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Department of Planning

RAAF Base Williamtown / Newcastle Airport Employment Zone Land Use Development Strategy

Stage 2: Revised Preliminary Geotechnical Assessment

August 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Appendices

1. Introduction

This revised report presents the results of a preliminary geotechnical assessment carried out by GHD Pty Ltd (GHD) for a proposed industrial development to be located at Williamtown, NSW. The report supersedes our earlier 'Stage 2 Preliminary Geotechnical Assessment' report (GHD Document Ref: 22/12808/73922) dated November 2006.

The earlier report was commissioned by the Department of Planning in July 2006, and supplemented a 'desktop study' undertaken as part of the Site Selection Report for Stage 1 of the RAAF Base Williamtown / NAL Employment Zone Land Use Strategy (GHD Document Ref: 22/12808/71988). Due to geotechnical and flooding issues identified during the previous Stage 2 Land Use Capability / Suitability Investigations Report issued in March 2007, a revised study area has since been selected which incorporates additional landholdings to the west of the previously investigated Stage 2 study area. Preliminary geotechnical assessment of this additional land was commissioned by the Department of Planning on 27 July 2007.

The Stage 1 geotechnical assessment involved a preliminary assessment of a 500 hectare study area, incorporating part of the site which has been included in the current assessment. The Stage 1 report identified general geotechnical constraints to land development based on the findings of a desktop study, which included a review of available published data including geological and soil landscape maps encompassing the study area.

Stage 2 of the project involved the preparation of a Land Use Capability / Suitability Investigations Report involving a more detailed review and verification of available data to assist in better defining the general geotechnical constraints to development of the preferred site selected in Stage 1. The subject of the Stage 2 assessment conducted in September 2006 occupied a plan area of approximately 100 hectares, bound by Nelson Bay Road to the east, Cabbage Tree Road to the south and the Williamtown RAAF Base / Newcastle Airport to the north.

The Stage 2 study area has since been revised to include an additional area of approximately 40 hectares (approximately 660m by 550 to 650m in plan), adjoining the north western corner of the site. The location of the site is shown on Figure 1, which is included in Appendix A.

The purpose of the current Stage 2 geotechnical assessment was to define the general geotechnical and geological site conditions and associated risks, issues and constraints to the proposed land development. Further detailed/specific geotechnical investigations will be required for each of the detailed design phases of the proposed development.

This report should be read in conjunction with the attached *General Notes,* included in Appendix B.

2. Method of Investigation

2.1 Previous Stage 2 Investigation Area

2.1.1 General

The Stage 2 investigation conducted in September 2006 comprised a desk top study followed by a site walkover and limited subsurface investigation to assess near surface soil profiles and collect representative samples for laboratory testing. The subsurface investigation also included sampling and testing as part of a preliminary Acid Sulfate Soil (ASS) assessment (reported under separate cover).

2.1.2 Desk Top Study

The first phase of the work included a desk top study to provide a preliminary geotechnical model and consideration of geotechnical issues. The desk top study included a review of the following geological and geotechnical information:

- A review of the 1:100,000 scale Geological Series Sheet 9231 'Newcastle Coalfield Regional Geology', published by the Department of Mineral Resources (1995);
- A review of the 1:100,000 scale Soil Landscape Sheet 9232 for Newcastle, published by the Department of Conservation and Land Management (1995);
- A review of the 1:25,000 scale Acid Sulfate Soil Risk Map for Williamtown, published by the Soil Conservation Service of NSW (1995).

2.1.3 Site Walkover

To assist with the appreciation of existing site conditions and assessment of potential geotechnical and geological constraints associated with the proposed land development, a site walkover was conducted by an Engineering Geologist to map significant surface features including signs of erosion, drainage paths and changes in terrain units and further 'ground truth' the results of the earlier desktop study. The site walkover was undertaken on the 22 and 29 September 2006 following a period of extended wet weather.

Site features observed during the Stage 2 walkover assessment are presented in Figure 2 in Appendix A.

2.1.4 Borehole Investigation

Nine shallow hand auger boreholes (BH1 – BH9) were drilled across the previous Stage 2 investigation area (refer to Figures 1 and 2) to confirm subsurface conditions and obtain samples for subsequent laboratory testing. Fieldwork was carried out on 22 and 29 September 2006, following an extended period of wet weather.

The boreholes were drilled to depths ranging from 1.0m to 2.3m. Several of the boreholes collapsed before reaching the target investigation depth of 2.0m due to the high water table and sandy/clayey nature of the site. Dynamic Cone Penetrometer (DCP) testing was undertaken adjacent to eight of the nine test locations to assess relative soil strength.

Acid Sulfate Soil (ASS) sampling was also undertaken, typically at 0.5m intervals in each of the boreholes, to allow for field indicator testing and subsequent detailed laboratory analysis. The results of the ASS testing and a discussion of the implications for management of ASS at the site are included under separate cover titled 'Stage 2: Preliminary Acid Sulfate Soil Assessment' (Doc Ref: 22/1280801/77825, August 2007).

Sampling within the 'Blind Harry Swamp' soil landscape was limited due to the area being waterlogged at the time of the fieldwork.

The fieldwork was undertaken by an experienced Geotechnical Engineer from GHD's Newcastle office who was responsible for logging the encountered strata, sampling and conducting insitu testing. Boreholes were located relative to existing site features. Approximate borehole locations are shown on Figure 2 in Appendix A.

Ground surface levels (to AHD) at each borehole location have been interpolated from 0.5m contour intervals shown on the site survey plan and are summarised in Table 2. It should be noted that these levels are approximate only and that detailed survey has not been undertaken as part of this preliminary investigation.

Limited subsurface investigation was also undertaken as part of the Stage 1 assessment, to confirm soil types at selected soil landscape boundaries. The four soil profile locations (P1 to P4) are indicated on Figure 2, and a summary of the subsurface profile encountered at each of the locations is summarised in Table 2.

2.2 Additional Landholdings

2.2.1 General

The preliminary assessment presented herein has been based on a desk top study and brief field inspection to 'ground truth' the results of the desk top study for the revised study area, and extrapolation of existing soils information obtained during the previous investigations at the site. No additional subsurface investigation was undertaken within the additional landholdings as part of the current assessment.

2.2.2 Desk Top Study

A desk top study has been carried out for additional landholdings located to the west of the previously investigated Stage 2 study area. The desk top study was required to highlight potential geotechnical issues associated the subject land for incorporation into the proposed Williamtown Employment Zone development.

The desk top study included a review of the following geological and geotechnical information:

- A review of the 1:100,000 scale Geological Series Sheet 9231 'Newcastle Coalfield Regional Geology', published by the Department of Mineral Resources (1995);
- A review of the 1:100,000 scale Soil Landscape Sheet 9232 for Newcastle, published by the Department of Conservation and Land Management (1995);
- A review of the 1:25,000 scale Acid Sulfate Soil Risk Map for Williamtown, published by the Soil Conservation Service of NSW (1995).

2.2.3 Site Walkover

To assist with the appreciation of existing site conditions and preliminary assessment of potential geotechnical and geological constraints associated with the proposed land development, a site walkover of the additional landholdings was conducted by an Engineering Geologist to map significant surface features including signs of erosion, drainage paths and changes in terrain units and further 'ground truth' the results of the desktop study. The site walkover was undertaken on the 8 August 2007.

Surface soils observed during the brief site visit were generally consistent with those encountered in representative boreholes and mapped soil landscape groups during the previous Stage 2 investigation conducted in September 2006.

Site features observed during the Stage 2 walkover assessments are presented on Figure 2 in Appendix A.

3. Site Description, Regional Geology & Soil Landscapes

3.1 Site Description

3.1.1 Site Location

The Stage 1 geotechnical assessment, completed in June 2006, included desktop study of an irregular shaped area of approximately 500 hectares extending from the south east corner of the Newcastle Airport, approximately 2 km to the south and approximately 1.5 km east and west of the centrally located Nelson Bay Road. Based on the findings contained within the Stage 1 Site Selection Report, this area was then revised for the Stage 2 Site Selection Report to include a smaller area of approximately 100 hectares bound by Newcastle Airport to the north and Nelson Bay Road and Cabbage Tree Road to the east and south respectively. As indicated earlier, due to geotechnical and flooding issues identified during the previous Stage 2 Land Use Capability / Suitability Investigations Report issued in March 2007, a revised study area has since been selected which incorporates additional landholdings to the west of the previously investigated Stage 2 study area. Reference should be made to Figure 1 in Appendix A which shows the aerial extents of the Stage 1 and Stage 2 study areas.

The majority of the study area comprises vacant land owned by B & M Ellison Pty Ltd, extending toward Nelson Bay and Cabbage Tree Roads in an inverted 'L' shape. The site also includes of a number of rural residential properties extending in a northerly direction from Cabbage Tree Road. The south western boundary of the site is defined by the S. Facer property (Lot 101 DP875155), while the north western boundary of the revised study area is defined by the northern portion of Lot 131 DP609165. Lot boundaries are shown on Figure 1 (Appendix A).

3.1.2 Topography

The majority of the site encompasses a relatively flat low lying alluvial plain, with surface elevations typically ranging from RL 1m to 2m AHD in the south western corner (Blind Harry's Swamp and Bobs Farm soil landscapes), to less than RL 1.0m AHD in the south eastern corner. This low area of the site was inundated at the time of the fieldwork carried out in September 2006, the approximate extent of which is shown on Figure 2.

A small central northern portion of the B.M Ellison property (Lot 11 DP1036501) is higher in elevation than the remainder of the site, representing the remnants of a Pleistocene dunal formation. The elevated area is approximately 50m to 100m wide and 275m long (from northwest to southeast). The remainder of the dune formation in the previously investigated study area has been sand mined for a distance of approximately 400m to 600m to the western boundary of the previously investigated Stage 2 study area. Remnant dunes were also noted in the central eastern portion of the additional landholdings, extending from the edge of the sand mined area, to the western boundary of Lot 11, occupying an area of approximately 70 to 120m wide by 300m long. Ground surface slopes are typically 5° to 15° on the lower slopes of the dunes, rising at angles of up to 35° to 45° to a near vertical scarp at the top of two of the larger eroded dunes (refer to Figure 2 in Appendix A).

Ground surface elevations typically range from RL 2m to 4m AHD in the sand mined area, rising to approximately RL 11m to 13m AHD in the remnant dunes. The scarp in the central northern portion of Lot 11 DP1036501 is estimated to be approximately 0.5m to 0.8m in height, extending along the top of the dune.

Extensive wind erosion was evident in the remnant dunes. Indurated sand (coffee rock) was exposed in the top of an eroded dune formation in the south eastern corner of the additional landholdings.

3.1.3 Vegetation

Parts of the previously investigated Stage 2 study area are heavily wooded with the majority of the wooded areas being waterlogged at the time of the field investigation undertaken in September 2006. Thick low grasses covered the remaining waterlogged areas across this part of the site, with sandy gravel and sparse grass cover predominant in the slightly raised areas. The north western most corner of the previously investigated site appeared to have been recently cleared and levelled.

The majority of the additional landholdings adjoining the western boundary of the area described above is densely vegetated. Access through this area of the site was limited at the time of the site visit in August 2007. The northern portion of Lot 11 DP1036501 is characterised by a tall eucalypt forest with a dense undergrowth comprising long grasses, reeds, bracken and low shrubs. The southern portion of Lot 11 DP1036501, on the southern side of the dune formation, largely comprises uncleared swamp forest, defining the northern margin of the Blind Harry Swamp soil landscape group. The southern and northern investigated portions (two thirds) of Lot 131 DP609165 and the investigated portion of Lot 132 DP609165 are characterised by dense undergrowth comprising long grasses, bracken and low shrubs, with extensive areas of small to medium sized paperbark trees and scattered tall eucalypts. The central investigated portion of Lot 131 was vegetated with long orange grasses and scattered stands of mature eucalypts.

3.1.4 Disturbed Terrain / Filling

Several fill mounds were also observed scattered across the site, comprising of a variety of materials including old cars and builders rubble. The approximate location of the filled areas is indicated on Figure 2 (Appendix A).

A disused roadway, partly paved in areas, was observed running north adjacent to Lot 6 DP4831 and extending in a northwest direction across the north western section of Lot 11 DP1036501. The roadway appeared to connect with Cabbage Tree Road to the south and comprised gravelly fill materials consisting of highly weathered carbonaceous siltstone, which appeared moderately compacted. Similar material was observed in a stockpile at the north eastern end of the access road.

An existing sewage treatment pond was observed within the disturbed (filled) area adjacent to the Newcastle Airport on the northern margin of the site.

3.1.5 Surface Water and Site Drainage

Numerous open drainage channels traverse the site. Water within the channels appeared to be draining to the south and southwest, towards Fullerton Cove, at the time of the field investigation undertaken in September 2006. The two dominant drainage lines that were identified typically aligned in a northwest to southeast and northeast to southwest orientation, extending from the swampy area in the central western portion of the site, joining at a low point on the boundary of Lots 9 and 10 DP4831 before flowing south toward a culvert under Cabbage Tree Road.

The drainage channels are typically about two to three metres wide and there are also a number of open drains that run roughly in a north to south orientation, adjacent to property boundaries, with lengths of approximately 500m. The open drains are estimated to be approximately three to four metres wide, lined by tall reeds which obscure the drains in some areas of the site. It is estimated that the drains are in excess of 1m deep.

The field investigation carried out in September 2006 took place two to three weeks after a heavy rainfall event. During that period several visits were made to assess site access. Poor drainage was noted across the site including partially blocked 'natural' drainage paths adjacent to Cabbage Tree Road. The accumulated water was observed to pond within the site for a period greater than three weeks. The majority of the lower lying southern half of the site was inaccessible at the time of the fieldwork. The approximate extent of boggy ground and inundated areas observed at the time of the previous field investigation is shown on Figure 2.

The north western corner of the study area was observed to be waterlogged at the time of the previous field investigation, following an extended period of wet weather. However, this area was observed to be relatively dry at the time of the recent site visit on 8 August 2007. The majority of the additional landholdings to the west of this area were observed to be dry at the time of the site visit, but localised waterlogging of organic-rich soils was observed in low lying swales (swampy depressions) at the base of the dune formations, and in the Blind Harry Swamp area to the south of the dune formation (refer to Figure 2 in Appendix A).

3.2 Regional Geology

Reference to the 1:100,000 'Newcastle Coalfield Regional Geology' map indicates that the site is underlain by Quaternary Alluvium. Broadly, units within the Quaternary Alluvium comprise (from oldest to youngest) Pleistocene clay, Pleistocene barrier sands, Holocene estuarine clay and recent floodplain deposits. Beneath these sediments, the bedrock comprises interbedded sandstone, siltstone, mudstone and coal of the Permian aged Tomago Coal Measures.

The majority of the site is typically underlain by gravels, sands, silts and clays deposited in either alluvial (point bar, levee) and/or estuarine environments; whilst the north-western quarter of the previous study area (adjacent to the airport) and the additional landholdings to the west are typically characterised by dune (Aeolian) and/or beach sand deposits overlying the Quaternary Alluvium.

3.3 Soil Landscape Groups

Reference to the 1:100,000 Soil Landscape Map of the Newcastle Region indicates that the site lies largely within the 'Bobs Farm' estuarine and a variant of the 'Tea Gardens' aeolian soil landscape groups. These unit boundaries correspond roughly with the geological unit boundaries described above and are shown in Figure 3 – Soil Landscape Groups Within the Study Area.

Minor soil landscapes also noted within the study area (and shown in Figure 3) include the 'Shoal Bay' a

eolian soil landscape group associated with the exposed dune system west of the airport access road in the central northern part of the site and the 'Blind Harry Swamp' soil landscape group associated with the patch of swampy ground near the centre of the study area, south of the dune system.

The 'Bobs Farm' (bf) soil landscape group incorporates broad inter-barrier estuarine flats on the Tomago Coastal Plain. The topography is characterised by slope gradients less than 1% and elevations between 1 and 3 metres. Soils within this group are typically deep (>3m) very poorly drained estuarine mud deposits. Dominant soil materials include organic rich loam (sandy silty clays) overlying saturated plastic clays.

The 'Tea Gardens' (tna variant) soil landscape group incorporates Pleistocene beach ridges on the Tomago Coastal Plain. The topography is characterised by slopes typically less than 5% and elevations between 5 and 8 metres. Soils have generally been re-worked by wind action producing irregular sandy low rises and broad deflation basins and swales. Dominant soil materials include loamy sand and/or beach sand topsoils overlying loam sand to sand subsoils.

The 'Blind Harry Swamp' (ba) soil landscape group incorporates waterlogged swales, periodically submerged swamp forest and deflation areas on sands of the Tomago Coastal Plain. The topography of the area is characterised by level to very gentle inclined closed depressions with extremely low reliefs. Dominant soils include organic fibrous peat overlying sand or loamy sand.

The 'Shoal Bay' (sb) soil landscape group incorporates Pleistocene sand sheets and low dunes on the Tomago Coastal Plain. The topography of the soil landscape incudes inclined sand sheets, low undulating dunes with slope gradients typically less than 15% and local relief less than 10 metres with minor swampy areas occurring in depressions. Dominant soils include sands and loamy sands.

3.4 Acid Sulfate Soils

Reference to the Acid Sulfate Soil Risk Map for Williamtown, published by the Soil Conservation of NSW, indicates that there is a high probability of occurrence of Acid Sulfate Soils (ASS) at shallow depth (between 1m and 3m depth below the natural ground surface) over the low-lying flood plains (elevation less than RL 4m AHD). The map also indicates that there is a low probability of occurrence of ASS at a depth of greater than 3m below the existing surface in the slightly elevated northern portion of the site (above RL 4m AHD). This elevated area is described by the Risk Map as a Pleistocene Aeolian Sandplain / Dune and, if present, ASS within this area are expected to be sporadic and buried by alluvium and/or Aeolian (windblown) sediments.

Reference to the ASS risk map indicates that the majority of the additional landholdings to the west of the previously investigated study area are characterised by a low probability of occurrence of ASS at a depth of greater than 3m below the existing surface. However, the ASS risk map defines this area as an aeolian sand plain with ground surface elevations greater than RL 4m AHD. Following review of a topographic map of the study area, it is apparent that ground surface elevations typically range between RL 1.5m and 4m AHD across this portion of the site, with the exception of localised dune formations. The soil landscape map of the Newcastle region also indicates that soils within the 'Tea Gardens' soil landscape group, which dominates this portion of the site, are strongly to extremely acidic. Thus, it is likely that acidic soils will be encountered in these areas.

Further discussion on Acid Sulfate Soil conditions is provided in GHD's 'Stage 2: Preliminary Acid Sulfate Soil Assessment' report (GHD Document Ref: 22/12808/77825).

4. Subsurface Conditions

The borehole logs from the previous geotechnical investigation conducted in September 2006 are presented in Appendix C. These logs should be read in conjunction with the attached standard sheets, which explain the terms, abbreviations and symbols used, together with interpretation and limitations of the logging procedure.

In general terms the boreholes within the 'Shoal Bay' and 'Tea Gardens' soil landscapes in the north of the site, adjacent to Newcastle Airport and within the former sand mined area, encountered Aeolian and Alluvial deposits typically comprising of loose to medium dense, fine to medium grained sands (with the exception of BH4 which encountered estuarine deposits associated with the 'Bobs Farm' soil landscape group overlying alluvial sand deposits).

On the basis of the insitu dynamic cone penetrometer (DCP) testing, the subsurface profiles below borehole termination depths within the 'Tea Gardens' soil landscape group are inferred to comprise loose to medium dense sand to 2.55m depth (limit of investigation). The 'Shoal Bay' soil landscape group is inferred to comprise very loose to loose near surface soils overlying loose to medium dense sand to 3.45m depth (limit of investigation).

The boreholes in the central and southern areas of the site, representing the 'Bobs Farm' soil landscape, encountered predominately very soft to soft organic (peaty) clay/clayey silt and soft to firm, high plasticity clay (up to 1.0m depth) underlain by very loose to loose, fine to medium grained clayey sands and sands. An exception to the above generalised profile was noted in BH8 (within the 'disturbed terrain' adjacent to Cabbage Tree Road) which encountered loose to medium dense, fine to medium grained sand, overlying high plasticity clay at 1.3m depth.

On the basis of the insitu dynamic cone penetrometer (DCP) testing, the subsurface profiles below borehole termination depths within the 'Bobs Farm' soil landscape are inferred to comprise very loose to loose sand to maximum investigation depths of 1.85m and 2.65m (limit of investigation).

Testing within the 'Blind Harry's Swamp' soil landscape group was limited, however the closest borehole (BH 3) encountered silty sand overlying sand.

The generalised soil units encountered in the boreholes are summarised in Table 1, whilst Table 2 provides a summary of the distribution of these units in the boreholes.

Groundwater was encountered at all test locations and was measured between 0.1m and 0.8m below the existing surface during the investigation. No attempt was made to correlate observed groundwater tables with rainfall and runoff movements during the investigation period.

Table 1 Summary of Soil Types Encountered during Subsurface Investigations

Geotechnical Soil Unit	Origin	Description
1	Aeolian	Light grey/yellow, loose to very loose, fine to medium grained SAND, becomes loose to medium dense with depth.
2	Alluvium	Dark grey/brown to black, loose, Silty SAND, with trace clay.
3a	Alluvium	Grey/black, loose to medium dense, medium grained SAND with trace silt. Becomes light grey (medium dense to dense) with depth.
3b		Dark brown to black, medium dense, fine to medium grained SAND, with silt and trace clay.
4a	Estuarine / Alluvium	Black, very soft to soft, high plasticity Organic (Peaty) CLAY with silt / Clayey SILT with trace fine grained sand, root fibres throughout, strong sulphurous odour.
4b		Grey mottled orange/yellow, soft, high plasticity CLAY, with some root fibres, becomes sandy with depth, strong organic/ sulphurous odour.
4c		Grey, loose to medium dense, fine to medium grained SAND, with trace silt / clay (clayey SAND in BH7, very loose to loose in BH8).
4d		Grey Sandy GRAVEL, medium grained, loose.
4e		Dark grey, very soft to soft, high plasticity CLAY with some medium grained sand.

Table 2 Summary of the Distribution of Inferred Geotechnical Soil Units at each Borehole Location

Soil Landscape Group	Borehole Location	Approx. RL (m) AHD	Inferred Geotechnical Soil Unit and Origin									Water Table
			Aeolian		Alluvial		Estuarine / Alluvial					
			Unit 1	Unit 2	Unit 3a	Unit 3b	Unit 4a	Unit 4b	Unit 4c	Unit 4d	Unit 4e	
			Depth in metres									
Tea Gardens (tna)	BH1	3.5	-	-	0.0 – 0.8	0.8 – 1.0	-	-	-	-	-	0.65
	BH6	2.6	0.0 – 1.0	-	-	1.0 – 1.55	-	-	-	-	-	0.80
	P3	-	-	-	-	0.0 – 0.9	-	-	-	-	-	0.40
Shoal Bay (sb)	BH2	3.2	0.0 – 0.7	-	0.7 – 1.0	1.0 – 1.65	-	-	-	-	-	0.80
	P1	-	0.0 – 1.0	-	-	-	-	-	-	-	-	>1.0
	P2	-	0.0 – 1.0	-	-	-	-	-	-	-	-	>1.0
Blind Harrys Swamp (ba)	BH3	2.0	-	0.0 – 0.6	0.6 – 1.15	-	-	-	-	-	-	0.55
Bobs Farm (bf)	BH4	3.0	-	-	-	-	0.0 – 0.7	-	0.7 – 1.5	-	-	0.10
	BH5	1.2	-	-	-	-	0.0 – 0.35	0.35 – 1.0	1.0 – 1.8	-	-	0.50
	BH7	1.4	-	-	-	-	0.0 – 0.2	0.2 – 0.7	0.7 – 2.3	-	-	0.20
	BH8	1.2	-	-	-	-	-	-	0.0 – 1.2	1.2 – 1.3	1.3 – 2.1	0.25
	BH9	1.1	-	-	-	-	0.0 – 0.2	0.2 – 0.5	0.5 – 1.85	-	-	0.35
	P4	-	-	-	-	-	0.0 – 0.4	-	0.4 – 0.9	-	-	0.30

5. Laboratory Test Results

Selected samples from the boreholes were tested in our NATA registered Sydney laboratory for measurement of moisture content, organic content, Atterberg Limits (plasticity), particle size distribution and Emerson Class dispersion.

The laboratory report sheets are provided in Appendix D and the test results are summarised in Table 3.

Moisture content tests on selected samples from the clay strata indicated field moisture contents close to or exceeding the liquid limit. These conditions are consistent with saturated normally consolidated clay soils.

The one organic content test on the peaty clayey SILT (Unit 4a) recorded a relatively high organic content of 12%.

Atterberg limits testing on two representative samples of the estuarine clays (Unit 4b) and one sample of the organic clay/silt (Unit 4a) suggest that these soils are highly compressible and have shrink-swell potential (based on liquid limits of 57% to 67% in Unit 4b and liquid limits of 95% in Unit 4a soils).

Selected particle size distribution tests confirm the poorly graded nature of the alluvial sands, typically being fine to medium grained (consistent with field logging).

The Emerson Class dispersion testing confirmed a non dispersive nature of the estuarine silts/clays tested (Units 4a and 4b).

Table 3 Results of Laboratory Testing

Borehole Location	Depth (metres from surface)	Material Description	Organic Content (%)	Atterburg Limits				Particle Size Distribution					Emerson Class Number
								% Fines (Clay & Silt)	% Sand			% Gravel	
				FMC	LL	PL	PI		% Fine	% Medium	% Coarse		
BH 1	0.1 - 0.2	Sand	-	-	-	-	-	5	15	78	2	0	-
BH 2	0.2 - 0.3	Sand	-	-	-	-	-	0	18	82	0	0	-
BH 5	0.1 - 0.3	Clayey Silt	12	128	95	76	19	-	-	-	-	-	4
BH 6	0.5 - 0.7	Sand	-	-	-	-	-	2	18	80	0	0	-
BH 7	0.3 - 0.4	Clay with Sand	-	58.7	59	27	32	-	-	-	-	-	4
BH 9	0.2 - 0.4	Clayey Silt	-	64.5	67	37	30	-	-	-	-	-	-

6. Discussion

6.1 General

The site is located in the Quaternary aged alluvial and fluvial deposits associated with the meandering Hunter River, defined by the geology maps as Quaternary Alluvium. As such, the site is expected to be underlain by vertically and laterally discontinuous sedimentary deposits comprising mixtures of sands, silts, clays and gravels.

At the time of the field investigations, shallow groundwater, the presence of drainage channels crossing the site and poor drainage / waterlogging of the surface soils resulted in the majority of the site becoming wet and boggy, with very poor trafficability. The majority of the southern half of the site was inaccessible by a 4WD vehicle at the time of the field work.

At the time of the earlier Stage 2 investigation, it was understood that the site would require substantial filling as most of it lay below the 1:100 year flood level. Preliminary estimates of 1,065,000m^3 of imported fill had been calculated (by others) to raise the surface level of the site to a minimum RL 2.5m AHD, as required by Port Stephens Council. We note that this volume of fill was a preliminary estimate only and did not include any special ground treatments or take into account the effects of consolidation. This estimate also only applies to the original Stage 2 investigation area, and does not incorporate fill requirements for the additional landholdings.

6.2 General Geotechnical and Geological Issues / Constraints

Based on the findings of this preliminary geotechnical assessment and on previous experience in the local area, the potential geotechnical issues/constraints to the proposed land development are expected to include (but are not necessarily limited to):

- Presence of soft ground, low bearing capacity compressible soils and unsuitable founding conditions;
- Magnitudes and rates of expected total and potential differential settlements;
- Fill platform/embankment foundation strength and likely impacts on batters and slope stability;
- High water table and waterlogged soils presenting a foundation hazard;
- Localised instability and/or erosion of dune slopes in the central portion of the site;
- Sources of available fill material to raise site levels above the 1:100 flood level;
- Potential disturbance of acid sulfate soils;
- Potential disturbance of contaminated soil.

The general geotechnical issues or hazards identified above are expected to be more prevalent across the lower lying central and southern portions of the site, typically presenting high (to severe) limitations to development, although the potential also exists for moderate limitations to development across the northern half of the site. The possible consequences of these hazards may also vary depending on the nature of the proposed development.

The soil landscape groups identified by the desktop study present moderate to significant general limitations to development within the study area, as discussed below:

- The 'Bobs Farm' soil landscape group presents generally high limitations for urban / industrial development in the central and southern portions of the site, including flooding, waterlogging and high foundation hazards. Organic clays of high plasticity do not generally provide a suitable foundation material due to the potential for compressibility of the organic matter and the high potential for differential settlement as a result of shrink/swell movements within the soil profile. Within this soil landscape group, estuarine and alluvial soil profiles are expected to be variable in extent, soil type and thickness, and both actual and potential Acid Sulfate Soils are expected at shallow depth. The high limitations to development also extend to earthworks within this unit, which would be affected by high water tables, high plasticity (and potentially reactive and acidic) subsoils.
- The 'Tea Gardens' soil landscape group presents moderate limitations for urban / industrial development in the northern margin of the site, including high foundation hazards in waterlogged swales, strongly to extremely acid soils and high wind erosion hazard. The sandy soils could present difficulties for earthworks operations, particularly in the silty strata.
- The 'Shoal Bay' soil landscape group also presents moderate limitations to urban / industrial development in the central northern portion of the site, similar to those of the Tea Gardens unit.
- The 'Blind Harry's Swamp' soil landscape group (identified as a submerged swamp forest) presents a severe limitation to urban or industrial development on the central western margin of the site. Soils within this area are generally waterlogged, strongly acid, highly organic and possess a low wet bearing strength, resulting in obvious constraints to foundations and earthworks.

The approximate boundary of each soil landscape unit is shown on Figure 3 in Appendix A.

Table 4 presents a summary of the potential geotechnical / geological constraints and associated risks to development within the study area and outlines possible control measures to reduce the identified risks.

Table 4 Summary of Potential Geotechnical / Geological Constraints or Limitations to Development within the Study Area

GEOTECHNICAL ISSUE / HAZARD	POTENTIAL RISK / CONSEQUENCE	POSSIBLE CONTROLS TO REDUCE RISK
Consolidation / differential settlement of loose or compressible soil layers	◗ Settlement issues for flexible structures, loss of serviceability	◗ Use of geotextiles and bridging layers; ◗ Use of preload to induce settlement prior to development.
Building footings on soft ground	◗ Low or variable bearing capacity; ◗ Differential settlement due to the presence of soft estuarine clay and loose sands; ◗ Potential lateral discontinuity of foundation materials and layers.	◗ Preload site using vertical drainage systems (eg, wick drains) if necessary to hasten consolidation; ◗ Reduce bearing pressures or design for higher settlements; ◗ Deepen foundations, selecting appropriate combinations of pile size, length and spacing; ◗ Use of piled raft slab.
Pavement construction on soft ground	◗ Pavement failure due to poor subgrade; ◗ Differential settlement leading to loss of shape.	◗ Raise subgrade level, improve subgrade; ◗ Provide appropriate pavement and subsoil drainage; ◗ Reinforce with geotextiles.
Placement of filling over soft ground to raise the site above the flood level	◗ Potential bearing capacity failures and slope instability at the edges of the fill platform; ◗ Magnitude and rate of total and differential settlements.	◗ Staged construction to allow for strength gain over time; ◗ Use of bridging layers and geotextiles; ◗ Use of light weight fill materials in embankment construction.
Availability of suitable resources required to construct embankments	◗ Expense, and environmental factors may make sourcing of large quantities of fill impractical.	◗ Minimise excavation of unsuitable on-site materials to reduce fill requirements (eg. Use bridging layers and preload rather than stripping excess quantities of soft soils).
Acid Sulfate Soils (ASS)	◗ Possible environmental impacts of disturbance, including damage to aquatic ecosystems; ◗ Aggressivity of the soil and groundwater to buried structural elements.	◗ Reduce excavation quantities; ◗ Treat spoil with lime, as per detailed ASS Management Plan (to be developed); ◗ Use of timber driven piles.

GEOTECHNICAL ISSUE / HAZARD	POTENTIAL RISK / CONSEQUENCE	POSSIBLE CONTROLS TO REDUCE RISK
Erosion	◗ Localised instability of dune slopes; ◗ Potential scouring of channels / environmental degradation.	◗ Regrading of over-steepened scarps; ◗ Protect against erosion by revegetation.
High watertable / poor drainage (Grading of development area may be required to provide drainage for subdivision & minimize flooding)	◗ Dewatering for construction requires the drawdown of the groundwater table which may lead to consolidation and may induce settlement of surrounding structures. ◗ Dewatering will expose / oxidise potential ASS.	◗ Minimise disturbance to natural soils where possible. Detailed hydraulic assessment of the site to be undertaken to determine fill levels and potential impacts of flooding onto adjacent land.
Contamination	◗ Potentially contaminating activities from past land use or nearby land use may impact on proposed development of the land.	◗ Undertake contamination assessment including site history review to identify areas of potential contamination.

It should be noted that at this stage we have only provided general comments on potential consequences of the identified hazards. Detailed geotechnical investigations will be required to determine the nature of the subsurface conditions at greater depth and assess the suitability of the site for the proposed development, including extensive site filling.

For each of the detailed design phases, a geotechnical risk register would need to be developed to determine the likelihood and severity of each hazard, and determine the necessary controls to reduce risks and associated constraints to development.

7. Further Investigation

This assessment of geotechnical conditions should be considered as preliminary only as it is based on very limited subsurface information. It should also be noted that preliminary assessment of the additional landholdings is based only on a desk top review, brief site visit to confirm the results of the desk top study and extrapolation of existing information, and that no subsurface investigations have been undertaken on this portion of the site.

Further specific geotechnical investigations will be required for each of the concept and detailed design phases of the proposed development, including detailed bearing capacity, settlement and stability analyses for proposed earthworks and infrastructure.

It is envisaged that further investigation would include:

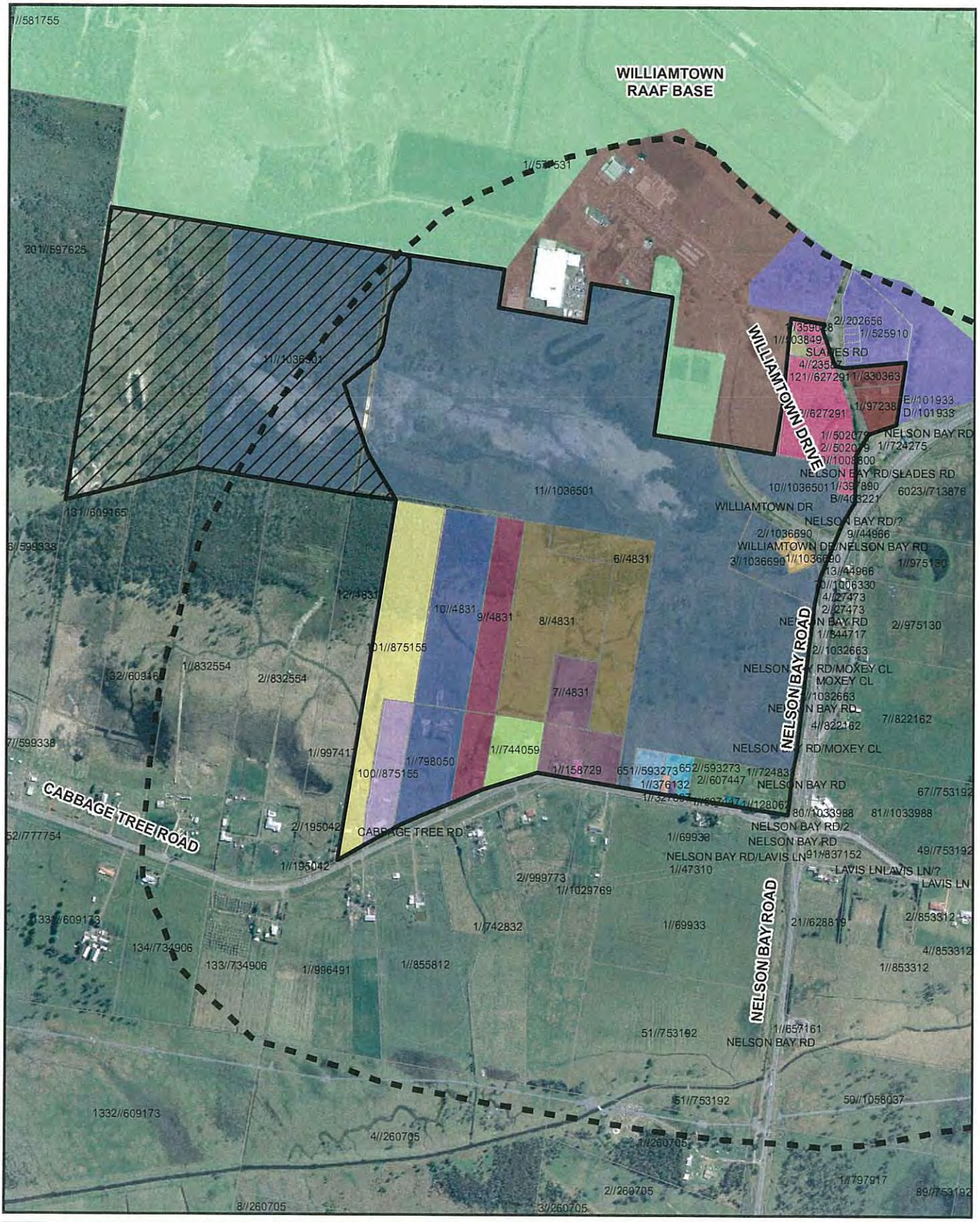
- Additional subsurface investigation including:
  - Piezocone Cone Penetrometer Test (CPT) probes to provide a continuous strength profile of the soil and identify weak zones;
  - Pore pressure dissipation tests to assess consolidation characteristics;
  - Boreholes / testpits to confirm subsurface conditions and obtain samples for laboratory testing at greater target investigation depths;
- Laboratory analysis including consolidation (oedometer) testing and soil index properties.

It should also be noted that this report does not specifically address site contamination. It is recommended that a Phase 1 Environmental Site Assessment, including a site history review, be undertaken to identify the potential for site contamination and associated constraints to land development.

Appendix A

Figures

GHD CLIENTS | PEOPLE | PERFORMANCE



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Metres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

GRID N

LEGEND
- Investigation Area (Stage 2)
- Additional Land for Investigation
- Study Area (Original Stage 1)

Spatial layers courtesy of Port Stephens Council

13 August 2007

Site Locality and Lot Boundaries

I:\2212808\GIS\Maps\Report Figures\Stage 2\Fig1_SiteLocality_130807.mxd

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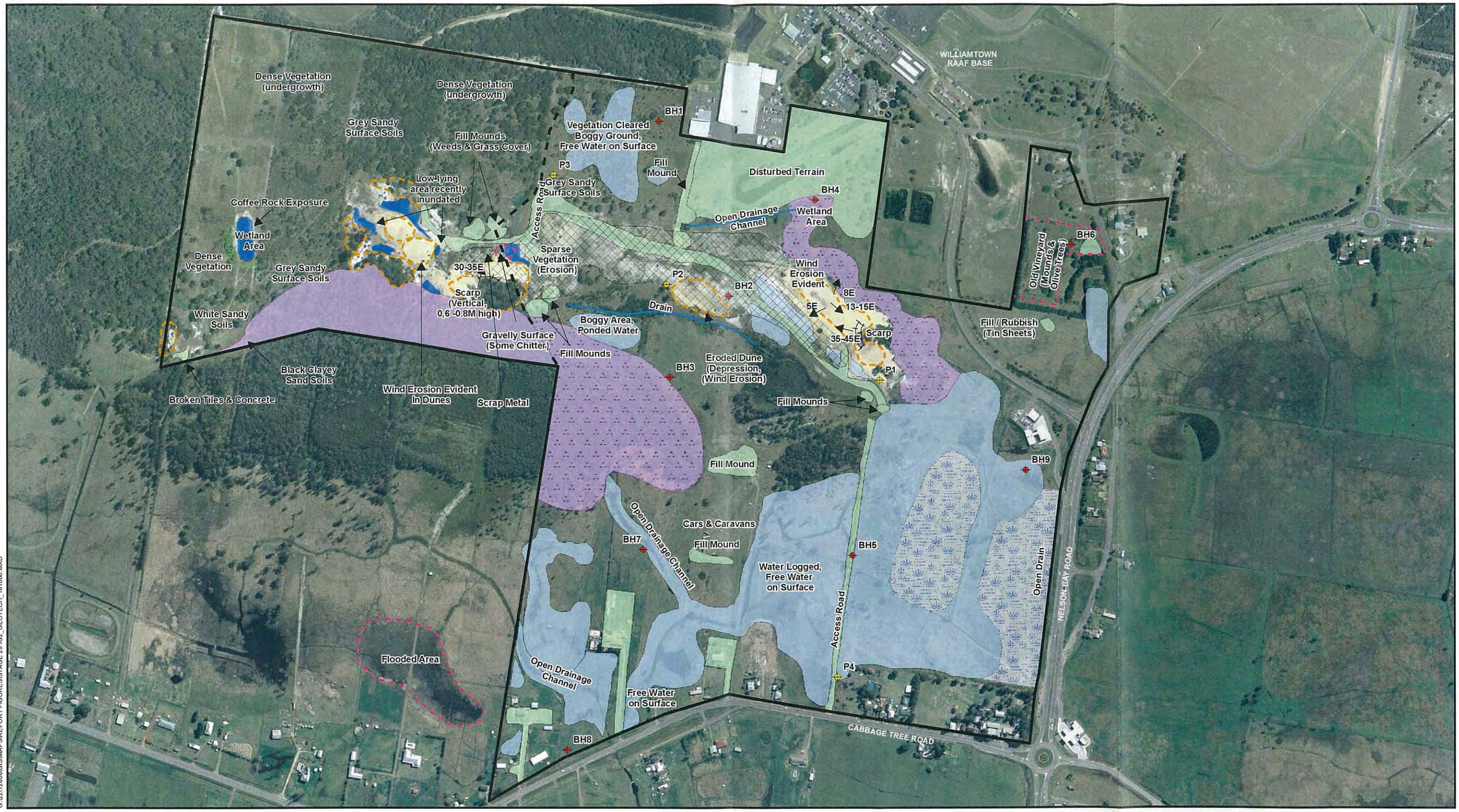

G:\22\12808\GIS\MAPS\REPORT FIGURES\STAGE 2\FIG2_GEOTECH_181006.MXD

1:7,000

0 50 100 200 300

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

GRID N

Legend

- Investigation Area (Including Additional Land)
- Borehole Locations Stage 2 (approximate)
- Soil Profile Locations - Stage 1 (approximate)
- Swampy Areas
- Dunes
- Approximate Extent of Filled Areas
- Boggy Ground / Inundated Area
- Boggy Ground, Tall Reeds
- Submerged Swamp Forest
- Low Lying Swamp Forest
- Approximate Extent of Sand Mined Area
- Dense Vegetation

15 August 2007

Site Mapping & Test Location Plan

GHD CLIENTS | PEOPLE | PERFORMANCE

G:/22/12808/GIS/Maps/Report Figures/Land Use & Development Strategy Part B/Fig3_SoilLandscape_130807.mxd

1:12,000
0 50 100 200 300
Metres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

GRID
N

LEGEND
Investigation Area (Including Additional Land)
Main Road
Road

Soil Landscapes
D, Disturbed Area
Sb, Shoal Bay Soil Landscape
ba, Blind Harry Swamp Soil Landscape
bf, Bobs Farm Soil Landscape
tna, Tea Gardens Variant (a) Soil Landscape

Spatial layers courtesy of Port Stephens Council

13 August 2007

Soil Landscape Groups Within the Study Area

Appendix B

Standard Sheets

GENERAL NOTES

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The report contains the results of a geotechnical investigation conducted for a specific purpose and client. The results should not be used by other parties, or for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where test information is available (field and/or laboratory results). The test hole logs include both factual data and inferred information. Moreover, the location of test holes should be considered approximate, unless noted otherwise (refer report). Reference should also be made to the relevant standard sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc.).

GROUNDWATER

Unless otherwise indicated, the water levels presented on the test hole logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeabilities (i.e. depending on response time of the measuring instrument). Further, variations of this level could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete test hole data, often with only approximate locations (e.g. GPS). Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions do occur in the natural environment, particularly between discrete test hole locations. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural forces.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to this firm for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process - investigation, construction verification, and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels, is required. There may be a requirement to extend foundation depths, to modify a foundation system or to conduct monitoring as a result of this natural variability. Allowance for verification by geotechnical personnel accordingly should be recognised and programmed during construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommended depth of any foundation (piles, caissons, footings etc.) is an engineering estimate. The estimate is influenced, and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions should include at least all of the relevant test hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

Ref: DS5.5.1_NO Issue 0 Date: 26/07/2005

GLOSSARY OF SYMBOLS

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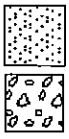
This standard sheet should be read in conjunction with all test hole log sheets and any idealised geological sections prepared for the investigation report.

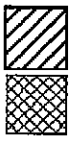
GENERAL

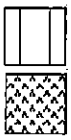
Symbol	Description	Symbol	Description
D	Disturbed Sample	PZ	Piezometer Installation
U	Undisturbed Sampled (suffixed by sample size or tube diameter in mm if applicable)	R	Rising Head Permeability Test
		F	Falling Head Permeability Test
C	Core Sample (suffixed by diameter in mm)	PBT	Plate Bearing Test
SV	Shear Vane Test (suffixed by value in kPa)	⊢	Water Inflow (make)
SPT	Standard Penetration Test (with blows per 0.15m)	⊣	Water Outflow (loss)
N	SPT Value	▽	Temporary Water Level
PK	Packer Test	▼	Final Water Level
PM	Pressuremeter Test	●	Point Load Test (axial)
PP	Pocket Penetrometer (suffixed by value in kPa)	○	Point Load Test (diametric)
IMP	Impression Device Test		
HB	SPT hammer bouncing		

SOIL SYMBOLS

Main Components


SAND


CLAY


SILT

GRAVEL

FILL

TOPSOIL

Minor Components


sandy


clayey


silty


gravelly


vegetation, roots

Note: Natural soils are generally a combination of constituents, e.g.


sandy CLAY

ROCK SYMBOLS

Sedimentary


SANDSTONE


SHALE

Igneous


GRANITE


CLAYSTONE


CONGLOMERATE


IGNEOUS DYKE


SILTSTONE


COAL

Note: Additional rock symbols may be allocated for a particular project.

NATURAL FRACTURES (Coding)

Fracture Type

JT	Joint
BP	Bedding Plane Parting
SM	Seam
FZ	Fragmented Zone
SZ	Shear Zone
VN	Vein

Orientation

For vertical non-oriented core ... "Dip" angle (eg. 5°) measured relative to horizontal
For inclined non-oriented core ... "Angle" measured relative to core axis.
For inclined oriented core ... "Dip" angle and "Dip Direction" angle (eg. 45°/225° mag.)

VT	Vertical
HZ or 0°	Horizontal
d	degrees

Infilling or Coating

CN	Clean
X	Carbonaceous
CLAY	Clay
KT	Chlorite
CA	Calcite
FE	Iron Oxide
MI	Micaceous
QZ	Quartz

Shape

PLN	Planar
CU	Curved
UN	Undulating
ST	Stepped
IR	Irregular

Roughness

POL	Polished
SLK	Slickensided
SO	Smooth
RF	Rough
VR	Very Rough

Others

DIS	Discontinuous
TI	Tight
OP	Open

Ref: DS6.5.1_NO Issue 0 Date: 26/07/2005

SOIL DESCRIPTION

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This procedure involves the description of a soil in terms of its visual and tactile properties, and relates to both laboratory samples and field exposures as applicable. A detailed soil profile description, in association with local geology and experience, will facilitate the initial (and often complete) site assessment for engineering purposes.

The method involves an evaluation of each of the items listed below and is in general agreement with both Australian Standard AS 1726 (the Site Investigation Code) and ASTM D2487 and D2488.

MOISTURE

The moisture condition of the soil is most applicable for cohesive soils as a precursor to the assessment of consistency and workability. The moisture condition is described as:-

Dry (dusty, dry to the touch) ***Slightly Moist*** ***Moist*** (damp, no visible water) ***Very Moist*** or ***Wet*** (visible free water, saturated condition)

In addition, the presence of any seepage or free water is noted on the testhole logs.

COLOUR

Colour is important for correlation of data between testholes and during subsequent excavation operations. The prominent colour is noted, followed by (spotted, mottled, streaked etc.) then secondary colours as applicable. Colour is usually described at as-received moisture condition, though both wet and dry colours may also be appropriate.

CONSISTENCY/RELATIVE DENSITY

This assessment is based on the effort required to penetrate and/or mould the soil, and is an indicator of shear strength.

Granular soils are generally described in terms of density index as listed in AS 1726. These soils are inherently difficult to assess and normally a penetration test procedure (SPT, DCP or CPT) is used in conjunction with published correlations. Alternatively, in-situ density tests can be conducted in association with minimum and maximum densities performed in the laboratory.

Cohesive soils can be assessed by direct measurement (shear vane), or estimated approximately by tactile means and/or the aid of a geological pick as given on the following table. It is emphasised that a "design shear strength" must take cognisance of the in-situ moisture content and the possible variations of moisture with time.

Term	Tactile Properties	Unconfined Compressive Strength q_u (kPa)
Very Soft	Extrudes from fingers when squeezed	<25
Soft	Easily penetrated by thumb about 30-40 mm. Pick head can be pushed in up to shaft. Moulded by light finger pressure.	25-50
Firm	Penetrated by thumb 20-30 mm with moderate effort. Sharp end of pick pushed in 30-40 mm. Moulded by strong finger pressure.	50-100
Stiff	Indented by thumb about 5 mm with moderate effort. Pick pushed in up to 10 mm. Cannot be moulded in fingers.	100-200
Very Stiff	Readily indented by thumb nail. Slight indentation produced by pushing pick into soil.	200-400
Hard	Difficult to indent with thumb nail. Requires power tools for excavation.	>400

STRUCTURE/OTHER FEATURES

The soil structure is generally applicable to cohesive soils and refers to the presence or absence of joints and layering. Typical terms use are intact (no joints), fissured (closed joints), shattered (open joints), slickensided (polished joints indicative of movement), and stratified/laminated. In addition, the presence of other features (ferricrete nodules, timber inclusions) should also be noted as applicable.

For granular soils, an assessment of grading (well, uniform or poor), particle size (fine, medium etc.) and angularity and shape may also be given.

SOIL TYPE

The soil is described in terms of its estimated grain size composition and the tactile behaviour (plasticity of any fines (less than *0.06 mm)). This system does not differentiate on grading below 0.06 mm, in accordance with the Unified Soil Classification (USC) procedure.

Furthermore, as most natural soils frequently are combinations of various constituents, the primary soil is described and modified by minor components. In brief, the system is as follows:-

Coarse Grained Soils		Fine Grained Soils	
% Fines	Modifier	% Coarse	Modifier
5	omit, or use "trace"	15	omit, or use "trace"
5-12	describe as "with clay/silt" as applicable	15-30	described as "with sand/gravel" as applicable
>12	prefix soil as "silty/clayey" as applicable	>30	prefix soil as "sandy/gravelly" as applicable

(* The 200# sieve (0.075 mm) is commonly used in practice to differentiate between fine and coarse grained soils).
Note: For soils containing both sand and gravel the minor coarse fraction is omitted if less than 15%, or described as "with sand/gravel" as applicable when greater than 15%.

The appropriate USC symbol may also be given after the soil type description in accordance with ASTM D2487 and D2488.

ORIGIN

An attempt is made, where possible, to assess origin (transported, residual, pedogenic, or fill etc.) since this assists in the judgement of probable engineering behaviour. This assessment is generally restricted to field logging activities. An interpretation of landform is a useful guide to the origin of transported soils (e.g. colluvium, talus, slide debris, slope wash, alluvium, lacustrine, estuarine, aeolian and littoral deposits) while local geology and remnant fabric will assist identification of residual soils.

Ref: DS6.5.1.1_NO Issue 0 Date: 26/07/2005

DYNAMIC CONE PENETROMETER (DCP) TESTING

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SCOPE

The Dynamic Cone Penetrometer (DCP) test comprises the measurement of the soil resistance to a steel rod driven into the ground by a dropped weight.

The DCP test is a simple manual test used in both sandy and clayey soils. The test is a measure of the shear strength of the soil at relatively shallow depth.

EQUIPMENT AND METHOD

A general description of the dynamic penetrometer apparatus used by LongMac is presented in Australian Standard AS 1289.6.3.2. The equipment utilises a 9kg sliding weight with a drop height of 510mm. It is fitted with a conical tip. The equipment can be adjusted for a fall of 600mm and use of a blunt tip in accordance with AS 1289.6.3.3.

The test data are generally recorded as the number of blows (n) per 50mm of penetration. The test data are processed by our in-house computer software. For specific applications (such as pavement investigations), the data may be collected in the reverse form, i.e. as mm per blow. The results are presented either in tabular or graphic form for reporting purposes.

INTERPRETATION

The interpretation of the DCP results is generally based on the assumption that the measured resistance is a function of soil strength. A profile of soil strength (cohesive soils) or density index (cohesionless soils) can thus be established. The test often can be used to qualitatively indicate the presence of soft or loose zones within a soil profile.

The energy of the system per unit area is similar to that of an SPT approach. Thus, the common relationships of SPT and other parameters (say Dutch cone) can be utilised as a means of estimating soil properties, after appropriate site specific correlation. The interpretations from the test are approximate only, and this is particularly pertinent to sand profiles where the magnitude of confinement stress is important in the assessment of the results.

Interpretation of the DCP penetration rate at depth (up to 5m) must be conducted with due regard to side friction effects. In particular, care must be exercised with soft clay profiles where shaft resistance may have a significant unconservative impact upon the results.

In-situ California Bearing Ratio (CBR) values of clay soil subgrades are sometimes interpreted directly from DCP test results for use in road pavement design. In this case, the correlation between DCP and CBR based on that published in AUSTROADS Pavement Design Manual (1992) may be applied. This correlation should be verified by site specific laboratory testing, where appropriate. In addition, the effects of moisture content variations (in-situ verses design conditions) must be considered, as clearly the DCP test only reflects the shear strength of the soil at the time of testing.

Ref: DS5.4.3_NO Issue 0 Date: 26/07/2005

LABORATORY TESTING

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GENERAL

Samples extracted during the fieldwork stage of a site investigation may be "disturbed" or "undisturbed" (as generally indicated on the trial hole logs) depending upon the nature and purpose of the sample as well as the method of extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results, which must of necessity reflect the effects of such disturbance.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory test results provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and project in hand.

TESTING

Laboratory testing is normally carried out in accordance with Australian Standard AS 1289 as amended, or RTA Standards when specified. The routine Australian Standard tests are as follows:-

Moisture Content	Test 2.1.1	
Liquid Limit	Test 3.1.1	)
Plastic Limit	Test 3.2.1	) collectively known as Atterberg Limits
Plasticity Index	Test 3.3.1	)
Linear Shrinkage	Test 3.4.1	
Particle Density	Test 3.5.1	
Particle Size Distribution	Tests 3.6.1, 3.6.2 and 3.6.3	
Emerson Class Number	Test 3.8.1	)
Percent Dispersion	Test 3.8.2	) collectively, Dispersive Classification
Pinhole Dispersion Classification	Test 3.8.3	)
Organic Matter	Test 4.1.1	
Sulphate Content	Test 4.2.1	
pH Value	Test 4.3.1	
Resistivity	Test 4.4.1	
Standard Compaction	Test 5.1.1	
Modified Compaction	Test 5.2.1	
Dry Density Ratio	Test 5.4.1	
Minimum Density	Test 5.5.1	
Density Index	Test 5.6.1	
California Bearing Ratio	Tests 6.1.1 and 6.1.2	
Shear Box	Test 6.2.2	
Undrained Triaxial Shear	Test 6.4.1	
One Dimensional Consolidation	Test 6.6.1	
Constant Head Permeability	Akroyd	

Where tests are used which are not covered by appropriate standard procedures, details are given in the report.

LABORATORY

Our laboratory is a Registered Laboratory in the terms of registration with the National Association of Testing Authorities (NATA) for the listed tests.

The oedometer, triaxial and shear box equipment are fully automated for continuous operation using computer controlled data acquisition, processing and plotting systems.

Appendix C

Borehole Logs

BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING			**HOLE No. BH1**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY				
Location :	WILLIAMTOWN			SHEET 1 OF 1	
Position :	Refer to Figure 2.0		**Surface RL:** G.L	**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger	**Mounting :** 50mm	**Contractor :** -	**Driller :** C.Roach	**Checked :** DMR
Date Started : 22/9/06			**Date Completed :** 22/9/06	**Logged by :** CR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0		SP-SM	Moist, grey / black, loose to medium dense, medium grained, SAND, with trace silt (alluvium).	
			D				0.4m, becoming very moist.	
			D				0.5m, becoming light grey, medium dense.	
			D	0.80		SP	Wet, dark brown, medium dense, fine to medium grained, SAND, with silt and trace clay (alluvium).	
				1.00			End of borehole at 1.0 metre. Terminated due to hole collapsing, unable to obtain sample.	
				1				
				2				

See standard sheets for details of abbreviations & basis of descriptions

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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. 22-12808-01

BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING	**HOLE No. BH2**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY		
Location :	WILLIAMTOWN	**SHEET** 1 **OF** 1	
Position :	Refer to Figure 2.0 **Surface RL:** G.L	**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger **Mounting :** 50mm **Contractor :** -	**Driller :** C.Roach	**Checked :** DMR
Date Started : 22/9/06	**Date Completed :** 22/9/06	**Logged by :** CR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0		SP	Dry, light grey / yellow, loose, medium grained, SAND (aeolian).	
							0.2m, becoming slightly moist.	
							0.4m, becoming grey (as above), loose to medium dense.	
			D	0.70		SP	Moist, dark grey, loose to medium dense, medium grained, SAND, with trace silt (alluvium).	
			D	1.00		SP	Wet, black, medium dense, medium grained, SAND, with clay (alluvium).	
			D					
				1.65			1.60m, as above, but brown.	
							End of borehole at 1.65 metres. Terminated due to hole collapsing, unable to obtain sample.	

0
1
2

See standard sheets for details of abbreviations & basis of descriptions

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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. 22-12808-01

BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING	**HOLE No. BH3**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY		
Location :	WILLIAMTOWN	SHEET 1 OF 1	
Position :	Refer to Figure 2.0 **Surface RL:** G.L	**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger **Mounting :** 50mm **Contractor :** -	**Driller :** C.Roach	**Checked :** DMR
Date Started :	22/9/06 **Date Completed :** 22/9/06	**Logged by :** DMR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0		SM	Slightly moist, dark grey / brown to black, loose, silty SAND, with trace of clay and some root fibres throughout (alluvium).	
							0.2m, becoming moist.	
							0.4m, becoming very moist, loose to medium dense.	
			D					
			D	0.60		SP	Wet, dark grey, loose to medium dense, medium grained, SAND, with some clay and trace silt (alluvium).	
			D					
			D	1.05		SP	Wet, grey / brown, medium dense, medium grained, SAND (alluvium).	
			D	1.15			End of borehole at 1.15 metres.	
							Terminated due to hole collapsing below water table, unable to obtain sample.	

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BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING	**HOLE No. BH4**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY		
Location :	WILLIAMTOWN	SHEET 1 OF 1	
Position :	Refer to Figure 2.0 — **Surface RL:** G.L — **Angle from Horiz. :** 90°		**Processed :** VN
Rig Type :	Hand Auger — **Mounting :** 50mm — **Contractor :** - — **Driller :** C.Roach		**Checked :** DMR
Date Started : 22/9/06 — **Date Completed :** 22/9/06 — **Logged by :** DMR/CR			**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0.10			Vegetation, decomposing grass and root fibres ~100mm.	Strong organic odour.
			D			CH	Wet, black, very soft to soft, organic, peaty CLAY, with silt and fine grained sand, root fibres throughout (estuarine).	
			D				0.4m, becoming grey, soft, increased sand content, less root fibres.	
			D	0.70		SP	Wet, pale brown / grey, medium dense, fine to medium grained, SAND, with trace silt. Some root fibres throughout (alluvium).	
			D					
			D					
			D	1.50			End of borehole at 1.50 metres. Terminated due to hole collapsing, unable to obtain sample.	

0 — 1 — 2

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BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING	**HOLE No. BH5**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY		
Location :	WILLIAMTOWN	SHEET 1 OF 1	
Position :	Refer to Figure 2.0 **Surface RL:** G.L	**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger **Mounting :** 50mm **Contractor :** -	**Driller :** C.Roach	**Checked :** DMR
Date Started : 22/9/06	**Date Completed :** 22/9/06	**Logged by :** DMR/CR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand augor	Nil	▽	D	0		OH	Very moist, black soft, high plasticity, organic clayey SILT, trace fine sand, root fibres throughout MC>>LL (estuarine).	100mm vegetation, decomposing grasses / root fibres (peat).
			D	0.35		CH	Very moist, grey mottled orange / yellow, soft to firm, high plasticity, CLAY, with some root fibres (estuarine).	Strong organic odour.
			D	1			0.55m, becoming grey, sandy.	
			D	1.00		SP	Wet, brown mottled orange, medium dense, medium grained, SAND, with clay (alluvium).	
				1.10		SP	Wet, grey, medium dense, medium grained, SAND, with some clay (alluvium).	
				1.80			End of borehole at 1.8 metres. terminated due to hole collapsing below water table, unable to obtain sample below 1.2m.	
				2				

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BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING			**HOLE No. BH6**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY				
Location :	WILLIAMTOWN			SHEET 1 OF 1	
Position :	Refer to Figure 2.0	**Surface RL:** G.L		**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger **Mounting :** 50mm	**Contractor :** -		**Driller :** C.Roach	**Checked :** DMR
Date Started : 28/9/06		**Date Completed :** 28/9/06		**Logged by :** CR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0		SP	Slightly moist, dark brown, loose to medium dense, fine to medium grained, SAND, with silt, trace root fibres (aeolian).	
			D	0.35		SP	Slightly moist to moist, light grey, loose to medium dense, medium grained, SAND (aeolian).	
			D				0.7m, as above, but becoming very moist.	
			D				0.8m, as above, but wet.	
			D	1.00		SP	Wet, dark brown, medium dense to dense, medium grained, SAND, with some silt (alluvium).	
				1.55			End of borehole at 1.55 metres. Terminated due to hole collapse, unable to obtain sample.	

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BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING			**HOLE No. BH7**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY				
Location :	WILLIAMTOWN			SHEET 1 OF 1	
Position :	Refer to Figure 2.0	**Surface RL:** G.L		**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger	**Mounting :** 50mm	**Contractor :** -	**Driller :** C.Roach	**Checked :** DMK
Date Started :	28/9/06	**Date Completed :** 28/9/06		**Logged by :** CR	**Date :** 9/11/06

DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	BOREHOLE DESCRIPTION — DESCRIPTION (Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength)	REMARKS
Hand augor	Nil	▽	D	0				
			D			CH	Moist, dark brown / black, very soft to soft, high plasticity, CLAY, with silt. Root fibres throughout (estuarine / alluvium).	
				0.20				
			D			CH	Moist to wet, grey, mottled orange and brown, soft, high plasticity, CLAY, with some silt (alluvium).	
				0.30			0.3m, some root fibres.	
			D			CH	Wet, grey mottled orange / brown, soft, high plasticity, CLAY, with some silt and fine grained sand, root fibres present, MC>>PL (alluvium).	
				0.70				
						SC	Wet, grey, loose, medium grained, clayey SAND, trace root fibres (alluvium)	
			D	1				
				1.50		SP-SC	Wet, grey, loose, medium grained, SAND, with clay (alluvium).	
			D					
			D	2				
				2.30			End of borehole at 2.30 metres. Terminated due to hole collapsing.	

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BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING			**HOLE No. BH8**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY				
Location :	WILLIAMTOWN			SHEET 1 OF 1	
Position :	Refer to Figure 2.0	**Surface RL:** G.L		**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger	**Mounting :** 50mm	**Contractor :** -	**Driller :** C.Roach	**Checked :** DMR
Date Started : 28/9/06		**Date Completed :** 28/9/06		**Logged by :** DMR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0		SP	Moist, grey, loose, fine to medium grained, SAND, with root fibres throughout (alluvium).	
			D	0.25		SP	Wet, pale grey, very loose to loose, medium grained, SAND, with some root fibres (alluvium).	
			D				0.5m, becoming very loose.	
			D				0.8m, sand becoming grey with brown mottling, very loose.	0.8m, DCP rods sank under weight of hammer.
			D	1.20		GM	Very moist to wet, grey, very loose, medium grained, sandy GRAVEL (alluvium).	
			D	1.30		CH	Very moist, dark grey, very soft, high plasticity, CLAY, with some medium grained sand (alluvium).	
			D				1.85m, clay becoming very soft to soft.	
			D	2.10			End of borehole at 2.10 metres. Terminated due to hole collapsing.	

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Job No. 22-12808-01

BOREHOLE LOG SHEET

BOREHOLE 2212808 01.GPJ GHD.GDT 9/11/06

Client :	DEPARTMENT OF PLANNING			**HOLE No. BH9**	
Project :	EMPLOYMENT ZONE LAND USE DEVELOPMENT STRATEGY				
Location :	WILLIAMTOWN			SHEET 1 OF 1	
Position :	Refer to Figure 2.0	**Surface RL:** G.L		**Angle from Horiz. :** 90°	**Processed :** VN
Rig Type :	Hand Auger	**Mounting :** 50mm	**Contractor :** -	**Driller :** C.Roach	**Checked :** DMR
Date Started : 28/9/06		**Date Completed :** 28/9/06		**Logged by :** DMR	**Date :** 9/11/06

DRILLING					BOREHOLE DESCRIPTION			
DRILLING METHOD	HOLE SUPPORT	WATER	SAMPLES & TESTS	DEPTH metres	GRAPHIC LOG	USC SYMBOL	DESCRIPTION Moisture, colour, consistency, structure, SOIL TYPE (origin) and ROCK TYPE, colour, grain size, structure, weathering, strength	REMARKS
Hand auger	Nil	▽	D	0		OH	Moist, dark brown / black, soft, high plasticity, clayey SILT, with silt, root fibres throughout (estuarine).	
			D					
				0.20		OH	Moist to wet, grey mottled orange / brown, soft, high plasticity, (MC>>PL), clayey SILT , root fibres throughout (alluvium). Sand content increasing with depth.	
			D					
			D					
				0.50		SP	Wet, grey mottled yellow, loose to medium dense, medium grained, SAND, with trace of clay (alluvium).	
			D	1				
			D					
				1.85			End of borehole at 1.85 metres Terminated due to hole collapse below water table.	
				2				

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CONSULTING GEOTECHNICAL ENGINEERS AND GEOLOGISTS

Job No. 22-12808-01

Appendix D

Laboratory Test Results

Soil Index Properties - Report

Report No. : 15794

Client: Department of Planning

Job Number: 221280801

Project: Employment Zone Land Use Stategy

Location: Williamtown, NSW

TEST METHODS :					
	Moisture Content	-	☒ AS1289.2.1.1	☐ RTA T120
	Liquid Limit (Four Point)	-	☒ AS1289.3.1.1	☐ RTA T102
	Liquid Limit (One Point)	-	☐ AS1289.3.1.2	☐ RTA T108
	Plastic Limit	-	☒ AS1289.3.2.1	☐ RTA T109
	Plasticity Index	-	☒ AS1289.3.3.1	☐ RTA T103
	Linear Shrinkage	-	☐ AS1289.3.4.1	☐ RTA T113

Sample History : Sampled by GHD Pty Ltd

Laboratory Sample No.	Client Sample ID	Test Hole	Depth (m)	Description	NBD/ NDD (t/m³)	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)
4211/03	n/a	BH5	0.1 to 0.3	Dark grey/black organic SILT	nt	128.0	95	76	19	nt
4211/05	n/a	BH7	0.3 to 0.4	Grey CLAY with sand	nt	58.7	59	27	32	nt
4211/06	n/a	BH9	0.2 to 0.4	Grey/dark grey SILT	nt	64.5	67	37	30	nt

Abbreviations :

LL	Liquid Limit	NDD	Natural Dry Density
PL	Plastic Limit	NBD	Natural Bulk Density
PI	Plasticity Index		
LS	Linear Shrinkage		
FMC	Field Moisture Content		
n/a	not applicable		
nt	not tested		
n/av	not available		

Note :

Sample History ☐ Natural — Liquid Limit ☐ Air Dried ☒ Oven Dried

Preparation Method ☐ Wet — Liquid Limit ☒ Dry

Type of Test ☒ Four Point — Liquid Limit ☐ One Point

Type of Test ☐ 125mm — Linear Shrinkage - Mould Size ☐ 150mm ☐ 250mm

Tested by:	GV
Date tested:	9/10/06
Checked by:	
Authorised Signatory :	D Brooke
Date:	12/10/06

GHD GEOTECHNICS
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Tel: (02) 9462 4700 Fax: (02) 9462 4710
GEOTECHNICAL TESTING SERVICES

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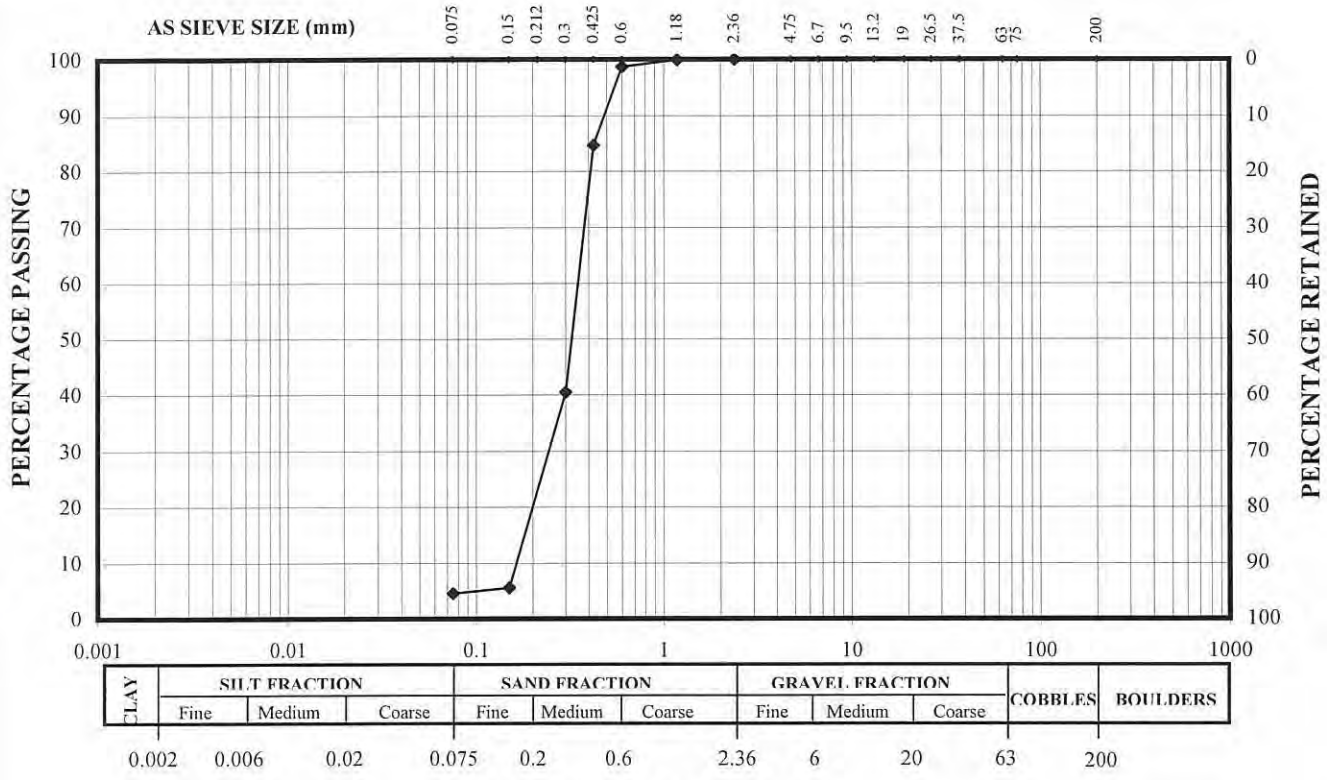
Laboratory Acreditation Number : 679

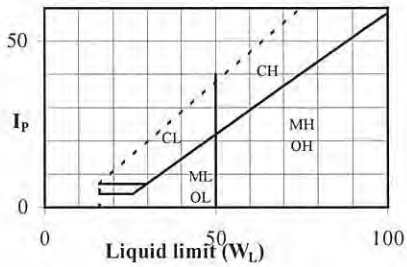
SOIL CLASSIFICATION REPORT

Trial Hole:	BH 1
Depth:	0.1 - 0.2
Sample No:	4211/01

Client: Department of Planning
Project: Employment Zone Land Use Strategy
Location: Williamtown, NSW

Client Sample No.: n/a
Sample History: Sampled by GHD Geotechnics





TEST METHODS
Classification AS1726 A2 Particle size AS1289.3.6.1

OTHER TESTS

GRADING
$C_u = D_{60} / D_{10} =$ 2.1
$C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ 1.1

PARTICLE DENSITY 2.65 (assumed)

PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve without dispersing agent

GROUP SYMBOL: SP

SOIL NAME: Poorly graded SAND

REMARKS:

INDEX PROPERTIES (%)
Liquid Limit = N/A Plastic Limit = N/A
Plasticity Index = N/A Linear Shrinkage % = Not determined

Atterberg Limits (History/preparation)

Liquid Limit (type of test)

Linear Shrinkage (mould size)

Tested by:	GV
Date tested:	5.10.06
Checked by:	
Date checked:	12.10.06

Approved Signatory:
Abrooke
12/10/06

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JOB No.	**221280801**
REPORT No.	**15779**

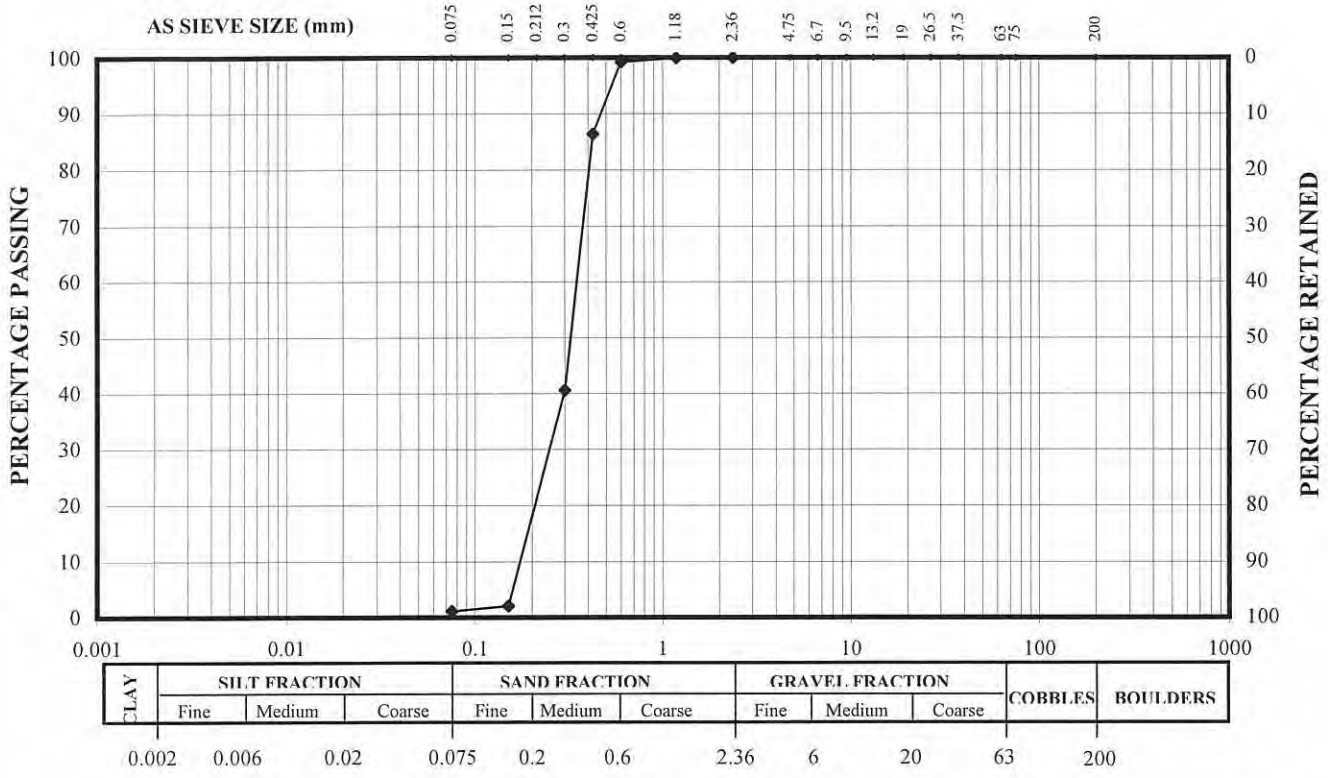
Ref: F:\SWUTIL\LAB\SST\ART\SIEVE

SOIL CLASSIFICATION REPORT

Trial Hole:	BH 2
Depth:	0.2 - 0.3
Sample No:	4211/02

Client: Department of Planning
Project: Employment Zone Land Use Strategy
Location: Williamtown, NSW

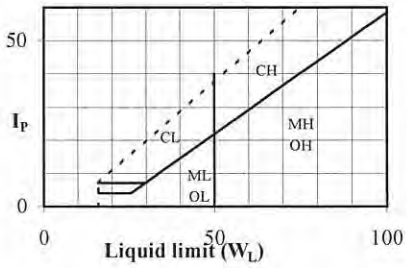
Client Sample No.: n/a
Sample History: Sampled by GHD Geotechnics



TEST METHODS
Classification AS1726 A2 Particle size AS1289.3.6.1

OTHER TESTS

GRADING
$C_u = D_{60} / D_{10} =$ 2.0
$C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ 1.0



PARTICLE DENSITY 2.65 (assumed)

PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve without dispersing agent

GROUP SYMBOL: SP

SOIL NAME: Poorly graded SAND

REMARKS:

INDEX PROPERTIES (%)
Liquid Limit = N/A Plastic Limit = N/A
Plasticity Index = N/A Linear Shrinkage % = Not determined

Atterberg Limits (History/preparation)

Liquid Limit (type of test)

Linear Shrinkage (mould size)

Tested by: GV
Date tested: 5.10.06
Checked by: [signature]
Date checked: 12.10.06

Approved Signatory: [signature] DBrooke 12/10/06

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Laboratory Accreditation Number: 679

JOB No.	**221280801**
REPORT No.	**15780**

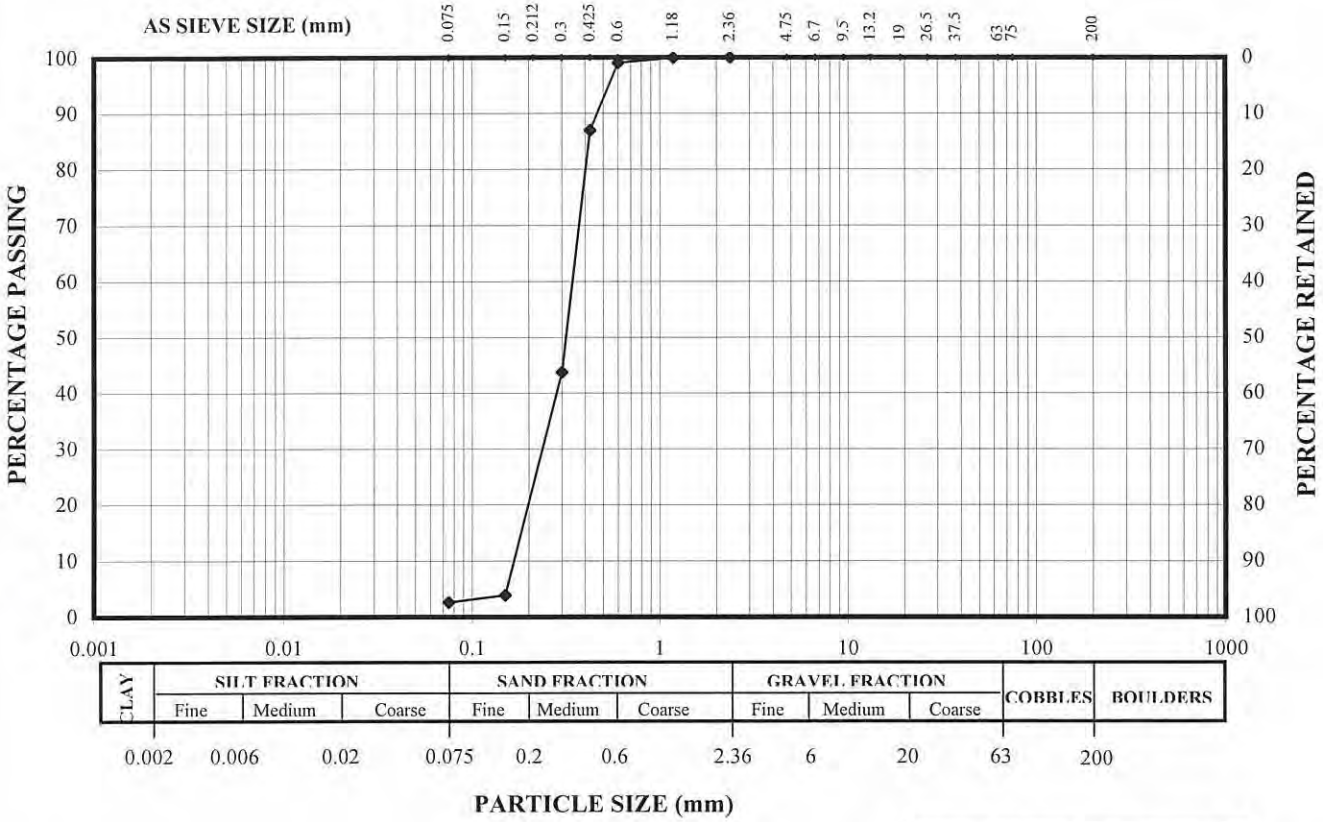
Ref: F:\SW\TIL\LAB\SSTART\SIEVE

SOIL CLASSIFICATION REPORT

Trial Hole:	BH 6
Depth:	0.5 - 0.7
Sample No:	4211/04

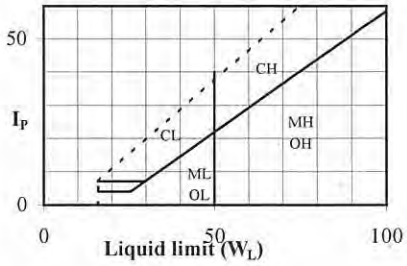
Client: Department of Planning
Project: Employment Zone Land Use Strategy
Location: Williamtown, NSW

Client Sample No.: n/a
Sample History: Sampled by GHD Geotechnics



TEST METHODS
Classification AS1726 A2 Particle size AS1289.3.6.1

OTHER TESTS



GRADING
$C_u = D_{60} / D_{10} =$ 2.0
$C_c = D_{30}^2 / (D_{10} \times D_{60}) =$ 1.0

PARTICLE DENSITY 2.65 (assumed)

PRE-TREATMENT HYDROMETER N/A

TEST CONDITION Washed sieve without dispersing agent

GROUP SYMBOL: SP

SOIL NAME: Poorly graded SAND

REMARKS:

INDEX PROPERTIES (%)
Liquid Limit = N/A Plastic Limit = N/A
Plasticity Index = N/A Linear Shrinkage % = Not determined

Atterberg Limits (History/preparation)

Liquid Limit (type of test)

Linear Shrinkage (mould size)

Tested by:	GV
Date tested:	5.10.06
Checked by:	
Date checked:	12.10.06

Approved Signatory: Brooke 12/10/06

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GEOTECHNICAL TESTING SERVICES

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Laboratory Accreditation Number: 679

JOB No.	221280801
REPORT No.	15781

Ref: F:\SWUTIL\LAB\SSTART\SIEVE

Emerson Class Number - Report

Report No. : 15793

Client :	Department of Planning
Project :	Employment Zone Land Use Strategy
Location :	Williamtown, NSW
TEST METHOD :	AS1289.3.8.1

Job No.:	221280801
Sample No.:	n/a
Test Hole No.:	n/a
Depth (m) :	n/a
Client Sample ID :	n/a

Sample History : Sampled by GHD
Date Sampled : n/a
Type of Water : Distilled
Water Temperature °C : 20

TEST RESULTS

Sample No	Client Sample ID	Depth (m)	Sample Description	Emerson Class Number
4211/03	BH5	0.1 to 0.3	Dark grey/black organic SILT	4
4211/05	BH7	0.3 to 0.4	Grey CLAY with sand	4

Notes :

Tested by:	GV
Date tested:	4/10/06
Checked by:	
Authorised Signatory :	DBrooke
Date:	12/10/06

GHD GEOTECHNICS
57 Herbert St, Artarmon NSW, 2064
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GEOTECHNICAL TESTING SERVICES

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Laboratory Acreditation Number : 679

WATERTEST

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A.C.N. 098 982 140
A.B.N. 76 098 982 140
NATA No: 1884

ANALYTICAL REPORT for:

GHD LONGMAC PTY LTD

LOCKED BAG 2727
ST LEONARDS NSW 1590

ATTN: DAVID BROOKE

JOB NO: WR1345

CLIENT ORDER: 211280801

DATE RECEIVED: 04/10/06

DATE COMPLETED: 31/10/06

TYPE OF SAMPLES: SOIL

NO OF SAMPLES: 1

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.....
Issued on 31/10/06
Sue Wyman
(Laboratory Supervisor)

ANALYTICAL REPORT

JOB NO: WR1345
CLIENT ORDER: 211280801

	SAMPLES	O.M. %
1	4211/03	12.0
	MDL	0.1
	Method Code	8.10
	Preparation	P5

ANALYTICAL REPORT

JOB NO: WR1345
CLIENT ORDER: 211280801

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P5	Sample dried, split and crushed to -150um
8.10	Organic Matter Content - AS 1289.4.1.1

A preliminary report was faxed on 31/10/06

Appendix E

Insitu DCP Field Test Sheets

DYNAMIC CONE PENETROMETER LOG SHEET

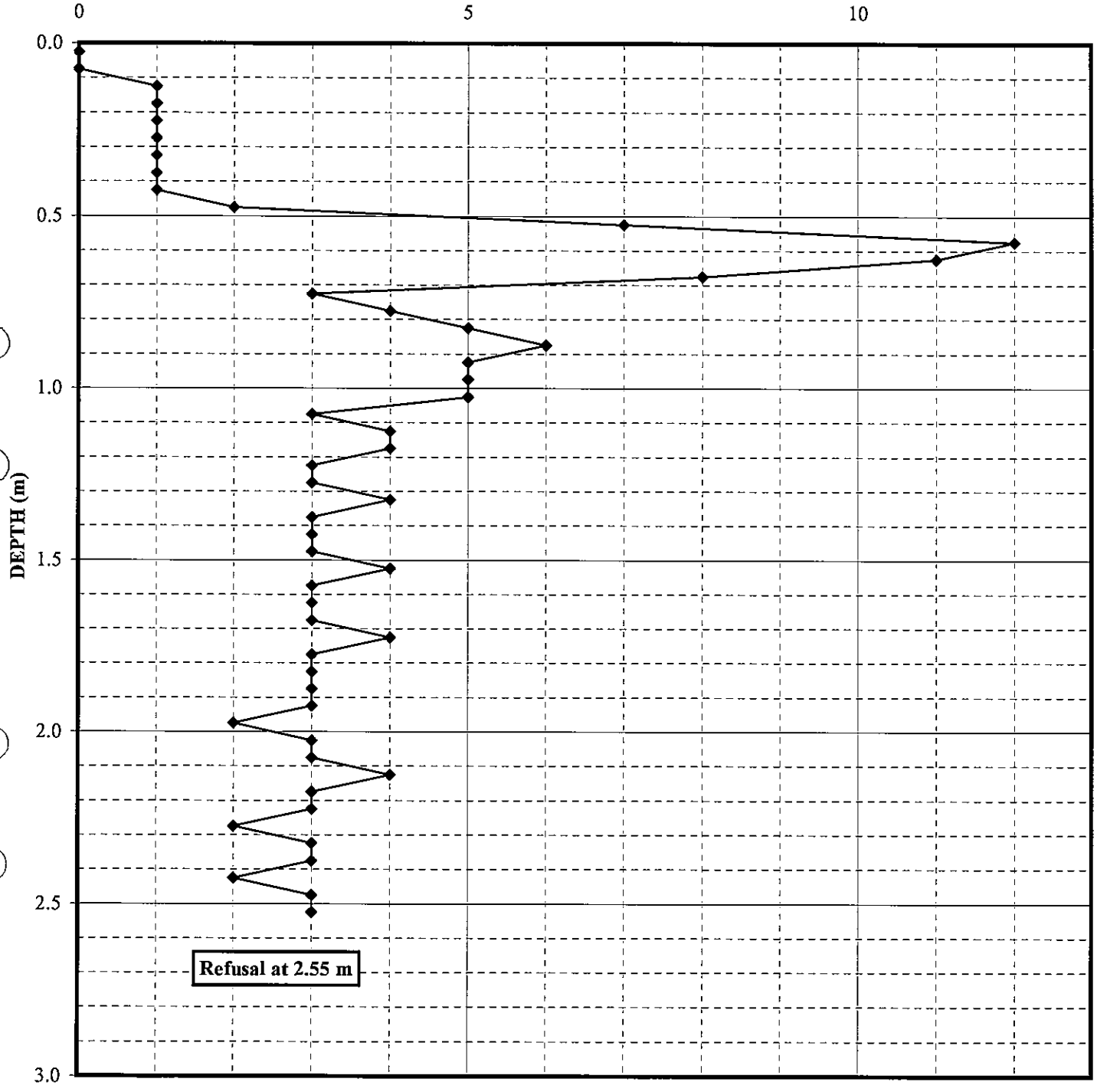
Client: Department of Planning
Project: Williamtown Land Use Study
Location: Williamtown

PROBE No. DCP1

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:		**Chainage:**	**Date:** 22/9/06
Elevation:	GL	**Offset:**	**Operator:** C Roach

NUMBER OF BLOWS TO PENETRATE 50 mm



Comments:

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Job No. 221280801

File: DCP1.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP1.xls

DYNAMIC CONE PENETROMETER LOG SHEET

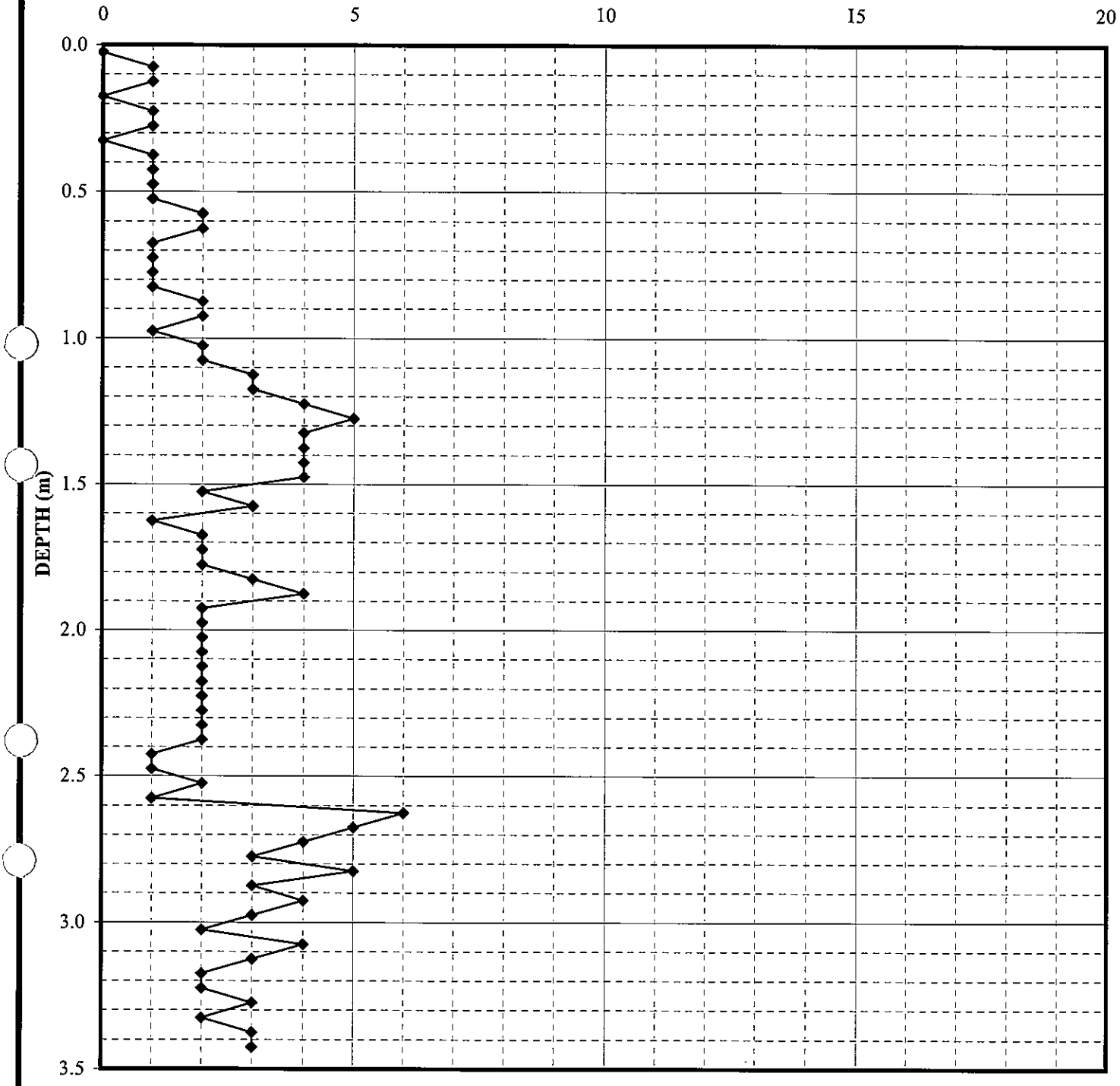
Client: Department of Planning
Project: Williamtown Land Use Study
Location: Williamtown

PROBE No. DCP2

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:	**Chainage:**	**Date:**	22/9/06
Elevation: GL	**Offset:**	**Operator:**	C Roach

NUMBER OF BLOWS TO PENETRATE 50 mm



Comments: Refusal at 3.45 m

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Job No. 221280801

File: DCP2.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP2.xls

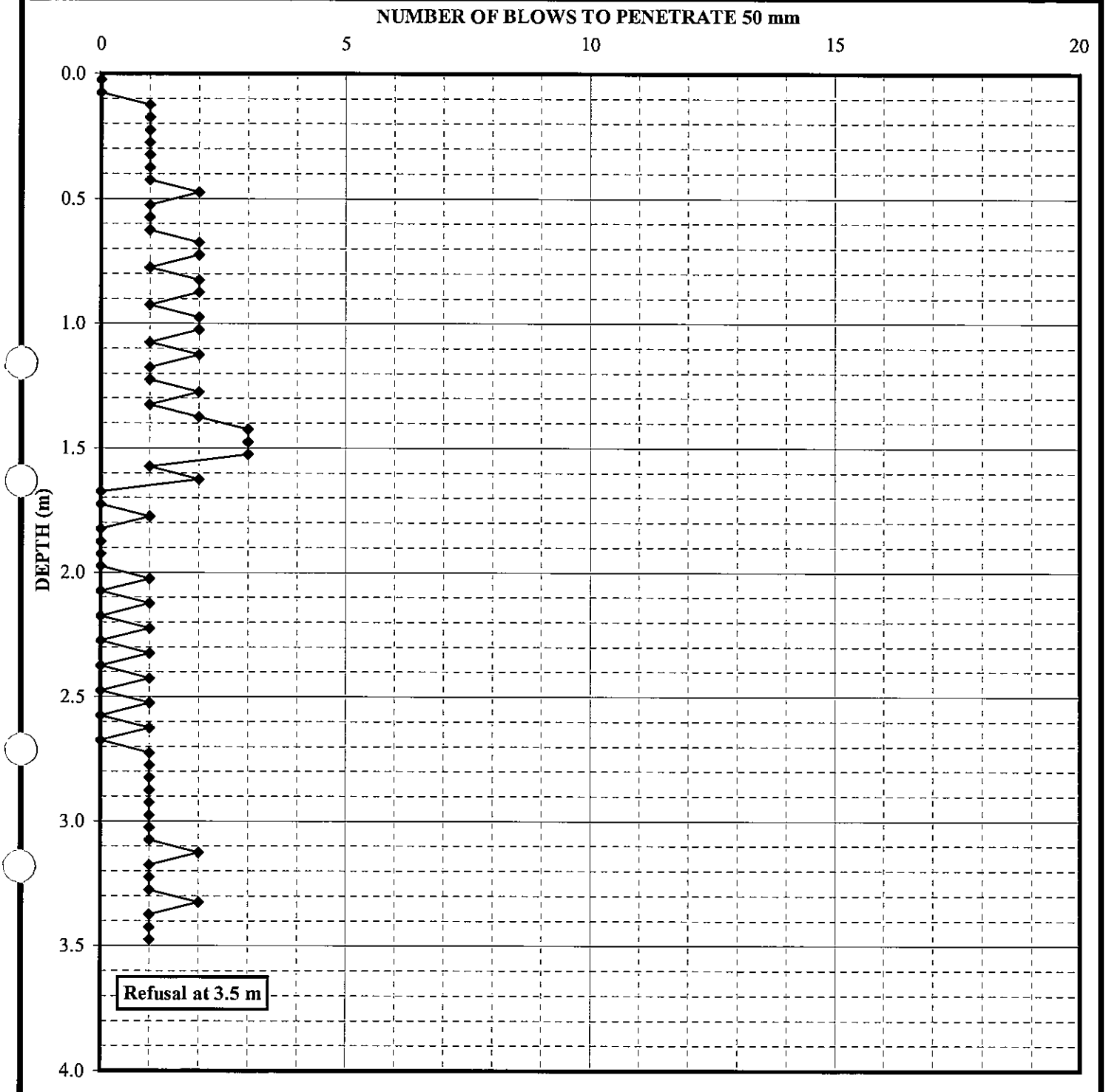
DYNAMIC CONE PENETROMETER LOG SHEET

Client: Department of Planning
Project: Williamtown Land Use Study
Location: Williamtown

PROBE No. DCP3

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:		**Chainage:**	**Date:** 22/9/06
Elevation:	GL	**Offset:**	**Operator:** C Roach



Comments:

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Job No. 221280801

File: DCP3.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP3.xls

DYNAMIC CONE PENETROMETER LOG SHEET

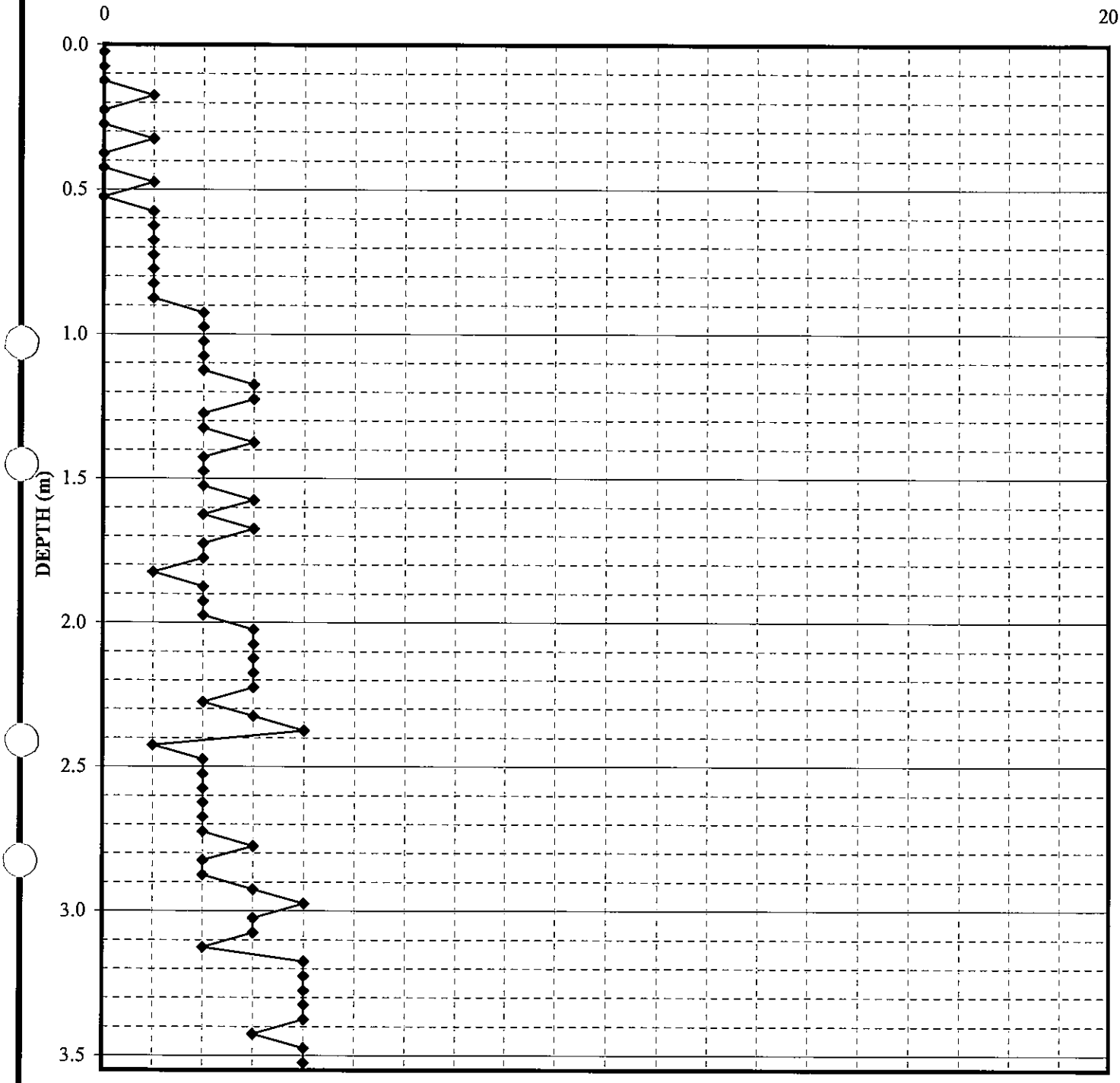
Client:	Department of Planning
Project:	Williamtown Land Use Study
Location:	Williantown

PROBE No. DCP4

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:	Refer to Test Location Plan	**Chainage:**		**Date:**	22/09/06
Elevation:	G.L	**Offset:**		**Operator:**	C.Roach

NUMBER OF BLOWS TO PENETRATE 50 mm



Comments: **End of Probe at 3.55 m**

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Job No. **221280801**

File: DCP4.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP4.xls

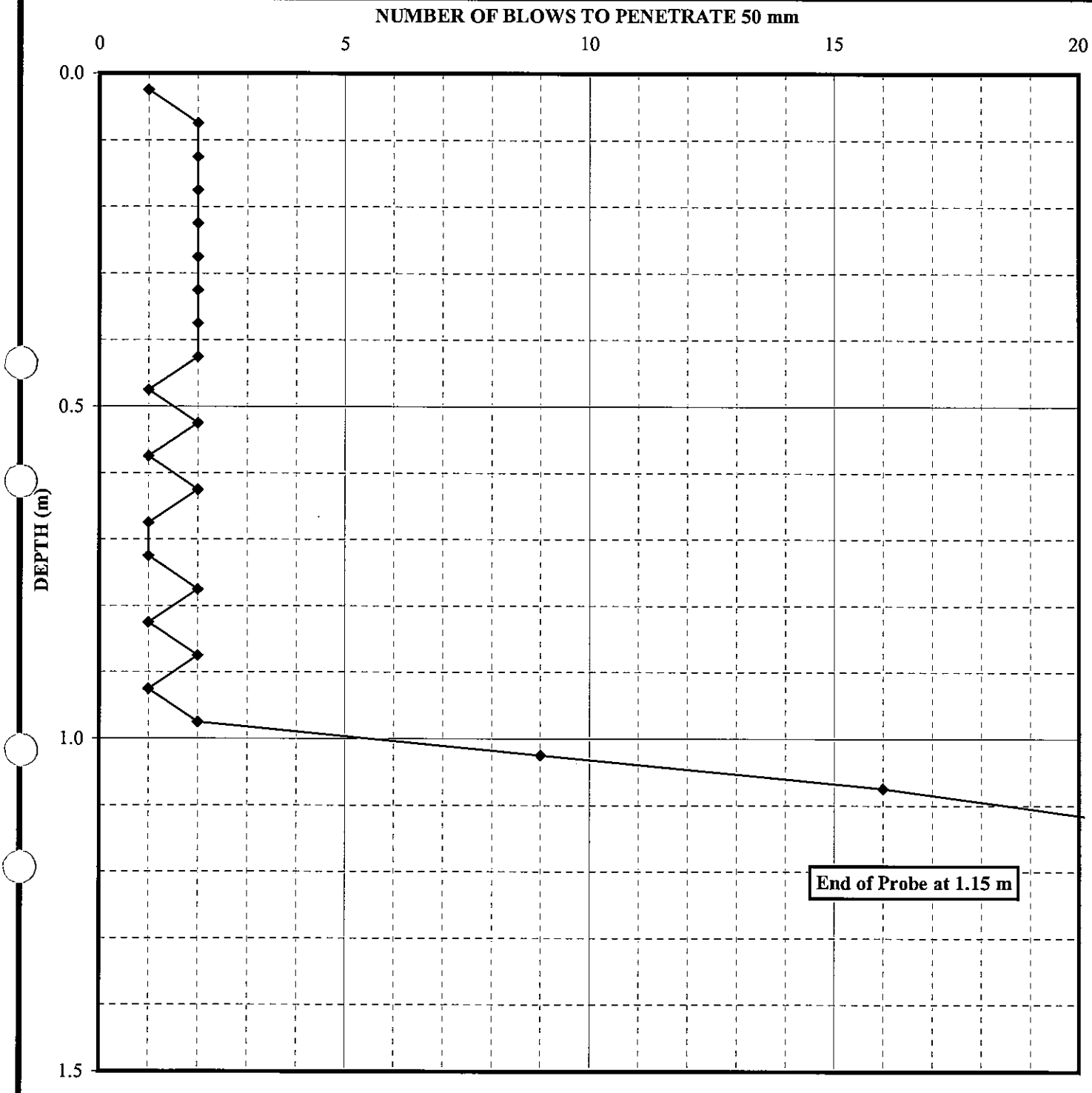
DYNAMIC CONE PENETROMETER LOG SHEET

Client: Department of Planning
Project: Williamtown Land Use Study
Location: Wiliamtown

PROBE No. DCP6

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:	**Chainage:**	**Date:**	22/9/06
Elevation: GL	**Offset:**	**Operator:**	C Roach



Comments:

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Job No. **221280801**

File: DCP6.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP6.xls

DYNAMIC CONE PENETROMETER LOG SHEET

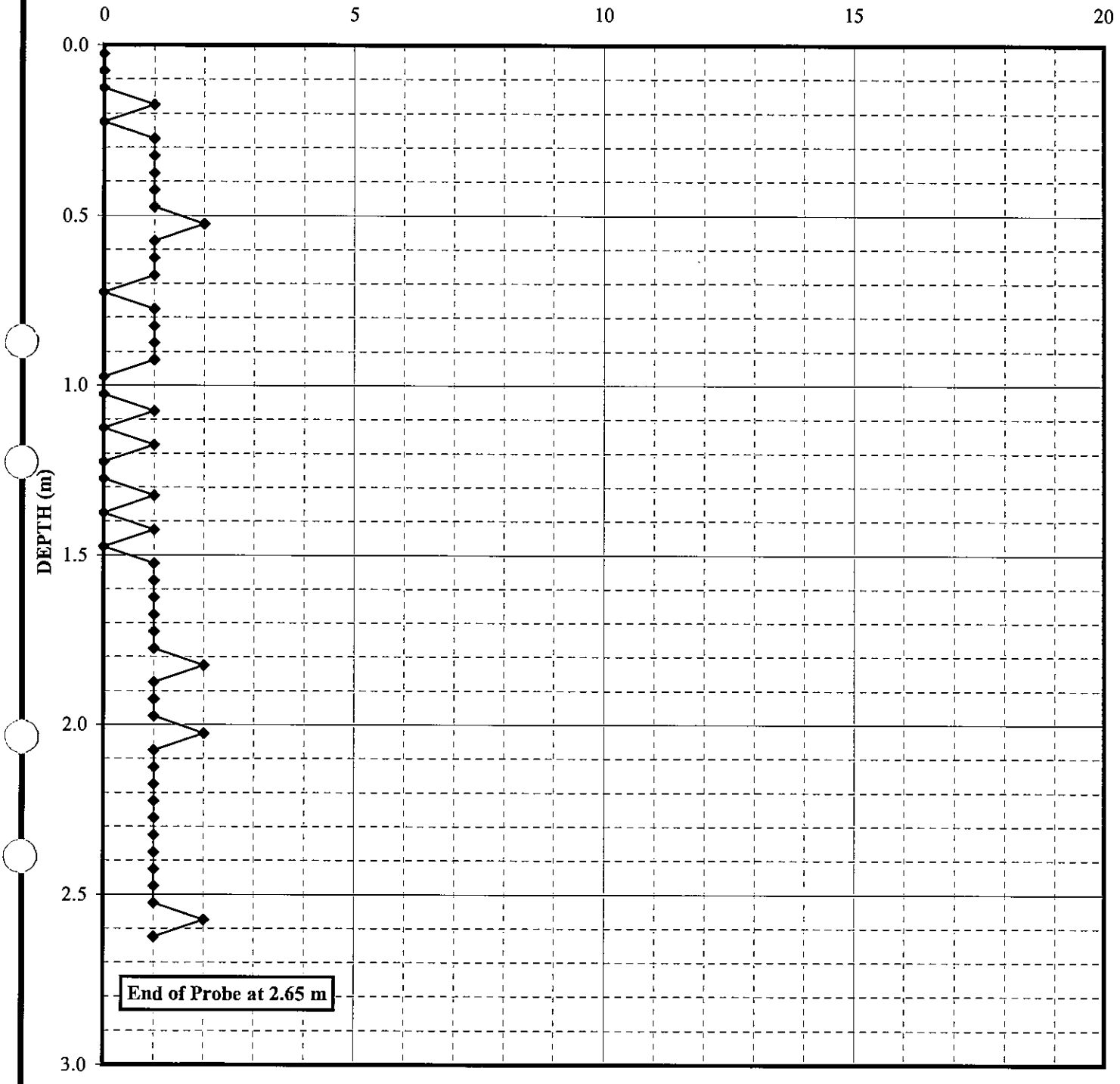
Client:	Department of Planning
Project:	Williamtown Land Use Study
Location:	Williantown

PROBE No. DCP7

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:	Refer to Test Location Plan	**Chainage:**		**Date:**	22/09/06
Elevation:	G.L	**Offset:**		**Operator:**	C.Roach

NUMBER OF BLOWS TO PENETRATE 50 mm



Comments:

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Job No. 221280801

File: DCP7.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP7.xls

DYNAMIC CONE PENETROMETER LOG SHEET

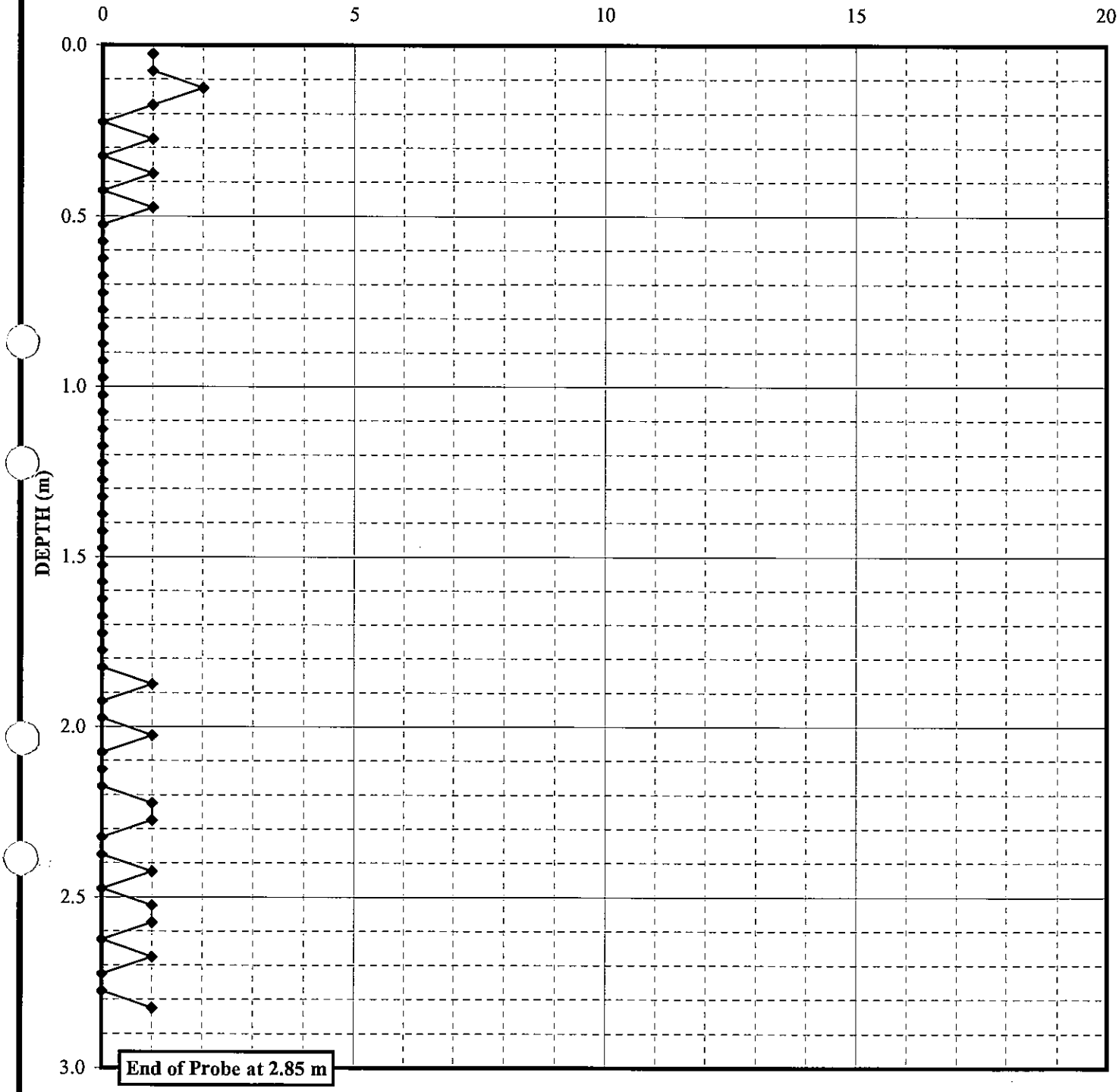
Client: Department of Planning
Project: Williamtown Land Use Study
Location: Wiliamtown

PROBE No. DCP8

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:	**Chainage:**	**Date:**	22/9/06
Elevation: GL	**Offset:**	**Operator:**	C Roach

NUMBER OF BLOWS TO PENETRATE 50 mm



Comments:

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Job No. 221280801

File: DCP8.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP8.xls

DYNAMIC CONE PENETROMETER LOG SHEET

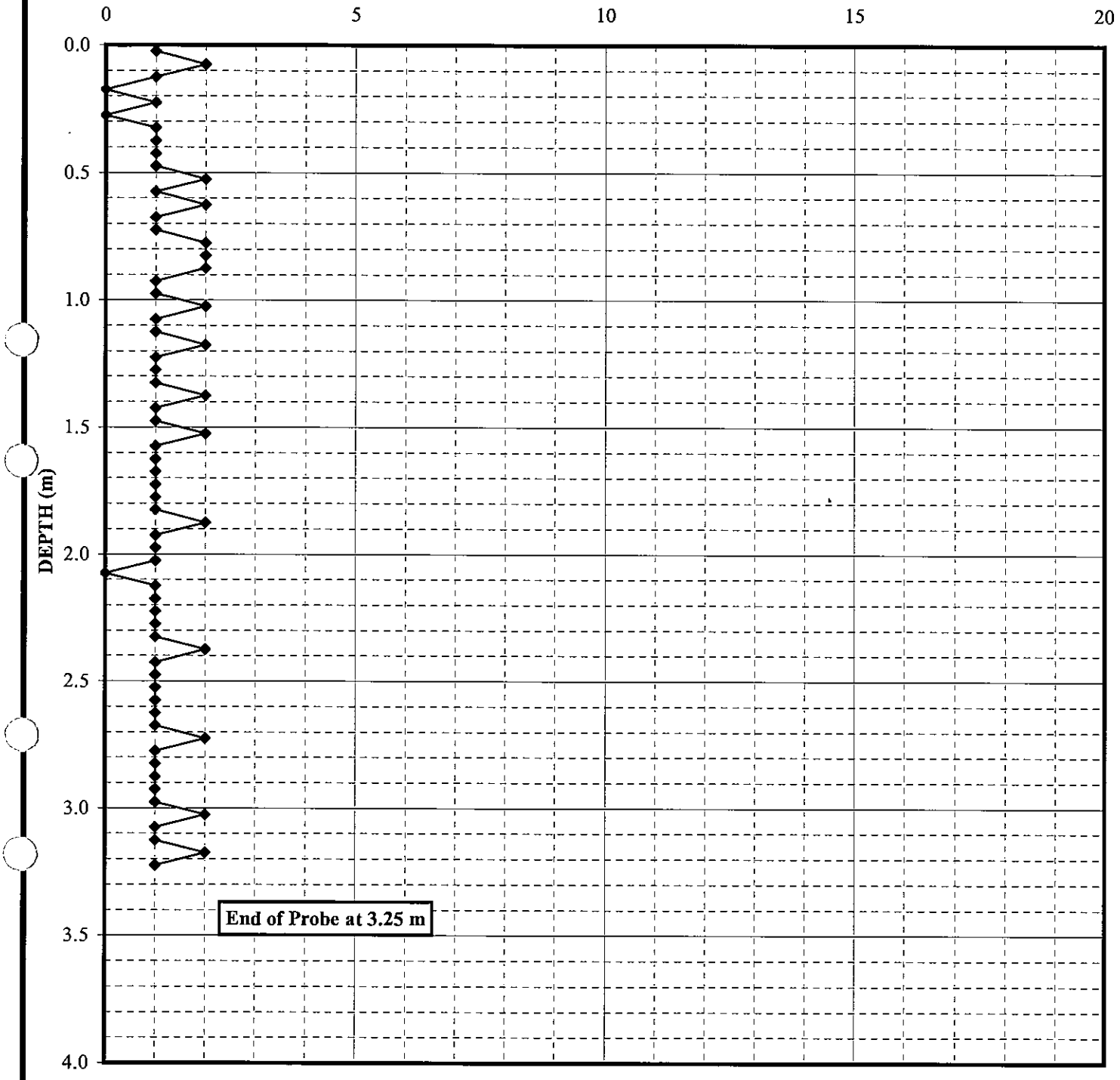
Client: Department of Planning
Project: Williamtown Land Use Study
Location: Wiliamtown

PROBE No. DCP9

AS1289 6.3.2 (Cone tip) 510 mm drop height.

Position:	**Chainage:**	**Date:**	22/9/06
Elevation: GL	**Offset:**	**Operator:**	C Roach

NUMBER OF BLOWS TO PENETRATE 50 mm



Comments:

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Job No. **221280801**

File: DCP9.xls

Template: \\G:21\GEO_LAB\FWP Results\DCP2005_GHD Newcastle.XLT
File:G:\22\12808\Technical\DCP Results\DTP9.xls

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	D Rogers	S Amoroso	S. Amoroso	K Blackmore	K. Blackmore	17/08/07

CLIENTS | PEOPLE | PERFORMANCE

Department of Planning

RAAF Base Williamtown / Newcastle Airport Employment Zone Land Use Development Strategy

Stage 2: Preliminary Acid Sulfate Soil Assessment

August 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Appendices

A. Figures

B. Results Tables

C. Laboratory Certificates and Chain of Custody

D. Characteristics of ASS

1. Introduction

1.1 General

GHD Pty Ltd (GHD) was commissioned by the Department of Planning to undertake a preliminary Acid Sulfate Soil (ASS) Assessment of an investigation area selected in Stage 1 of the RAAF Base Williamtown / Newcastle Airport Employment Zone Land Use Development Strategy.

This revised report follows on from our Preliminary ASS Assessment report (Document Ref: 22/12808/73890) issued in February 2007. Due to geotechnical and flooding issues identified during a review of the Stage 2 Land Use Capability / Suitability Investigations Report in March 2007, a revised study area has been selected which incorporates additional landholdings to the west of the previously investigated Stage 2 study area. Preliminary investigation of this additional land was commissioned by the Department of Planning on 27 July 2007.

The results of this assessment were used to identify landuse limitations and management strategies associated with the disturbance of ASS at the site.

1.2 Previous Investigations

A study undertaken by Environmental & Earth Sciences Pty Ltd (2000) defined the extent and severity of ASS in the Port Stephens area, and assessed the degree of oxidation and acid production that had occurred up until early 2000. Soils from the single borehole tested for ASS within the study site revealed undetectable levels of actual acidity, but considerable amounts of potential acidity that could be produced if these soils were excavated and/or de-watered. Based on the results of this study, it is therefore expected that potential future disturbance of these soils from development activities could lead to increased acid production and environmental impacts.

2. Scope of Work

This assessment aims to address the requirements of Section 117 of the Environmental Planning and Assessment Act 1979, Ministerial Direction No.1 in relation to ASS.

The scope of work for the assessment may be defined as follows:

- Undertake preliminary intrusive investigations to delineate and characterise the areas of ASS affected within the site. This included the hand augering of nine boreholes within the original Stage 2 study area. The boreholes were drilled to a maximum depth of 1.5 m, with ASS field testing undertaken every 0.5 m or change in strata and Suspension Peroxide Oxidisable Combined Acidity and Sulfide (SPOCAS) testing on nine selected samples; and
- Outline landuse limitations and management strategies associated with the disturbance of ASS as per the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998).

It should be noted that intrusive investigations were not undertaken within the additional landholdings to the west of the previously investigated Stage 2 study area. Assessment of the additional landholdings has been based on a desk top review of existing published information and subsequent ‘ground truthing’ the results of the desk top study. It is recommended that further assessment of ASS conditions, including subsurface investigation, sampling and laboratory analyses, be undertaken at the concept design phase of the project to confirm the conditions that have been assumed in this preliminary assessment.

3. Site Condition

3.1 Site Location and Description

The site is situated immediately south of the RAAF Base at Williamtown. The original study area that was the subject of the Stage 1 Site Selection Report included a 500 hectare parcel of land extending from the south east corner of the Newcastle Airport, approximately 2 km to the south and approximately 1.5 km east and west of the centrally located Nelson Bay Road.

Based on the findings contained within the Stage 1 Site Selection Report, this area was then revised for the Stage 2 Site Selection Report to include a smaller area of approximately 100 hectares bound by Newcastle Airport to the north and Nelson Bay Road and Cabbage Tree Road to the east and south respectively. However, due to geotechnical and flooding issues identified during the previous Stage 2 Land Use Capability / Suitability Investigations Report issued in March 2007, a revised study area has since been selected which incorporates additional landholdings to the west of the previously investigated Stage 2 study area. Reference should be made to Figure 1 in Appendix A which shows the areal extent of the revised Stage 2 study area.

The subject land for the Stage 2 Assessment is generally low lying (flood prone), mostly cleared of vegetation and includes the following land uses:

- The Newcastle Airport (an area of approx. 28 hectares) the subject of a 40 year lease from the Commonwealth Government for civilian airport facilities;
- Residential and rural residential properties with frontages to Nelson Bay Road and Cabbage Tree Road; and
- Rural land used for grazing purposes generally south and in the vicinity of the civil airport and RAAF Base Williamtown facilities.

3.2 Surrounding Land uses

The site is generally surrounded by land zoned for rural purposes to the east, west and south of the site. Immediately north of the subject site the land is zoned Defence Purposes 5(a). Further to the west and north and just outside of the study area there is a large tract of land zoned 7(c) Environmental Protection – Water Catchment.

The land in the vicinity of the study area is generally used for rural purposes and has a rural, agricultural character. Grazing lands dominate the landscape with patches of vegetation and sand dunes. In the locality there is a school, a church, numerous rural dwellings, farms, two service stations, a car hire business and other home businesses in the vicinity of the NAL and RAAF Base Williamtown facilities.

3.3 Geology and Hydrogeology

Groundwater levels at the site are expected to range between 0m and 3m AHD, with the highest groundwater levels coinciding with the highest period of rainfall between the months of January and June (Woolley et al., 1995; GHD, 2006). Some lowering of the groundwater via drainage channels located within the site is expected to occur, however the degree to which this occurs has not been yet been determined.

Groundwater flow directions from the site are to the southeast to southwest towards the lowlands of the Tilligerry Valley (Woolley et al., 1995). The closest Hunter Water Corporation Pump Stations, PS5, PS7, PS9 and PS23, are located a few kilometres to the north of the study site.

The soils in the northern part of the site are dominated by permeable sands, which are highly vulnerable to contamination. This part of the site falls within a HWC Special Area, which is a gazetted area of land that is intended to represent the catchment area of Hunter Water's drinking water sources. The Hunter Water (Special Areas) Regulation 2003 imposes controls on intensive agriculture, sewage disposal, and the bringing of potential pollutants within gazetted Special Areas. The Department of Defence have been monitoring groundwater quality within the northern part of the site in the vicinity of their Sewage Treatment Facility since 1999. Groundwater in this portion of the site is fresh (TDS < 500 mg/L) and moderately acidic.

The southern half of the site is primarily comprised of poorly-drained waterlogged soils and dark muds with high ASS potential, which are part of the Tilligerry Valley separating the Stockton and Tomago sand ridges. This valley forms part of a remnant tidal waterway that once extended along the Stockton Dune Ridge from Fullerton Cove to Tilligerry Creek (Woolley et al., 1995). Unlike the more northern portions of the site and the rest of the Tomago sandbeds, soils along the Tilligerry Valley are expected to have low infiltration rates, and are less susceptible to contamination.

These alluvial plain soils are dominated by low permeability estuarine clays (Bobs Farm estuarine and Fullerton Cove soil landscapes), which have been associated with the presence of ASS.

3.4 ASS Risk Map

Reference to the Acid Sulfate Soil Risk Map for Williamtown, published by the Soil Conservation of NSW, indicates that there is a high probability of occurrence of Acid Sulfate Soils (ASS) at shallow depth (between 1m and 3m depth) below the natural ground surface level in the southern portion of the site. This high probability of occurrence of ASS extends over the low-lying flood plains (elevation less than RL 4m AHD), with disturbance activities such as drainage and excavation potentially leading to environmental degradation of sensitive groundwater and surface water resources.

The map also indicates that there is a low probability of occurrence of ASS at a depth of greater than 3m below the existing surface in the slightly elevated northern portion of the site (above RL 4m AHD). This elevated area is described by the Risk Map as a Pleistocene Aeolian Sandplain / Dune and, if present, ASS within this area are expected to be sporadic and buried by alluvium and/or Aeolian (windblown) sediments.

Reference to the ASS risk map indicates that the majority of the additional landholdings to the west of the previously investigated study area are characterised by a low probability of occurrence of ASS at a depth of greater than 3m below the existing surface.

3.5 Soil Landscape Groups

Reference to the 1:100,000 Soil Landscape Map of the Newcastle Region indicates that the site lies largely within the 'Bobs Farm' estuarine and a variant of the 'Tea Gardens' aeolian soil landscape groups. These unit boundaries correspond roughly with the geological unit boundaries described above and are shown in **Figure 2** (**Appendix A**). Minor soil landscapes also noted within the study area include the 'Blind Harry Swamp' soil landscape group associated with the patch of swampy ground near the western margin of the study area and the 'Shoal Bay' aeolian soil landscape group associated with the exposed dune system west of the airport access road in the central northern part of the site.

The 'Bobs Farm' (bf) soil landscape group incorporates broad inter-barrier estuarine flats on the Tomago Coastal Plain. The topography is characterised by slope gradients less than 1% and elevations between 1 and 3 metres. Soils within this group are typically deep (>3m) very poorly drained estuarine mud deposits. Dominant soil materials include organic rich loam (sandy silty clays) overlying saturated plastic clays. Both actual and potential Acid Sulfate Soils are expected at shallow depth within this soil landscape.

The 'Tea Gardens' (tna variant) soil landscape group incorporates Pleistocene beach ridges on the Tomago Coastal Plain. The topography is characterised by slopes typically less than 5% and elevations between 5 and 8 metres. Soils have generally been re-worked by wind action producing irregular sandy low rises and broad deflation basins and swales. Dominant soil materials include loamy sand and/or beach sand topsoils overlying strongly to extremely acid loam sand to sand subsoils.

The ‘Blind Harry Swamp’ (ba) soil landscape group incorporates waterlogged swales, periodically submerged swamp forest and deflation areas on sands of the Tomago Coastal Plain. The topography of the area is characterised by level to very gentle inclined closed depressions with extremely low reliefs. Soils within this area are generally waterlogged, strongly acid and highly organic. Dominant soils include organic fibrous peat overlying sand or loamy sand.

The ‘Shoal Bay’ (sb) soil landscape group incorporates Pleistocene sand sheets and low dunes on the Tomago Coastal Plain. The topography of the soil landscape incudes inclined sand sheets, low undulating dunes with slope gradients typically less than 15% and local relief less than 10 metres with minor swampy areas occurring in depressions. Dominant soils include sands and loamy sands.

4. Sampling Plan and Methodology

4.1 Sampling Plan

Sampling procedures were in general accordance with the ASSMAC guidelines (1998). A total of nine boreholes were drilled and sampled during this preliminary assessment. The depths of these boreholes are provided in **Table 4.1** (sampling locations plotted on **Figure 1** in **Appendix A**).

Table 4-1 Locations of Boreholes

Borehole ID	Total Depth (m)
BH1	1.0
BH2	1.65
BH3	1.15
BH4	1.45
BH5	1.8
BH6	1.55
BH7	2.3
BH8	2.1
BH9	1.85

4.2 Field Methods

Fieldwork was generally conducted in accordance with Standards Australia Site Investigation Code AS 1726 and the ASSMAC Guidelines (1998). Soil samples were collected by a GHD Geotechnical Engineer from boreholes drilled on 22 September 2006.

4.2.1 Sampling and Storage

Samples were collected approximately every 0.5 m and placed in Ziplock bags once logging had been completed and labelled according to the hole and sample identification. A record was retained of the depth of each sample and the borehole number. Sample bags were then placed in an esky filled with ice to ensure minimal oxidation of the sample.

At the completion of the field-sampling and testing program, representative samples were transferred on ice to Newcastle Australian Laboratory Services (ALS).

Chain of Custody EB0609847 was issued with the samples sent to ALS. Chain of Custody and laboratory reports are provided in **Appendix C**.

4.2.2 ASS Field Indicator Testing

Field indicator pH testing was completed on sub-samples collected every 0.5 m or change in strata along the entire available profile.

At the completion of the fieldwork, each sample was placed in a jar where 30% H_2O_2 (adjusted to pH 5.5 using NaOH) was added to the sample. After a sufficient period of time, the pH of the mixture was measured and recorded against the pH of the non-reacted (no addition of peroxide) soil sample.

All testing was completed in accordance with the ASSMAC guidelines (1998).

The pH meter was calibrated at the commencement of the exercise, to ensure accurate measurements were attained.

4.2.3 Soil Laboratory Analysis

Based on the results of the ASS indicator testing, nine samples with the greatest change in pH after peroxide oxidation (i.e. pH_f - pH_{fox}) were submitted for SPOCAS (Ahern *et al*., 2004) suite of analysis at ALS, a specialist analytical laboratory. The SPOCAS method was selected, as it would provide data from both the sulfur trail (indicating the level of sulfur in the soil available for oxidation) and the acid trail (supplying the existing and predicted acid production) of the material. This acid-base accounting approach of SPOCAS is considered more accurate than the standard Peroxide Oxidisable Combined Acidity and Sulfide (POCAS) for calculating the net acidity of soils (Ahern *et al*., 2004). The net acidity generated from a soil sample, which is used to calculate the ASS risk and liming rates, is derived using the following equation:

Net Acidity =

Potential Sulfidic Acidity + Actual Acidity + Retained Acidity – Acid Neutralising Capacity

4.3 Assessment Criteria

The ASSMAC (1998) action criteria for treatment of ASS based on the percentage of oxidisable sulfur or equivalent Titratable Actual Acidity (TAA) or Titratable Peroxide Acidity (TPA) for broad soil texture categories are presented in **Table 3.2**. When analysis results exceed the action criteria a treatment regime and management plan for the materials is triggered. For disturbances of less than 1000 tonnes, the action criteria vary according to the texture of the material, however if more than 1000 tonnes is to be disturbed, all action criteria are the same: S% 0.03 and Acid 18 mol/tonne. For the purposes of this assessment the most conservative criteria applied for >1000 tonnes of soil disturbed has been adopted.

Table 4-2 Action Criteria for Treatment of AASS and PASS

Soil Texture	Clay Content %	< 1000 Tonnes Disturbed		> 1000 Tonnes Disturbed	
		Sulfur Content %	Acid Trail mol/tonne	Sulfur Content %	Acid Trail mol/tonne
Coarse (sands-gravels)	≤ 5	0.03	18	0.03	18
Medium (sandy loam-light clay)	5 - 40	0.06	36		
Fine (medium to heavy clays, silty clays)	≥ 40	0.10	62		

Source: Ahern *et al*., 1998.

Note: AASS – Actual Acid Sulfate Soils

PASS – Potential Acid Sulfate Soils

5. Discussion of Results

5.1 Analysis Suite

Three (3) analysis methods were used to assess the samples collected during the drilling and testing program. In addition to the geological description and interpretation of the profiles, two chemical analysis methods were employed: field pH and laboratory assay.

5.2 Field Investigation Results

Soils investigated within the northern portion of the site consisted primarily of grey sands, while the southern portion of the site consisted primarily of clays and silty to clayey sands. Soils in the southern area of the site generally increased in sand content with depth. The majority of soils tested were in a moist to wet condition.

5.3 Field pH

All field testing results have been presented in **Table A1** in **Appendix B.** The pH_f of all soil samples collected and tested ranged between 4.20 to 6.78, with a mean ± standard deviation of 5.52 ± 0.62.

After oxidation, samples reported pH_{fox} between 1.56 and 5.10, with a mean ± standard deviation of 3.82 ± 0.93. pH_{fox} less than 4 was generally found within the southern portion of the sampling area. Vertical pH_{fox} profiles at these locations do not indicate any consistent depth trends in acidity, with low pH_{fox} detected in both shallow and deeper soils within the sampled profiles.

5.4 Laboratory Analysis

All laboratory results have been presented in **Table A2** in **Appendix B**. All soils selected for testing were located within the High Probability ASS Map Class, which dominates the southern portion of the site, excluding BH6 1.0-1.1 located within the Low Probability ASS Map Class.

5.4.1 Sulfur Trail

In the “sulfur trail”, acidity is indirectly determined using a combination of sulfur determinations and stoichiometric relationships.

Peroxide oxidisable sulfur (S_{pos}%) values ranged between <0.02 to 0.61%, with a mean ± standard deviation of 0.18 ± 0.22% (which corresponds to a potential sulfidic acidity of 138 ± 142 mole H^+ /tonne of soil). The sample tested from BH6 (BH6 1.0-1.1) (located in the northern portion of the site) reported no detectable peroxide oxidisable sulfur. Six of the nine samples collected from the site and SPOCAS analysed returned S_{pos}% values equal to or greater than the most protective action criteria of 0.03% set for > 1000 tonnes of soil disturbed, as presented in **Section 3.3**.

5.4.2 Acid Trail

In the “acid trail”, acidity is directly determined by titration.

TAA values ranged between <2 to 84 mole H^+ /tonne of soil, with a mean ± standard deviation of 37 ± 25 mole H^+ /tonne of soil. TPA values ranged between 34 to 537 mole H^+ /tonne of soil, with a mean ± standard deviation of 160 ± 150 mole H^+ /tonne of soil. Reported TPA values were generally highest in the middle and northern portions of the sampling area, at depths between 0.5 m and 2.25 m.

In all nine samples analysed TPA exceeded TAA, indicating that the acidity in these soils is mostly present as potential acidity in the form of unoxidised sulfide or pyrite, referred to as Total Sulfidic Acidity (TSA).

5.4.3 Retained Acidity

Retained acidity is a measure of the “less available” fraction of the existing acidity not measured by TAA, which is released by the hydrolysis of sulfate salts (Ahern *et al*., 2004). Retained acidity was not tested for in any of the samples submitted for analysis as all reported pH_{KCL} values were greater than 4.5.

5.4.4 Excess Acid Neutralising Capacity

Excess Acid Neutralising Capacity (ANC_E) is the neutralising capacity naturally existing within a soil sample in excess of that needed to neutralise the acidity generated through the oxidation of sulfides (Ahern *et al*., 2004). As pH_{ox} (pH after oxidation with peroxide) values were less than 6.5, ANC_E was considered to be zero.

5.4.5 Net Acidity

The net acidity values of soils tested ranged between 18 and 432 mole H^+/tonne of soil, with an mean ± standard deviation of 143 ± 130 mole H^+ /tonne of soil (or equivalent sulfur units 0.23 ± 0.21 %S). When net acidity values are used, all samples tested, excluding BH6 1.0-1.1, exceed the soil action criteria of 18 mole H^+ /tonne set for > 1000 tonnes of soil disturbed, as presented in **Section 3.3**.

6. ASS Assessment

The Williamtown ASS Risk map, published by the Soil Conservation Service of NSW (1997) indicates a high probability of ASS occurring between 1 and 3 m below ground level (BGL) within the majority of the southern portion of the site (referred to as the High Probability ASS Map Class area) and a low probability of ASS occurring at depths >3 m BGL within the majority of the northern portion of the site, including the additional landholdings to the west of the previously investigated Stage 2 study area (referred to as the Low Probability ASS Map Class area).

Generally, the High Probability ASS Map Class area is associated with the 'Bobs Farm' and 'Blind Harry Swamp' soil landscape groups, while the Low Probability ASS Map Class area is associated with the 'Tea Gardens' and 'Shoal Bay' soil landscape groups. The approximate extent of these soil landscape groups, within the study area, is shown on **Figure 2** in **Appendix A**.

ASS field indicator pH testing was completed on sub-samples collected every 0.5 m or change in strata along the entire available profile of the nine boreholes drilled within the site. Field-testing indicated that unoxidised pyrite was present at depths of 0.4 m up to the maximum depth tested at 2.25 m. Based on the field testing, nine samples with the greatest change in pH after peroxide oxidation (i.e. pH_f - pH_{fox}) were submitted for SPOCAS analysis.

Six of the nine soil samples analysed for SPOCAS during this preliminary investigation had concentrations >0.03% of S_{pos}%, suggesting that acidity in these soils is largely present as unoxidised pyrite (i.e. PASS). SPOCAS testing revealed that some minor oxidation of these soils may have already occurred on site, since most samples reported detectable concentration of TAA accompanied by mildly acidic pH_{KCl}.

The one sample tested from the northern portion of the site (within the Low Probability ASS Map Class area), which had the greatest field indicator pH change of all the soils tested within this portion of the site, reported a Net Acidity concentration below the ASSMAC (1998) designated action criteria of 18 mole H^+ /tonne set for > 1000 tonnes of soil disturbed.

All samples tested from the High Probability ASS Map Class area reported Net Acidity concentrations that exceeded the ASSMAC (1998) designated action criteria of 18 mole H^+ /tonne. A preliminary recommended liming rate of 18 kg $CaCO_3$ / tonne of soil has been calculated for soil disturbed in this portion of the site (based on the use of agricultural lime and a safety factor of 1.5). The liming rate has been calculated from the 95% Upper Confidence Level (95% UCL) of reported liming results (**Table A2** in **Appendix B**).

Soils located within the High Probability ASS Map Class are likely to present a major ASS risk if excavated, drained or dewatered, thus triggering the need for a treatment regime and management plan if these soils are to be disturbed.

Based on the results of this investigation, it is considered that the soils in the northern portion of the site (Low Probability ASS Map Class area) are unlikely to present a major ASS risk if disturbed. However, based on available soil landscape data, it is anticipated that naturally acidic soils will be encountered in this portion of the site, overlain by aeolian (wind blown) sediments. Ground surface elevations typically range between RL 1.5m and 4m AHD across the majority of the northern portion of the site, with the exception of localised dune formations associated with the 'Shoal Bay' soil landscape group. The soil landscape map also indicates that soils within the 'Tea Gardens' soil landscape group, which dominates the northern portion of the site, are strongly to extremely acidic. The acidic soils may be due to the acidic nature of parent material from which the soil originated, and is unlikely to be due to the oxidation of pyrite. However, the excavation and stockpiling of acidic soil, regardless if the acidity is derived from pyrite or not, still has the potential to impact on receiving environments. As such, a treatment regime and management plan may be required for future development, to manage the potential detrimental effects to the surrounding environment. This will be verified by intrusive investigations to be carried out at the conceptual design stage.

Any disturbances of acidic soil or ASS are unlikely to impact Tomago Drinking Water resources as water from this area is expected to discharge to the low-lying Tilligerry Valley. Water from soil disturbed in this area could, however, impact upon run-off surface water quality, which is of concern given the presence of major drainage systems within the site that discharge into Tilligerry Creek and Fullerton Cove.

The requirements of Section 117 of the Environmental Planning and Assessment Act 1979, Ministerial Direction No.1 relate to ASS. The requirements of this direction have been addressed by this assessment. In accordance with Port Stephens LEP 2000, Port Stephens Council's ASS Policy and the ASS Model LEP, development consent will be required for works undertaken more than 1 m below the natural ground surface, and works likely to lower the watertable to a depth of more than 1 m below the natural ground surface within the High Probability ASS Map Class area. These works will require a detailed ASS Assessment and an Acidic Soil / Acid Sulfate Soil Management Plan (ASSMP) to be lodged with the development application. It is advisable that the landuses permitted within the High Probability ASS Map Class area of the site have well managed temporary or minimal to no disturbances to the soil or groundwater.

This preliminary ASS assessment has been carried out in accordance with the relevant sections of the NSW ASS Manual, which includes the ASS Planning Guidelines, ASS Assessment Guidelines and ASS Management Guidelines.

7. Scope and Limits of Preliminary ASS Assessment

This report presents the results of a Preliminary ASS Assessment prepared for the purpose of this commission. The data and advice provided herein relate only to the project described herein and must be reviewed by a competent engineer/scientist before being used for any other purpose. GHD Pty Ltd (GHD) accepts no responsibility for other use of the data.

This ASS assessment should be considered as preliminary only as it is based on very limited subsurface information. It should also be noted that preliminary assessment of the additional landholdings is based only on a desk top review of available published soil maps, and extrapolation of existing information, and that no subsurface investigations have been undertaken on this portion of the site.

The advice tendered in this report is based on information obtained from the assessment locations, tests points and sample points and is not warranted in respect to the conditions that may be encountered across the site at other than these locations. It is emphasised that actual characteristics of the subsurface materials may vary significantly between adjacent test points and sample intervals and at locations other than where observations, explorations and investigations have been made. Subsurface conditions, including groundwater levels and contaminant concentrations can also change in a limited time. This should be borne in mind when assessing the data.

It should be noted that because of the inherent uncertainties in subsurface evaluations, changed or unanticipated subsurface conditions may occur that could affect total project cost and/or execution. GHD does not accept responsibility of the consequences of significant variances in the conditions and the requirements for execution of the work. It is recommended that further, detailed subsurface investigations be undertaken in the design phase to confirm the conditions which have been assumed in this assessment.

During remediation or subsequent investigations the subsurface and surface earthworks and excavations should be examined by a suitably qualified and experienced engineer/scientist who shall judge whether the revealed conditions accord with both the assumptions in this report and/or the design of the remediation works. If they do not accord, the engineer/scientist shall modify the advice in this report and/or design of the works to accord with the circumstances that are revealed.

An understanding of the subsurface site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experience based. Hence this report should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances which arise from the issue of the report which has been modified in any way as outlined above.

8. References

Acid Sulfate Soil Risk Map (1:25 000), “Williamtown”, Ed.2. Dec 1997.

Ahern, C.R., McElnea, A.E., Sullivan, L.A. (2004) Acid Sulfate Soils Laboratory Methods Guidelines, Queensland Department of Natural Resources, Mine and Energy, Indooroopilly, Queensland, Australia.

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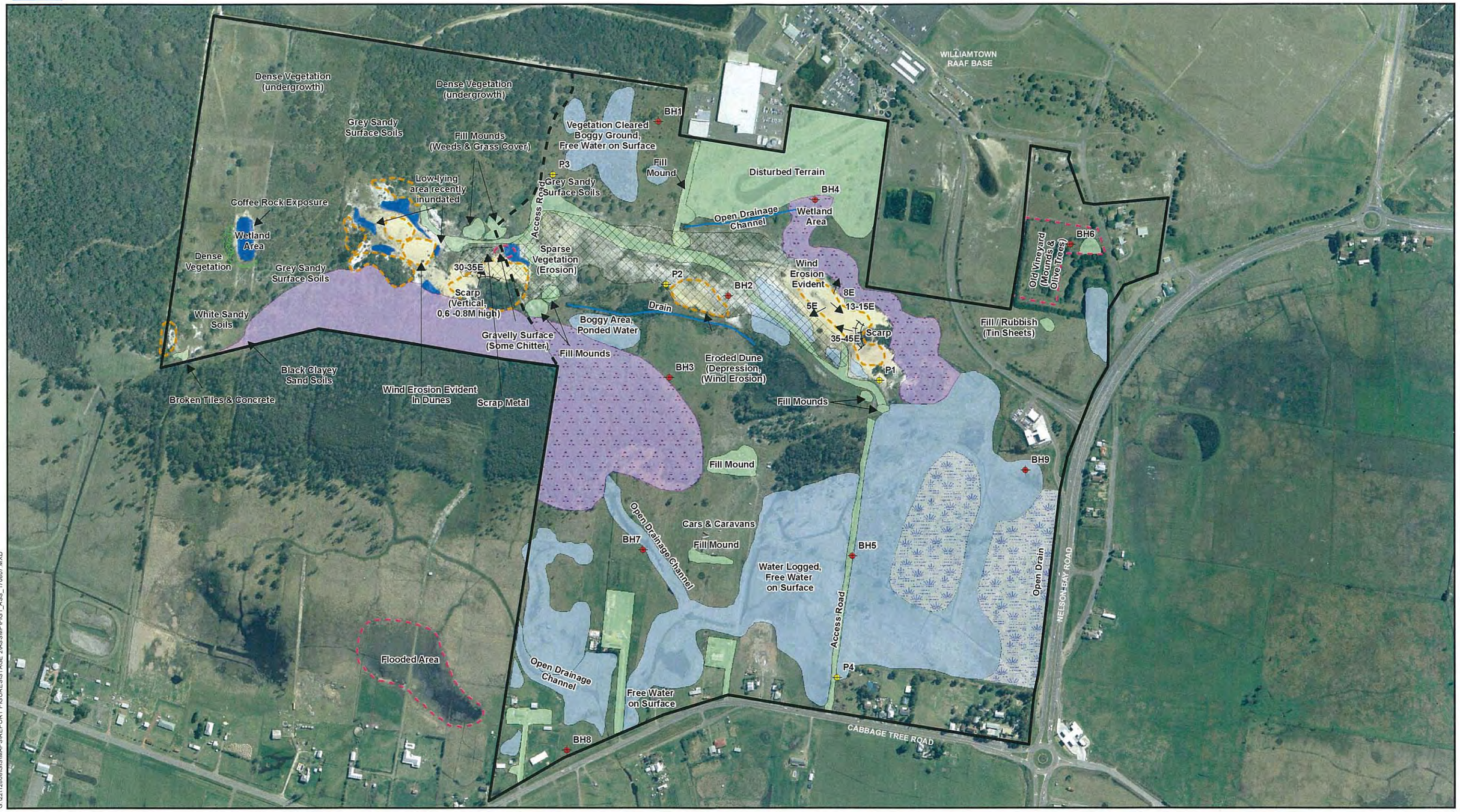
Woolley, D., Mount, T. and Gill J. (1995) NSW Department of Water Resources, Tomago Tomaree Stockton Groundwater – Technical Review.

Appendix A

Figures

GHD CLIENTS | PEOPLE | PERFORMANCE



G:\22\12808\GIS\MAPS\REPORT FIGURES\STAGE 2\ASSMPIFIG1_ASS_170807.MXD

1:7,000

0 50 100 200 300

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

GRID N

Legend

- Investigation Area (Including Additional Land)
- Borehole Locations Stage 2 (approximate)
- Soil Profile Locations - Stage 1 (approximate)
- Swampy Areas
- Dunes
- Approximate Extent of Filled Areas
- Boggy Ground / Inundated Area
- Boggy Ground, Tall Reeds
- Submerged Swamp Forest
- Low Lying Swamp Forest
- Approximate Extent of Sand Mined Area
- Dense Vegetation

17 August 2007

Site Mapping & Test Location Plan

Preliminary Acid Sulfate Soil Assessment

Williamtown Employment Zone - Stage 2

Figure 1

GHD CLIENTS | PEOPLE | PERFORMANCE

G:/22/12808/GIS/Maps/Report Figures/Land Use & Development Strategy Part B/ASSMP/Fig2_SoilLandscape_170807.mxd

1:12,000
0 50 100 200 300
Metres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

GRID
N

LEGEND

Investigation Area (Including Additional Land)
Main Road
Road

Soil Landscapes
D, Disturbed Area
Sb, Shoal Bay Soil Landscape
ba, Blind Harry Swamp Soil Landscape
bf, Bobs Farm Soil Landscape
tna, Tea Gardens Variant (a) Soil Landscape

Spatial layers courtesy of Port Stephens Council

17 August 2007

Soil Landscape Groups Within the Study Area

Appendix B

Results Tables

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Client: Department of Planning
Title: Stage 2 : Acid Sulfate Soil Assessment Williamtown Employment Zone
Job No: 221280801

Table A1: Acid Sulfate Field Indicator Testing

Sample Number	Sample ID	Depth Range (m)	pH Initial	pH after H_2O_2	Change pH	Reaction Strength[1]	Colour Change	Heat (°C)	Soil Classification[2]	Comments
1	BH1 0.4-0.5	0.4-0.5	4.46	4.59	-0.13	1	no	21	SM	
2	BH1 0.5-0.6	0.5-0.6	4.61	4.82	-0.21	1	no	21.2	SM	
3	BH1 0.7-0.8	0.7-0.8	4.66	4.06	0.60	1	no	21.3	SM	
4	BH2 1.05-1.1	1.05-1.1	4.2	3.66	0.54	1	no	21.4	SC	
5	BH3 0.5-0.6	0.5-0.6	5.49	4.49	1.00	1	no	21.3	SM	
6	BH3 0.8-0.9	0.8-0.9	5.41	4.87	0.54	1	no	21.4	SC	
7	BH3 1.1-1.25	1.1-1.25	5.35	5.10	0.25	1	no	21.5	SP	
8	BH4 0.1-0.3	0.1-0.3	5.58	4.74	0.84	2	no	22.2	Pt	
9	BH4 0.4-0.5	0.4-0.5	5.8	5.00	0.80	2	no	21.7	SM	
10	BH4 0.9-1.05	0.9-1.05	5.76	4.97	0.79	2	no	21.6	SM	
11	BH4 1.15-1.3	1.15-1.3	5.72	4.69	1.03	1	no	21.9	SM	
12	BH4 1.4-1.45	1.4-1.45	5.59	4.97	0.62	2	no	21.5	SM	
13	BH5 0.2-0.3	0.2-0.3	5.59	3.52	2.07	2	no	30.2	CH	
14	BH5 0.4-0.5	0.4-0.5	6.04	3.82	2.22	2	no	25.5	CH	orange/yellow mottling, strong sulfur odour
15	BH5 0.7-0.8	0.7-0.8	5.96	3.67	2.29	2	no	25.6	SC	
16	BH5 1.1-1.2	1.1-1.2	6.78	1.56	5.22	2	no	55	SC	
17	BH6 0.6-0.7	0.6-0.7	6.03	4.22	1.81	1	no	24.2	SP	
18	BH6 0.8-0.9	0.8-0.9	5.42	3.68	1.74	2	no	22.9	SP	
19	BH6 1.0-1.1	1.0-1.1	6.15	3.39	2.76	1	no	23.6	SM	
20	BH6 1.3-1.45	1.3-1.45	5.93	4.83	1.10	1	no	21	SM	
21	BH7 0.0-0.1	0.0-0.1	4.9	3.82	1.08	2	no	21.6	CH	
22	BH7 0.2-0.3	0.2-0.3	4.88	3.50	1.38	1	no	21.1	CH	orange and brown mottling
23	BH7 1.0-1.15	1.0-1.15	5.67	2.78	2.89	2	no	22.6	SC	
24	BH7 1.5-1.7	1.5-1.7	5.16	3.92	1.24	2	no	23.6	SC	
25	BH7 2.0-2.25	2.0-2.25	6.35	1.90	4.45	3	no	>51.7	SC	
26	BH8 0.4-0.5	0.4-0.5	5.92	3.85	2.07	2	no	21.9	SP	
27	BH8 0.8-0.9	0.8-0.9	5.09	3.36	1.73	2	no	23.7	SP	
28	BH8 1.3-1.45	1.3-1.45	6.26	3.29	2.97	2	no	23.5	CH	
29	BH8 1.7-1.8	1.7-1.8	6.42	3.44	2.98	3	no	41.5	CH	
30	BH8 2.0.2.1	2.0.2.1	6.33	3.11	3.22	2	no	28.5	CH	
31	BH9 0.05-0.1	0.05-0.1	4.68	4.24	0.44	2	no	27.1	CH	
32	BH9 0.4-0.5	0.4-0.5	4.72	3.56	1.16	2	no	25.3	CH	
33	BH9 0.5-0.6	0.5-0.6	5.14	3.93	1.21	2	no	23.1	SM	
34	BH9 1.2-1.3	1.2-1.3	5.35	1.64	3.71	2	no	32.8	SM	
35	BH9 1.65-1.75	1.65-1.75	5.71	2.57	3.14	2	no	21.9	SM	

Notes

1. No visible effervescence = 1, Slight to moderate reaction = 2, Vigorous effervescence = 3

2. SM = silt sands / sand-silt mixtures , SC = clayey sands / sand-clay mixtures, SP = porrly graded to uniform sands, Pt = highly organic soils, CH = high plasticity clays

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Client: Department of Planning
Title: Stage 2 : Acid Sulfate Soil Assessment Williamtown Employment Zone
Job No: 221280801

Table A2: sPOCAS Laboratory Results

Sample ID	Depth (m)	Map Class	pH_{KCl}	pH_{ox}	TAA (mole H+ /tonne)	TPA (mole H+ /tonne)	TSA (mole H+ /tonne)	Peroxide Oxidisable Sulfur (sulfur units) % S	Peroxide Oxidisable Sulfur (acidity units) (mole H+ /tonne)
BH3 0.5-0.6	0.5-0.6	HIGH (1-3 m)	4.8	4	33	44	11	<0.02	<10
BH5 0.4-0.5	0.4-0.5	HIGH (1-3 m)	4.6	4.2	69	165	96	0.04	28
BH5 1.1-1.2	1.1-1.2	HIGH (1-3 m)	4.7	2.1	50	537	487	0.61	382
BH6 1.0-1.1	1.0-1.1	LOW (> 3 m)	5.4	3.3	18	66	48	<0.02	<10
BH7 1.0-1.15	1.0-1.15	HIGH (1-3 m)	4.8	2.9	40	143	103	0.22	140
BH7 2.0-2.25	2.0-2.25	HIGH (1-3 m)	6.6	2.4	<2	276	276	0.54	336
BH8 0.8-0.9	0.8-0.9	HIGH (1-3 m)	4.9	3.8	21	34	12	0.03	18
BH8 1.7-1.8	1.7-1.8	HIGH (1-3 m)	4.6	4.2	84	154	70	0.08	47
BH9 1.2-1.3	1.2-1.3	HIGH (1-3 m)	5	2.8	25	87	62	0.13	79
BH9 1.65-1.75	1.65-1.75	HIGH (1-3 m)	5	2.8	23	98	75	0.12	77

Sample ID	Depth (m)	Map Class	Neutralising Capacity % $CaCO_3$	Net Acidity (sulfur units) % S	Net Acidity (acidity units) (mole H+ /tonne)	Liming Rate (1.5 saftey factor) (kg $CaCO_3$/tonne)
BH3 0.5-0.6	0.5-0.6	HIGH (1-3 m)	ND	0.05	33	2
BH5 0.4-0.5	0.4-0.5	HIGH (1-3 m)	ND	0.16	97	7
BH5 1.1-1.2	1.1-1.2	HIGH (1-3 m)	ND	0.69	432	32
BH6 1.0-1.1	1.0-1.1	LOW (> 3 m)	ND	0.03	18	1
BH7 1.0-1.15	1.0-1.15	HIGH (1-3 m)	ND	0.29	180	14
BH7 2.0-2.25	2.0-2.25	HIGH (1-3 m)	ND	0.47	296	22
BH8 0.8-0.9	0.8-0.9	HIGH (1-3 m)	ND	0.06	39	3
BH8 1.7-1.8	1.7-1.8	HIGH (1-3 m)	ND	0.21	131	10
BH9 1.2-1.3	1.2-1.3	HIGH (1-3 m)	ND	0.17	104	8
BH9 1.65-1.75	1.65-1.75	HIGH (1-3 m)	ND	0.16	100	8

NOTE:
*ND = Not Determined
TAA - Titratable Actual Acidity
TPA - Titratable Peroxide Acidity
TSA - Titratable Sulfidic Acidity

Appendix C

Laboratory Certificates and Chain of Custody

ALS Environmental

CERTIFICATE OF ANALYSIS

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Facsimile	: 02 4979 9988	Facsimile	: +61 (07) 3243 7259		
Project	: 221280801 Land Use Strategy	Quote number	: EN/005/05	Date received	: 5 Oct 2006
Order number	: 2290731			Date issued	: 19 Oct 2006
C-O-C number	: - Not provided -			No. of samples	- Received : 10
Site	: Williamtown				Analysed : 10

ALSE - Excellence in Analytical Testing

NATA Accredited Laboratory 825

This document is issued in accordance with NATA's accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Position	Department
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics - NATA 825 (818 - Brisbane)

ALS Environmental

Analytical Results

Analyte	CAS number	LOR	Units	Client Sample ID : BH3 0.5-0.6	BH5 0.4-0.5	BH5 1.1-1.2	BH6 1.0-1.1	BH7 1.0-1.15
Sample Matrix Type / Description :				SOIL	SOIL	SOIL	SOIL	SOIL
Sample Date / Time :				(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)
Laboratory Sample ID :				EB0609847-001	EB0609847-002	EB0609847-003	EB0609847-004	EB0609847-005
EA029-A: pH Measurements								
pH KCl (23A)		0.1	pH Unit	4.8	4.6	4.7	5.4	4.8
pH OX (23B)		0.1	pH Unit	4.0	4.2	2.1	3.3	2.9
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)		2	mole H+ / t	33	69	50	18	40
Titratable Peroxide Acidity (23G)		2	mole H+ / t	44	165	537	66	143
Titratable Sulfidic Acidity (23H)		2	mole H+ / t	10	96	487	48	103
sulfidic - Titratable Actual Acidity (s-23F)		0.02	% pyrite S	0.05	0.11	0.08	0.03	0.06
sulfidic - Titratable Peroxide Acidity (s-23G)		0.02	% pyrite S	0.07	0.26	0.86	0.10	0.23
sulfidic - Titratable Sulfidic Acidity (s-23H)		0.02	% pyrite S	<0.02	0.15	0.78	0.08	0.16
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)		0.02	% S	<0.02	<0.02	0.11	<0.02	<0.02
Peroxide Sulfur (23De)		0.02	% S	<0.02	0.04	0.72	<0.02	0.22
Peroxide Oxidisable Sulfur (23E)		0.02	% S	<0.02	0.04	0.61	<0.02	0.22
acidity - Peroxide Oxidisable Sulfur (a-23E)		10	mole H+ / t	<10	28	382	<10	140
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)		0.02	% Ca	<0.02	0.29	0.22	0.08	0.11
Peroxide Calcium (23Wh)		0.02	% Ca	<0.02	0.30	0.18	0.09	0.11
Acid Reacted Calcium (23X)		0.02	% Ca	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Acid Reacted Calcium (a-23X)		10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)		0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)		0.02	% Mg	<0.02	0.11	0.03	<0.02	<0.02
Peroxide Magnesium (23Tm)		0.02	% Mg	<0.02	0.12	0.03	<0.02	<0.02
Acid Reacted Magnesium (23U)		0.02	% Mg	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Acid Reacted Magnesium (a-23U)		10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)		0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
EA029-H: Acid Base Accounting								
ANC Fineness Factor		0.5		1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)		0.02	% S	0.05	0.16	0.69	0.03	0.29
Net Acidity (acidity units)		10	mole H+ / t	33	97	432	18	180
Liming Rate		1	kg CaCO3/t	2	7	32	1	14

ALS Environmental

Surrogate Control Limits

- No surrogates present on this report.

ALS Environmental

CERTIFICATE OF ANALYSIS

Client	: GHD SERVICES PTY LTD	Laboratory	: ALS Environmental Brisbane	Page	: 1 of 5
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Project	: 221280801 Land Use Strategy	Quote number	: EN/005/05	Date received	: 5 Oct 2006
Order number	: 2290731			Date issued	: 19 Oct 2006
C-O-C number	: - Not provided -			No. of samples	- Received : 10
Site	: Williamtown				Analysed : 10

ALSE - Excellence in Analytical Testing

NATA Accredited Laboratory 825

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This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Position	Department
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics - NATA 825 (818 - Brisbane)

ALS Environmental

Analytical Results

Analyte	CAS number	LOR	Units	Client Sample ID : BH3 0.5-0.6	BH5 0.4-0.5	BH5 1.1-1.2	BH6 1.0-1.1	BH7 1.0-1.15
Sample Matrix Type / Description :				SOIL	SOIL	SOIL	SOIL	SOIL
Sample Date / Time :				(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)	(3 Oct 2006) (15:00)
Laboratory Sample ID :				EB0609847-001	EB0609847-002	EB0609847-003	EB0609847-004	EB0609847-005
EA029-A: pH Measurements								
pH KCl (23A)		0.1	pH Unit	4.8	4.6	4.7	5.4	4.8
pH OX (23B)		0.1	pH Unit	4.0	4.2	2.1	3.3	2.9
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)		2	mole H+ / t	33	69	50	18	40
Titratable Peroxide Acidity (23G)		2	mole H+ / t	44	165	537	66	143
Titratable Sulfidic Acidity (23H)		2	mole H+ / t	10	96	487	48	103
sulfidic - Titratable Actual Acidity (s-23F)		0.02	% pyrite S	0.05	0.11	0.08	0.03	0.06
sulfidic - Titratable Peroxide Acidity (s-23G)		0.02	% pyrite S	0.07	0.26	0.86	0.10	0.23
sulfidic - Titratable Sulfidic Acidity (s-23H)		0.02	% pyrite S	<0.02	0.15	0.78	0.08	0.16
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)		0.02	% S	<0.02	<0.02	0.11	<0.02	<0.02
Peroxide Sulfur (23De)		0.02	% S	<0.02	0.04	0.72	<0.02	0.22
Peroxide Oxidisable Sulfur (23E)		0.02	% S	<0.02	0.04	0.61	<0.02	0.22
acidity - Peroxide Oxidisable Sulfur (a-23E)		10	mole H+ / t	<10	28	382	<10	140
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)		0.02	% Ca	<0.02	0.29	0.22	0.08	0.11
Peroxide Calcium (23Wh)		0.02	% Ca	<0.02	0.30	0.18	0.09	0.11
Acid Reacted Calcium (23X)		0.02	% Ca	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Acid Reacted Calcium (a-23X)		10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)		0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)		0.02	% Mg	<0.02	0.11	0.03	<0.02	<0.02
Peroxide Magnesium (23Tm)		0.02	% Mg	<0.02	0.12	0.03	<0.02	<0.02
Acid Reacted Magnesium (23U)		0.02	% Mg	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Acid Reacted Magnesium (a-23U)		10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)		0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
EA029-H: Acid Base Accounting								
ANC Fineness Factor		0.5		1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)		0.02	% S	0.05	0.16	0.69	0.03	0.29
Net Acidity (acidity units)		10	mole H+ / t	33	97	432	18	180
Liming Rate		1	kg CaCO3/t	2	7	32	1	14