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WINTEN PROPERTY GROUP

PROPOSED RESIDENTIAL SUBDIVISION DEVELOPMENT MARSDEN PARK PRECINCT – NORTH WEST GROWTH CENTRE RICHMOND ROAD, MARSDEN PARK

LAND CAPABILITY, SALINITY AND CONTAMINATION ASSESSMENTS REPORT

REPORT NO 12576/1-AA 27 FEBRUARY 2012

Lemko Place, Penrith NSW 2750
Telephone (02) 4722 2700
e-mail: info@geotech.com.au

PO Box 880, Penrith NSW 2751
Facsimile (02) 4722 2777
www.geotech.com.au

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Job No: 12576/1
Our Ref: 12576/1-AA

27 February 2012

Winten Property Group
Level 10
61 Lavender Street
MILSONS POINT NSW 2061
email: Bsarkis@winten.com.au

Attention: Mr W Sarkis

Dear Sir

re: **Proposed Residential Subdivision Development**
Marsden Park Precinct – North West Growth Centre
Land Capability, Salinity and Contamination Assessments

Please find herewith our *Land Capability Assessment* report for the proposed residential subdivision development of the above site.

The assessment was commissioned by Mr W Sarkis of Winten Property Group in a letter dated 12 October 2011 and was carried out as per our proposal ER.JN/Q5538 dated 6 October 2011.

The objective of the land capability assessment was to identify geotechnical, salinity and contamination issues that might have relevance to the proposed development.

If you have any questions, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

ANWAR BARBHUYIA
Associate

Reviewed

EMGED RIZKALLA
Director

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e-mail: info@geotech.com.au

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EXECUTIVE SUMMARY

This executive summary presents a synopsis of geotechnical, salinity and contamination assessments (land capability assessment) completed for Marsden Park Precinct located within the North West Growth Centre in the Blacktown Local Government Area (Figure 1). The site area measures approximately 1800 hectares (ha) and expected to accommodate about 10,000 dwellings. The site also includes 600ha of Airservices Australia in the south, which will be set aside as a conservation area.

This objective of the assessment was to determine key opportunities and constraints for the site and to ascertain the capability of the site to support future residential development.

Method of Assessment

- Desktop study to identify areas of potential contamination.
- Site inspection to identify site features, salinity and erosion hazards, slope stability and visible and olfactory indication of potential soil contamination.
- Excavation of test pits and recovery of soil samples for laboratory testing.
- Assessment of the laboratory analytical results against current applicable guidelines.
- Preparation of land capability report.

Site History & Description

The site is located within the North West Growth Centre in the Blacktown Local Government Area. The area between Richmond Road and Bells Creek generally consists of residential buildings. The plan area of the site is approximately 1800 hectares (ha), including approximately 600ha of the Airservices Australia site in the south, which is intended to be set aside for conservation and open space.

The history of the site suggests predominant use for horticultural activities, including market gardening, poultry and cattle farming. One lot was used for possible laundry activities. NSW WorkCover information indicates the presence of underground fuel tanks in one lot.

Sub-surface Conditions

A number of test pits were excavated across the site. Based on the geological and soil landscape maps and sub-surface conditions encountered in the test pits, the site can be divided into two geotechnical units comprising alluvium and residual soils. Except for some seepage located at some locations, groundwater was not encountered in the test pits. Monitoring wells were installed and encountered groundwater.

Geotechnical Assessment

- Topographic conditions across the site are unlikely to impose any significant constraints for the proposed development.
- The majority of the site, excluding flood prone areas, easements for creeks and riparian zones for existing creeks, is assessed to be suitable for the proposed residential subdivision.
- The site for proposed development is assessed to have a “Very Low” risk of slope instability.
- Sub-surface conditions across the site are unlikely to impose any significant constraints in design and construction of floor slabs and footings for proposed buildings and pavement for internal roads.

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- Site classifications as per AS2870-2011 “Residential slabs and footings” for the residential lots are likely to be Class “M” (Moderately reactive) to Class “H1” (Highly reactive).

Salinity Assessment

Available information, field observations, soil and water sampling and testing indicates the following;

- Soil testing revealed that the topsoil is generally non-saline and that underlying alluvium soils are generally slightly saline, grading to moderately saline at depths generally greater than 1m. Very saline to highly saline soils were encountered at various locations.
- Exposure classification for individual lots (AS2870-2011) should be carried out upon completion of site works and prior to construction to determine construction materials. The exposure classification for the majority of the lots is likely to be Class “A1” (non to slightly saline) or “A2” (moderately saline).
- The soils are non-aggressive to iron/steel and low aggressive to concrete.
- The soils across the site are highly sodic and susceptible to erosion. A soil salinity management plan should be implemented for site works.

Contamination Assessment

The potential for site contamination is assessed as;

- The history of the site suggests predominant use for horticultural activities, including market gardening, poultry and cattle farming. There is minor potential for elevated metals and/or pesticides concentrations in surface soils within various sections of Richmond Road and South Street.
- Lot 9 in DP1078187 was used for possible laundry in between the 1940s and 1970s, which indicates the potential for chemicals to have migrated into the site. The use of chemicals could lead to Trichloroethylene and 1,1,1-trichloroethane, carbon tetrachloride and perchlorethylene contamination.
- NSW WorkCover information indicated the presence of underground fuel tanks in Lot 2 in DP260476, which could pose potential petroleum hydrocarbon contamination. A former browser was also noted in Lot 9 in DP1078187 during field work.
- A search of the POEO Public Register on 6 December 2011, as a part of NSW OEH records, found a number of notices for 1270 Richmond Road, Marsden Park (Lot 2 in DP260476). The details of relevant POEO licenses should be considered for any potential contamination issues prior to detailed contamination assessment of that property.
- Fill materials observed in the site, including illegal dumping in Lot 10 in DP70287, could be contaminated.
- Chicken carcasses might have been buried in the poultry farms (Site Feature 21, see Drawing No 12576/1-AA1).
- Blacktown Council Depot is considered contaminated land due to previous land filling activities.

Overall, the risk posed by the site on human health and the environment is considered to be low and the potential for contamination is likely to be localised only.

Further Investigations

In order to address the identified areas of potential contamination outlined, the following further investigation recommendations are provided;

- Conduct further investigation around the perimeter of the Blacktown Council Depot to determine possible migration of contamination, if any.
- Conduct further assessment/detailed contamination assessment in the areas of concern, including lots that may have received illegal dumping.
- Conduct soil sampling and testing beneath the buildings and sheds after removal.
- Conduct soil sampling and testing following removal of underground fuel tanks.
- Groundwater testing might also be required.

In addition, the following further investigations are recommended;

- Detailed sampling and testing in the vicinity of locations of concern to delineate the extent of contamination.
- Development of a remedial action plan (RAP) to remediate the elevated Metals, Benzo(a)Pyrene, Total PAH and TPH (C10-C40) concentrations and asbestos-cement pieces, followed by appropriate validation.

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APPENDICES

1.0 INTRODUCTION

This report details land capability, contamination and salinity assessments of Marsden Park Precinct, located within the North West Growth Centre in the Blacktown Local Government Area. The site location is shown on Figure 1 below. The site is about 1800 hectares (ha) in plan area and is expected to accommodate up to 10,000 dwellings. The site includes approximately 600ha of Airservices Australia in the south, which is intended to be set aside for conservation and is not included in this study. The development includes construction of roads, retail centre, sports fields, school, etc.

Figure 1

Map data ©2011 Google, Whereis(R), Sensis Pty Ltd

The objective of the land capability assessment was to identify geotechnical, salinity and contamination issues that might have relevance to the proposed residential subdivision.

2.0 METHOD OF INVESTIGATION

The method of investigation for the land capability assessment included a desktop study of available information, field work including site inspection and excavation of test pits, soil sampling and testing, installing monitoring wells, groundwater sampling and testing and preparation of this report.

2.1 Desktop Study

- A desktop study of the following to assist in ascertaining the history of the site and identification of potential contamination issues;
  - Historical and current aerial photographs dating back to 1947
  - NSW Land & Property Information records (past land titles and lease arrangements) of selected lots
  - NSW WorkCover records
  - NSW Office of Environment and Heritage (OEH) record of Notices for Contaminated Land
- Review of geological, soil landscape, salinity and acid sulphate maps.
- Acquisition of groundwater bore information for the region.
- Review of reports prepared by others relating to Blacktown Council Depot (received in January 2012)

2.2 Field Work

As part of the land capability assessment, a series of test pits were excavated across the site. The purpose of the exercise was as follows;

- To establish sub-surface conditions across the site.
- To confirm the salinity and erosion hazards identified during inspection.
- To measure shallow groundwater/seepage, if encountered.
- To enable recovery of soil samples for laboratory testing

Site works included but not limited to:

- Site inspection by professional staff from Geotechnique Pty Ltd (Geotechnique), to identify current site activities, site features, soil landscapes, salinity and erosion hazards and identify visible and olfactory indicators of potential contamination. Site features are shown on Drawing 12576/1-AA1, generalised sub-surface conditions on 12576/1-AA2, salinity hazard on 12576/1-AA4 and erosion hazard on 12576/1-AA5 in Appendix A.
- Scanning underground services at the test pit locations so that excavation would not damage the services. A specialist was hired for this purpose.
- Preparation of a SWMS and OH&S site risk assessment prior to field work, to the satisfaction of the client.
- Excavation of eighty test pits (TP1 to TP80) to depths ranging from 1.3m to 2.5m, using a medium sized rubber tyred backhoe, under full time supervision of an Environmental Scientist from Geotechnique. The test pit locations were surveyed using a GPS and are mapped onto Drawing No 12576/1-AA3 in Appendix A. The pits were terminated at depths ranging from 1.3m to 3m. One test pit (TP42) was inadvertently excavated outside the northern boundary of the site
- The test pits were spread across the site and located based on the results of the inspection. Test pit locations are shown on Drawing 12576/1-AA3.
- Recovery of soil samples from the excavated test pits for visual inspection and laboratory testing to assist in determining salinity, sodicity, plasticity (reactivity) and potential contamination issues of sub-surface soils.
- Measurement of groundwater and/or seepage, where encountered during excavation.

- Judgemental soil sampling in two stockpiles, sediment of two dams and some partially dry waterways, beneath the above ground fuel tank and in the vicinity of the disused bower for visual inspection and laboratory testing to assist in determining potential contamination issues of sub-surface soils. Judgemental sample locations are shown on Drawing No 12576/1-AA3. The sample logs are shown in Table 1 in Appendix D.
- Sampling of dam waters to assist in determining surface water salinity characteristics.
- Installation of two monitoring wells, MW1 and MW2, for groundwater level monitoring and sampling. MW1 was located near the boundary with Airservices Australia and terminated to a depth of 10m and MW2 was constructed in the Market Garden (Lot 10/DP235714) on the northern side of Blacktown Council Depot to a depth of 5m. Monitoring well locations are shown on Drawing No 12576/1-AA3. The monitoring well logs are shown in Appendix D.

2.3 Laboratory Testing

Representative soil samples were recovered from near surface and at regular depth intervals. The recovered soil samples were forwarded to the NATA accredited laboratory of SGS Environmental Services (SGS). A few selected samples were also tested in the NATA accredited laboratory of Geotech Testing Pty Ltd to assess the following geotechnical properties;

- Emerson Crumb Dispersion
- Atterberg Limits

The results of the above laboratory tests are summarised in various sections of the report and certificates given in Appendix E.

For contamination assessment, a number of discrete fill, topsoil, natural soil, soil stockpile, sediment samples and a number of composited topsoil, natural soil, sediment samples were scheduled for a range of typical and indicator analytes, including metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc), Total Petroleum Hydrocarbons (TPH), BTEX (Benzene, Toluene, Ethyl Benzene, Xylene), Polycyclic Aromatic Hydrocarbons (PAH), Organochlorine Pesticides (OCP), Polychlorinated Biphenyls (PCB) and/or Phenols. Some fibro-cement pieces were encountered in the soil profile at test pit locations TP10, TP55 and stockpile sample SP1. Therefore, the corresponding soil layer and the fibro-cement pieces were also analysed for asbestos.

For screening purposes, two groundwater samples were analysed for metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc), TPH, BTEX, PAH, OCP, PCB, Phenols, Nitrogen and Phosphorus.

The results of the above laboratory tests for are summarised in various sections of the report and detailed in Appendix I, whilst the sampling procedure for contamination assessment and data quality indicators for the sampling phase is detailed in Appendix K.

3.0 SITE HISTORY

In order to formulate a picture of the site history, Geotechnique obtained and/or reviewed information including historical aerial photographs, certificates of land titles (past and present), records of WorkCover NSW and NSW OEH contaminated land records.

The history of the site suggests predominant use for horticultural activities, including market gardening, poultry and cattle farming. One lot (Lot 9 in DP1078187) was used for possible laundry activities. NSW WorkCover information indicates the presence of underground fuel tanks in one lot (Lot 2 in DP260476). A search of the Protection of the Environment Operations (POEO) Public Register on 6 December 2011, as a part of NSW OEH records, found a number of notices for 1270 Richmond Road, Marsden Park (Lot 2 in DP260476).

Results of the review of historical aerial photographs, records of land titles, NSW WorkCover and NSW OEH are detailed in Appendix B.

The aerial photographs revealed that the site originated from a large parcel of vacant/grazing land. Most site alteration took place in the 1950s, inwards from the eastern and western boundaries. The site was mainly used for grazing. Some possible intensive horticultural activities, such as poultry farming, are evident in properties at various sections of Richmond Road and South Street. Most residential activities are located in the southern portion of Richmond Road. Surrounding properties underwent development in a similar fashion. The site and surrounding properties remained essentially unchanged from 1994 to 2004. Reference may be made to Appendix B1 for details of the aerial photographs.

A request was made to WorkCover NSW to search for any information on licences to store dangerous goods, including underground tank(s) and/or other underground facilities at the site. A search of the Stored Chemical Information Database (SCID) records held by WorkCover NSW, is detailed Appendix B2 of this report.

The NSW OEH maintains records of EPA notices for contaminated sites under Section 58 of the Contaminated Land Management (CLM) Act 1997. The notices relate to investigation and/or remediation of site contamination considered to pose a significant risk of harm under the definition of the CLM Act.

A search of the OEH records on 6 December 2011 found no EPA Notices issued for the site. It should be noted that the OEH records of EPA notices for contaminated land do not provide records of all contaminated land in NSW. At the time of searching the records, 327 sites in NSW were registered in the database.

The OEH issues environment protection licences to owners or operators of various industrial premises under the Protection of the Environment Operations Act 1997 (POEO Act). Licence conditions relate to pollution prevention and monitoring and cleaner production through recycling and re-use and the implementation of best practice.

A search of the POEO Public Register on 6 December 2011 found a number of notices for 1270 Richmond Road, Marsden Park (Lot 2 in DP260476). The details of relevant POEO licenses should be considered for any potential contamination issues prior to detailed contamination assessment of that property. NSW OEH records are detailed in Appendix B3 of this report.

4.0 REVIEW OF AVAILABLE INFORMATION

4.1 Regional Geology

Reference to the Geological Map of Penrith (1:100,000) indicates that the majority of the site (i.e. northern, western and south-western portions) is underlain by Quaternary and Tertiary deposits comprising the following;

- Fine grained sand, silt and clay
- Clay patches of ferruginised, consolidated sand
- Conglomerate, matrix supported

The map indicates that the eastern and south-eastern portions of the site are underlain by Bringelly Shale belonging to the Wianamatta Group of Shales and comprising shale, carbonaceous claystone, laminite, fine to medium grained lithic sandstone, rare coal.

A small strip of the site area on the western side of Bells Creek (eastern boundary of the site) is also underlain by Quaternary deposits (Qal).

The Soil Landscape Map of Penrith (1:100,000) indicates that the majority of the site in the northern, western and south-western portions belong to the fluvial landscapes; the South Creek group and the Berkshire Park Group and the rest of the site in eastern and south-eastern portions to the residual landscape of the Blacktown Group. The area on the western side of Bells Creek also belongs to the South Creek Group. Descriptions of these landscapes are as follows;

Fluvial Landscapes

- The South Creek Group comprises flood plains, valleys, flats and drainage depressions of the channels on the Cumberland plains, usually flat with incised channel. Soils in this landscape are often very deep layers of sediments over bedrock or relict soils. This landscape is subject to frequent flooding and erosion hazards.
- The Berkshire Park Group is characterised by dissected, gently undulating low rises on Tertiary terraces of the Nepean and Hawkesbury River systems. Soils in this landscape comprise clay and clayey sands, with ironstone nodules and silcrete and impermeable subsoils, which are susceptible to gully, sheet and rill erosion and water-logging.

Residual Landscape

- The Blacktown Group is characterised by gently undulating rises on Wianamatta Group of Shales, with local relief to 30m, ground slope less than 5%, broad rounded crests and gently inclined slopes. The sub-surface soil in this landscape is likely to be up to 3m thick, moderately reactive, high plasticity and with poor drainage.

4.2 Hydrogeology

A search was carried out through the Department of Natural Resources (NSW Natural Resource Atlas) for any registered groundwater bore data within and near the site. No water bearing data or standing water levels were available.

It is considered that the regional groundwater level beneath the site would be at significant depth below the site levels (approximately 20m within the underlying Bringelly Shale bedrock). More localised groundwater, perched groundwater, or water bearing zones are expected in lower lying areas within the site close to the creeks. In these areas, groundwater levels of less than 3m below the existing ground levels could be experienced during flooding.

Based on the topography and locations of the creeks, it is anticipated that groundwater flow beneath the site would be towards the north and north-west.

As discussed earlier, South Creek is located on the north and north-western boundaries of the site and a number of unnamed creeks pass through the site. Surface water run-off exiting the site would generally flow into one of these creeks.

4.3 Salinity

The Salinity Potential in Western Sydney (2002) Map indicates the following;

- Salinity areas in a small strip on the north eastern boundary close to Richmond Road. These salinity areas are generally characterised by the presence of scalding, salt efflorescence, vegetation dieback, salt tolerant species and waterlogging.
- High salinity potential along the unnamed creeks, South Creek and Bells Creek. These are the areas where soil, geology, topography and groundwater conditions predispose a site to salinity. These conditions are similar to the areas of Known salinity. These areas are more common in lower slopes and drainage systems where water accumulation is high.
- Moderate salinity potential in the rest of the site. Areas on Wianamatta Group Shales and Tertiary Alluvial Terraces. Scattered areas of scalding and indicator vegetation have been noted but no concentrations have been mapped.

4.5 Acid Sulphate Soils

There are no acid sulphate soil maps that cover Greater Western Sydney.

5.0 SITE DESCRIPTION AND FEATURES

The site is located within the North West Growth Centre in the Blacktown Local Government Area (Figure 1). The site is bound by South Creek to the north, Richmond Road to the east, the Marsden Park Industrial Site (MPIS) and St Mary's subdivision to the south and Stony Creek Road to the west. The area bound by Richmond Road, Bells Creek, Vine Street and South Street on the eastern side is also included in the site. Most of the site is generally used for cattle farming. There are a variety of businesses (shops, market gardens, poultry farms, a construction company depot etc.) and rural residential buildings along Richmond Road. The area between Richmond Road and Bells Creek generally consists of residential buildings. The plan area of the site is approximately 1800 hectares (ha), including approximately 600ha of the Airservices Australia site in the south, which is intended to be set aside for conservation and open space.

- The majority of the site is occupied by three large properties belonging to Woorong Park Pty Ltd in the west, FG Pace Poultry and Beef Farm in the north and Air Services Australia in the south. These properties are large open areas covered with grass and scattered trees. The Woorong Park property is generally used for cattle grazing. Individual paddocks within this property are fenced. FG Pace property has a poultry farm and is also used for cattle grazing. There are a number of dams within these two properties. Airservices Australia area was not inspected, but Google maps indicate that this area is covered with bushland.

- The rest of the site along Richmond Road and bound by Bells Creek on the eastern boundary is occupied by smaller properties that are mainly rural residential, market garden, poultry or cattle farms, shops, a construction company depot etc. There are also a number of dams within this area.
- The northern and western portions of the site generally comprise relatively flat to gently sloping alluvial plains, with unnamed creeks/drainage depressions. The surface levels (AHD) within this area range approximately from RL76m to RL100m.
- The eastern and south-eastern portions of the site comprise undulating rises with gentle side slopes. There is a main ridge (approximately north-south trending at ≈RL120m) on the western/south-western side of the Blacktown City Council Depot. There are also a number of small ridges in the south-eastern and eastern portions of the site.
- No indicators of slope instability were identified during the inspection.
- Inspection of the site generally indicated erosion areas mostly along unnamed creeks or drainage depressions. Pockets of salinity indicators such as dead trees and bare patches were identified. Salt tolerant plant species, such as spiny rush (Juncus Acutus), which is widespread in damp places and infrequently inundated watercourses on the coast and inland, were also identified. The plant comprises short rhizomatous, tussocky perennial rush to 1.6m high. Flowering stems and stem-like leaves arise from the base at varying angles, giving the whole plant a characteristic globe shape. The identified salinity and erosion areas are shown on the Drawings 12576/1-AA4 and 12576/1-AA5 respectively.
- Blacktown City Council depot is located in the eastern portion of the site close to Richmond Road.
- Other site features noted within the site are highlighted on the Site Features Drawing 12576/1-AA1. These features are mainly fill and suspected fill areas, scattered mostly in the eastern portion of the site. In particular, above ground diesel and petroleum storage tanks and a disused fuel dispenser (bowser) from a former underground petroleum storage tank, marked as features 24 and 25 respectively in the above drawing.
- For various reasons, twelve (12) properties, as shown on Drawing No 12576/1-AA1, were not accessible for inspection and testing.
- Most of the site open areas are grass covered and contain scattered tree growth. Airservices Australia and properties along the western portion of South Street appeared to be covered with natural bushland.
- There was no petroleum hydrocarbon staining on the ground surface of the site that would indicate the potential for contamination, except for a small area associated with the above ground tanks.
- There were no signs of soil staining, plant distress or visible indicators of potential contamination.
- There were no olfactory indicators of potential contamination.

Reference should be made to Drawing 12576/1-AA1 and site topography map prepared by AECOM for site features, contours and boundaries.

6.0 SUB-SURFACE CONDITIONS

6.1 Test Pits

Sub-surface conditions encountered in the test pits are summarised in Table 1 below and detailed in the attached engineering logs.

TABLE 1

TP	Termination Depth (m)	Topsoil (m)	Fill (m)	Alluvium (m)	Residual (m)	Bedrock (m)
1	2.5	0.0 – 0.1	NE	0.1 – 1.3	1.3 -> 2.5	NE
2	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
3	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
4	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
5	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
6	2.5	NE	NE	0.0 -> 2.5	NE	NE
7	2.5	NE	NE	0.0 -> 2.5	NE	NE
8	2.5	NE	NE	0.0 -> 2.5	NE	NE
9	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
10	2.5	NE	0.0 – 0.9	0.9 -> 2.5	NE	NE
11	2.5	NE	NE	0.0 -> 2.5	NE	NE
12	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
13	2.5	NE	NE	0.0 -> 2.5	NE	NE
14	2.5	0.0 – 0.1	NE	0.1 – 1.7	1.7 – 2.1	2.1 -> 2.5
15	2.5	0.0 – 0.1	NE	0.1 – 1.5	1.5 –> 2.5	NE
16	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
17	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
18	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
19	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
20	2.5	NE	NE	0.0 -> 2.5	NE	NE
21	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
22	2.5	NE	NE	0.0 -> 2.5	NE	NE
23	2.5	NE	NE	0.0 -> 2.5	NE	NE
24	2.5	NE	NE	0.0 – 2.3	2.3 -> 2.5	NE
25	2.5	NE	NE	0.0 -> 2.5	NE	NE
26	2.5	NE	NE	0.0 -> 2.5	NE	NE
27	2.5	NE	NE	0.0 -> 2.5	NE	NE
28	1.6	NE	NE	0.0 -> 1.6	NE	NE
29	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
30	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
31	2.5	NE	NE	0.0 -> 2.5	NE	NE
32	2.5	NE	NE	0.0 -> 2.5	NE	NE
33	2.5	NE	NE	0.0 -> 2.5	NE	NE
34	2.5	NE	NE	0.0 -> 2.5	NE	NE
35	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
36	3.0	0.0 – 0.1	NE	0.1 -> 3.0	NE	NE
37	2.5	NE	NE	0.0 -> 2.5	NE	NE
38	2.5	NE	NE	0.0 -> 2.5	NE	NE
39	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
40	2.5	NE	NE	0.0 -> 2.5	NE	NE

TABLE 1 continued

TP	Termination Depth (m)	Topsoil (m)	Fill (m)	Alluvium (m)	Residual (m)	Bedrock (m)
41	2.5	NE	NE	0.0 -> 2.5	NE	NE
42	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
43	2.5	NE	NE	0.0 -> 2.5	NE	NE
44	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
45	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
46	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
47	2.5	NE	0.0 – 1.3	1.3 -> 2.5	NE	NE
48	1.3	0.0 – 0.1	NE	0.1 -> 1.3	NE	NE
49	2.5	0.0 – 0.3	NE	0.3 -> 2.5	NE	NE
50	2.5	0.0 – 0.3	0.3 – 0.7	0.7 -> 2.5	NE	NE
51	2.5	0.0 – 0.15	NE	0.15 -> 2.5	NE	NE
52	2.0	0.0 – 0.3	NE	0.3 -> 0.7	0.7 – 2.0	=>2.0
53	2.5	NE	0.0 – 1.2	1.2 -> 2.5	NE	NE
54	1.7	NE	0.0 – 0.3	0.3 – 1.2	1.2 – 1.7	=>1.7
55	2.5	NE	0.0 – 1.0	1.0 – 1.3	1.3 –> 2.5	NE
56	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
57	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
58	2.5	NE	0.0 – 0.15	0.15 -> 2.5	NE	NE
59	2.5	NE	0.0 – 0.8	0.8 -> 2.5	NE	NE
60	2.0	0.0 – 0.1	NE	0.1 -> 2.0	NE	NE
61	2.1	0.0 – 0.15	NE	0.15 – 1.2	1.2 – 2.0	2.0 –> 2.1
62	2.5	0.0 – 0.1	NE	0.1 – 1.9	1.9 -> 2.5	NE
63	1.5	0.0 – 0.1	NE	0.1 – 1.0	1.0 – 1.5	=>1.5
64	2.5	NE	0.0 – 0.3	0.3 -> 2.5	NE	NE
65	2.5	NE	0.0 – 1.2	1.2 -> 2.5	NE	NE
66	2.5	NE	0.0 – 0.15	0.15 -> 2.5	NE	NE
67	1.8	0.0 – 0.1	NE	0.1 – 0.4	0.4 – 1.8	=>1.8
68	2.2	0.0 – 0.1	NE	0.1 – 1.8	1.8 – 2.2	=>2.2
69	2.5	0.0 – 0.1	NE	0.1 - 2.2	2.2 –> 2.5	NE
70	2.5	0.0 – 0.1	0.1 – 0.4	0.4 – 1.2	1.2 -> 2.5	NE
71	2.5	0.0 – 0.1	NE	0.1 –> 2.5	NE	NE
72	2.0	0.0 – 0.1	0.1 – 0.6	0.6 – 1.3	1.3 – 2.0	=>2.0
73	2.5	0.0 – 0.1	NE	0.1 – 1.5	1.5 -> 2.5	NE
74	2.5	0.0 – 0.1	NE	0.1 -> 2.5	NE	NE
75	2.5	0.0 – 0.15	NE	0.15 – 1.5	1.5 -> 2.5	NE
76	2.5	NE	0.0 – 0.4	0.4 – 1.5	1.5 -> 2.5	NE
77	2.5	NE	0.0 – 0.3	0.3 – 2.0	2.0 -> 2.5	NE
78	2.5	NE	0.0 – 0.5	0.5 -> 2.5	NE	NE
79	2.5	NE	NE	0.0 – 1.5	1.5 -> 2.5	NE
80	2.5	0.0 – 0.2	NE	0.2 – 1.7	1.7 -> 2.5	NE

Based on the above, the site can be divided into two geotechnical units.

Unit 1: Alluvial soils throughout the excavated depths of the test pits (i.e. to depths of 2.5m) in the northern, western and south-western portions of the site (occupied by three large properties Woorong Park Pty Ltd, FG Pace and Airservices Australia) and the area on the western side of Bells Creek, as shown on Drawing 12576/1-AA2.

Descriptions of sub-surface materials encountered in Unit 1 are as follows;

Topsoil	Silty Clay, low plasticity, brown, trace of roots
Fill	Sand, fine to medium grained, brown, with brick, concrete and sandstone fragments, trace of fibro cement fragments
	Silty Clay, low to medium and high plasticity, brown and pale gray, with gravel and fragments of building debris at places
Alluvium	Silty to Sandy Clay & Clay, low to medium and high plasticity, grey-brown, trace of ironstones and river gravel
	Clayey Silt & Silt, low plasticity, brown

Bedrock was not encountered within Unit 1 to the maximum excavated depths of 2.5m to 3m. Groundwater monitoring well MW1, installed near the boundary with Airservices Australia, disclosed shale bedrock at about 4.2m.

Unit 2: Alluvial soils, overlying residual soils, overlying bedrock in the eastern portion of the site, as shown on Drawing 12576/1-AA2.

Topsoil	Silty Clay, low plasticity, brown, trace of roots
Fill	Sand, fine to medium grained, brown, with brick, concrete and sandstone fragments, trace of fibro cement fragments
	Silty Clay, low to medium and high plasticity, brown and pale gray, with gravel and fragments of building debris at places
Alluvium	Silty to Sandy Clay & Clay, low to medium plasticity and high plasticity, grey-brown, trace of ironstones and river gravel
	Clayey Gravel, fine to coarse grained, brown-yellow, grey, clay of low to medium plasticity
Residual	Clay grading to Shaley Clay, medium to high plasticity, pale grey, with ironstones and shale gravel
Bedrock	Shale/Siltstone, grey, very low to low grading at places to medium strength, extremely to distinctly weathered

Bedrock was encountered at seven test pit locations at varying depths ranging from 1.5m to 2.2m below existing grade.

During field work, fibro-cement pieces were encountered in the soil profile in test pits TP10, TP55 and soil stockpile SP1. The other test pits, sample and soil stockpile did not reveal any visual evidence of asbestos or other indicators of significant contamination, such as staining, odours or significant foreign matter.

6.2 Groundwater Conditions

Groundwater was not encountered within the excavated depths of the test pits, ranging from 1.3m to 3m. However, seepage was encountered in Unit 1 at various depths ranging from 0.5m to 1.5m.

Monitoring Well MW1, installed near the boundary with Airservices Australia in Unit 1, encountered groundwater at about 8.2m. MW2 installed to the north of the Blacktown City Council deport in Unit 2 encountered groundwater at about 2.5m during drilling, rising to about 1.8m. We do not believe that the groundwater in MW2 is regional groundwater level and could be perched water level or seepage at the interface with the shale bedrock.

7.0 LABORATORY TESTS RESULTS

7.1 Geotechnical Test Results

Selected soil samples recovered from the test pits were analysed in the NATA accredited laboratory of Geotech Testing Pty Ltd for Dispersion (Emerson Crumb Method) and plasticity (Atterberg Limits) properties. The purpose of the testing was to confirm field assessment of dispersive soils and plasticity (reactivity) of the soils. The laboratory test results certificates are attached and summarised below.

TP	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Emerson Class Number
3	0.5 – 0.6	NT	NT	NT	NT	4
4	1.0 – 1.1	60	18	42	8.3	NT
13	1.0 – 1.1	56	16	40	13.3	NT
16	1.5 – 1.6	NT	NT	NT	NT	4
22	2.0 – 2.1	NT	NT	NT	NT	1
27	0.5 – 0.6	NT	NT	NT	NT	5
30	0.0 – 0.1	NT	NT	NT	NT	1
31	1.0 – 1.1	NT	NT	NT	NT	3
37	1.0 – 1.1	NT	NT	NT	NT	1
40	0.5 – 0.6	32	15	17	9.3	NT
43	2.0 – 2.1	NT	NT	NT	NT	3
60	0.5 – 0.6	NT	NT	NT	NT	4
61	1.0 – 1.1	44	18	26	12.4	NT

NT : Not Tested

The above results confirm the following;

- The soils across the site are medium to high plasticity and susceptible to shrink/swell movements.
- The soils across the site are generally moderately to highly dispersive and susceptible to erosion.

7.2 Salinity Test Results

The laboratory test results certificates from SGS are included in Appendix F. Tables AA to AC present the results, together with the assessment criteria adopted, soil descriptions and appropriate multiplication factors. The test results are discussed in Section 9.0 of this report.

7.3 Chemical Test Results

The laboratory test results certificates from SGS and Envirolab are included in Appendix I. The chemical test results for the quality assurance / quality control (QA/QC) and recovered soil and groundwater samples are also summarised in Tables A to Q in Appendix J, together with the assessment criteria adopted. The assessment criteria for soil and groundwater samples are detailed in Appendix C.

A discussion of the test data is presented in the following sub-sections.

7.3.1 QA / QC Samples

As a part of field QA/QC, rinsate, trip spike, duplicate and inter laboratory duplicate/split samples were prepared and analysed.

The test data of field QA/QC samples indicate acceptable concentrations in rinsate blank water samples, acceptable recoveries of spike concentrations in trip spike samples, acceptable RPD for duplicates and splits comparison overall, as detailed in Appendix H. Reference can also be made to Appendix H for laboratory QA/QC and data quality indicators for the analytical phase.

7.3.2 Soil Samples

7.3.2.1 Metals

The metals test data for discrete samples are presented in Table H. As shown in the table, the concentrations of all Metals were below the relevant provisional phytotoxicity based investigation levels (PPBIL) and the Health Investigation Levels (HIL) for residential development with access to soil (HIL 'A'), with the exception of highlighted, copper (Cu), lead (Pb) and zinc (Zn) concentrations.

The highlighted Cu and Zn concentrations exceeded the relevant PPBIL, but were below the relevant HIL'A', whilst the highlighted Pb concentration exceeded both the PPBIL and HIL'A'.

The Cu concentration (180mg/kg) and Zn concentrations (250mg/kg and 980mg/Kg) might impact on the growth of certain plant species, but would not present a risk of harm to human health. However, the Pb concentration (1400mg/kg) presents a risk of harm to human health and might impact on the growth of certain plant species.

The metals test data for the composited samples are presented in Table G. As indicated in Table G, with the exception of highlighted arsenic (As), cadmium (Cd) and Zn concentrations, the concentrations of other Metals were below the relevant Adjusted PPBIL and the Adjusted HIL 'A'.

The highlighted As, Cd and Zn concentrations exceeded the Adjusted PPBIL, but were below the Adjusted HIL'A'. The sub-samples of the failed composite samples were therefore analysed for As, Cd and/or Zn. The test results are summarised in Tables G1 to G3.

As shown in Table G1, all As concentrations were below the PPBIL and the HIL'A'.

As indicated in Table G2, all Cd concentrations were below the PPBIL and the HIL'A'.

As indicated in Table G3, with the exception of the highlighted concentrations, the remaining concentrations of Zn were below the Adjusted PPBIL and the Adjusted HIL'A'.

The highlighted Zn concentrations exceed the PPBIL, but were below the HIL'A'. The Zn concentrations (ranging from 220mg/kg to 1000mg/kg) might impact on the growth of certain plant species, but would not present a risk of harm to human health.

7.3.2.2 TPH and BTEX

The TPH and BTEX test data for the discrete samples are presented in Table H, as compositing is not appropriate for volatile analysis

As shown in Table H, with the exception of the highlighted concentration of TPH (C10-C40), all other TPH (with or without silica gel clean up) and BTEX were below the suggested Levels in the EPA service station guidelines. The concentrations of TPH (C6-C9) and BTEX were also less than the laboratory limits of reporting (LOR).

The highlighted TPH (C10-C40) concentration exceeded the suggested Levels in the EPA service station guidelines, which present a risk of harm to human health.

7.3.2.3 Polycyclic Aromatic Hydrocarbons (PAH)

The PAH test results for discrete samples are presented in Table I as Benzo(a)Pyrene and Total PAH. Benzo(a)pyrene is a known human carcinogen and in high concentrations presents a significant human health risk. The NSW EPA has produced health based assessment criteria for Benzo(a)Pyrene, as well as the sum of PAH.

The Benzo(a)Pyrene concentrations (ranging from 1.2mg/kg to 14mg/kg) and Total PAH concentrations (ranging from 34mg/kg to 154mg/kg) present a risk of harm to human health.
The PAH test results for composited samples are presented in Table J and as indicated, all Benzo(a)Pyrene and Total PAH were below the relevant Adjusted HIL'A'.

7.3.2.4 Organochlorine Pesticides (OCP)

The OCP test results for the discrete samples are presented in Table I and as indicated, the concentrations of OCP were all below the HIL 'A'. Most of the OCP concentrations were also less than the laboratory LOR.

The OCP test results for the composited samples are presented in Table J and as indicated, the concentrations of OCP were all below the Adjusted HIL 'A'. Most of the OCP concentrations were also less than the laboratory LOR.

7.3.2.5 Polychlorinated Biphenyls (PCB)

The PCB test results for the discrete samples are presented in Table I and as indicated, the concentrations of PCB were all less than the laboratory LOR and below the HIL 'A'.

The PCB test results for the composited samples are presented in Table J and as indicated, the concentrations of both PCB were less than the laboratory LOR and below the Adjusted HIL 'A'.

7.3.2.6 Phenols

The Phenols test results for the discrete samples are presented in Table I and as indicated, the concentrations of Phenols were all well below the HIL 'A'.

7.3.2.7 Asbestos

As shown in Table K, no asbestos fibres were detected in the soil samples.

As also shown in Table K, the fibro-cement pieces found in the soil profile at TP10, TP55 and soil stockpile SP1 contain Chrysotile Asbestos and/or Amosite Asbestos.

As presented in summary tables F to K and discussed above, most of the laboratory data and/or data sets satisfied the criteria for stating that the analytes selected are either not present, or present in the sampled soils at concentrations that do not pose a risk of hazard to human health or the environment, under a "residential with access to soil" form of development. The exceptions included the following identified locations of concern, which are indicated and tabulated on Drawing No 12576/1-AA6;

- Locations where lead (Pb), Benzo(a)Pyrene, Total PAH and/or TPH (C10-C40) present a potential risk of harm to human health.
- Locations where copper (Cu) and/or zinc (Zn) could potentially impact on the growth of certain plant species but would not present a risk of harm to human health.
- Asbestos-cement pieces pose a potential risk of harm to human health.

Off-site impacts of contaminated soil are generally governed by the contaminant concentrations in the soils, the transport media available and likely receptor(s). The most common transport medium is water, whilst receptors include groundwater, surface waterbodies, humans, flora & fauna.

Migration of soil contaminants to the groundwater regime would generally be via leaching from the soil, facilitated by infiltration of surface water. The residual (natural) silty clay beneath the site is relatively impermeable. As such, leaching of any contaminants into the groundwater regime is unlikely.

South Creek is located on the north and north-western boundaries of the site and a number of unnamed creeks pass through the site. Surface water run-off exiting the site would generally flow into one of these creeks.

7.4.3 Groundwater Samples

7.4.3.1 Acidity & Salinity

Two groundwater samples were recovered from groundwater monitoring wells MW1 & MW2 on 16 November 2011. The test results are shown below.

Test Result	MW1	MW2
pH	7.1	7.0
EC (dS/m)	24	17

The pH results indicate non acidic conditions.

Based on the above, the water samples indicate mild aggressiveness to steel and moderate aggressiveness to concrete and high risk to plant growth.

7.4.3.2 Metals and Hardness

As indicated in Table L, the hardness of the groundwater samples is more than 400mg/L, which is extremely hard.

Based on the hardness, as detailed in Table 3.4.3 of the ANZ Guidelines 2000, the corresponding multiplying factors (refer to Table L) are applied to the trigger values for cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni) and zinc (Zn). Subsequently, the relevant hardness-modified trigger values were derived and are presented in Table L.

As shown in Table L, the concentrations of all Metals were either below the laboratory LOR and/or below the relevant trigger values / the hardness-modified trigger values for aquatic ecosystems (fresh water), at a protection of 95% species.

As also shown in Table L, the concentrations of all Metals were below the relevant long-term and short-term trigger values for irrigation water, the relevant available guideline values for livestock drinking water and water for recreational purposes in the ANZ Guidelines 2000 and the relevant health level and/or aesthetic values for drinking water in the Australian Drinking Water Guidelines 2004.

7.4.3.3 TPH and BTEX

As indicated in Table M, the concentrations of BTEX and TPH (C6-C9) were all less than the laboratory LOR. Moreover, all BTEX concentrations were below the relevant trigger values for aquatic ecosystems (fresh water) at a protection of 95% species, the relevant available guideline values for livestock drinking water and water for recreational purposes in the ANZ Guidelines 2000 and the relevant health level and/or aesthetic values for drinking water in the Australian Drinking Water Guidelines 2004.

The TPH concentrations were also less than the criteria for Airport (Environment Protection) Regulations.

7.4.3.4 Polycyclic Aromatic Hydrocarbons (PAH)

As shown in Table N, the concentrations of PAH were all less than the laboratory LOR. Moreover, all PAH concentrations were below the relevant trigger values for aquatic ecosystems (fresh water) at a protection of 95% species, the relevant available guideline value for livestock drinking water and water for recreational purposes in the ANZ Guidelines 2000 and the relevant health level for drinking water in the Australian Drinking Water Guidelines 2004.

7.4.3.5 Organochlorine Pesticides (OCP)

As indicated in Table O, the concentrations of OCP were all less than the laboratory LOR. Moreover, all OCP concentrations were below the relevant trigger values for aquatic ecosystems (fresh water) at a protection of 95% species, the relevant available guideline values for livestock drinking water and water for recreational purposes in the ANZ Guidelines 2000 and the relevant health levels for drinking water in the Australian Drinking Water Guidelines 2004.

7.4.3.6 Polychlorinated Biphenyls (PCB)

As indicated in Table P, the concentrations of PCB were all less than the laboratory LOR. Moreover, all PCB concentrations were below the relevant trigger values for aquatic ecosystems (fresh water) at a protection of 95% species and the relevant available guideline values for water for recreational purposes in the ANZ Guidelines 2000.

7.4.3.7 Phenols

As indicated in Table N, the concentrations of Phenols were below the trigger value for aquatic ecosystems (fresh water) at a protection of 95% species and the guideline value for water for recreational purposes in the ANZ Guidelines 2000.

7.4.3.8 Nutrients (Nitrogen and Phosphorus)

As shown in Table Q, all the concentrations of nitrogen and phosphorus were either below the laboratory LOR and/or below the available relevant trigger values for aquatic ecosystems (fresh water), at a protection of 95% species, the relevant long-term and short-term trigger values for irrigation water, the relevant available guideline values for livestock drinking water and water for recreational purposes in the ANZ Guidelines 2000 and the relevant health level and/or aesthetic values for drinking water in the Australian Drinking Water Guidelines 2004.

As presented in summary tables L to Q and discussed above, the groundwater condition in two monitoring wells is generally good, and will not impact on aquatic life within the fresh water aquatic ecosystems in the waterbodies in the region, if the groundwater is eventually discharged there. The water is also suitable to use for irrigation, recreational activities and drinking purposes.

8.0 GEOTECHNICAL ASSESSMENT

8.1 Existing Fill

Fill was encountered at various test pit locations at various depths ranging from 0.15m to 1.3m. The fill, encountered at the test pits summarised below, was found to contain brick fragments, fibro cement fragments, concrete fragments, large concrete pieces (garden decoration) and other non-soil materials, indicating the fill to be uncontrolled.

Test Pit	**TP10**	**TP47**	**TP50**	**TP53**	**TP54**	**TP55**	**TP58**	**TP59**
Depth of fill (m)	0.9	1.3	0.7	1.2	0.3	1.0	0.15	0.8
Test Pit	**TP64**	**TP65**	**TP66**	**TP70**	**TP72**	**TP76**	**TP77**	**TP78**
Depth of fill (m)	0.3	1.2	0.15	0.4	0.6	0.4	0.3	0.5

The attached Drawing 12576/1-AA7 indicates the majority of the test pits that encountered fill are located towards the eastern boundary of the proposed development. It appears that placement of fill may have been associated with the development of the rural lots. The drawing also indicates a few isolated locations on the western portion of the development. It should be noted that fill materials might be encountered at other locations where test pits were not excavated.

We recommend that prior to placing any structural loads all fill areas should be evaluated for the suitability to support structural loads, by conducting proof rolling (8 to 10 tonne roller) and insitu density testing. The presence of deleterious materials or significant movement during proof rolling or low density results (Relative Compaction < 95% Standard Maximum Dry Density) will indicate the fill to be uncontrolled and unsuitable. Uncontrolled fill should be removed and replaced with well compacted controlled fill, as recommended in the section “Site Preparation”.

We do not anticipate any geotechnical constraints due to the presence of the fill at the site (mostly eastern portion) for the proposed development, provided the fill is evaluated and treated as recommended above.

8.2 Topographic Conditions

Based on site walkover survey and review of the topographical drawing provided by AECOM, the site topography consists of the following:

- The northern and western portions of the site generally comprise flat to gently sloping alluvial plains, with unnamed creeks/drainage depressions. The surface levels (AHD) within this area range from approximately from RL76m to RL100m.
- The eastern and south-eastern portions of the site comprise undulating rises with gentle side slopes. There is a main ridge (approximately north-south trending, ≈RL120 (AHD) on the western/south-western side of the Blacktown City Council Depot. There are also a number of small ridges in the south and eastern portions of the site.

The topographical conditions across the site do not impose any major constraints for the proposed development.

8.3 Erosion Potential

Erosion is the detachment and movement of soil materials. The process might be natural or accelerated by human activity. Depending on the local landscape and weather conditions, erosion could be very slow or very rapid. Water erosion results from the removal of soil materials by flowing water. Susceptibility of soils to erosion depends on dispersivity (and sodicity) of soils. Based on observations of erosion scars on creek banks and turbidity of water in dams within the site, near surface soils are assessed to be potentially dispersive or dispersive in nature.

Erosion of soils is generally assessed using physical tests (Emerson Class, Pinhole Class, Percent Dispersion etc) and chemical tests to determine sodicity (Exchangeable Sodium Percentage and Sodium Absorption Ratio). Sodic soils are susceptible to erosion. However, for present assessment only Emerson Class and Exchangeable Sodium Percentage tests were carried out.

Emerson Class test grades soils into eights classes, with Class 1 being highly dispersive and Class 8 being non-dispersive. Soils with Emerson Classes 1 to 4 are to be treated with caution due to their susceptibility to erosion.

Laboratory tests were carried out to determine Emerson Class for nine (9) representative soil samples recovered from different soil types encountered across the site. The test results indicated generally Emerson Class of 1 to 4, indicating highly dispersive soils and susceptible to erosion. Therefore, it is our assessment that excessive erosion of soils across the site might impose some constraints unless appropriate measures are implemented to reduce the impact of erosion. It is also our assessment that stabilising with gypsum or lime could reduce susceptibility of these soils to erosion. Earthworks for a proposed development should be carried out in accordance with an appropriate soil management plan.

8.4 Slope Stability

Site factors such as slope angles, depth of insitu soils, strength of sub-surface material and concentrations of water generally govern the slope stability of a site. The Australian Geomechanics Society (AGS) recommends that the landslide risk of a site is assessed on the basis of the likelihood of a landslide event and the consequences of that event. The guidelines on qualitative measures for the likelihood and consequence of landslides and assumed level of risk are provided by AGS. Applying the AGS guidelines, the site for the proposed development may be assessed as follows.

Qualitative Measures of Likelihood: It is our assessment that the event of a landslide within the site is conceivable but only under very exceptional circumstances ($\approx 10^{-5}$), i.e.: it is "Rare". It should also be noted that the landslides are inconceivable in almost flat portions of the site with alluvial profile.

Qualitative Measures of Consequences to Property: It is our assessment that the consequences of landslides within the site to properties would be "Minor", causing limited damage to part of structures, or part of the site requiring some reinstatement/stabilisation work.

Qualitative Risk Analysis: Based on the above Qualitative Measures, the site for proposed development is assessed to have a "**Very Low**" Risk of slope instability. The abstract of definitions of risk levels provided by AGS is as follows:

Risk Level		**Implication**
VH	Very High Risk	Extensive detailed investigation and research, planning and implementation of treatment options, essential to reduce risk to acceptable levels; may be too expensive and not practical.
H	High Risk	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels.
M	Moderate Risk	Tolerable, provided a treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.
L	Low Risk	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	Very Low Risk	Acceptable. Manage by normal slope maintenance procedures.

It is our assessment that the site is suitable for the proposed residential development, from a slope stability point of view. Significant ground modifications, including fill placement, excavation and formation of batters should be carried out in accordance with good engineering and construction practices.

8.5 Site Preparation

Considering the topography of the site, we consider that construction of roads, buildings etc., will require some site preparation works, including cut and fill operations. We anticipate that the excavation will be limited to 2m to 3m.

The eighty test pits excavated at the site generally encountered alluvial and residual soils to termination depths ranging from 1.3m to 3m. Bedrock was encountered in the eastern portion of the site near Richmond Road, at depths ranging from 1.5m to 2.2m. We do not anticipate any geotechnical constraints for excavation of overburden alluvial and residual soils and extremely low to low strength bedrock. These materials could be easily excavated using conventional earthmoving equipment such as excavators and dozers. If excavation extends into boulders (TP28 and TP48), a large excavator (30 tonnes) or rock hammer could be required.

Excavation, if it extends into medium to high strength bedrock will require large equipment such as a Caterpillar D9 or rock header or rock hammer or saw cutters. We suggest that selection of rock cutting equipment is based on site access, desired smoothness of the excavated rock surface and acceptable ground vibration during rock excavation. A detailed geotechnical investigation should be carried out to determine the bedrock ripability.

Selection of excavation equipment should be based on site access, strength of sub-surface materials and on the likely impact of vibration to neighbouring structures (building, houses, roads, etc) in the vicinity of the proposed excavation. Acceptable vibration is based on the nature and state of neighbouring structures, which will have to be established by a dilapidation survey. As a general guide, the acceptable maximum peak particle velocity in a residential area would range from about 5mm/s to 10mm/s.

With the exception of some seepage at five test pit locations, groundwater was not encountered to the excavated depths of the test pits. MW1 encountered groundwater at about 8.2m and MW2 at about 2.5m during drilling. We do not anticipate that excavation will extend to these depths. Hence, no groundwater related problems are anticipated. However, due to variations in rainfall and/or other factors, groundwater level or seepage might be encountered during excavation. Minor groundwater, if encountered, during site works could be readily managed utilising conventional pump and sump system. Trafficability problems might arise locally during wet weather or if water is allowed to pond at the site.

We recommend the following procedures for placement of controlled fill, where required;

- Strip topsoil and stockpile for possible future use in landscaping.
- Undertake proof rolling (using an 8 to 10 tonne roller) of the exposed alluvial or residual soils to detect potentially weak spots (ground heave). Excavate areas of localised heaving to a depth of about 300mm and replace with granular fill, compacted as follows:
- Undertake proof rolling of compressible zones backfilled with granular fill, as described above. If the backfilled area shows further movements during proof rolling, this office should be contacted for additional recommendations. Further movement may mean that the existing fill materials should be removed and replaced with controlled fill.
- Fill should be placed in horizontal layers of 200mm to 250mm, maximum loose thickness (depending on the size of equipment) and compacted to a Minimum Dry Density Ratio (MDDR) of 95% Standard, as recommended for residential subdivisions in AS3798-2007 (Guidelines on Earthworks for Commercial and Residential Developments) at moisture content within 2% of Optimum Moisture Content (OMC).
- The MDDR should be increased to at least 98% for commercial development (such as retail development) or residential development that would impose floor loading in excess of 20kPa and/or strip/pad footings in excess of 100kPa. This might also be applicable for dwellings in excess of two levels.
- The upper 300mm of fill forming subgrade for the pavement should be compacted to a Minimum Dry Density Ratio (MDDR) of 100% Standard, at moisture content within 2% of Optimum Moisture Content (OMC).
- Structural fill should preferably comprise non to low reactive fill, with a maximum particle size not exceeding 75mm, such as low plasticity clay. Existing natural soils (alluvial and residual) and bedrock obtained from excavations within the site may be used in controlled fill after removal of deleterious materials, if any, and moisture conditioning.
- Fill placement should be supervised to ensure that material quality, layer thickness, testing frequency and compaction criteria conform to the specifications. We recommend "Level 1" supervision, in accordance with AS3798-2007.

8.6 Batter Slopes and Earth Pressure

The natural ground surface within the site is assessed to have a very low risk of instability. However, development of the site could involve ground modifications, including excavation and fill placement. In general, the cut and fill slopes for the proposed development are anticipated to be less than 3m in height and cut slopes will be limited to alluvial soil or residual soil. Therefore, for unsupported cut and fill slopes, recommended batter slopes for permanent and temporary slopes are 1 Vertical to 2.5 Horizontal and 1 Vertical to 1 Horizontal respectively. It is also recommended that adequate surface and sub-surface drainage is provided at the crest and toe of the batter slopes.

If batter slopes steeper than those recommended are required, the materials would need to be retained by engineered retaining structures. Appropriate retaining structures would comprise bored pier walls installed prior to excavation or gravity walls constructed after excavation is completed. The pressure distribution on such retaining structures is assumed to be triangular and estimated as follows;

$$p_h = \gamma k H$$

Where,

p_h = Horizontal pressure (kN/m^2)
γ = Wet density (estimated to be 18kN/m^3)
k = Coefficient of earth pressure (k_a or k_o)
H = Retained height (m)

For design of flexible retaining structures, where some lateral movement is acceptable, an active earth pressure coefficient (ka = 0.35) is recommended. If it is critical to limit the horizontal deformation of the retaining structure, the use of an earth pressure coefficient at rest (ko = 0.55) should be considered.

The above coefficients assume that ground level behind the retaining structures is horizontal and the retained material is effectively drained. Additional lateral pressure, due to surcharge load and groundwater pressure, if any, should also be allowed for in the design of retaining structures.

8.7 Site & Exposure Classification (AS2870)

It is our assessment that the site is suitable for construction of residential buildings upon completion of site preparation works.

At completion of site preparation for proposed development works, when building platforms and subgrade are ready for construction of residences and roads, sub-surface profiles within the residential lots are anticipated to be as follows;

Unit -1 (Drawing 12576/1-AA2)

- Type 1-1 – Profile comprising alluvial soils.
- Type 1-2 – Profile comprising a sequence of controlled fill over alluvial soils.

Unit 2 (Drawing 12576/1-AA2)

- Type 2-1 – Profile comprising alluvial soils over residual soils.
- Type 2-2 – Profile comprising a sequence of fill over alluvial soils over residual soils over bedrock.
- Type 2-3 – Profile comprising residual soils over bedrock.
- Type 2-4 – Profile comprising a sequence of fill over residual soils over bedrock.
- Type 2-5 – Profile comprising bedrock (after removal of natural soils)

The magnitude of ground surface movement due to moisture variation, which is required for site classification, depends on shrink-swell index values and thickness of soils underlying a building slab. Based on the results of the investigation, alluvial and residual soils are medium to high plasticity, with pockets of low plasticity silt/clayey silt and shaley clay. Hence, the natural soils and controlled fill are likely to be moderately to highly reactive.

Based on anticipated thickness of soils (including controlled fill, alluvial soil and residual soils) and estimated shrink-swell movements, site classifications for future residential lots across the site are anticipated to be to Class "M" (Moderately reactive) or "H1" (Highly reactive), in accordance with AS2870-2011 "Residential Slabs and Footings". General definitions of site classes provided in AS2870-2011 are reproduced below.

Site Classification	Foundation Condition	Ground Surface Movement (mm)
Class A	Most sand and rock sites with little or no ground movement from moisture changes	Not Applicable
Class S	Slightly reactive clay sites, which may experience with only slight ground movement from moisture changes	Less than 20
Class M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 to 40
Class H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 to 60
Class H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 to 75

Based on information in the above table, site classifications for individual residential lots can be determined on completion of fill placement. The appropriate site classifications for individual residential lots should be determined by conducting sampling and testing in accordance with AS2870-2011 "Residential slabs and footings".

With the exception of the low lying areas in the north and west of Unit 1, the remaining area of the site is suitable for the proposed residential subdivision development. The low lying areas are within or in proximity to South Creek and other unnamed creeks/drainage depressions, which are likely to be subject to flooding and are not suitable for construction of residential buildings. However, ground levels in such areas may be raised by placing controlled fill, in accordance with the recommendations presented in this report, then used for construction of buildings. Alternatively, such areas may be developed for open parks or recreational use.

The exposure classifications with regard to salinity, provided in AS2870-2011, are reproduced below:

EC_e (dS/m)	Exposure Classification*
<4	A1
4 – 8	A2
8 – 16	B1
>16	B2

Detailed results of the salinity assessment are given in Section 9.0 and indicate that the majority of the lots may be classified as Class “A1” or “A2”.

8.8 Floor Slabs and Footings

Floor slabs for future residential buildings may be designed either as ground bearing or suspended slabs supported by footings. If ground bearing floor slabs are desired, slabs appropriate for site classes may be designed in accordance with AS2870-2011 "Residential Slabs and Footings".

Site classification in accordance with AS2870-2011 is only applicable for the design of footing systems for a single dwelling, house, townhouse or similar structure that would be detached or separated by a party wall or common wall. AS2870 is not suitable for dwellings that are situated vertically above or below another dwelling, including buildings classified as Class 1 and Class 10a in the Building Code of Australia (BCA). Therefore, a geotechnical investigation will be required for other dwellings that would be classified in accordance with the BCA.

Foundation materials across the site will vary from controlled fill to alluvial soil to residual soil to bedrock, depending on the location of a building with regard to cut and fill profile. Therefore, assessment of foundation materials and allowable bearing pressure for a specific building should be reassessed after completion of site preparation works and during footing construction.

8.9 Pavements

We anticipate that pavements will be constructed by cut and fill. Subgrade conditions for the pavements are likely to be alluvial clays or residual clays (cut areas) and controlled fill (fill areas). Although no CBR tests were conducted, we anticipate a CBR in the range of 3% to 6% for both alluvial and residual soils. Subgrade conditions consisting of alluvium are likely to vary across the site and so the CBR value could also vary. In areas where poor subgrade conditions are encountered (CBR values less than 3%), then subgrade improvement by replacement or insitu stabilisation will be required. In cut areas where bedrock and residual clays are encountered at subgrade level, over-excavation of about 300mm of bedrock and re-compaction will be required to provide uniform subgrade. Subgrade preparation for pavement construction should be carried out as recommended in the earlier section “Site Preparation” of this report.

Geotechnical investigation for pavement design should be carried out at different stages of development to confirm subgrade conditions and determine design CBR values.

9.0 SALINITY ASSESSMENT

Salinity is the accumulation of mineral salts in the soil, groundwater and surface waters. It is primarily a groundwater problem that produces effects at the soil surface, which can lead to serious land degradation problems. High salinity can also cause dehydration of plant cells, reducing plant growth potential and sometimes causing death of a species. Saline soils in an urban environment can cause damage to bitumen, concrete structures, bricks and steel (including pipes).

The three main sources of salts are as follows;

- Salts transported from the ocean and deposited by rainfall.
- Salts released during the process of soil and rock weathering.
- Salts naturally present in the soil profile, resulting from marine sediments deposited in earlier geological times.

Soil salinity in western Sydney is thought to be primarily the result of early marine sediment deposits and the extent is largely related to the underlying Wianamatta Group shales. Soil salinity in western Sydney can also be related to the process of soil and rock weathering and therefore it is not unusual for higher salt content to be present at or close to the soil / bedrock interface in a residual soil profile.

Surface water and groundwater can dissolve salts present in soils and mobilise these salts to other areas. Over time, a balance is reached between water and the movement of salt and ecosystems will develop that are adapted to the salt in soil and water.

Land development can change the movement of surface and groundwater and as a consequence, carry the salts to other areas potentially outside the balanced environment. This movement can have adverse impacts on ecosystems; particularly plant growth and can also result in damage to building materials where salts accumulate.

9.1 Salinity Testing

EC testing was carried out to assess soil salinity. The test conducted on a soil sample for salinity is generally made up of 1:5 soil water suspension, which is one part air dried soil to five parts distilled water. The determined EC is multiplied by a factor (varying from 6 to 17) based on the texture of the soil sample, to obtain Corrected Electrical Conductivity designated as EC_e, as outlined in the OEH (Office of the Environment & Heritage) publication, "*Site Investigations for Urban Salinity - 2002*".

The OEH publication defines various classes of saline soils, as follows.

Classification	EC_e (dS/m)
Non-saline	<2
Slightly saline	2 – 4
Moderately saline	4 – 8
Very saline	8 – 16
Highly saline	>16

The soil samples, recovered during the field work, were tested in the laboratory of SGS Environmental Services to determine EC.

The laboratory test results are detailed in Tables AA1 to AA4 (Appendix G). The following table presents a summary of the salinity testing results, including pH results.

Depth (m)	Samples Tested	Average pH	ECe Range dS/m		Average ECe dS/m	Salinity Assessment	Very (8-16dS/m) to Highly Saline (>16dS/m) Values
0.0-0.1	73	8.1	0.01	7.06*	1.3*	Non saline	33.15(TP25),27.2(TP8), 10.2 (TP27) 10.20 (TP32), 12.75(TP33)
0.5-1.0	36	5.4	0.31	7.80*	2.5*	Slightly	14.0(TP32)
1.0-2.0	76	5.7	0.27	7.80*	4.3*	Moderately	10.8(TP18),13.3(TP25),11.9(TP32), 9.6(TP60), 12.0(TP62)
>2.0	37	6.0	0.18	7.80*	4.5*	Moderately	12.6(TP8), 9.6(TP21), 8.4(TP22), 11.9(TP25), 9.6(TP27), 8.4(TP35), 12.6(TP59)

* Excludes exceptionally high values recorded separately in the last column

Based on the above results, the topsoils and surface soils to a depth of 1m are considered to be non-saline grading to slightly saline, but the natural soils to a depth of 2.5m (or shale bedrock) are considered to be moderately saline.

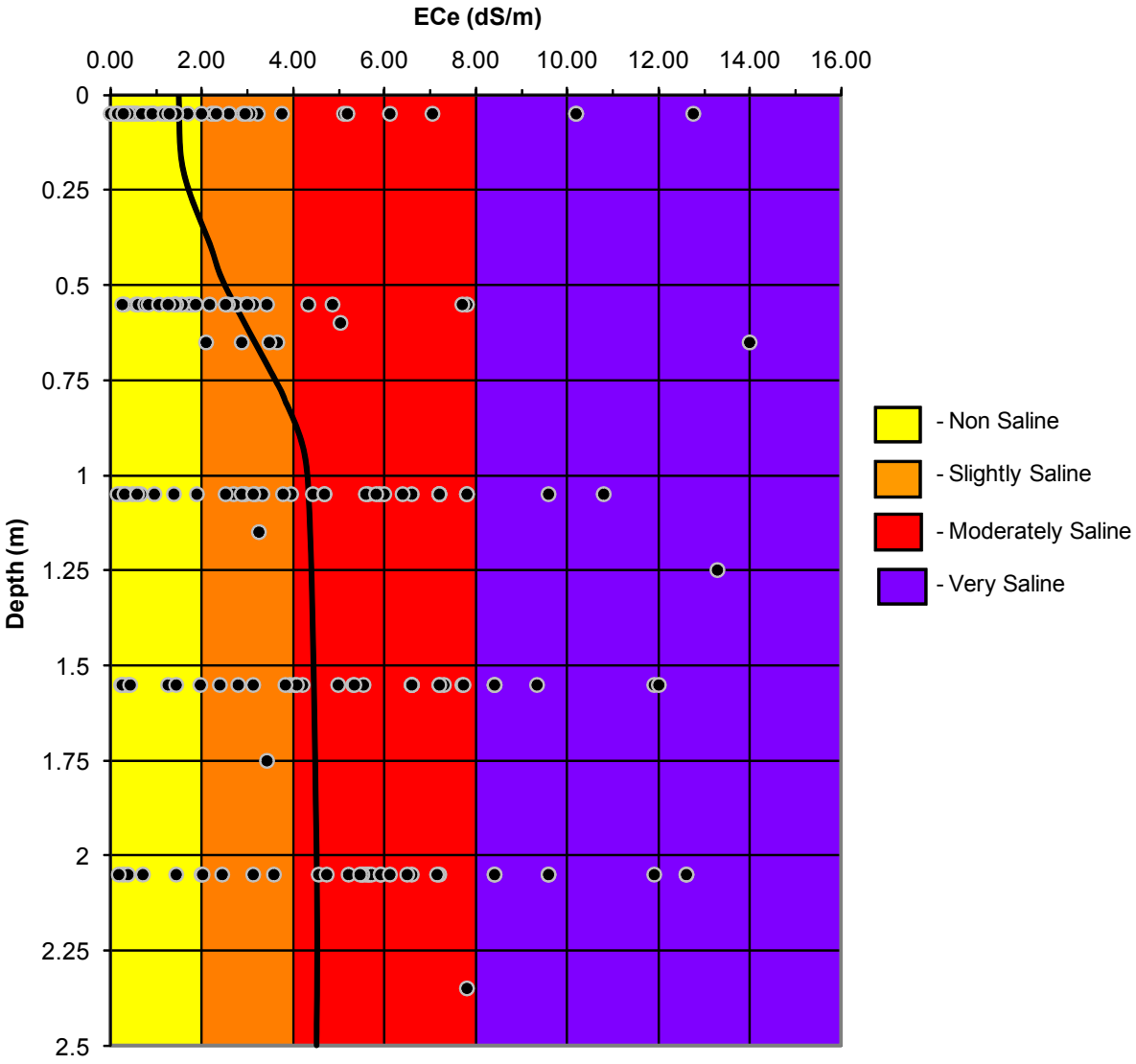
The exceptionally high salinity values indicate that;

- Very to highly saline soils were encountered at 2m to 3m depth intervals in TP8, 25, 27 & 32.
- Very saline soils were encountered at one depth interval in TP18, 21, 22, 27, 33, 35, 59, 60 & 62.
- The horizontal extent of very to highly saline soils is shown on Drawing 12576/1-AA4. The extent of these areas is located within Unit 1 soil, which mainly comprises alluvium clays, silty clays, sandy clays, silts clayey silts and clayey gravel.
- With reference to the aerial photographs, these areas are generally located within the flood plains of one or two adjacent creeks.

The EC_e results have been plotted versus depth on the salinity profile and indicate an overall “normal” salt profile. However, due to the nature of the site and presence of flood affected and low-lying areas, there will be specific areas where the soil salt profile could be reflecting discharge, recharge and intermittent profiles as described in the above publication.

Figure 2

Salinity Profile Plot



9.2 Aggressivity Testing

The OEH suggests reference to the following;

- Australian Standard AS3600: Concrete Structures
- Australian Standard AS3700: Masonry Structures
- Australian Standard AS2159: Piling – Design and Installation
- Australian Standard AS2870: Residential Slabs and Footings

The laboratory test results indicate the following average results.

Depth (m)	pH	Chlorides (mg/kg)	Sulphates (SO_4) (mg/kg)	Sulphates (SO_3) (mg/kg)	Magnesium (mg/kg)
0.0-0.1	8.1	279	64	51	414
0.5-1.0	5.4	853	258	207	940
1.0-2.0	5.7	723	217	174	1018
>2.0	6.0	1017	212	169	909
Overall	6.3	717	194	156	860

9.2.1 Iron & Steel

Aqueous solutions of chlorides cause corrosion of iron and steel, including steel reinforcement in concrete. Corrosion damage by chlorides is only relevant to iron and steel. The aggressivity classifications of soil and groundwater applicable to iron and steel, in accordance with Australian Standard AS2159, are given below.

Chloride in Soil (mg/kg)	pH	Low Permeability Soil
<5,000	>5.0	Non-aggressive
5,000-20,000	4.0-5.0	Mild
20,000-50,000	3.0-4.0	Moderate
>50,000	<3.0	Severe

Based on the average pH and chloride results (Tables AA1 to AA4 & AB (Appendix F), the soils are considered to be non-aggressive to steel.

9.2.2 Concrete

The aggressivity classifications of soil and groundwater applicable to concrete, in accordance with Australian Standard AS2159, are given below.

Sulphate expressed as SO_3 in Soil (mg/kg)	pH	Low Permeability Soil
<2,000	>6.5	Non-aggressive
2,000-5,000	5.0-6.0	Non-aggressive
5,000-10,000	4.5-5.0	Mild
10,000-20,000	4.0-4.5	Moderate
>20,000	<4.0	Severe

Approximately 100ppm of SO_4 = 80ppm of SO_3

Based on the average pH and sulphate results (Table AB, Appendix F), the soils are considered to be non-aggressive to concrete.

The aggressivity classifications of soil and groundwater applicable to concrete, in accordance with The German Standard (DIN 4030: Corrosivity Assessment for Concrete), are as follows.

Sulphate expressed as SO_4 in Soil (mg/kg)	Magnesium in Soil (mg/kg)	pH	Soil
200 - 600	300 - 1000	5.5 – 6.5	Low
600 - 3000	1000 - 3000	4.5 – 5.5	High
>3000	>3000	<4.5	Extremely High

Based on the pH, sulphate and magnesium test results (Tables AA1 to AA4 & AB, Appendix F), the soils are of low aggressivity to concrete. Therefore, it is our opinion that the soils could be considered as low aggressive to concrete.

9.3 Dam Water Testing

The aggressiveness of saline water on building structures and/or the impacts of saline water on plant growth has been assessed through pH levels (Australian Standards mentioned above) and a position paper prepared by Simon Leake, the Principal Soil Scientist with Environmental and Soil Laboratory Pty Ltd. The paper is titled "*Salinity and Structures: Measurement and Interpretation of Results*". In the paper, Mr Leake makes reference to EC of water and the potential impacts on building structures and plant growth. The following table summarises Mr Leake's position.

Electrical Conductivity (dS/m)	Aggressiveness to Concrete	Aggressiveness to Steel	Risk to Plant Growth
≤5.5	non	mild	Most plants show yield decline
5.5 - 13.8	mild	mild	Severe yield decline in all plants
13.8 - 27.5	moderate	mild	Acute toxicity to crop plants
≥55 (sea water)	severe	moderate	Specialist halophytes still alive

Three dam water samples (designated DW4, DW5 & DW6) were recovered on 3 November 2011 and tested for pH and Electrical Conductivity.

The EC results range from 0.71dS/m to 1.2dS/m. The pH results range from 7.3 to 7.8, indicating non-acidic conditions.

Based on the above table, the water samples are non-aggressive to steel and concrete and pose no risk to plant growth.

9.4 Erodibility (Sodicity) Testing

Sodicity is measured by the Exchangeable Sodium Percentage or ESP. The recommended thresholds are shown below.

ESP (%)	Assessment
<5	Non sodic
5 – 10	Marginally
>10	Highly

Soil samples were tested for ESP. The results are summarised in Table AC (Appendix F) and in the following table.

Depth	Range	Average	Assessment
0.0-0.1	1 – 57%	18%	Highly sodic
0.5-1.0	12 – 52%	28%	Highly sodic
1.0-2.0	2 – 50%	29%	Highly sodic
>2.0	5 – 56%	36%	Highly sodic
Overall		28%	Highly sodic

Based on the test results the soils on site are generally highly sodic and increase in sodicity with depth.

9.5 Soil Management Plan

The laboratory test results indicate the following soil salinity profile and general properties.

Soil layer	Salinity	Sodicity (Dispersion)	Acidity	Aggressivity to Steel	Aggressivity to Concrete
Surface	Non saline[1]	Highly sodic[2]	Non acidic	Non aggressive	Low aggressive
0.1 – 1.0m	Slightly saline[1]	Highly sodic[2]	Non acidic	Non aggressive	Low aggressive
1.0 – 2.0m	Moderately saline[1]	Highly sodic[2]	Non acidic	Non aggressive	Low aggressive
>2.0m	Moderately saline[1]	Highly sodic[2]	Non acidic	Non aggressive	Low aggressive

1. Pockets of very to highly saline soils within the layer
2. Highly sodic and increasing in sodicity with depth

We expect that earthworks for the proposed subdivision development will involve cut and fill operations, as follows;

- Construction of building platforms for future residential dwellings.
- Construction of roads.

The objectives of this soil management plan are as follows;

- Minimise erosion and sediment loss before, during and after construction.
- Minimise water pollution due to erosion, siltation and sedimentation.
- Maximise re-use of on-site materials.
- Reduce and manage salinity within the site so that impacts on future structures (including buildings, roads etc) and planting are minimised and acceptable.

The following should be considered as part of the Soil Management Plan;

- Develop the best use of the existing topography in order to minimise cut and fill operations, thus minimising site works and working with marginally sodic soils, with possible pockets of highly sodic soils.
- Minimise site works to 1m depth. Site works below 1m are likely to expose moderately saline soils that might affect the exposure classification of the finished lots. Alternatively, localised or imported soil can be used to cover up such soils by at least 1m (below finished level).
- Very to highly saline soils on Drawing 12576/1-AA4 should not be used as structural fill, unless based deep below finished level by at least 2m and not placed in areas with expected hydraulic flow.
- Erosion and Sediment Control Plans must be developed and implemented by the earthworks contractors. All sediment and erosion controls proposed by the Erosion and Sediment Control Plan are to be installed prior to commencement of any construction works.
- Ensure that earthworks and construction activities do not affect the natural flow of groundwater. If groundwater is intercepted during development works/excavation, the flow should be diverted to stormwater drains or creeks by providing appropriate surface and sub-surface drainage.
- Reduce groundwater recharge through appropriate land use and land management practices. This can be achieved by minimising deep infiltration by providing a well compacted impermeable liner along surfaces of waterways (drains, channels, creeks etc.) and maximising vegetation cover, planting of deep rooted trees and use of salt tolerant plants.
- Reduce the effect of rising salinity on roads by reducing groundwater recharge and maintaining effective subsoil drainage below the roads subgrade. Construction of roads in flat and/or hilly areas should consider recommendations given in the publication: “Roads and salinity – 2003”.
- For low lying portions of the site, stormwater drains along roads can be used to control groundwater level. However, to reduce the distance between drains, subsoil drains could also be installed along the property boundaries.
- Construct a dish drain behind the crest of all slopes to divert water away from the slope face to minimise erosion of the face
- On cut and fill batters, provide a secured turf overlay to guard against erosion.
- Utilise native and deep-rooted plants to minimise soil erosion.
- Retaining walls for cut and fill slopes, where required, should be provided with adequate and appropriate drainage.
- Selection, construction and management of parklands should consider the recommendations in the publication: “Waterwise Parks and Gardens – 2004”.
- Conduct a post site works salinity assessment to confirm salinity and aggressivity of the completed subdivision.
- Select construction materials and techniques suitable for the exposure classification (post site works). This would include, but not be limited to, the following;
  - Building in a saline environment (2003)
  - AS2870-2011: Residential Slabs and Footings
  - AS3600-2009: Concrete Structures
  - AS3700-2011: Masonry Structures

10.0 SITE CONTAMINATION

10.1 Potential for Contamination

The potential for site contamination, or areas of environmental concern, has been assessed by review of the site history, field observations, sub-surface profiling and limited soil and groundwater testing. Based on all the information obtained, the potential for site contamination is assessed as follows;

- The history of the site suggests predominant use for horticultural activities, including market gardening, poultry and cattle farming. There is minor potential for elevated metals and/or pesticides concentrations in surface soils within various sections of Richmond Road and South Street.
- Lot 9 in DP1078187 was used for possible laundry in between the 1940s and 1970s, which indicates the potential for chemicals to have migrated into the site. The use of chemicals could lead to Trichloroethylene and 1,1,1-trichloroethane, carbon tetrachloride and perchlorethylene contamination.
- NSW WorkCover information indicated the presence of underground fuel tanks in Lot 2 in DP260476, which could pose potential petroleum hydrocarbon contamination. A former bowser was also noted in Lot 9 in DP1078187 during field work.
- A search of the POEO Public Register on 6 December 2011, as a part of NSW OEH records, found a number of notices for 1270 Richmond Road, Marsden Park (Lot 2 in DP260476). The details of relevant POEO licenses should be considered for any potential contamination issues prior to detailed contamination assessment of that property.
- Fill materials observed in the site, including illegal dumping in Lot 10 in DP70287, could be contaminated.
- Chicken carcasses might have been buried in the poultry farms (Site Feature 21, see Drawing No 12576/1-AA1).
- Blacktown Council Depot is likely to be contaminated due to land filling activities (Refer Below).

Overall, the risk posed by the site on human health and the environment is considered to be low. The potential for contamination outlined in this section suggests that if contamination exists, it is likely to be localised only.

10.2 Land Fill Operations, Blacktown Council Depot

The Blacktown Council Depot (The Grange Avenue Waste Management Centre) site is located at the western end of Grange Avenue (Feature No 11 on Drawing 12576/1-AA1). The landfill site is 48.8 hectares and was generally used as a landfill for domestic waste (putrescible waste). The site operated between 1975 and 1993 to receive both commercial and municipal waste. From 1993, only solid municipal waste was received until closure on 1 February 2001. Therefore, the depot has been closed for 11 years. A Landfill Closure Plan was prepared by GHD LM in October 2002 (Report 21/11153/00/85213). The plan detailed ongoing management and monitoring, including leachate, surface water, landfill gas, groundwater contamination, in accordance with an implementation plan.

The landfill area is covered with a capping layer, which was subject to an investigation in September 2003 (GHD LM Report 21/12183). The landfill capping layer should incorporate a 220mm layer of granular topsoil and a compacted clay layer (500mm in thickness with permeability of not more than 1×10^{-8} m/s). The investigation recommended further capping material to be placed and compacted to satisfy regulatory requirements. The report also recommended re-grading of low-lying areas to minimise water ponding and water penetration into the landfill. It is understood from Mr Janusz Dorolot of Waste Management Corporation that these recommendations were implemented.

An Environmental Management Plan was prepared by GHD LM (Report GA-EMP-002) and recommended continuous monitoring of groundwater and surface water after capping and rehabilitation process for post landfill purposes. The plan included a risk assessment strategy with objectives to evaluate the magnitude and relative importance of human health, risks associated with waste disposal activities, evaluate the effectiveness and need for improvement of existing management practices. It is understood from Mr Janusz Dorolot of Waste Management Corporation that these recommendations were implemented.

We are in receipt of Coffey Environments Annual Reports (Annual Report to 31 July 2010- Reference Envirhod00298AB-R13 dated 27 September 2010 and Annual Report to 31 July 2011-Reference Envirhod00298AB-R17 dated 26 September 2011). The reports presented the annual results of chemical testing conducted on recovered water samples from surface and groundwater and leachate, with some comparison with previous records. Results of environmental water samples collected during a twelve month period were generally comparable with previous monitoring data.

We are in receipt of measured surfaced gas concentrations at the Council depot prepared by Waste Assets Management Cooperation (taken 14 December 2011). The report measured Methane equivalent concentrations across the site. No readings exceeding the 500 ppm guideline level were reported, which is the threshold for further investigation and corrective action. The report recommended continuous monitoring on a six monthly basis.

10.3 Further Investigations

In order to address the identified areas of potential contamination outlined, the following further investigation recommendations are suggested;

- Conduct further investigation around the perimeter of the Blacktown Council Depot to determine possible migration of contamination, if any.
- Conduct further assessment/detailed contamination assessment in the areas of concern, including lots that might have received illegal dumping.
- Conduct soil sampling and testing beneath the buildings and sheds after removal.
- Conduct soil sampling and testing following removal of underground fuel tanks.
- Groundwater testing might also be required.

Based on limited soil sampling and testing a number of locations were identified to be contaminated due to elevated metals, PAH and/or TPH (C10-C40) concentrations, as detailed on Drawing No 12576/1-AA6 in Appendix A. Asbestos-cement pieces were also encountered in two test pits and a small soil stockpile. Therefore, the following further investigations are recommended:

- Detailed sampling and testing in the vicinity of locations of concern to delineate the extent of contamination.
- Development of a remedial action plan (RAP) to remediate the elevated Metals, Benzo(a)Pyrene, Total PAH and TPH (C10-C40) concentrations and asbestos-cement pieces, followed by appropriate validation.

11.0 MARSDEN PARK PRECINCT MASTER PLANNING

The master plan for the Marsden Park Precinct (Prepared by AECOM, Revision 3, dated 22 November 2011) indicates four different options, with variations of the number of possible dwellings from 9,300 up to 12,100. The Master Plan generally includes;

- Sporting fields at the location of the Blacktown Council Depot
- Medium and high density residential to the east, north and south of the playing fields
- Low to medium residential to the east of Richmond Road
- One school site and two to three commercial centres
- Riparian corridors and parks to the north and west
- A road reserve along Richmond Road

12.0 SUMMARY OF LAND CAPABILITY, SALINITY AND CONTAMINATION ASSESSMENT

Based on the results of the land capability assessment, salinity assessment and contamination assessment, it is concluded that the four options of the Master plan prepared by AECOM would generally be suitable for the site conditions.

The following is a summary of land capability in terms of the proposed residential/commercial form of development;

- The overall potential for contamination of the site is considered to be low
- The topographic site conditions and the Very Low risk of slope instability are unlikely to impose constraints for the proposed development, provided slopes are re-shaped or retained by engineered retaining structures.
- The majority of the site, excluding anticipated easements for creeks and riparian zone for existing creeks, is assessed to be suitable for proposed development works. Site works for site preparation would be required.
- Soils across the site are unlikely to impose any significant constraints in design and construction of floor slabs, footings, roads and retaining walls.
- Site classifications of lots for the majority of the site (AS2870-2011) are likely to be Class “M” (Moderately reactive) to Class “H1” (Highly reactive).
- The site is characterised by generally non-saline soils within the upper 1.0m of the profile, increasing to moderately saline at greater depths. The impact of moderately saline soils can be readily managed through good engineering practices, as outlined in this report.
- Materials for construction of individual residences should be selected based on the exposure classification of the soils after completion of site works. The exposure classification (AS2870-2011) for the majority of the lots is likely to be Class “A1” (non to slightly saline) or “A2” (moderately saline). Some lots would be classified as “B1” (Very saline) and located at two areas of the site (Refer to Drawing 12576/4-AA: Saline areas).
- The soils are assessed to be non to low aggressive to concrete and steel. As such, soil aggressiveness does not impose a constraint on the proposed development.

- The soils are highly dispersive (sodic) and susceptible to erosion. The impact of sodic soils can be readily managed by application a “Soil Management Plan”
- The existing dam waters are non-saline.
- Test results on the groundwater samples indicate mild aggressiveness to steel and moderate aggressiveness to concrete and high risk to plant growth.
- Recommendations are provided in this report for investigation of identified areas of potential contamination and in the vicinity of locations of concern, already identified during limited soil sampling and testing, and development of a RAP.

13.0 LIMITATIONS

This work was performed in accordance with the scope of work outlined in Geotechnique Quote Q5538 dated 6 October 2011, in a manner consistent with the level of quality and skill generally exercised by members of the profession and consulting practice.

This report has been prepared for Winten Property Group, for the purposes stated within. Relevant authorities involved in assessment of the rezoning submission may also rely on the report. Any reliance on this report by other parties shall be at such parties' sole risk, as the report might not contain sufficient information for other purposes.

This report shall only be presented in full and may not be used to support any other objective than those set out in the report, except where written approval is provided by Geotechnique.

Despite all reasonable care and diligence, site conditions could change over time in response to either natural conditions or manmade influences. The information in this report is considered accurate at the date of issue, in accordance with the current conditions of the site. Any variations to the site form or use beyond this date might nullify the conclusions stated.

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APPENDIX A

DRAWINGS

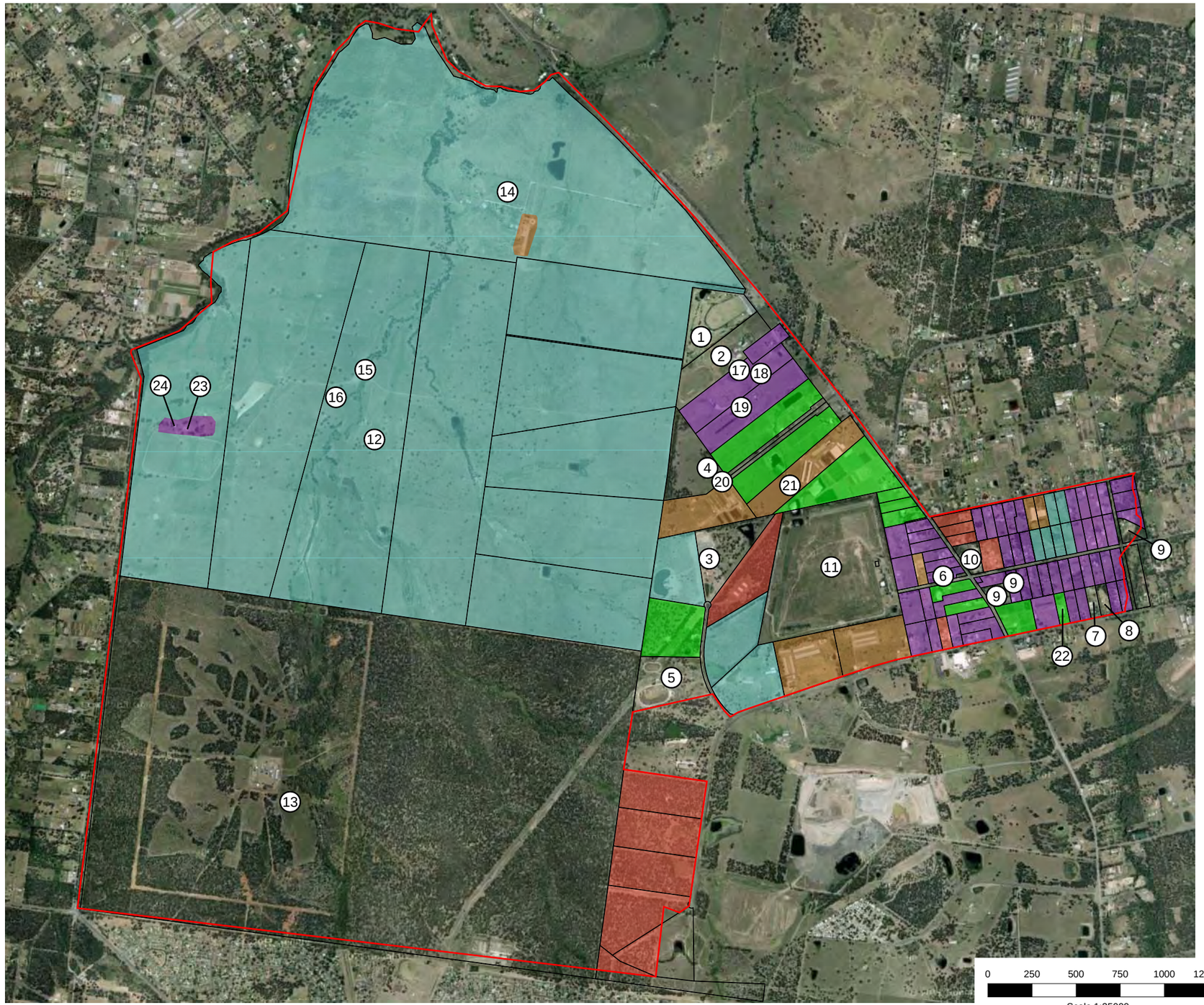
12576/1-AA1 – Site Features
Topographical Map Prepared by AECOM
12576/1-AA2 – Generalised Sub-surface Conditions
12576/1-AA3 – Test Pit, Sample, Dam Water & Monitoring Well Locations
12576/1-AA4 – Saline Areas
12576/1-AA5 – Erosion Areas
12576/1-AA6 – Locations of Contamination
12576/1-AA7 – Depth of Fill

S/F#	Description
1	Golf course
2	Former pig farm
3	Civil construction company
4	Landscaping paver storage yard
5	Horse training facility
6	Garden centre and stockpile of demolition waste
7	Landscaping company
8	Mechanic workshop with scattered scrap metal
9	Trucking company
10	Landscape supplies
11	Blacktown City Council depot
12	Woorong Park Pty Ltd
13	Airservices Australia
14	FG Pace
15	Filled area
16	Possible filled area
17	Backfilled dam
18	Filled and disturbed area
19	Filled area
20	Possible filled area
21	Filled area with soil stockpile where chicken carcasses were buried. Suspected fill under the two poultry sheds nearby.
22	Filled area at the back of the property near the dam
23	Above ground diesel and petroleum tanks
24	Disused bowser from a former underground petroleum storage tank

S/F# : Site Feature Number

LEGEND

- (1) Site Feature Number
- Poultry Farm
- Cattle Farm
- Rural Residential Land
- Market Garden
- Area inaccessible at the time of inspection



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GEOTECHNIQUE PTY LTD
CONSULTING ENGINEERS

PO Box 880
Penrith NSW 2750
Tel: 02 4722 2700
Fax: 02 4722 2777

e-mail:info@geotech.com.au
www.geotech.com.au

NOTES

1. This drawing has been produced using a base plan provided by others, to which additional information e.g., test pits, borehole locations or notes have been added. Some or all of the information on this plan may not be relevant at the time of producing this drawing.
2. Site features are shown at approximate locations and are not to scale.

Winten Property Group
Marsden Park Precinct
North West Growth Centre
Marsden Park

Site Features

Drawing No: 12576/1-AA1
Job No: 12576/1
Drawn By: MH
Date: 1 December 2011
Checked By: ZA/AB

File Ref: 12576-1
Layers: 0, AA1