:-

- In areas which are to be filled, all trees, grass, weed zones, rocks and debris must be removed from the existing ground surface to expose competent natural soil or weathered rock. Tree root matter typically extends to a depths ranging between 0.2m and 0.4m below the existing natural ground surface.

- No filling or residential development should take place within any surface irregularities such as landslips, scarps, washouts, hummocky terrain or erosion features. If filling or development is to occur in these areas, surface irregularities must be removed prior to development and appropriate drainage provisions must be implemented in accordance with the recommendations described in Section 7.0 of this report. The unstable areas are typically limited to the Drainage Features and the Moderate to Steep Sloping Topography Landforms as shown on the attached Landform Unit Map

- If development is proposed to encroach into the alluvial plains adjacent to the creeks and weak, wet soils and groundwater is encountered, all weak, wet soils should be removed to a competent base. The foundation must then be reinstated using -300mm shot rock or similar suitably placed and raised to a level of at least 1.0m above the water table. A layer of geofabric material should then be placed over the shotrock and the area can be filled to the finished level by placing suitable fill materials in thin layers with each layer compacted to 95% SMDD for residential Lots and 100% SMDD below pavements. Drilling did not encounter groundwater in these areas but there may be localised areas where groundwater is present.

- If filling or residential development is to take place within the drainage features, properly designed and constructed drainage systems or structures must be implemented. Prior to development within the drainage features, the drainage feature should be dewatered and all soft/loose soil should be removed from the base to spoil. Appropriate drainage measures must then be installed at the base of the drainage feature to maintain positive drainage. The drainage feature can then be filled by placing suitable fill materials in thin layers with each layer compacted to 95% SMDD for residential Lots and 100% SMDD below pavements. The above recommendations for the drainage features also apply to the dams.

- The fill behind the retaining walls and used in the construction of the batters is placed and compacted to 95% Standard Maximum Dry Density and is “Controlled Fill” in accordance with A.S. 2870 (Clause 6.4.2 (a)) – “Residential Slabs and Footings” and A.S. 3798.

- Filling should be benched into the sloping ground surface and be supported by engineered retaining walls or battered to the appropriate angles described in section 9.0 below. The fill slopes should be over-constructed and trimmed back to ensure compaction in the outer zones. Vertical heights of natural soil and fill batters should preferably not exceed 5.0m.

- All permanent excavations exceeding 1.0m must be supported by adequately engineered retaining walls incorporating drainage or battered at appropriate angles. Retaining walls should also found in the competent soils or rock below all surficial soils prone to movement.

- All retaining walls must be individually designed to have a factor of safety of at least 1.5 with respect to internal stability, including sliding and overturning. A global stability assessment of the proposed retaining wall sections should be carried out when detailed design for the retaining walls is finalised.

- Earthworks should take account of the sloping terrain and be limited to cuts and fills which can be adequately constructed by medium sized civil contractors without resorting to specialised contractors.

9.0 TEMPORARY AND PERMANENT BATTERS

Maximum safe cut batter angles for the different materials encountered on site are shown below in Table 3 for unsurcharged batters less than 3.0m high. Where surcharges are located within H(m) (height of the batter) of the top of the batter, then some reduction in the design angle will be required.

Table 3 – Safe Batter Angles for Cuts

Material	Short Term	Long Term
Silty Sand/Clayey Sand	35^0 (1V:1.5H)	26^0 (1V:2H)
Stiff and Very Stiff Clay Soils	40^0 (1V:1.2H)	26^0 (1V:2H)
Hard Clay Soils	45^0 (1V:1H)	26^0 (1V:2H)
XW VLS Rock	60^0 (1V:0.6H)*	45^0 (1V:1H)*
Note: * Subject to inspection by experienced geotechnical engineer/engineering geologist. It should also be noted that soft or firm clay soils which are to be battered should be inspected onsite during excavations.		

Structural fill batters should be overconstructed and trimmed back at no steeper than 2(H):1(V) or 26^0. It is recommended that for cut batters which only partially expose XW bedrock in the face, the cut should be battered to an angle of no steeper than 2(H):1(V) or 26^0 unless inspected by a geotechnical engineer or engineering geologist.

All exposed permanent batters should be properly vegetated and mulched to minimise erosion. Properly maintained vegetation should reduce the occurrence of surface erosion by impingent rainfall. Upslope surficial water flows should also be directed away from the batters limiting the ingress of water into the fill. The pavement drainage system may be sufficient for some batters.

10.0 BROAD RECOMMENDATIONS FOR RESIDENTIAL DEVELOPMENT

Generally, most of the site is assessed to be satisfactory for residential development. Exceptionally, the Drainage Features and Moderate to Steep Sloping Topography Landforms exhibit evidence of slope instability which must be addressed if development is proposed in these areas.

Providing the following recommendations for residential development and the recommendations described in Sections 7.0 to 9.0 of this report are implemented, the site is considered to be satisfactory for the long term residential development.

Recommendations for residential development are as follows:-

- This office should be actively involved on-site during the earthworks repair of all areas displaying evidence of instability.

- Vegetation clearing must be kept to a minimum, in small sections at a time, with revegetation commencing immediately after the completion of earthworks to minimise future erosion.

- The footings of the retaining walls must be founded in the rock or competent soils with a minimum allowable bearing pressure of 150kPa, rather than on alluvial soils or colluvial soils which may be subject to movement.

- All footings shall found in competent soil, weathered rock or structural fill, below all non structural fill or soils subject to movement and below a line extending up from the toe of all retaining walls at 30^0.

- No development should take place within any surface irregularities such as slips, scarps, washouts, erosion features or hummocky terrain. If development is to occur in these areas, surface irregularities must be removed and repaired prior to development and the drainage improved.

- No residential development should take place below the Council regulated design flood levels.

- In all Landform Units the Recommendations for Residential Development and the attached Guidelines for Hillside Engineering (Appendix C) must be followed.

- Slope sensitive residential design and construction, which minimises earthworks should be adopted for all Lots located on slopes with a surface gradient of greater than 15^o. Slope sensitive design for housing includes conventional pole houses, concrete framed houses with suspended floors which overly the natural contours and split level on-grade raft slab floors and/or suspended floors. All footings should found in the competent soils or weathered rock below the soils which are suspect to downslope creep movement, and the structural design should ensure stiffness in the downslope direction eg. strip footings, slab beams or bearers aligned up and down the slope.

The site is considered satisfactory for residential development in relation to slope stability if the recommendations stated in Section 7.0 to 9.0 of this report and the recommendations outlined above are followed.

11.0 SUITABILITY AND FEASIBILITY OF PROPOSED DEVELOPMENT

Most of the proposed Precinct 1 development area appears to be geotechnically stable at present with respect to slope stability due to the typically mild surface gradients, shallow depths to bedrock and favourably geology. The main geotechnical constraints or issues which have the potential to impact on the proposed development are typically limited to the Drainage Features and Moderate to Steep Sloping Topography Landform. Addressing the instability in these areas and providing adequate drainage is critical with respect to the residential development and must be addressed to minimise the potential for instability in these areas.

From results of the broad geotechnical assessment it is assessed that the site is considered to be suitable and feasible for the proposed development providing the guidelines for hillside construction and the recommendations stated in this report, including the recommendations for development in unstable areas such as the Drainage Features and Moderate to Steep Sloping Topography Landforms, are followed. Prior to the commencement of earthworks, a more detailed

investigation as well as a surface and groundwater hydrology study within the lower, flat portions of the site adjacent to the creeks is recommended. This detailed investigation and hydrology study is recommended to accurately identify the extent of the geotechnical constraints which may impact on the proposed development such as groundwater issues, piping or tunnel erosion and the possibility of weak, unstable soils in the alluvial plains, and therefore provide more detailed recommendations with regards to the remediation works required including drainage provisions within these areas.

The sensitivity of localised areas within the site to potential instability requires care in construction. Earthworks operations should not be carried out without geotechnical engineering supervision. This includes carrying out:-

- Regular site attendances by a geotechnical engineer or engineering geologist who is familiar with the constraints of the site.

- Level 1 earthworks supervision as defined in Australian Standard AS3798-2007.

12.0 LIMITS OF INVESTIGATION

Recommendations given in this report are based on information supplied regarding the proposed project in conjunction with the findings of the investigation.

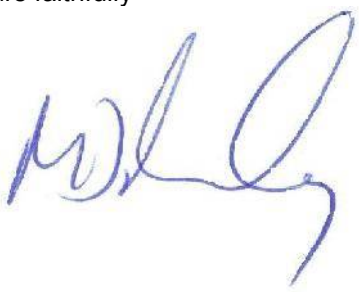
Every reasonable effort has been made to locate test sites so that test pits are representative of the soil conditions within the area to be investigated.

In some cases, soil conditions can change dramatically over short distances, therefore even careful exploration programmes may not locate all the variations. If soil conditions differing from those shown on the log sheet are encountered during construction, this office should be advised immediately.

Unless otherwise stated in commissioning documents, any dimensions or slope directions and magnitudes should not be used for any building or costing calculations. Any sketch supplied should be considered only as approximate pictorial evidence of site work.

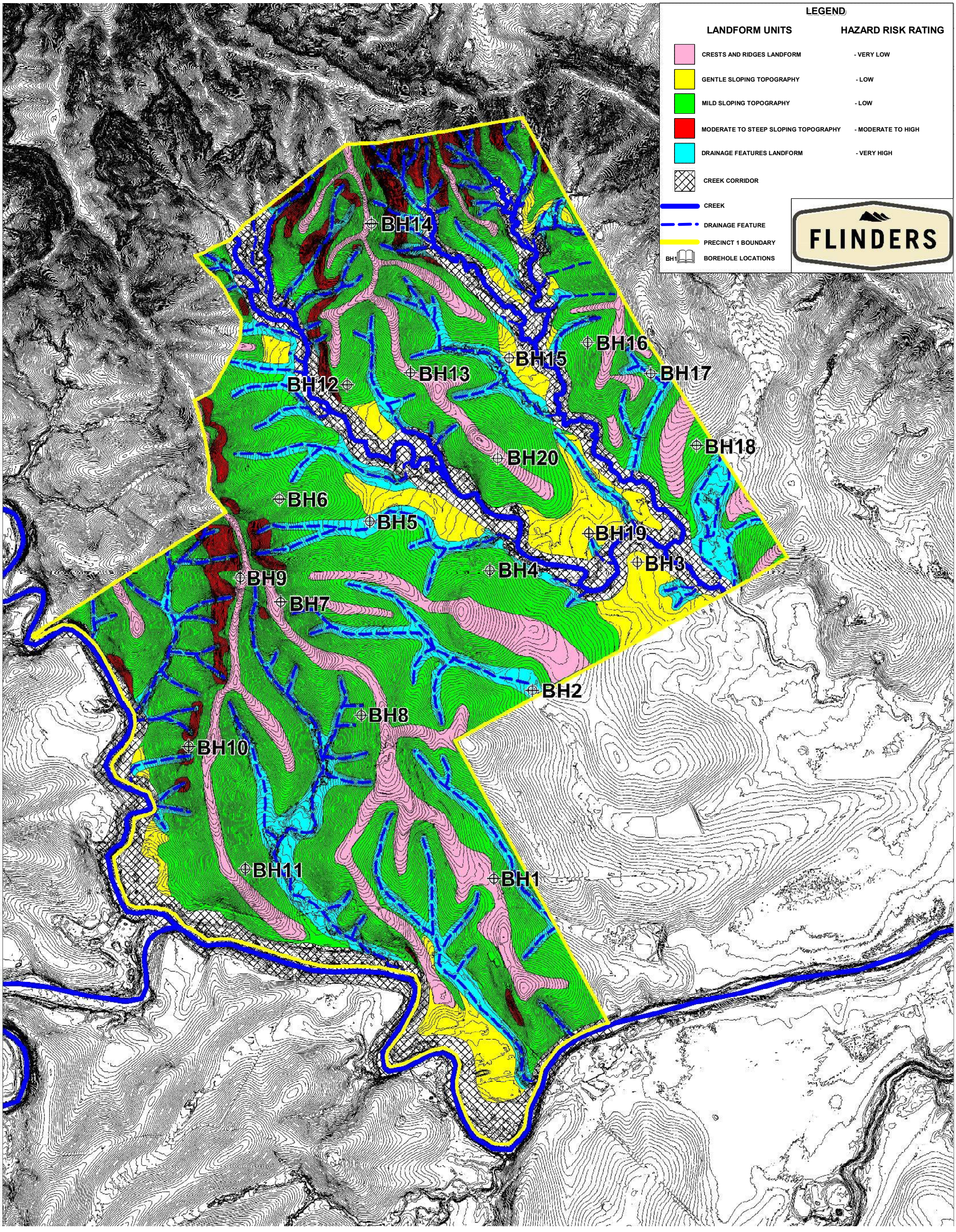
If you have any queries please do not hesitate to contact our Brisbane office.

Yours faithfully



M D RILEY (RPEQ 5641)
for and on behalf of
MORRISON GEOTECHNIC PTY LIMITED

Encl Landform Unit Map (Includes borehole Locations)
Reference Plan (Precinct 1)
Slope Analysis Plan (Precinct 1)
Appendix A - Site Photographs
Appendix B - Borehole Log Sheets
Appendix C - Guidelines for Hillside Engineering
Important Information About Your Geotechnical Report



MORRISON GEOTECHNIC PTY LTD
ABN: 51 009 878 899

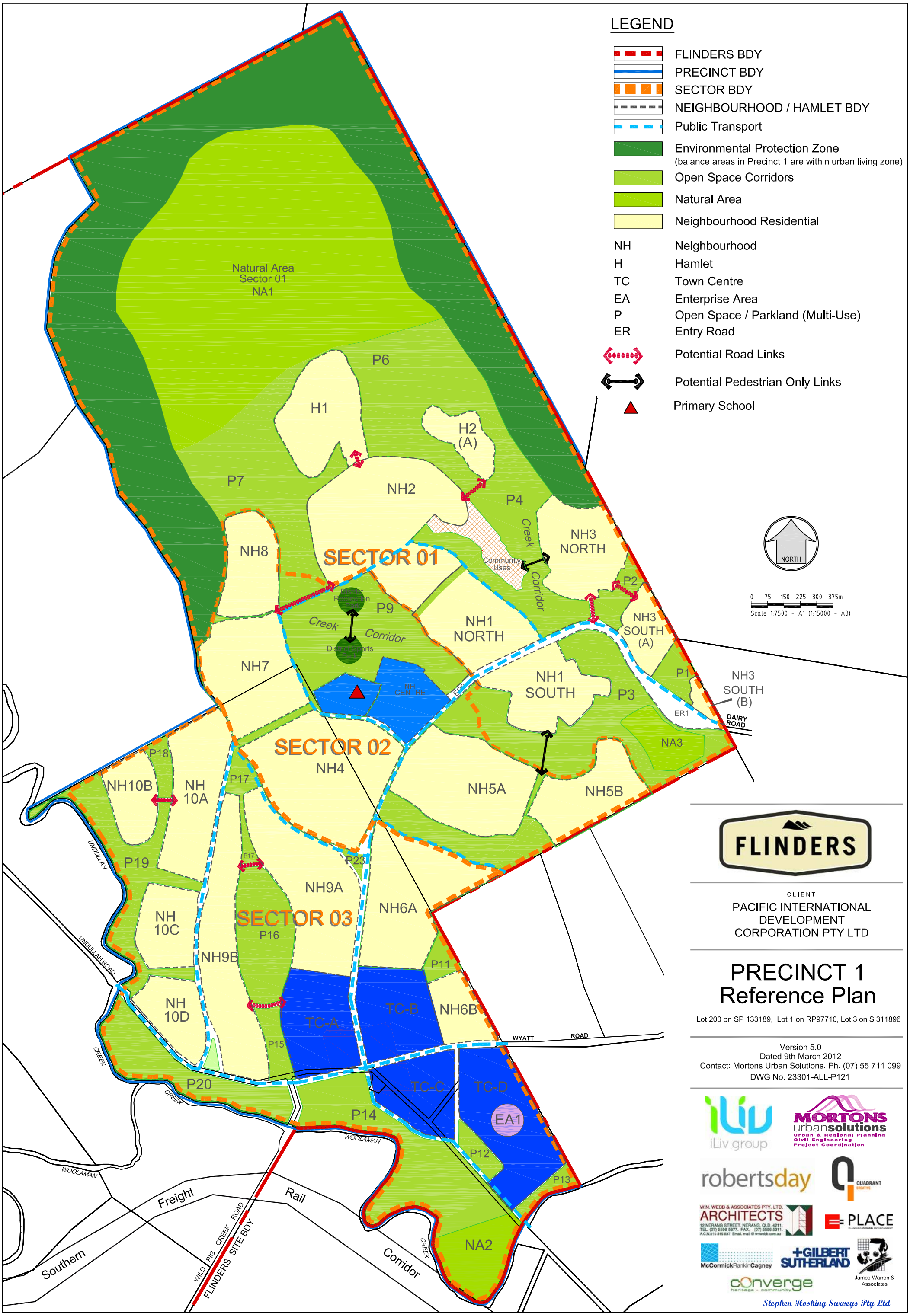
MORRISON GEOTECHNIC

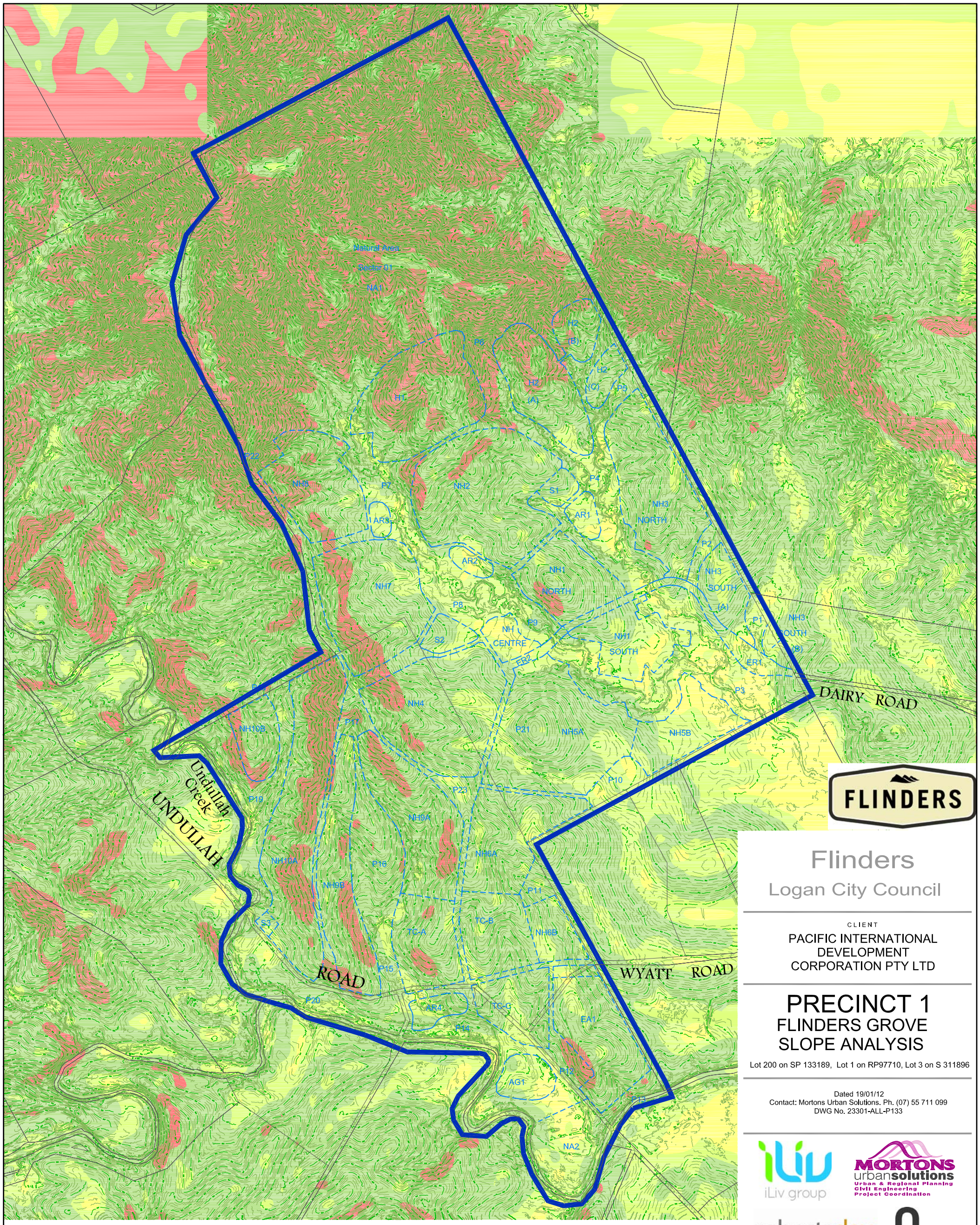
Unit 5/ 36 Lawrence Drive, Nerang 4211 Ph: 5596 1599
Email: goldcoastlab@morrisongeo.com.au Fax: 5527 2027

Engineers: D.Riley, D. Dragan
J. Daly & B. Elsmore
Geologists: L.Bexley & R.Howchin
Laboratory: M.Morrison & I. Masman

N W E S

Map Description :	**LANDFORM UNIT MAP**				
Client :	**PACIFIC INTERNATIONAL DEVELOPMENT CORPORATION**				
Project :	**BROAD GEOTECHNICAL ASSESSMENT- PRECINCT 1 NH1 - NH10, FLINDERS DEVELOPMENT, UNDULLAH**				
Project No :	**GE12/005**	Drawing No :	**0936GE12/005**	Scale :	**1:15000** (A3)


LEGEND
FLINDERS BDY
PRECINCT BDY
SECTOR BDY
NEIGHBOURHOOD / HAMLET BDY
Public Transport
Environmental Protection Zone
(balance areas in Precinct 1 are within urban living zone)
Open Space Corridors
Natural Area
Neighbourhood Residential
NH Neighbourhood
H Hamlet
TC Town Centre
EA Enterprise Area
P Open Space / Parkland (Multi-Use)
ER Entry Road
Potential Road Links
Potential Pedestrian Only Links
Primary School
Natural Area
Sector 01
NA1
P6
H1
H2
(A)
P7
NH2
P4
Creek
Corridor
NH3
NORTH
NH8
SECTOR 01
Community
Uses
P2
District
Recreation
Park
P9
Creek
Corridor
NH1
NORTH
NH3
SOUTH
(A)
NH7
District Sports
Park
NH
CENTRE
NH1
SOUTH
P3
P1
NH3
SOUTH
(B)
ER1
DAIRY
ROAD
NA3
SECTOR 02
NH4
P18
P17
NH10B
NH
10A
NH5A
NH5B
UNDULLAH
P19
P17
P23
NH9A
NH6A
NH
10C
SECTOR 03
P16
NH9B
P11
NH
10D
TC-A
TC-B
NH6B
P15
WYATT
ROAD
CREEK
P20
CREEK
TC-C
TC-D
P14
EA1
WOOLAMAN
P12
P13
WOOLAMAN
Freight
Rail
Corridor
NA2
Southern
WILD PIG CREEK ROAD
FLINDERS SITE BDY
CREEK
NORTH
0 75 150 225 300 375m
Scale 1:7500 - A1 (1:15000 - A3)
FLINDERS
CLIENT
PACIFIC INTERNATIONAL
DEVELOPMENT
CORPORATION PTY LTD
PRECINCT 1
Reference Plan
Lot 200 on SP 133189, Lot 1 on RP97710, Lot 3 on S 311896
Version 5.0
Dated 9th March 2012
Contact: Mortons Urban Solutions. Ph. (07) 55 711 099
DWG No. 23301-ALL-P121
iLiv group
MORTONS urbansolutions
Urban & Regional Planning
Civil Engineering
Project Coordination
robertsday
QUADRANT
W.N. WEBB & ASSOCIATES PTY. LTD.
ARCHITECTS
PLACE
McCormickRankinCagney
GILBERT SUTHERLAND
James Warren & Associates
cOnverge
Stephen Hosking Surveys Pty Ltd



LEGEND

- Precinct Site Boundary
- Neighborhood Boundary
- Cadastral Boundary

NH	Neighbourhood
H	Hamlet
TC	Town Centre
EA	Enterprise Area
P	Open Space / Parkland (Multi-Use)
ER	Entry Road

SLOPE

- 0-2.5%
- 5-7.5%
- 10-12.5%
- >15%

FLINDERS

Flinders

Logan City Council

CLIENT

PACIFIC INTERNATIONAL DEVELOPMENT CORPORATION PTY LTD

PRECINCT 1

FLINDERS GROVE SLOPE ANALYSIS

Lot 200 on SP 133189, Lot 1 on RP97710, Lot 3 on S 311896

Dated 19/01/12
Contact: Mortons Urban Solutions. Ph. (07) 55 711 099
DWG No. 23301-ALL-P133

iLiv group

MORTONS urbansolutions
Urban & Regional Planning
Civil Engineering
Project Coordination

robertsday

QUADRANT CREATIVE

W.N. WEBB & ASSOCIATES PTY. LTD.
ARCHITECTS
12 NERANG STREET, NERANG, QLD. 4211.
TEL. (07) 5596 5677. FAX. (07) 5596 5311.
A.C.N.010 316 837 Email. mail @ wnwebb.com.au

PLACE

McCormickRankinCagney

GILBERT SUTHERLAND

James Warren & Associates

converge

Stephen Hosking Surveys Pty Ltd

A P P E N D I X A

SITE PHOTOGRAPHS

Plate 1 - Outer bend of creek adjacent to NH2 which has been significantly eroded.

Plate 2 - Gentle Sloping Topography Landform Unit within NH1 South.

Plate 3 - Sink holes at head of flat drainage feature.

Plate 4 - Highly eroded drainage feature with no vegetation evident.

Plate 5 - Sink holes adjacent to flat drainage feature.

Plate 6 - Moderate to Steep Sloping Topography Landform Unit with cobbles on surface.

Plate 7 - Mild Sloping Topography Landform with drainge feature in centre.

Plate 8 - Erosion and slips within drainage feature.

Plate 9 - Ponded water in drainage feature with minor slips and slumping along banks.

Plate 10 - Highly eroded area at head of minor drainage feature.

Plate 11 - Sink holes within flat drainage feature.

Plate 12 - Rocky mounds in distance within Moderate to Steep Sloping Topography Landform Unit.

A P P E N D I X B

BOREHOLE LOG SHEETS

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH1

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489818.00
Northing: 6919785.00
RL:
Total Depth: 3.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark brown, moist.		M	L				
				Slope wash		CH	**Silty CLAY**: Firm, high plasticity, grey mottled orange brown, moist.		M	F				
			0.4	Residual		CH	**Silty CLAY**: As above but stiff.		M	St		0.5	PP	140 kPa
			0.95 1.0			CI/CH	**Sandy CLAY**: Hard, medium to high plasticity, orange brown streaked grey, fine grained sand, moist.		M	H		1.2	PP	490 kPa
			1.4	Rock		SST	**SANDSTONE**: Extremely low strength, extremely weathered, orange brown streaked grey, interbedded layers of siltstone.	XW		ELS				
			2.0											
			2.1			SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown bleached grey.	XW		VLS				
			3.0											
							3.00m: BOREHOLE TERMINATED							
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH2

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489989.00
Northing: 6920622.00
RL:
Total Depth: 7.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Alluvial		SC	**Clayey SAND**: Loose, fine to medium grained sand, grey brown, wet.		W	L				
						CH	**Sandy CLAY**: Firm, high plasticity, brown mottled grey, fine to medium grained sand, wet.		W	F		0.2	PP	80 kPa
			0.4			CI	**Sandy CLAY**: As above but very stiff, medium plasticity, trace of coarse grained sand, moist.		M	VSt		0.5	PP	290 kPa
			1.0											
			1.1			SC	**Clayey SAND**: Medium dense, fine to medium grained sand, some coarse brown low plasticity clay fines, moist.		M	MD				
			1.55			CH	**Silty CLAY**: Very stiff, high plasticity, brown bleached grey, moist.		M	VSt				
			2.0											
												2.4	PP	380 kPa
			2.6			CH	**Silty CLAY**: As above but some fine to medium grained sand.		M	VSt				
			3.0											
			3.1			CL	**Sandy CLAY**: Very stiff, low plasticity, trace of coarse grained sand, brown mottled grey, moist.		M	VSt				
			3.5			SM	**Silty SAND**: Dense, fine to medium grained sand, some coarse, orange brown streaked grey, moist.	XW	M	D				
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH2

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489989.00
Northing: 6920622.00
RL:
Total Depth: 7.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			4.7			SM	**Silty SAND**: Dense, fine to medium grained sand, some coarse, orange brown streaked grey, moist.	XW	M	VL				
			5.0			CL	**Silty CLAY:** Very stiff, low plasticity, trace of coarse grained sand, brown mottled grey, moist.		M	VSt				
			5.6			CL	**Silty CLAY:** As above but some fine size gravels.		M	VSt				
			6.0											
			6.3			CL	**Silty CLAY:** As above but some medium size gravels.		M	VSt				
			6.5	Residual		CI/CH	**Sandy CLAY**: Very stiff to hard, medium to high plasticity, brown and grey brown, fine grained sand, some medium, moist.		M	VSt-H				
			7.0											
			7.1	Rock		SST	**SANDSTONE**: Extremely low strength, extremely weathered, orange brown and grey, some clay layering.	XW		ELS				
			7.5				**7.50m: BOREHOLE TERMINATED**							
			8.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH3

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 490416.00
Northing: 6921205.00
RL:
Total Depth: 7.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Alluvial		SC	**Clayey SAND**: Loose, fine to coarse grained sand, grey brown, medium plasticity clay, moist.		M	L				
						CH	**Silty CLAY**: Stiff, high plasticity, grey brown and yellow brown, some fine grained sand, moist.		M	St		0.25	PP	120 kPa
			0.6			CH	**Silty CLAY**: As above but very stiff.		M	VSt				
			0.9			CH	**Silty CLAY**: As above but very stiff to hard, some fine size gravel, trace of medium size gravel.		M	VSt-H		0.9	PP	260 kPa
			1.0											
			1.6			CH	**Silty CLAY**: As above but hard.		M	H		1.6	PP	330 kPa
			2.0											
			2.2			Cl	**Sandy CLAY**: Very stiff to hard, medium to high plasticity, grey brown mottled orange, fine grained sand, some medium, moist.		M	VSt-H				
			2.7			Cl	**Sandy CLAY**: As above but very stiff.		M	VSt				
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH3

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 490416.00
Northing: 6921205.00
RL:
Total Depth: 7.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger	SWL		5.0			CI	**Sandy CLAY**: As above but very stiff.		M	VSt				
			5.2			CL	**Sandy CLAY**: Stiff to very stiff, low to medium plasticity, grey mottled orange brown, fine to coarse grained sand, moist.		M	St-VSt				
			5.8	Residual		CL	**Sandy CLAY**: As above but low plasticity.		M	St-VSt				
			6.0											
			7.0											
			7.2			CL	**Sandy CLAY**: Stiff, low plasticity, grey mottled orange brown, fine to coarse sand lensing, moist.		M	St				
			7.5				**7.50m: BOREHOLE TERMINATED**							
			8.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH4

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489800.00
Northing: 6921156.00
RL:
Total Depth: 2.30
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.05	Topsoil		SM	**Silty SAND**: Very loose, fine to medium grained sand, some coarse, dark grey brown, some clay fines, wet.		W	VL				
			0.2			SM			W	VL				
				Slope		Cl	**Silty SAND**: As above but light orange brown.		M	St		0.3	PP	120 kPa
			0.5	Residual			**Sandy CLAY**: Stiff, medium plasticity, light grey brown mottled orange brown, fine to medium grained sand, moist.							
						CL	**Sandy CLAY**: As above but low plasticity and some coarse grained sand.		M	St				
			0.7	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown streaked grey.	XW		VLS				
			1.0											
			1.8			SST	**SANDSTONE**: As above but dark brown and some low strength layering.	XW		VLS				
			2.0											
			2.3				**2.30m: BOREHOLE TERMINATED**							
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH5

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489266.00
Northing: 6921392.00
RL:
Total Depth: 6.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SC	**Clayey SAND**: Very loose to loose, fine to medium grained sand, dark grey brown, medium plasticity clay, moist to wet.		M-W	VL-L				
			0.25	Alluvial		SM			M	L				
						CH	**Silty SAND**: Loose, fine to medium grained sand, grey mottled orange, moist.		M	St		0.25	PP	120 kPa
			0.6				**Sandy CLAY**: Stiff, high plasticity, grey mottled orange brown, fine grained sand, moist.							
			0.9			CI	**Sandy CLAY**: As above but medium plasticity and moist.		M	St		0.75	PP	140 kPa
			1.0			CI	**Sandy CLAY**: As above but medium plasticity and hard.		M	H		1.1	PP	330 kPa
			2.0											
			3.0											
			3.1			CL/CI	**Sandy CLAY**: As above but low to medium plasticity and fine to medium grained sand.		M	H				
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH5

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489266.00
Northing: 6921392.00
RL:
Total Depth: 6.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			4.4			CL	**Sandy CLAY**: As above but low plasticity and fine to medium grained sand.		M	H				
			4.7			CL	**Sandy CLAY**: As above but some fine to coarse size gravel.		M	H				
			5.0	Residual		CI	**Sandy CLAY**: As above but medium plasticity.		M	H				
			5	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered.	XW		VLS				
			6.0											
			6				**6.00m: BOREHOLE TERMINATED**							
			7.0											
			8.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH6

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 488864.00
Northing: 6921474.00
RL:
Total Depth: 1.30
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty Gravelly SAND**: Loose, fine to coarse grained sand, brown mottled orange brown, fine to medium size gravel, moist.		M	L				
						CH	**Sandy CLAY**: Stiff, high plasticity, red brown mottled orange brown, fine to medium grained sand, moist.		M	St		0.3	PP	150 kPa
			0.4	Slopewash		CI	**Sandy CLAY**: As above but medium plasticity and grey brown mottled orange brown.		M	St				
			0.7	Residual		CL	**Sandy CLAY**: As above but low plasticity.		M	St		0.7	PP	130 kPa
			0.8	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, grey brown.	XW		VLS				
			1.0											
			1.2			SST	**SANDSTONE**: As above but low strength.	XW		LS				
			1.3				**1.30m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH7

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 488870.00
Northing: 6921016.00
RL:
Total Depth: 1.85
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark brown mottled orange, some clay fines, moist.		M	L				
				Residual		CL/CI	**Sandy CLAY**: Stiff, low to medium plasticity, grey brown mottled .orange, fine grained sand, some medium, moist		M	St				
			0.4			CI	**Sandy CLAY**: Stiff, medium plasticity, grey brown mottled yellow .orange, fine grained sand, moist		M	St		0.5	PP	120 kPa
			0.6	Rock		SST	**SANDSTONE**: Extremely low strength, extremely weathered, grey .orange brown, some low plasticity clay layering	XW		ELS				
			1.0											
			1.3			SST	**:SANDSTONE** .As above but very low strength	XW		VLS				
			1.8			SST	**:SANDSTONE** As above but low strength	XW		LS				
			1.85				**1.85m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH8

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489228.00
Northing: 6920512.00
RL:
Total Depth: 2.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to coarse grained sand, dark brown, some clay fines, moist.		M	L				
				Slope wash		CH	**Sandy CLAY**: Stiff, high plasticity, grey brown mottled orange, fine to medium grained sand, moist.		M	St		0.25	PP	120 kPa
			0.35	Residual		CL	**Sandy CLAY**: As above but very stiff to hard, low plasticity and grey brown.		M	VSt-H				
			0.7			CI	**Sandy CLAY**: As above but medium plasticity.		M	VSt-H				
			1.0											
			1.3	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown.	XW		VLS				
			1.9			SST	**SANDSTONE**: As above but low strength.	XW		LS				
			2.0				**2.00m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH9

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 488682.00
Northing: 6921123.00
RL:
Total Depth: 1.75
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.15	Topsoil		SM	**Silty SAND**: Loose, fine to coarse grained sand, dark grey brown, moist		M	L				
				Slope wash		CH	**Sandy CLAY**: Stiff, high plasticity, light grey brown mottled orange, fine to medium grained sand, moist.		M	St		0.3	PP	110 kPa
			0.45	Residual		CI	**Sandy CLAY**: As above but medium plasticity and some fine size gravel.		M	St				
			0.8			CL	**:Sandy CLAY** .As above but low plasticity		M	St				
			1.0											
			1.4	Rock		SST	**:SANDSTONE** .Very low strength, extremely weathered, orange brown	XW		VLS				
			1.7			SST	**SANDSTONE** As above but low strength:	XW		LS				
			1.75				**1.75m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH10

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 488461.00
Northing: 6920373.00
RL:
Total Depth: 1.30
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, grey brown mottled orange, some fine size gravel, moist.		M	L				
						SM			W	L				
			0.25	Sloped wash		Cl	**Silty SAND**: As above but orange brown and wet.		M	St				
			0.5	Residual		Cl	**Sandy CLAY**: Stiff, medium plasticity, orange brown mottled grey, fine to medium grained sand, moist.		M	VSt-H				
			0.7			CL	**Sandy CLAY**: As above but very stiff to hard.		M	H				
			0.8			SST	**Sandy CLAY**: As above but hard and low plasticity.	XW		VLS				
			1.0	Rock			**SANDSTONE**: Very low strength, extremely weathered, orange brown streaked grey.							
			1.2			SST	**SANDSTONE**: As above but low strength and light orange brown.	XW		LS				
			1.3				**1.30m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH11

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 488713.00
Northing: 6919828.00
RL:
Total Depth: 1.40
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: B. Elsmore
Date: 03/02/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark grey brown, trace of fine size gravel, moist.		M	L				
						SM			M	L				
			0.25	Residual		Cl	**Silty SAND**: Loose, fine to coarse grained sand, light grey mottled orange, some clay fines, moist.		M	St				
			0.55				**Sandy CLAY**: Stiff, medium plasticity, grey brown mottled orange brown, fine to coarse grained sand, moist.							
			0.6	Rock		CL		XW	M	St				
						SST	**Sandy CLAY**: As above but low plasticity.			VLS				
			1.0				**SANDSTONE**: Very low strength, extremely weathered, orange brown.							
			1.3			SST	**SANDSTONE**: As above but low strength.	XW		LS				
			1.4				**1.40m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH12

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489166.00
Northing: 6921982.00
RL:
Total Depth: 1.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 16/01/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose to medium dense, fine to medium grained sand, dark brown, moist.		M	L-MD				
						SM	**Silty SAND**: As above but dense and light grey.		M	D				
			0.4	Slopewash / Residual		CL/CI	**Sandy CLAY**: Hard, low to medium plasticity, orange brown mottled grey, fine to medium grained sand, moist.		M	H		0.6	PP	>600 kPa
			0.85	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown mottled grey.	XW		VLS				
			0.95			SST	**SANDSTONE**: As above but very low to low strength.	XW		VLS-LS				
			1.0				**1.50m: BOREHOLE TERMINATED**							
			1.5											
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH13

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489447.00
Northing: 6922036.00
RL:
Total Depth: 1.70
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 16/01/2012

Drilling Information				Material Description								Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Medium dense, fine to medium grained sand, dark brown, moist.		M	MD				
				Residual		CL/CI	**Sandy CLAY**: Hard, low to medium plasticity, orange brown mottled grey, fine to medium grained sand, moist.		M	H		0.4	PP	>600 kPa
			0.5	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown mottled grey.	XW		VLS				
			0.75			SST	**SANDSTONE**: As above but low strength.	XW		LS				
			0.85			SST	**SANDSTONE**: As above but very low strength.	XW		VLS				
			1.0											
			1.35			SST	**SANDSTONE**: As above but extremely low strength.	XW		ELS				
			1.5			SST	**SANDSTONE**: As above but very low strength.	XW		VLS				
			1.6			SST	**SANDSTONE**: As above but low strength.	XW		LS				
			1.7				**1.70m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH14

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489273.00
Northing: 6922699.00
RL:
Total Depth: 1.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 16/01/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.05	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark brown, moist.		M	L				
			0.15			SM			M	MD				
				Residual		CL	**Silty SAND**: As above but medium dense and orange brown bleached grey.		M	H				
			0.45				**Sandy CLAY**: Hard, low plasticity, orange brown mottled grey, fine to medium grained sand, moist.							
						SST		XW		VLS				
				Rock			**SANDSTONE**: Very low strength, extremely weathered, orange brown streaked grey.							
			1.0											
			1.4			SST	**SANDSTONE**: As above but low strength.	XW		LS				
			1.5				**1.50m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			2.0											
			3.0											
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH15

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489886.00
Northing: 6922101.00
RL:
Total Depth: 3.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 16/01/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark brown, moist.		M	L				
						SM	**Silty SAND**: As above but dense and light grey.		M	D				
			0.35	Slopewash		CI/CH	**Sandy CLAY**: Hard, medium to high plasticity, orange brown mottled grey and brown, fine to medium grained sand, moist.		M	H				
			1.0	Alluvial								1 –	PP	>600 kPa
			1.2			CI	**Sandy CLAY**: As above but medium plasticity and orange brown mottled grey.		M	H				
			1.7			CI/CH	**Sandy CLAY**: As above but medium to high plasticity and grey streaked orange brown.		M	H		1.8 –	PP	>600 kPa
			2.0	Residual		CL/CI	**Sandy CLAY**: As above but low to medium plasticity.		M	H				
			2.4	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown.	XW		VLS				
			3.0				**3.00m: BOREHOLE TERMINATED**							
			4.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH16

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 490235.00
Northing: 6922170.00
RL:
Total Depth: 4.50
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 16/01/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.05	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark brown, some clay fines, moist.		M	L				
						SM			M	MD-D				
			0.4	Slopewash		CH	**Silty SAND**: As above but medium dense to dense and light grey bleached orange brown.		M	H		0.5	PP	>600 kPa
			0.7				**Sandy CLAY**: Hard, high plasticity, grey streaked brown, fine to medium grained sand, moist.							
			1.0	Residual		CH	**Sandy CLAY**: As above but orange brown mottled grey.		M	H		1	PP	>600 kPa
			2.0									2	PP	>600 kPa
			2.1			CH	**Sandy CLAY**: As above but fine grained sand with some medium and grey mottled orange brown.		M	H				
			2.8			CL/CI	**Sandy CLAY**: As above but orange brown mottled grey and low to medium plasticity.		M	H				
			3.0											
			3.2	Rock		SST	**SANDSTONE**: Extremely low strength, extremely weathered, orange brown bleached grey.	XW		ELS				
			3.6			SST	**SANDSTONE**: As above but extremely low to very low strength.	XW		ELS-VLS				
			4.0											
			4.5				**4.50m: BOREHOLE TERMINATED**							
			5.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Moisture
D Dry M Moist W Wet

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH17

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 490515.00
Northing: 6922031.00
RL:
Total Depth: 3.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 17/01/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.25	Alluvial Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, orange brown bleached grey, some clay fines, moist.		M	L				
			0.45			CH	**Sandy CLAY**: Firm, high plasticity, orange brown mottled grey, fine to medium grained sand, moist to wet.		M-W	F		0.4	PP	80 kPa
			0.85			CI	**Sandy CLAY**: Hard, medium plasticity, grey mottled orange brown, fine to medium grained sand, moist.		M	H		0.8	PP	>600 kPa
			1.0	Residual		CL/CI	**Sandy CLAY**: As above but low to medium plasticity and orange brown mottled grey.		M	H				
			1.55	Rock		SST	**SANDSTONE**: Very low strength, extremely weathered, orange brown mottled grey.	XW		VLS				
			2.0											
			2.1			SST	**SANDSTONE**: As above but extremely low strength and brown.	XW		ELS				
			2.6			SST	**SANDSTONE**: As above but very low strength and orange brown mottled grey.	XW		VLS				
			3.0				**3.00m: BOREHOLE TERMINATED**							
			4.0											
			5.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH18

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 490719.00
Northing: 6921712.00
RL:
Total Depth: 3.00
Drilling Rig: Jacro 200
Driller: Battison & Sons
Logged By: L. Bexley
Date: 17/01/2012

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose, fine to medium grained sand, dark brown, moist.		M	L				
						SM			M	MD				
			0.4	Slopewash			**Silty SAND**: As above but medium dense and light grey bleached orange brown.							
						CI/CH	**Sandy CLAY**: Hard, medium to high plasticity, grey mottled orange brown, fine to medium grained sand, moist.		M	H		0.5	PP	>600 kPa
			0.7	Residual		CL			M	H				
			0.8			SST	**Sandy CLAY**: As above but low plasticity and orange brown mottled grey.	XW		VLS				
			1.0	Rock			**SANDSTONE**: Very low strength, extremely weathered, orange brown mottled grey.							
			2.0											
			2.4			SST	**SANDSTONE**: As above but extremely low strength.	XW		ELS				
			2.8			SST	**SANDSTONE**: As above but very low strength.	XW		VLS				
			3.0				**3.00m: BOREHOLE TERMINATED**							
			4.0											
			5.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH19

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 490243.00
Northing: 6921314.00
RL:
Total Depth: 4.50
Drilling Rig: Jehyco Digga
Driller: Morrison Geotechnic
Logged By: E. Levingston
Date: 15.9.11

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.3	Alluvial		CH	**Silty Sandy Clay**: Firm, high plasticity, grey, fine to medium sand, moist to wet		M-W	F	1 0 2			
			0.5			CH	**Silty Clay**: Stiff, high plasticity, grey, trace of fine sand, moist		M	St	3 2			
			0.6			CH	**Silty Clay**: As above, but very stiff, light brown		M	VSt	5			
			1.0			CH	**Silty Sandy Clay**: Hard, high plasticity, light brown, fine to medium sand, moist		M	H	9 11 8			
			1.2			CH	**Silty Sandy Clay**: As above, but grey		M	H	6 12 12			
			1.5			CH	**Silty Clay**: Hard, high plasticity, grey, with sand layers, moist		M	H	8 9 14			
			2.0			CH	**Silty Clay**: As above, but trace of fine to medium gravel		M	H	7 6 6 6 5 5 5 6 6 7 7 8 8			
			3.0			SC	**Clayey Sand**: Dense, grey mottled brown, fine to coarse sand, medium plasticity fines, moist		M	D	15 15/75m			
			4.0	Residual		CH	**Silty Sandy Clay**: Very stiff, high plasticity, grey mottled light brown and orange, fine to medium sand, moist		M	VSt				
			5.0				**4.50m: BOREHOLE TERMINATED**							

Comments:

Authorised by: ……

Date: ……..……..……

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

Morrison Geotechnic Pty Ltd
A.B.N. 051 009 878 899
PO Box 3063, Darra, QLD 4076
Phone: (07) 3279 0900 Fax: (07) 3279 0955

Engineering Log - Borehole

Borehole No.: BH20

Job Number: GE12/005
Client: Pacific International Development Corporation
Project: Broad Geotechnical Assessment
Location: Precinct 1, NH1 to NH10, Flinders Development

Easting: 489835.00
Northing: 6921655.00
RL:
Total Depth: 3.20
Drilling Rig: Jacro 200
Driller: Morrison Geotechnic
Logged By: L. Bexley
Date: 08/08/2011

Drilling Information				Material Description							Test Samples			
Drill Method	Water	RL	Hole Depth (m)	Soil Origin	Graphic Log	Classification Code	Description	Weathering	Moisture	Consistency - Density - Strength	DC Test Results	Test Depth	Tests	Sample/Result
TC bit with 100mm Dia. Auger			0.1	Topsoil		SM	**Silty SAND**: Loose to medium dense, fine to medium grained sand, dark brown, moist		M	L-MD				
			0.25	Slope wash		SM			M	MD				
			0.5	Residual		SM	**Silty SAND**: As above but medium dense and brown		M	D				
			1.0	Bedrock		SST	**Silty SAND**: As above but dense and orange brown	XW		VLS				
							SANDSTONE: Extremely weathered, very low strength, orange brown streaked grey							
			1.5			SST	**SANDSTONE**: As above but with some sandy clay layering	XW		VLS				
			1.9			SST	**SANDSTONE**: As above but no clay layering	XW		VLS				
			2.4			SST	**SANDSTONE**: As above but very low to low strength	XW		VLS-LS				
			3			SST	**SANDSTONE**: As above but low strength	XW		LS				
			3.2				**3.20m: BOREHOLE TERMINATED AT MAXIMUM TC REFUSAL**							
			4.0											
			5.0											

Comments:

Authorised by: ……

Date: ……..…..……..

Water
- Water level on date shown
- Water inflow
- Water outflow

Weathering
- RS Residual soil
- XW Extremely weathered
- DW Distinctly weathered
- SW Slightly weathered
- FR Fresh

Consistency
- VS Very soft
- S Soft
- F Firm
- St Stiff
- VSt Very stiff
- H Hard

Moisture
D Dry M Moist W Wet

Density
- VL Very loose
- L Loose
- MD Medium dense
- D Dense
- VD Very dense

Rock Strength
- ELS Extremely low
- VLS Very low
- LS Low
- MS Medium
- HS High
- VHS Very high
- EHS Extremely high

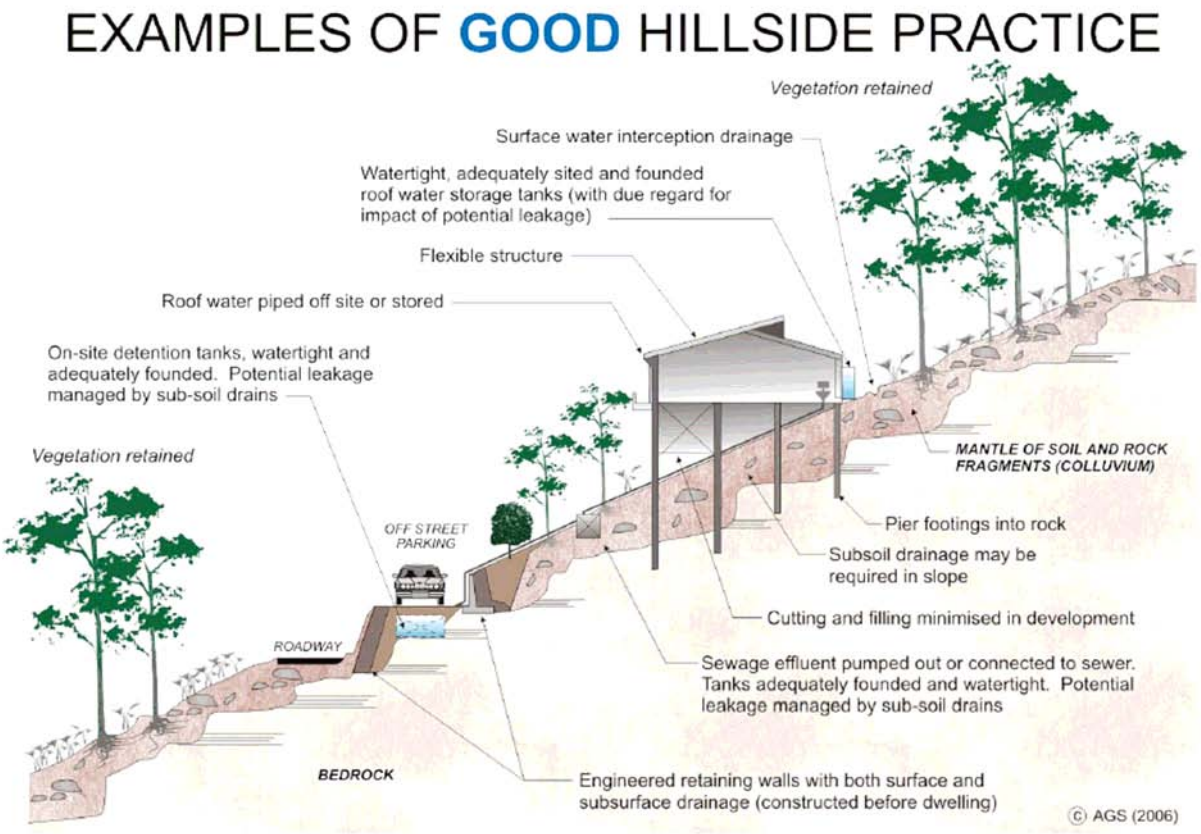
Tests & Results
- U50 Undisturbed 50mm diam tube.
- D Disturbed sample.
- SPT Standard Penetration Test, N = number of blows to drive 50mm sampler 300mm with a 63.6kg hammer falling 762mm.
- PP Hand penetrometer estimate of unconfined compressive strength, kPa.
- S Vane shear value kPa
- DC Dynamic Cone test, 9.09kg hammer, fall 508mm, driving 20mm, 30 deg taper cone fitted to rods of smaller section. From AS1289-1993 Methods of Testing Soils for Engineering Purposes

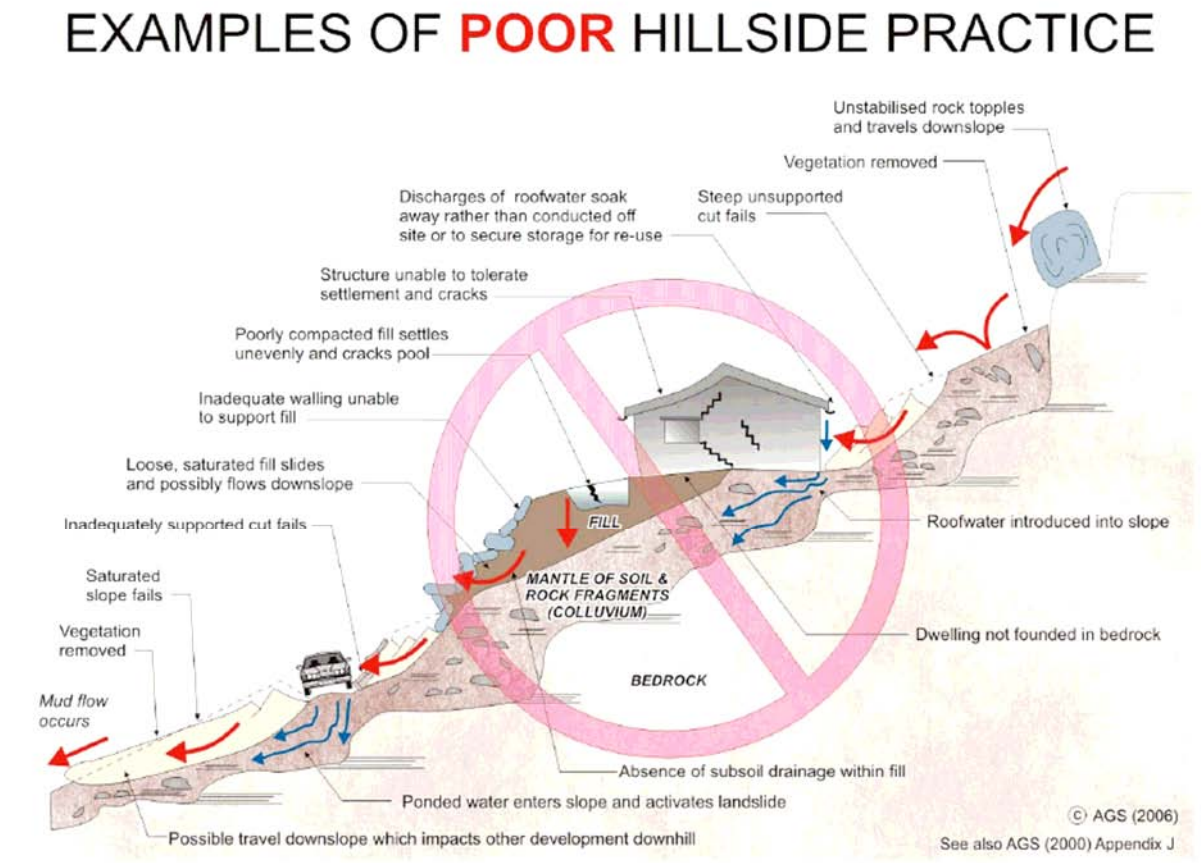
A P P E N D I X C

GUIDELINES FOR HILLSIDE ENGINEERING

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.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
OFF STREET PARKING
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
ROADWAY
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Vegetation removed
Dwelling not founded in bedrock
BEDROCK
Mud flow occurs
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
© AGS (2006)
Possible travel downslope which impacts other development downhill
See also AGS (2000) Appendix J

Important Information About Your Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. *No one except you* should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one—not even you*—should apply the report for any purpose or project except the one originally contemplated.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, *do not rely on a geotechnical engineering report* that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions *only* at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an *opinion* about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final*, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject To Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce such risks, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations", many of these provisions indicate where geotechnical engineers responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Rely on Your Geotechnical Engineer for Additional Assistance

Membership in ASFE exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE PROFESSIONAL FIRMS PRACTICING IN THE GEOSCIENCES

8811 Colesville Road Suite G106 Silver Spring, MD 20910
Telephone: 301-565-2733 Facsimile: 301-589-2017
email: info@asfe.org www.asfe.org

IIGER06983.5M