REPORT

TO

REDFERN-WATERLOO AUTHORITY

ON

PRELIMINARY GEOTECHNICAL INVESTIGATION

FOR

PROPOSED REDEVELOPMENT OF NORTH EVELEIGH RAIL YARDS

AT

WILSON STREET, EVELEIGH, NSW

2 April 2008
Ref: 21823SBrpt

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EXECUTIVE SUMMARY

Future redevelopment of the North Eveleigh Rail Yards is proposed, comprising refurbishment of heritage buildings within the site and construction of new multi-storey commercial, retail and residential buildings over common basements of two levels. In addition, a railway tunnel is proposed within the adjacent rail corridor to the south of the site. The tunnel will be located at a maximum of about 19m below the existing ground surface. This preliminary geotechnical investigation report has been prepared based on previously obtained subsurface information to assess the geotechnical issues for the proposed redevelopment and in particular the Director General's requirements (DGR's) for Environmental Assessment of the Concept Plan, Application No. MP 08_0015.

The subsurface investigations of the site indicate that the site is underlain by surface fill covering natural silty clays that grade into shale bedrock. Groundwater was encountered within the upper shale strata.

The geotechnical issues for future development of the site are detailed within this report, together with general geotechnical recommendations on design and construction. Overall, based on the results of this preliminary geotechnical investigation, we consider that the site is suitable for the proposed redevelopment and such construction works would be similar to those undertaken at other nearby sites. Provided the detailed geotechnical investigations are carried out and design and construction of the proposed works are carried out in accordance with the general recommendations given within this report, we do not consider that the proposed redevelopment will have any adverse effects on the adjacent RailCorp facilities and corridor or result in unacceptable risks of geotechnical instability of the site or the adjoining properties. It is considered that the redevelopment works can be carried out in order to satisfy the Director General's requirements (Application No. MP 08_0015) in relation to geotechnical aspects.

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1 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation for the proposed redevelopment of the North Eveleigh Rail Yards at Wilson Street, Eveleigh, NSW. This report was commissioned by Mr Jack Borozan of the Redfern-Waterloo Authority and was prepared in accordance with our proposal, Ref: P14658SB2.

A previous geotechnical investigation of the site was carried out by Jeffery and Katauskas Pty Ltd and is detailed in our report dated 9 July 1998 (Ref: 13447Srpt). The purpose of this report is to use the previously obtained geotechnical subsurface information to provide geotechnical recommendations for the current proposed redevelopment concept plan for the site.

2 PROPOSED REDEVELOPMENT

The North Eveleigh Rail Yard site covers an area of about 9 hectares, being about 130m wide (north-south) and 950m long (east-west).

Redfern-Waterloo Authority has prepared a concept plan for the redevelopment of the North Eveleigh Rail Yards. The concept plan of the redevelopment is shown in the supplied plans by Bates Smart (Project No. S10914).

The central part of the site containing the Carriage Works building and the Blacksmith's workshop have been or will be refurbished with the buildings remaining. The remainder of the site to the east and west of the Carriage Works building will be redeveloped with the construction of multi-storey commercial and residential buildings. Most of the existing buildings in these area will be demolished to allow redevelopment, with most of the Paint Shop building to the east of the Carriage Works to remain and be incorporated into a new building and other small buildings to be retained and refurbished for community and residential use, as shown on the concept plans. The commercial buildings will be located in the eastern portion of the site with residential building mostly within the western portion.

The buildings will range in height from about 4 to 12 above ground levels, with the taller buildings located on the southern side of the site. Basement parking levels are proposed under the new buildings and will comprise common basements extending below several of the tower buildings. Generally the basement will be of two levels, with excavations to depths of about 6m, but along the northern boundary of the site (adjacent to Wilson Street) additional excavations will be required due to Wilson Street being about 3m higher that the main ground level of the site.

In addition to the above redevelopment of the site, a railway tunnel is proposed along the southern boundary of the site within the adjacent railway corridor, as shown in the supplied draft concept plan by Connell Wagner (Project No. 27551.001, Drawing No. SK-100. Rev 1). The tunnel will commence at grade opposite the western end of the site and will then fall in level via a cut and cover tunnel and then a driven tunnel opposite the eastern portion of the site. Two options for the depth of the tunnel are being considered, with the rail level for the deepest option being about 19m below the existing ground surface.

3 INVESTIGATION PROCEDURE

The fieldwork, as detailed below, was carried out in 1998. However, in order to complete this report a subsequent site visit was made by our Senior Associate, Mr Daniel Bliss, on 14 March 2008 to assess if the site was unchanged from the time of the fieldwork.

The fieldwork for the investigation comprised the drilling of 20 boreholes (BH1 to BH20), excavation of three test pits (TP101 to TP103) and logging of the battered slope along the Wilson Street boundary at five locations (201 to 205). All the above locations are shown on the attached Figure 1. The boreholes and test pit locations were selected from a number of locations set out by CH2M Hill, who carried out a contamination assessment of the site in conjunction with our previous geotechnical investigation.

The boreholes were drilled using a truck-mounted BCD350 and BCD450 rigs. Standard Penetration Tests (SPT) were carried out within the boreholes and hand penetrometer tests performed on recovered clayey samples to assess the soil strength. The bedrock strength was assessed by observation of drilling resistance from the tungsten carbide (TC) bit fitted to spiral augers, and examination of recovered rock chips. Groundwater levels were recorded both during and soon after the completion of drilling. No long term groundwater monitoring was carried out.

The test pits were excavated using a Komatsu PC45. The soil strength was assessed from hand penetrometer readings on the test pit wall, and the rock strengths assessed from exposed shale along the wall.

The battered slope along the Wilson Street boundary was logged at randomly selected strips. Soil and rock strengths were assessed from observation of hand-excavated samples from the exposed materials. Slope angles were measured using a handheld inclinometer.

The fieldwork was conducted under the full-time supervision of a geotechnical engineer who nominated the sampling and testing and prepared the various logs.

The borehole and test pit logs, which include groundwater observations and field test results, along with the battered slope logs (Figures 3 to 7), are presented with this report together with a set of explanatory notes which further explain the investigation techniques, and their limitations, and define the logging terms and symbols used.

Samples were recovered from the site and tested in our NATA registered laboratory to determine field moisture contents and Atterberg Limits. The results are summarised in Table A. Contamination testing of site soils was carried out by CH2M Hill.

4 RESULTS OF INVESTIGATION

4.1 Site Description

The site description given below has been compiled from a combination of the site description given in our previous report (Ref: 13447Srpt) and observations made during the site visit on 14 March 2008. The current site development is shown in the survey plans by Whelans Insites Pty Ltd (Ref: C641SC, Sheets 1 to 3, dated August 2007).

Natural ground slopes in the area generally fall to the south at approximately 5° from King Street/City Road which is located several hundred metres to the north. The site itself is located at the base of the hill with the northern edge of the site, adjacent to Wilson Street, cut into the hillside. The majority of the site is flat, with surface levels at about RL25m, apart from a batter along the northern edge of the site.

The battered slope was up to approximately 3.5m high, and sloped at approximately 45° to 85° from Wilson Street down to the site. The slope exposed silty clay and shale, as described in Figure 3 to 7. The steep batters showed signs of surface fretting and slumping of the shale. It is noted that at location 202 the previous batter is no longer present with a service building constructed right up to the boundary, with part of a piled retaining wall able to be seen along this section of the boundary. A number of workshop and office buildings were present along parts of the northern boundary, with brick walls retaining the cuts along the boundary where the buildings were located.

The central portion of the site was dominated by two large, double storey brick workshops. The western building comprised the Carriage Works and had been partially refurbished at the time of our 2008 site visit into the theatres and studios. A number of brick and metal clad buildings ranging from one to three storeys, were located throughout the remainder of the site. The buildings at the eastern end of the site were generally located along the northern boundary and at the level of Wilson Street, with the site sloping down to the main RL25m level to the south of the building. However, access to this end of the site was not possible during the current site visit so the slope angles and details of this end of the site could not be confirmed.

The areas between the buildings were covered with concrete and gravel pavements and railway tracks. The rail tracks to the east of the large workshops are set on gravel ballast.

The site was bounded to the north by Wilson Street and to the south by the main western railway line, which comprised many rail tracks at about the same level as the subject site. Along most of the western boundary was Ivery's Lane, with two storey brick terraces located on the western side of Ivery's Lane and adjacent to the site boundary on Wilson Street.

The majority of the eastern boundary consisted of a sandstone retaining wall up to 4.5m high, that was in poor condition during the fieldwork in 1998. However this end of the site could not be inspected during the current site visit. Several two storey brick terraces were located to the east of the site along Wilson Street. A separate property to the subject site is located on Wilson Street opposite BH17.

This property was occupied by a three storey rendered apartment/townhouse building with a basement level below the level of Wilson Street.

4.2 Subsurface Conditions

The Sydney 1:100 000 geological series sheet shows that the area is underlain by Ashfield Shale member of the Wianamatta Group. The investigation has generally revealed strata which are characteristic of this geological environment and a summary of these general characteristics is presented below. For more detailed information reference should be made to the attached borehole logs, test pit logs and geotechnical sections. The graphical borehole summaries presented as Figures 2A and 2B, and the plan showing the depth of fill and bedrock at the borehole locations presented as Figure 8 provide a helpful overview of the subsurface conditions.

Fill

A variety of fill types and thicknesses occur within the site. In many areas a relatively thin (less than 1m) layer of predominantly granular material forms the pavement and track bed areas. These materials are assessed to range from poorly to well compacted.

Locally deeper fill embankments occur towards the southern side of the site, consistent with cut-to-fill earthworks associated with the levelling of the site area. The deeper fill layers generally comprise silty clay and are assessed to be poorly compacted. Locally, the fill was also found to contain deleterious materials such as slag and timber pieces. Locally poor quality backfill should also be expected within the numerous service trenches which are present within the site area.

Alluvial Clay

In BH2, a soft to firm alluvial clay of low plasticity and dark grey colour was encountered to a depth of 2m. This material is probably characteristic of an old creek channel which was present in this area. Other similar areas could be present elsewhere within the site.

Residual Clay

Residual clay soils derived from insitu weathering of the underlying shale bedrock occurred widely throughout the site. Towards the northern side of the site most or all of the clays have been removed as part of the earlier site earthworks, but elsewhere the clay soils extend up to 5m below the existing site levels, for example at BH7, BH12 and BH14 near the southern boundary. The clay soils are typically of medium to high plasticity and range from stiff to hard in strength. Locally the upper surface of the clays may be softened perhaps due to poor drainage and seepage through the base of overlying fill materials, as for example at BH14. With depth there is often a transition to shaly clay which is difficult to identify in the augered boreholes.

Shale Bedrock

The shale within the site typically comprises a dark grey laminated mudstone. The extent of weathering and strength reduction varies considerably, but there is generally a transition from either shaly clay or extremely weathered, extremely low strength shale through distinctly weathered, very low to low strength material and thence low to medium strength at depth. In BH1, BH5, BH7, BH9, BH10, BH12 and BH14, the better quality low to medium strength shale was not encountered within the maximum depth of investigation which generally ranged from 6m to 7.5m. BH8 was terminated on buried concrete and the shale was not encountered.

As part of preparation of this report we have obtained geotechnical information on a Transgrid service tunnel that crosses the site. A long section of the tunnel is given in the drawings by SMEC Australia Pty Ltd (Ref: 31281-T-0204 and 31281-T-0205), which shows summary geotechnical borehole logs, of which boreholes appear to be located to the north and south of the site. These boreholes indicate Ashfield Shale increasing in strength with depth to about RL-5m, where the Mittagong formation (shale and sandstone) of high strength was encountered to RL-2.7m and RL-3.5m, and thereafter Hawkesbury Sandstone of high to very high strength.

Groundwater

Groundwater seepage was encountered in most boreholes during drilling, generally within the upper shale strata. In all boreholes except BH19, standing water levels were recorded in the boreholes a short time after drilling was completed. These standing levels varied considerably as shown on Figures 2A and 2B. As the boreholes had to be backfilled shortly after completion, it was not possible to carry out longer term groundwater monitoring.

4.3 Laboratory Test Results

The laboratory test results are consistent with field assessment of soil and rock properties shown on the borehole logs. The results are presented in the attached Table A.

5 COMMENTS AND RECOMMENDATIONS

5.1 Geotechnical Issues for Future Development

Based on the results of the geotechnical investigations carried out at the site to date, the main geotechnical issues for the future development of the site are as follows. Further comments on these issues and general recommendations on future development of the site are provided within the subsequent sections of this report.

- Fill was encountered within the boreholes and it must be considered 'Uncontrolled' as no records of placement or compaction control are available. In addition, the fill was generally assessed to be poorly compacted and would not be suitable for the support of footings. However, within the building areas the fill will be excavated to form the proposed basements. In areas away from the basements for the proposed pavements treatment of the fill may be required to provide a suitable subgrade. Treatment or removal of the fill may also be required due to contamination issues and reference should be made to any available contamination assessment reports to assess any such issues for the site.
- Some relatively thick concrete pavements and buried concrete were encountered in the boreholes and considering the history of the site, we would expected that such buried concrete, old footings and thick pavements would be present that will need to be removed and result in ground disturbance. Underground tanks or inspection pits may also be located within the site and these will need to be identified and backfilled with engineered fill where they are located outside of the proposed basements.
- Excavations for the proposed basements will be possible within the soils and extremely weathered shale using conventional earthmoving equipment, such as the buckets of hydraulic excavators. Excavation of the low or greater strength shale will require assistance with rock breaking/ripping equipment. Within bulk

excavations, the use of large dozers with ripping tynes may be appropriate, but the use of hydraulic rock hammers may be required for detailed excavations. The effect of the vibrations generated by hydraulic rock hammers will need to be considered during their use, particularly, due to the heritage buildings at the site that will be retained.

- The excavations within the soils and poor quality shale will not be self supporting and will need to be formed at suitable batters (where space permits) or retention systems installed prior to the start of the excavations. Particular care will be required with the excavations along the northern boundary (Wilson Street) where the existing retaining walls along this side of the site will be removed and excavations taken deeper. Piled retaining walls will need to be constructed behind the existing walls prior to removal or new retention systems installed in front of the existing walls prior to bulk excavations. Careful design and detailing of such works will be required.
- Groundwater seepage should be expected into the basement excavations and drainage systems will be required to control such seepage. Conventional sump and pump techniques are expected to be feasible to control seepage during construction, but dewatering of the deeper basement excavations may be required. In the long term, drainage will be required around and below the basement, or the basement slabs designed as 'tanked' basements to resist hydrostatic uplift forces.
- The basement and footing designs will need to take into account the proposed railway tunnel along the southern boundary of the site. The buildings located near the proposed tunnel may require piles to be drilled to depths below the influence zone of the tunnel, requiring the use of large capacity piling rigs to drill through medium to high strength rock. The design and construction of these buildings will need to be carried out in accordance with any RailCorp requirements due to the proposed tunnel.
- Since the basement excavations will encounter shale, pad or strip footings within the shale may be feasible. However, given the size of the proposed

buildings, piles may still be required to encounter medium or high strength shale appropriate for higher bearing pressures. Where the buildings extend outside of the proposed basements, piles will be required so that the buildings are uniformly supported within the shale. Minor, lightly loaded structures that are separate from the buildings founded within the shale may be supported on high level footings founded below the fill and within the residual silty clays.

- New pavements will be required between the proposed buildings to provide site access. The clay fill and natural silty clays are considered a relatively poor subgrade and may have CBR values of 2% or less. Many of the boreholes encountered a substantial thickness (≥0.4m) of granular fill, which may have been placed as a capping layer to form a trafficable surface. This granular layer may be able to be retained as a capping layer below the new pavements (depending on final design levels), subject to assessment of the quality of the granular fill and the overall pavement thickness designs.

General geotechnical recommendations are given in the following sections of this report, but since the redevelopment is only at the concept stage site specific recommendations and advice must be obtained for each of the proposed buildings once the exact development details are known. For each of the individual building sites, additional geotechnical investigations must be carried out to assess the local subsurface conditions. In addition, most of the current boreholes have not be drilled to sufficient depths for the proposed excavations for two basement levels and the additional geotechnical investigations must include boreholes drilled to below the base of the proposed excavations. These additional boreholes should involve coring of the bedrock once it is encountered to allow the quality of the rock, both strength and defects present, to be assessed in order to maximise the footing bearing pressures for use in design and assess the excavation and retention conditions.

Overall, based on the results of the preliminary geotechnical investigation, we considered that the site is suitable for the proposed redevelopment and such construction works would be similar to those undertaken at other nearby sites. Provided the detailed geotechnical investigations are carried out and design and construction of the proposed works are carried out in accordance with the general recommendations given within this report, we do not consider that the proposed redevelopment will have any adverse effects on the adjacent RailCorp facilities and corridor or result in unacceptable risks of geotechnical instability of the site or the adjoining properties. It is considered that the redevelopment works can be carried out in order to satisfy the Director General's requirements (Application No. MP 08_0015) in relation to geotechnical aspects.

5.2 Excavations and Groundwater

Excavations for the proposed basement will encounter fill, natural clays and weathered shale. The weathered shale will initially be of extremely low strength, but would increase in strength with depth and medium or high strength shale may be encountered within the deeper excavations.

Excavation of the soils and extremely weathered shale would be achievable using conventional earthmoving equipment, such as the buckets of hydraulic excavators. Excavation of the shale of low or greater strength will require assistance with rock breaking/ripping equipment. Bulk excavations may be feasible using the ripping tynes of large dozers, such as D8 or D9. Detailed excavations may require the use of hydraulic rock hammers, but care must be taken when using such equipment due to the vibrations generated by such equipment. Where rock hammers are to be used close to the existing buildings, the transmitted vibrations should be monitored and alternate equipment used, such as ripping hooks, rotary grinders or rock saws, where the vibrations are excessive.

Groundwater was encountered within the boreholes at depths of 2m to 3m, but the groundwater was not able to be measured over an extended time period.

Groundwater seepage should be expected into the basement excavations, which would tend to increase during and following rainfall. Seepage into shallow excavations is expected to be controllable using conventional sump and pump techniques, but within deeper excavations more substantial drainage or dewatering systems may be required. The groundwater levels and expected seepage should be assessed as part of the detailed geotechnical investigations for each building site.

In the long term, drainage will be required behind the basement retaining walls and below the basement slab. Alternatively, the basements may be designed as 'tanked' basements with the slabs designed to resist hydrostatic uplift loads.

5.3 Earthworks

Outside of the proposed basements, earthworks for the proposed pavement areas should comprise stripping of any topsoil, organic soils or deleterious fill (including in regard to soil contamination). Where granular fill is present it may be possible to leave this fill in place as a capping layer over the clays, depending on design pavement levels. If this granular fill must be excavated, it may be stockpiled and used to replace unstable subgrade areas or as a select fill layer below the proposed pavements.

Following stripping, the subgrade should be proof rolled with at least 8 passes of a minimum 10 tonne deadweight smooth drum vibratory roller. The final pass of the proof rolling should be inspected by a geotechnical engineer or experienced geotechnician to detect any weak subgrade areas. Any weak areas detected should be locally excavated to a sound base and the material, replaced with engineered fill. Further advice on treatment of any weak areas should be provided by the geotechnical engineer following proof rolling. Any fill placed to raise site levels should also comprise engineered fill.

If weak subgrade areas are found to extend to depths in excess of say 1m, then the use of bridging layers comprising geotextiles and granular fill may be more appropriate. Further advice on such bridging layers must be obtained during earthworks, but we would expect such layer to be no more than 0.6m thick. Lower compaction densities may need to be accepted within the first layer of granular fill depending on its response to compactive effort.

Particular attention may be required near BH2 where organic clays were encountered within the borehole.

Care must be taken during rolling near existing buildings due to the risk of damage from the vibrations. In these areas compaction may need to be carried out without vibration. The vibrations transmitted to the existing building should be monitored during rolling and the vibration reduced or ceased as required. Where static rolling can only be carried out, the effectiveness of such rolling to achieve the required compaction would have to be reviewed by the geotechnical engineer.

From the borehole results we expect that weak subgrade areas would be encountered due to the existing poorly compacted fill. The extent of the weak areas can be reduced provided good site drainage is maintained and the earthworks are carried out during good weather. Should any soft areas be found then further advice and inspections will be required to assess the most suitable method of subgrade improvement. Allowance should be made for either, tyning, aerating and drying the subgrade, or removal and replacement with a select imported fill. If the clay is exposed to prolonged periods of rainfall, softening will result and site trafficability will be poor. If soil softening occurs, the subgrade should be over-excavated to below the depth of moisture softening and the excavated material replaced with engineered fill.

5.4 Engineered Fill and Compaction Control

Engineered fill should preferably comprise well graded granular materials, such as ripped rock or crushed sandstone, free of deleterious substances and having a maximum particle size not exceeding 75mm. The existing sandy and gravelly fill on site would be suitable for reuse as engineered fill, provided it is free of deleterious materials and particles greater than 75mm in size. Such fill should be compacted in horizontal layers of not greater than 200mm loose thickness, to a density of at least 98% of Standard Maximum Dry Density (SMDD). For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness.

Density tests should be regularly carried out on the fill to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 500m^2 or three tests per visit, whichever requires the most tests., in accordance with AS3798. Preferably the geotechnical testing authority should be engaged directly on behalf of the client and not by the earthworks subcontractor.

5.5 Retention

Temporary batters of less than 3m high may be formed at slopes of no steeper than 1 Vertical in 1 Horizontal (1V:1H). Such batters should remain stable in the short term provided all surcharge loads, including construction loads, are kept well clear of the crest of the batters. However, flatter batters and additional shoring may be required where groundwater is encountered. Permanent batters should be no steeper than 1V:2H, but flatter batters of the order of 1V:3H may be preferred to allow access for maintenance of vegetation. Permanent batters should be covered with topsoil and planted with a deep rooted runner grass following construction to reduce erosion. All stormwater run-off should be directed away from all temporary and permanent slopes.

For the deeper basement excavations, the use of piled retaining walls installed prior to the start of bulk excavations will be required. Where some adjacent ground movements are tolerable and no building are located behind the wall, soldier pile retaining walls with shotcrete infill panels may be used. Where buildings are located behind the walls, more rigid contiguous or secant pile walls would be required. Lateral support of such piled walls would be required in the form of internal props or external anchors. However, the use of anchors may be restricted along the southern side of the site due to the railway corridor and any tunnels present at the time of construction. Permission would need to be obtained from the owners of adjoining properties before the installation of anchors below those properties.

Particular care must be taken with the design and construction of walls along the northern boundary where they are to replace the existing brick walls. The construction of piled walls behind the existing walls prior to demolition may be required, or the construction of retention systems in front of the existing walls.

Preliminary design of propped or anchored retaining walls may be based on a trapezoidal lateral pressure of 6H kPa (where H is the retained height in metres) where adjacent buildings or movement sensitive services are located beyond 2H of the wall. Where buildings and services are located within 2H of the wall, a higher lateral pressure distribution of 8H kPa should be used. These maximum lateral pressures should be kept constant for the central 50% of the pressure distribution. For detailed design of the retaining walls the use of computer based design software, such as Wallap, should be considered as such analysis can result in significant project savings.

Cantilevered retaining walls where some resulting ground movements are tolerable, of no more than 3m high, may be designed based on a triangular earth pressure distribution using an active earth pressure coefficient, K_a, of 0.33 and a bulk unit weight of 20kN/m^3.

The above lateral pressures and coefficients assume horizontal backfill surfaces and where inclined backfill is proposed the lateral pressures or coefficients would need to be increased or the inclined backfill taken as a surcharge load. All surcharge loads should be allowed for in the design. Full hydrostatic pressures should be considered unless measures are undertaken to provide complete and permanent drainage of the ground behind the wall.

5.6 Footings

Lightly loaded structures, of say one or two storeys, may be supported on shallow footings founded within the natural clays or engineered fill. However, within such building areas, we recommend that all existing fill be excavated and replaced within controlled engineered fill, or the building be designed with a fully suspended floor slab.

Shallow footings founded within the natural silty clays of at least very stiff strength may be preliminarily designed based on an allowable bearing pressure of 150kPa. Such footings should also be designed to accommodate the expected shrink/swell movements of the clays, which we would expect to be similar to a Class H site in accordance with AS2870.

Within the basement excavations shale will be encountered and the use of pad or strip footings may be feasible. However, if only extremely low or very low strength shale is encountered within the base of the excavations, the use of piles may still be required to reach better quality shale. Outside of the basement excavations, the multi-storey building will need to be supported on piles founded within the shale.

The effect on the proposed buildings of the proposed rail tunnel on the southern side of the site must also be taken into account. Where the buildings are located within the influence zone of the tunnel, piles may need to be founded at significant depths to be below the influence zone of the tunnel. The drilling of such piles may encounter medium or high strength rock and large capacity rigs may be required. The specific requirements for foundations close to the tunnel should be assessed for each building on the southern side of the site.

Bored piers may be appropriate for shallow piles, but for deeper drilling groundwater seepage is expected to make such piers difficult to construct. In addition, where uncontrolled fill is present difficulties with collapse of the fill may also be encountered. The use of auger, grout injected (CFA) piles or auger screw piles, such as 'Atlas' or Omega' piles, would be feasible for this site to overcome the construction difficulties of bored piers. The use of driven piles may also be considered, but the suitability of such piles would need to be assessed taking into account the vibrations generated and the effect on the existing buildings.

Footings may be designed based on an allowable bearing pressure of 600kPa within shale of extremely low strength or 1500kPa within shale of low to medium strength. Higher bearing pressure of at least 3500kPa would be possible within good quality medium or high strength shale, but this would need to be confirmed by cored boreholes to fully assess the quality of the shale. The appropriate bearing pressure for the design of each building should be assessed following the detailed geotechnical investigations of each of the building sites.

Allowable adhesions of the rock sockets equivalent to 10% of the above allowable bearing pressures, may be used for design of piles in compression, below the 0.3m nominal socket and provided socket cleanliness and roughness is maintained.

5.7 Pavements

Site specific testing of the pavement subgrade soils must be carried out to allow detailed design. However, as a guide, we would expect that for a clay subgrade prepared as detailed in Section 5.3 a design CBR of the order of 2% would be appropriate. Higher design CBR values would be appropriate where granular fill is present to sufficient depth, but this would require detailed testing and investigation of specific areas.

The use of flexible or rigid pavements would be appropriate for this site, but the use of rigid pavements may be preferred within the heavily trafficked areas.

Concrete pavements should have a subbase layer of at least 100mm thickness of crushed rock to RTA QA specification 3051 (1994) unbound base material (or equivalent good quality and durable fine crushed rock), which is compacted to at least 100% of SMDD. Concrete pavements should be designed with an effective shear transmission at all joints by way of either doweled or keyed joints.

6 GENERAL COMMENTS

The recommendations presented in this report must be considered as preliminary only to provide guidance for future development of the site. Detailed, site specific geotechnical investigations of each of the building areas within the site must be carried out to allow detailed design and construction of each building. In the event that any of the detailed design phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Jeffery and Katauskas Pty Ltd accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly investigated, 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 judgement from an experienced engineer. Such judgement 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.

The offsite disposal of soil will most likely require classification in accordance with the Department of Environment & Conservation (NSW) guidelines as inert, solid, industrial or hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected. We strongly recommend this issue be addressed prior to commencement of excavation on site.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

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Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD.

Daniel Bliss
Senior Associate

Reviewed by:

for Paul Stubbs
Principal

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	SAMPLE DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
BH 1	0.70 - 1.15	21.6	64	20	44	15½
BH 1	3.00 - 3.45	17.7				
BH 1	5.80 - 6.00	10.3*				
BH 2	0.80 - 1.25	30.2				
BH 2	1.50 - 1.70	46.0				
BH 2	5.80 - 6.00	8.0*				
BH 3	1.50 - 1.60	6.6				
BH 3	2.50 - 3.00	3.6*				
BH 4	0.50 - 0.80	12.1				
BH 4	2.50 - 3.00	10.7				
BH 4	5.50 - 6.00	4.0*				
BH 5	0.50 - 0.95	22.4	62	19	43	15½
BH 5	3.00 - 3.25	13.2				
BH 5	4.30 - 4.50	12.4				
BH 5	5.80 - 6.00	11.9*				
BH 6	0.50 - 0.95	13.6				
BH 6	2.50 - 3.00	15.9				
BH 6	4.00 - 4.50	15.8				
BH 6	7.20 - 7.50	7.6*				

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TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	SAMPLE DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
BH 7	0.50 - 0.95	31.8				
BH 7	1.50 - 1.95	30.8				
BH 7	5.50 - 6.00	13.3				
BH 9	1.00 - 1.45	13.1				
BH 9	3.00 - 3.10	10.1				
BH 9	4.00 - 4.50	15.8				
BH 10	0.50 - 0.95	13.2				
BH 10	2.50 - 3.00	12.2				
BH 10	5.50 - 6.00	14.9				
BH 11	0.80 - 1.00	11.7				
BH 11	2.80 - 3.00	10.9				
BH 11	4.30 - 4.50	9.3				
BH 12	1.50 - 1.95	24.2				
BH 12	7.30 - 7.50	14.9				
BH 13	1.50 - 1.70	12.9				
BH 13	4.30 - 4.50	8.5				
BH 14	0.90 - 0.95	28.0				
BH 14	5.80 - 6.00	9.9				
BH 15	1.30 - 1.50	10.4				

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TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	SAMPLE DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
BH 15	2.80 - 3.00	7.5*				
BH 16	0.50 - 0.85	13.4				
BH 16	2.80 - 3.00	8.6				
BH 16	4.30 - 4.50	7.6				
BH 17	1.50 - 1.80	11.5				
BH 17	4.30 - 4.50	10.8				
BH 18	1.50 - 1.80	12.9				
BH 18	4.30 - 4.50	9.8				
BH 18	5.80 - 6.00	9.9				
BH 19B	3.00 - 3.45	15.4				
BH 19B	5.80 - 6.00	11.9				
BH 20	1.50 - 1.95	14.8				
BH 20	3.00 - 3.30	16.0				
BH 20	5.80 - 6.00	8.4				

NOTE *Denotes non standard test sample mass- rock chips only(Not NATA endorsed).

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BOREHOLE LOG

Borehole No.
1
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
						0			FILL: Silty sandy gravel, fine to coarse igneous gravel, fine to medium grained sand, brown.	M			APPEARS WELL COMACTED
				■	N = 14 5,6,8	1		CH	SILTY CLAY: high plasticity, pale grey mottled red and orange brown, with a trace of fine to medium grained ironstone gravel.	MC>PL	H	520 400 520	STRONG ODOUR TO 1.0m
				■	N = 21 7,9,12	2						520 490 580	
AFTER 6 HRS								CL	SHALY CLAY: medium plasticity, pale grey.	MC<PL			
				■	N = 28 6,11,17	3						>600 >600 >600	
						4							
▶				■	N > 21 11,10/ 50mm			–	SHALE: pale grey to grey, with a trace of iron indurated bands.	EW	EL	–	VERY LOW 'TC' BIT RESISTANCE
						5			SHALE: dark grey and brown, with a trace of clay bands.	DW	VL–L		
				■		6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No. 2 1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES ES U50 DB DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		–	FILL: Silty sandy gravel, fine to coarse grained igneous gravel, fine to medium grained sand, brown.	M			STEEL REINFORCEMENT 12mm.t 100mm FROM SURFACE
					–	CONCRETE: 240mm.t				
						FILL: fine to medium grained slag gravel.				
		N = 13 1,1,2	1		CL	FILL: Gravelly sand, fine to medium grained sand, fine to coarse grained sandstone gravel.	MC>PL	F	100 80 90	–
						SILTY CLAY: low plasticity, grey and dark grey.				
					OL	ORGANIC CLAY: low plasticity, grey and dark grey, with fine organic fibres.		(S–F)		ORGANIC ODOUR
			2		CL	SILTY CLAY: low to medium plasticity, mottled grey, dark grey and brown, with a trace of fine roots.		(St)		–
AFTER 4.5 HRS		N = 6 2,2,4	3						130 130 350	
						SILTY CLAY: medium plasticity, pale grey mottled red brown, with a trace of fine to medium grained ironstone gravel.		VSt		
			4		–	INTERBEDDED SHALY CLAY AND SHALE: pale grey to grey.	MC<PL XW	H/ EL		
		N > 16 16/ 100mm								
AFTER 5 MINS			5		–	SHALE: brown, with iron indurated bands and a trace of clay bands.	DW	L–M	–	LOW TO MODERATE 'TC' BIT RESISTANCE
			6			END OF BOREHOLE AT 6.0m				
			7							

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BOREHOLE LOG

Borehole No.
3
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES ES U50 DB DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 5 MINS			0			FILL: Silty sandy gravel, fine to medium grained, dark grey.	D			ROADBASE
					–	FILL: Silty sandy clay, low to medium plasticity, dark grey.	MC>PL			
			1		–	SHALE: grey and dark grey.	DW	L	–	LOW 'TC' BIT RESISTANCE
		N > 10 10/ 100mm BOUNCING						L–M		LOW TO MODERATE RESISTANCE
			2					H		HIGH RESISTANCE
			3					M		MODERATE RESISTANCE
			4							
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No.
4
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

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
DRY ON COMPLETION						0			CONCRETE: 200mm.t				STEEL REINFORCEMENT AT 70mm FROM SURFACE
								–	FILL: Silty clay, high plasticity, with fine to medium grained shale gravel and a trace of fine to medium grained sand.	MC>PL	–	–	
					N > 47 19,28/ 150mm R			–	SHALE: pale grey to grey with red brown iron induration.	XW	EL	–	– LOW 'TC' BIT RESISTANCE
						1							
						2							
									SHALE: grey and brown.	DW	VL–L		LOW RESISTANCE WITH LOW TO MODERATE BANDS
						3							
▼ AFTER 1 HOUR													
						4			SHALE: dark grey.		L		LOW TO MODERATE RESISTANCE
											M		MODERATE RESISTANCE
						5							
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No. 5 1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		0		FILL: Silty sandy gravel, fine to medium grained igneous gravel, fine to medium grained sand, grey brown.	M			
			–	CONCRETE: 160mm.t				
			–	FILL: fine to medium grained igneous gravel.				
	N = 14 2,5,9		CH	SILTY CLAY: high plasticity, pale grey mottled pale orange brown, with fine to medium grained ironstone gravel.	MC>PL	VSt H	380 450 420	–
		1						
	N = 21 5,9,12							
		2						
			–	SHALE: pale grey to grey, with iron indurated bands.	XW	EL	–	–
	N > 25 11,15/ 100mm	3						
		4						
AFTER 3 HRS								
		5		SHALE: dark grey and brown.	DW	VL–L		LOW 'TC' BIT RESISTANCE
		6		END OF BOREHOLE AT 6.0m				
		7						

SAMPLES: ES, U50, DB, DS

Graphic Log

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BOREHOLE LOG

Borehole No.
6
1/2

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Silty sandy gravel, fine to coarse grained igneous gravel, fine to coarse grained sand, dark grey.	D			
			CH	SILTY CLAY: high plasticity, pale grey, orange red brown.	MC<PL	(H)	–	–
	N = 32 10,17,15		CL	SHALY CLAY: medium plasticity, pale grey mottled pale brown and red brown, with iron indurated bands.	MC<PL	H	–	LOW 'TC' BIT RESISTANCE WITH MODERATE STRENGTH BANDS
		1						
	N > 36 7,16,20/ 100mm R		–	SHALE: pale grey to grey, with iron indurated bands.	XW	EL	–	
AFTER 5.5 HRS		2						
		3						
		4		SHALE: pale grey and pale brown.				
		5		as above, but grey and dark grey.	XW–DW	EL–VL		
		6						
		7						

SAMPLES: ES U50 DB DS

Graphic Log

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BOREHOLE LOG

Borehole No.
6
2/2

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER
BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./

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
						7			SHALE: grey and dark grey.	XW–DW	EL–VL		
				■					SHALE: dark grey.	DW	L		LOW TO MODERATE RESISTANCE
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							

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BOREHOLE LOG

Borehole No.
7
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER
BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./B

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 sandy gravel, fine to coarse grained igneous gravel, dark grey.	D			
				■	N = 3 1,1,2				FILL: Silty clay, medium to high plasticity, brown and grey, with a trace of fine grained gravel.	MC>>PL	–	250 200 250	APPEARS POORLY COMPACTED
▼ AFTER 4.5 HRS						1							
				■	N = 2 1,1,1							220 230 250	
						2							
▶								CH	SILTY CLAY: high plasticity, pale grey mottled red brown.	MC≥PL	H	–	–
				■	N = 16 6,6,10	3						>600 >600 >600	
						4							
				■	N = 20 3,10,10								
						5		–	SHALE: pale grey.	XW	EL–VL		LOW 'TC' BIT RESISTANCE
				■									
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No. 8
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./B

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			CONCRETE: 130mm.t				
				■	N > 8 1,0,8/ 100mm			–	FILL: Silty sandy gravel, fine to medium grained igneous gravel, fine to coarse grained sand, dark grey.	W	–	–	APPEARS POORLY COMPACTED
				■	BOUNCING	1		–	FILL: Silty clay, high plasticity, pale grey and dark grey.	MC<PL	–	–	HIGH 'TC' BIT RESISTANCE
									CONCRETE	–			'TC' BIT REFUSAL
									END OF BOREHOLE AT 1.15m				
						2							
						3							
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No.
9
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./B

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
DRY ON COMPLETION						0			CONCRETE: 180mm.t				STEEL REINFORCEMENT AT 70mm FROM SURFACE
							▨	–	FILL: Concrete and brick fragments up to 200mm diameter, with whole bricks.	D	–	–	–
				■	N = 35 4,15,20	1	▤	–	SHALE: grey and brown, with iron indurated bands.	XW	EL–VL	–	VERY LOW TO LOW 'TC' BIT RESISTANCE
													LOW RESISTANCE
▼ AFTER 2.5 HRS						2							
				■	N > 20 20/ 100mm	3	▤		as above but grey, with occasional red brown iron indurated bands.		VL		
				■		4	▤		SHALE: dark grey.	DW			
						5							
				■									
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No.
10
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28–5–98
Method: SPIRAL AUGER BCD350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			CONCRETE: 200mm.t				
								–	FILL: Silty clay, medium to high plasticity, grey and brown, with fine grained gravel.	–	–	–	–
					N = 23 3,8,15			CL–CH	SILTY CLAY: medium to high plasticity, pale grey mottled orange brown, with iron indurated bands and shale bands.	MC<PL	H	–	–
						1							
					N > 24 24/ 150mm			–	SHALE: pale grey to grey, with occasional iron indurated bands.	XW	EL		LOW RESISTANCE WITH OCCASIONAL MODERATE BANDS
						2							
						3							
▼ AFTER 1.5 HRS						4			SHALE: grey and brown.	DW	VL		
						5							
											VL–L		
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No.
11
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD350
R.L. Surface: N/A
Datum:
Logged/Checked by: B.S./

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			CONCRETE: 400mm.t				
					N > 19 9,19/ 50mm	1		–	SHALE: grey and brown, with iron indurated bands.	XW	EL	–	–
						2			SHALE: grey to dark grey.	DW	VL		VERY LOW 'TC' BIT RESISTANCE
AFTER 1.5 HRS						3			SHALE: dark grey.		L–M		LOW TO MODERATE RESISTANCE
						4 5 6 7			END OF BOREHOLE AT 6.0m				

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BOREHOLE LOG

Borehole No.
12
1/2

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
DRY ON COMPLETION						0			CONCRETE: 400mm.t				
				■	N = 9 4,5,4			–	FILL: Silty clay, medium plasticity, mottled pale grey, grey and orange brown, with fine to medium grained ironstone and shale gravel.	MC>PL	–	250 200 300	APPEARS WELL COMPACTED
						1							
				■	N = 6 2,2,4			CL	SILTY CLAY: low plasticity, brown, with a trace of fine ironstone gravel.	MC>PL	St	– 120 120 120	–
						2		CH	SILTY CLAY: high plasticity, pale grey and red brown, with fine ironstone gravel.	MC=PL	H		
				■	N = 22 7,9,13	3						>600 >600 >600	
						4							
						5		CL	SHALY CLAY: medium plasticity, pale grey, with iron indurated bands.	MC<PL			
				■									
						6		–	SHALE: pale grey to grey.	XW	EL	–	–
AFTER 3/4 HR						7							

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BOREHOLE LOG

Borehole No. 12 2/2

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

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
				■		7	▤		SHALE: pale grey to grey.	XW	EL		
									END OF BOREHOLE AT 7.5m				
						8							
						9							
						10							
						11							
						12							
						13							

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BOREHOLE LOG

Borehole No.
13
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			CONCRETE: 130mm.t				
								–	FILL: Silty sandy gravel, fine to medium grained igneous gravel, fine to medium grained sand, dark grey.	M	–	–	APPEARS WELL COMPACTED
				■	N = 6 4,2,4				as above, but with slag and timber pieces.				APPEARS POORLY COMPACTED
▼ AFTER 20 MINS						1		–	SHALE: dark grey, with a trace of iron indurated bands.	XW	EL	–	–
				■	N > 18 7,11/ 50mm								
						2							
						3							
▶									SHALE: dark grey.	DW	L		LOW 'TC' BIT RESISTANCE
						4					L–M		LOW TO MODERATE RESISTANCE
									END OF BOREHOLE AT 4.5m				
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No.
14
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER
BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

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
DRY ON COMPLETION						0	▩		FILL: Sandy gravel, medium to coarse grained igneous gravel, fine to medium grained sand, grey.	M			APPEARS POORLY COMPACTED
				■	N = 3 2,1,2		▩		FILL: Silty sandy gravel, fine to medium grained slag, fine to medium grained sand, dark grey.	MC>PL		100 100 50	
						1	▨	CL	FILL: Silty clay, low plasticity, mottled pale grey and orange brown, with a trace of ironstone gravel and sand.	MC>PL	S		–
				■	N = 3 1,1,2		▨		SILTY CLAY: low plasticity, dark grey, with a trace of fine rootlets.		St	120 120 180	
						2	▨		SILTY CLAY: medium plasticity, pale brown and grey, with fine to medium grained ironstone gravel.				
							▨		SILTY CLAY: medium plasticity, pale grey, with a trace of red brown mottling and iron indurated bands.		H		
				■	N = 15 3,6,9	3	▨					500 500 450	
						4	▨		as above, but with iron indurated bands.				
				■	N = 31 7,12,19		▨					>600 >600 >600	
▼ AFTER 3.5 HRS						5	▤		SHALE: grey and brown, with clay bands.	XW-DW	EL-VL		VERY LOW 'TC'BIT RESISTANCE
				■			▤						
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No. 15
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 28-5-98
Method: SPIRAL AUGER BCD 450
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

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
DRY ON COMPLETION						0	▩		FILL: Silty gravelly sand, fine to medium grained, dark brown, with fine to medium grained igneous gravel and a trace of slag.	M			APPEARS WELL COMPACTED
				■	N > 22 12,10/ 50mm		▤	–	SHALE: grey and dark grey.	DW	VL	–	–
				■		1	▤				L–M		LOW 'TC' BIT RESISTANCE
				■		2	▤		SHALE: dark grey.		M		MODERATE RESISTANCE
						3			END OF BOREHOLE AT 3.0m				
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No.
16
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./RB

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		CONCRETE: 150mm.t				
			–	FILL: Silty sandy gravel, fine to medium grained igneous gravel and slag, fine to medium grained sand, with a trace of glass.	M	–	–	APPEARS MODERATELY COMPACTED
	N > 23 9,12,10/ 50mm		–	SHALE: grey and brown, with clay bands.	XW	EL	>600 >600 >600	VERY LOW 'TC' BIT RESISTANCE
		1						
	N > 21 11,10/ 50mm						>600 >600	
AFTER 5 HRS		2		SHALE: dark grey.	DW	VL-L		VERY LOW TO LOW RESISTANCE
		3						
						M		MODERATE RESISTANCE
		4				L-M		LOW TO MODERATE RESISTANCE
		5				H		HIGH RESISTANCE
				END OF BOREHOLE AT 4.5m				
		6						
		7						

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BOREHOLE LOG

Borehole No.
17
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./PB

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0	CL	FILL: Silty sandy gravel, fine to medium igneous gravel, fine to medium grained sand, grey.	MC>PL	H	–	–
				■	N = 26 4,11,15		CL	SILTY CLAY: medium plasticity, pale grey and orange brown, with iron indurated bands.	MC<PL		>600 >600 >600	
								SHALY CLAY: medium plasticity, pale grey and grey, with interbedded shale bands.				
						1	–	SHALE: grey and brown.	XW	EL		–
				■	N > 35 15,20 BOUNCING							
						2			DW	VL–L		LOW 'TC' BIT RESISTANCE
▼ AFTER 3 HRS						3		SHALE: dark grey and brown.	DW	L–M		LOW TO MODERATE RESISTANCE
				■		4						
								END OF BOREHOLE AT 4.5m				
						5						
						6						
						7						

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BOREHOLE LOG

Borehole No.
18
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER BCD 350
Logged/Checked by: S.E./
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			FILL: Silty sandy gravel, fine to medium grained igneous gravel and slag, with a trace of sandstone gravel, fine to medium grained sand, dark grey.	M			APPEARS WELL COMPACTED
				■	N = 20 5,9,11	1		CL	SHALY CLAY: medium plasticity, pale grey, with interbedded shale of extremely low strength.	MC<PL	H	–	–
▼ AFTER 4.5 HRS				■ ■	N > 27 7,20	2		–	SHALE: grey and brown.	XW	EL	–	VERY LOW 'TC' BIT RESISTANCE
				■		3 4			SHALE: grey and brown, with ironstone bands of moderate to high strength.	DW	L		LOW RESISTANCE
				■		5 6			SHALE: dark grey.		L–M		LOW TO MODERATE RESISTANCE
						7			END OF BOREHOLE AT 6.0m				

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BOREHOLE LOG

Borehole No.
19A 1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER
BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./RB

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: Sandy gravel, medium to coarse grained igneous gravel, fine to medium grained sand, dark grey brown.	D M			APPEARS WELL COMPACTED
				■	N > 2 1,1		▨		FILL: Sandy gravelly clay, low plasticity, grey and orange brown.	MC>PL	–	–	APPEARS POORLY COMPACTED
▶					BOUNCING				END OF BOREHOLE AT 0.8m				AUGER REFUSAL (POSSIBLE SERVICE)
						1							
						2							
						3							
						4							
						5							
						6							
						7							

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BOREHOLE LOG

Borehole No.
19B 1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./B

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U50	DB	DS									
DRY ON COMPLETION						0			FILL: Sandy gravel, medium to coarse grained igneous gravel, fine to medium grained sand, dark grey brown.	D M			APPEARS WELL COMPACTED
									FILL: Sandy gravelly clay, low plasticity, grey and orange brown.	MC>PL	–	–	APPEARS POORLY COMPACTED
					N = 11 2,4,7	1		CL	SILTY CLAY: medium plasticity, mottled pale grey and orange brown, with a trace of fine to medium grained ironstone gravel and sand.	MC>PL	VSt	–	–
						2		CL	SHALY CLAY: medium plasticity, pale grey with orange mottling and occasional iron indurated bands.	MC<PL	H		
				■	N = 32 5,12,20	3						>600 >600 >600	
				■		4		–	SHALE: dark grey and brown, with occasional iron indurated bands.	DW	L	–	LOW 'TC' BIT RESISTANCE
						5			SHALE: dark grey, with occasional thin interbedded fine grained sandstone bands.		L–M		LOW TO MODERATE RESISTANCE HOLE COLLAPSED TO 5.2m AFTER 2 HOURS
				■									
						6			END OF BOREHOLE AT 6.0m				
						7							

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BOREHOLE LOG

Borehole No.
20
1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 1-6-98
Method: SPIRAL AUGER BCD 350
Logged/Checked by: S.E.
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0			FILL: Silty sandy gravel, fine to coarse grained igneous gravel, fine to medium grained sand, dark grey.	M			APPEARS WELL COMPACTED
▼ AFTER 1 HR				■	N = 25 5,20,5				as above, but fine to medium grained igneosu gravel, with a trace of timber pieces.				STRONG ODOUR TO 1.0m
						1		CL	SHALY CLAY: medium plasticity, pale grey to grey, with iron indurated bands.	MC<PL	H	–	HOLE COLLAPSED TO 0.9m AFTER 1 HOUR
				■	N > 30 13,17	2						>600 >600 >600	
				■	N > 35 15,20	3		–	SHALE: grey, dark grey and orange brown, with a trace of clay bands.	XW	EL	>600 >600	–
						4			SHALE: dark grey.	DW	VL–L		LOW 'TC' BIT RESISTANCE
				■		5			SHALE: dark grey with interbedded fine grained sandstone, brown.		L–M		LOW TO MODERATE RESISTANCE
				■		6			END OF BOREHOLE AT 6.0m				
						7							

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TEST PIT LOG

Test Pit No. 101 1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Date: 27-5-98
Method: KOMATSU PC45
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION						0	▩		FILL: Silty sandy gravel, fine to medium grained igneous gravel, brown, with fine rootlites.	M			
							▤	–	FILL: Slag gravel, fine to medium grained, grey, with a trace of coarse grained sandstone gravel.	DW	VL	–	APPEARS WELL COMPACTED
											L–M		–
						1			SHALE: grey, with extremely weathered bands, and iron indurated bands, fragmented.				
									END OF TEST PIT AT 0.8m				
						2							
						3							
						4							
						5							
						6							
						7							

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TEST PIT LOG

Test Pit No.
102 1/1

Client:
Project: PROPOSED DEVELOPMENT
Location: EVELEIGH RAIL YARDS

Job No. 13447S
Method: KOMATSU PC45
R.L. Surface: N/A
Date: 27-5-98
Datum:
Logged/Checked by: S.E./

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
DRY ON COMPLETION						0	▨		FILL: Silty sandy gravel, fine to medium grained slag, dark grey, with a trace of timber pieces and coarse grained sandstone gravel.	M			APPEARS WELL COMPACTED
							≡	–	SHALE: grey and brown.	DW	L	–	–
									END OF TEST PIT AT 0.6m				
						1							
						2							
						3							
						4							
						5							
						6							
						7							

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TEST PIT LOG

Test Pit No. 103 1/1

Client:

Project: PROPOSED DEVELOPMENT

Location: EVELEIGH RAIL YARDS

Job No. 13447S

Date: 27-5-98

Method: KOMATSU PC45

R.L. Surface: N/A

Datum:

Logged/Checked by: S.E./

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
DRY ON COMPLETION						0			FILL: Silty sandy gravel, fine to medium grained igneous gravel, grey.	M			APPEARS WELL COMPACTED
								CH	FILL: Silty sandy gravel, fine to medium grained slag, dark grey, with a trace of coarse grained sandstone gravel and timber pieces.	MC>PL	H	500 500 >600 >600	VERY MOIST AT 0.3m
						1			SILTY CLAY: high plasticity, pale grey, with a trace of indurated bands.				–
								–	INTERBEDDED SHALE AND SILTY CLAY: grey and pale grey.	XW MC>PL	EL/H		
									END OF TEST PIT AT 1.2m				
						2							
						3							
						4							
						5							
						6							
						7							

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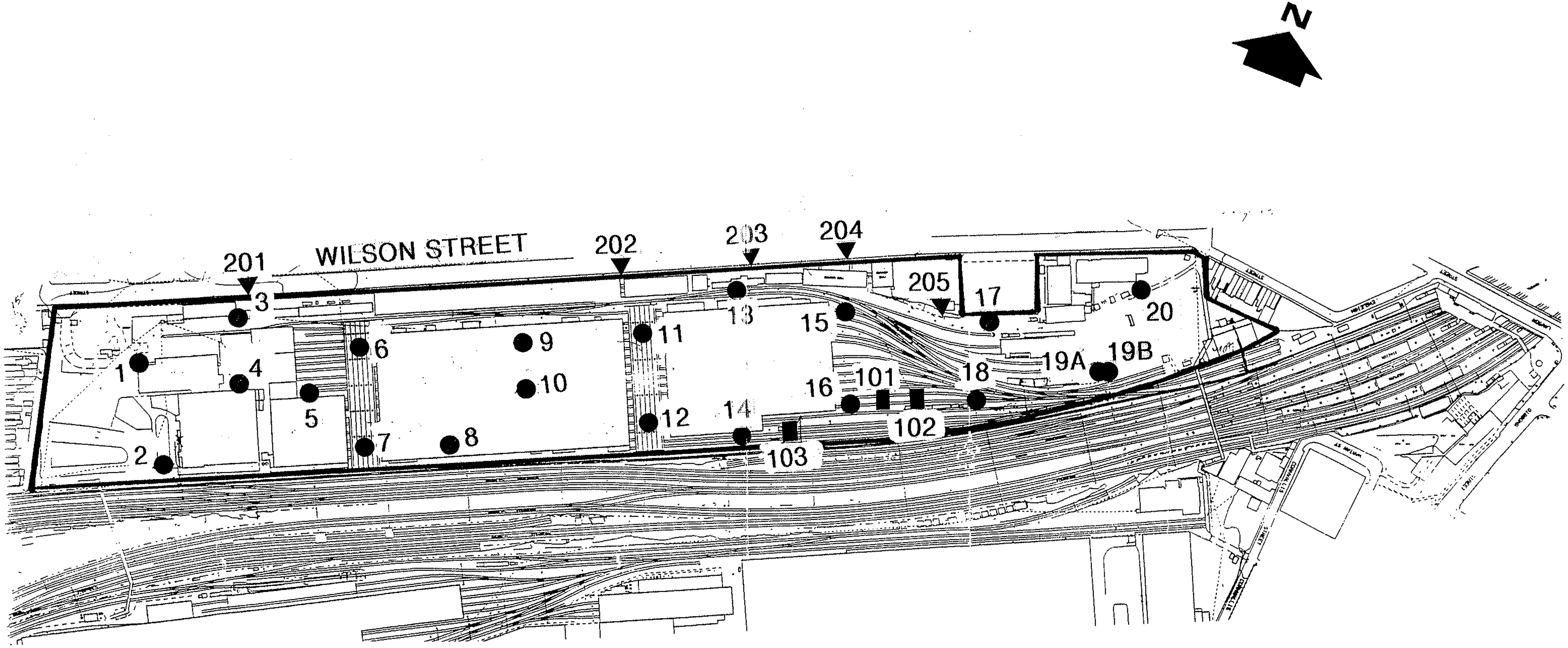

LEGEND

● BOREHOLE LOCATION

■ TESTPIT LOCATION

▼ BATTERED SLOPES LOGGED

SCALE

0 150m

BOREHOLE AND TESTPIT LOCATION PLAN

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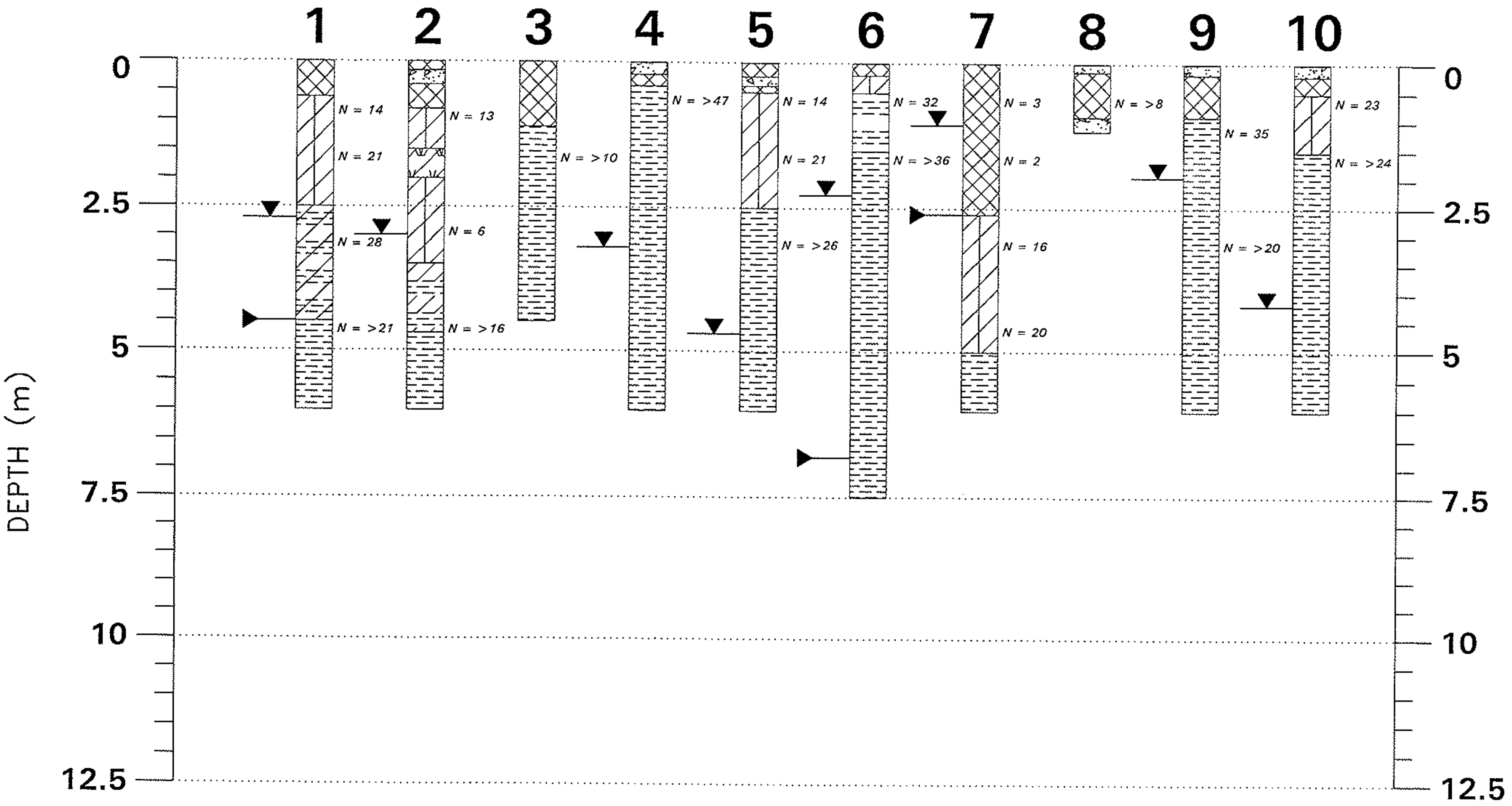
Report No. 13447S Figure No. 1

GRAPHICAL BOREHOLE SUMMARY



Strata symbols

▨	FILL	▨	SHALY CLAY
▨	SILTY CLAY	▤	SHALE
		▒	CONCRETE
▨	PEATY CLAY	▤	INTERBEDDED SHALE AND CLAY
▤	SHALE FRACTION		

Misc. Symbols

▼	Standing water level
▶	Groundwater seepage level

ABBREVIATIONS

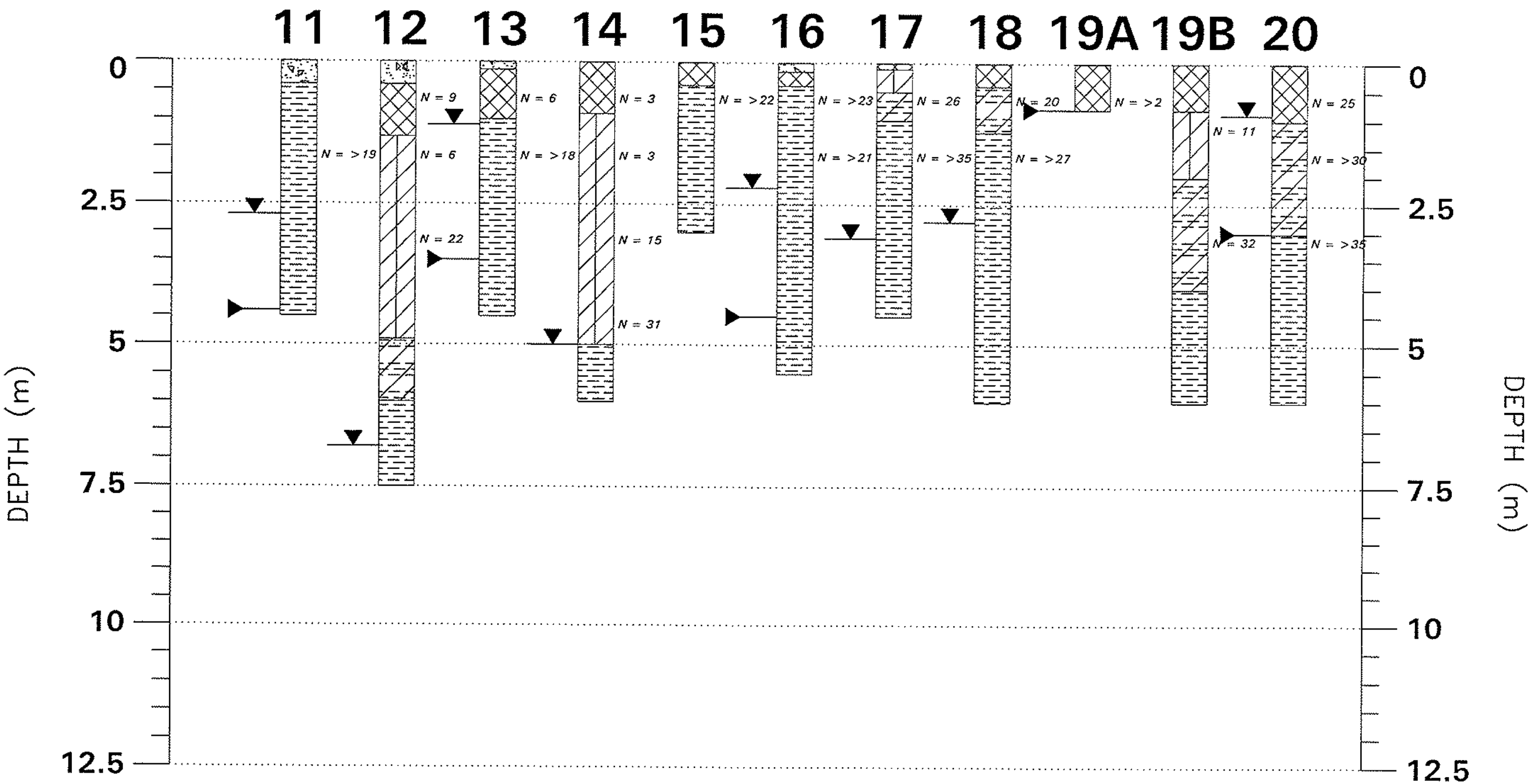
N	SPT "N" VALUE
Nc	SOLID CONE BLOW COUNTS PER 150mm

Scale: 1 : 100 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 13447S **Figure No.:** 2A

GRAPHICAL BOREHOLE SUMMARY



Strata symbols

CONCRETE

SHALE

FILL

SILTY CLAY

SHALY CLAY

Misc. Symbols

▼ Standing water level

► Groundwater seepage level

ABBREVIATIONS

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

Scale: 1 : 100 (vert) ; NTS (horiz)

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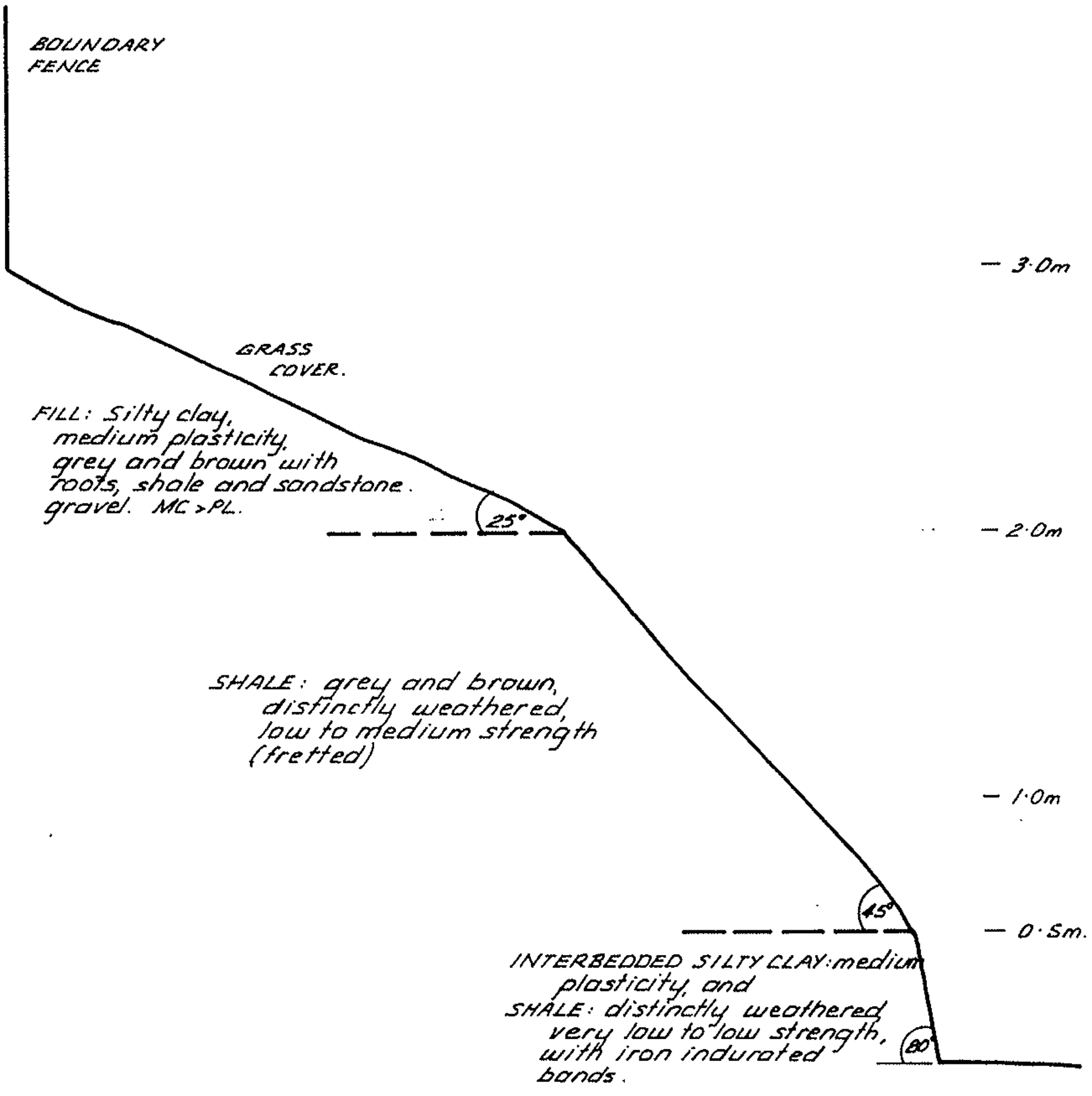
Job No.: 13447S Figure No.: 2B

LOCATION 201



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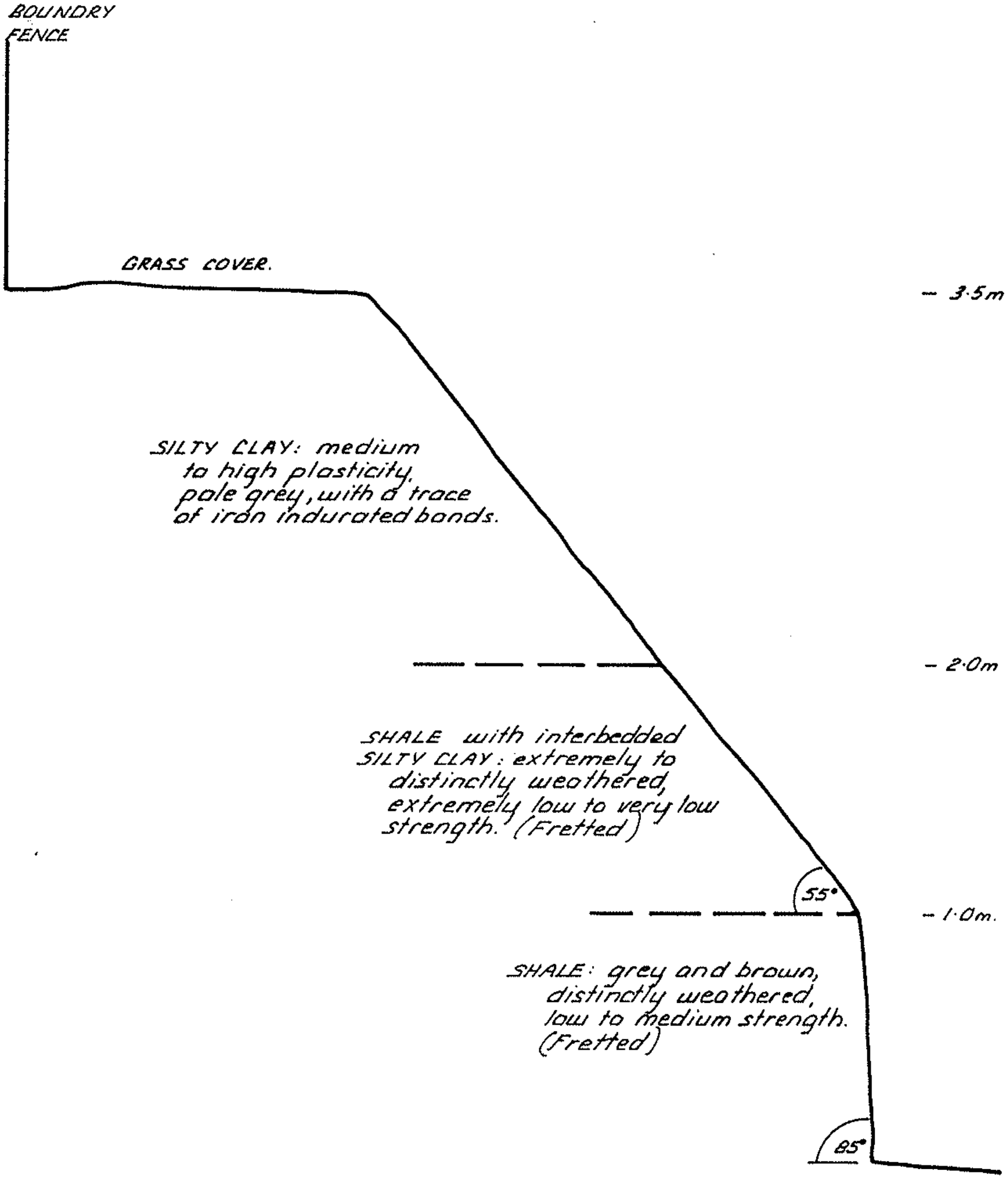
Report No. 13447S Figure No. 3

LOCATION 202



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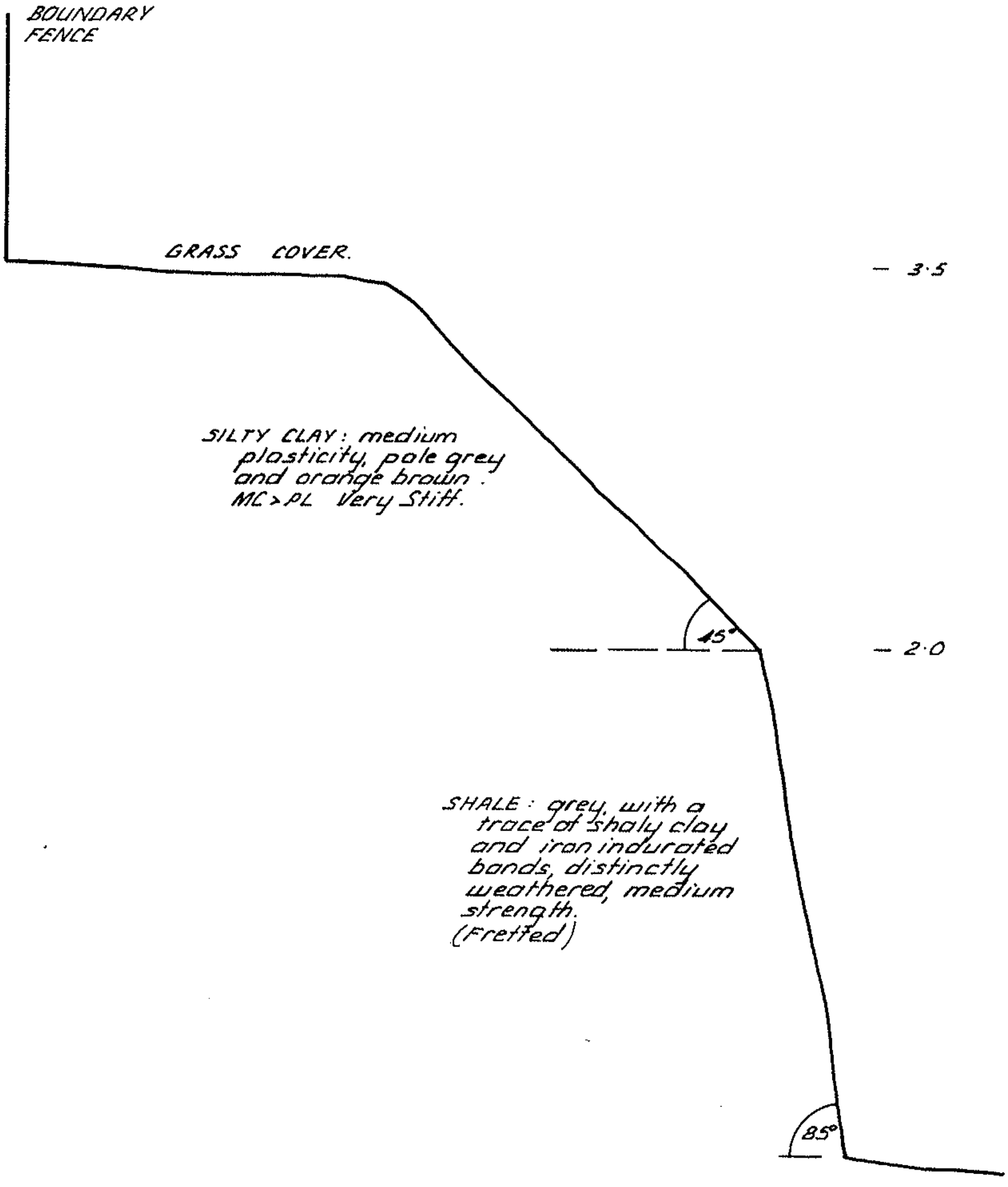
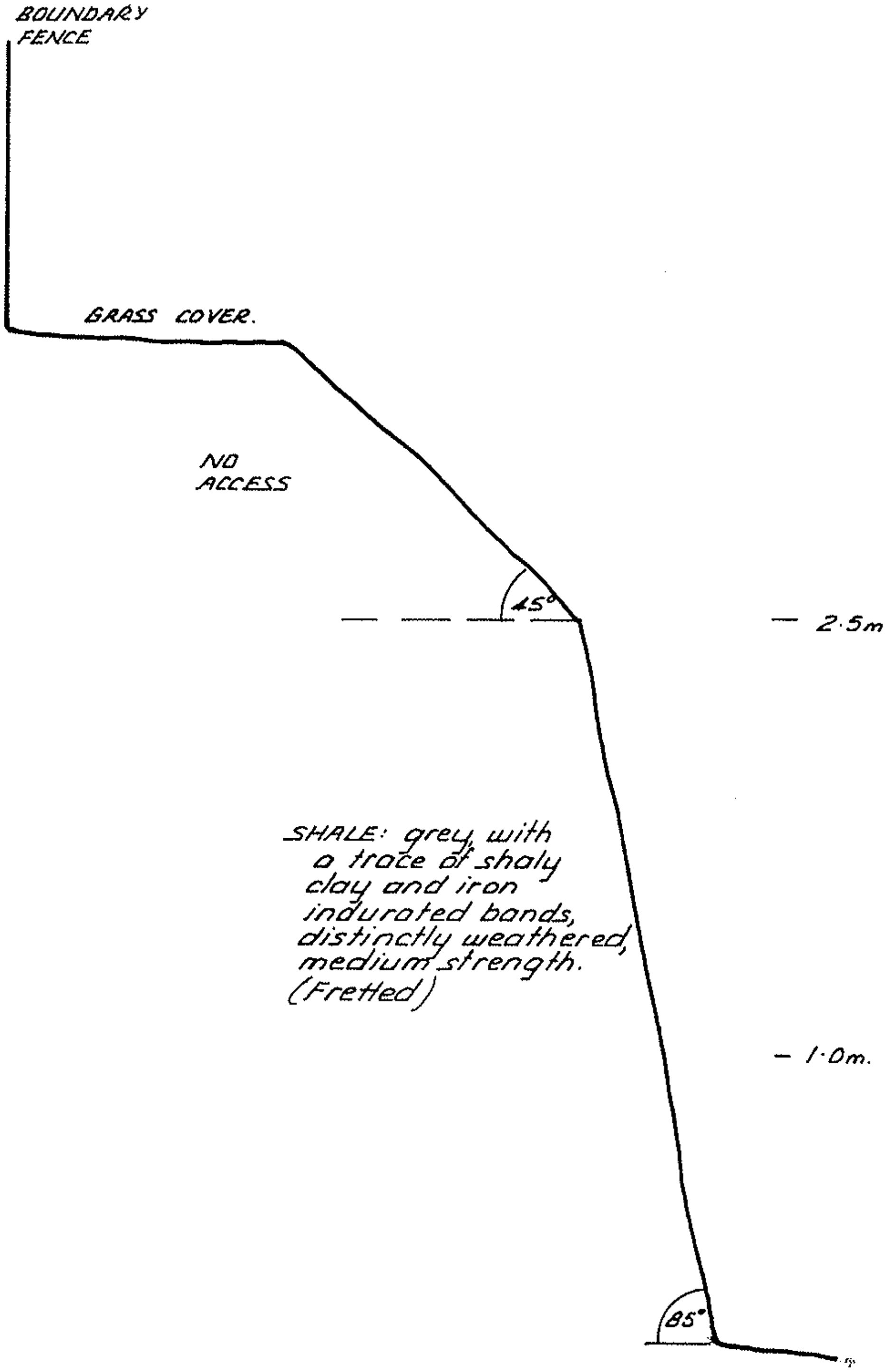
Report No. 13447S Figure No. 4

LOCATION 203



LOCATION 204



NOTE: PARTIAL COLLAPSE OF SHALE ALONG SURROUNDING SLOPE

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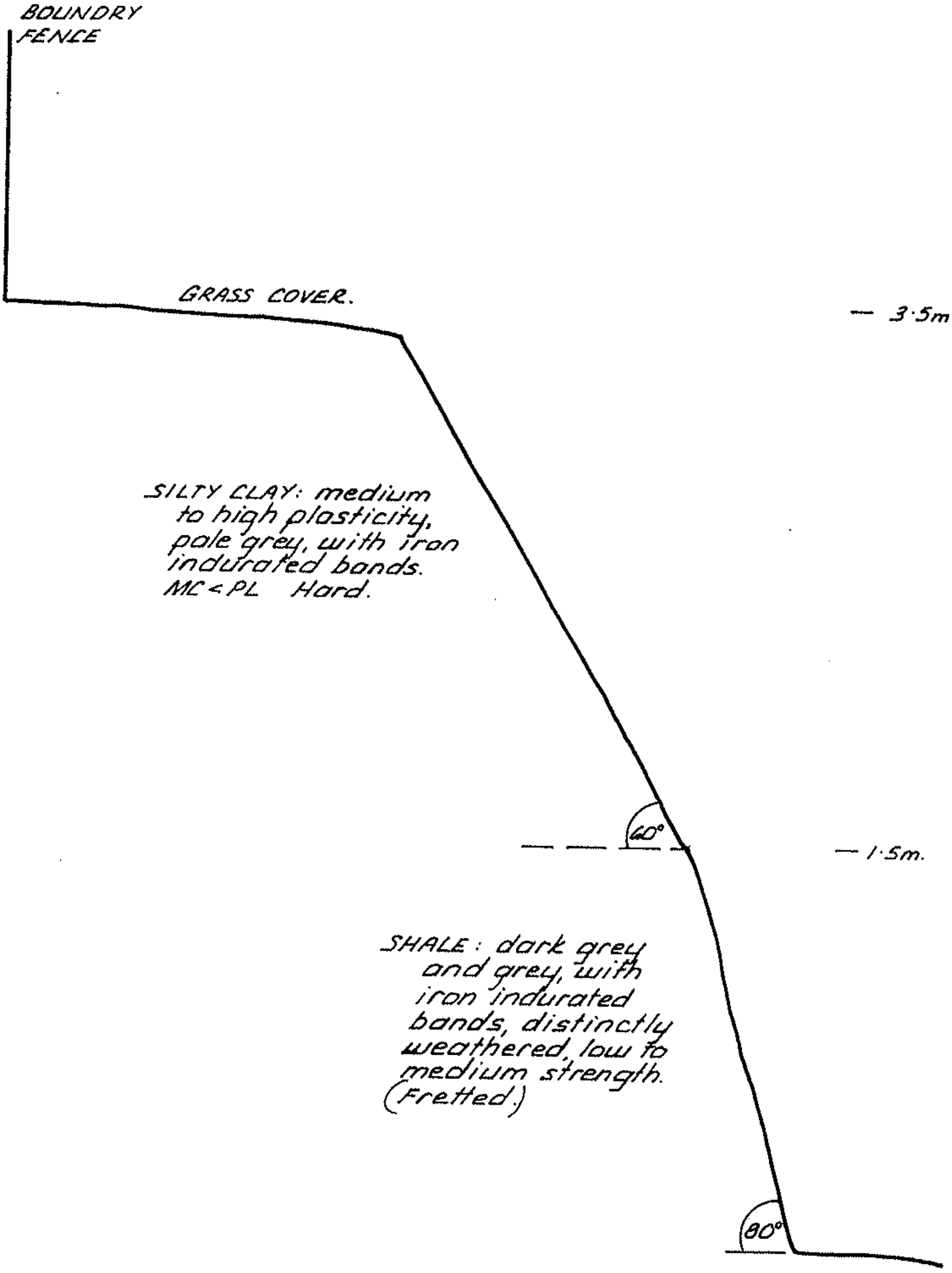
Report No. 13447S Figure No. 6

LOCATION 205



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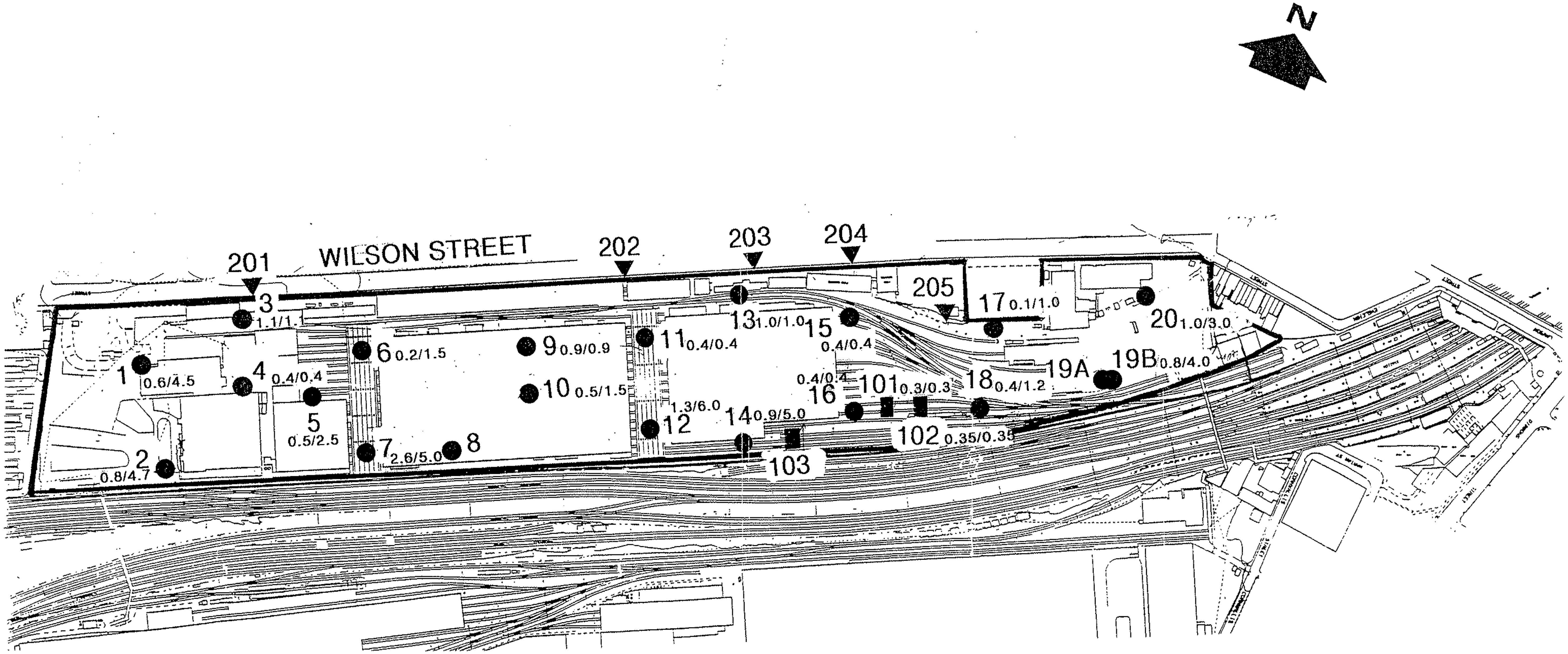
Report No. 13447S Figure No. 7



LEGEND

● BOREHOLE LOCATION

▮ TESTPIT LOCATION

▼ BATTERED SLOPES LOGGED

Note: ● 9 0.9/0.9: Depth of fill(m)/Depth to bedrock(m)

SCALE

0 ▬ ▬ ▬ ▬ ▬ 150m

BOREHOLE AND TEST PIT LOCATION PLAN
SHOWING DEPTHS OF FILL AND BEDROCK

Jeffery and Katauskas Pty Ltd
Report No. 13447S Figure No. 8

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
ABN 17 003 550 801

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 (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 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 subsurface 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.

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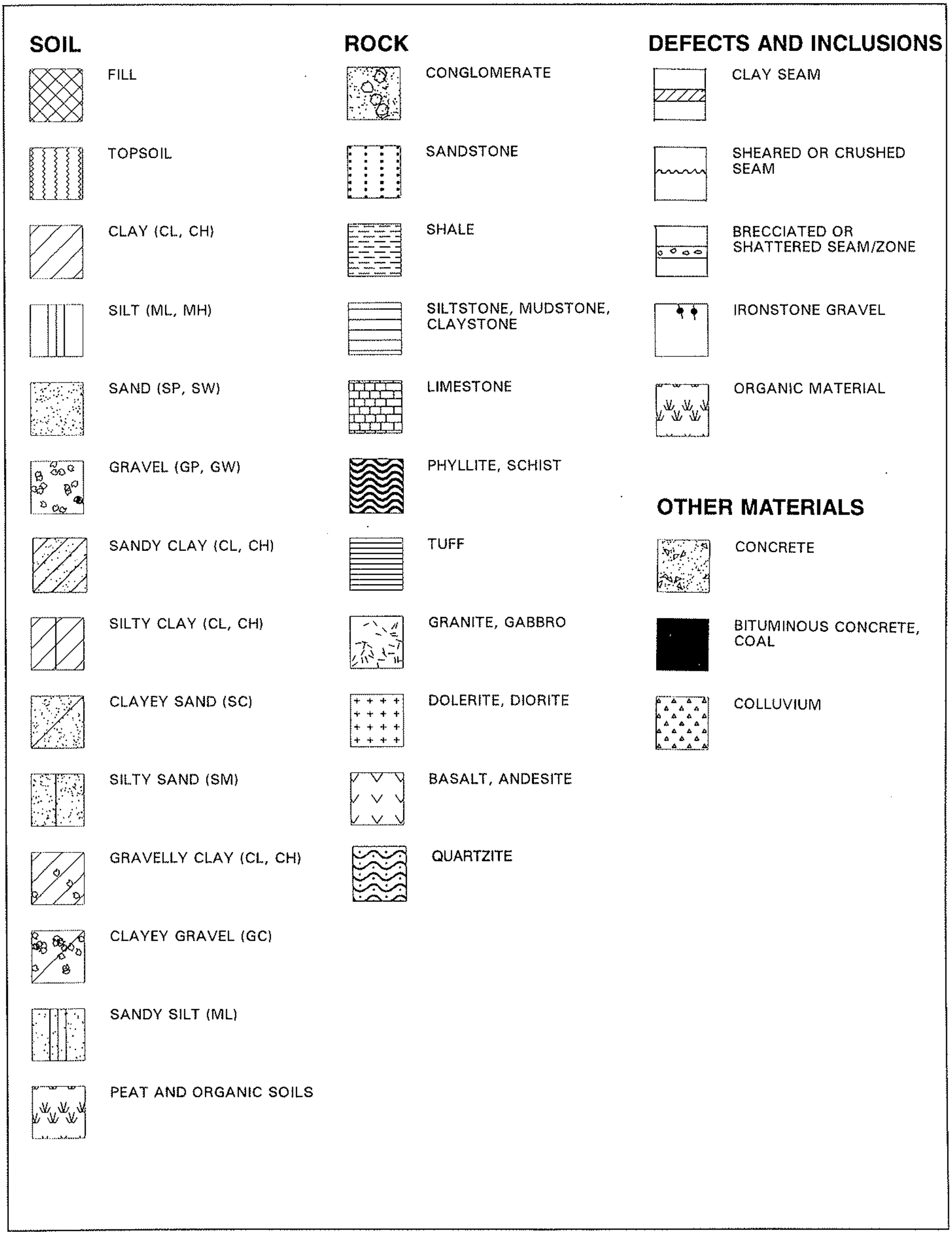
GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS



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

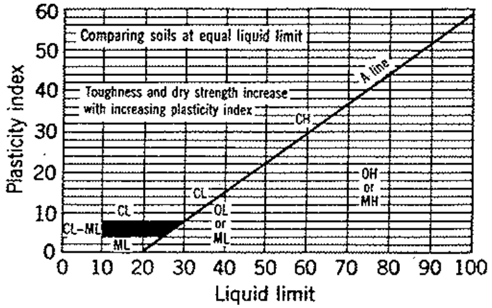
DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

UNIFIED SOIL CLASSIFICATION TABLE

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	
			Predominantly one size or a range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines				Not meeting all gradation requirements for *GW*	
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures				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
			Plastic fines (for identification procedures, see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures				Atterberg limits above "A" line, with *PI* greater than 7	
	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				$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines				Not meeting all gradation requirements for *SW*	
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures				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
			Plastic fines (for identification procedures, see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures				Atterberg limits below "A" line with *PI* greater than 7	
Fine-grained soils More than half of material is *smaller* than 75 µm sieve size	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*)		 Plasticity chart for laboratory classification of fine grained soils		
			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					

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. 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.

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LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION		
Groundwater Record	—τ—	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.		

Ref: Standard Sheets/Log Symbols
November 2007

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LOG SYMBOLS

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	

Ref: Standard Sheets/Log Symbols
November 2007