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Marsden Park Developments Pty Ltd

Preliminary Report for Marsden Park Industrial Precinct

Geotechnical Assessment

May 2009

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

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1. Executive Summary

1.1 Introduction

GHD Pty Ltd (GHD) Geotechnics has undertaken a Planning Level Preliminary Geotechnical Assessment of an approximately 570 ha area of land off Richmond Road, Marsden Park, NSW. This work was conducted concurrently with a preliminary contamination assessment (Phase 1/ Phase 2) carried out by GHD's Contaminated Lands Group (CLG). The site assessed comprises the Marsden Park Industrial Precinct (MPIP), as shown on Figure 1, which is part of the North West Growth Centre.

The site currently includes both industrial and rural/residential development, and is earmarked for re-zoning and re-development as industrial/employment land, with likely small areas of public open space and residential development.

Preliminary geotechnical advice was prepared based on a desktop study and site observations conducted by GHD Geotechnics in August 2008. Based on this preliminary study, geotechnical input was provided into a Sampling Analysis and Quality Plan (SAQP) being prepared by CLG, for the intrusive (Phase 2) contamination investigations (reported under separate cover).

The preliminary geotechnical advice identified a number of different geotechnical zones within the site - dependent on topography, geology, drainage, soil landscape and previous land use. Data from the SAQP was utilised to augment/confirm these geotechnical zones.

Objectives

The objectives of the preliminary geotechnical assessment were to:

- Provide a preliminary model of the geotechnically-related characteristics and constraints within the Site.
- Provide a description of the impact of the geotechnically-related characteristics and constraints on the proposed site development.
- Develop preliminary geotechnical management requirements pertinent to the proposed development.

Scope of Works

The scope of work completed by GHD included the following:

- A desktop study.
- A site walkover and surface soil/water sampling.
- Input into SAQP for geotechnical assessment purposes.
- Geotechnical testing of intrusive investigation soil and groundwater samples.
- Preparation of a preliminary (planning level) geotechnical report

Summary of Investigation Results

The findings of the planning level geotechnical assessment indicate that, apart from the quarry/landfill disturbed area, there do not appear to be any major underlying geotechnical issues that would prevent development of the site. The following generalised geotechnical characteristics have been identified:

- The presence of dispersive and reactive clay soils within the regolith (soil cover to bedrock) across the site.
- Residual soils are present away from creek lines.
- Quaternary Alluvium exists in the vicinity of major creek lines (sand, silt and clay).
- Remnant Tertiary Alluvium is located higher in the landscape.
- Bedrock, which is anticipated to be at moderate depth in the gently sloping lower landscape and at shallow depth higher in the landscape, is expected to comprise predominantly shale with minor sandstone.
- A quarried/landfilled igneous intrusion (diatreme) is located in the central west of the site.
- Seepage lines, dams and some shallow to moderate filling are present in the valley floor and gentle valley slope areas.
- Localised (shallow) cut to fill, associated with existing residential & light commercial development, was observed in some areas.
- Existing deeper cuts, fill and stockpiled excavation material, associated with the quarrying and landfill operations, was noted in the vicinity of the quarry/landfill area.

These characteristics, and the associated geotechnical constraints within different geotechnical domains are discussed within this report.

Supplementary geotechnical investigations and monitoring are recommended for assessing any proposed development options within the disturbed quarry area.

2. Introduction

2.1 General

This report presents the results of geotechnical desktop study and walkover investigations undertaken by GHD Geotechnics in order to provide a preliminary level geotechnical assessment for potential rezoning and development of the site, known as the Marsden Park Industrial Precinct (MPIP), as shown on Figure 1. This assessment was undertaken in conjunction with our preliminary salinity assessment of the site, which is reported under separate cover (Doc ref: AZ127, dated February 2009).

The MPIP is part of the North West Growth Centre and is earmarked for re-zoning and re-development. The majority of the site will be re-developed as employment land, with a strip of mixed-use development proposed along Richmond Road.

The purpose of this report is to assist in the facilitation of the planning stage of this development.

The site is approximately 570 hectares in area and comprises 65 separate plots of land. The majority of the Site is under the ownership of Ganlan Pty Ltd. The remainder of the Site is owned by private landowners, the Town and Country Caravan Park, Valad Property Group, the Ahmadiyya Muslim Association of Australia, Winten Property Group, the RTA and small businesses along Richmond Road.

The purpose of the preliminary geotechnical assessment was to assess the various geotechnical domains within the site, and to provide description of the impact of the geotechnical characteristics and constraints for assistance in planning of the potential future development.

2.2 Scope of Work

The scope of the geotechnical assessment included:

- A desktop study of published information on topographical, geological and soil landscape information pertinent to the site.
- Engineering geological review of aerial photography, both recent and historical, of the site area.
- Site walkover/observations to provide ground truthing by a Principal Geotechnical Engineer.
- Input into Sampling and Analysis Plan (SAQP) for geotechnical selection and assessment of samples obtained in the Phase 2 intrusive Contamination investigations.
- Preparation of a preliminary (planning level) geotechnical report.

2.3 Limitations

This report has been prepared for the use of Marsden Park Developments Pty Ltd (MPD) in relation to the rezoning investigations and development for the Site, and comprises preliminary appraisal/comments for planning purposes only.

This report should be read in conjunction with the attached General Notes.

3. Desk Study Review

3.1 Reference Documentation

The following published documentation was referenced in the desktop study:

- DIPNR Map of Salinity Potential for Western Sydney 2002.
- Geological Series Sheet 9030 for Penrith (1:100,00 scale)
- Soil Landscape Series Sheet 9030 for Penrith (1:100,000 scale)
- Topographic Map for Riverstone 9030-I-S (1:25,000 scale).
- Aerial photographs covering the site.

3.2 Site Setting

The site, as shown on Figure 1, is located off Richmond Road, Marsden Park, NSW, approximately 500m north west of the M7 Westlink freeway.

Land in close proximity to Bells Creek, which runs south to north along the eastern boundary of the Site is understood to be affected by potential flooding.

3.3 Topography

Contours as shown on Figure 1 illustrate the site topography. Apart from the south-east section of the site (east of Bells Creek), the main site area slopes gently to the west and east from a central ridge running SE-NW. The highest point on the site lies near the central southern boundary at about RL 60m AHD. In the east, along Bells Creek the elevation ranges from about RL25-30m AHD and in the west, from about RL 35-40m AHD. The far south-east portion of the proposed development, east of Bells Creek straddles a north-south trending ridge, with steeper slopes present on the east side of this ridge (circa 1V:5H to 1V:10H).

Drainage courses/tributaries form minor valleys that drain to Bells Creek in the east and to South Creek in the west.

The topography around the existing waste facility in the central north-west of the site has been altered by quarrying and stockpiling operations, as indicated by the concentration of 40-50m AHD contours in this area (refer Figure 1).

3.4 Soil Landscapes

The soils landscapes, as shown on Figure 2, include Berkshire Park (fluvial) Landscape comprising a significant portion of the western site area. However, reference to the Geological mapping (Figure 3) shows this area to comprise Bringelly Shale (residual) strata. Limited field observations and sampling indicates this area is residual (consistent with the geological mapping), with localised (fluvial) deposits present only in the vicinity of creeks and drainage lines.

Also as shown on Figure 2, most of the site is shown situated on the Blacktown Unit landscape with a zone of South Creek (fluvial) landscape running north-south in the vicinity of Bells Creek.

The Blacktown soil landscape is described as a 'Residual Landscape' with gentle undulating rises on Wianamatta Group (shale) bedrock. The soils typically comprise hard setting, mottled texture contrast soils, including shallow (<1.5m) red and brown podsols on the crests, grading to deeper (>2m) yellow podsols on the lower slopes and near drainage lines. This landscape is associated with dryland salinity, low to very low permeability soils, which are moderately to highly reactive and dispersive. Waterlogging and known salinity hazard is common in streamlines. This unit typically has a high capability for urban development, when conducted with appropriate salinity and geotechnical design measures.

The South Creek soil landscape is described as a 'Fluvial Landscape' comprising floodplains, valley flats and drainage depressions on the Cumberland Plain. It is typically flat with incised channels and predominantly cleared. The soils are often deep consisting of alluvium over residual clays/bedrock. This landscape is also associated with known salinity hazard, flood hazard, localised moderately reactive and dispersive/erodable soils. This unit generally typically has a low capability for urban development due to flood hazard/erosion, varying alluvial soils and salinity.

The Berkshire Park soil landscape is described as a 'Fluvial Landscape' comprising gently undulating rises of Tertiary alluvium terraces of the Hawkesbury/Nepean river system. The soils typically comprise 'heavy' clays and clayey sands with silcrete (cemented) cobbles and boulders. This unit, which apart from a small segment in the north-west corner of the site is expected to lie outside of the proposed development, appears to have significant capability for urban development when conducted with appropriate salinity and geotechnical design measures, and subject to floodplain considerations. Stated limitations are very high wind erosion potential, gully, sheet and rill erosion on dissected areas, waterlogging and impermeable soils.

3.5 Geology

Reference to the 1:100,000 scale Geological Series Sheet for Penrith (sheet 9030) indicates that most of the site is underlain by Bringelly Shale of the Wianamatta Group (refer to Figure 3).

Bringelly Shale, which was formed as an alluvial and estuarine coastal plain (saline) deposit, generally forms the slopes and upper landscape within the site, and comprises essentially shale, carbonaceous claystone, claystone, laminsite, fine to medium grained quartz-lithic sandstone, with rare coal and tuff. Claystone and siltstone are normally dominant. The Bringelly Shale contains swelling clay minerals that can result in ready disintegration of the rock fabric on immersion in fresh water (apart from the Minchinbury Sandstone basal unit) and is generally less durable on exposure than the underlying Ashfield Shale (also Wianamatta Group).

Quaternary alluvium is shown to underlie the area in the vicinity of Bells Creek, and is inferred in the vicinity of the tributary creeks/drainage lines, though not shown at the 1:100,000 scale mapping. Quaternary Alluvium typically comprises fine grained sand, silt and clay. The nature of the alluvium is variable and depends on the lithology of the source material and characteristics of the depositional stream flow. It is often poorly drained and subject to flooding.

St Marys Formation Tertiary alluvium (Ts) is shown over the ridge previously described as trending in a north-south direction across the far south-east portion of the site (east of Bells Creek). The Ts is present as a remnant alluvial terrace, with a moderate to steep slope down towards lower ground in the east. This strata, which typically comprises clay and sands deposited in the Tertiary Period (older than the Quaternary deposits), can be ferruginously cemented.

Londonderry Clay Tertiary alluvium (Tl), which comprises clay with minor sand and ferruginous cementation, shown to underlie a small zone on north-west corner of the site.

Volcanic Breccia Daltrome (Jv). The site area has been intruded by volcanic activity, which formed the large volcanic breccia diatrome shown in the central west of the site (refer Figure 3). This intrusion has been quarried in order to provide gravel.

Diatremes are generally considered to be the result of a volcanic eruption. Their composition can be highly variable, with the rapid expulsion of volcanic material and host rock, and collapse of surrounding material forming breccia (variously a mixture of pyroclastics, ash, shale and sandstone). Diatremes may present adverse conditions for excavation and for founding strata.

Igneous (basaltic or doleritic) dykes and joint swarms may also exist in the surrounding region, due to the past volcanic activity. Dykes are linear, sub-vertical volcanic intrusions of variable width (general in the range of 0.3 to 3 m, though can be wider). At the surface, dykes in the Sydney Region are generally weathered back to clay (and may not be noted when encountered in residual clays of the Bringelly Shale due to similar surface weathering). As such, undetected dykes may be present in this region. Joint swarms are closely spaced sub-vertical joint sets, which occur as a result of tectonic stresses/movements, and may be more prevalent in areas of volcanic activity. The presence of dykes and joint swarms could to lead to concentration of seepage (drainage issues) and to difficult excavation/founding conditions.

Saline groundwater is typically expected within the Bringelly Shale and Quaternary Alluvium, with joints and more permeable horizons within the bedrock expected to be the main avenues for groundwater migration.

3.6 Salinity Potential

The site is shown on the Salinity Potential Map for Western Sydney (DIPNR 2002), reproduced in part on Figure 4, to lie within an area of moderate salinity potential, with high salinity potential in the vicinity of the creek and drainage lines.

Areas of moderate salinity potential generally consist of areas susceptible to saline affectation if disturbed, particularly if saline groundwater/seepage is intercepted and/or if areas of water-logging can occur. These areas are generally higher in the landscape where the geology pre-disposes a site salinity potential.

High saline risk zones occur generally lower in the landscape, or at permeability contrasts, where saline groundwater may come within close proximity to the ground surface or where seepage causes waterlogged conditions, thereby concentrating salts. Typically scattered saline indicator vegetation occurs in these areas.

Dispersive erosion is often a feature of the soils in such dryland salinity areas.

Areas with moderate salinity potential, if managed inappropriately can lead to worsening salinity conditions creating high salinity potential and salinity outbreaks, and to increased off-site discharge of saline water. Such areas are also often prone to dispersive soil erosion.

3.7 Groundwater

Perched (saline) groundwater may be present within any localised (shallow) filled areas and generally within the soils in the lower landscape.

Saline groundwater is also expected to be present at relatively shallow depth in the lower landscape, hosted by fracturing/jointing within the Wianamatta Shales. This groundwater is likely to have some connectivity within Quaternary Alluvium (if present).

The 1:2 000 000 Department of Water Resources Groundwater in NSW, Assessment of Pollution Risk map indicates that the groundwater salinity is >14 000mg/l and therefore unsuitable for stock use. This map also indicates that the site is likely to be underlain by shales and that the potential for groundwater movement is likely to be low.

3.8 Aerial Photograph Interpretation

Aerial photo sets taken in the period 1947 to 2005 were viewed through a stereoscope and the following observations were made;

- The major change to the Site area has been the formation of the quarry/landfill area (GD5) and associated filling to the south-west (GD5a) of the quarry area. Both the quarry area and the fill area to the south-west (SWF) are shown approximately on Figure 1.
- The vegetation has changed from grasses with sparse tree coverage to essentially cleared and grassed land, with some localised areas of denser tree cover, and with the ongoing earthworks within the quarry site.
- The SWF appears to have covered the north-east branch of a tributary watercourse that drained to the south-west. Changes to the natural drainage within this area are likely to have lead to water-logging of the site soils. As far as we are aware the SWF has not been placed as a controlled (engineered) fill.

4. Investigation Procedure

4.1 Site Walkover

Site walkovers were conducted on 8 August 2008 and 15 December 2008 by a Principal engineer from this office, who also conducted the site salinity observations and associated surface soil and water sampling.

Locations of photographic observations were recorded using a hand held autonomous GPS unit, which is generally accurate to within about 10m of the grid position.

The locations of the referenced observations are shown on Figure 5 'Geotechnical Domains'

Selected photographs are presented in Appendix A.

4.2 Geotechnical Laboratory Testing

A number of samples collected during the SAQP were tested for geotechnical assessment purposes as follows:

- 8 field moisture content and Atterberg limit tests.
- 11 Emerson crumb dispersive erosion tests.

The results of the geotechnical laboratory testing are summarised in Table 1, and the laboratory test certificates are provided in Appendix B.

5. Geotechnical Investigation Results

5.1 Walkover Observations

The geotechnical observations made on the walkovers are presented below:

- Surface and ponded water was observed in the higher landscape to the east of the quarry. This is inferred due to quarry/landfill operations. Refer P1, P2.
- Stockpiles of excavated material were observed to the north-west of the quarry. Refer P3.
- The dispersive nature of the site soils was evident from observed erosion gullies and dispersed clay areas such as seen in P4 in the lower landscape.
- Areas of localised filling were reported in the Phase 2 Contamination report, as well as filling greater than 2.5m thick in the SWF. P4 provides a view over the SWF from the west.
- Wetter zones were noted downstream of a number of dams. Such zones are typically the result of seepage/elevated groundwater within the lower landscape, which is elevated by the presence of the dam. Refer P5. Typically in dispersive clay environments, such as indicated for much of the site area, such seepage can lead to dispersive erosion (piping) failure.
- Stockpiles of excavated material were also observed to the east of the quarry. Refer P6.
- The Minchinbury Sandstone unit was not observed as outcrop nor recorded within the Phase 2 contamination investigation borehole logs (reported under separate cover) but, if encountered within the bedrock, is expected to lead to a permeability contrast with increased seepage issues.
- Access to the steeper area of Tertiary alluvium in the south-east of the Site was difficult/distant from Richmond Road on the west and restricted by the M7 motorway on the south. Accordingly, this area of the site was not accessed during the walkover activities. The steeper topography on the east slopes suggests a stronger (cemented?) soil structure may be present here, but potential soil creep and instability on this slope is also possible.

5.2 Geotechnical Test Results

The results of the geotechnical testing conducted on the SAQP samples are summarised in Table 1 below:

Geotechnical Test Results – SAQP Holes **TABLE 1**

Test Hole	Depth (m)	Description	FMC (%)	Atterberg Limits LL/PI/PL (%)	Emerson Class
BH1	2.0	Grey Brown Clay (CH)	15.1	68/46/22	1
MW4	1.0	Grey Brown Clay (CH)	25.4	74/49/25	3(s)
MW4	2.0	Grey Clay (CH)	-	-	4
MW4	3.0	Grey red Clay/XWShale (CI)	-	-	4

TP8	0.6	Grey brown Clay with XW Shale gravel (CI)	12.4	41/21/20	3(c)
TP10	1.1	Red grey Clay with ironstone gravel (CH)	23.8	76/52/24	3(s)
TP19	0.8	Light brown sandy Clay (CI)	-	-	1
TP19	1.9	Brown sandy Clay (CI)	-	-	2(m)
TP29	0.8	Orange grey Clay with minor Shale gravel (CH)	20.8	66/44/22	4
TP29	2.1	Grey red Clay with XW Shale gravel (CH)	16.1	60/37/23	-
TP35	0.9	Orange grey Clay occasional Shale gravel (CH)	19.7	65/41/24	1
TP35	1.7	Grey red Clay with XW Shale (CH)	14.4	51/30/21	1

The results indicate that the site soils encountered comprised generally medium to high plasticity (moderately to highly reactive) clays which range from non-dispersive (Emerson Class 4) to highly dispersive (Emerson Class 1).

The locations of the above test holes are shown on Figure 5.

6. Geotechnical Domains

6.1 Summary

The following summary comments are provided regarding the geotechnical characteristics and constraints of the Site:

- Essentially five Geotechnical Domains (GD1-GD5) have been identified based on the investigations described herein. These domains are shown on Figure 5.
- Apart from the quarry/landfill site (GD5), there appear to be no underlying geotechnical issues noted that would prevent development of the site from a geotechnical perspective, following detailed geotechnical subsurface investigations to address specific development proposals.
- Further investigations and detailed delineation of the areas affected by quarrying will be need to be conducted within GD5 in order to define what potential development options might apply to these areas.
- The use of the creek/Quaternary alluvium areas for riparian corridors, as shown on the Draft Indicative Layout Plan provided to us, is consistent with avoiding those potentially more problematic saline/geotechnical domains for development.
- Development in the south-west will need to take account of the significant depth of uncontrolled fill (1m to > 2.5m) recorded in the contamination investigation test pits within GD5a (Lots 35 & 36 of DP 262886).

The Geotechnical Domains, together with preliminary geotechnical comments for the proposed development are described below.

6.2 GD1 - Bringelly Shale

Domain GD1 covers most of the site area and includes the following geotechnical characteristics:

- The topography comprises generally gently to moderately sloping hills
- Dispersive and reactive clay soils of low to very low permeability are present within the regolith (soil cover to bedrock).
- The site soils are prone to salinity issues due to the connate salts contained in the parent bedrock (Wianamatta Shale), the atmospheric salt load and the generally low permeability of the site soils.
- Residual soils are present away from creek lines.
- Alluvium is present in the vicinity of major creek lines (discussed under GD4).
- Shale bedrock is anticipated at moderate depth in the gently sloping lower landscape.
- Shale with minor siltstone and possibly fine-grained sandstone bedrock is anticipated at shallow depth higher in the landscape.
- An igneous intrusion (Quarry site), which is treated as a separate Geotechnical Domain (GD5) is surrounded by GD1.

- Groundwater migration is generally controlled by joints and permeability contrasts within the bedrock. Perched groundwater exists in the residual clays and at permeability contrasts such as fine grained sandstone/shale.
- Seepage lines and dams exist in the valley floor (wet) areas - lower landscape.
- Given the dispersive and reactive nature of the site clays, water management and in particular drainage will be important in controlling reactive soil movements, dispersive soils erosion and water-logging issues.
- Lime stabilisation of the surface (say 0.3m) of building platforms formed in clay may be found to be beneficial in controlling excessive (dispersive) erosion, shrink/swell movement and to improve traffickability.
- Detailed drainage design measures and surface profiling to manage/control stormwater runoff and seepages will be important both during and after construction, in order to reduce erosion, to prevent water logging and to reduce associated shrink/swell movements by limiting soil wetting and drying depths.
- Batter slopes may need to be flatter than required purely for geotechnical stability purposes. Alternatively batters might be protected by using chemical/physical treatment layers such as gypsum/lime stabilisation for clay and shotcrete or other 'engineered' cover to bedrock exposed in cuttings.
- Early establishment of topsoil/mulch and vegetation will assist in reducing erosion, particularly on batters/sloping ground.

6.3 GD2 - Tertiary Alluvium (Tl and Ts)

Domain GD2 comprises remnant clay and sand alluvium of the Londonderry Clay (Tl) and the St Marys (Ts) Formations, which were deposited in the Tertiary Period (pre-dating the Quaternary alluvium deposits). These deposits can be ferruginously (iron) cemented and lateritic (containing significant ironstone gravel). It is anticipated that the GD2 deposits will in general be reasonably good construction/founding materials for development purposes, but can be variable and will need to be 'proved' for use as engineering materials for any given development.

The ferruginously cemented nature of some of these deposits, particularly the 'Ts' strata, may also lead to difficult excavation in some areas.

6.4 GD3 - Tertiary Alluvium Steeper Slopes

Domain GD3 comprises the steeper slopes shown in the site topography on the eastern side of Tertiary Alluvium ridge 'Ts' deposits. The steepness of this terrain is inferred to arise from higher strength (cemented) soils. It has been identified as a separate domain which has potential slope stability issues that will need to be addressed for future development (if occurring) on these slopes.

6.5 GD4 - Quaternary Alluvium

Domain GD4, the Quaternary alluvium, comprises typically varying amounts of fine grained sand, silt and clay. The nature of the alluvium depends on the lithology of the source material and characteristics of the depositional stream flow. The alluvium presents more problematic founding conditions for the built

environment than do the residual soils, due to the generally poor and variable geotechnical engineering properties and varying depth of alluvium.

The alluvium can also be dispersive and saline, and is likely to be affected by waterlogging/perched groundwater and flooding.

Accordingly, this alluvium, where present in significant depth is more suited to wetland features/riparian zones within development options.

6.6 GD5 – Quarry/Landfill Site

Domain GD5 contains a previously quarried volcanic breccia/basalt intrusion that is now being utilised for landfilling. Excavations of both the igneous material and some of the surrounding clay/shale have occurred in the past. It will be necessary to define the past excavations/filling in terms of location, depth and nature (e.g.,using historical records, boreholes, Ground Penetrating Radar etc as necessary), in order to assess this site for any envisaged development purpose. In particular, the potential for methane production and migration through joints in the bedrock will also need evaluation for any adjacent development (refer to contamination study).

The extent of the area within GD5 that is not affected by igneous intrusion or by deep excavation/fill needs to be delineated, in order to allow such land to be developed under similar geotechnical constraints to geotechnical domain GD1, subject to any contamination and landfill gas issues.

Areas of igneous intrusion, not affected by significant excavation/fill will require geotechnical investigation to determine appropriate development parameters for such potentially geotechnically variable zones. Moreover, particular care will need to exercised in geotechnical design where the proposed development crosses both igneous and sedimentary geology, due to the likely very different geotechnical properties of these strata.

Areas affected by deeper excavation/filling will need separate assessment for development options. Such assessment should include determining the excavated profile, the nature and condition of the backfill, the condition of the underlying strata, and any contamination/landfill gas constraints.

Potential land use in the deeper excavation areas could possibly include activities such as hardstand (storage) areas, which are less likely to be affected by ongoing settlements than other forms of development. Where the excavation/fill is shallower (say <5m), piled foundations or impact/dynamic compaction may be suitable as development options, subject to geotechnical assessment. Any development considered for such areas will need detailed geotechnical investigation/assessment and may be subject to contamination/landfill gas constraints.

Areas surrounding GD5 may have been affected to some degree by the quarrying operations. In particular, zone GD5a (as described below) has been extensively filled and irrigation inferred from quarry water management was observed east of GD5. This latter area may also have been affected by earthworks (disturbed ground noted), as evidenced by the cleared/disturbed apperance of this land, and by its proximity to the quarry. The potential for any existing filling should be investigated in this area.

Also, management of a potential increase in salinity concentrations and design measures to allow for subsequent drying shrinkage of the moderately to highly reactive clays will need to be addressed in areas that have been irrigated by the quarry operations over an extended period of time e.g., stiffer/deeper founding system and design for at least moderate exposure conditions as defined in AS2159 (Piling Code, 1995) may be required.

6.6.1 GD5a South-West Fill Area

This area, to the south-west of the quarry, appears to have been utilised for the storage of predominantly moderately to highly reactive clay fill, with some shale and sandstone, excavated from the quarry. Reference to Table 5 of the Phase 2 Contamination Report (ref: 145254) indicates that the fill in this area ranged from some 1m to >2.5m in thickness, where encountered in the SAQP test pits, and that this filling was placed over the existing topsoil/organic layers. The underlying strata is shown on the geological mapping to comprise Bringelly Shale (GD1) with Quaternary alluvium (GD4) inferred present in the vicinity of a tributary creek line bisecting the fill platform, and draining to the west.

Development of this area will need to take account of the presence of this fill, which does not appear to have been 'controlled'. The condition of this fill will need to be geotechnically assessed for the evaluation of geotechnical treatment/management options prior to development. Treatment, subject to any contamination status constraints, could include but is not limited to excavation, stripping of the old topsoil/organic layers and replacement as engineered fill (under controlled moisture conditioning and compaction) for at least part of this area, or excavation and beneficial re-use within the landfill as a cover material.

7. Discussion

Apart from the areas affected by quarrying and associated filling activities (GD5/5a), from a geotechnical perspective, urban development of the site is expected to be suitable, subject to geotechnical intrusive investigations and the development of detailed geotechnical design and site management measures described herein.

It is noted that there are a number of existing small (farm) dams in the lower slope areas and to a lesser in the upper slopes. It is considered unlikely that those existing dams will meet current engineering design requirements, particularly with respect to protection measures against dispersive soil (piping) failure, and thus they may require removal for urban development purposes.

New retention basins will need to be designed in accordance with best practice principles for dispersive and saline soil conditions.

Excavated residual clay soil/bedrock is expected to be suitable for re-use as engineered fill, subject to geotechnical investigations. However, given the expected dispersive and reactive potential of the clays and possibly some of the Bringelly Shale bedrock, the use of lime stabilisation in the surficial zone of proposed fill platforms in order to reduce the potential for softening and erosion, may assist in the construction process.

Typically low California Bearing Ratio (CBR) pavement strength values are anticipated for the site clays. Accordingly, preferential zoning of excavated bedrock into the top (select) zone of fill platforms for industrial development/roads may be an alternative to lime stabilisation. Such zoning, subject to geotechnical verification, is expected to achieve a stronger subgrade, which is both less reactive and less dispersive than the on-site clays.

The softer/wetter soils in the some valley floor areas may create difficult access conditions for earthmoving equipment such as scrapers, even if 'self elevating'. It is possible that some areas will require removal of localised softer zones using excavators and 4WD trucks (on prepared access tracks). Moreover, 'wet' clays are expected to require moisture conditioning (drying) prior to re-use as engineered fill.

Apart from the filling noted to the south-west of the quarry (GD5a), and within the quarry operations area itself (GD5), no other major fill areas were identified. GD5 and GD5a will require detailed geotechnical intrusive investigations in order to assess possible development options.

Comments on potential contamination issues for the Site materials are made under separate cover in the Phase 2 Contamination report.

References

1. Soil Conservation Service of NSW, Soil Landscape Series Sheet 9030, Penrith.
2. Geological Survey of NSW, Department of Minerals and Energy, Geological Series Sheet 9030, Penrith, Edition 1, 1991.
3. Dept Mineral Resources (1976), 'The Geology and Resource Potential of the Wianamatta Group', Chris Herbert, Bulletin No. 25.

Figures

1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

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

N

Legend

- Study Area
- Fill Area (Approx)
- Quarry & Landfill Area (Approx)
- Contours
  - Major
  - Minor

Locality Map

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AAP Corporation
Marsden Park Industrial Precinct
Geotechnical Investigation

Job Number	21-17717
Revision	A
Date	17 February 2009

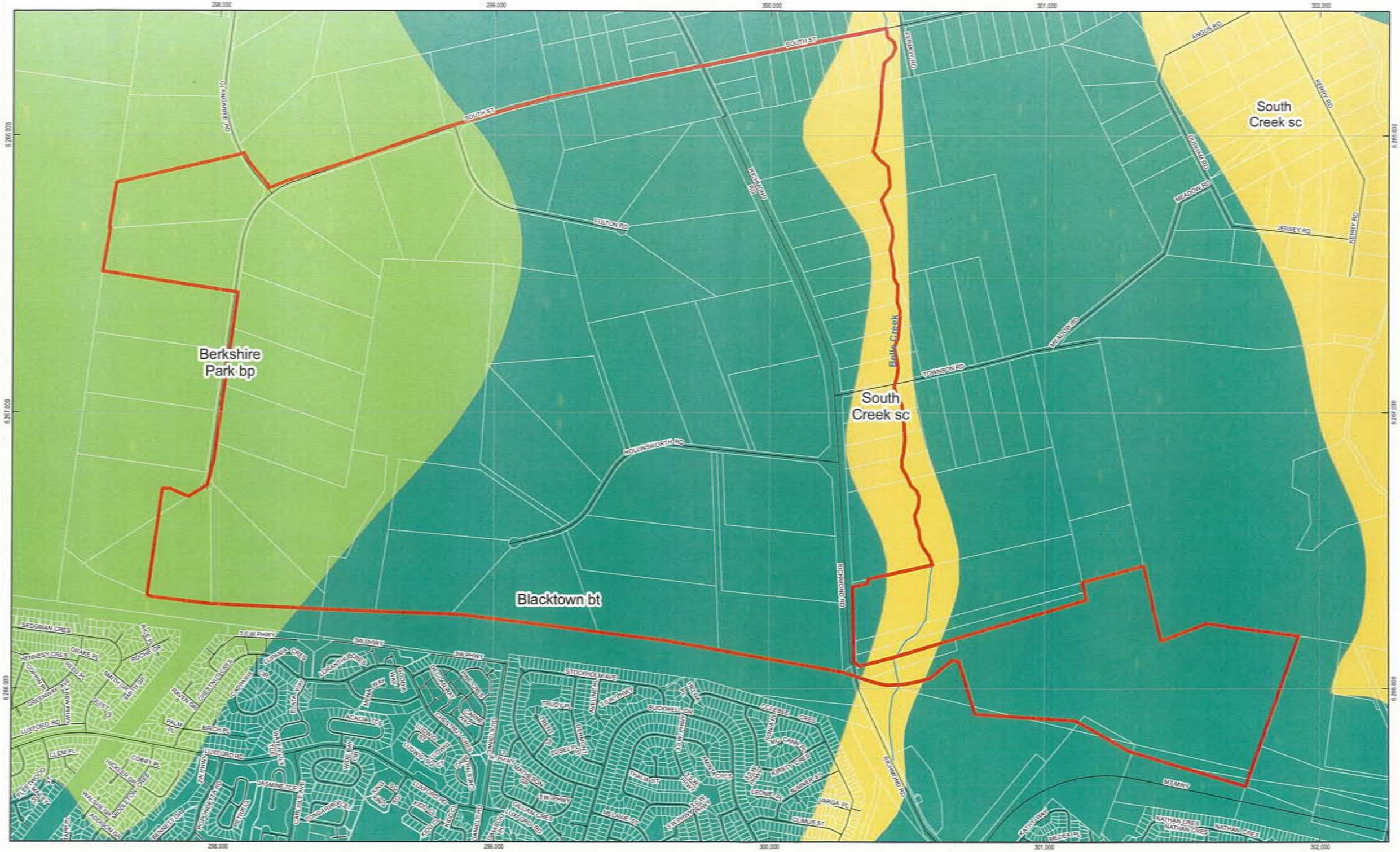
Site Location Plan

Figure 1

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG001.mxd

Data Source: Google Inc. Google Earth 2008 NSW Department of Lands Cadastre, Contours 2008 Created by: ppresvedoros, qichung, RCJOHNSON

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au



1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

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

N

Legend

Study Area
Cadastre
Roads
Soil Landscapes

Locality Map

SYDNEY

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Marsden Park Industrial Precinct
Salinityl Investigation

Job Number	21-17717
Revision	A
Date	12 February 2009

Soil Landscapes

Figure 2

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG002.mxd

Data Source: NSW DECC Penrith 1: 100K Sheet Soil Landscapes 1990 NSW Department of Lands Cadastre, Roads 2008 Created by: RCJOHNSON, rjohung

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Londonderry Clay, Tl

Volcaniic Breccia, Jv

Bringelly Shale, Rwb

Quaternary Alluvium, Qal

Quaternary Alluvium, Qal

Tertiary Alluvuim
St Marys Formation, Ts

Rwb

Jv13

Ts

SOUTH ST

RICHMOND RD

FULTON RD

SOUTH ST

HOLLINSWORTH RD

STOWNSON RD

MEADOW RD

DARNHAM RD

JERSEY RD

ANGUS RD

CREEK ST

BELLS CREEK

Bells Creek

LUXFORD RD

STOCKHOLM AVE

3W PHWY

MT MNY

298,000

299,000

300,000

301,000

302,000

6,268,000

6,267,000

6,266,000

1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

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

N

Legend

Study Area
Geology
Cadastre
Roads
Qal
Jv
Rwb
Ts
Tl

Locality Map

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AAP Corporation
Marsden Park Industrial Precinct
Geotechnical Investigation

Job Number 21-17717
Revision A
Date 13 May 2009

Geology

Figure 3

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG003.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW Department of Lands Cadastre, Roads 2008 NSW Department of Primary Industries Sydney 100K Sheet Geology 2005 Created by: RCJOHNSON

MAPPING CATEGORY	ASSOCIATED SOIL LANDSCAPES	LANDFORM - GEOLOGY
KNOWN SALINITY Areas where there is a known occurrence of saline soil or where air photo interpretation and field observations have confirmed more than one of these: a - scalding b - salt efflorescence c - vegetation dieback d - salt tolerant plant species e - waterlogging A high relative wetness index occurs in these areas.	* Salinity outbreaks occur in Blacktown (Bt), Luddenham (Ld) and Richmond (Rd) Soil Landscapes - common at breaks of slope, lower slopes and drainage lines. * Berkshire Park (Bp) and Upper Castlereagh (uc) Soil Landscapes have localised salinity due to the impermeable nature of the clay parent material. South Creek (sc), Monkey Creek (mk), Freemans Reach (fr), and Theresa Park (tp) Soil Landscapes have common saline outbreaks due to high run-on and low local relief. * Soils in the above landscapes have high clay content in subsoils and are imperfectly to poorly drained.	* Break of slope, lower slope and drainage lines of Wianamatta Shales (Rwb,Rwa and Rwm). * Localised salinity also occurs at the geological boundary between Tertiary Gravels (Ts, Tn) and underlaying Wianamatta Shales (Rwb) Rwa) Quaternary Alluvials (Qpd, Qpa, Qst, Qal). * Localised salinity occurs in Quaternary Alluvium (Qal, Qpn, Qpd) which underlies many of the drainage systems and wetland margins.
HIGH SALINITY POTENTIAL Areas where soil / geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to areas of known salinity (see above). These areas are most common in lower slopes and drainage systems where water accumulation is high (ie. high relative wetness index).	* Soil Landscapes include Birrong (bi), Blacktown (bt) Berkshire Park (bp), Freemans Reach (fr), South Creek (sc), Theresa Park (tp), Richmond (rn) and Luddenham (ld). Drainage systems and convergent slopes are areas of highest risk. * Soils in these landscapes have high clay content in the subsoils, low permeability and high run-on. * Soil profiles may display signs of high salt concentrations at depth (i.e. >8 5m).	* Salinity is most likely to occur in lower slopes, foot slopes, floodplains and creek lines on Quaternary Sediments (Qal, Qpn, Qpd, Qpa, Qpb, Qha) Wianamatta Shales (Rwb, Rwm, Rwa) where run-on is high, resulting in seasonally high water tables and soil saturation.
MODERATE SALINITY POTENTIAL Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and eucalypt vegetation have been noted but no concentrations have been mapped. Saline areas may occur in this zone, which have not yet been identified or may occur if risk factors change adversely.	* Areas of Agnes Banks (ab), Berkshire Park (bp), Blacktown (bt), Luddenham (ld) and Lucas Heights (lh). * Steeper areas with moderate to high local relief and well drained subsoils such as Picton (pn), West Fernhill Hills (wf) and Glenrose (gn) are at a lower risk of developing salinity. * Soils are moderate to well drained due to their elevated position in the landscape.	* Hill slopes and hill crests on Wianamatta Shales (Rwb, Rwm, Rwa). * Raised abandoned alluvial terraces and drainage lines on Quaternary Alluvium (Qal, Qpn, Qpd, Qpa). Soil from Richmond to Camden and west to Rookwood. Localised areas of elevated, well drained Tertiary Gravels (Ta, Tl, Tn).
VERY LOW SALINITY POTENTIAL Areas where salinity processes do not operate to any of major significance. Soils are rapidly drained and underlaying strata (Hawkesbury/Narrabeen Sandstone) are highly permeable, resulting in continual flushing and removal of salts in the landscape. No salinity has been observed in these areas and is not expected to occur.	* Rapidly drained soil landscapes with shallow soils include Warragamba (wa) and Hawkesbury (hw). * Gymea (gy) and Faulconbridge (fb) Soil Landscapes consist of highly permeable sands with well drained subsoils. * Soils are well to rapidly drained. * Soils have high sand content.	* Occurring on Hawkesbury and Narrabeen Sandstone (Rh, Rnc). * Groundwater is relatively fresh in these areas due to the sandstone's elevated position in the landscape and highly permeable nature, resulting in continuous flushing of the system (removal of any accumulated salts).

1:12,500 (at A3)

0 50 100 200 300 400 500

Metres

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

N

Legend
- Study Area
- Roads
- Land Parcels

Locality Map

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AAP Corporation
Marsden Park Industrial Precinct
Geotechnical Investigation

Job Number 21-17717
Revision A
Date 9 February 2009

Salinity Potential

Figure 4

G:\21\17717\CAD\GIS\MapDocuments\21-17717-FIG004.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW DECC Salinity Potential in Western Sydney 2002 NSW Department of Lands Cadastre, Roads 2008 Created by: RCJOHNSON, rjchung

1:12,549 (at A3)

0 50 100 200 300 400 500

Metres

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

N

Legend

- Study Area
- Cadastre
- Roads
- Test Pit
- Borehole
- Photos

Geotechnical Domains

- Bringelly Shale - GD 1
- Quarry/landfill-GD5 & Fill Areas-GD5a
- Quaternary Alluvium - GD 4
- Steeper Slope in Tertiary Alluvium - GD 3
- Tertiary Alluvium - GD 2
- Volcanic Breccia

Locality Map

SYDNEY

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Marsden Park Industrial Precinct
Geotechnical Investigation

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Date	17 February 2009

Geotechnical Domains

Figure 5

G:\21\17717\CADD\GIS\MapDocuments\21-17717-FIG005.mxd

10 Bond Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data Source: NSW Department of Lands Cadastre, Roads 2008 Google Inc. Google Earth 2008 Created by: RCJOHNSON, qjchung

Appendix A

Site Walkover Photographs

P1 – P6

P 1 Head of Lower landscape valley in Upper landscape east of Quarry. View north from access road. Overland water flow and swale appear associated with quarry irrigation operations. East of Geotechnical Domain GD5

P 2 Access road east of Quarry. View east. Overland flow water emerging to pond south of the quarry access road.

P 3 Stockpile of excavated material (predominantly clay) on NW corner of the quarry/landfill (GD5).

P4 Dispersive erosion on creek line. Fill area (GD5a) in background.

P 5 Lower landscape east of Quarry and west of Richmond Road. Waterlogged ground below dam

P6 Stockpiles of excavated material (mainly mix of clay and shale) east of the quarry/landfill area (GD5).

Appendix B

Geotechnical Test Results

GHD Report SYD081615

GHD Report SYD081673

GHD GEOTECHNICS
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Fax:(02) 9462 4710

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GHD GEOTECHNICS

Material Test Report

Report No: SYD081615
Issue No: 1

Client: APP Corporation
Marsden Park Industrial Precinct
Marsden Park NSW

Project: 2117717

NATA Accredited Laboratory Number: 679

This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO IEC 17025
Laboratory Accreditation No. 679

Approved Signatory: D.P Brooke (Sydney Laboratory Manager)

Date of Issue: 16/12/2008

Material Details

Source:
Description:
Specification:
Sampled From:
Location:
Sample Method:

Sample Details

Sample ID:	SYD08-3018	SYD08-3019	SYD08-3020	SYD08-3021	SYD08-3023
Field Sample ID:	TP8, 0.6m	TP10, 1.1m	TP19, 0.8m	TP19, 1.9m	TP29, 0.8m
Date Sampled:	7/10/2008	7/10/2008	7/10/2008	7/10/2008	7/10/2008

Other Test Results

Description	Method	Results				Limits
Sample History	AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1	Oven-dried	Oven-dried			Oven-dried
Preparation		Dry Sieved	Dry Sieved			Dry Sieved
Linear Shrinkage (%)		N/A	N/A			N/A
Mould Length (mm)		0	0			0
Crumbling		No	No			No
Curling		No	No			No
Liquid Limit (%)		41	76			66
Method		Four Point	Four Point			Four Point
Plastic Limit (%)		20	24			22
Plasticity Index (%)		21	52			44
Emerson Class Number	AS 1289.3.8.1	3(c)	3(s)	1	2(m)	4
Soil Description		clay	clay	clay	clay	clay
Type of Water		Distilled	Distilled	Distilled	Distilled	Distilled
Temperature of Water (°C)		22	22	22	22	22
Moisture Content (%)	AS 1289.2.1.1	12.4	23.8			20.8

Comments

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Material Test Report

Report No: SYD081673
Issue No: 1

Client: APP Corporation
Marsden Park Industrial Precinct
Marsden Park NSW

Project: 2117717

NATA Accredited Laboratory Number: 679

This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO IEC 17025
Laboratory Accreditation No. 679

Approved Signatory: D.P Brooke (Sydney Laboratory Manager)

Date of Issue: 16/12/2008

Material Details

Source:
Description:
Specification:
Sampled From:
Location:
Sample Method:

Sample Details

Sample ID:	SYD08-3024	SYD08-3025	SYD08-3026	SYD08-3027	SYD08-3028	SYD08-3029
Field Sample ID:	TP29, 2.1m	TP35, 0.9m	TP35, 1.7m	MW4, 1.0m	MW4, 2.0m	MW4, 3.0m
Date Sampled:	7/10/2008	7/10/2008	7/10/2008	7/10/2008	7/10/2008	7/10/2008

Other Test Results

Description	Method	Results					Limits
Sample History	AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1	Oven-dried	Oven-dried	Oven-dried	Oven-dried		
Preparation		Dry Sieved	Dry Sieved	Dry Sieved	Dry Sieved		
Linear Shrinkage (%)		N/A	N/A	N/A	N/A		
Mould Length (mm)		0	0	0	0		
Crumbling		No	No	No	No		
Curling		No	No	No	No		
Liquid Limit (%)		60	65	51	74		
Method		Four Point	Four Point	Four Point	Four Point		
Plastic Limit (%)		23	24	21	25		
Plasticity Index (%)		37	41	30	49		
Moisture Content (%)	AS 1289.2.1.1	16.1	19.7	14.4	25.4		
Emerson Class Number	AS 1289.3.8.1		1	1	3(s)	4	4
Soil Description			clay	sandy clay	clay	clay	clay
Type of Water			Distilled	Distilled	Distilled	Distilled	Distilled
Temperature of Water (°C)			22	22	22	22	22

Comments

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Material Test Report

Report No: SYD081673
Issue No: 1

Client: APP Corporation
Marsden Park Industrial Precinct
Marsden Park NSW

Project: 2117717

NATA Accredited Laboratory Number: 679

This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO IEC 17025
Laboratory Accreditation No. 679

Approved Signatory: D.P Brooke (Sydney Laboratory Manager)

Date of Issue: 16/12/2008

Material Details

Source:
Description:
Specification:
Sampled From:
Location:
Sample Method:

Sample Details

Sample ID:	SYD08-3031
Field Sample ID:	BH1
Date Sampled:	7/10/2008

Other Test Results

Description	Method	Results	Limits
Sample History	AS 1289.3.1.1, AS 1289.3.2.1, AS 1289.3.3.1	Oven-dried	
Preparation		Dry Sieved	
Linear Shrinkage (%)		N/A	
Mould Length (mm)		0	
Crumbling		No	
Curling		No	
Liquid Limit (%)		68	
Method		Four Point	
Plastic Limit (%)		22	
Plasticity Index (%)		46	
Moisture Content (%)	AS 1289.2.1.1	15.1	
Emerson Class Number	AS 1289.3.8.1	1	
Soil Description		clay	
Type of Water		Distilled	
Temperature of Water (°C)		22	

Comments

GHD

10 Bond Street Sydney NSW 2000

T: 2 9239 7100 F: 2 9239 7199 E: sydmail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0 (Draft)	Bob Batcheldor					
1	Bob Batcheldor	Tony Colenbrander				24/9/09