REPORT

TO
MANLY COUNCIL

ON
SUPPLEMENTARY GEOTECHNICAL INVESTIGATION

FOR
PROPOSED MANLY ANDREW 'BOY' CHARLTON SWIM CENTRE REDEVELOPMENT

AT
KENNETH ROAD, MANLY, NSW

16 August 2013
Ref: 26655ZH2rpt

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1 INTRODUCTION

This report presents the results of a supplementary geotechnical investigation for the proposed Manly Andrew 'Boy' Charlton (ABC) Swim Centre ('swim centre') Redevelopment at the corner of Balgowlah and Kenneth Roads, Manly, NSW. The supplementary investigation was commissioned by Mr Gordon Malesevic of Manly Council by email, dated 24 July 2013. The commission was on the basis of our proposal, Ref: P26655ZH, dated 15 July 2013.

JK Geotechnics previously completed a preliminary geotechnical investigation at the site for the proposed redevelopment when it was at a concept stage. The results of the preliminary geotechnical investigation were presented in our report, Ref: 26655ZHrpt, dated 18 July 2013. This standalone report confirms and amplifies the comments and recommendations made in our previous report and also incorporates the borehole logs (BH1 to BH4) and laboratory test results from the previous report.

To assist us with the supplementary investigation, we have been supplied with the following information:

1. A Geotechnical Brief prepared by Geoff Ninnes Fong and Partners Pty Ltd (GFNP), dated 10 July 2013.
2. Architectural drawings prepared by Tompkins MDA Architects (Project No. 1310, Drawing Nos. 103 to 106, dated 1 August 2013);
3. A survey plan prepared by 'Planning and Strategy' (Drawing No. EX01^{A}, dated March 2003). The survey datum is not indicated and therefore has been assumed; and
4. Preliminary concourse slab and sub-floor sketches prepared by GFNP (Drawing Nos. SK1 and SK2, dated 7 August 2013).

Based on the supplied information, we understand that the existing 'swim centre' will be extended to the south-east and will comprise construction of a new two storey building (with a sub-floor lower ground floor level) that will incorporate a new leisure pool, 25m pool and program pool. The concourse level will be constructed at reduced levels (RLs) between RL4.2m and RL6.0m. With exception of the north-eastern portion of the proposed building that will abut the existing 50m pool, the proposed ground floor level will be between about 0.5m and 2.6m above existing grade. From information shown on the supplied architectural drawings and GFNP sketches the proposed pools will be maximum 1m (leisure pool), 1.5m (25m pool) and 1.25m (program pool) deep. Based on a base slab thickness of 0.25m as shown on the GFNP sketches, the base of each pool

will extend down to about RL4.2m (leisure pool), RL2.4m (25m pool) and RL2.7m (program pool). To achieve these levels, excavation to a maximum depth of about 0.5m will be required in areas external to the existing 'swim centre'. However, localised excavation to a maximum depth of about 2m will be required for the proposed program pool and 25m pool immediately adjacent to the existing 50m pool where ground surfaced levels have been raised by past filling. The approximate outline of the proposed building is shown on Figure 1.

The floor level for the proposed plant room that will be located below the proposed leisure pool will be at RL3.4m (as per the level shown on the architectural drawings) and therefore will be at or close to existing grade.

An on-grade car park is proposed on the north-western side of the existing swim centre.

The supplied GNFP brief implies piled structures with maximum pile loads in the order of 500kN to 600kN, with a permitted maximum differential settlement of 3mm for the proposed pool structures.

The purpose of the investigation was to assess the subsurface conditions at fourteen borehole locations (BH1 to BH4 from the preliminary investigation and BH101 to BH110 from the supplementary investigation), and based on the information obtained, to present our comments and recommendations on excavation conditions and support, dewatering, retaining walls, footings, external pavements and soil aggression.

We were also commissioned to carry out a Preliminary Environmental Site Assessment. This work was carried out by Environmental Investigation Services (EIS) [the environmental consulting division of the Jeffery and Katauskas Group] who prepared a report, Ref: E26655KHrpt, dated August 2013. This geotechnical report must be read in conjunction with the EIS report.

2 INVESTIGATION PROCEDURE

Prior to the commencement of the fieldwork, a 'Dial Before You Dig' search was undertaken and the borehole locations were electromagnetically scanned by a specialist sub-contractor for buried services.

The fieldwork was carried out on 1 and 2 July 2013 (preliminary investigation) and 30 and 31 July 2013 (supplementary investigation) and comprised the drilling of fourteen boreholes (BH1 to BH4

and BH101 to BH110) at the locations shown on Figure 1. Figure 1 is based on the supplied survey plan. The datum has been assumed. The borehole locations were set out by tape measurements from existing surface features and apparent site boundaries.

The boreholes were auger drilled to depths between 3.0m (BH107 and BH106) and 14.5m (BH1) below existing grade using our track and truck mounted drill rigs. BH108, BH109 and BH110 were then extended into the underlying bedrock using rotary diamond coring techniques with an NMLC triple tube core barrel and water flush to final depths of 7.05m (BH108), 12.14m (BH109) and 10.82m (BH110). With exception of BH106 and BH107 which were drilled for environmental purposes, the primary purpose of the additional boreholes was to further assess bedrock levels and rock quality within the footprint of the proposed building. Groundwater observations were made in each borehole during the fieldwork. A Class 18 uPVC standpipe was installed into BH4 to 5.0m depth. The basal 4m of the standpipe was slotted. The top of the standpipe was protected by cast iron gatic cover.

The nature and composition of the soil and rock horizons were assessed by logging the materials recovered during drilling. In the boreholes drilled for the preliminary investigation, the relative compaction and density of the subsoil profile were assessed from the Standard Penetration Test (SPT) 'N' values, Solid Cone Penetration Test 'N_c' values and a single auger push. The strength of the upper weathered bedrock profile was assessed by observation of auger penetration resistance when using a tungsten carbide (TC) bit, together with examination of recovered rock cuttings and correlation with subsequent moisture content tests (BH3 only). Due to the very loose/loose sands and depth to the underlying bedrock in BH1, the augers were damaged at depth whilst proving the bedrock. The strength of the cored bedrock was assessed by examination of the recovered rock cores, together with correlations with subsequent laboratory Point Load Strength Index ($I_{S(50)}$) tests. Further details of the methods and procedures employed in the investigation are presented in the attached Report Explanation Notes.

Our geotechnical engineers were present on a full-time basis during the fieldwork to set out the borehole locations, direct the electromagnetic scanning, nominate the testing and sampling, direct the standpipe installation and prepare the attached borehole logs. The Report Explanation Notes define the logging terms and symbols used.

Selected soil and rock cutting samples were returned to NATA registered laboratories (Soil Test Services Pty Ltd and Envirolab Services Pty Ltd) for moisture content, particle size distribution, soil pH, chloride and sulphate, Standard compaction and four day soaked CBR testing. The test

results are summarised in the attached Tables A, B, C and D. The Envirolab Services Pty Ltd *"Certificate of Analysis"* is attached in Appendix A.

The recovered rock cores were photographed and also returned to STS for Point Load Strength Index testing. The photographs are enclosed facing the relevant cored borehole logs. The Point Load Strength Index test results are plotted on the borehole logs and are also summarised in the attached Table A1. The unconfined compressive strengths (UCS), as estimated from the Point Load Strength Index test results, are also summarised in Table A1.

3 RESULTS OF THE INVESTIGATION

3.1 Site Description

The following site description should be read in conjunction with the attached Figure 1.

The existing 'swim centre' is located just beyond the toe of a moderately sloping north facing hillside and is relatively flat. Manly Lagoon is located about 500m to the north of the site. The 'swim centre' is bound by Kenneth Road to the north, Balgowlah Road to the east and south and LM Graham Reserve to the west.

At the time of the fieldwork, the western side of the 'swim centre' was occupied by an on-grade car park that was surfaced with asphaltic concrete (AC) and/or a bituminous seal. The pavement surface was in poor condition and contained longitudinal and crocodile cracking, pot holes, shallow depressions, rutting and previous AC patch repairs. The adjoining LM Graham Reserve was surfaced with patchy grass. The site appeared to be poorly drained, as noted by ponding water in pot holes and shallow surface depressions, both within the carpark and LM Graham Reserve.

Sandstone bedrock outcropped on the southern side of Balgowlah Road opposite the site

There were several small to medium size trees located along the Kenneth and Balgowlah Road site frontages, as well as along the perimeter of the car park. The adjoining 50m pool to the north and east of the car park was supported by a 1.8m high brick retaining wall, that appeared to be in fair condition, with some loss of mortar between bricks observed.

3.2 Subsurface Conditions

The 1:100,000 Geological Map of Sydney indicates the site is underlain by Hawkesbury Sandstone, close to the contact with the overlying Quaternary alluvial deposits comprising *'Silty to peaty quartz sand, silt and clay. Ferruginous and humic cementation in places. Common Shell layers'* associated with Manly Lagoon.

In summary, the boreholes encountered pavements (BH4, BH101 and BH110) and fill overlying predominantly alluvial sands and silty sands with weathered sandstone bedrock at depths ranging between 2.2m (BH3) and 13.6m (BH1) below existing grade. Reference should be made to the attached borehole logs for specific details at each location.

Figure 2 presents a plan showing the outline of the proposed building and indicative bedrock surface contours, as well as the RL at the top of the bedrock encountered within each borehole located within the proposed building footprint. Sections A-A and B-B, which also present graphical borehole summaries, are presented as Figures 3 and 4. A summary of the subsurface characteristics is provided below:

Pavements

A thin bituminous seal or asphaltic concrete wearing surface was encountered at the top of BH4, BH101 and BH110 and was either 30mm (BH4 and BH101) or 50mm (BH11) thick. The wearing surfaces were underlain by a 270mm (BH4 and BH101) and 350mm (BH110) thick granular 'base course' layer.

Fill

Fill comprising silty sand and clayey sand was encountered from the ground surface in BH1 to BH3 and BH102 to BH109 and below the granular base course layer in BH4, BH101 and BH110 and extended down to depths between 1.0m (BH4 and BH101) and 1.8m (BH3) below existing grade. Inclusions of igneous and sandstone gravel, shell and glass fragments and slag were present within the fill. Based on the SPT 'N' values, the fill in BH1 to BH4 was assessed to be variably compacted, but predominantly poorly compacted.

Alluvial Soils

Alluvial soils comprising predominantly sand, silty sand and clayey sand were encountered below the fill in each borehole. Where tested, the alluvial sands were generally very loose and loose, with occasional medium dense bands. In BH2, a band of soft silty clay was encountered between about 8.8m and 10.0m depth. BH106 and BH107 were terminated within the alluvial soil profile.

Weathered Sandstone Bedrock

With the exception of BH106 and BH107, weathered sandstone bedrock was encountered in each borehole at depths between 2.2m (BH3) and 13.6m (BH1) below existing grade and extended down to the borehole termination depths. The sandstone bedrock was of variable quality ranging from extremely weathered and extremely low strength to slightly weathered and fresh and medium and high strength, however, the bedrock often rapidly improved in quality with depth. 'TC' bit refusal occurred within high strength sandstone bedrock in BH3 and BH102.

The diamond cored portions of BH108, BH109 and BH110 encountered relatively few defects including sub-horizontal bedding partings, extremely weathered seams, clay seams and inclined joints. The spacing of the defects increased with depth.

The "core loss" zones encountered in BH108 and BH110 at depths of 4.39m (BH108) and 8.06m and 8.57m (BH11) were between 90mm and 430mm thick and are inferred to be extremely weathered bands/seams or clay/crushed seams which have "washed away" during the coring process.

An indicative engineering classification of the sandstone bedrock (in accordance with Pells et al. 1978, as revised by Pells et al. 1998) has been carried out and is tabulated below:

Borehole	Surface RL (m)	Indicative Engineering Classification of Sandstone Bedrock Depths (m)				
		Class V	Class IV	Class III	Class II	Class I
1	2.4	-	13.6* – 14.5	-	-	-
2	2.8	-	12.1* – 13.5	-	-	-
3	3.2	2.2* – 2.6	2.6* – 3.9	-	-	-
4	3.4	4.9* – 5.5	5.5* – 7.5	-	-	-
101	3.1	4.7*- 5.9	5.9* – 7.5	-	-	-
102	3.2	-	3.3* – 3.6	-	-	-
103	3.1	-	6.5* – 9.0	-	-	-
104	2.9	10.0* – 10.5	10.5* – 11.0	-	-	-
105	2.7	10.2* – 10.5	10.5* – 11.5	-	-	-
108	3.2	3.9* – 4.48	-	4.48 – 5.80	5.80 – 7.05	-
109	2.9	8.4* – 9.98	-	-	9.98 – 12.14	-
110	3.0	5.8* – 9.11	9.11* – 9.30	-	9.30 – 10.82	-

* based (wholly or in part) on the augered portion of the borehole

Reference should be made to the attached Figure 2, where we have interpreted, based on the boreholes, indicative bedrock contours. The contour interval adopted was 1m and assumes linear interpolation between the boreholes. Based on the known weathering pattern of Hawkesbury Sandstone, the sandstone bedrock is likely to vary as 'steps' between specific

borehole levels. We note that the contours shown on Figure 2 and the 'steps' shown on Figures 3 and 4 are indicative only and do not infer where such 'steps' might occur.

Based on the investigation results and with reference to Figures 2, 3 and 4, the sandstone bedrock surface is relatively shallow on the southern and eastern sides of the proposed building and 'steps' down relatively uniformly to the north and north-west. The most significant 'step' down in levels, however, is between BH108 and BH104 (north-south) and BH101 and BH109 (east-west).

Groundwater

Groundwater seepage was encountered during drilling at depths between 0.6m (BH4) and 2.0m (BH101). On completion of drilling (including rock coring) and after a short time from the completion of drilling, groundwater was recorded in each borehole at depths between 0.8m (BH1 to BH4) and 1.6m (BH103 to BH105). We note that groundwater levels may not have stabilised within the short observation period. No long term groundwater monitoring was carried out, although the standpipe installed into BH4 may be used for such purpose.

3.3 Laboratory Test Results

The results of the moisture content tests carried out on recovered rock cutting samples did not correlate well with our field assessment of bedrock strength, most likely due to the rock cuttings being recovered from below the groundwater table. However, the results of the Point Load Strength Index tests carried out on the recovered rock cores correlated well with our field assessment of bedrock strength. The estimated UCSs generally ranged between 5MPa and 38MPa, however, there was a single test result as low as 1MPa.

The results of the particle size distribution test carried out on a sample of natural sand from BH1 indicated the sample had a very low fines content of 4%.

The soil pH test results ranged from 5.4 to 6.2, which show the samples tested to be slightly acidic. The soil sulphate and chloride test results were less than or equal to 150mg/kg, which indicate very low sulphate and chloride contents.

The four day soaked CBR test carried out on silty sand fill sample from BH2 resulted in a value of 7% when compacted to 92% of Standard Maximum Dry Density (SMDD). The relatively low density was due to the insitu moisture content being 5.9% "wet" of the Standard Optimum

Moisture Content (SOMC). Nevertheless, the CBR value indicates a reasonably good subgrade is present despite the high insitu moisture content.

4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Issues

Based on the investigation results, we consider the following to be the primary geotechnical issues for the proposed 'swim centre' redevelopment:

- The shallow excavation cuts will extend through the fill and alluvial soils and will require support by shoring walls, unless temporary batters can be accommodated within the site geometry. If temporary batter slopes cannot be accommodated within the site geometry or are not preferred, then the shoring walls must be installed prior to the commencement of excavation;
- The sandstone bedrock is relatively shallow at the southern end of the proposed building but 'steps' down to the north and north-west towards Manly Lagoon. Bedrock in the vicinity of BH2 at the north-western corner of the proposed building is in the order of about 12m below existing grade;
- The alluvial soils, which are predominantly very loose and loose sands, are associated with low bearing pressures and high settlements. Based on the type of pool structure proposed and maximum pile loads indicated the pile footings will need to be uniformly founded in the underlying sandstone bedrock;
- The groundwater table is quite shallow and may be encountered within the depth of excavation;
- Localised dewatering may be required during excavation so that construction can be carried out in 'dry' conditions; and
- Construction of new pavements will be difficult based on the relatively shallow groundwater level and presence of poorly compacted fill.

The above geotechnical issues are addressed in the following sections of this report.

4.2 Dilapidation Surveys

Council should consider completing a dilapidation survey on the western half of the existing pool structure. The dilapidation survey should be completed prior to the commencement of demolition, excavation and dewatering.

The dilapidation survey should include a detailed inspection where all defects are rigorously described including defect type, length and width. Emptying of the existing 50m pool water would be required.

The dilapidation report may then be used as a benchmark against which to assess possible future claims for damage arising from the works. We could carry out the dilapidation survey if commissioned to do so.

4.3 Excavation Conditions

Reference should be made to the Code of Practice *'Excavation Work'*, dated July 2012 prepared by WorkCover NSW for guidance on demolition and excavation.

Excavation to a maximum depth of about 0.5m will be required below the proposed pools, but will be locally deeper (up to about 2m) adjacent to the existing swimming pool where ground surface levels have been raised behind the existing brick retaining wall. Based on the investigation results, the excavations are expected to extend through the pavements and fill and possibly into the natural silty sand/sands and possibly below the groundwater table. Excavation may be completed using buckets fitted to hydraulic excavators and dozers.

Prior to any bulk excavation works, we recommend that details be obtained (such as by excavation of test pits or review of as built structural drawings) for the adjoining brick retaining wall which supports the raised area adjacent to the existing 50m pool, as well as the 50m pool structure itself. We note that existing 50m pool will abut the proposed new building. Care must be taken to avoid undermining or removing lateral support from the 50m pool structure and any portion of the brick retaining wall that will remain. This will enable appropriate consideration to be made during design of the shoring.

4.4 Excavation Retention

4.4.1 Support Systems

Following dewatering, if required, temporary batter slopes through the soil profile will be feasible in areas where the site boundaries and the existing pool structure are set back at least 1m from the any excavation that extends to a maximum depth of about 0.5m below existing grade. Temporary batters may also be feasible adjacent to the existing 50m pool where most of the excavation will extend through the retaining wall backfill, provided the construction of the

temporary batters does not underline or remove lateral support from the 50m pool structure. The temporary batter slopes should be cut no steeper than 1 Vertical (V) on 1 Horizontal (H). A conventional reinforced block wall can then be constructed at the toe of the batters and subsequently backfilled. An allowance should be made for sand bagging along the toe of the temporary batters to reduce the likelihood of slumping along the toes.

For those areas where temporary batter slopes cannot be accommodated within the site geometry, or are not desired, an insitu shoring system will need to be installed prior to the commencement of excavation. The shoring system will need to be designed and installed so that adverse impacts on the 50m pool structure from shoring wall deflections are reduced. Suitable shoring system options include grout injected secant pile retaining walls and steel sheet pile retaining walls (where excavation extends below the groundwater table) and contiguous pile and steel sheet pile retaining walls (where excavation extends above the groundwater table).

Regardless of which shoring option is adopted, the structural elements/piles must be founded to sufficient depth below bulk excavation level (including nearby footing/service trenches) to satisfy stability, piping and founding considerations.

4.4.2 Shoring Design Parameters

The major consideration in the selection of earth pressures for the design of the shoring system is the need to limit deformations occurring outside the excavation. The magnitude of acceptable deformation will be largely dictated by the presence of any structures or buried services behind the retaining wall. The following characteristic earth pressure coefficients and subsoil parameters may be adopted for a simple static design of the shoring system.

- For cantilevered shoring systems or for free standing cantilevered walls, where some wall movements are tolerable (for example, walls which support grass or landscaped areas), we recommend the use of a triangular earth pressure distribution and an “active” earth pressure coefficient (K_a) of 0.35 for the soil profile, assuming a horizontal retained surface.
- For cantilevered shoring systems or for propped walls, where wall movements are to be reduced (for example, adjacent to the existing brick retaining walls which support the area surrounding the existing 50m outdoor pool), we recommend the use of a triangular earth pressure distribution and an “at rest” earth pressure coefficient (K_o) of 0.55 for the soil profile, assuming a horizontal retained surface.
- A bulk unit weight of 20kN/m^3 should be adopted for the soil profile above the groundwater table.

- Any surcharge (including construction loads, traffic, nearby footings, inclined backfill surfaces etc.) affecting the shoring walls should be allowed in the design using the appropriate earth pressure coefficient from above.
- Hydrostatic pressures also need to be considered in the wall design and these are additional to the earth pressure recommendations above. Particular attention needs to be given to the hydrostatic pressures during dewatering as differential water pressures will occur and will have a significant impact on the wall stability and loads.
- Based on the shallow groundwater table which may rise to the surface during or following heaving rainfall, the structures must be designed to allow for a groundwater level that rises to the ground surface. Therefore, any part of the proposed structure which is located below existing ground surface must be designed to withstand hydrostatic lateral and uplift pressures and have non-return valves installed.
- A check for flood levels must also be made, as water above existing ground level will impose additional lateral pressures which the structures must also be designed to accommodate.
- The toe resistance for the retention systems (assuming a high level footing is proposed for the expected low height retaining walls and the walls are independent of the proposed pool structure) may be estimated using a "passive" earth pressure coefficient (K_p) of 2.7 and a triangular earth pressure distribution. This should be applied to the very loose or denser sands. A Factor of Safety of at least 2 should be applied to the passive pressure to limit deformations. This passive earth pressure coefficient assumes horizontal ground in front of the wall. The embedment depth for passive toe restraint should be taken from below bulk excavation level, including nearby footing/service trenches. The passive pressure due to the upper 0.2m depth of embedment should be ignored due to excavation tolerance effects. Allowable bearing pressures for high level footings must be limited to no more than 50kPa, subject to geotechnical inspection of the foundation material.
- The toe resistance for piles socketed into the underlying sandstone bedrock may be designed for an allowable lateral capacity of 200kPa through Class IV or better quality sandstone bedrock. However, lateral restraint should be disregarded over the upper 1.5xB of the rock socket, where B is the pile diameter in metres. The passive restraint from the overlying soil profile should be ignored due to strain incompatibility.

If the retaining walls will be designed using limit state or computer based analyses, then further geotechnical advice should be sought.

4.5 Dewatering

Based on the shallowest groundwater level encountered in our investigation ie. about 0.8m depth, it is unlikely that dewatering will be required.

However, it is possible that groundwater levels may rise to the surface, during or following heavy rainfall and therefore an allowance must be made for localised internal dewatering, in order to maintain a 'dry' excavation during construction.

Due to the expected relatively high permeability of the fill and natural sand profile, we expect that dewatering could be carried out using a spear point system or well system.

Approvals will be required from statutory authorities for temporary dewatering.

4.6 Footings

Based on the shallow groundwater table, collapsing nature of the underlying alluvial silty sand/sand profile and maximum pile loads indicated, grout injected piles (otherwise known as continuous flight auger (CFA) piles) are considered a suitable pile type for this site.

CFA piles socketed at least 0.3m into Class IV or better quality sandstone bedrock may be designed for a maximum allowable end bearing pressure of 2,500kPa. Sockets formed below the minimum 0.3m length requirement may be designed for maximum allowable shaft adhesion values of 250kPa (compression) and 125kPa (tension), provided the bedrock quality is at least Class IV. A maximum allowable shaft adhesion of 100kPa (compression) and 50kPa (tension) is applicable for the Class V sandstone bedrock. The provided bearing pressure is based upon serviceability criteria of deflections at the pile base of less than 1% of the minimum pile diameter.

Due to the presence of 'step' downs in the sandstone bedrock profile below the footprint of the proposed building, we recommend that piling commence at the north-western corner of the proposed building where the bedrock was found to be the deepest. The piling contractor's engineer must keep an accurate log of the subsurface profile at each pile location for bedrock surface profile assessment, so that piles are adequately socketed. We forewarn that piles founded immediately behind the crest of a 'step down in the bedrock surface and which have a nominal rock socket, may be susceptible to pile toe instability.

Use of steel screw piles founded on the sandstone bedrock is not recommended due to the pile only bearing on the central shaft, not the full pile diameter. We do not recommend that conventional bored piles be constructed at this site, due to the expected collapsing nature of the pile shaft through the sands and shallow groundwater table. Driven piles would also be considered unsuitable as there is a need to control ground borne vibrations due to the nearby swimming pool and buried services.

The prospective piling contractors should be provided with a full copy of this report so that appropriate piling rigs and equipment, capable of drilling through medium and high strength sandstone bedrock, are brought to site.

We recommend that the initial stage of CFA piling be witnessed by a geotechnical engineer to check the piling depths with the depth to sandstone bedrock encountered in our boreholes.

4.7 Earthworks

4.7.1 Existing Fill

We note that no details on the existing fill have been provided to us, including placement method, compaction specification, density test records, etc. Nonetheless, based on the presence of poorly compacted fill, we consider the existing fill is not a "*structural fill*" as outlined in Clause 1.2.13 of AS3798-2007. The existing fill will be suitable to support the proposed new on-grade car park on condition that the subgrade preparation works as outlined in Section 4.7.5 below are carried out.

We recommend that a generous time and budget allowances be provided for subgrade improvement works on this site.

4.7.2 Site Drainage

Whilst a mostly sandy fill subgrade is expected at design subgrade level, due to the inherent variability of fill, the fill may undergo a loss in strength when wet, particularly if groundwater levels rise to the surface. Therefore, there may be delays during construction where the fill becomes wet. It will be important to provide good and effective site drainage during construction. The principle aim of the drainage is to promote run-off and reduce ponding. A poorly drained fill subgrade may become untraffickable when wet. The earthworks should be carefully planned and scheduled to maintain good cross-falls during construction.

4.7.3 Site Preparation

All existing pavements, grass, topsoil, root affected soils and any deleterious or contaminated existing fill should be stripped from below the footprint of the proposed car park. Stripped topsoil and root affected soils should be stockpiled separately as they are considered unsuitable for reuse as engineered fill. They may however be reused for landscaping purposes.

Reference should be made to the EIS report for guidance on the offsite disposal of soil.

4.7.4 Subgrade Preparation

Following stripping and excavation down to design subgrade level, we recommend that the subgrade be proof rolled with at least eight passes of a smooth drum roller of at least 10 tonnes deadweight. The final pass of proof rolling should be carried out under the direction of an experienced geotechnical engineer for the detection of unstable or soft areas. To reduce the potential for "pumping" of subgrade fines and groundwater, we recommend that the vibratory mode on the roller be switched off.

Based on the investigation results, we expect that unstable areas of subgrade will be detected during proof rolling. Unstable subgrade areas should be locally removed to a stable base and replaced with engineered fill, as outlined in Section 4.7.5 below. Possible alternatives to stripping the full depth of any unstable subgrade must be provided by the geotechnical engineer during the proof rolling inspection, if appropriate.

Stripped material that is removed may be suitable for reuse as engineered fill, subject to geotechnical inspection. If there is any 'wet' stripped material, we expect the material will need to be spread out and dried out so that it can be reused. We forewarn depending on the silt content, some of the fill, may not be considered suitable for reuse by the geotechnical engineer. If clayey fill is encountered, we do not recommend such material be reused.

Engineered fill must be used where site levels need to be raised.

4.7.5 Engineered Fill

Excavated sandy fill or natural sands/silty sands will most likely be suitable for reuse as engineered fill, subject to geotechnical inspection of the material prior to reuse and on condition the material is "clean", free of organic matter and free of particle sizes greater than 75mm.

Engineered fill comprising excavated sandy fill and natural sands/silty sands should be compacted in maximum 200mm thick loose layers using a large roller to a minimum density of 98% of SMDD to a minimum I_D of 70%. Engineered fill comprising a well graded granular material, such as imported crushed sandstone, should be compacted in maximum 200mm thick loose layers using a large roller to a minimum density of 98% of SMDD.

Density tests should be regularly carried out on the engineered fill to confirm the above specification is achieved. The frequency of density testing should be at least one test per layer per 1,000m^2 or 1 test per 200m^3, whichever requires the most tests. Level 2 testing of fill compaction is the minimum permissible in AS3798-2007. Due to an inherent conflict of interest, the geotechnical testing authority (GTA) should be directly engaged by Council (or their representative) and not by the earthworks contractor or sub-contractors.

4.8 External Pavements

We recommend that the proposed new pavement be designed for a CBR value of 5.0% or a short term Young's Modulus (E) of 25MPa. This recommended design CBR value is less than the laboratory CBR value, but takes into account the presence of fill and its potential variability.

Assuming the proposed pavement will comprise a flexible AC surface pavement, we recommend that all base course materials comprise DGB20 in accordance with RTA QA Specification 3051 unbound base. The DGB20 material should be compacted in maximum 200mm thick loose layers using a large static smooth drum roller to at least 98% of Modified Maximum Dry Density (MMDD). Adequate moisture conditioning to within 2% of Modified Optimum Moisture Content (MOMC) should be provided during placement so as to reduce the potential for material breakdown during compaction.

We further recommend that all sub-base materials comprise DGS40 in accordance with RTA QA Specification 3051 unbound base. Recycled materials may be used provided they conform to the specification requirements of DGS40. If the recycled materials contain brick or ceramic fragments, it is highly unlikely that they will conform to the specification requirements. The DGS40 material should be compacted in maximum 200mm thick loose layers using a large smooth drum roller to at least 95% of MMDD. Again, adequate moisture conditioning to within 2% of MOMC should be provided during placement so as to reduce the potential for material breakdown during compaction.

Density tests should be regularly carried out on the granular pavement materials to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 1,000m^2, or 1 test per 200m^3, whichever requires the most tests. Level 2 testing of fill compaction is the minimum permissible in AS3798-2007. The GTA should be directly engaged by Council (or their representative) and not by the earthworks contractor or sub-contractors.

4.9 Soil Aggression

Based on the investigation results, the exposure classification to buried concrete is "moderate" in accordance with Table 6.4.2(C) of AS2159-2009 ('Piling – Design and Installation').

4.10 Additional Geotechnical Input

We summarise below the previously recommended additional work that needs to be carried out:

1 Dilapidation survey on the western half of the existing pool structure.
2 Proof rolling inspections
3 Geotechnical inspection of stripped materials considered for reuse as engineered fill.
4 Density testing of engineered fill and granular pavement materials.
5 Witnessing of CFA pile installations.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to

identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
MOISTURE CONTENT TEST REPORT

Client:	JK Geotechnics	**Ref No:**	26655ZH
Project:	Proposed Manly ABC Swim Centre Redevelopment	**Report:**	A
		Report Date:	15/07/2013
Location:	Kenneth Road, Fairlight, NSW	**Page 1 of 1**	

AS 1289 **TEST METHOD** **2.1.1**

BOREHOLE NUMBER	DEPTH	MOISTURE CONTENT
	m	%
3	2.60-3.00	17.6
3	3.80-3.90	9.9
4	7.50-8.00	5.6

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A1
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	JK Geotechnics	**Ref No:**	26655ZH2
Project:	Proposed Redevelopment of Manly ABC Swim Centre	**Report:**	A1
		Report Date:	7/08/2013
Location:	Kenneth Road, Manly, NSW	**Page 1 of 1**	

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
108	4.76-4.81	1.2	24
	5.24-5.28	0.7	14
	5.69-5.74	0.5	11
	6.16-6.20	0.7	14
	6.72-6.75	0.8	16
109	9.00-9.05	0.2	5
	9.58-9.62	0.06	1
	10.14-10.17	0.5	10
	10.81-10.84	1.2	23
	11.25-11.28	0.8	17
	11.77-11.82	0.9	19
	12.04-12.08	1.2	25
110	7.57-7.61	1.9	38
	7.76-7.81	1.5	30
	8.40-8.44	0.3	5
	9.21-9.25	0.3	5
	9.73-9.77	0.5	11
	10.18-10.22	0.7	14
	10.70-10.74	0.6	13

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :

   U.C.S. = 20 $I_{S(50)}$

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client: JK Geotechnics
Project: Proposed Manly ABC Swim Centre Redevelopment
Location: Kenneth Road, Fairlight, NSW

Ref No: 26655ZH
Report: B
Report Date: 15/07/2013
Page 1 of 1

BOREHOLE NUMBER	2
DEPTH (m)	0.20 - 1.00
Surcharge (kg)	4.5
Maximum Dry Density (t/m^3)	1.71 STD
Optimum Moisture Content (%)	16.8
Moulded Dry Density (t/m^3)	1.57
Sample Density Ratio (%)	92
Sample Moisture Ratio (%)	134
Moisture Contents	
Insitu (%)	22.7
Moulded (%)	22.5
After soaking and	
After Test, Top 30mm(%)	19.8
Remaining Depth (%)	19.5
Material Retained on 19mm Sieve (%)	0
Swell (%)	0.0
C.B.R. value: @5.0mm penetration	7

NOTES:

- Refer to appropriate notes for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1
- Date of receipt of sample:3/7/13

NATA Accredited Laboratory Number:1327

Authorised Signature / Date
(A. Tatikonda) 15/7/13

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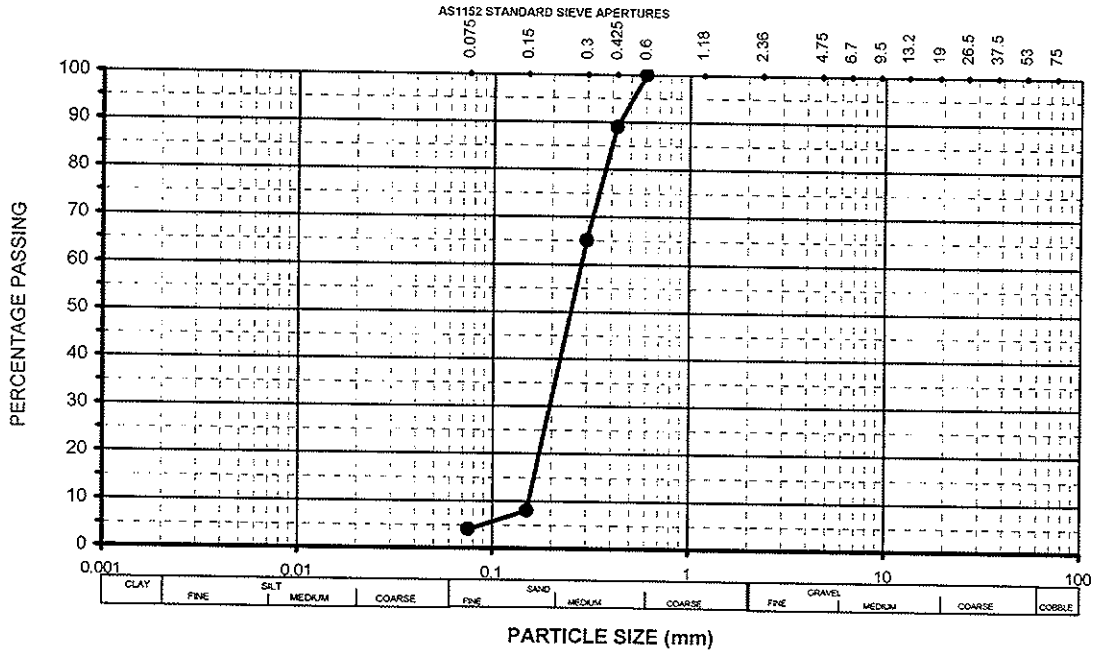
SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
PARTICLE SIZE DISTRIBUTION CURVE

Client: JK Geotechnics
Project: Proposed Manly ABC Swim Centre Redevelopment
Location: Kenneth Road, Fairlight, NSW

Ref No: 26655ZH
Report No: C
Report Date: 15/07/2013

Borehole Number: 1
Depth (m): 1.50-1.95



SIEVE ANALYSIS RESULTS

SIEVE SIZE	% PASSING
600 um	100
425 um	89
300 um	65
150 um	8
75 um	4

Test Method: AS1289.3.6.1 Dry Sieve(washed)

• **Notes:**

• Please refer to appropriate notes for soil descriptions

NATA
NATA Accredited Laboratory Number:1327

Approved Signatory / Date
15/7/13
(A. Tatikonda)

TABLE D
SUMMARY OF SOIL CHEMISTRY TEST RESULTS
SOIL pH, SULPHATE AND CHLORIDE

Borehole Number	Sample Depth (m)	Sample Description	pH Units	Sulphate (mg/kg)	Chloride (mg/kg)
BH3	1.5 - 1.8	Fill: Silty sand	6.2	20	41.0
BH4	3.0 - 3.45	Silty Sand	5.4	150	51.0
BH4	1.5 - 1.95	Silty Sand	6.1	60	58

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BOREHOLE LOG

Borehole No. 1
1/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 2.4m

Date: 1&2-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼					N = 8 2,3,5	0			FILL: Silty sand, fine to medium grained, brown, trace of shell fragments and root fibres.	D			GRASS COVER
									FILL: Silty sand, fine to medium grained, brown, trace of shell fragments.				APPEARS POORLY TO MODERATELY COMPACTED
▶						1				W			
					N = 6 3,3,3			SP	SAND: fine to medium grained, light grey, trace of silt fines and shell fragments.	W	L		ALLUVIAL
						2							
					N = 4 2,2,2	3					VL		
						4							
					N = 2 1,1,1	5							
									as above, but with clay fines.		L		
					N = 8 4,4,4	6							
						7							

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BOREHOLE LOG

Borehole No. **1** 2/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 2.4m

Date: 1&2-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■		8		SP	SAND: fine to medium grained, light grey, with clay fines.	W			THE SOIL DESCRIPTION BELOW 7.5m DEPTH WAS BASED ON THE DRILL SPOIL RETURN. PURPOSE OF DEEPER DRILLING WAS TO PROVE BEDROCK ONLY
						9							
						10							
						11							
						12							
						13							
						14		-	SANDSTONE BEDROCK: fine to coarse grained, light brown.	SW	M		MODERATE 'TC' BIT RESISTANCE

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BOREHOLE LOG

Borehole No. **1** 3/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 2.4m

Date: 1&2-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE BEDROCK: fine to coarse grained, light brown.	SW	M		
						15			END OF BOREHOLE AT 14.5m				DRILLING TERMINATED AT 14.5m DEPTH, DUE TO AUGER BREAKING WHILST PROVING BEDROCK. BEDROCK DESCRIPTION, WEATHERING AND STRENGTH BASED ON BH2 CONDITIONS
						16							
						17							
						18							
						19							
						20							

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BOREHOLE LOG

Borehole No. **2** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 2.8m

Date: 1&2-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼					N = 2 2,1,1	0			FILL: Silty sand, fine to medium grained, brown, trace of clay fines and root fibres.	M			GRASS COVER
									FILL: Silty sand, fine to medium grained, brown, trace of clay fines.				APPEARS POORLY COMPACTED
▶						1				W			
					N = 8 2,4,4			SM	SILTY SAND: fine to medium grained, grey brown.	W	L		ALLUVIAL
						2							
									as above, but light grey.		VL		
					N = 2 1,1,1	3							
						4							
					N = 0 0,0,0	5							
								SC	CLAYEY SAND: fine to coarse grained, light grey and brown, trace of shell fragments.				
					N = 2 2,1,1	6							
						7							

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BOREHOLE LOG

Borehole No. **2** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 2.8m

Date: 1&2-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■	Nc= 2 2 3	8		SC	CLAYEY SAND: fine to medium grained, light grey.	W	VL		
				■	Nc= 0 0 0	9		CH	SILTY CLAY: high plasticity, dark grey.	MC>PL	VS	20 20 20	HP TESTING CARRIED OUT ON REMOULDED AUGER SAMPLE
						10		SC	CLAYEY SAND: fine to medium grained, light grey.	W	(MD)		- 10mm
						11							
						12		-	SANDSTONE: fine to coarse grained, light brown.	SW	M-H		MODERATE TO HIGH 'TC' BIT RESISTANCE
				■		13							
									END OF BOREHOLE AT 13.5m				
						14							

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BOREHOLE LOG

Borehole No. **3** 1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 3.2m

Date: 1-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼					N = 3 1,1,2	0			FILL: Silty sand, fine to medium grained, brown, with fine to medium grained sandstone gravel, trace of root fibres.	D			GRASS COVER APPEARS POORLY COMPACTED
					N = 10 1,1,9	1			FILL: Silty sand, fine to coarse grained, brown and orange brown, with clay fines, trace of sandstone gravel.	W			
						2		SP	SAND: fine to coarse grained, light grey.	W	L		ALLUVIAL
						3		-	SANDSTONE: fine to coarse grained, light grey.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
										SW	L-M		LOW TO MODERATE RESISTANCE
										SW-FR	H		HIGH RESISTANCE
						4			END OF BOREHOLE AT 3.9m				'TC' BIT REFUSAL
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **4** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 3.3m

Date: 1-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			BITUMINOUS SEAL: 30mm.t	D			
									FILL: Silty sandy gravel, fine to coarse grained igneous, dark grey, fine to coarse grained sand.				APPEARS WELL COMPACTED
▶				■	N > 28 11,17, 11/100mm				FILL: Clayey sand, fine to coarse grained, brown, with fine to medium grained sandstone gravel, trace of fine to medium grained igneous gravel and slag.	M			
▼ ON COMPLET-ION & AFTER 3.5 HRS					REFUSAL	1		SM	SILTY SAND: fine to medium grained, light grey and grey.	W	MD		ALLUVIAL
				■	N = 13 4,5,8	2							
									SILTY SAND: fine to medium grained, brown.		VL		
				■	N = 1 1,1,0	3							
						4		SC	CLAYEY SAND: fine to medium grained, light grey and brown.		L		
				■	N > 8 3,3,5/ 100mm								
					REFUSAL	5		-	SANDSTONE: fine to medium grained, light grey, brown and red brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
										DW	L		LOW TO MODERATE RESISTANCE
						6			SANDSTONE: fine to medium grained, light grey and red brown.		M		MODERATE RESISTANCE
						7							

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BOREHOLE LOG

Borehole No. 4
2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 3.3m

Date: 1-7-13 **Datum:** ASSUMED

Logged/Checked by: D.S./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■					SANDSTONE: fine to medium grained, light grey and red brown.	DW	M		
						8			END OF BOREHOLE AT 7.5m				CLASS 18 uPVC STANDPIPE INSTALLED TO 5m DEPTH SLOTTED BETWEEN 1m AND 5m, UNSLOTTED BETWEEN 0m AND 1m DEPTH, BACKFILLED WITH 2mm SAND FROM 1m TO 5m DEPTH, BENTONITE SEAL FROM 0.5m TO 1m DEPTH, GATIC COVER CONCRETED AT SURFACE
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. 101 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			ASPHALTIC CONCRETE: 30mm.t FILL: Sandy gravel, fine to medium grained igneous, dark grey, fine to medium grained sand. FILL: Silty sand, fine to medium grained, dark brown, with clay.	M			
ON COMPLET-ION ▼						1		SM	SILTY SAND: fine to medium grained, grey and light grey.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
▶						2				W			
						3							STRONG HYDROCARBON ODOUR BETWEEN APPROXIMATELY 3.0m AND 4.7m DEPTH
						4							
						5		-	SANDSTONE: fine to medium grained, light grey, brown and red brown, with L strength bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						6			SANDSTONE: fine to medium grained, light grey and red brown.	DW	L		LOW RESISTANCE
						7							

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **101** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							
						14							

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 102
1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK305
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.2m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel, roots and root fibres.	M			GRASS COVER
▼ ON COMPLET-ION						1				W			HYDROCARBON ODOUR BETWEEN APPROXIMATELY 1.2m AND 1.7m DEPTH
						2		SP	SAND: fine to medium grained, grey.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3		-	SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		LOW TO MODERATE 'TC' BIT RESISTANCE
											H		HIGH RESISTANCE 'TC' BIT REFUSAL
									END OF BOREHOLE AT 3.6m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **103** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, dark brown, with fine to medium grained sandstone and igneous gravel, roots and root fibres.	M			
▼ ON COMPLET-ION						1		SP	SAND: fine to medium grained, grey and light grey, trace of quartz gravel.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3							
						4							
						5							
						6							
						7		-	SANDSTONE: fine to coarse grained, light grey.	SW	L		LOW 'TC' BIT RESISTANCE

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BOREHOLE LOG

Borehole No. **103** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.1m

Date: 30-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE: fine to coarse grained, light grey.	SW	L		
				■		8					L-M		LOW TO MODERATE RESISTANCE
						9			END OF BOREHOLE AT 9.0m				
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **104** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.9m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, brown, trace of clay fines, roots and root fibres.	M			GRASS COVER
									FILL: Silty sand, fine to medium grained, brown, trace of clay fines.				
ON COMPLET-ION ▼						1		SM	SILTY SAND: fine to medium grained, grey brown.	M	-		ALLUVIAL
▶						2				W			PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **104** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.9m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						8		SM	SILTY SAND: fine to medium grained, grey.	W	-		
						9							
						10		-	SANDSTONE: fine to coarse grained, light grey and orange brown.	DW	VL-L		LOW 'TC' BIT RESISTANCE
				■							L-M		
						11					M-H		MODERATE TO HIGH RESISTANCE
									END OF BOREHOLE AT 11.0m				
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **105** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.7m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, brown and dark brown, trace of clay fines and glass fragments.	M			
ON COMPLET-ION						1		SM	SILTY SAND: fine to medium grained, grey brown.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2				W			
						3			as above, but light grey.				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **105** 2/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.7m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	■					8		SM	SILTY SAND: fine to medium grained, light grey.	W	-		
						9							
						10		-	SANDSTONE: fine to medium grained, light grey.	DW	VL-L		LOW 'TC' BIT RESISTANCE
						11				SW	M-H		MODERATE RESISTANCE
						12			END OF BOREHOLE AT 11.5m				
						13							
						14							

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BOREHOLE LOG

Borehole No. **106** 1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 2.4m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLETION ▼	■					0			FILL: Silty sand, fine to medium grained, brown, trace of shell fragments and root fibres.	M			
									FILL: Silty sand, fine to medium grained, brown, trace of shell fragments.				
▶	■					1				W			
	■							SP	SAND: fine to medium grained, light grey, trace of shell fragments.	W	-		ALLUVIAL
	■					2							
	■					3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **107** 1/1

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 3.4m

Date: 30&31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained igneous gravel and root fibres.	M			GRASS COVER
						1			as above, but with fine to medium grained igneous gravel.				
ON COMPLET-ION ▼								SM	SILTY SAND: fine to medium grained, light grey and brown.	M	-		ALLUVIAL
▶						2				W			
						3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No. **108** 1/2

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 3.2m

Date: 31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼						0			FILL: Silty sand, fine to medium grained, dark brown, trace of fine to medium grained sandstone gravel, roots and root fibres.	M			
						1				W			
						2		SP	SAND: fine to medium grained, grey.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						3							
						4		-	SANDSTONE: fine to coarse grained, light grey.	SW-FR	M-H		MODERATE 'TC' BIT RESISTANCE
						5			REFER TO CORED BOREHOLE LOG				
						6							
						7							

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CORED BOREHOLE LOG

Borehole No. **108** **2/2**

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 3.2m

Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		4		START CORING AT 4.39m					
				CORE LOSS 0.09m					
NO RET-URN		5		SANDSTONE: fine to coarse grained, light grey, bedded at 0-5°.	SW - FR	M-H M			- Be, 0-10°, Un, S - XWS, 0°, 15mm.t
		6		as above, but with dark grey laminae bedded at 0-5°, spacing 0-20mm.		M			
		7		END OF BOREHOLE AT 7.05m					- Be, 0°, P, S
		8							
		9							
		10							


JOB NO. 26655ZHZ . BH108 START CORING AT 4.39m
4
CORE LOSS
5
6
7
END OF BOREHOLE AT 7.05m

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BOREHOLE LOG

Borehole No. **109** 1/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 2.9m

Date: 31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
ON COMPLET-ION ▼						0			FILL: Silty sand, fine to medium grained, brown and dark brown, with clay and fine to medium grained sandstone gravel, trace of roots and root fibres.	M			GRASS COVER
						1				W			
								SM	SILTY SAND: fine to medium grained, grey brown.	W	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2							
						3							
						4							
						5							
						6							
								SP	SAND: fine to medium grained, grey and light grey.				
						7							

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BOREHOLE LOG

Borehole No. **109** 2/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≈ 2.9m

Date: 31-7-13 **Datum:** ASSUMED

Logged/Checked by: O.F./A.J.H.

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
								SP	SAND: fine to medium grained, grey and light grey.	W	-		
						8		-	SANDSONE: fine to coarse grained, light grey.	DW	VL-L		LOW 'TC' BIT RESISTANCE
						9			REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

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CORED BOREHOLE LOG

Borehole No. 109 3/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 2.9m

Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific / General
		8		START CORING AT 8.97m					
FULL RET-URN		9		SANDSTONE: fine to coarse grained, light grey, bedded at 0-5°.	DW	VL-L			- CS, 0°, 70mm.t - CS, 0°, 40mm.t - J, 45°, P, R - XWS, 10°, 5mm.t - XWS, 0-5°, 50mm.t
					XW	EL			
		10		as above, but dark brown and light grey, bedded at 5-15°.	DW	M-H			
		11							- XWS, 10°, 3mm.t - HEALED J, 80-90°, Un, IS
		12							- XWS, 5°, 3mm.t
				END OF BOREHOLE AT 12.14m					
		13							
		14							


JOB NO. 26655ZH2 BH109 START CORING AT 8.97m
9
10
11
12
END OF BOREHOLE AT 12.14m

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BOREHOLE LOG

Borehole No. 110
1/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13
Method: SPIRAL AUGER JK350
Logged/Checked by: O.F./A.J.H.
R.L. Surface: ≈ 3.0m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0		-	ASPHALTIC CONCRETE: 50mm.t FILL: Sandy gravel, fine to medium grained igneous, dark grey.	M			
ON COMPLET-ION ▼						1			FILL: Silty sand, fine to medium grained, dark brown, with clay fines.				
▶								SM	SILTY SAND: fine to medium grained, grey and dark grey.	M	-		ALLUVIAL PURPOSE OF BOREHOLE WAS TO PROVE BEDROCK ONLY. THE SOIL DESCRIPTION WAS ASSESSED FROM THE DRILL SPOIL
						2				W			
						3							
						4							
						5							
						6		-	SANDSTONE: fine to medium grained, light grey brown and red brown.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						7							

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BOREHOLE LOG

Borehole No. 110
2/3

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

Job No. 26655ZH2
Date: 30-7-13

Method: SPIRAL AUGER
JK350

Logged/Checked by: O.F./A.J.H.

R.L. Surface: ≈ 3.0m
Datum: ASSUMED

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SANDSTONE: fine to medium grained, light grey and red brown.	DW	L-M		LOW TO MODERATE RESISTANCE
						8			REFER TO CORED BOREHOLE LOG				
						9							
						10							
						11							
						12							
						13							
						14							

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CORED BOREHOLE LOG

Borehole No. **110** **3/3**

Client: MANLY COUNCIL

Project: PROPOSED REDEVELOPMENT OF MANLY ABC SWIM CENTRE

Location: CNR. KENNETH AND BALGOWLAH ROADS, MANLY, NSW

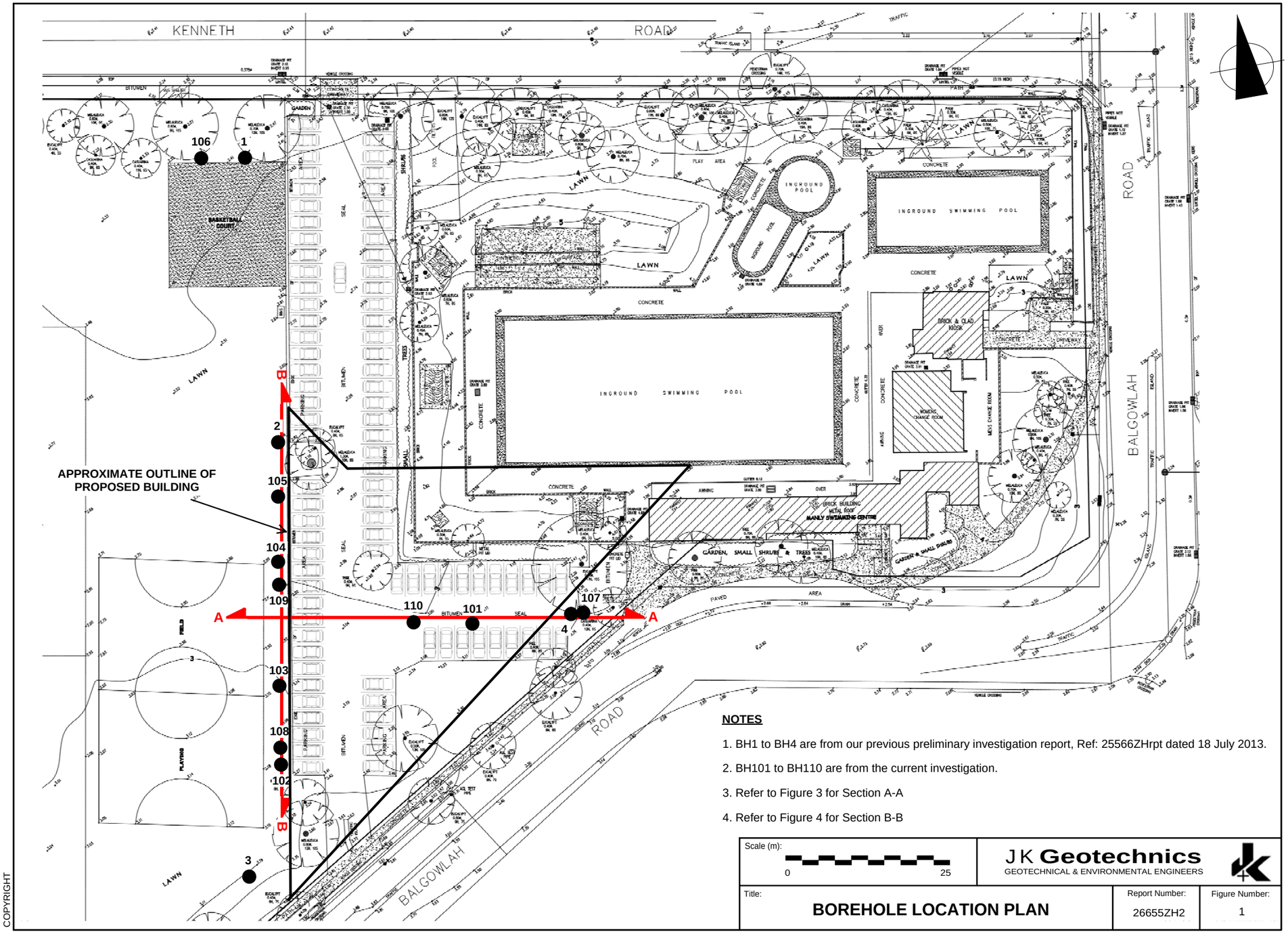
Job No. 26655ZH2 **Core Size:** NMLC **R.L. Surface:** ≈ 3.0m

Date: 31-7-13 **Inclination:** VERTICAL **Datum:** ASSUMED

Drill Type: JK350 **Bearing:** - **Logged/Checked by:** O.F./A.J.H.

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_S(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		7		START CORING AT 7.56m					
		8		SANDSTONE: fine to medium grained, light grey and brown, with dark grey laminae at 0°-5°.	DW	M			- Be, 5°, P, S - CS, 0°, 220mm.t
				CORE LOSS 0.15m					
				SANDSTONE: fine to medium grained, light grey, trace of quartz gravel, bedded at 0-5°.	SW	M			
				CORE LOSS 0.43m					
FULL RET-URN		9		SANDSTONE: fine to medium grained, light grey, massive.	XW SW-FR	EL M			- XWS, 5°, 5mm.t
		10							
				END OF BOREHOLE AT 10.82m					
		11							
		12							
		13							

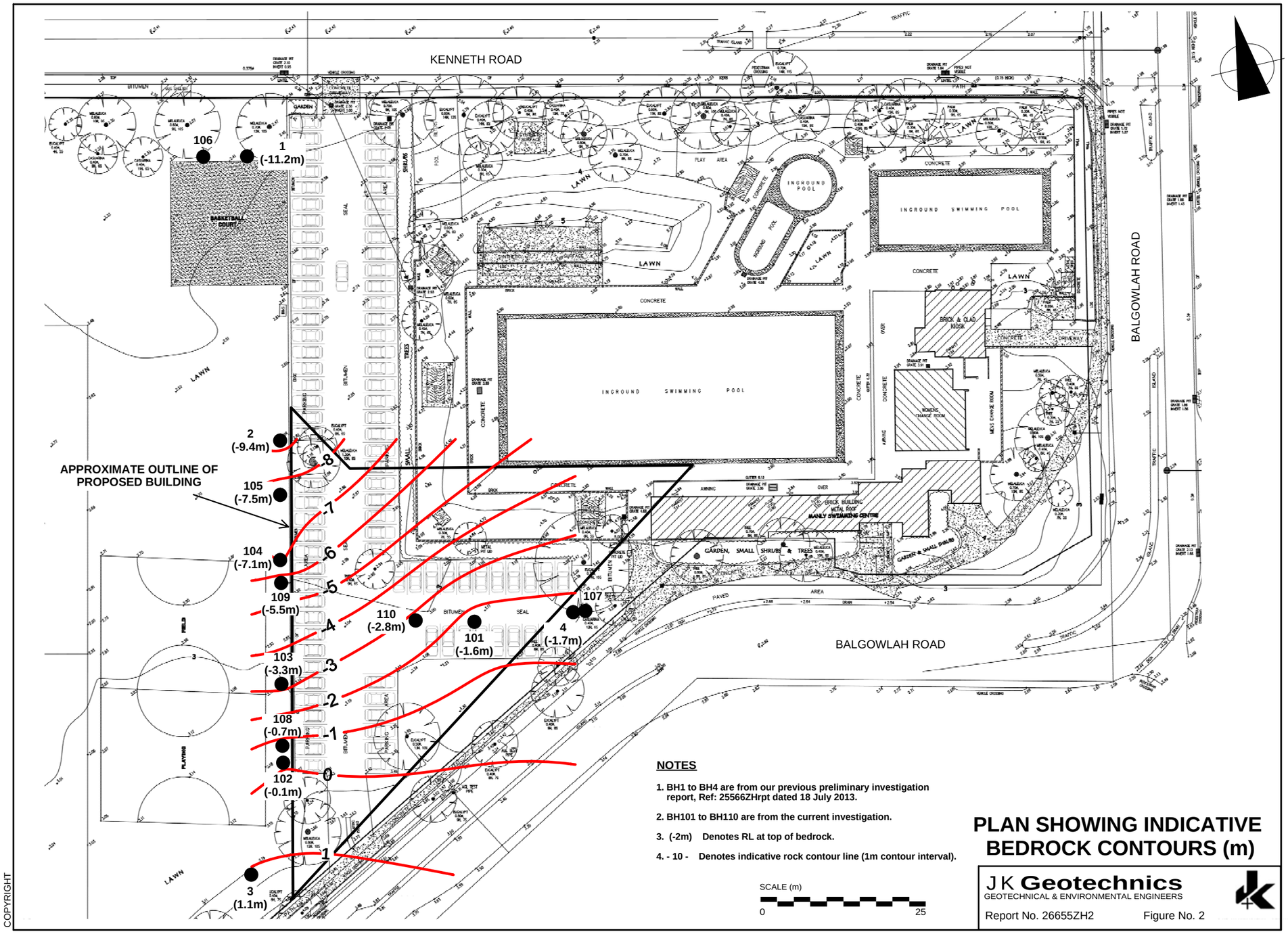

JOB NO. 26655ZH2 BH110 START CORING AT 7.56m
7
8
CORE LOSS
CORE LOSS : 0.43m
9
10
EOBH AT 10.82m



NOTES

1. BH1 to BH4 are from our previous preliminary investigation report, Ref: 25566ZHrpt dated 18 July 2013.
2. BH101 to BH110 are from the current investigation.
3. Refer to Figure 3 for Section A-A
4. Refer to Figure 4 for Section B-B

Scale (m): 0 — 25	JK Geotechnics GEOTECHNICAL & ENVIRONMENTAL ENGINEERS		
Title: **BOREHOLE LOCATION PLAN**		Report Number: 26655ZH2	Figure Number: 1



NOTES

1. BH1 to BH4 are from our previous preliminary investigation report, Ref: 25566ZHrpt dated 18 July 2013.
2. BH101 to BH110 are from the current investigation.
3. (-2m) Denotes RL at top of bedrock.
4. - 10 - Denotes indicative rock contour line (1m contour interval).

SCALE (m)
0 25

PLAN SHOWING INDICATIVE BEDROCK CONTOURS (m)

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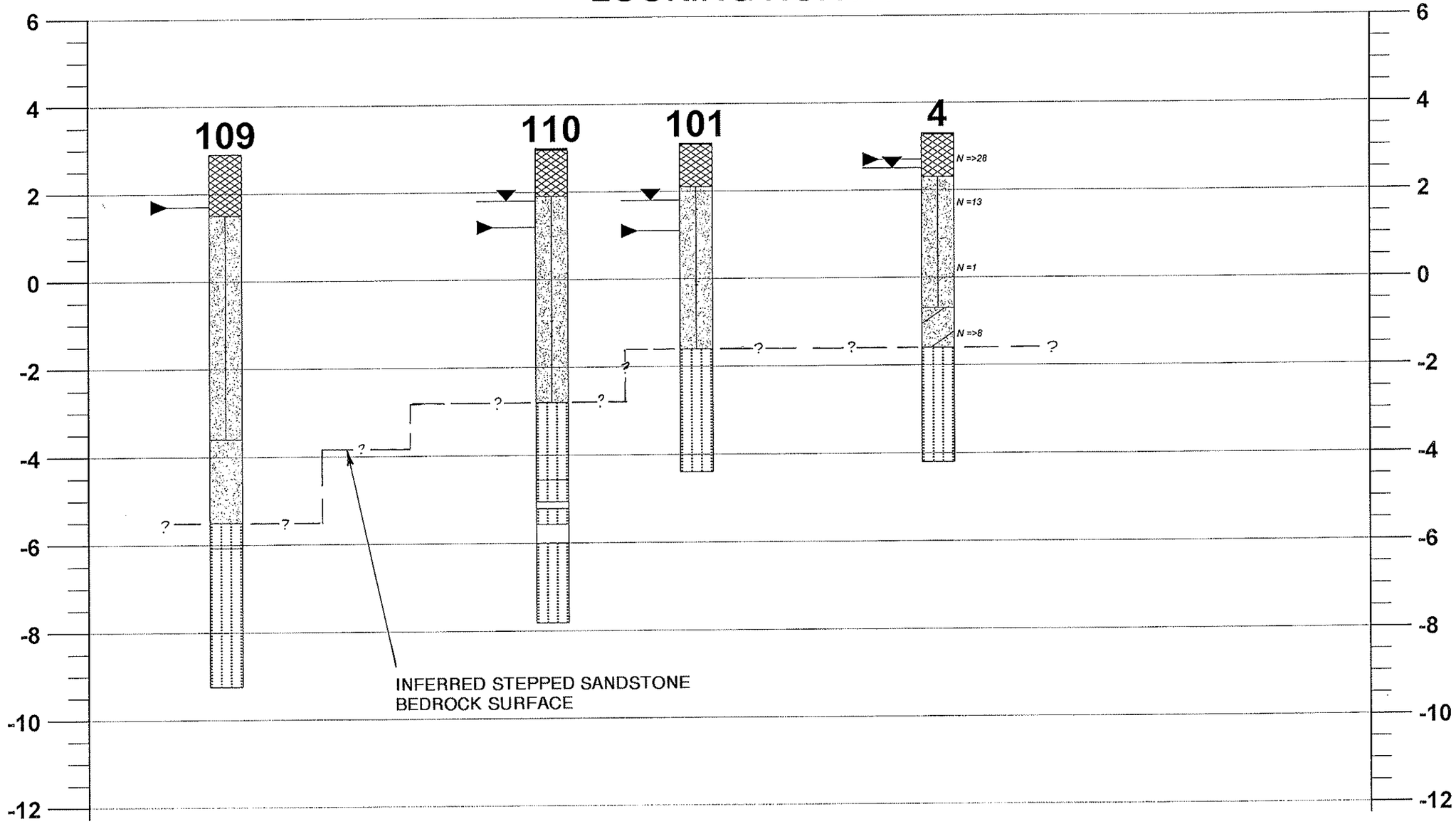
Report No. 26655ZH2 Figure No. 2

GRAPHICAL BOREHOLE SUMMARY

SECTION A–A
LOOKING NORTH



Fill
Silty Sand
Sand
Sandstone/ Greywacke
Core Loss/ Empty
Asphaltic/ Bituminous Paving or Coal
Clayey Sand
Groundwater seepage level
Observed water level

N SPT "N" VALUE
Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 100 (vert) ; APPROX. 1:300 (horiz)

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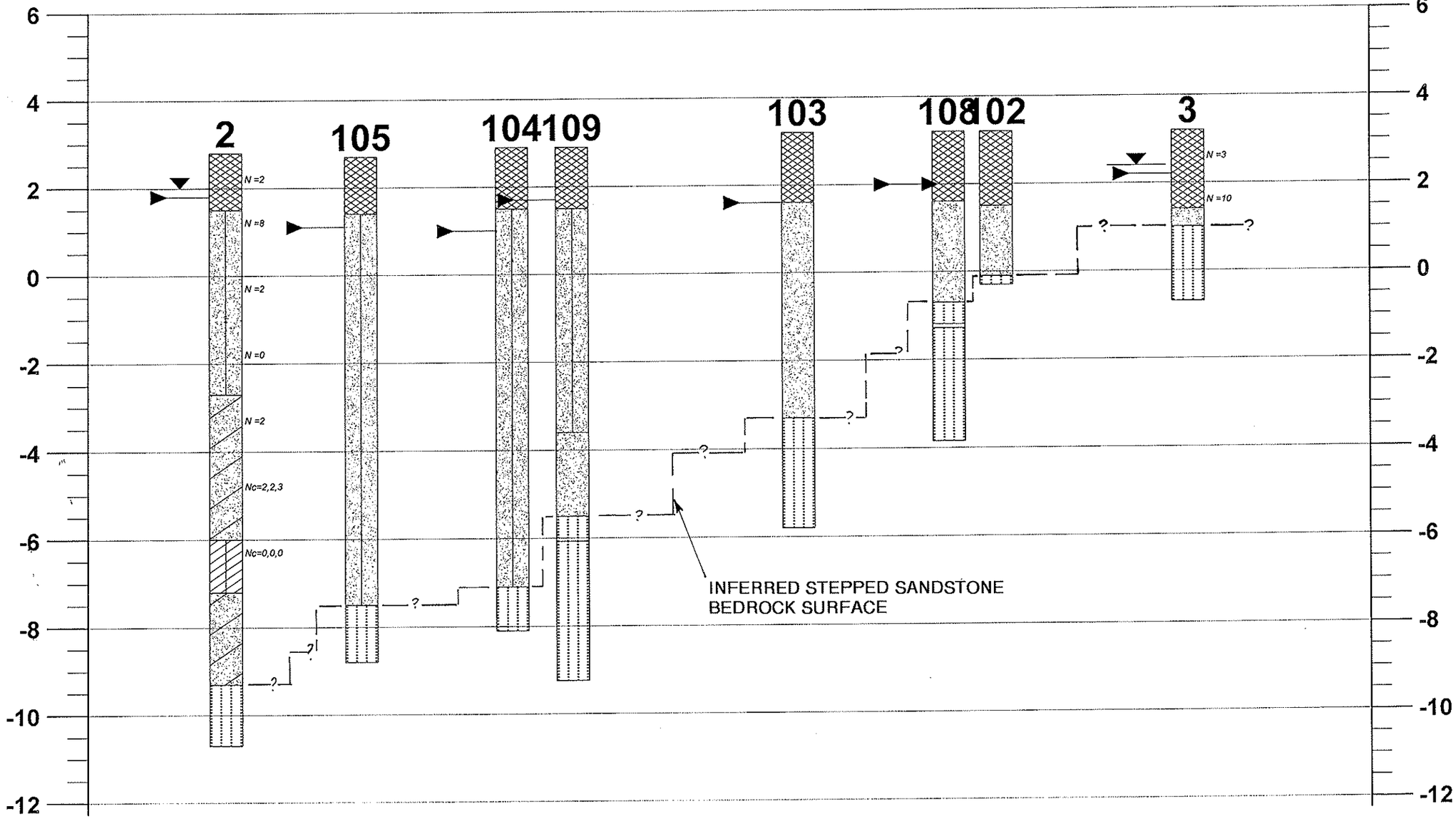
Job No.: 26655ZH2

Figure No.: 3

GRAPHICAL BOREHOLE SUMMARY

SECTION B–B
LOOKING EAST



Fill
Silty Clay
Core Loss/ Empty
N SPT "N" VALUE
Silty Sand
Sandstone/ Greywacke
Observed water level
Nc SOLID CONE BLOW COUNTS PER 150mm
Clayey Sand
Sand
Groundwater seepage level

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 100 (vert) ; APPROX. 1:300 (horiz)

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Job No.: 26655ZH2

Figure No.: 4

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (e.g. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N>30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than “straight line” variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or ‘reverted’ chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or

iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL


FILL


TOPSOIL


CLAY (CL, CH)


SILT (ML, MH)


SAND (SP, SW)


GRAVEL (GP, GW)


SANDY CLAY (CL, CH)


SILTY CLAY (CL, CH)


CLAYEY SAND (SC)


SILTY SAND (SM)


GRAVELLY CLAY (CL, CH)


CLAYEY GRAVEL (GC)


SANDY SILT (ML)


PEAT AND ORGANIC SOILS

ROCK


CONGLOMERATE


SANDSTONE


SHALE


SILTSTONE, MUDSTONE, CLAYSTONE


LIMESTONE


PHYLLITE, SCHIST


TUFF


GRANITE, GABBRO


DOLERITE, DIORITE


BASALT, ANDESITE


QUARTZITE

DEFECTS AND INCLUSIONS


CLAY SEAM


SHEARED OR CRUSHED SEAM


BRECCIATED OR SHATTERED SEAM/ZONE


IRONSTONE GRAVEL


ORGANIC MATERIAL

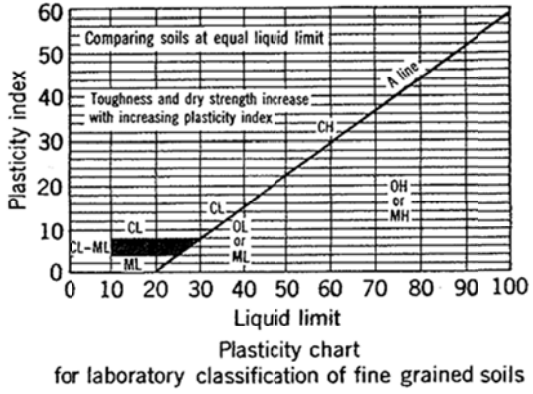
OTHER MATERIALS


CONCRETE


BITUMINOUS CONCRETE, COAL


COLLUVIUM

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)				Group Symbols [a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *GW* Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits above "A" line, with *PI* greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for *SW* Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols Atterberg limits below "A" line with *PI* greater than 7
		Gravels with fines (appreciable amount of fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		
			Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines		
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm Sieve Size						
		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)			
	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	C	Extent of borehole collapse shortly after drilling.
	▶	Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY – Runs freely through fingers.
	M	MOIST – Does not run freely but no free water visible on soil surface.
	W	WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – Unconfined compressive strength less than 25kPa
	S	SOFT – Unconfined compressive strength 25-50kPa
	F	FIRM – Unconfined compressive strength 50-100kPa
	St	STIFF – Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF – Unconfined compressive strength 200-400kPa
	H	HARD – Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose <15 0-4
	L	Loose 15-35 4-10
	MD	Medium Dense 35-65 10-30
	D	Dense 65-85 30-50
	VD	Very Dense >85 >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
----------	----------	0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
----------	----------	0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
----------	----------	0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
----------	----------	1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
----------	----------	3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
----------	----------	10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	

APPENDIX A

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

CERTIFICATE OF ANALYSIS 93215

Client:
Environmental Investigation Services
PO Box 976
North Ryde BC
NSW 1670

Attention: David Schwarzer

Sample log in details:

Your Reference:	**26655ZH, Kenneth Rd, Fairlight**		
No. of samples:	3 soils		
Date samples received / completed instructions received	02/07/13	/	02/07/13

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	3/07/13	/	3/07/13
Date of Preliminary Report:	Not issued		

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Results Approved By:

Jacinta Hurst
Laboratory Manager

Miscellaneous Inorg - soil				
Our Reference:	UNITS	93215-1	93215-2	93215-3
Your Reference	----------	BH3	BH4	BH4
Depth	----------	1.5-1.8	3.0-3.45	1.5-1.95
Date Sampled		01/07/2013	01/07/2013	01/07/2013
Type of sample		Soil	Soil	Soil
Date prepared	-	03/07/2013	03/07/2013	03/07/2013
Date analysed	-	03/07/2013	03/07/2013	03/07/2013
pH 1:5 soil:water	pH Units	6.2	5.4	6.1
Chloride, Cl 1:5 soil:water	mg/kg	41	51	58
Sulphate, SO4 1:5 soil:water	mg/kg	20	150	60

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 22nd ED, 4110 -B.

Client Reference: 26655ZH, Kenneth Rd, Fairlight

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			03/07/2013	[NT]	[NT]	LCS-1	03/07/2013
Date analysed	-			03/07/2013	[NT]	[NT]	LCS-1	03/07/2013
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	101%
Chloride, Cl 1:5 soil:water	mg/kg	2	Inorg-081	<2	[NT]	[NT]	LCS-1	96%
Sulphate, SO4 1:5 soil:water	mg/kg	2	Inorg-081	<2	[NT]	[NT]	LCS-1	92%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable.