REPORT TO

DEPARTMENT OF EDUCATION

ON

FURTHER GEOTECHNICAL INVESTIGATION

FOR

NORTHERN RIVERS FLOOD RECOVERY -
RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT

AT

163 – 170 ALEXANDRA PARADE,
NORTH LISMORE, NSW

Date: 16 July 2025
Ref: 37635UORrpt

JKGeotechnics

www.jkgeotechnics.com.au

T: +61 7 3012 6339
JK Geotechnics Pty Ltd
ABN 17 003 550 801

dlcs ISO 9001 certified ISO 45001 certified ISO 14001 certified

Report prepared by:

Paul Roberts CP Eng
Principal | Engineering Geologist

Report reviewed by:

Ignacio Ortega CP Eng
Principal | Geotechnical Engineer

For and on behalf of
JK GEOTECHNICS
PO Box 503,
Cooroy, QLD, 4563

Head Office
PO BOX 976
NORTH RYDE BC NSW 1670

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ATTACHMENTS

1 INTRODUCTION

This Geotechnical Investigation Report has been prepared to support a Review of Environmental Factors (REF) for the rebuild of Richmond River High Campus (the activity) (RRHC). The REF has been prepared to support an approval for the RRHC development under Section 68 of the NSW Reconstruction Authority Act 2022 (RA Act).

The purpose of this report is to present the results of a further geotechnical investigation (supplementary to two previous investigations carried out by JK Geotechnics [JKG] in 2024) for the activity at 163 & 170 Alexandra Parade, North Lismore, NSW. The location of the site is shown in Figure 1.

The site is located at Dunoon Road, North Lismore, also known as 163 and 170 Alexandra Parade, North Lismore. The site comprises three separate lots, located to the north of Alexandra Parade, with Dunoon Road running parallel to the eastern boundary of the site.

The site is legally described as:

- Lot 1 DP 539012
- Lot 2 DP 539012
- Lot 1 DP 376007

The site area is approximately 33.53 hectares, and is outlined in Plante 1. The proposed activity will be undertaken mainly within the southeastern portion of the site.

Plate 1 Aerial image of site (Source: Nearmap)

The proposed activity comprises the relocation and rebuild of the Richmond River High Campus from its existing temporary location alongside The Rivers Secondary College Lismore High Campus at East Lismore, to the site at 163 and 170 Alexandra Parade, North Lismore.

The school will be delivered in one stage. A description of the proposed development is as follows:

1. Demolition of existing features including existing buildings, cattle drinking well, cattle sheds, and wire fencing, and removal of trees to accommodate school development.
2. Construction of new 3 storey buildings on the southeastern portion of the site for the proposed public secondary school including:
   a. General and Specialist Learning Spaces, and Workshops.
   b. Administration, and Staff facilities.
   c. Library, Hall, and Movement Studio.
   d. Construction, Hospitality, and Agricultural Learning Facilities.
   e. Amenity, Plant, Circulation, and Storage areas.
   f. Outdoor Learning Spaces and play spaces.
3. Landscaping including tree planting.
4. Public domain works comprising:
   - Access road off Dunoon Road, comprising a separate shared bicycle/pedestrian pathway, and internal access roundabout.
   - Kiss and ride drop-off and pick up zones.
   - Bus transport arrangements with a separate bus zone.
5. Outdoor spaces including assembly zones, agricultural spaces, sports fields, games courts, dancing circles, yarning and dancing circles, seating and shade structures.
6. On-site carparking, including accessible spaces and provision for EV charging spaces.

Plate 2 below show the scope of works.

Plate 2 Overall Site Context Plan (Source: EJE Architecture)

2 COMMISSION

The geotechnical investigation has been carried out by JKG, commissioned to that purpose by School Infrastructure NSW (SINSW), on behalf of the Department of Education, by executed Part D – Standard Form Agreement signed by SINSW on 17 April 2025 and signed by JKG on 22 April 2025. The commission was on the basis of our proposal P70994UOR2, dated 11 April 2025, which was prepared based on the requirements of the document 'School Infrastructure Request for Tender, Richmond River High Campus (Flood Recovery), Further Geotechnical Investigations' (Ref. SI-07702/25), referred to hereon as the RFT.

3 BACKGROUND

JKG previously completed a geotechnical desk top assessment report (Ref. 36313BTrpt) dated 18 December 2023 (referred to hereon as JKG 2023), and carried out two previous geotechnical investigations at the site in late 2024. The results of the previous geotechnical investigations and geotechnical advice on the previous proposed form of the project are presented in the following geotechnical reports:

- Preliminary geotechnical report (Ref. 36314LTrpt) dated 29 November 2024 (referred to hereon as JKG 2024); and
- Additional geotechnical investigation report (Ref. 36314LT2let) dated 10 January 2025 (referred to hereon as JKG 2025).

Following issue of our JKG 2025 report, the RRHC development was re-located to the south-eastern portion of the site. The details of the proposed RRHC development are presented in Section 4.

Prior to commencement of the JKG geotechnical investigations, and on behalf of SINSW, JKG engaged GB Geotechnics (Australia) Pty Ltd (GBG) to complete a geophysical survey of the proposed RRHC development site. The scope of the geophysical survey was agreed between JKG and SINSW.

The purpose of this geotechnical investigation was to obtain further geotechnical information on the subsurface conditions over the south-eastern portion of the site, and to use this as a basis for providing comments and recommendations on site stability, site classification, earthworks, footings and pavement design. This report consolidates the information from all the JKG investigations and the previous JKG reports, in order to provide a standalone report for the proposed RRHC development. For details of the procedures adopted for the desk top study and geotechnical investigations completed in 2024, reference should be made to our previous reports: JKG2023, JKG2024 and JKG2025.

Our environmental division, JK Environments (JKE) has also carried out an environmental site assessment. Reference should be made to the separate report by JKE, Ref: EE36314PT3rpt2-SI, for the results of the environmental site assessment.

4 PROPOSED DEVELOPMENT

A description of the proposed RHHC development was presented in Section 1. From a geotechnical perspective, the following aspects of the proposed RRHC development are pertinent with regard to the geotechnical advice presented in this report:

- Demolition of existing structures and removal of trees.
- Construction of new buildings and structures, Outdoor Learning Spaces, play spaces.
- Landscaping, including tree planting.
- Public domain works including the access road off Dunoon Road and comprising a separate shared bicycle/pedestrian pathway, internal access roundabout, Kiss and ride drop-off and pick up zones and separate bus zone.
- Outdoor spaces, including assembly zones, agricultural spaces, sports fields, games courts, dancing circles, yarning and dancing circles, seating and shade structures.
- On-site carparking.

We have been provided with the following additional information:

- A bulk earthworks sketch plan (Drawing Number SKC20250618.01, dated 18 June 2025) prepared by TTW.
- A series of sections through the proposed development area and one along the alignment of the proposed access road dated 19 June 2025 and prepared by TTW. The sections were prepared at locations requested by JKG.

A review of the provided information indicates that, in order to achieve the proposed floor level at RL17.45 m for the main buildings, cut and fill earthworks will be required. Excavation will generally be limited for the main buildings, although will locally extend down a maximum of approximately 3.0 m. Filling up to a maximum of approximately 2.0 m is proposed within the main building areas. Cut and fill earthworks are also proposed for the main access road on the western side of the main buildings, with maximum extents of 3.0 m (cut) and 1.3 m (fill). The initial approximately 100 m length of the access road from the Alexandra Parade frontage will require the majority of the fill earthworks, and the northern portion of the access road, from approximate chainage 310 m to chainage 459 m (the northern end of the access road), will require the majority of the cut earthworks. Within the eastern and south-eastern portions of the site, the depth of cut and of fill will be less than approximately 1.0 m and 1.5 m, respectively. Two OSD tank excavations are proposed immediately downslope of Buildings B and C, and have been estimated to extend a further 2 m below the design surface level of the proposed buildings.

Structural loads and have not been provided. As such, typical loads for this type of development have been assumed in our analysis.

5 INVESTIGATION PROCEDURE

The fieldwork for the investigation was carried out in three stages:

- Stage 1- geophysical survey completed by GBG on 8 and 9 April 2025;
- Stage 2 –a walkover inspection and test pit investigation carried out between 15 and 22 May 2025, which also included set out of the proposed investigation locations and directing a buried services scan prior to commencing the test pit investigation; and
- Stage 3 – an investigation comprising cored boreholes carried out between 27 May and 5 June 2025.

Further details of the methods and procedures employed in the geotechnical investigations, and their limitations, are presented in the attached Report Explanation Notes.

Details of the three stages of investigation are provided below.

5.1 Stage 1 Geophysical Survey

GBG completed a geophysical investigation at the site which used Seismic Refraction (SR) techniques. Six SR lines were completed at the locations indicated on Plate 3.

Plate 3 Location of SR Lines (Source: GBG Report dated June 2025, see Appendix A)

The locations of the SR lines were agreed between JKG and CBG before site works commenced. However, some minor re-location of the SR lines was discussed on site between GBG and a representative of SINSW, due to obstacles along the original alignment of the SR lines. The SR extended to depths between approximately 10 m and 25 m below existing surface levels.

Further details of the geophysical survey, the methodologies adopted and their limitations are outlined in the GBG report (Ref. GBGA2804 Rev. 1) dated 25 June 2025 and attached in Appendix A.

5.2 Stage 2 Walkover Inspection, Test Pit Investigation and Set Out of Investigation Locations

A Principal Engineering Geologist completed a walkover inspection of the southern portion of the site. The purpose of the walkover inspection was to gain an appreciation of the topographic setting of this portion of the site in relation to the previous walkover inspections to the north. The principal aim was to check for any obvious signs of slope instability on the hillside to the west of the development area, and on the hillside slopes over the south-eastern portion of the site, within the development area.

Following the walkover inspection, thirteen test pits (TP201 to TP205, TP207 to TP210 and TP215 to TP218) using a 20 tonne tracked excavator and a 1.1 m wide bucket, were carried out to a maximum depth of 4.7 m below existing surface level. The test pits were terminated at either the maximum reach of the excavator, the refusal of the excavator bucket on competent bedrock, or where the pit sides collapsed. The test pits were excavated under the full time direction of our Senior Geotechnical Engineer, and with our Principal Engineering Geologist present on site for the initial stages of the test pit investigation, on 19 and 20 May 2025.

The test pit and cored borehole locations, as shown on the attached Figure 2, and relevant portions of archaeological exclusion zones in close proximity to the investigation locations (provided by GML – the archaeological heritage consultant) were set out using coordinates input into the portable DGPS rover prior to our site visit. The reduced levels (RLs) at the test pit and borehole locations were also recorded using the portable DGPS rover. We note that the DGPS rover typically has an accuracy of ±20 mm.

The consistency of the encountered cohesive soil was assessed from hand penetrometer readings taken in the sides and bases of the test pit (to a maximum depth of 1.1 m) and then on recovered bucket samples. The sides and bases of the test pits and the recovered bucket samples were also inspected for indications of shear planes and fissuring in order to assist with our assessment of the lateral extent and depth of any landslide movements that have impacted the subsurface profile. The strength of the bedrock exposed in the test pits was assessed by ease of excavation, tactile assessment of the exposed bedrock and recovered bedrock samples and probing with a geopick. The estimation of rock strength in this way is approximate, and variations of about one order of strength should not be unexpected.

Groundwater observations were made in the test pits during and on completion of the excavations.

Our Senior Geotechnical Engineer logged the encountered subsurface profile and prepared cross sectional sketches of the test pits. The test pit cross sectional sketches (which include field test results and groundwater observations), are presented on the attached Figures 3 to 14, together with a glossary of logging terms and symbols used.

5.3 Stage 3 Cored Borehole Investigation

The fieldwork for Stage 3 comprised six boreholes (namely, BH206, BH211, BH212, BH213, BH214 and BH218). We note that due to encountering an archaeological heritage artifact in test pit TP207, the positions of the proposed boreholes were reviewed. As a result, BH215 was relocated to within the footprint of TP206, and the designation of this borehole was changed to BH206. In addition, on the advice of GML and at the location of BH213, an archaeological test pit was excavated using a 5 tonne tracked excavator to 0.4 m, and then backfilled with sand, prior to commencing BH213.

The boreholes were auger drilled using our track mounted JK300 and JK309 drill rigs, to depths between 1.9 m (BH206) and 13.95 m (BH214). The boreholes were then extended, using NMLC diamond coring techniques and water flush, to final depths between 14.32 m (BH213) and 16.9 m (BH214).

Groundwater monitoring wells (GMWs) were installed in BH206, BH212 and BH214, for the purpose of longer term groundwater monitoring and screening by JKE. The GWM at BH214 was installed in a separate borehole, open hole drilled, and immediately adjacent to the cored borehole. The GMWs were installed to depths of 5.7 m (BH206), 6.0 m (BH212) and 6.3 m (BH214). For further details on the GMW installations, reference should be made to the respective borehole log.

The relative density of the natural granular soils and the consistency of the natural clays were assessed from the Standard Penetration Test (SPT) 'N' values, augmented with hand penetrometer test results on cohesive soil samples, recovered either from the SPT split spoon sampler. Undisturbed 50 mm diameter tube samples were recovered in the cohesive materials where possible. In some instances, the presence of gravels in the clays prevented tube samples been recovered.

The strength of the upper portion of the bedrock was assessed from observation of drilling resistance when using a tungsten carbide ('TC') bit and from examination of the recovered rock cuttings. The estimation of rock strength in this way is approximate, and variations of about one order of strength should not be unexpected. The strength of the bedrock within the cored portions of the boreholes were estimated based on examination of the recovered rock core, and based on the results of subsequent laboratory Point Load Strength Index ($I_{S(50)}$) tests.

Groundwater observations were made in the boreholes during and on completion of auger drilling, and on completion of core drilling. However, the water flush introduced during core drilling masks any meaningful groundwater readings. No longer term ground monitoring has been carried out to date.

Our geotechnical engineers Cody Surawski and Andrew Griffiths, and our engineering geologist Keagen Rousseau, were present full-time during the fieldwork, and logged the encountered subsurface profile, nominated the in-situ testing and sampling and directed the installation of the GMWs. The borehole logs (which include field test results, point load strength index results and groundwater observations) are attached, together with a glossary of logging terms and symbols used.

5.4 Laboratory Soil and Rock Test Schedules

Selected soil samples from the boreholes and test pits were returned to the Coffey Testing Pty Ltd (CTPL) and Soil Test Services Pty Ltd (STS) NATA accredited laboratories for moisture content, Atterberg Limits and linear shrinkage, shrink-swell index and CBR testing. The results of these laboratory tests are presented on the attached CTPL reports and STS Tables A, B and C **(TBC)**.

Selected soil samples were also returned to an alternate NATA registered analytical laboratory (EnviroLab Services Pty Ltd) for soil pH, chloride content, sulfate content and resistivity testing. The test results are summarised in the attached Envirolab Services 'Certificate of Analysis' 382702.

The recovered rock core was returned to the JKG Brendale and Sydney offices, where it was photographed and Point Load Strength Index Tests completed. Using established correlations, the Unconfined Compressive Strength (UCS) of the bedrock was then calculated from the $Is_{(50)}$ results. These Point Load Strength test results and estimated UCSs are summarised in the attached Table A, and on the cored borehole logs. The core photographs are included with the relevant cored borehole log.

6 RESULTS OF THE INVESTIGATION

We provide below a summary of the pertinent sections of the previous desk top study (JKG 2023), of the relevant site observations from the 2024 investigations, of the site observations from the current investigation, and of the subsurface conditions encountered in both the current investigation and the relevant investigation locations from the 2024 investigations.

6.1 Site History

From a review of the historical aerial imagery obtained by JKE, a selection of which is attached as Appendix A in JKG2024, the site appears to have comprised grazing farmland in the 1942 image, with two residences present, one each at 163 and 170 Alexandra Parade. These buildings appear to be the same houses as those currently present within the site. Several small buildings are also visible within the properties. Within this image, indications of instability of the hillslope are present in the north-western and south-western corners of the site, in the form of 'hummocky' ground. The site is largely clear of mature vegetation in the 1942 image, and it is anticipated that slope instability will have been exacerbated by clearing of native vegetation in the decades prior to this image. We understand, from discussions on site with the former landowner at No. 163, that 'land sliding' also occurred in the north-western corner of the site in the 1960s.

Dams, which are present within the site, appear in the images between 1979 and 1987, and are located towards the head of the north-western gully and near the residence at 170 Alexandra Parade. Vegetation regrowth is present within the various images between 1942 and 2023, located either side of the western boundary. Apart from vegetation regrowth, dam construction, and service installation, the site appears to have remained relatively unchanged since 1942.

From Google Street View imagery, in 2015 a buried service appears to have been installed within the site, adjacent and roughly parallel to the eastern site boundary. We understand, from discussion with the former landowner at No. 163, that the sewer main has been installed within a trench several metres deep.

Within the properties to the north, vegetation clearing and earthworks appear to have been commenced in the 2020 image, with large areas of exposed soil present within that image. However, these areas appear to have been revegetated in the 2023 image, indicating a cessation in the development.

6.2 Land Classification Mapping

We understand from the 1:100,000 Lismore-Casino Land Classification plan, prepared by Chestnut (1980), that the site is mapped to be underlain by areas classified as Classes IV, IVB and I, from the eastern side of the site to the west, respectively. The majority of the site is mapped as Class I.

The commentary for the mapping states that areas mapped as Class I are considered to have a high risk of slope instability, particularly when disturbed. The high-risk areas on the plan are defined with respect to catastrophic land movement, such as “slump-flow” type landslides, rather than slower moving creep type landslides. We note, however, that although creep slides do not generally pose as high a risk to life, they will still cause ongoing and potentially major damage to structures. The aerial imagery and anecdotal evidence indicate that instability has occurred within at least the north-western corner of the site. It is difficult to assess if the ‘hummocky’ appearance of the ground is due to deposition of debris from a flow slide or from creep movement of the soils, or from other surface disturbance not associated with slope instability. The Class I area broadly aligns with the area mapped to be underlain by basalt bedrock.

Areas mapped as Class IV and IVB are considered to have minimal risk of slope instability, unless extensive earthworks or poor hillside construction practices are carried out. Areas mapped as Class IV are however prone to inundation.

6.3 Site Observations

The site is located at a transition between undulating topography associated with the North Lismore Plateau, comprising rolling hills generally sloping at approximately 5° to 15°, and the relatively level floodplain around Wilsons River and Leycester Creek to the south and south-east.

The site is located on the eastern flank of a north-south orientated ridgeline, with surface levels appearing to generally follow the natural hillside, which slopes down to a relatively level area within the eastern portion of the site. The flank of the ridgeline, within the northern and central portion of the site, is defined by two spurs separated by a gully located within the north-western portion of the site. Surface levels in the western third of the site generally slope down at a maximum of between approximately 20° and 25° over the backslope of the hillside and flatten to approximately 6° on the footslope in the central portion of the site. At the base of the hillside, surface levels appear to flatten to approximately 1° to 2° across the areas associated with the floodplain. There appears to be an approximately 100 m height relief within the site.

The site currently comprises two farms (Nos. 163 and 170 Alexandra Parade) which are, or have been, used for grazing. Each farm contains a residence with several smaller outbuildings also present. The residence at No. 163 is of weatherboard construction with an in-ground rear yard pool, whilst the residence at No. 170 is of brick and weatherboard construction. Both buildings and the pool appear to be in fair external condition.

The site predominantly comprises grassed paddocks with very sparse tree cover in the eastern portion of the site. However, within the steeper, western portion of the site, trees become more numerous. On the surface of the hillside within the western portion of the site, basalt boulders with minimum dimensions of up to 0.5 m are present. A small dam is located in the upper reaches of the gully in the north-western corner of the site. On the eastern side of the dam is an embankment which has a maximum height of approximately 6 m and slopes down at about 25°. On the western side of the dam, excavation into the hillside appears to have exposed basalt bedrock. A second overgrown dam appears to be located north of the residence at No. 170. Towards the eastern site boundary, a number of sewer pit lids, which are anticipated to correlate with the deep sewer main installation discussed in Section 6.1, are present.

North of the site are two lots within which recent earthworks for a proposed development have been carried out. No structures are present within either of these lots. Adjacent to the north-eastern site boundary, a raised earthen platform appears to have been constructed with levels sloping down into the site through a batter on the southern side of the platform.

West of the site, surface levels appear to ascend across the shoulder of the hillside towards the crest of the ridgeline. The land to the west of the site appears undeveloped and is heavily vegetated. Set back approximately 200 m from the western boundary is a deep excavation which is likely to be a former quarry.

The site has frontages with Alexandra Parade and Dunoon Road to the south and east respectively. Dunoon Road is a TfNSW Regional Road.

In addition to the above general observations, the walkover inspections by our Principal Geotechnical Engineer on 10 December 2024 and our Principal Engineering Geologist on 19 May 2025 noted the following additional details:

- The northern end of the site (north of the creek and gully feature) has undergone more recent landslide movement. There were many cobbles and boulders on the surface, and the surface was wet under foot in many areas.
- There were numerous surface indications of slumping and flow slides within the western portion of the site, particularly in the more steeply sloping areas, with dense bushland located immediately upslope. However, the long grass prevented more detailed observations - although flatter sections were evident over the south-western portion of this area of the site. We note that our previous investigations have encountered reasonably shallow bedrock depths over the northern and central sections of this area.

- The farm dam, located on the steep sloping hillside at the western end of the gully feature, comprised an embankment estimated to be about 3 m to 4 m high, and was covered with grass and woody vegetation. An informal spillway was located at the northern abutment. In our opinion, the farm dam is located on an active landslide, as inferred from the above-mentioned surface indications of slumping and flow slides.
- The side slopes of the spur over the central portion of the site typically sloped down to the north, west and south, at approximately 10^{o} from a gently sloping crest area to the relatively flat flood plain below.

However, we note that the grass and vegetation were quite thick during the visits (particularly across the hillside over the western portion of the site), so surface features were difficult to assess.

6.4 Subsurface Conditions

6.4.1 Overview

The NSW Seamless Geology Version 2.4 indicates that site is mapped to be underlain by Tertiary age Lismore Basalt within the western, elevated portion of the site. A channel of Quaternary alluvial and colluvial fan deposits is mapped within the north-eastern portion of the site, and Quaternary alluvial deposits are mapped within the low-lying area within the eastern portion of the site.

The Lismore Basalt forms a portion of the Lamington Volcanics in the southern part of the Tweed Shield Volcano and primarily comprises andesite. However, for ease of understanding for the reader, the term basalt has been used (rather than andesite). The Lismore Basalt also contains icelandite, which is an iron rich form of andesite.

We note that some of the rock descriptions include siltstones and ferricrete. The lava flows forming the Lismore basalt formed over a period of approximately 8 million years. As a result, there were periods where the lava flows were exposed at surface level and were affected by weathering and erosion processes. The localised areas of siltstone and ferricrete encountered in the current investigation are the products of these processes. The siltstone most likely represents flood plan deposits, and the ferricrete represents hard, erosion-resistant layers, that have been cemented into a hardpan (duricrust) by iron oxides that form at or near the land surface, as part of the weathering of the ancient basalt land surface. The iron oxide cements are derived from the oxidation of percolating solutions of iron salts.

The attached Figure 15 presents the approximate bedrock surface contours, based on the results of our investigations.

The western portion of the site, in the more steeply sloping areas, and the southern ridgeline spur, which extends through the proposed development area, were characterised by a reasonably shallow depth to bedrock, with the soil profile comprising colluvial and/or residual sands, gravels and clays.

Towards the toe of the more steeply sloping areas, the depth to bedrock increased sharply and was overlain primarily by alluvial clays with some localised residual soils encountered towards the bedrock surface.

Bedrock was not encountered within the depth of the investigations below the relatively flat eastern end of the site (flood plain area). In this regard, we note that the bedrock surface contains a gully feature that approximately corresponds to the surface gully feature and creek line. Deep alluvial clay deposits were encountered at this location.

In the current investigation the test pits intermittently encountered groundwater seepage in the alluvial clays at moderate depth.

A summary of the geotechnical conditions encountered in the various JKG investigations relevant to the proposed RRHC development is provided in the following sections. However, for a detailed description at each location, reference should be made to the attached test pit cross sectional sketches from the current investigation (Figures 3 to 14), the borehole logs form the current investigation and the borehole logs and test pit cross sectional sketches from our previous investigations presented in Appendix B). The attached geotechnical cross sectional sketches (Figures 18 to 23) provide summaries of the subsurface profile at six locations across the site.

6.4.2 Geotechnical Units

The investigations have identified several geotechnical units within the subsurface profile. We provide in the following a summary of the pertinent features of each of these units.

6.4.2.1 Unit 1 – Topsoil/Fill

Fill was encountered in BH30 and BH61 (JKG 2024), to depths of 0.1 m, comprising silty clay (although it also contained inclusions of ceramic and glass fragments, observed in TP107) and most likely represents disturbed topsoil. In BH211, the fill comprised a surficial 0.1 m thickness of silty clay topsoil fill overlying silty clay, which extended to 0.5 m depth. A 0.2 m thickness of surficial gravel fill was encountered in BH212, and in BH218 the fill comprised a silty gravelly clay. In the remaining boreholes and test pits, topsoil was encountered from the surface to depths ranging from 0.1 m to 0.5 m, though generally the topsoil was 0.1m to 0.3m thick. The topsoil was assessed as comprising high plasticity silty clay with roots and root fibres.

6.4.2.2 Unit 2 – Alluvial Clay

Within the lower, eastern portion of the site, alluvial silty clay assessed as being of high plasticity, was encountered below the topsoil/fill. In general, the consistency of the alluvial clays was stiff becoming very stiff with depth, although in some areas the consistency of the upper portion of the alluvial clays was firm. The alluvial clay contained varying amounts of gravel, cobble and boulder sized inclusions of basalt or ironstone (ferricrete). Root fibres were commonly noted in the alluvial clays and typically extended to depths in the order of 1 m to 1.5 m, although in some instances root fibres were encountered to greater depths.

Alluvial clays were encountered in all test pits except in TP101, TP103, TP105, TP106, TP109, TP110, TP114 and TP115 (excavated for the JKG2025 investigation), and in the current investigation were encountered in TP202, TP203, TP204, TP207, TP208, TP209 and TP216, and in boreholes BH211, BH214 and BH216.

In BH30, BH51 and BH53, slickensided surfaces were observed within the SPT split tube samples, from 0.5-0.95 m (BH30) or 4.5-4.95 m (BH51 and BH53).

In all the test pits where alluvial clays were encountered, sub-horizontal shear planes and sub-vertical fissures were recorded, from depths between 0.2m and 0.8m to the base of the alluvial clays (or, where the test pit was terminated, or collapsed, in the alluvial clays, to the base of the test pit). The shear planes and fissures comprised striated or smooth surfaces, typically undulating and often moist.

In TP102, TP104, TP113, TP119, TP120, TP123, TP203, TP204 and TP208 the test pit sides collapsed at respective depths of 2.5 m, 3.5 m, 4 m, 4 m, 3.4 m, 2.9 m, 3.4 m, 3.2 m and 2.0 m. Where the pit sides collapsed, sub-vertical continuous smooth undulating fissures were exposed in the alluvial clays at the rear of the collapsed area, and the collapse debris contained numerous shear planes and fissures.

6.4.2.3 Unit 3 – Colluvial Soils

In the boreholes, the silty clays on the hillside within the western portion of the site were generally assessed as being colluvial. The test pits also encountered colluvial silty clays, assessed as being of high plasticity, over the western portion of the site in TP103, TP105, TP106, TP110, TP114, TP115, TP201 and TP205. The consistency of the colluvial clays was generally stiff to very stiff, and occasionally firm or hard. The colluvial clays contained varying amounts of gravel, cobble and boulder sized inclusions of basalt and ferricrete (ironstone). In TP206, the colluvial clays were overlying colluvial clayey gravel and in BH212 the colluvial soils comprised gravelly of stiff consistency overlying clayey gravel assessed to be of very dense relative density was underlying the alluvial clays. The colluivial gravels extended to the bedrock surface.

In borehole BH80 (JKG 2024), slickensided surfaces were observed in the colluvial clay within the SPT split tube sample from 1.5-1.95 m.

In TP105, TP106, TP110, TP115, TP117, TP201 and TP205 the colluvial clays contained sub-horizontal shear planes and sub-vertical fissures, recorded from depths between 0.15 m and 0.8 m to the base of the colluvial clays (which corresponded to either the bedrock surface or the interface with the underlying residual soils). The shear planes and fissures comprised striated or smooth surfaces, typically undulating and often moist.

6.4.2.4 Unit 4 – Residual Soils

Residual soils were intermittently encountered over the western and southern portions of the site. In the boreholes, the residual silty clays were assessed as being of high plasticity and generally of very stiff to hard consistency (stiff consistency in BH218). The residual silty clays generally had a high proportion of basalt gravel, and in BH213 the residual soils comprised silty gravelly clay of hard consistency and medium plasticity.

In the test pits, residual soils were only encountered in TP101 (below the topsoil), TP104 (below the alluvial clay), TP106 (below the colluvial clay), TP107 (below the alluvial clay), TP109 (below the topsoil), TP114 (below the colluvial clay), TP115, TP116, TP121 and TP122 (below the alluvial clay), TP202 (below the alluvial clay), TP205 (below the colluvial clay), TP206, TP210 and TP217 (below the topsoil). In TP115, the residual silty clay contained thin bands of weathered siltstone bedrock.

In TP109, the residual soils comprised clayey sands with silty clay bands and contained basalt gravels. In the remaining test pits, the residual soils comprised silty clays assessed as being of high plasticity and of stiff, very stiff or hard consistency, and containing varying amounts of gravel and cobble sized inclusions of basalt.

In TP106, TP107, TP121, TP122, TP202 and TP205, the residual clays below the topsoil, colluvial or alluvial clays contained sub-horizontal shear planes and sub-vertical fissures, which were recorded to the base of the residual clays and corresponded to the bedrock surface. The shear planes and fissures comprised striated or smooth surfaces, typically undulating and often moist.

We note that TP104 collapsed at 3.5 m depth, and whilst shear planes were not recorded in the residual clays below 3m depth, the overlying alluvial clays did contain shear planes the presence of shear planes within the underlying residual clays cannot be discounted.

6.4.2.5 Unit 5 - Bedrock

Weathered bedrock was encountered at shallow to moderate depths in the JKG2024 investigation in BH1, BH3, BH26, BH28, BH51, BH53, BH62, BH71, BH80, BH82, BH85 and BH89, and inferred at TC bit refusal at the base of BH87. For the purposes of this report, the boreholes of relevance are BH51, BH53, BH62, BH71, BH80, BH82, BH85, BH87 and BH89 and the pertinent details are discussed below. For further information on the remaining boreholes, the reader is referred to Section 3.4 of JKG 2024.

All six of the cored boreholes completed from in the current investigation (BH206, BH211, BH212, BH213, BH214 and BH218) encountered bedrock.

In the test pits, weathered bedrock was encountered at shallow to moderate depth in TP101, TP103, TP105, TP106, TP107, TP109, TP110, TP111, TP114, TP115, TP116, TP117, TP118, TP121, TP122, TP201, TP202, TP205, TP206, TP207, TP209, TP210, TP216 and TP217. For the purposes of this report, the test pits from JKG2025 of relevance are TP111, TP114, TP115, TP116, TP117, TP118, TP121 and TP122 and the pertinent details are discussed below. For further information on the remaining test pits, the reader is referred to Section 3.4 of JKG 2024.

The attached Figure 15 presents approximate contours of the bedrock surface, which clearly indicate the presence of the bedrock surface gully feature (orientated approximately east-west). The northern side of the proposed RRHC development site is located on the southern side of the bedrock surface gully feature. From the upper western portion of the site, the bedrock surface slopes down to the east, and at the gully feature slopes down to the south and north-east. The bedrock surface slopes down to the east and south-east around the eastern and southern sides of the spur feature.

The bedrock corresponds to the Lismore Basalt, and whilst the majority of the encountered bedrock comprises basalt, the test pits revealed a slightly more variable bedrock composition that reflects the various periods of lava flows, the nature of the volcanic activity, and intervening periods between volcanic activity where the ancient landform was subjected to weathering and erosion processes.

Weathered basalt was encountered at depths ranging from 0.7 m to 6.0 m below existing surface levels, with the depth generally increasing towards the east. These depths correlate with levels ranging from RL22.0 m to RL8.8 m.

The bedrock profile has been separated into the following sub-units:

- Extremely Weathered Basalt: Hard clay consistency, contains varying amounts of gravel sized basalt inclusions and/or bands of low (or higher) strength basalt, or clayey gravel of very dense relative density.
- Competent Basalt Bedrock: Generally, slightly weathered and of high and very high strength, although some highly to moderately weathered basalt typically of low to medium strength (occasionally very low to low) was also encountered. Often the bedrock contains numerous defects (primarily sub-horizontal to sub-vertical joints).

A summary of the bedrock conditions encountered in each of the boreholes relevant to the proposed RRHC development is tabulated below. Where drilling has terminated on or at shallow depths within the inferred competent basalt bedrock, we have noted that the depth to this stratum has not been proven.

Borehole	Top of Extremely Weathered Basalt		Top of Competent Basalt Bedrock	
	Depth (m)	RL (mAHD)	Depth (m)	RL (mAHD)
51	6.0	13.3	>8.5	<10.8
53	6.0	9.0	12.0	3.0
62	Not encountered	Not encountered	7.0	11.6
71	Not encountered	Not encountered	7.1 Not proven	9.9 Not proven
80	3.0	13.4	>9.7	<6.7
82	3.4	8.8	>9.0	<3.2
85	1.5	20.2	6.9 Not proven	14.8 Not proven
89	0.7	13.0	>4.5	<9.2
206	Not encountered	Not encountered	1.3[1]	16.5[1]
211	1.9	17.3	4.6[2]	14.6[2]
212	5.8[3]	16.4[3]	7.8	14.4
213	Not encountered	Not encountered	1.2[4]	18.4[4]
214	3.3	11.3	13.95	0.65
218	1.3	22.0	3.0	20.3

NOTES:

1. No core zones below 4.15 m and below 12.95 m depth the bedrock comprised a volcanic breccia, highly weathered very low to low strength improving to medium strength with depth. BH206 was terminated in the volcanic breccia.
2. Below 12.35 m depth the bedrock comprised a volcanic breccia, moderately weathered and of medium strength. BH211 was terminated in the volcanic breccia.
3. Below 5.8 m depth the colluvial clayey gravel may represent extremely weathered basalt.
4. From 3.7 m to 5.5 m depth, extremely weathered basalt bands and a no core zone were present.

The cored portions of BH80 and BH82 appear to have extended through the extremely weathered basalt with relatively thick 'no core' or extremely weathered zones encountered with intermittent high to very high strength layers, which are interpreted to comprise core stones.

Within the cored portions of the basalt, defects primarily comprise joints inclined at 0° to 90° and extremely weathered seams. Joints were primarily iron stained with some containing extremely weathered or crushed infill. Extremely weathered seams, which have likely formed along joints in the rock mass, were also encountered in the core and ranged from 1 mm to 440 mm thick.

The "no core" zones encountered in BH53, BH206 and BH213 are inferred to have occurred as a result of washing away of extremely weathered material.

Over the upper north-western portion of the site TP114 and TP117 encountered tuff bedrock, assessed to be highly weathered and of very low or low to medium strength. More competent (medium to high strength) tuff bedrock was inferred based on the bucket refusal at depths of 0.5 m to 1.75 m (TP114) and 2.9 m (TP117).

Over the central portion of the site (corresponding to the northern portion of the proposed RRHC development area), in the relevant test pits from JKG2025, from first contact basalt bedrock was encountered, with the following characteristics:

- In TP111, the basalt was assessed to be extremely weathered and comprised silty clay of hard clay consistency.
- In TP121, on first contact the basalt was assessed to be highly to moderately weathered, and of low to medium strength, improving to moderately to slightly weathered, and to medium to high strength below 3.7 m depth and was highly fractured. The bucket refusal in the test pit was inferred to indicate basalt of at least high strength.

Locally in TP115, TP116, TP118 and TP122, from first contact the bedrock comprised thinly laminated siltstone with ferricrete (ironstone) bands that became more frequent with depth. The bedrock was highly fractured and contained spherical ironstone inclusions, typically of cobble size. The siltstone was typically highly weathered and of very low to low strength, and the ferricrete was typically of medium to high strength. However, due to the highly fractured nature of the rock, the bedrock was readily excavated.

In TP115, TP116, TP118 and TP122, the siltstone and ferricrete was underlain by basalt bedrock assessed to be slightly weathered and of high strength at respective depths of 3.85 m, 4.25 m, 3.7 m and 4.5 m. Bucket refusal was met within a maximum of 0.1 m below the basalt bedrock surface.

A summary of the details of the bedrock encountered in the test pits from the current investigation are as follows:

- In TP201 (south-western portion of the site) basalt bedrock, assessed to be slightly to moderately weathered and high strength, was encountered at the base of the test pit at 0.9 m depth where practical excavator bucket refusal was met.
- In TP205 (south-western portion of the site), tuff bedrock was encountered at 0.6 m to 0.8 m depth. The tuff was extremely weathered on first contact (comprising a sandy gravel), becoming highly weathered and of low strength below 1.0 m depth, and extended to the basalt bedrock surface at 2.7 m depth. The basalt bedrock, assessed to be moderately weathered and of high strength, was encountered at 2.7 m depth, and bucket refusal occurred at 2.9 m depth has been inferred to represent basalt of at least high strength.
- In TP202 (southern portion of the site), thinly laminated and highly fractured siltstone bedrock, assessed to be highly to moderately weathered and low to medium strength, was encountered at 3.4 m depth. The siltstone contained high strength ferricrete bands and the bucket refusal at 4.7 m depth has been inferred to represent high strength basalt or ferricrete.
- In TP206 (southern central portion of the site), fractured basalt bedrock assessed to be moderately weathered and of medium strength, was encountered at 0.6 m depth and extended to the test pit termination depth at 1.3 m. For further details below this depth please refer to the above table summarising the bedrock encountered in the boreholes.
- In TP207, TP209 and TP210 (southern central portion of the site), siltstone bedrock was encountered at respective depths of 1.3 m, 2.8 m and 0.7 m, and on first contact comprised a 0.1 m to 0.2 m thickness of extremely weathered siltstone (comprising gravelly clay/clayey gravel) overlying thinly laminated and highly fractured siltstone bedrock assessed to be highly to moderately weathered and low to medium strength. The siltstone contained high strength ferricrete bands, and the bucket refusal at respective depths of 2.8 m, 3.9 m and 0.8 m to 1.25 m has been inferred to represent high strength ferricrete or basalt.
- In TP216 (southern central portion of the site) siltstone bedrock, assessed to be highly weathered and of low strength, was encountered at 1.0 m depth and was thinly laminated and highly fractured. At 1.4 m depth, interbedded basalt and tuff was encountered, and was assessed to be highly weathered and of medium strength. The bucket refusal at 1.9 m depth has been inferred to represent high strength basalt.
- In TP217 (south-eastern portion of the site), the bedrock on first contact comprised a mix of interbedded highly weathered very low to low strength siltstone and extremely weathered siltstone (comprising gravelly clay), with an area of highly weathered basalt of low strength. From 1.0 m to 1.3 m depth, thinly laminated and highly fractured siltstone bedrock, assessed to be moderately weathered and of medium strength, was encountered. The siltstone contained high strength ferricrete bands and the bucket refusal at 1.0 m to 1.3 m has been inferred to represent high strength ferricrete.

The attached Figure 16 presents approximate contours of the competent bedrock surface, typically comprising the medium to high strength basalt or tuff and the low to medium strength siltstone with higher strength ferricrete bands. It should be noted that there is a localised deep zone of extremely weathered basalt bedrock inferred in the area of BH89 and BH213 over the eastern portion of the northern side of the spur feature.

6.4.2.6 Groundwater

Groundwater was encountered in the JKG2024 investigation during or on completion of drilling in several boreholes, particularly within the lower, eastern portion of the site.

Groundwater seepage was only encountered in BH214 in the extremely weathered basalt at 5.9 m depth, but was ‘dry‘ on completion of auger drilling.

Groundwater was intermittently encountered whilst excavating the following test pits:

- TP112: in the alluvial clays, seepage was recorded at the base of the test pit (6.25 m depth), with a standing water level recorded at 6.2 m depth, approximately 5 minutes after completion of the test pit.
- TP119: in the alluvial clays, seepage was recorded at 4 m depth, and the test pit sides collapsed a short time afterwards.
- TP202: in the siltstone bedrock, a standing water level was recorded at 4.6 m depth on completion of the test pit.
- TP210: in the siltstone bedrock, a standing water level was recorded at 1.2 m depth approximately 10 minutes after on completion of the test pit.

Groundwater measurements were made by JKE in each of the six installed monitoring wells installed as part of the JKG2024 fieldwork, on 16 November 2024 and again on 5 December 2024. Readings were also taken at selected monitoring wells by JKE on 31 May 2025, and are summarised in the table below.

Borehole	Groundwater Depth (m) / Groundwater Level (mAHD) 16 November 2024	Groundwater Depth (m) / Groundwater Level (mAHD) 5 December 2024	Groundwater Depth (m) / Groundwater Level (mAHD) 31 May 2025
4	0.2 / 11.1	0.2 / 11.1	-
24	0.1 / 9.5	0.2 / 9.4	-
28	5.4 / 11.8	5.4 / 11.8	-
60	0.0 / 10.4	0.0 / 10.4	-
62	7.0 / 11.6	7.0 / 11.6	6.8 / 11.8
85	‘Dry’	‘Dry’	-
206	-	-	2.4 / 15.4
212	-	-	4.9 / 17.3
214	-	-	3.3 / 11.3

6.5 Laboratory Test Results

The moisture content and Atterberg Limits tests on the natural clay and weathered bedrock correlated reasonably well with our field assessments. Based on the Atterberg limits, linear shrinkage and shrink-swell index test results, the natural clays are of high plasticity and are assessed to have a high potential for shrink-swell movements with changes in moisture content.

The four-day soaked CBR tests on the samples of colluvial and alluvial clay compacted to 98% to 100.5% of their Standard Maximum Dry Density (SMDD) generally returned values in the range of 1% and 2.5%, except for the sample from BH85, which returned a value of 7%. The higher CBR value attained on the sample from BH85 is anticipated to be due to a higher proportion of gravel and to the proximity of this material to the underlying extremely weathered basalt. The in-situ moisture contents of the clays were generally in the range of 3.4% to 7.3% 'wet' of their Standard Optimum Moisture Contents. The alluvial clay from BH60, TP203 and TP204 had in-situ moisture contents between 15% and 20.5% 'wet' of their Optimum Moisture Content (OMC). During soaking, swell values ranging from 1% to 9.5% were measured, indicating a high reactivity to variations in moisture content.

The four-day soaked CBR test on the extremely weathered basalt from BH89 returned a CBR value of 7%. No swelling was measured during soaking of the sample and the in-situ moisture content of the material was 6.8% 'wet' of its OMC.

Based on the Emerson dispersion test determinations:

- The samples of alluvial silty clay tested from TP202, TP203, TP209 and TP210 returned Emerson Class Numbers ranging between 5 and 7, indicating that the alluvial silty clays have a low potential for dispersive behaviour.
- The sample of alluvial silty clay tested from TP207 returned an Emerson Class Number 1, indicating that the alluvial silty clay in this area of the site has a high potential for dispersive behaviour.

The soil aggression test results are summarised in the table below:

Borehole/ Test Pit No.	Sample Depth (m)	Soil Type	pH	Chloride Content (mg/kg)	Sulphate Content (mg/kg)	Resistivity (ohm.cm)
BH26	0.5-0.95	COLLUVIAL Silty Clay	6.1	460	57	2,500
BH28	9.5-9.7	RESIDUAL Silty Clay	8.1	32	25	10,000
BH53	6.0-6.1	XW Basalt	8.2	89	29	8,500
BH71	4.0-4.5	RESIDUAL Silty Clay	8.5	160	120	3,800
BH82	4.5-4.65	XW Basalt	8.8	20	20	16,000
BH87	2.7-2.9	RESIDUAL Silty Clay	8.2	330	140	2,900
TP202	0.6-0.7	ALLUVIAL Silty Clay	7.3	58	34	7,800
TP202	3.0-3.4	RESIDUAL Silty Clay	7.2	660	190	3,700
TP203	1.0-1.1	ALLUVIAL Silty Clay	7.6	190	210	3,700
TP203	1.5-1.6	ALLUVIAL Silty Clay	7.7	140	200	2,700
TP207	0.6-0.65	ALLUVIAL Silty Clay	7.9	220	110	2,000
TP207	1.1-1.2	ALLUVIAL Silty Clay	7.5	47	110	2,000
TP207	1.4-1.5	XW Siltstone	8.1	20	20	2,000
TP208	0.3-0.4	ALLUVIAL Silty Clay	4.6	1,700	430	1,800

Borehole/ Test Pit No.	Sample Depth (m)	Soil Type	pH	Chloride Content (mg/kg)	Sulphate Content (mg/kg)	Resistivity (ohm.cm)
TP208	0.7-0.8	ALLUVIAL Silty Clay	4.6	1,700	470	1,500
TP208	1.3-1.4	ALLUVIAL Silty Clay	4.7	1,500	230	1,600
TP208	2.3-2.4	ALLUVIAL Silty Clay	6.8	1,100	160	1,700
TP208	3.0-3.1	ALLUVIAL Silty Clay	7.1	870	150	1,700
TP209	2.3-2.4	ALLUVIAL Silty Clay	7.3	1,300	480	1,500
BH212	1.5-1.7	COLLUIVIAL Clayey Gravel	7.5	380	160	1,400
BH212	3.0-3.1	COLLUIVIAL Clayey Gravel	8.1	130	39	1,500
BH212	6.0-6.1	XW Basalt	8.1	42	20	2,000
TP217	0.2-0.3	RESIDUAL Silty Clay	6.5	<10	10	3,300

6.6 Review of Results of Geophysical Survey

The SR survey results have identified the bedrock surface as the 750 m/s contour. Over the higher elevation areas of the five SR survey lines, the 750 m/s contour shows reasonable correlation with the results of the JKG intrusive investigations. Due to the variable nature and depth of the more weathered upper profile of the bedrock, the transition between primarily colluvial and/or residual soils and the bedrock is difficult to define as a single contour. However, the deeper extremely weathered profile in the area of BH213 does appear to be reflected in the plots of survey lines 4 and 5 presented in the GBG report. GBG discuss the limitations of interpreting the bedrock surface in their report.

However, over the lower elevation areas of SR lines 4, 5 and 6, where deeper alluvial clays have been encountered in the JKG investigations, the 750 m/s contour does not appear to reflect this. It may well be that deeper alluvial clays of hard consistency are resulting in higher velocities rather than the extremely weathered bedrock (typically hard clay consistency). The only way to resolve this potential discrepancy will be to drill further boreholes in these areas. However, considering the locations of the proposed buildings and structures, we do not consider that such boreholes are required for this purpose.

We note that the geophysical survey results only provide a broad interpretation of the subsurface profile and the most accurate and reliable interpretation of the subsurface profile is provided by intrusive investigations.

Further details of the geophysical survey, the methodologies adopted and their limitations are outlined in the GBG report (Ref. GBGA2804 Rev. 1) dated 25 June 2025 and attached in Appendix A.

7 SLOPE INSTABILITY

The test pits completed in the current and previous investigations have indicated that the alluvial clays are fissured with a substantial amount of sub-horizontal shear planes and sub-vertical fissures, whose surfaces are typically undulating, smooth and often moist. These shear and fissures surfaces will have a very low shear strength (potentially at or close to residual shear strength parameters) and are located in areas of flat or gently sloping topography. Similar sub-horizontal shear planes and sub-vertical fissures were also identified in some of the colluvial clay and residual clay profiles, and also indicate that ground movements have impacted some of these soils.

The presence of the shear and fissures surfaces indicates that previous ground movements have occurred. It is likely that these movements are mostly translational, with the soil mass sliding along the interface between soils and rock (or between the residual soils and the overlying alluvial and colluvial soils). It is likely that these movements reactivate during periods of heavy rainfall. As the groundwater level raises in periods of rainfall, the water pressure increases in the soil profile, resulting in reactivation of ground movements, particularly in lower shear strength materials.

The sub-horizontal shear planes are likely associated with pre-existing translational movements. The smooth sub-vertical fissures most likely indicate vertical ground movements associated with reactive ground movements (in some cases in the alluvial clays) exacerbated by loading and unloading associated with deposition and erosion of recent geological time. In addition, some of these sub-vertical fissures will correspond to release features of the translational landslip movements. At this stage, without any ground monitoring data (such as using inclinometers installed into boreholes), we cannot advise whether these ground movements are on-going and/or the rate of movement.

Figure 17 shows the depth contours of the shear planes and fissures encountered in all the soil profiles, and it also indicates our assessment of the likely upslope (western) extent of the clays containing shear planes and fissures within the bedrock gully feature area. It is evident from Figure 17 that the deeper alluvial clay profile, which contains shear planes and fissures, is located within the bedrock gully feature area (see Figure 15), and extends eastwards into the flood plain area.

In some test pits the shear surfaces and fissures were more prominent and were concentrated in thinner zones. Where test pit sides collapsed there were numerous sub-vertical fissures exposed in the collapsed zone.

Considering the topography of the site, the results of our walkover inspection and the three phases of geotechnical investigation, we consider that the site is not impacted by a deep-seated 'global' landslip involving the soil and bedrock profiles. Rather, the steeper (western) portion of the site, including the hillside slope to the west of the proposed RRHC development, has been impacted by a series of localised slumps and flow slides over the recent geological past, resulting in the collection of a colluvial soil profile that has continued to creep downslope. This creep has impacted the soil profile at the south-western corner of the proposed RRHC development. However, this still involves a considerable volume of material. The instability is also likely to have been controlled to some degree by the form of the gully feature in the bedrock surface and the orientation of the gully sides.

We note that the southern side of the gully feature is defined by the northern side of the central spur feature. The spur feature is characterised by residual soils overlying bedrock at relatively shallow depth and no shear planes were observed in the residual clays. However, we reiterate, as discussed above, that the colluvial and residual clays upslope to the west of the spur feature, within the steeper section of the site and to the south-west of the spur feature, contain shear planes.

The gully feature has subsequently been infilled by the soils derived from slope instability (colluvium) and flood events (alluvium). The flood events have also deposited alluvium over the residual soils and bedrock forming the spur feature.

It is also likely that the lower portion of the colluvial soil slope to the north of the spur feature was, in the recent geological past, eroded by flood events that led to further activation of the older creep land slip movements (further reducing the shear strength of the soil profile). It is our opinion that the localised bedrock surface highpoint forming the spur feature represented a localised more erosion-resistant feature and slope instability on the flanks of the elevated spur were therefore restricted. The northern side of the spur feature formed a topographic feature that contained the more extensive area of instability that has impacted the gully feature described above.

The past flood events also likely resulted in the deposition of the Quaternary age alluvial soils. The deeper (older) alluvial clays are likely to be over-consolidated to some degree. Fissuring of the alluvial clays will likely have developed as a response to historic shrink swell movements and by responses to cyclic periods of fluctuations in overburden pressure as a result of periods of deposition and erosion.

We believe that on-going creep of the steeper western portion of the site has, in the area of the gully feature, resulted in lateral movements shearing the deeper soil profile present below the gently sloping to relatively flat portion of the site to the east. These movements likely resulted in the formation of the sub-horizontal and sub-vertical undulating and smooth shear planes and fissures encountered in the test pits and reactivation of movement along pre-existing sub-vertical fissures. Over the south-eastern portion of the site, to the east and south of the spur feature, the alluvial clays have not been subjected to additional lateral movements associated with on-going creep of the entire hillside above. Indeed, the spur feature has formed a buffer between the instability over the steeper hillside to the west, and the alluvial plain to the east.

Broadly speaking the site conditions may be summarised as follows:

- The western portion of the site in the more steeply sloping areas appears to have a reasonably shallow depth to bedrock, but there are numerous surface indications of slumping and flow slides. Towards the toe of the more steeply sloping areas to the north of the spur feature, the depth to rock increases sharply (Figure 15 shows the bedrock surface contours). At the southern end of this area, to the south of the spur feature, where slopes are less steep, the depth to bedrock also increases. The shear planes and fissures in the clay soils (typically colluvial and residual) are generally present through the full depth of the profile down to the bedrock surface, although their frequency reduces with depth. The site area corresponds to the blue and green shaded areas presented on Figure 15 (i.e. Zones i and ii discussed in Section 8 below).
- At the flatter toe sections of the western slopes within the gully feature and into the flood plain area, the test pits showed substantial fissuring and shear surfaces throughout the clay profile down to depths of at least 6m. The site area corresponds to the orange shaded area presented on Figure 15 (i.e. Zone iii later discussed in Section 8).
- On the eastern and southern flanks of the spur feature, the slopes are moderately steep and have a reasonably shallow depth to bedrock although shear planes and fissures in the residual soils were not

present. The site area corresponds to the red shaded area presented on Figure 15 (Zone iv later discussed in Section 8).

- On the eastern and southern side of the spur feature, the flatter toe sections of the eastern and southern side of the spur feature extend into the flood plain area. The test pits showed substantial fissuring and shear surfaces throughout the clay profile down to the collapse depth of the test pits (maximum 3.4 m depth). The site area corresponds to the yellow shaded area presented on Figure 15 (i.e. Zone v later discussed in Section 8).

The above indicates that the majority of the soils at the site have moved in the past and/or have been fissured as a consequence of historic shrink swell movements and cyclic loading and unloading as a response to deposition and erosion. The soils are particularly prone to movement again or could induce instability of fill batters, if poor construction practises are followed, such as uncontrolled and unsupported excavations, over steep fill batters etc. This will need to be carefully considered in the design and construction of the northern end of the access road and Buildings C and D, as well as the proposed fill at the southern end of the proposed access road. However, these impacts are reduced over the central-southern portion of the site, where previous slope instability appears to be confined to the steeper western hillside above the proposed access road adjacent to the spur feature. Even so, the flatter portions of the south-eastern portion of the site are also impacted by the fissured clays.

We consider that the site is suitable for the proposed development on condition that the design of the currently proposed development includes additional targeted geotechnical investigation to inform the detailed design, in particular to the specific provisions required to reduce the risk to acceptable levels with regards to the existing slope instability over the north-western and western portions of the proposed RRHC development, and the geotechnical challenges posed by the fissured alluvial clays over the flatter eastern portion of the proposed RRHC development area. Advice on mitigation measures to manage these geotechnical challenges are presented in Section 9 of this report.

8 GEOTECHNICAL MODEL

Based on the results of the investigations and our consideration of likely stability issues and other geotechnical challenges, the overall geological model may be summarised as follows:

- **Zone i:** The central and-western portion of the site, typically characterised by a relatively shallow depth of soil over bedrock. The bedrock surface is deeper at the southern end of the western portion of the site. The bedrock typically includes the thinly laminated and highly fractured siltstone (with ferricrete bands) overlying basalt. Locally tuff bedrock underlies the soil profile. This portion of the site is susceptible to shallow surface slumping and rock falls (see area shaded blue on Figure 15).
- **Zone ii:** The northern portion of the site typically characterised by a relatively shallow depth of soil over bedrock and surface slopes are less steep than Zone i. The bedrock includes the thinly laminated and highly fractured siltstone (with ferricrete bands) overlying basalt or basalt. This portion of the site is susceptible to shallow surface slumping however rock falls are less likely to occur when compared to Zone i (see area shaded green on Figure 15).

- **Zone iii:** The central and eastern portion of the site, which has a typically much deeper soil profile which is fissured. This zone is susceptible to larger scale deep seated landsliding (see area shaded orange on Figure 15).
- **Zone iv:** The central portion of the site, where the spur feature slopes are typically moderately steep and have a reasonably shallow depth to bedrock with no shear planes and fissures in the residual soils. The bedrock includes the thinly laminated and highly fractured siltstone (with ferricrete bands) and/or basalt. Slope instability in this zone is not expected (see area shaded red on Figure 15).
- **Zone v:** The eastern and southern sides of the spur feature, beyond the toe of slopes, which is gently sloping and has a typically much deeper soil profile, which is fissured, and whilst not susceptible to large scale deep seated landsliding, will still present challenging subgrade conditions for any localised cut and fill earthworks (see area shaded yellow on Figure 15).

We provide below our preliminary summary of geotechnical soil parameters for the fissured/sheared clay soils and highly fractured siltstone (containing ferricrete bands) that may be used in numerical analyses. However, we strongly recommend that further specific laboratory testing of the fissured clays be undertaken to confirm the values presented in the table below.

Soil/Rock Type	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Elastic Modulus (MPa)
Fissured Clays (Very Stiff to Hard)	19	5	15	50
Fissured Clays (Stiff to Very Stiff)	18	2	15	30
Fissured Clays (Stiff)	17	0	15	15
Heavily Fissured Clays	17-19	0	15	15-50
Residual clays (Non Fissured) Typically Very Stiff to Hard	19	5	28	40
Highly Fractured Siltstone (with ferricrete bands) and highly fractured basalt.	22	5	35*	100*

* The potential for adversely orientated joints within the bedrock will also need to be considered.

9 PRELIMINARY COMMENTS AND RECOMMENDATION

9.1 Geotechnical Issues

The following geotechnical issues will need to be considered in the detailed design stage and during the construction phase of the proposed RRHC development:

- The presence of slope instability on the north-western and western portions of the site is considered to be the main geotechnical risk constraining the development of the site. We confirm that based on the geotechnical investigations completed to date, there are no obvious signs of slope instability over the remainder of the development site.

- Uncontrolled and unsupported excavations within and at the toe of the slopes will have a very high likelihood of instigating large scale slope failures. This must be avoided; all excavations will need to be supported by properly designed shoring walls.
- As the site is susceptible to slumps and flows from upslope, in the detailed design stage, consideration will need to be given to reducing the risk to buildings if and when such failures occur in the future. Options, such as some freeboard on the top of the shoring wall and/or additional buffer zones, might be considered. The buffer zones may comprise landscaped areas immediately upslope and downslope of the shoring wall. The roads immediately downslope of the shoring wall may also be considered as a buffer zone.
- Any uncontrolled (i.e. over steep temporary batter slopes) and unsupported excavations within the fissured clays over the relatively flat portion of the site must be avoided as they are prone to collapse at any time without warning.
- Proposed fill embankments must be carefully designed with due regard for the presence of fissured clays and the potential for embankment instability. High embankments should be avoided. The proposed fill embankment at the southern end of the proposed main access road will be constructed over natural clays containing shear planes and fissures, and will need to be designed to withstand potential creep movements on the upslope soil profile.
- Implementation of an adequately designed drainage system, preventing water from running over the slopes or ponding in critical area, will be required.
- The existing farm dam in the north-western portion of the site appears to be poorly formed and the existing embankment also appears to have undergone some slumping in the past. Maintaining dams on a potentially unstable slope is not good practise, and this dam will probably need to be decommissioned to reduce the risk of a dam failure impacting structures, roads, etc, downstream.
- The natural clays are highly reactive and therefore footings will need to consider the potential for large shrink-swell movements with changes in moisture content within the design, particularly considering the possibility of periodic flooding. Additional consideration will need to be given at the detailed design stage to detailing of services, vegetation etc in accordance with the requirements of AS2870-2011, which may otherwise affect the future performance of structures.
- The natural clays will likely undergo substantial strength loss when wet. Earthworks using these materials will be difficult as the soils generally appear to currently be ‘wet’ of their Optimum Moisture Content which will require time to dry out prior to being suitable for use as engineered fill. Delays will likely occur during earthworks following rain events to remove water-softened material and dry out the clays.
- The natural clays have low CBR values. This will require the use of relatively thick pavements, with some form of subgrade treatment to improve the subgrade quality, or bound subbases for concrete pavements. Working platforms will be required to facilitate trafficability of the site for plant and construction of pavements and floor slabs.
- Groundwater appears to be present at relatively shallow depths within the eastern portion of the site. It is likely that this will present challenges to earthworks in this area.
- Weathered basalt was encountered within the western portion of the site and generally increased in depth towards the east. The basalt generally comprised an upper extremely weathered (XW) material

that has properties similar to a hard clay, and contains basalt gravel and larger core stones. The weathering patterns of basalt are such that the strength and defects of the basalt may vary significantly over relatively short distances.

- Competent basalt bedrock, which generally appears to comprise slightly weathered basalt of at least medium strength, was encountered below the XW basalt. This material generally contained highly weathered bands along the joints in the rock mass. This more competent basalt will be suitable for higher bearing pressures, however it has been encountered at levels ranging from RL13.95 m to locally RL0.65 m across the site. Where piles are targeted to this stratum the basalt will be abrasive and difficult to penetrate, requiring large piling rigs. Productivity is expected to be slow for piling.

We understand that a contractor will be engaged on a D&C basis. Our strong advice is to critically review all D&C proposals from contractors. SINSW must ensure that any contractor that is engaged has demonstrated a thorough knowledge of the geotechnical issues and limitations on this site and has factored these into their tenders. We recommend SINSW engage a suitably experienced geotechnical consultant to review the tender submissions to verify this understanding and appreciation of the geotechnical challenges presented by the site.

Further comments on these issues are provided within the following sections of this report although these are of a general nature only as detailed comments and recommendations will depend on further investigation to inform the detailed design.

9.2 Site Classification

We note that in the strictest sense, AS2870-2011 does not apply to developments such as this, however it provides a useful guide for footing design on reactive clay sites. Reference may also be made to AS2870 for design, construction, performance criteria and maintenance precautions on reactive clay sites. As the site contains unstable ground the site classification will be Class 'P' and therefore foundations will need to be designed in accordance with engineering principles.

Assessment of the characteristic surface movements for this site has been completed with reference to the results of the shrink-swell index, Atterberg Limits and linear shrinkage testing completed on the natural clays. The soils encountered were found to be of such reactivity that, even assuming no earthworks, and that the clays are not subject to any adverse moisture conditions (such as from slope instability, flooding, trees, buildings etc.), the site will classify as ranging between Class 'H1' and Class 'H2' in accordance with AS2870-2011.

However, the site will almost certainly be subject to adverse moisture conditions, and also cut and fill earthworks, where greater soil shrink-swell conditions can occur. Therefore, considering the site conditions, our recommendation is that structures be designed to accommodate shrink-swell movements normally associated with a Class 'E' site.

To assist in controlling reactive surface movements, consideration could be given to importing non-reactive soils as engineered fill. However, even if engineered fill comprising non-reactive materials is used, there will still remain the potential for reactive movements within the in-situ reactive clays to impact the proposed development. The magnitude of the reactive movements will depend on the reactivity of the in-situ clays and the thickness of the overlying imported fill. This will lead to a complex interaction between the reactive movements within the in-situ alluvial clays and the settlement of the engineered fill. Once further details of the proposed development are known, including the nature of the engineered fill materials (reactive or non-reactive) then further geotechnical advice must be sought in order to satisfactorily address these issues in the detailed design.

Apart from the characteristics of the soil and the presence of fill, there are many factors that affect the actual surface movements that occur. Such factors include:

- The presence of slope instability;
- The depth of the soil profile;
- The likelihood of flooding;
- The presence of trees, past, present and future;
- The control and maintenance of drainage; and
- The installation of underground services.

The designers of structures on soils with the potential for Class 'E' movements must consider the additional requirements of such sites as defined in Sections 5.6 and 6.6 of AS2870-2011. Owners of such lots must be made aware of the foundation maintenance requirements as stated in Appendix B of AS2870-2011. The landscape designers, structural and civil engineers should also be made aware of potential reactive soil issues.

9.3 Earthworks

9.3.1 Site Drainage

The clayey soils at the site are expected to undergo substantial loss in strength when wet. Furthermore, based on our site investigation, the natural clay subgrade is expected to have a high shrink-swell reactive potential and a variable dispersive potential. Therefore, and as advised in Section 9.1, it will be important to provide good and effective site drainage both during construction and for long-term site maintenance. The principal aim of the drainage is to promote run-off and reduce ponding. A poorly drained clayey subgrade may become un-trafficable when wet, and consideration should be given to providing a crushed rock or crushed concrete working platform to minimise delays following rainfall. The earthworks should be carefully planned and scheduled to maintain good cross-falls during construction.

Good surface and subsurface drainage must also be provided post construction to improve the long-term performance of the external paved areas.

9.3.2 Site Preparation

Prior to placing engineered fill and forming access road, car park pavements or other external paved areas, site preparation must include:

- Demolition, including removal of existing paved surfaces and trees resulting in abnormal moisture conditions.
- Removal of the existing uncontrolled fill and any obviously deleterious or contaminated natural soils should also be removed in accordance with the advice presented in the JKE report. The stripped contaminated materials should be taken off-site as they are not suitable for re-use as engineered fill.
- Stripping of topsoil or root affected soils which should be separately stockpiled for re-use in landscape areas as such soils are not suitable for re-use as engineered fill or disposed of off site.

Tree root systems dry out the surrounding clayey soils and their removal will result in localised moisture recovery leading to swelling which may have a detrimental impact on the performance of nearby buildings and paved surfaces founded/supported in the clayey soil profile within the site. Therefore, trees should only be removed where absolutely necessary and as soon as practicable, in order for the moisture content of the clayey subsoils to recover; ideally this would be years in advance of construction though we understand this is not practical here. The same applies to the demolition of existing structures and pavements within the building footprint as these also result in abnormal moisture conditions.

9.3.3 Subgrade Preparation

Following site preparation as described above, completion of bulk excavations to achieve design surface levels, and prior to placing engineered fill, the subgrade should be proof rolled with a static (non-vibratory) smooth drum roller. The size of roller will depend on the proposed loads however for areas requiring deep filling or subject to vehicular loads we recommend that the roller be at least 12 tonnes deadweight. The final pass of proof rolling should be carried out under the direction of an experienced geotechnical engineer for the detection of unstable or soft areas.

Subgrade heaving during proof-rolling is anticipated to occur in areas where the clays have become 'saturated' and/or are of firm to stiff strength. The investigations indicate that stiff clays will be encountered across a large proportion the subgrade, particularly within the eastern portion of the site. In this regard, bridging layer support using appropriately sized well graded durable crushed rock, and possibly high tensile geogrids, could be considered to facilitate earthworks and trafficability of the site during construction. Options and detailed design of subgrade improvement works must be provided by the geotechnical engineer following the proof rolling inspection.

If soil softening occurs after rainfall periods or flooding, the clay subgrade should be over-excavated to below the depth of moisture softening and replaced with engineered fill. If the clay subgrade exhibits shrinkage cracking, then the surface must be moistened with a water cart and rolled until the shrinkage cracks are no longer evident. Care must be taken not to over-water the subgrade as this will result in softening.

Over any sloping areas, benches should be cut into the slope to accommodate the roller and facilitate more effective proof rolling and for keying-in of the new engineered fill layers. Benches will need to be of a suitable size to accommodate the rollers.

Engineered fill must be used to raise site levels.

9.3.4 Engineered Fill

Although the use of site won clays is feasible, the site-won clays are likely to present challenging earthworks conditions as the clays are generally 'wet' of their Optimum Moisture Contents, with one of the tested samples up to 20% 'wet'. This will require either drying out or stabilisation of the materials with a binding agent such as lime to reduce the plasticity and sensitivity to variations in moisture content. Drying out of the soils will take time and require a continuous program of turning and aerating the soils to reduce the moisture contents towards OMC. Further advice may be sought from stabilisation experts however mixing of binding agents with the site-won materials will need to be completed with specialist equipment such as pugmills to ensure the agent is suitably blended.

The compaction specification for fill will depend on the type of material and the adjacent ground conditions. Further advice will need to be provided as the detailed design is developed.

Where any engineered fill is to be placed on slopes, the slope surface must be benched as described above to accommodate the roller and facilitate more effective fill compaction.

The fill required to raise surface levels for the southern end of the proposed main access road will be placed over a moderately steep slope with the soils containing shear planes. Stability of the embankment will need to be carefully assessed and require numerical analysis by the geotechnical engineer. Depending on the results of the analysis, some ground treatment involving removal of the sheared clays down to bedrock may be warranted and/or the adoption of flatter fill batter slopes. Careful consideration will need to be given to the 'tying in' of engineered fill to temporary cut batter slopes and at the edge of fill batters where under compaction generally occurs.

Material stockpiles will need to be stored above flood levels and on areas not susceptible to slope instability.

Density testing will be required to be carried out regularly on engineered fill to confirm the earthworks specification is achieved. The frequency of testing will depend on the volume of excavations. Supervision and regular density testing in accordance with Level 1 requirements of AS3798-2007 *'Guidelines on Earthworks for Commercial and Residential Developments'* is recommended if engineered fill is required to support structural loads from buildings.

Backfill used in retaining walls should also comprise engineered fill. Well graded granular materials such as crushed sandstone and demolition rubble will be suitable for this purpose. This granular fill should be free of deleterious substances and should have a maximum particle size not exceeding 40 mm. Such fill should be compacted in horizontal layers as above using a hand-held plate compactor (e.g. whacker packer). Care will be required to ensure excessive compaction stresses are not transferred to the retaining walls.

As alternative engineered fill for retaining wall backfill could comprise single sized granular material (or 'no fines' gravel), and this material will also act as the drainage behind the wall and will only require nominal compaction (with no compaction testing). However, such material will not be suitable where building footings founded on Level 1 engineered fill are located close to the retaining wall backfill. The drainage material should be wrapped in a non-woven geotextile fabric (e.g. Bidim A34) to act as a filter against subsoil erosion. Further, unless covered by the external pavements or slabs, the free draining retaining wall backfill should be provided with a cap of clay of at least 0.3m thickness at surface level to reduce the likelihood of surface water entering the backfill and surcharging the retaining walls.

Density tests should be carried out at the frequencies outlined in AS3798 (Table 8.1) for the volume of fill involved. Where the fill is required to support structural loads, Level 1 testing as defined in AS3798 is recommended, if not, then, Level 2 testing as defined in AS3798 will be appropriate. Any areas of insufficient compaction will require reworking. The Geotechnical Testing Authority should be directly engaged by the client or their representative and not by the earthworks contractor.

9.4 Excavation Conditions and Seepage

9.4.1 Excavation Conditions

The excavation recommendations provided below should be complemented by reference to the current NSW Workcover Code of Practice 'Excavation Work'.

To achieve design surface levels, excavations for the main building platforms, access roads and other internal paved areas (such as car parks) will locally extend down a maximum of approximately 3.0 m within the area of the main buildings and the main access road on the western side of the main buildings. Within the eastern and south-eastern portions of the site, the depth of excavation will be less than approximately 1.0 m. Two OSD tank excavations are proposed immediately downslope of Buildings B and C and have been estimated to extend a further 2.0 m below the design surface level of the proposed buildings.

On the basis of the investigation results, following site preparation, the proposed excavations will encounter the clayey and granular soil profile and bedrock.

Excavation of the soils and extremely weathered bedrock should be achievable using the buckets of large hydraulic excavators. Large core stones should be expected to be encountered within both the soil and extremely weathered profiles. Hydraulic rock hammers may need to be used to break down excavated core stones.

Excavation of competent basalt and other bedrock types such as the ferricrete is anticipated to require hard rock excavation techniques such as rock saws, rock grinders and/or hydraulic impact hammers attached to large excavators. Ripping tyne attachments to large dozers or excavators may also be suitable, particularly where the bedrock is more fractured. The basalt, tuff and ferricrete bedrock will be abrasive to excavation equipment and as such excavation costs will be high. Due to the distance from the site boundaries to adjacent structures we do not consider that quantitative vibration monitoring will be required where hydraulic impact hammers are used.

Slightly weathered or fresh basalt of very high strength may also be completed using controlled, non-explosive blasting techniques however further advice on the suitability of such techniques will need to be discussed with specialist subcontractors.

9.4.2 Seepage

Groundwater is anticipated to be encountered during excavation within the western portion of the hillside particularly following heavy rainfall and may occur at shallow depth within the alluvial clays over the eastern and south-eastern portions if the site. These conditions will present difficult conditions for earthworks and excavation, particularly with regard to excavation of service trenches and localised dewatering may be required. On-going monitoring of the monitoring wells installed by JKE is recommended and should include installation of data loggers to provide near continuous readings and provide information on the response of groundwater to rainfall events.

As the site is located within an area prone to flooding, we anticipate that the groundwater table will be elevated for a period of time after the flood/heavy rainfall following flood/heavy rainfall events. In this regard, excavations may become inundated with water for a period following flooding/heavy rainfall. If this occurs, sump and pump techniques may be required to dewater excavations to allow construction to proceed.

Depending on the seepage conditions revealed during bulk excavation for the northern end of the main access road, there may be a need for additional large subsurface trench drains upslope of the retention system. However, the need for this will need to be assessed during excavations and with regard for the design capacity of the drainage behind the retention system. The location of drainage trenches will need to be coordinated with the structural design so that footings do not extend through these trenches.

9.5 Retention and Temporary and Permanent Batter Slopes

9.5.1 Temporary Batter Slopes

Temporary excavation batter slopes through the clayey soil profile and extremely weathered bedrock (hard clay soil consistency) no steeper than 1V in 1H, or 1V in 2H through granular soils, are considered to be appropriate, provided surcharge loads such as from plant and stockpiles of material are kept well clear of the crests of the temporary batter slopes, say at least a distance equivalent to the depth of the excavation. These temporary batters are not appropriate in any areas where shear planes within the natural soils have been identified and stockpiles around any such excavations must be avoided.

Competent bedrock (low or higher strength) may be cut vertically, subject to confirmation by geotechnical inspection during excavation to check for any adverse defects that may require stabilisation, such as rock bolts, shotcrete etc. However, highly fractured bedrock will need to excavated to a temporary batter slope of 1V in 2H due to the likelihood of collapse at steeper cut angles.

Where shear planes within the natural soils have been identified particular care and attention will be required to maintain the stability of the temporary excavation. The options are likely to include:

- Option 1 - Support the excavations with engineer designed shoring systems (i.e. contiguous pile wall) prior to commencing excavations, possibly with the use of permanent anchors.
- Option 2 - Excavate in short panel lengths (as a guide say a maximum of 3 m long), adopt a temporary batter slope of around 1V in 2H irrespective of the soil type, and construct the permanent retaining wall within the batter slope. More than one panel may be excavated at any one time but will require sequencing in a similar manner as underpinning, such as 'hit 1 miss2'. However, the panel length and sequencing will need to be trialled on site with the Contractor, structural and geotechnical engineers in attendance to confirm such details. The sequencing will also need to take into account the practical time to construct the retaining wall, including placement of reinforcement and formwork, concrete strength gain, propping and installing behind wall drainage.

Our strong preference is to adopt Option 1 as the stability of the excavation will be maintained throughout, the construction sequence is expected to be more efficient and the likelihood of batter slope or hillside slope will be much lower than for Option 2.

Steeper (sub-vertical) temporary soil batters may be considered in the natural clays, say for trench excavations, but will only be feasible for cut faces of less than about 1.0 m height (or 1.5 m height if no site personnel are required to access the trench), and on condition that no structures are located within a horizontal distance equivalent to at least twice the vertical height of the cut, and that the trenches are backfilled as soon as practicable. However, due to the fissured nature of the alluvial clays and the presence of shear planes and fissures in some of the residual or colluvial clays, collapse of temporary vertical batters may still occur, as was observed during both phases of test pit investigation. Where there are such concerns regarding the stability of the temporary trench sides and/or new buildings and structures are in close proximity to the sub-vertical trench excavations, a temporary trench shoring system will be required and will also be necessary if sub-vertical batters are preferred and proposed trench depths are in excess of 1.0 m and need to be accessed by site personnel.

9.5.2 Retention

Where temporary excavation through soils containing shear planes and fissures is expected, in particular at the northern end of the main access road and the western side of Buildings C and D, where excavation to a maximum depth of 3.0 m is required, we note the following:

- Bedrock is expected to be encountered within about 1.5 m depth, increasing to approximately 3.0 m towards Building B to the south.
- The bedrock is of variable quality and typically extremely weathered.

As described above, the options for retention systems include retaining walls constructed in sequential panel lengths (to be determined by site trials), or installation of a piled shoring wall (possibly permanently anchored) before excavation commencing. For either selection, the retaining wall or piled wall will need to be designed to resist the sloping soil slope above which contains shear planes (with the soils at, or approaching, residual parameters).

At this stage, for planning purposes, and until further detailed design is carried out, it should be assumed that the retention system will comprise a contiguous piled wall with at least one row of anchors. Earth pressures on retention systems will be significantly higher than conventional retention systems as a result of the retention system supporting an upslope hillside with the soil impacted by past landslip movements, containing shear planes and requiring design adopting residual shear strength parameters. The design will need to be based on the parameters provided in Section 8 and require numerical modelling to be completed by both the geotechnical and structural engineers in order to inform the detailed design.

A significant socket length into bedrock may also be required and in some instances will be difficult to achieve without large powerful piling rigs due to the presence of medium to high (or very high) strength bedrock. Even with large powerful piling rigs design sockets may not be achievable; further advice will need to be sought from piling contractors.

Long-term support of the piled wall retention system could be provided by permanent anchors or buttresses.

For preliminary design, cantilever or gravity retaining walls, not exceeding say 3.0 m height and constructed within stable areas (i.e. no retained soils containing shear planes), may be designed using the below parameters and recommendations:

- Where some movement can be tolerated, we recommend a triangular lateral earth pressure distribution using an 'active' earth pressure coefficient (K_a) of 0.35.
- For walls which will be propped by floor slabs or where movements are to be reduced, we recommend a triangular lateral earth pressure distribution using an 'at rest' earth pressure coefficient (K_0) of 0.6.
- The bulk unit weights provided in Section 8 should be adopted for the various retained materials.
- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic, inclined backfill or natural slopes, etc.) are additional to the earth pressure recommendations above and should be included in the design using appropriate modelling tools. Further geotechnical advice can be provided once details of the proposed design are known.
- Retaining walls should be designed as drained and provision made for permanent and effective drainage of the ground behind the walls. Subsurface drains must incorporate a non-woven geotextile fabric, such as Bidim A34, to act as a filter against subsoil erosion. The subsoil drains must discharge into the stormwater system.
- Lateral restraint of retaining walls founded in the soil profile below adjacent surface levels may be provided by the passive pressure of the soil below these levels. A 'passive' earth pressure coefficient, Kp, of 3 may be adopted, using a triangular pressure distribution and provided a Factor of Safety of at

least 2 is used in order to reduce the high deflections that are associated with achieving a full passive case. Localised excavations in front of the walls e.g. for buried services etc must also be taken into account in the design.

- For wall footings founded on bedrock (at least extremely weathered), a friction angle of 30^{o} may be adopted concrete footing – bedrock interface for assessment of sliding, provided the bedrock foundation is cleared of any loose debris and/or water softened materials and the concrete footing is poured as soon as practicable after cleaning the bedrock foundation. If sufficient shear capacity cannot be achieved then sub-vertical permanent rock bolts will need to be used and designed using similar parameters to those recommended for micropiles in Section 9.6.
- Retaining wall footings should be designed based on the bearing pressure provided in Section 9.6.
- Due to the variable foundation conditions; reactive clays and bedrock, potential differential movements can be expected, it is recommended that closely spaced articulation joints be provided.

9.5.3 Retaining Walls Supporting Engineered Fill

Where any areas require raising of site surface levels and retaining walls are proposed to support the fill, the construction sequencing may involve:

- Fill initially placed and then cut back to allow retaining wall construction; this will only be feasible where there was sufficient space to place the fill outside the area of the works within the site.
- The retaining wall constructed first and then backfilled.

In either case, good compaction close to the retaining wall may not be feasible and some post-construction settlement of the fill surface may occur. In addition, care will be required not to transfer compaction stresses to the retaining wall, hence the use of free draining backfill, where appropriate, which does not require significant compaction. Further guidance on engineered fill placement and compaction is provided above.

9.5.4 Permanent Batter Slopes

If required, permanent fill batter slopes up to 3 m in height must be formed at no steeper than 1V in 2H, and may need to be locally flatter due to the presence of fissured clays. The design slope must be checked by numerical analyses (e.g. using Slope/W software) once the nature of the engineered fill and the design details are known. As outlined above, this will be essential over the southern end of the proposed main access road.

For ease of maintenance (such as mowing) flatter slopes of 1V in 4H might be more appropriate. For the permanent fill batter slopes, this assumes that the fill is placed as engineered fill in accordance with the advice provided in this report. Surface erosion protection, for example, quick establishing grass or proprietary erosion protection systems, must be provided as part of the permanent batter slope design. This is of particular importance where natural clays sourced from the site are used as engineered fill due to their variable potential for dispersive behaviour.

9.6 Foundations

9.6.1 Main Buildings

Due to the presence of shear planes within the soil profile, movement of the soil profile may occur particularly if additional structural loads are imposed. Therefore, our recommendation is that all footings for the main buildings be extended into the competent bedrock. Due to the depth to bedrock, piled foundations will be required in most instances for the main buildings.

Bored piers should be feasible, provided significant groundwater seepage does not occur into the pier holes. In those circumstances, either the use of sacrificial liners to support the side walls to prevent collapse may be considered, or grout-injected, continuous flight auger (CFA) piles should be adopted.

We recommend that piles are founded at least 0.5 m within bedrock or, where appropriate, pad or strip footings keyed at least 0.3 m into the bedrock.

The parameters provided in the following tables can be adopted for design. We note that on first contact the bedrock was variable in terms of its type, degree of weathering, strength and degree of fracturing and so relatively conservative parameters have been provided. Further investigation comprising deep cored boreholes at relatively close spacing will be required to confirm the depth and continuity of the competent bedrock (bedrock of at least low to medium strength) in order to provide further guidance on whether higher bearing parameters can be adopted.

Ultimate End Bearing Pressures For Piles

	Ultimate End Bearing Pressure in Compression (MPa)	Elastic Modulus, E (MPa)
Competent bedrock	2	150
Extremely Weathered Bedrock	1	75

For the design of pile rock sockets, the following ultimate shaft adhesion values may be adopted:

Ultimate Shaft Adhesion Values

	Ultimate Shaft Adhesion Value in Tension (kPa)	Ultimate Shaft Adhesion Value in Compression (kPa)
Competent bedrock	150	300
Extremely Weathered Bedrock	75	150

Where ultimate end bearing and skin friction values are adopted, then the ultimate values recommended in the table above must be reduced by an appropriate geotechnical reduction factor. The geotechnical reduction factor should be based on the risk assessment procedure set out in Table 4.3.2 (A) of AS2159-2009, but should not be greater than 0.4, unless the risk factors producing a higher geotechnical reduction factor can be fully justified. Consideration should also be given to the pile testing requirements when determining a suitable geotechnical strength reduction factor. Detailed settlement analysis of piles is recommended to check that predicted settlements are within acceptable limits for the structural design.

In order to achieve the recommended skin friction values nominated in the table above, it is essential that rock sockets be cleaned of any clay smear and suitably roughened using a side wall grooving tool, and that they be at least as rough as Roughness Class R2. We note that an R2 roughness is equivalent to grooves 1 mm to 4 mm deep and grooves 2 mm wide, which are spaced at 50 mm to 200 mm down the socket length. It will be the responsibility of the piling contractor to ensure that he has the appropriate equipment and methodology to satisfy this roughness criteria.

High level (pad or strip) footings the following allowable bearing pressures can be adopted:

	Allowable Bearing Pressure (kPa)
Competent bedrock	1,200
Extremely Weathered Bedrock	600

The allowable bearing pressures are based on a settlement criterion of typically less than 1% of the minimum footing dimension.

Piled footings will need to be drilled with large piling rigs which can penetrate through any upper higher strength basalt core stones or layers within the extremely weathered and highly weathered bedrock. We note that the drilling of piled footings through corestones and/or bands of basalt within the extremely weathered profile may result in difficulties achieving pile verticality. If the works are completed following prolonged rainfall, seepage could be encountered and there will be difficulties maintaining clean and dry bases in bored pile holes (if preferred to CFA piles) as the extremely weathered basalt will be susceptible to softening if water is present and will require over-drilling to remove such materials. It will therefore be imperative to drill, clean out, inspect and pour bored pile footings with minimal delay.

In summary, piling operations will be difficult on this site, considering the required specifications discussed in the above. Consideration may be given to an alternative piling system using micro piles drilled with down-hole hammer techniques. These are relatively small diameter holes relying on the skin friction for their load capacity. As the piles work in friction, it will be advantageous to sleeve the piles through the reactive clays through the depth of soil design suction change (1.5 m) so that all of the friction below this depth can be used to support the structural loads.

The conditions at each micropile are likely to be different due to the nature of corestone weathering, with some encountering 'strong' basalt at shallow depth and adjoining locations encountering extremely weathered basalt or clay. Therefore, such micropiles must be installed using an experienced and reputable contractor on a design and construct basis.

The micropiles could be designed using an allowable bond of 50 kPa in hard clay and extremely weathered basalt, and 200 kPa within basalt, if at least low strength. Selected piles should be load tested to confirm the load capacity as the capacity can also be influenced by inadequate cleaning of the hole etc. These load tests could be completed in tension, possibly with sacrificial test piles, again with the upper length through the depth of soil design suction change (1.5 m) being de-bonded. We also forewarn that micropile design should be checked for buckling of the upper section where it may be less confined ion the weaker soil profile when compared to the bedrock socket below.

Steel screw piles are not recommended as they will be unable to penetrate even the first corestone encountered.

For floor slabs suspended from piled footings, void formers must be provided below the slab and beams between the piles, so that the swell pressures from the reactive clays are not transferred to the slabs. Further advice on appropriate void former thicknesses can be provided once further details on the design are known.

The structural capacity of the piles will need to be checked in relation to the above ultimate bearing pressures and elastic shortening.

The piling contractor must be provided with a copy of this report so that they can provide appropriate equipment in order to install the piles. The design of the piles must be based upon the pile design parameters provided above. The piling contractor must also certify the geotechnical and structural capacity of their installed piles. Pile testing, if completed, should be completed in accordance with the requirements of AS2159-2009.

We recommend that a geotechnical engineer witness the installation of the initial piles or micro pile trial piles in order to confirm adopted design bearing pressures.

Support of piling rigs will require appropriately designed working platforms and further geotechnical advice will be required.

9.6.2 Minor Structures

Lightly loaded, flexible structures may be designed to be supported on high-level footings within the natural clay of at least stiff consistency, engineered fill (placed under Level 1 control) or extremely weathered basalt (if assessed as stable).

At this stage an allowable bearing pressure of 100 kPa is recommended for design of high level footings in clay of at least stiff consistency, engineered fill (placed under Level 1 control), and 600 kPa for extremely weathered bedrock. For any high level footings founded in natural clays containing shear planes, additional geotechnical advice will be required.

For high-level footings founded within reactive clay, these will need to be designed to accommodate the shrink-swell movements which will depend on the material used as fill, the excavations carried out and the presence of nearby trees. All of these factors will need to be taken into account to determine the appropriate shrink-swell movements for each structure as it may vary in different areas of the site. Reference should be made to Section 8.2 above on likely shrink-swell movements. Particular consideration will also need to be given to the effect of reactive engineered fill as greater surface movements may apply. Reference should also be made to Appendix B of AS2870-2011 which provides further guidance on foundation performance and maintenance for structures on reactive silty clay soils.

9.7 Exposure Classification

Based on the soil aggression test results, the natural clays and extremely weathered bedrock are classified as having a 'Non-aggressive' to 'Mild' exposure classification for concrete and steel piles in accordance with Tables 6.4.2(C) and 6.5.2(C) of AS2159-2009 'Piling – Design and installation'. We recommend the adoption of the 'Mild' exposure classification. For concrete structures in contact with the natural clays and extremely weathered bedrock an exposure classification of 'A1' to Á2'will apply in accordance with Table 4.8.1 of AS3600-2018. We recommend the adoption of the 'A2' exposure classification.

9.8 Earthquake Design

Based upon AS1170.4:2024 "Structural Design Actions, Part 4: Earthquake actions in Australia", the following preliminary design parameters may be adopted:

- Hazard Factor (Z) = 0.08;
- Class Ce – Shallow soil site.

Further investigation will be required within the eastern and south-eastern portions of the site if structures are proposed in these areas to confirm the depth of the soil profile. It is possible that a Class D_e subsoil classification may apply if significantly deep alluvial soils are present.

9.9 Pavement Design

Due to the very low CBR values obtained from the laboratory testing, construction of pavements without subgrade improvement will be difficult to achieve. In this regard we consider that some options for pavement design and construction are as follows:

1. Provide an appropriate well, graded good quality ripper or crushed basalt select fill layer as part of the overall pavement thickness.

OR

2. Stabilise the subgrade to a depth of about 300 mm by the addition of lime.

OR

3. If rigid pavements are preferred a 150 mm lean-mix concrete subbase should be placed below the concrete base course such that an effective subgrade strength of 5% may be adopted.

Where a working platform and/or bridging layer is adopted then this layer may be included within the pavement design. Due to the highly reactive nature of the clay, a low-permeability capping layer should be incorporated within the pavement profile to limit moisture related movement. The capping layer should comprise a select fill or subbase material with a minimum thickness of the greater of 150 mm or 2.5 times the maximum particle size. The capping layer should extend at least 500 mm past the edge of the pavement, including kerb and gutter.

To further reduce the potential for moisture variations below the pavements, consideration should be given to including sealed shoulders and impermeable verge materials with a minimum width of 1 m from the pavement edges.

In order to protect pavements, subsoil drains should be provided along the perimeter of all proposed pavement areas. Subsoil drains should not extend into the reactive alluvial clay subgrade to reduce the potential for variations in moisture content. The drainage trenches should be excavated with a continuous longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. from the subsoil drains should be piped to the stormwater system for disposal.

9.10 Further Geotechnical Input

The following is a summary of the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Further site investigation to confirm the depth to competent basalt bedrock for foundations including for piled wall rock sockets, if piled wall retention systems are adopted.
- Detailed slope stability analysis to provide detailed comments and recommendations on earthworks and retention systems for sections of the proposed development within areas of slope instability and fissured clays.
- Further assessment of reactive soil movements once further details of the proposed development including the engineered fill materials are known.
- Numerical analyses to confirm permanent batter slopes for engineered fill.
- Proof-rolling inspections and further advice on subgrade treatment such as bridging layers and/or lime stabilisation.
- In-situ density testing of all materials placed as engineered fill to confirm that it complies with the earthworks specification.
- Design of working platforms for the specific piling rigs proposed.
- Inspection of footing excavations and piling.

10 CONCLUSION

We consider that the site is suitable for the proposed development on condition that the design of the currently proposed development includes additional targeted geotechnical investigation to inform the detailed design, in particular to the specific provisions required to reduce the risk to acceptable levels with regards to the existing slope instability over the north-western and western portions of the proposed RRHC development, and the geotechnical challenges posed by the fissured alluvial clays over the flatter eastern portion of the proposed RRHC development area. Advice on mitigation measures to manage these geotechnical challenges are presented in Section 9 of this report.

11 GENERAL COMMENTS

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

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between and beyond the 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.

Waste categorisation is required under the Environmental Protection (Regulated Waste) Amendment Regulation (2018) for commercial or industrial waste including soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as non-regulated waste, Category 2 regulated waste or Category 1 regulated waste. Analysis can take up to five to ten working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) could be expected. A soil disposal permit for contaminated soils may be required from the Department of Environment, Science, and Innovation (DESI) prior to transport and disposal of regulated waste off-site. We strongly recommend that this requirement for waste categorisation is addressed well before the commencement of excavation on site.

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.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

Material Test Report

Report Number:	**NBRS25010-1**
Issue Number:	1
Date Issued:	10/07/2025
Client:	Jeffery and Katauskas Services Pty Ltd unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact:	Cody Surawski
Project Number:	NBRS25010
Project Name:	Site Investigation
Project Location:	163 Alexandra Parade, Lismore, NSW
Client Reference:	37365UOR - 37365UOR
Work Request:	121
Sample Number:	NBRS121A
Date Sampled:	02/06/2025
Dates Tested:	13/06/2025 - 30/06/2025
Sampling Method:	AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location:	**TP202, Depth: 0.3-0.35**
Material Source:	Insitu

coffey TESTING
North Brisbane Laboratory
3 Roseby Road Caboolture QLD 4510
Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Travis Driver
Laboratory Accreditation Number: 431

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	83		
Plastic Limit (%)	23		
Plasticity Index (%)	**60**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	**30.0**		
Cracking Crumbling Curling	Curling		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**5**		
Soil Description	Silty CLAY		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	22		

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	35.4		

Material Test Report

Report Number:	**NBRS25010-1**
Issue Number:	1
Date Issued:	10/07/2025
Client:	Jeffery and Katauskas Services Pty Ltd unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact:	Cody Surawski
Project Number:	NBRS25010
Project Name:	Site Investigation
Project Location:	163 Alexandra Parade, Lismore, NSW
Client Reference:	37365UOR - 37365UOR
Work Request:	121
Sample Number:	NBRS121B
Date Sampled:	02/06/2025
Dates Tested:	13/06/2025 - 27/06/2025
Sampling Method:	AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location:	**TP203, Depth: 0.3-0.4**
Material Source:	Insitu

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3 Roseby Road Caboolture QLD 4510

Phone: 0419 664 279

Email: Travis.Driver@coffeytesting.com

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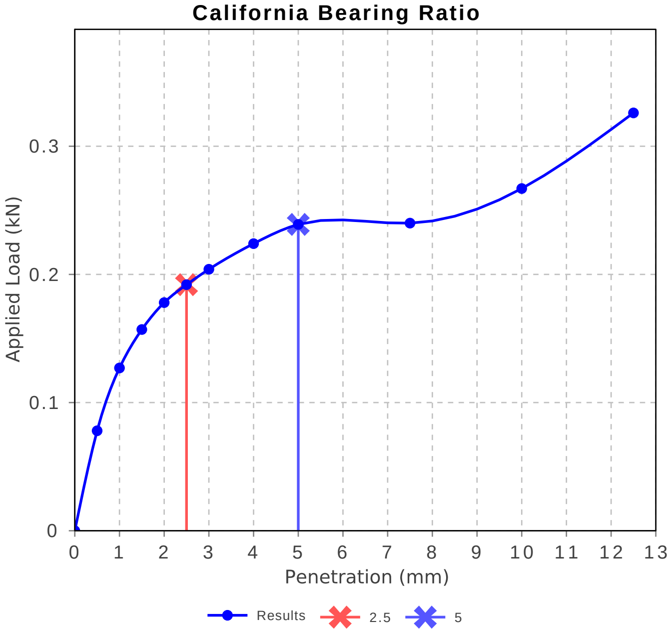
Approved Signatory: Travis Driver

Laboratory Accreditation Number: 431

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**1.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual/Tactile		
Maximum Dry Density (t/m^3)	1.25		
Optimum Moisture Content (%)	40.0		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	102.0		
Dry Density after Soaking (t/m^3)	1.20		
Field Moisture Content (%)	55.0		
Moisture Content at Placement (%)	40.7		
Moisture Content Top 30mm (%)	50.0		
Moisture Content Rest of Sample (%)	37.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	144		
Swell (%)	3.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**7**		
Soil Description	Silty Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	22		



Material Test Report

Report Number:	**NBRS25010-1**
Issue Number:	1
Date Issued:	10/07/2025
Client:	Jeffery and Katauskas Services Pty Ltd unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact:	Cody Surawski
Project Number:	NBRS25010
Project Name:	Site Investigation
Project Location:	163 Alexandra Parade, Lismore, NSW
Client Reference:	37365UOR - 37365UOR
Work Request:	121
Sample Number:	NBRS121C
Date Sampled:	02/06/2025
Dates Tested:	13/06/2025 - 25/06/2025
Sampling Method:	AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location:	**TP203, Depth: 0.4-0.5**
Material Source:	Insitu

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North Brisbane Laboratory
3 Roseby Road Caboolture QLD 4510
Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

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Laboratory Accreditation Number: 431

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	81		
Plastic Limit (%)	32		
Plasticity Index (%)	**49**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**23.0**		
Cracking Crumbling Curling	Cracking & Crumbling		

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	61.5		

Material Test Report

Report Number: **NBRS25010-1**
Issue Number: 1
Date Issued: 10/07/2025
Client: Jeffery and Katauskas Services Pty Ltd
unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact: Cody Surawski
Project Number: NBRS25010
Project Name: Site Investigation
Project Location: 163 Alexandra Parade, Lismore, NSW
Client Reference: 37365UOR - 37365UOR
Work Request: 121
Sample Number: NBRS121D
Date Sampled: 02/06/2025
Dates Tested: 13/06/2025 - 27/06/2025
Sampling Method: AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location: **TP204, Depth: 0.4-0.5**
Material Source: Insitu

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North Brisbane Laboratory
3 Roseby Road Caboolture QLD 4510
Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

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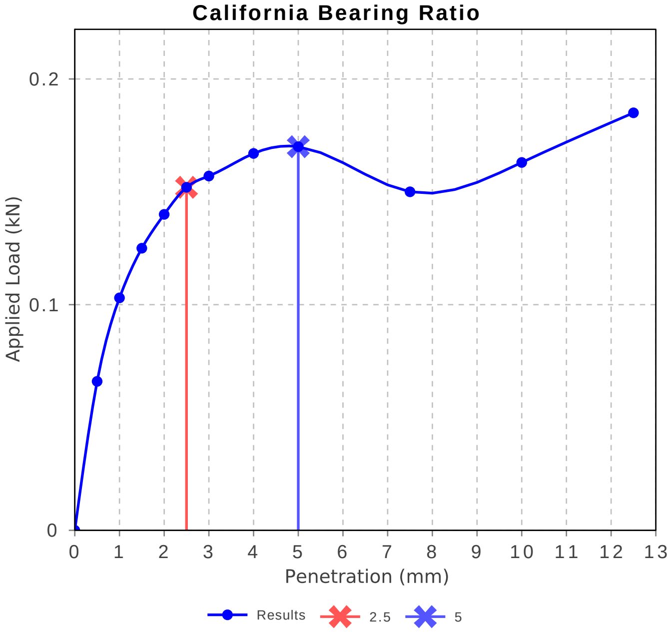
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**1.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual/Tactile		
Maximum Dry Density (t/m^3)	1.16		
Optimum Moisture Content (%)	45.0		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.07		
Field Moisture Content (%)	60.7		
Moisture Content at Placement (%)	44.7		
Moisture Content Top 30mm (%)	57.4		
Moisture Content Rest of Sample (%)	37.4		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	149.8		
Swell (%)	9.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Report Number:	**NBRS25010-1**
Issue Number:	1
Date Issued:	10/07/2025
Client:	Jeffery and Katauskas Services Pty Ltd unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact:	Cody Surawski
Project Number:	NBRS25010
Project Name:	Site Investigation
Project Location:	163 Alexandra Parade, Lismore, NSW
Client Reference:	37365UOR - 37365UOR
Work Request:	121
Sample Number:	NBRS121E
Date Sampled:	02/06/2025
Dates Tested:	13/06/2025 - 27/06/2025
Sampling Method:	AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location:	**TP207, Depth: 0.4-0.5**
Material Source:	Insitu

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Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

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Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	64		
Plastic Limit (%)	24		
Plasticity Index (%)	**40**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	**24.5**		
Cracking Crumbling Curling	Curling		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**1**		
Soil Description	Silty CLAY		
Nature of Water	Distilled		
Temperature of Water (^oC)	22		

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	35.5		

Material Test Report

Report Number:	**NBRS25010-1**
Issue Number:	1
Date Issued:	10/07/2025
Client:	Jeffery and Katauskas Services Pty Ltd unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact:	Cody Surawski
Project Number:	NBRS25010
Project Name:	Site Investigation
Project Location:	163 Alexandra Parade, Lismore, NSW
Client Reference:	37365UOR - 37365UOR
Work Request:	121
Sample Number:	NBRS121F
Date Sampled:	02/06/2025
Dates Tested:	13/06/2025 - 30/06/2025
Sampling Method:	AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location:	**TP209, Depth: 0.4-0.5**
Material Source:	Insitu

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3 Roseby Road Caboolture QLD 4510
Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

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Approved Signatory: Travis Driver
Laboratory Accreditation Number: 431

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	81		
Plastic Limit (%)	24		
Plasticity Index (%)	**57**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**28.5**		
Cracking Crumbling Curling	Cracking & Curling		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**5**		
Soil Description	Sandy CLAY		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	22		

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	37.7		

Material Test Report

Report Number: **NBRS25010-1**
Issue Number: 1
Date Issued: 10/07/2025
Client: Jeffery and Katauskas Services Pty Ltd
unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact: Cody Surawski
Project Number: NBRS25010
Project Name: Site Investigation
Project Location: 163 Alexandra Parade, Lismore, NSW
Client Reference: 37365UOR - 37365UOR
Work Request: 121
Sample Number: NBRS121G
Date Sampled: 02/06/2025
Dates Tested: 13/06/2025 - 30/06/2025
Sampling Method: AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location: **TP210, Depth: 0.2-0.25**
Material Source: Insitu

coffey TESTING
North Brisbane Laboratory
3 Roseby Road Caboolture QLD 4510
Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

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Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	49		
Plastic Limit (%)	26		
Plasticity Index (%)	**23**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**12.5**		
Cracking Crumbling Curling	Curling		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	Sandy CLAY		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	22		

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	33.8		

Material Test Report

Report Number:	**NBRS25010-1**
Issue Number:	1
Date Issued:	10/07/2025
Client:	Jeffery and Katauskas Services Pty Ltd unit 7,40 Leonard Crescent, Brendale QLD 4500
Contact:	Cody Surawski
Project Number:	NBRS25010
Project Name:	Site Investigation
Project Location:	163 Alexandra Parade, Lismore, NSW
Client Reference:	37365UOR - 37365UOR
Work Request:	121
Sample Number:	NBRS121H
Date Sampled:	02/06/2025
Dates Tested:	13/06/2025 - 25/06/2025
Sampling Method:	AS 1289.1.2.1 6.5.4 - Machine excavated pit or trench
Sample Location:	**BH212, Depth: 0.5-0.95**
Material Source:	Insitu

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North Brisbane Laboratory
3 Roseby Road Caboolture QLD 4510
Phone: 0419 664 279
Email: Travis.Driver@coffeytesting.com

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Approved Signatory: Travis Driver
Laboratory Accreditation Number: 431

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Wet Sieve		
Liquid Limit (%)	90		
Plastic Limit (%)	24		
Plasticity Index (%)	**66**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**28.0**		
Cracking Crumbling Curling	Cracking & Curling		

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	29.1		

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
MOISTURE CONTENT, ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client:	JK Geotechnics	**Report No.:**	37635UOR - A
Project:	Proposed High School	**Report Date:**	3/07/2025
Location:	163-170 Alexandria Parade, North Lismore, NSW	**Page 1 of 1**	

AS 1289	**TEST METHOD**	**2.1.1**	**3.1.2**	**3.2.1**	**3.3.1**	**3.4.1**
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**	**LIQUID LIMIT %**	**PLASTIC LIMIT %**	**PLASTICITY INDEX %**	**LINEAR SHRINKAGE %**
211	0.50 - 0.95	36.0	83	28	55	21.5*
213	0.50 - 0.90	15.6	50	25	25	8.0
214	0.50 - 0.95	33.4	81	31	50	22.5*
214	1.50 - 1.95	29.4	75	29	46	14.0
214	3.00 - 3.35	35.0	61	21	40	15.5
218	0.50 - 0.95	39.3	90	20	70	21.0**

Notes:
- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample: 17/06/2025.
- Sampled and supplied by client. Samples tested as received.
- * Denotes Linear Shrinkage curled.
- ** Denotes Linear Shrinkage cracked.

NATA
NATA Accredited Laboratory Number:1327

03/07/2025
Authorised Signature / Date
(D. Treweek)

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

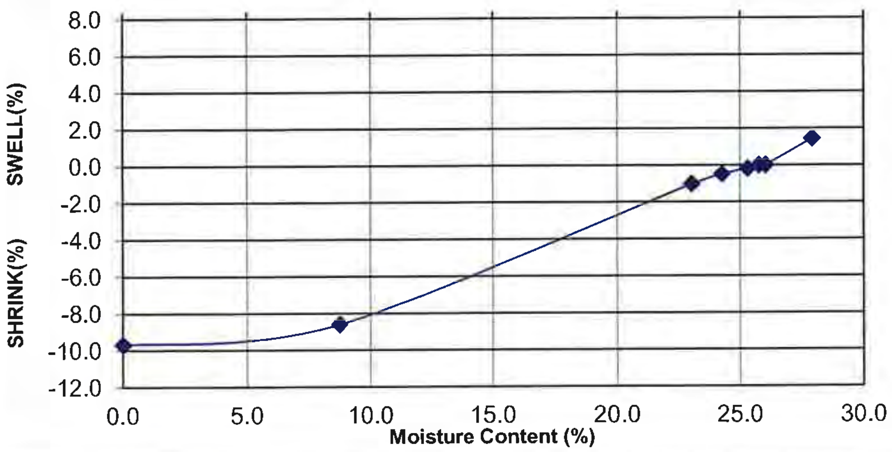
Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandria Parade, North Lismore, NSW

Report No.: 37635UOR - B
Report Date: 3/07/2025

Borehole No.: 211		Depth: 0.95 - 1.31m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
26.0%	27.9%	190 kPa	120,140 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.6%	1.4%	9.4%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
5.64 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 17/06/2025.

NATA
NATA Accredited Laboratory Number:1327

Accredited for compliance with ISO/IEC 17025 - Testing.
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Authorised Signature / Date
(D. Treweek) 30/7/25

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

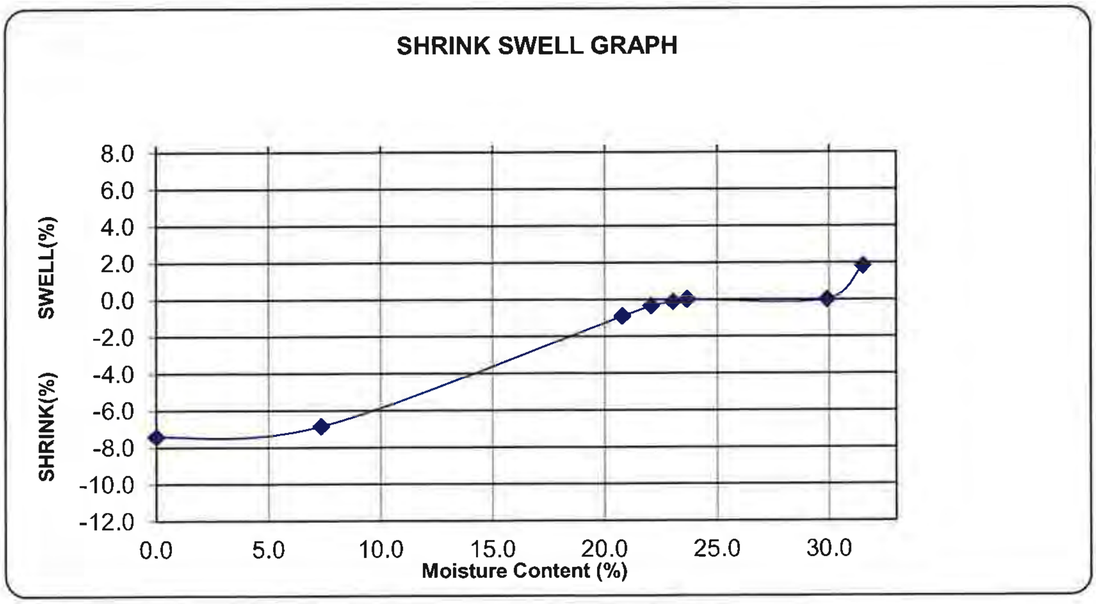
ABN 43 002 145 173

TABLE B
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandria Parade, North Lismore, NSW

Report No.: 37635UOR - B
Report Date: 3/07/2025

Borehole No.: 214		Depth: 1.00 - 1.22m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
29.9%	31.5%	220,260 kPa	190 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.2%	1.8%	7.3%



SHRINK SWELL INDEX
4.55 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 17/06/2025.

NATA

NATA Accredited Laboratory Number:1327

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3/7/25

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North Ryde, Bc 1670
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Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

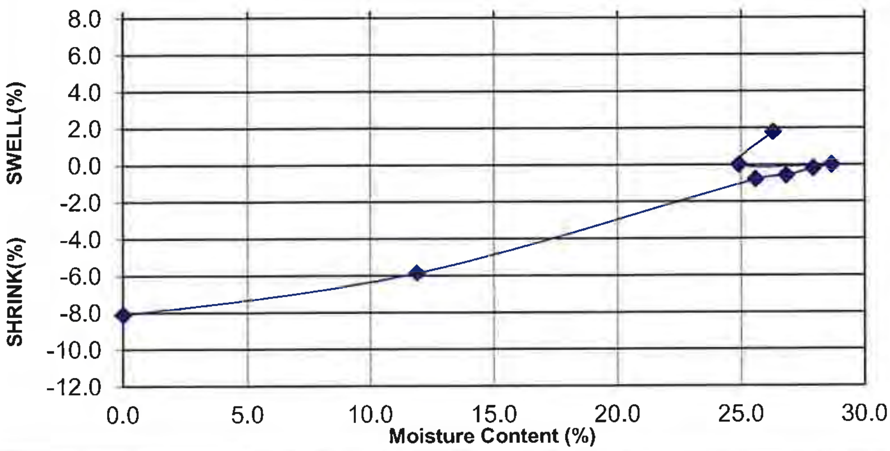
TABLE B
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandria Parade, North Lismore, NSW

Report No.: 37635UOR - B
Report Date: 3/07/2025

Borehole No.: 214		Depth: 3.00 - 3.42m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
24.9%	26.3%	>600 kPa	140,170 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.2%	1.8%	7.9%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
4.86 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 17/06/2025.

NATA
NATA Accredited Laboratory Number:1327

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Authorised Signature / Date (D. Treweek) 3/7/25

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

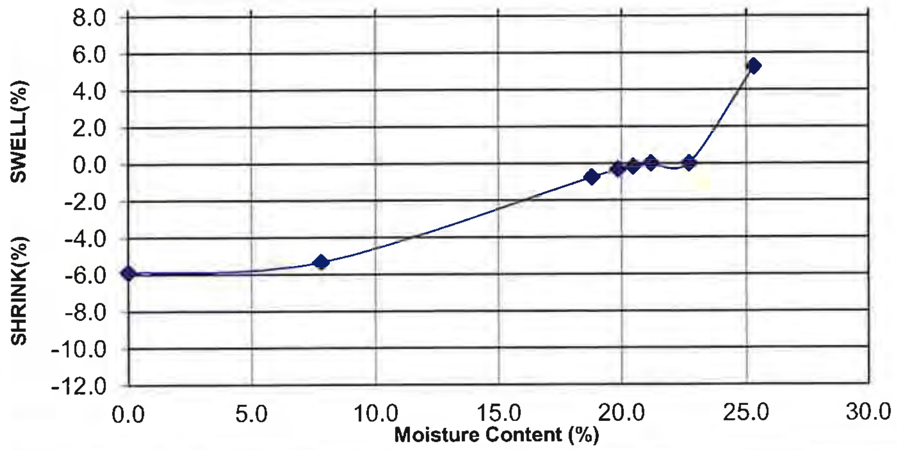
ABN 43 002 145 173

TABLE B
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client:	JK Geotechnics	**Report No.:**	37635UOR - B
Project:	Proposed High School	**Report Date:**	3/07/2025
Location:	163-170 Alexandria Parade, North Lismore, NSW	**Page**	4 of 4

Borehole No.: 218 | Depth: 0.50 - 0.95m

MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
22.7%	25.3%	400,600 kPa	240,280 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.3%	5.2%	5.7%



SHRINK SWELL INDEX
4.64 %/pF

Notes: Sampled and supplied by client. Sample tested as received.

- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 17/06/2025.

NATA
NATA Accredited Laboratory Number:1327

Accredited for compliance with ISO/IEC 17025 - Testing.
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In full without approval of the laboratory. Results relate only to the items tested or sampled.

Authorised Signature / Date
(D. Treweek) 3/7/25

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

CERTIFICATE OF ANALYSIS 382702

Client Details

Client	JK Geotechnics
Attention	Cody Surawski
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**37635UOR, North Lismore**
Number of Samples	17 Soil
Date samples received	06/06/2025
Date completed instructions received	06/06/2025

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	16/06/2025
Date of Issue	16/06/2025

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Inorganics Supervisor

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		382702-1	382702-2	382702-3	382702-4	382702-5
Your Reference	UNITS	TP202	TP202	TP203	TP203	TP207
Depth		0.6-0.7	3.0-3.4	1.0-1.1	1.5-1.6	0.6-0.65
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/06/2025	12/06/2025	12/06/2025	12/06/2025	12/06/2025
Date analysed	-	12/06/2025	12/06/2025	12/06/2025	12/06/2025	12/06/2025
pH 1:5 soil:water	pH Units	7.3	7.2	7.6	7.7	7.9
Chloride, Cl 1:5 soil:water	mg/kg	58	660	190	140	220
Sulphate, SO4 1:5 soil:water	mg/kg	34	190	210	200	110
Resistivity in soil*	ohm m	78	37	37	27	20

Misc Inorg - Soil						
Our Reference		382702-6	382702-7	382702-8	382702-9	382702-10
Your Reference	UNITS	TP207	TP207	TP208	TP208	TP208
Depth		1.1-1.2	1.4-1.5	0.3-0.4	0.7-0.8	1.3-1.4
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/06/2025	12/06/2025	12/06/2025	12/06/2025	12/06/2025
Date analysed	-	12/06/2025	12/06/2025	12/06/2025	12/06/2025	12/06/2025
pH 1:5 soil:water	pH Units	7.5	8.1	4.6	4.6	4.7
Chloride, Cl 1:5 soil:water	mg/kg	47	20	1,700	1,700	1,500
Sulphate, SO4 1:5 soil:water	mg/kg	110	20	430	470	230
Resistivity in soil*	ohm m	20	20	18	15	16

Misc Inorg - Soil						
Our Reference		382702-11	382702-12	382702-13	382702-14	382702-15
Your Reference	UNITS	TP208	TP208	TP209	TP212	TP212
Depth		2.3-2.4	3.0-3.1	2.3-2.4	1.5-1.7	3.0-3.1
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	12/06/2025	12/06/2025	12/06/2025	12/06/2025	12/06/2025
Date analysed	-	12/06/2025	12/06/2025	12/06/2025	12/06/2025	12/06/2025
pH 1:5 soil:water	pH Units	6.8	7.1	7.3	7.5	8.1
Chloride, Cl 1:5 soil:water	mg/kg	1,100	870	1,300	380	130
Sulphate, SO4 1:5 soil:water	mg/kg	160	150	480	160	39
Resistivity in soil*	ohm m	17	17	15	14	15

Misc Inorg - Soil			
Our Reference		382702-16	382702-17
Your Reference	UNITS	TP212	TP217
Depth		6.0-6.1	0.2-0.3
Type of sample		Soil	Soil
Date prepared	-	12/06/2025	12/06/2025
Date analysed	-	12/06/2025	12/06/2025
pH 1:5 soil:water	pH Units	8.1	6.5
Chloride, Cl 1:5 soil:water	mg/kg	42	<10
Sulphate, SO4 1:5 soil:water	mg/kg	20	10
Resistivity in soil*	ohm m	20	33

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	382702-2
Date prepared	-			12/06/2025	1	12/06/2025	12/06/2025		12/06/2025	12/06/2025
Date analysed	-			12/06/2025	1	12/06/2025	12/06/2025		12/06/2025	12/06/2025
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	7.3	7.3	0	98	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	58	56	4	92	#
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	34	33	3	91	86
Resistivity in soil*	ohm m	1	Inorg-002	<1	1	78	62	23	[NT]	[NT]

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	12/06/2025	12/06/2025		[NT]	[NT]
Date analysed	-			[NT]	11	12/06/2025	12/06/2025		[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	11	6.8	6.9	1	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	1100	1100	0	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	160	160	0	[NT]	[NT]
Resistivity in soil*	ohm m	1	Inorg-002	[NT]	11	17	16	6	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Air volumes are typically provided by customers (often as flow rate(s) and sampling time(s) and/or simply volumes) sampled or exposure times (determines 'volume' passive badges are exposed to)). Hence in such circumstances the volume measurement is inevitably not covered by Envirolab's NATA accreditation. An exception may occur where Envirolab Newcastle does the sampling where accreditation exists for certain types of sampling and hence volume determination(s). Note air volumes are often used to determine concentrations for dust and/or analyses on filters, sorbents and in impingers. For canister sampling, the air volume is covered by Envirolab's NATA accreditation.

Urine Analysis - The BEI values listed are taken from the 2022 edition of "TLVs and BEIs Threshold Limits" by ACGIH.

Report Comments

MISC_INORG_DRY: # Percent recovery is not applicable due to the high concentration of the analyte/s in the sample/s. However an acceptable recovery was obtained for the LCS.

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	Department of Education	**Ref No:**	37635UOR
Project:	Northern Rivers Flood Recovery - Richmond River High Campus Development	**Report:**	A
Location:	163 & 170 Alexadra Parade, North Lismore, NSW	**Report Date:**	16/06/25

BOREHOLE NUMBER	DEPTH (m)	$I_{S\,(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
206	3.30 - 3.34	0.8	16	A
	3.73 - 3.77	1.2	24	A
	4.72 - 4.76	0.2	4	A
	5.39 - 5.42	0.3	6	A
	5.95 - 5.98	0.6	12	A
	6.60 - 6.64	0.3	6	A
	7.10 - 7.14	0.5	10	A
	8.33 - 8.37	0.8	16	A
	9.17 - 9.20	0.3	6	A
	9.68 - 9.72	0.1	2	A
	10.22 - 10.26	0.7	14	A
	10.67 - 10.71	0.6	12	A
	11.16 - 11.20	4.3	86	A
	11.54 - 11.58	3.3	66	A
	11.77 - 11.81	0.6	12	A
	12.16 - 12.20	0.7	14	A
	12.54 - 12.57	0.7	14	A
	13.63 - 13.67	0.07	1	A
	13.80 - 13.83	0.2	4	A
	14.29 - 14.32	0.4	8	A
211	5.86 - 5.90	0.2	4	A
	6.10 - 6.14	0.3	6	A
	6.35 - 6.39	3.1	62	A
	6.93 - 6.97	3.6	72	A
	7.13 - 7.17	3.5	70	A

NOTE: SEE PAGE 4

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	Department of Education	**Ref No:**	37635UOR
Project:	Northern Rivers Flood Recovery - Richmond River High Campus Development	**Report:**	A
Location:	163 & 170 Alexadra Parade, North Lismore, NSW	**Report Date:**	16/06/25

BOREHOLE NUMBER	DEPTH (m)	$I_{S(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
211	7.67 - 7.71	0.08	2	A
	7.85 - 7.88	0	<1	A
	8.26 - 8.30	0.8	16	A
	8.30 - 8.34	1	20	A
	8.68 - 8.71	2.4	48	A
	9.08 - 9.11	0.3	6	A
	9.62 - 9.65	0.08	2	A
	10.36 - 10.39	0.9	18	A
	10.56 - 10.59	5.4	108	A
	10.76 - 10.80	4.2	84	A
	11.05 - 11.09	3.4	68	A
	11.59 - 11.63	0.5	10	A
	11.83 - 11.87	0.2	4	A
	12.25 - 12.28	0.5	10	A
	12.91 - 12.93	0.4	8	A
	13.18 - 13.21	0.5	10	A
212	8.90 - 8.94	3.8	76	A
	8.90 - 8.94	3.8	76	A
	9.37 - 9.40	5.2	104	A
	10.38 - 10.42	3.8	76	A
	11.40 - 11.45	3.3	66	A
	12.74 - 12.78	7.6	152	A
	13.47 - 13.51	5.5	110	A
	14.62 - 14.66	5.4	108	A

NOTE: SEE PAGE 4

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client: Department of Education **Ref No:** 37635UOR

Project: Northern Rivers Flood Recovery - Richmond River High Campus Development **Report:** A

Location: 163 & 170 Alexadra Parade, North Lismore, NSW **Report Date:** 16/06/25

BOREHOLE NUMBER	DEPTH (m)	$I_{S\ (50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
213	2.12 - 2.16	3.9	78	A
	2.60 - 2.64	3.9	78	A
	3.06 - 3.09	1.8	36	A
	3.86 - 3.90	2.1	42	A
	4.01 - 4.04	0.6	12	A
	4.88 - 4.92	0.6	12	A
	5.60 - 5.64	3.9	78	A
	6.06 - 6.10	3.5	70	A
	6.86 - 6.90	3.9	78	A
	7.26 - 7.30	3.8	76	A
	7.78 - 7.81	4.3	86	A
	8.08 - 8.12	4	80	A
	8.33 - 8.37	4.2	84	A
	9.11 - 9.14	0.5	10	A
	9.85 - 9.89	1.5	30	A
	10.25 - 10.29	0.8	16	A
	10.77 - 10.81	3.9	78	A
	11.10 - 11.13	3.6	72	A
	11.97 - 12.00	4.8	96	A
	12.28 - 12.31	5.1	102	A
	12.89 - 12.92	0.6	12	A
	12.92 - 12.95	1.9	38	A
	13.15 - 13.17	5.5	110	A
	13.65 - 13.68	0.4	8	A
	14.07 - 14.11	0.4	8	A

NOTE: SEE PAGE 4

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	Department of Education	**Ref No:**	37635UOR
Project:	Northern Rivers Flood Recovery - Richmond River High Campus Development	**Report:**	A
Location:	163 & 170 Alexadra Parade, North Lismore, NSW	**Report Date:**	16/06/25
		Page 4 of 4	

BOREHOLE NUMBER	DEPTH (m)	$I_{S\ (50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
214	14.44 - 14.48	4.3	86	A
	14.62 - 14.65	0.1	2	A
	14.90 - 14.94	3.6	72	A
	15.24 - 15.27	4.1	82	A
	15.87 - 15.90	4.6	92	A
	16.25 - 16.29	4.1	82	A
	16.82 - 16.85	4.3	86	A
218	8.17 - 8.21	4.2	84	A
	8.72 - 8.74	5.2	104	A
	9.14 - 9.18	3.6	72	A
	9.86 - 9.89	4.4	88	A
	10.23 - 10.27	3.2	64	A
	10.70 - 10.74	3.7	74	A
	11.21 - 11.25	3.9	78	A
	11.78 - 11.82	3.3	66	A
	12.50 - 12.52	2.7	54	A
	12.72 - 12.75	4.3	86	A
	12.76 - 12.80	0.7	14	A
	13.20 - 13.24	3.6	72	A
	13.74 - 13.77	4.5	90	A
	14.32 - 14.36	3.9	78	A
	14.50 - 14.53	4.4	88	A

NOTES

1. In the above table, testing was completed in test direction A for the axial direction, D for the diametral direction, B for the block test and L for the lump test.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa.
5. The estimated Unconfined Compressive Strength was calculated from the Point Load Strength Index based on the correlation provided in AS1726:2017 'Geotechnical Site Investigations' and rounded off to the nearest whole number: U.C.S. = 20 $I_{S(50)}$.

JKGeotechnics

BOREHOLE LOG

Borehole No.
206

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 17.8 m
Date: 28/5/25 TO 29/5/25 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** A.G./P.R.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
ON COMPLETION OF CORING / DRY ON COMPLETION OF AUGERING							0			TOPSOIL: Silty clay, medium plasticity, dark brown, with root fibres.	w>PL			
									CI	Silty CLAY: medium plasticity, dark brown, with fine to coarse grained, sub-angular basalt gravel.	w>PL	St - VSt		RESIDUAL
						17	1		-	BASALT: grey, highly fractured, with numerous clay bands.	HW - MW	L - M		LISMORE BASALT LOW BUCKET RESISTANCE
						16	2			BASALT: dark grey.	MW	H		HIGH 'TC' BIT RESISTANCE
						15, 14, 13, 12, 11	3, 4, 5, 6			REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 5.7m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 5.7m TO 1.5m. CASING +1.05m TO 1.5m. 2mm SAND FILTER PACK 5.7m TO 1.0m. BENTONITE SEAL 1.0m TO 0.1m. BACKFILLED WITH SAND AND CUTTINGS TO THE SURFACE. COMPLETED WITH A CONCRETED MONUMENT.

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CORED BOREHOLE LOG

Borehole No. 206

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR | **Core Size:** NMLC | **R.L. Surface:** 17.8 m
Date: 28/5/25 TO 29/5/25 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK300 | **Bearing:** N/A | **Logged/Checked By:** A.G./P.R.

Water Loss\Level	Depth (m)	CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) Specific / General	Formation
	to 2.65	START CORING AT 2.65m					
20% RETURN	2.65–4.15	BASALT: dark grey.	MW	M - H	0.80, 1.2	(2.85m) J, 90°, C, R, Fe Sn (2.65-4.15m) J, 15°, P, R, Fe Sn, Spaced 10mm-50mm (2.65-4.15m) J, 45°, P, R, Fe Sn, Spaced 10mm-50mm	Lismore Basalt
	4.15–4.42	NO CORE 0.27m					
30% RETURN / 20% RETURN	4.42–7.10	BASALT: dark grey.	HW	L - M / M	0.20, 0.30, 0.60, 0.30, 0.50	(5.62m) XWS, 45°, 2 mm.t (4.42-6.90m) J, 45 - 60°, P, S, Fe Sn, Spaced 10mm-40mm (5.78m) XWS, 45°, 2 mm.t (6.26-6.60m) J, 45 - 90°, Ir, R, Fe Sn (6.73m) XWS, 0°, 20 mm.t (6.84m) J, 0°, P, R, Fe Sn	Lismore Basalt
	7.10–7.70	NO CORE 0.60m					
20% RETURN	7.70–8.65	BASALT: dark grey.	HW	M	0.80	(7.69-8.63m) J, 0 - 10°, Ir, R, Fe Sn, Spaced 5mm-50mm (8.42m) J, 90°, Ir, R, Fe Sn (8.52m) J, 65°, P, R, Clay FILLED, 2 mm.t	Lismore Basalt
	8.65–8.90	NO CORE 0.25m					
	8.90–	BASALT: dark grey.	HW	L - M		(8.87m) XWS, 0°, 70 mm.t	

RL (m AHD): 15, 14, 13, 12, 11, 10, 9

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CORED BOREHOLE LOG

Borehole No.
206

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Core Size:** NMLC **R.L. Surface:** 17.8 m
Date: 28/5/25 TO 29/5/25 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK300 **Bearing:** N/A **Logged/Checked By:** A.G./P.R.

Water Loss\Level	CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	Point Load Strength Index $I_s(50)$	Formation
80% RETURN	BASALT: dark grey. *(continued)*	HW	L - M	0.30, 0.10	Lismore Basalt
80% RETURN			M	0.70, 0.60	
		SW	VH	4.3, 3.3	
		HW	M	0.60, 0.70, 0.70	
	NO CORE 0.15m				
	VOLCANIC BRECCIA: grey and light grey brown, fine to coarse grained angular basalt gravel.	HW	VL - L	0.070	Lismore Basalt
			M	0.20	
	as above, but fine grained and dark grey.			0.40	
	END OF BOREHOLE AT 14.55 m				

RL (m AHD): 8, 7, 6, 5, 4, 3, 2
Depth (m): 10, 11, 12, 13, 14, 15

Point load strength index scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH
Spacing (mm): 600, 200, 60, 20

DEFECT DETAILS – DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness)

Specific / General

- (9.09m) XWS, 0°, 30 mm.t
- (9.24m) XWS, 0°, 5 mm.t
- (9.55m) J, 0°, P, R, Fe FILLED
- (9.85m) XWS, 0°, 10 mm.t
- (10.11m) XWS, 30°, 8 mm.t
- (8.88-11.65m) J, 15 - 90°, P or Ir, R, Fe Sn, Spaced 10mm-150mm
- (8.88-12.95m) Ji, 15 - 90°, Ir, Fe FILLED, Spaced 1mm-50mm
- (11.12m) J, 5°, Ir, R, Fe Sn
- (11.17m) J, 0°, Ir, R, Fe Sn
- (11.42m) J, 90°, Un, R, Fe Sn
- (13.00m) XWS, 0°, 100 mm.t
- (13.19m) XWS, 20°, 18 mm.t
- (13.40m) XWS, 0°, 140 mm.t
- (14.05m) J, 55°, Ir, R, Fe Sn
- (14.11m) J, 45°, P, S, Fe Sn
- (14.15m) J, 45°, P, R, Fe Sn
- (14.21m) Cr, 0°, 35 mm.t
- (14.36m) XWS, 70°, 40 mm.t
- (14.48m) J, 70°, P, R, Clay Vn

JK 9.02.4 LIB.GLB Log JK CORED BOREHOLE - MASTER 37635UOR NORTHLISMORE.GPJ <<DrawingFile>> 15/07/2025 11:18 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH 206
DEPTH: 2.65m to 11.00m
JKGeotechnics
Kodak Gray Scale
Kodak Color Control Patches
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
36314UOR BH206 START CORING AT 2.65m
2
3
4
NO CORE 0.27mt
5
NO CORE 0.21mt
6
7
NO CORE 0.6mt
8
NO CORE 0.25mt
9
10


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH 206
DEPTH: 11.00m - 14.55m
JKGeotechnics
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
11
12
13
14
NO CORE 0.15mt
END OF BOREHOLE AT 14.55m

JKGeotechnics

BOREHOLE LOG

Borehole No.
211

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 19.2 m
Date: 4/6/25 TO 5/6/25 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./P.R.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING		19	0		FILL: Silty clay topsoil, high plasticity, dark brown, trace of root fibres.	w>PL			
					FILL: Silty clay, high plasticity, brown, red brown and dark brown, trace of fine to medium grained ironstone gravel.	w>PL			
	N = 3 0,1,2	18	1	CH	Silty CLAY: high plasticity, dark brown, trace of ironstone gravel.	w>PL	F	70 60 60	COLLUVIAL
	N = 17 3,5,12						VSt - Hd	280 430 440	
		17	2	-	Extremely Weathered basalt, silty gravelly CLAY, low plasticity, grey and brown, fine grained basalt gravel, with very low to low strength basalt bands.	XW	Hd		LISMORE BASALT VERY LOW 'TC' BIT RESISTANCE WITH OCCASIONAL MODERATE TO HIGH BANDS
30 MINS AFTER COMPLETION OF CORING	N=SPT 16/ 40mm REFUSAL	16 / 15	3 / 4						
		14	5		BASALT: grey and dark grey, trace of very low strength bands.	MW	M - H		MODERATE TO HIGH RESISTANCE WITH OCCASIONAL VERY LOW BANDS
		13	6		REFER TO CORED BOREHOLE LOG				

SAMPLES: ES, U50, DB, DS

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
211

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR	**Core Size:** NMLC	**R.L. Surface:** 19.2 m
Date: 4/6/25 TO 5/6/25	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK309	**Bearing:** N/A	**Logged/Checked By:** A.G./P.R.

Column headings: Water Loss\Level | Barrel Lift | RL (m AHD) | Depth (m) | Graphic Log | CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components) | Weathering | Strength | POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH) | DEFECT DETAILS: SPACING (mm) (600, 200, 60, 20) | DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) Specific / General | Formation

RL (m AHD): 14, 13, 12, 11, 10, 9, 8
Depth (m): 6, 7, 8, 9, 10, 11

Water Loss\Level: 50-75% RETURN (from 5.50m to approx. 9.7m); 50% RETURN (below)

START CORING AT 5.50m

Core description

Depth (m)	Description
5.50 – 8.65	BASALT: grey and dark grey, with brown and red brown staining, with occasional extremely weathered gravel inclusions, rounded.
8.65 –	as above, but dark grey, with brown and red brown staining, trace of very low strength bands.

Weathering / Strength

Depth (m)	Weathering	Strength
5.50 – 6.30	MW	L - M
6.30 – 7.60	SW	VH
7.60 – 8.20	HW	VL - L
8.20 – 9.05	SW	M - H
9.05 – 10.50	MW	L - M
10.50 – 11.50	SW	VH
11.50 –	HW	L - M

Point load strength index $I_s(50)$: 0.20, 0.30, 3.1, 3.6, 3.5, 0.080, 0.80, 1.0, 2.4, 0.30, 0.080, 0.90, 5.4, 4.2, 3.4, 0.50, 0.20

Defect details – Description (Specific)

(5.67m) J x 2, 40°, Fe Ct
(5.77m) J, 10°, C, S, Fe Sn
(5.81m) J, 85°, Un, R, Cn
(6.11m) Jx 2, 45°, P, S, Cn
(6.18m) Jx 2, 30 - 60°, Ir, R, Fe Sn
(6.27m) J, 30 - 70°, R, Cn
(6.46m) J, 90°, Ir, R, Clay Cn
(6.85m) J, 90°, Un, R, Clay FILLED, and Fe, Sn
(7.16m) XWS, 0°, 30 mm.t
(7.27m) Jx 3, 20 - 80°, P, S, Fe Sn
(7.41m) XWS, 0°, 25 mm.t
(7.57m) J, 10°, P, S, Clay Vn
(7.61m) J, 20 - 90°, Fe Sn
(7.67m) CS, 0°, 20 mm.t
(7.94m) J, 10°, P, S, Clay Vn
(8.00m) J, 80°, Ir, R, Fe Sn
(8.32m) Cr, 0°, Fe St, 150 mm.t
(8.54m) Jix 3, 80°, Fe Sn
(8.69m) J, 70°, C, R, Fe Sn
(8.80m) J, 75°, P, S, Fe Sn
(8.85m) Cr, 70°, 30 mm.t
(8.93m) J, 70 - 80°, C, R, Cn
(9.03m) J, 15°, P, R, Fe Sn
(9.14m) J, 0°, Ir, R, Fe Sn
(9.22m) J, 60°, Ir, S, Fe Sn
(9.38m) J, 75°, P, S, Fe Sn
(9.48m) J, 80°, Fe Sn
(9.56m) J, 35°, P, S, Cn
(9.63m) Jx 2, 20 - 70°, P, S, Fe Sn
(9.72m) CS, 0°, 30 mm.t
(9.80m) Jx 3
x 2, 75°, P, S, Fe Sn
(9.87m) J, 80°, P, S, Cn
(9.91m) Cr, 0°, 90 mm.t
(10.08m) J, 60°, P, S, Fe Sn
(10.13m) J, 30°, P, S, Fe Sn
(10.21m) XWS, 0°, 15 mm.t
(10.25m) J, 35°, P, S, Fe Sn
(10.34m) J, 40°, P, S, Fe Sn
(10.45m) XWS, 0°, 20 mm.t
(10.58m) J, 30°, P, S, Cn
(10.82m) J, 0°, P, S, Fe Sn
(10.90m) J, 10°, P, S, Clay FILLED
(11.11m) J, 10°, P, S, Fe Sn
(11.28m) J, 20°, P, S, Fe Sn
(11.38m) J, 0°, P, S, Fe Sn
(11.46m) J, 10°, P, S, Cn
(11.55m) J, 10°, P, S, Fe Sn
(11.61m) J, 5°, P, S, Fe Sn
(11.70m) J, 20°, C, S, Fe Sn
(11.74m) Cr, 0°, 45 mm.t

Formation: Lismore Basalt

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
211

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR	**Core Size:** NMLC	**R.L. Surface:** 19.2 m
Date: 4/6/25 TO 5/6/25	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK309	**Bearing:** N/A	**Logged/Checked By:** A.G./P.R.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS: SPACING (mm)	DEFECT DETAILS: DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)	Formation
50% RETURN		7			BASALT: as above	HW	L - M	0.50		(11.79-12.34m) J, 10 - 60°, Fe Sn, Spaced every 5-10mm	Lismore Basalt
0-25% RETURN		6	13		VOLCANIC BRECCIA: brown and orange brown,, fine to coarse grained angular basalt gravel and clay inclusions, with tuff matrix.		M	0.40 0.50		(12.72m) J, 0°, P, S, Clay FILLED (13.23m) J, 0°, P, S, Clay FILLED (13.35m) Highly Fractured Zone, 510 mm.t	
		5 4 3 2 1	14 15 16 17 18		END OF BOREHOLE AT 13.86 m						

Point load strength scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH. Spacing scale: 600, 200, 60, 20.

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
JKGeotechnics
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH211
DEPTH: 5.50m - 13.86m
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
37365UOR BH211 START CORING AT 5.50m
5
6
7
8
9
10
11
12
13
END OF BOREHOLE AT 13.86m

JKGeotechnics

BOREHOLE LOG

Borehole No.
212

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 22.2 m
Date: 27/5/25 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** C.S./P.R.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING	ES		22	0		FILL: Gravel, fine to coarse grained, angular, grey.	D			
	ES					FILL: Sandy gravel, fine to medium grained, angular, brown, fine to coarse grained sand.	M			
	DS	N = 6 2,3,3		1	CH	Gravelly CLAY: high plasticity, dark grey mottled brown, fine to medium grained angular gravel,, trace of roots.	w>PL	St	240 220 160 190	ALLUVIAL
ON COMPLETION OF CORING	DS	N=SPT 20/ 120mm REFUSAL N=SPT 20/ 100mm REFUSAL	21 20 19 18	2 3 4	GC	Clayey GRAVEL: fine to medium grained, angular, dark grey mottled dark red, orange, grey and brown, with clay bands, some shear planes in clay bands.	M D	(VD)		COLLUVIAL
	DS	N=SPT 10/ 50mm REFUSAL	17	5	-	BASALT: brown mottled grey.	HW	(L)		POSSIBLE BOULDER
	DS	N=SPT 15/ 100mm REFUSAL	16	6	GC	Clayey GRAVEL:fine to coarse grained angular, brown mottled orange, grey and yellow.	D	(VD)		POSSIBLE EXTREMELY WEATHERED BASALT

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BOREHOLE LOG

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 22.2 m
Date: 27/5/25 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** C.S./P.R.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
						15			GC	Clayey GRAVEL:fine to coarse grained angular, brown mottled orange, grey and yellow. *(continued)*	D	(VD)		
						14	8		-	BASALT: grey.	HW	(L)		LISMORE BASALT
						13, 12, 11, 10, 9	9, 10, 11, 12, 13			REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 6.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 6.0m TO 1.0m. CASING 0m TO 1.0m. 2mm SAND FILTER PACK 6.0m TO 1.0m. BENTONITE SEAL 1.0m TO 0.1m. STEEL COVER INSTALLED FLUSH WITH GROUND AND CONCRETED.

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CORED BOREHOLE LOG

Borehole No.
212

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR | **Core Size:** NMLC | **R.L. Surface:** 22.2 m
Date: 27/5/25 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK300 | **Bearing:** N/A | **Logged/Checked By:** C.S./P.R.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness — Specific	General	Formation
		14			START CORING AT 8.65m							
100% RETURN		13, 12, 11, 10, 9, 8	9, 10, 11, 12, 13, 14		BASALT: dark grey, trace of chlorite seams.	FR	VH	3.8, 5.2, 3.8, 3.3, 7.6, 5.5, 5.4		(8.90m) XWS, 5°, 1 mm.t (9.14m) J, 15°, P, S, Cn (9.49m) XWS, 5°, 2 mm.t (9.56m) J, 40°, P, S, Cn (9.61m) XWS, 0°, 2 mm.t (9.90m) J, 0°, Ir, R, Fe Sn (9.98m) J, 45°, St, R, Ca Vn (10.05m) J, 5°, P, S, Chlorite Vn (11.09m) J, 15°, P, S, Fe Sn, x 2, and Chlorite Veneer (11.39-11.91m) Numerous J's, 0 - 30°, P and C, S, Chlorite Vn, Spaced ~100mm (12.18m) J, 0°, P, S, Chlorite Vn (12.20m) J, 0°, P, S, Chlorite Vn (12.26m) J, 0°, P, S, Chlorite Vn (12.73m) J, 30°, P, S, Chlorite Vn (13.13-13.60m) J, 5°, P, S, Chlorite Vn, Spaced 60mm-180mm (13.85m) J, 35°, P, R, Cn		Lismore Basalt
					END OF BOREHOLE AT 14.73 m							

Point load strength index scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH
Spacing scale: 600, 200, 60, 20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
JKGeotechnics
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH212
DEPTH: 8.65-14.73m
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
37635UOR BH212 START CORING AT 8.65m
8
9
10
11
12
13
14
15 END OF BOREHOLE AT 14.73m

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BOREHOLE LOG

Borehole No.
213

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 19.6 m
Date: 3/6/25 TO 4/6/25 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./P.R.

Groundwater Record	SAMPLES ES / U50 / DB / DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING							FILL: Sand	M			BACKFILLED ARCHAEOLOGIST TEST PIT EXCAVATED TO 0.4m DEPTH
		N > 28 5,12,16/ 100mm REFUSAL	19	1		CL	Silty gravelly CLAY: medium plasticity, brown and grey mottled, fine to coarse grained angular basalt.	w<PL	(Hd)		RESIDUAL TOO GRAVELLY FOR HP TESTING
			18			-	BASALT: dark grey.	SW	H		LISMORE BASALT HIGH 'TC' BIT RESISTANCE
			17, 16, 15, 14, 13	2, 3, 4, 5, 6			REFER TO CORED BOREHOLE LOG				

JKGeotechnics

CORED BOREHOLE LOG

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR | **Core Size:** NMLC | **R.L. Surface:** 19.6 m
Date: 3/6/25 TO 4/6/25 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK309 | **Bearing:** N/A | **Logged/Checked By:** A.G./P.R.

Water Loss\Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	Point Load Strength Index $I_s(50)$	Formation
	0.00–1.90	START CORING AT 1.90m				
20% RETURN	1.90–3.62	BASALT: dark grey.	SW	VH (to ~2.9m), H (~2.9–3.62m)	3.9, 3.9, 1.8	Lismore Basalt
90% RETURN	3.62–4.44	Extremely Weathered basalt: silty clayey GRAVEL, fine to medium grained, dark brown, with medium and high strength basalt bands up to 80mm.t.	XW	(VD)	2.1, 0.60	Lismore Basalt
	4.44–4.66	NO CORE 0.22m				
	4.66–4.97	BASALT: dark grey.	MW	M	0.60	Lismore Basalt
	4.97–5.54	Extremely Weathered basalt: silty clayey GRAVEL, fine to medium grained, dark brown, with basalt bands up to 80mm.t.	XW	(Hd)		Lismore Basalt
	5.54–7.90	BASALT: dark grey.	SW	VH	3.9, 3.5, 3.9, 3.8, 4.3	Lismore Basalt

RL (m AHD): 18, 17, 16, 15, 14, 13, 12

DEFECT DETAILS

Spacing (mm): 600, 200, 60, 20

Description: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)

- (2.12m) J, 25°, P, R, Cn
- (2.24m) J, 65°, P, R, Cn
- (2.27m) J, 30°, P, R, Cn
- (2.31m) J, 45°, P, R, Cn
- (2.33m) J, 0°, P, S, Cn
- (2.50m) J, 0°, P, S, Cn
- (2.57m) J x 2, 0°, P, R, Cn
- (2.74m) J, 90°, Un, R, Fe Sn
- (2.83m) J, 45°, P, R, Fe Ct
- (2.88m) XWS, 0°, 120 mm.t
- (3.05m) J, 5°, P, S, Cn
- (3.11m) XWS, 5°, 120 mm.t
- (3.49m) J, 5°, P, R, Cn
- (3.52m) J, 0°, Ir, R, Cn
- (3.59m) J, 45°, Ir, R, Fe Vn
- (3.62-3.70m) Ji, 45°, P, Fe FILLED, Spaced 5mm
- (4.66m) J, 45°, P, R, Cn
- (4.78m) J, 0°, P, R, Cn
- (4.80m) Ji x 2, 45°, P, R, Cn
- (4.87m) J, 45°, P, R, Cn
- (4.90m) J, 10°, P, R, Fe Sn
- (4.96m) J, 10°, P, R, Fe Sn
- (5.14m) J, 45°, P, R, Fe Sn
- (5.60m) J, 90°, P, R, Fe Vn
- (5.68m) J, 45°, C, R, Cn
- (5.82m) J, 45°, Ir, R, Fe Sn
- (5.90m) J, 90°, Un, R, Fe Sn
- (6.00m) XWS, 15°, 20 mm.t
- (6.09m) J, 0°, P, S, Cn
- (6.15m) XWS, 0°, 5 mm.t
- (6.50m) J, 90°, Un, Fe Ct
- (6.82m) J, 45°, P, R, Fe Sn
- (6.86m) J, 45°, P, R, Cn
- (6.88m) J, 0°, P, R, Cn
- (6.98m) J, 80°, P, R, Fe Sn
- (7.00m) XWS, 0°, 60 mm.t
- (7.12m) J, 45°, C, R, Fe Sn
- (7.21m) J, 90°, Ir, R, Fe Sn
- (7.25m) J, 45°, C, R, Fe Sn
- (7.59m) J, 45°, Ir, R, Cn
- (7.61m) J, 30°, P, R, Cn
- (7.65m) J, 90°, P, R, Fe Sn
- (7.70m) J, 10°, P, S, Cn
- (7.80m) J, 45°, Ir, R, Fe Sn
- (7.87m) J, 60°, Ir, R, Fe Sn

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics

CORED BOREHOLE LOG

Borehole No. 213

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR	**Core Size:** NMLC	**R.L. Surface:** 19.6 m
Date: 3/6/25 TO 4/6/25	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK309	**Bearing:** N/A	**Logged/Checked By:** A.G./P.R.

Columns: Water Loss\Level | Barrel Lift | RL (m AHD) | Depth (m) | Graphic Log | CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components) | Weathering | Strength | POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH) | DEFECT DETAILS: SPACING (mm) (600, 200, 60, 20); DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness — Specific / General) | Formation

RL (m AHD) scale: 11, 10, 9, 8, 7, 6, 5
Depth (m) scale: 9, 10, 11, 12, 13, 14

Water Loss\Level: 90% RETURN

Formation: Lismore Basalt

Core Description	Weathering	Strength	Point Load $I_s(50)$
BASALT: dark grey. *(continued)*	SW	VH	4.0, 4.2
	MW	M - H	0.50, 1.5, 0.80
	SW	VH	3.9, 3.6, 4.8, 5.1
	MW - SW	M - H	0.60, 1.9
		VH	5.5, 0.40
as above, but trace of thin extremely weathered bands. BASALT: dark grey.	HW	M	0.40
END OF BOREHOLE AT 14.32 m			

Defect Details – Description (Specific):

- (7.35-8.50m) J, 0°, P, R, Fe, or Clay, Vn, Spaced 40mm-120mm
- (7.93m) J, 80°, Ir
- (7.98m) J, 45°, P, R, Fe Sn
- (8.14m) J, 45°, P, R, Cn
- (8.50m) J, 90°, P, R, Cn, and XWS. 0°, 440mm.t
- (9.01m) J, 45°, P, S, Cn
- (9.15m) J, 45°, P, S, Fe Sn
- (10.13m) J, 45°, P, R, Fe Sn
- (10.47m) XWS, 45°, 5 mm.t
- (10.85m) J, 10°, P, R, Cn
- (10.89m) J, 10°, P, R, Cn
- (10.94m) J, 15°, P, R, Fe Sn
- (11.00m) J, 90°, Un, R, Fe Sn
- (11.10m) J, 0°, P, S, Fe Sn
- (11.15m) J, 45°, P, R, Fe Sn
- (11.20m) J, 5°, P, R, Fe Sn
- (11.59m) J, 25°, P, R, Fe Sn
- (8.94-14.32m) J, 45°, P, Fe FILLED, Spaced 5mm-150mm
- (11.75m) J, 90°, Ir, Fe FILLED
- (11.90m) J, 45°, C, R, Fe Sn
- (12.02m) J, 90°, Ir, R, Fe Sn
- (12.17m) J, 45°, Ir, R, Fe Sn
- (12.86m) J, 20°, P, R, Fe Sn
- (11.66-14.32m) J, 0 - 10°, P, R, Fe Sn, Spaced 40mm-150mm
- (13.04m) J, 20°, P, R, Fe Sn
- (13.43m) J, 45°, P, R, Fe Sn
- (13.49m) J, 50°, P, R, Fe Sn
- (13.68m) J, 45°, P, R, Fe Sn
- (13.90m) J, 90°, Ir, R, Cn
- (14.18m) XWS, 0°, 40 mm.t
- (14.24m) J, 0°, Ir, t, Fe Sn

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH213
DEPTH: 1.90m - 10.00m
JKGeotechnics
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
37635UOR BH213 START CORING AT 1.90m
1
2
3
4
NO CORE 0.22mt
5
6
7
8
9


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH213
DEPTH: 10.00m - 14.32m
JKGeotechnics
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
10
11
12
13
14
END OF BH AT 14.32m

JKGeotechnics

BOREHOLE LOG

Borehole No.
214
1 / 3

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 14.6 m
Date: 4/6/25 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./P.R.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING					TOPSOIL: Silty clay, high plasticity, dark brown, trace of root fibres.	w>PL			
				CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained basalt and ironstone gravel.	w>PL	St	110 130 190	ALLUVIAL
	N = 5 2,2,3	14						160 190 210	
			1						
	N = 8 2,3,5	13					St - VSt	270 340 340 370	
			2						
		12							
ON COMPLETION OF CORING	N > 13 3,8,5/ 50mm REFUSAL		3		Silty CLAY: high plasticity, light brown and brown, trace of fine to medium grained ironstone gravel.		VSt - Hd	360 360 420	RESIDUAL
		11		-	Extremely Weathered BASALT: Silty gravelly clay, low plasticity, brown, fine to medium grained basalt and ironstone gravel.	XW	(Hd)		LISMORE BASALT
			4						
	N=SPT 6/ 50mm REFUSAL	10			Extremely Weathered BASALT: Clayey GRAVEL, fine grained, brown, basalt and ironstone gravel.		(VD)		LOW 'TC' BIT RESISTANCE GROUNDWATER MONITORING WELL INSTALLED TO 6.3m DEPTH IN ADJACENT BOREHOLE. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 6.3m TO 1.3m. CASING 0m TO 1.3m. 2mm SAND FILTER PACK 6.3m TO 0.5m. BENTONITE SEAL 0.5m TO 0m.
			5						
		9							
			6						
		8			Extremely Weathered BASALT: Clayey GRAVEL, fine grained, brown, basalt and ironstone gravel, with low to high strength bands of basalt and ironstone.				LOW RESISTANCE WITH OCCASIONAL HIGH RESISTANCE BANDS

SAMPLES: ES, U50, DB, DS

JKGeotechnics

BOREHOLE LOG

Borehole No.
214

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 14.6 m
Date: 4/6/25 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./P.R.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
						7, 6, 5, 4, 3, 2, 1	8, 9, 10, 11, 12, 13		-	Extremely Weathered BASALT: Clayey GRAVEL, fine grained, brown, basalt and ironstone gravel, with low to high strength bands of basalt and ironstone. *(continued)*	XW	(VD)		LOW RESISTANCE WITH OCCASIONAL HIGH RESISTANCE BANDS
							13							HIGH RESISTANCE
										REFER TO CORED BOREHOLE LOG				'TC' BIT REFUSAL

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CORED BOREHOLE LOG

Borehole No.
214

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR | **Core Size:** NMLC | **R.L. Surface:** 14.6 m
Date: 4/6/25 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK309 | **Bearing:** N/A | **Logged/Checked By:** A.G./P.R.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL-0.1, L-0.3, M-1, H-3, VH-10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)	Formation
		1			START CORING AT 13.95m						
90% RETURN		0	14		BASALT: dark grey, trace of rounded gravel sized green chlorite inclusions.	SW	VH	4.3		(14.03m) J, 45°, P, R, Fe Sn (14.08m) J, 30°, P, R, Fe Sn (14.16m) J, 90°, Un, R, Cn (14.26m) XWS, 20°, 100 mm.t (14.40m) Jh, 85°, P, Chlorite FILLED (14.48m) Jh, 45°, P, Chlorite FILLED (14.53m) J, 45°, P, Chlorite FILLED	Lismore Basalt
						HW	L	0.10		(14.60-14.90m) J, 0 - 45°, P, Fe Sn, Spaced 5mm-40mm	
		-1	15			SW	VH	3.6 4.1		(15.14m) J, 35°, P, R, Fe Sn (15.42m) J, 45°, P, R, Cn	
		-2	16					4.6 4.1 4.3		(16.07m) J, 65°, P, R, Cn (16.30m) J, 15°, P, R, Cn	
		-3, -4, -5	17, 18, 19		END OF BOREHOLE AT 16.90 m						

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH 214
DEPTH: 13.95m - 16.90m
JKGeotechnics
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
37635UOR BH214 START CORING AT 13.95m
13
14
15
16
EOH AT 16.90m

JKGeotechnics

BOREHOLE LOG

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 23.3 m
Date: 30/5/25 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** A.G./P.R.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING		0		FILL: Silty gravelly clay, low plasticity, dark brown, fine to coarse grained basalt gravel, trace of basalt cobbles, brick fragments and root fibres.	w>PL			
	N = 6 3,2,4	0.5	CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained ironstone gravel.	w>PL	St	150 170 180	RESIDUAL
	N=SPT 23/ 140mm REFUSAL	1.3	-	Extremely Weathered basalt: silty CLAY, medium plasticity, light grey, light brown and grey, trace of fine grained ironstone gravel.	XW	Hd	490 510 570 >600 >600 >600	LISMORE BASALT
ON COMPLETION OF CORING		3.0		BASALT: brown.	HW	L - M		BANDED LOW TO MODERATE 'TC' BIT RESISTANCE
		6.8						HIGH RESISTANCE

RL (m AHD) scale: 23, 22, 21, 20, 19, 18, 17. Depth (m) scale: 1, 2, 3, 4, 5, 6.

SAMPLES: ES, U50, DB, DS

JKGeotechnics

BOREHOLE LOG

Borehole No.
218

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR **Method:** SPIRAL AUGER **R.L. Surface:** 23.3 m
Date: 30/5/25 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** A.G./P.R.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
										BASALT: brown.	HW	L - M		
										REFER TO CORED BOREHOLE LOG				
						16								
							8							
						15								
							9							
						14								
							10							
						13								
							11							
						12								
							12							
						11								
							13							
						10								

JKGeotechnics

CORED BOREHOLE LOG

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR	**Core Size:** NMLC	**R.L. Surface:** 23.3 m
Date: 30/5/25	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK300	**Bearing:** N/A	**Logged/Checked By:** A.G./P.R.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components (START CORING AT 7.10m)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL-0.1, L-0.3, M-1, H-3, VH-10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness – Specific	General	Formation
90% RETURN		16 – 10	8 – 13		BASALT: dark grey, trace of rounded gravel sized green chlorite inclusions.	SW	VH	4.2		(7.28-7.77m) J, 45°, P, R, Fe Sn, Spaced 8mm-60mm		Lismore Basalt
								5.2		(7.82m) XWS, 10°, 10 mm.t		
								3.6		(7.86m) J, 85°, P, R, Fe Ct		
								4.4		(7.90m) XWS, 0°, 20 mm.t		
								3.2		(7.99m) J, 0°, P, R, Fe Sn		
								3.7		(8.05m) J, 15°, Ir, R, Fe Vn		
								3.9		(8.33m) J, 20°, P, R, Cn		
								3.3		(8.45m) J, 15°, C, R, Fe Vn		
								2.7		(8.73m) J, 15°, C, R, Fe Vn		
								4.3		(8.76m) J, 5°, C, R, Fe Vn		
					thin medium strength band			0.70		(9.40m) J, 0°, P, R, Cn		
								3.6		(9.88m) J, 0°, P, R, Cn		
								4.5		(9.92m) J, 45°, C, R, Cn		
										(9.98m) J, 10°, P, R, Cn		
										(10.38m) J, 0°, Un, R, Chlorite Vn		
										(10.85m) J, 0°, Ir, R, Cn		
										(10.87m) J, 65°, P, e, Cn, Patchy Chlorite coating		
										(11.04m) J, 0°, P, R, Cn		
										(11.25m) J, 10°, P, R, Cn		
										(11.34m) Chlorite Seam, 30°, 5 mm.t		
										(11.84m) J, 45°, P, R, Cn		
										(11.99m) J, 0°, P, R, Cn		
										(12.20m) J, 10°, C, R, Cn		
										(12.24m) J, 0°, P, R, Cn		
										(12.52m) J, 15°, P, S, Cn		
										(12.55m) J, 0°, P, R, Cn		
										(12.79m) J, 15°, P, S, Cn		
										(13.04m) J, 65°, P, R, Cn		
										(13.22m) J, 0°, P, R, Cn		
										(13.46m) J, 0°, P, S, Cn		
										(13.75m) J, 10°, P, R, Fe Sn		
										(13.92m) J, 0°, P, R, Chlorite Ct		

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
218

Client: DEPARTMENT OF EDUCATION
Project: NORTHERN RIVERS FLOOD RECOVERY-RICHMOND RIVER HIGH CAMPUS REDEVELOPMENT
Location: 163 AND 170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 37635UOR | **Core Size:** NMLC | **R.L. Surface:** 23.3 m
Date: 30/5/25 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK300 | **Bearing:** N/A | **Logged/Checked By:** A.G./P.R.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness – Specific	General	Formation
90% RETURN		9			BASALT: dark grey, trace of rounded gravel sized green chlorite inclusions. *(continued)*	SW	VH	3.9 4.4		(13.96m) J, 45°, P, S, Cn (14.05m) J, 45°, C, R, Cn (14.26m) J, 30°, P, R, Cn (14.37m) J, 45°, P, R, Fe Sn (14.43m) J, 45°, P, R, Fe Sn (14.45m) J, 15°, P, R, Fe Sn		Lismore Basalt
		8 7 6 5 4 3	15 16 17 18 19 20		END OF BOREHOLE AT 14.88 m							

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


PROJECT: Northern Rivers Flood Recovery - Richmond River High Campus Development
PROJECT No: 37635UOR
DATE: 16/06/25
LOCATION ID: BH 218
DEPTH: 7.28m to 14.88m
JKGeotechnics
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
37635UOR BH218 START CORING AT 7.28m
7
8
9
10
11
12
13
14
15
END OF BOREHOLE AT 14.88m

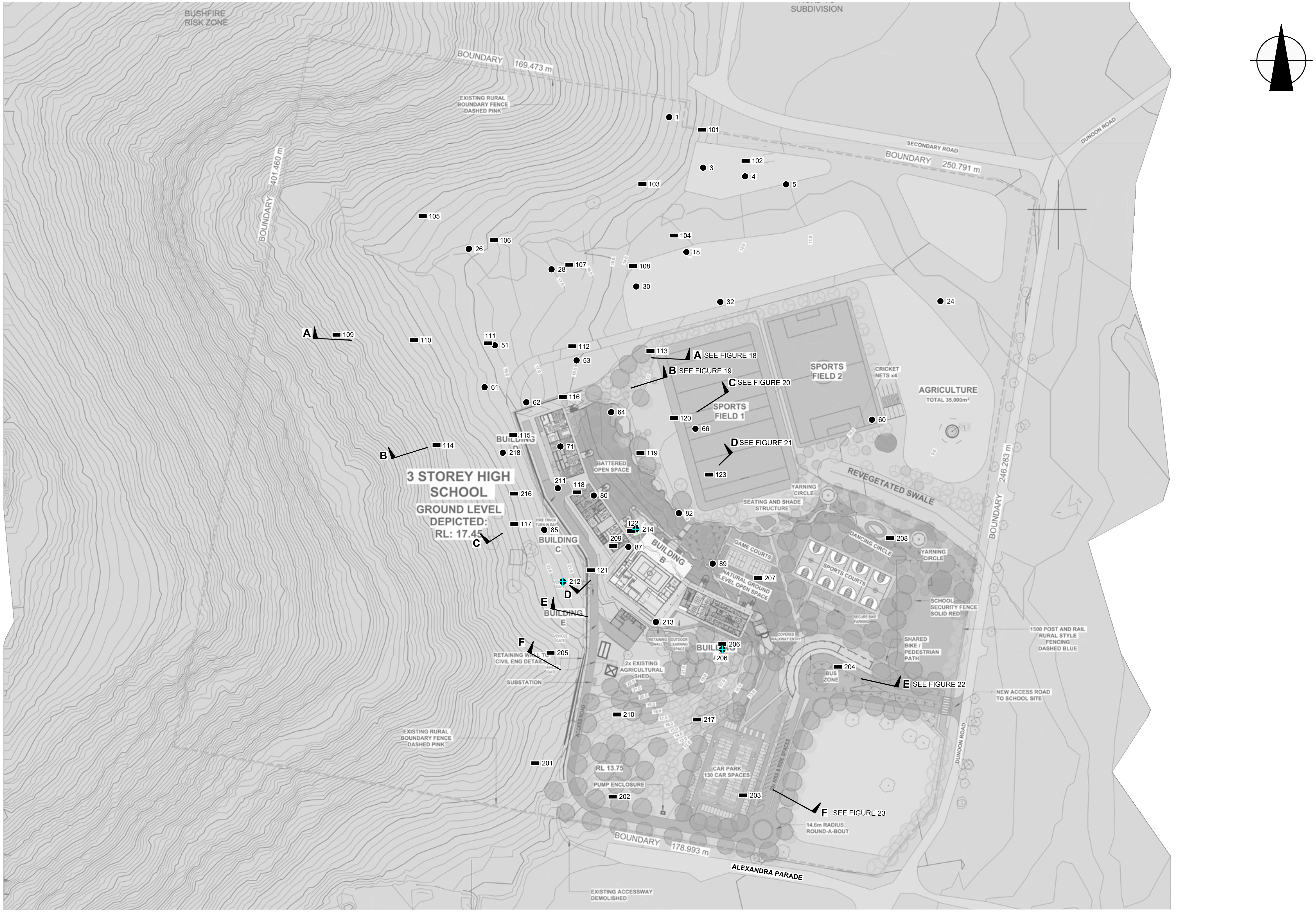
AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

This plan should be read in conjunction with the JK Geotechnics report.

Title:	**SITE LOCATION PLAN**
Location:	163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
Report No: 37635UOR	Figure No: 1

JKGeotechnics

PLOT DATE: 23/06/2025 2:36:08 PM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG



LEGEND

- JKE/JKG BOREHOLE AND GROUNDWATER MONITORING WELL (MAY AND JUNE 2025)
- JKG BOREHOLE (1, 2, 3 ETC, JKG 2024 INVESTIGATION. 206 ETC, MAY AND JUNE 2025)
- JKG TEST PIT (101, 102 ETC, JKG 2025 INVESTIGATION. 201, 202 ETC, MAY AND JUNE 2025)

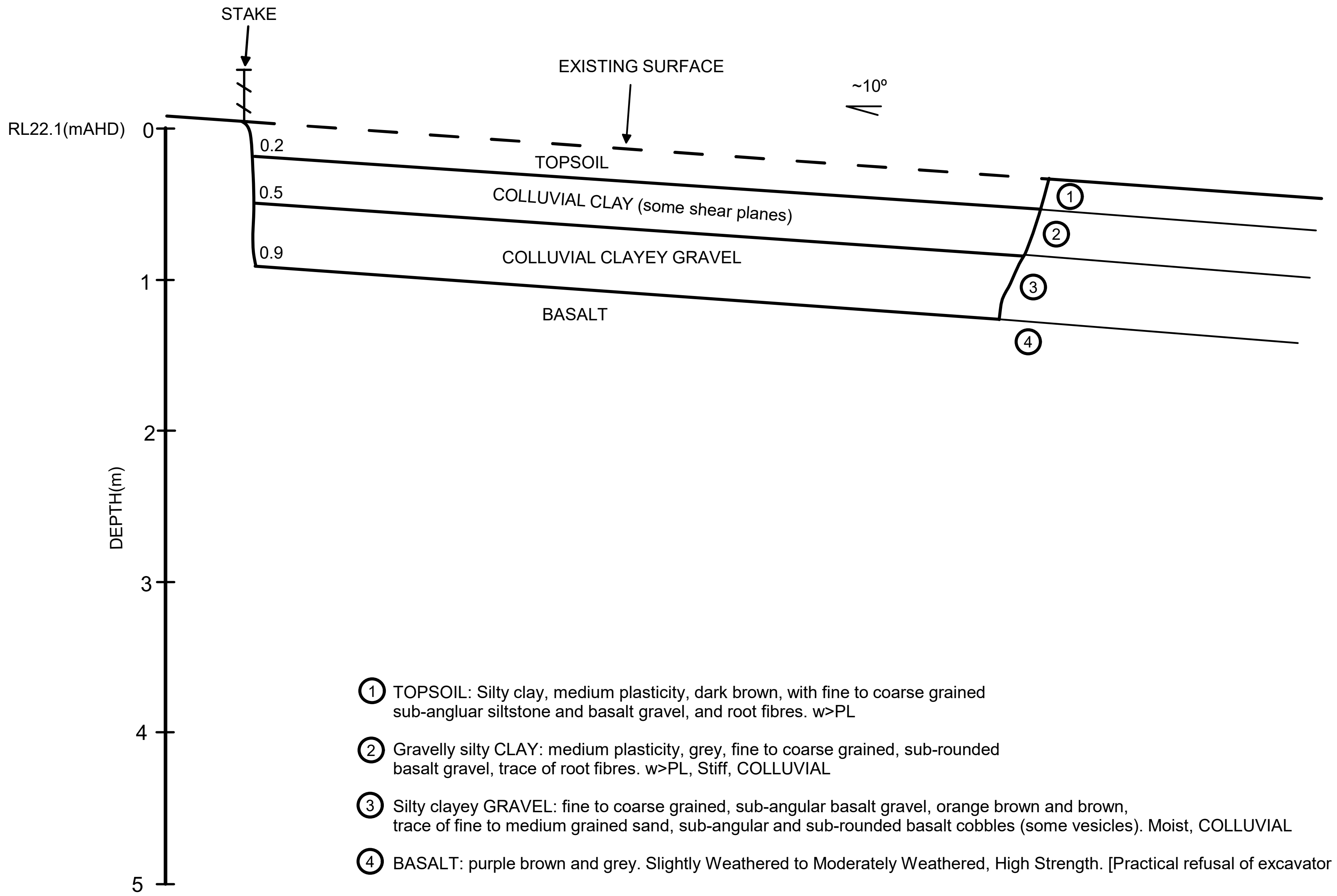
0 30 60 90 120 150
SCALE 1:3000 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:	INVESTIGATION LOCATION PLAN
Location:	163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
Report No: 37635UOR	Figure No: 2

JKGeotechnics

PLOT DATE: 27/06/2025 8:35:55 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG



1 TOPSOIL: Silty clay, medium plasticity, dark brown, with fine to coarse grained sub-angluar siltstone and basalt gravel, and root fibres. w>PL

2 Gravelly silty CLAY: medium plasticity, grey, fine to coarse grained, sub-rounded basalt gravel, trace of root fibres. w>PL, Stiff, COLLUVIAL

3 Silty clayey GRAVEL: fine to coarse grained, sub-angular basalt gravel, orange brown and brown, trace of fine to medium grained sand, sub-angular and sub-rounded basalt cobbles (some vesicles). Moist, COLLUVIAL

4 BASALT: purple brown and grey. Slightly Weathered to Moderately Weathered, High Strength. [Practical refusal of excavator bucket]

SAMPLES
N/A

HAND PENETROMETER (kPa)
0.2-0.3: 110, 110, 120
0.3-0.4: 150, 160, 170
0.4: 140, 170, 150

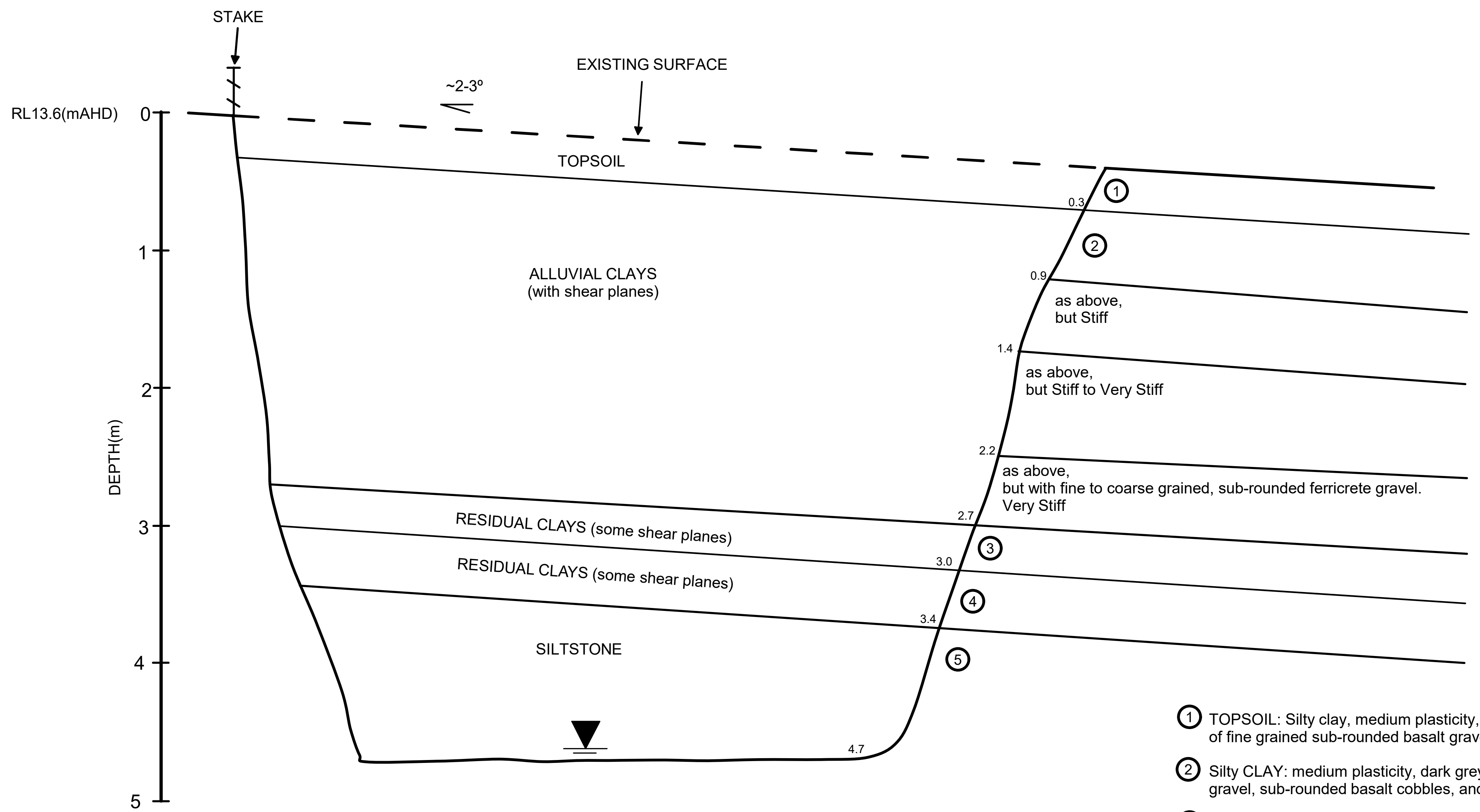
END OF TEST PIT AT 0.9m DEPTH
BUCKET REFUSAL ON
SLIGHTLY TO MODERATELY WEATHERED
HIGH STRENGTH BASALT
'DRY' ON COMPLETION

TEST PIT 201
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 3



SAMPLES
CBR: 0.3-0.35
DS: 0.6-0.7
DS: 1.2-1.3
DS: 3.0-3.4
DS: 4.7-4.8

HAND PENETROMETER (kPa)
0.3: 100, 140, 170, 90, 100, 100
0.9: 140, 150, 160, 150
1.4: 170, 210, 200, 190, 210, 160
2.0: 150, 170, 210, 220, 200
2.2: 310, 310, 290, 270
3.0: 310, 370, 310

1 TOPSOIL: Silty clay, medium plasticity, dark grey, with organics and root fibres, trace of fine grained sub-rounded basalt gravel. w>PL

2 Silty CLAY: medium plasticity, dark grey, trace of coarse grained, sub-rounded basalt gravel, sub-rounded basalt cobbles, and root fibres. w>PL, Firm to Stiff, ALLUVIAL

3 Silty CLAY: medium plasticity, brown, with fine to coarse grained, sub-angular basalt and ferricrete gravel. w~PL, Very Stiff, RESIDUAL

4 Silty CLAY: medium plasticity, orange brown and grey, with fine to coarse grained, sub-angular basalt gravel, and basalt cobbles. w~PL, Very Stiff, RESIDUAL

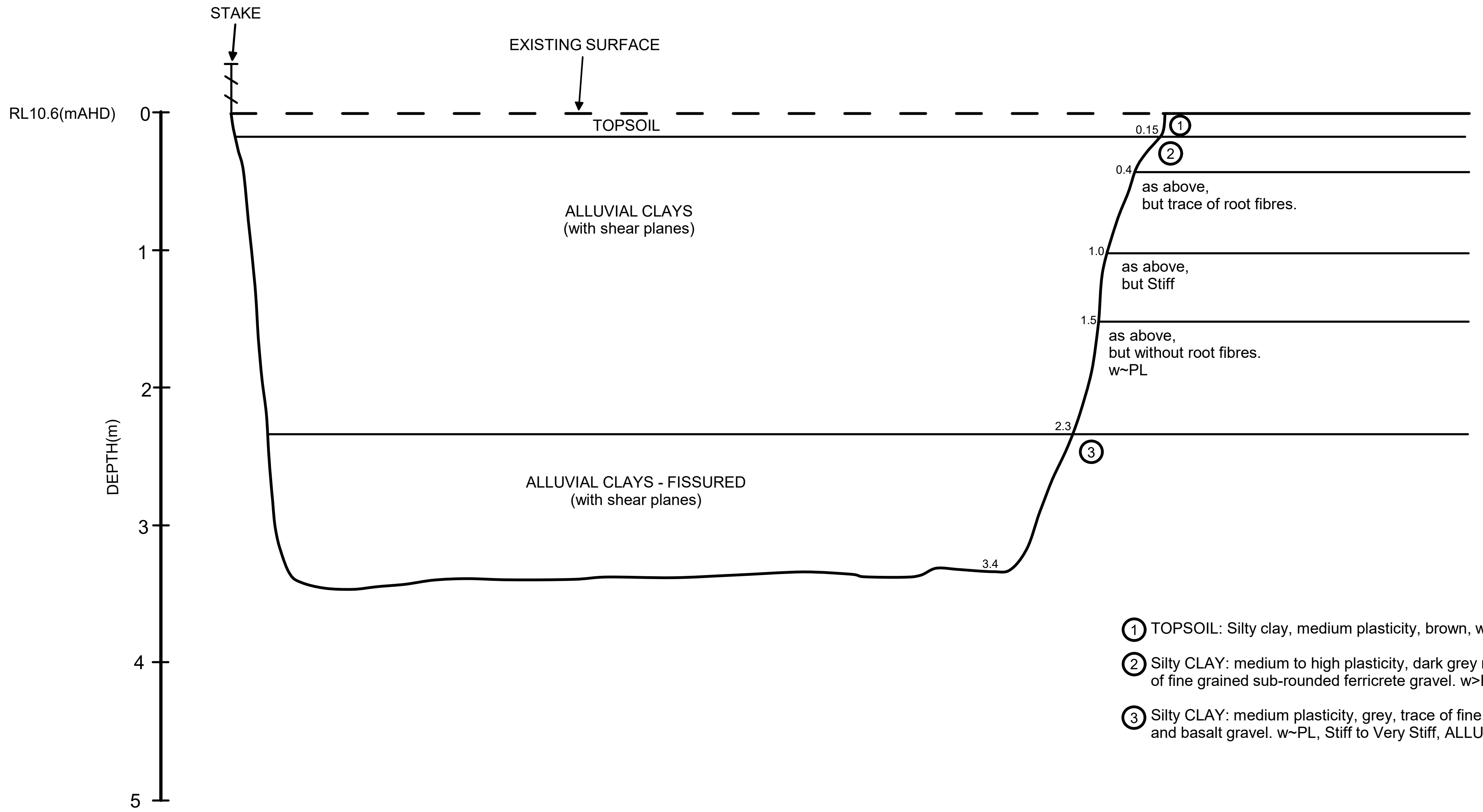
5 SILTSTONE: red brown, thinly laminated and highly fractured, with high strength ferricrete bands and nodules, trace of extremely weathered bands.
Highly Weathered to Moderately Weathered, Low to Medium strength [Low to Moderate Bucket Resistance]

END OF TEST PIT AT 4.7m DEPTH
BUCKET REFUSAL ON HIGH STRENGTH
FERRICRETE BAND, OR POSSIBLY
HIGH STRENGTH BASALT
WATER AT 4.6m ON COMPLETION
MINOR COLLAPSE OF NORTHERN WALL AT ~3.0m

TEST PIT 202
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 — 2.0
Scale 1:40 @A3 Metres

JKGeotechnics
Report No. 37635UOR
Figure No. 4



SAMPLES
CBR: 0.3-0.4
DS: 0.4-0.5
DS: 1.0-1.1
DS: 1.5-1.6

HAND PENETROMETER (kPa)
0.2-0.3: 100, 90, 90, 110, 120, 90
0.4-0.5: 100, 110, 120, 100, 120
1.6: 110, 120, 110, 120, 120
1.8: 130, 150, 150, 150
2.3: 210, 220, 210, 210
3.0-3.2: 210, 200, 190, 240

1 TOPSOIL: Silty clay, medium plasticity, brown, with root fibres. w>PL

2 Silty CLAY: medium to high plasticity, dark grey mottled orange brown, with root fibres, trace of fine grained sub-rounded ferricrete gravel. w>PL, Firm to Stiff, ALLUVIAL

3 Silty CLAY: medium plasticity, grey, trace of fine grained, sub-rounded to sub-angular ferricrete and basalt gravel. w~PL, Stiff to Very Stiff, ALLUVIAL

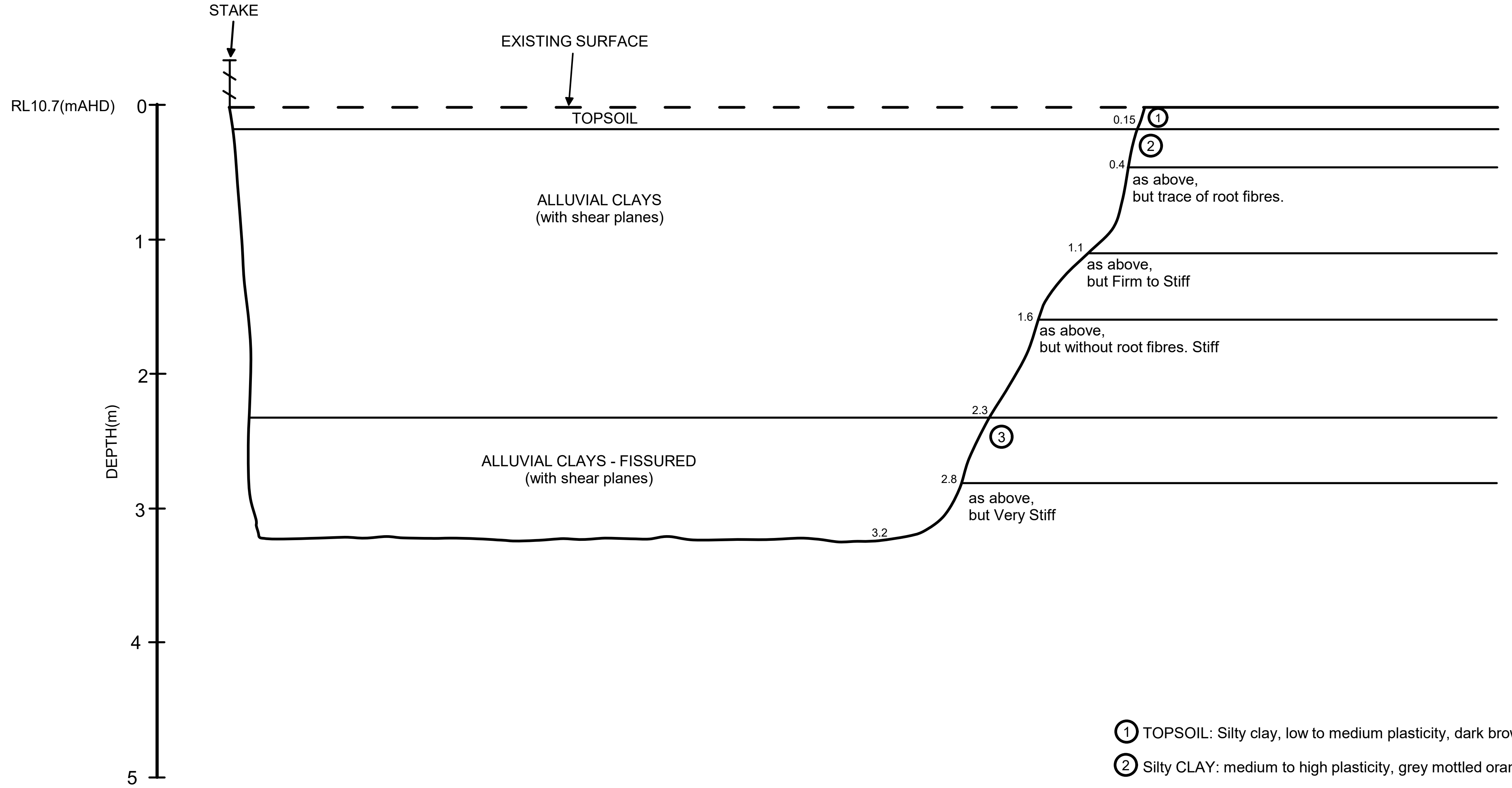
END OF TEST PIT AT 3.4m DEPTH
SOUTHERN PIT WALL COLLAPSE AT ~2.3m
DUE TO SUB-VERTICAL AND SUB-HORIZONTAL
INTERCONNECTING SMOOTH FISSURES/SHEAR PLANES
'DRY' ON COMPLETION

TEST PIT 203
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 5



SAMPLES
CBR: 0.4-0.5
DS: 0.8-0.9
DS: 1.6-1.65
DS: 2.3-2.4
DS: 3.0-3.2

HAND PENETROMETER (kPa)
0.3: 110, 130, 130, 120, 110
0.5: 80, 90, 110, 80, 80
0.8: 90, 90, 100, 90
1.1: 90, 110, 110, 100
1.6: 120, 120, 110, 120, 120
2.3: 210, 170, 200
2.8: 240, 210, 240, 210
3.0-3.2: 210, 240, 210, 200

1 TOPSOIL: Silty clay, low to medium plasticity, dark brown, with organics and root fibres. w>PL

2 Silty CLAY: medium to high plasticity, grey mottled orange brown, with root fibres. w>PL, Firm, ALLUVIAL

3 Silty CLAY: medium to high plasticity, grey. w~PL, Stiff to Very Stiff, ALLUVIAL

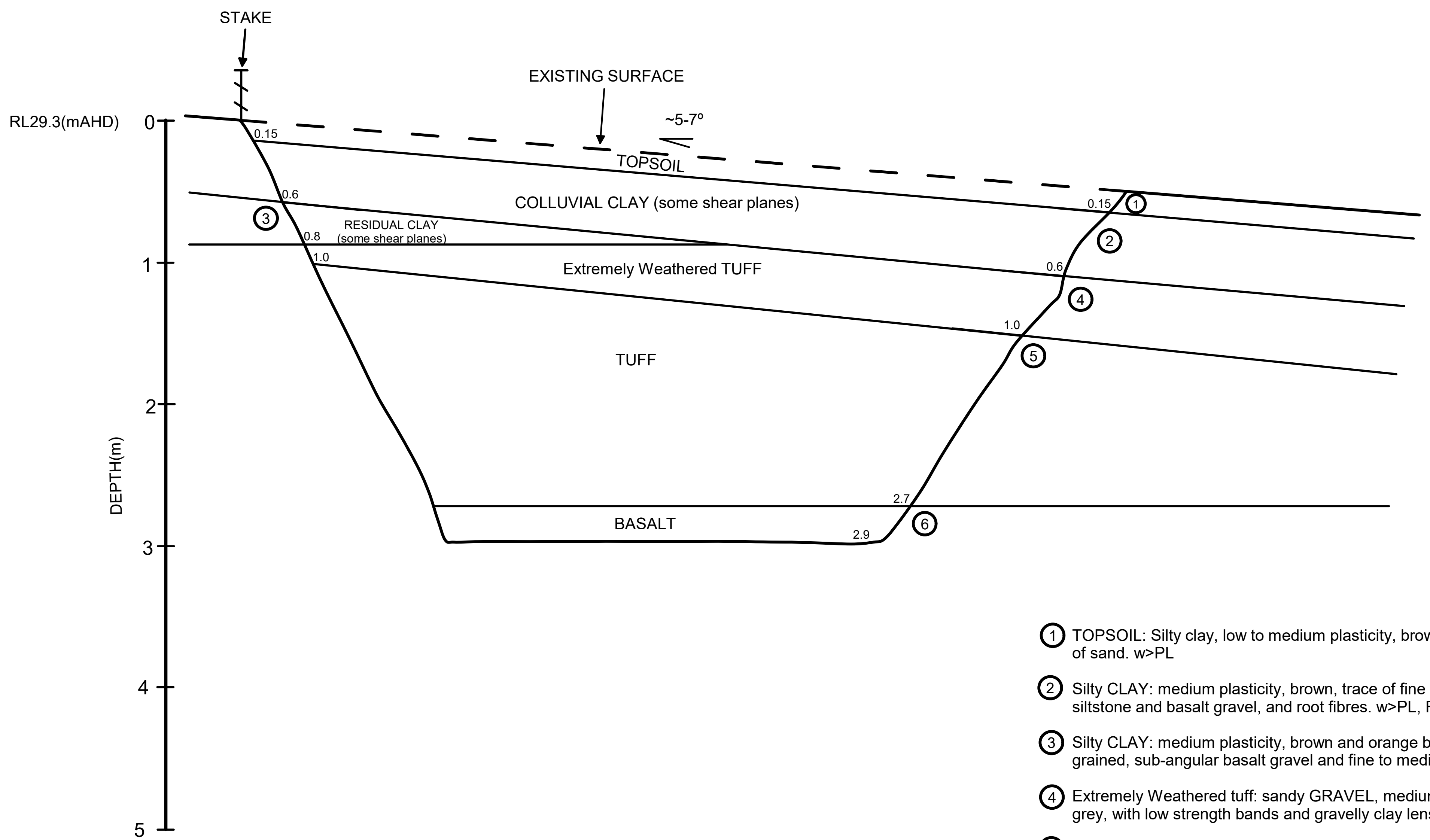
END OF TEST PIT AT 3.2m DEPTH
SOUTHERN AND NORTHERN PIT WALLS
COLLAPSE AT ~2.3m DUE TO SUB-VERTICAL
AND SUB-HORIZONTAL INTERCONNECTING
SMOOTH FISSURES/SHEAR PLANES
'DRY' ON COMPLETION

TEST PIT 204
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 6



SAMPLES
N/A

HAND PENETROMETER (kPa)
0.2-0.3: 90, 100, 120, 90, 140, 90
0.7-0.8: 150, 150, 120, 170

1 TOPSOIL: Silty clay, low to medium plasticity, brown, with organics and root fibres, trace of sand. w>PL

2 Silty CLAY: medium plasticity, brown, trace of fine grained, sub-rounded to sub-angular siltstone and basalt gravel, and root fibres. w>PL, Firm to Stiff, COLLUVIAL

3 Silty CLAY: medium plasticity, brown and orange brown mottled grey, with fine to medium grained, sub-angular basalt gravel and fine to medium grained sand, trace of root fibres. w>PL, Stiff, RESIDUAL

4 Extremely Weathered tuff: sandy GRAVEL, medium to coarse grained, brown, red brown and grey, with low strength bands and gravelly clay lenses.

5 TUFF: medium to coarse grained, red brown, orange brown and grey, with fine grained vesicles, trace of moderately weathered basalt lenses, highly fractured.
Highly Weathered, Low Strength, with medium strength bands [Low Bucket Resistance]

6 BASALT: red brown, with fine to medium grained vesicles. Moderately Weathered, High Strength [High Bucket Resistance]

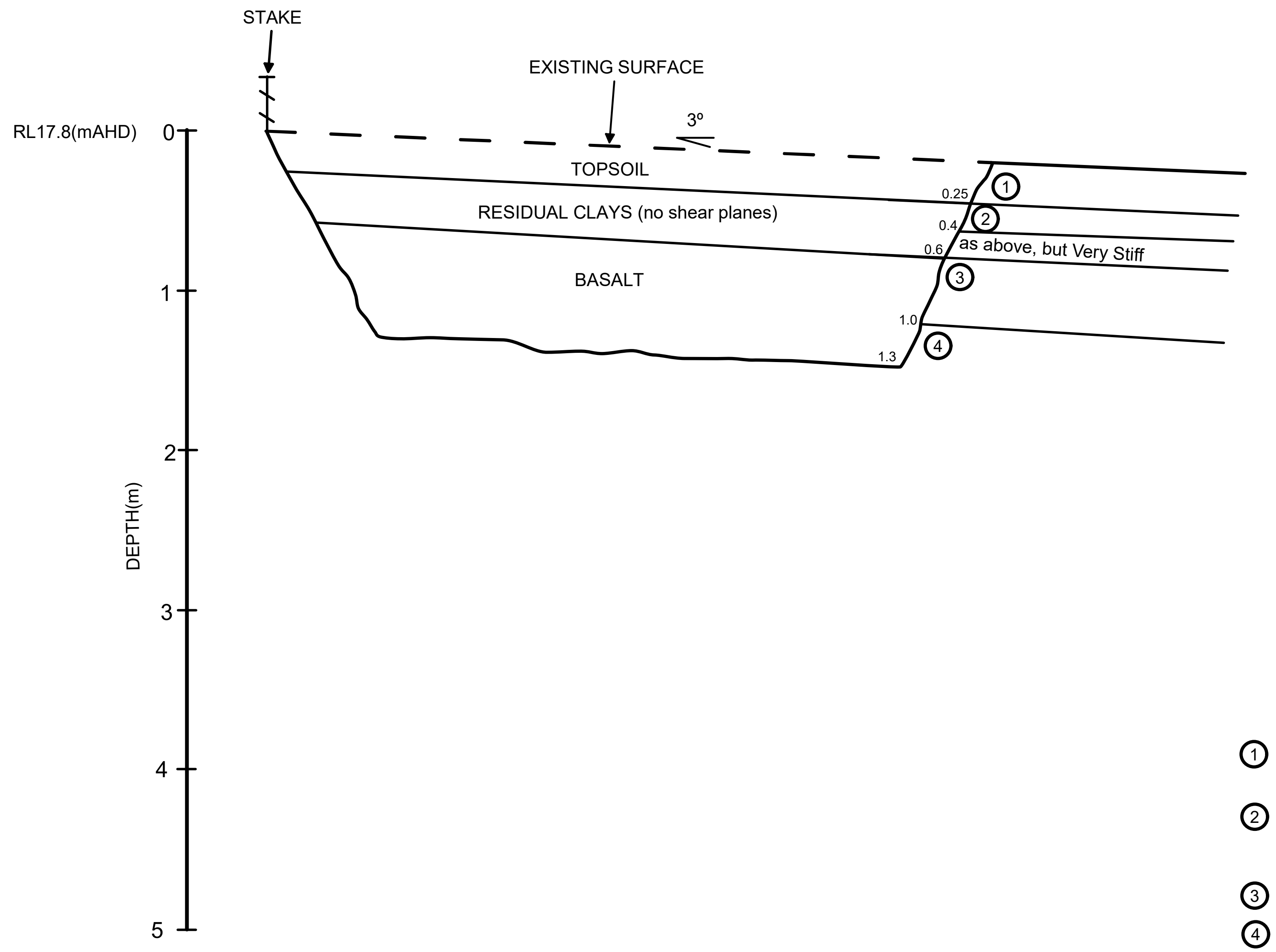
END OF TEST PIT AT 2.9m DEPTH
BUCKET REFUSAL ON MODERATELY
WEATHERED HIGH STRENGTH BASALT
'DRY' ON COMPLETION

TEST PIT 205
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 7



SAMPLES
N/A

HAND PENETROMETER (kPa)
0.25: 140, 200, 130, 140, 140
0.4: 270, 320, 300, 270

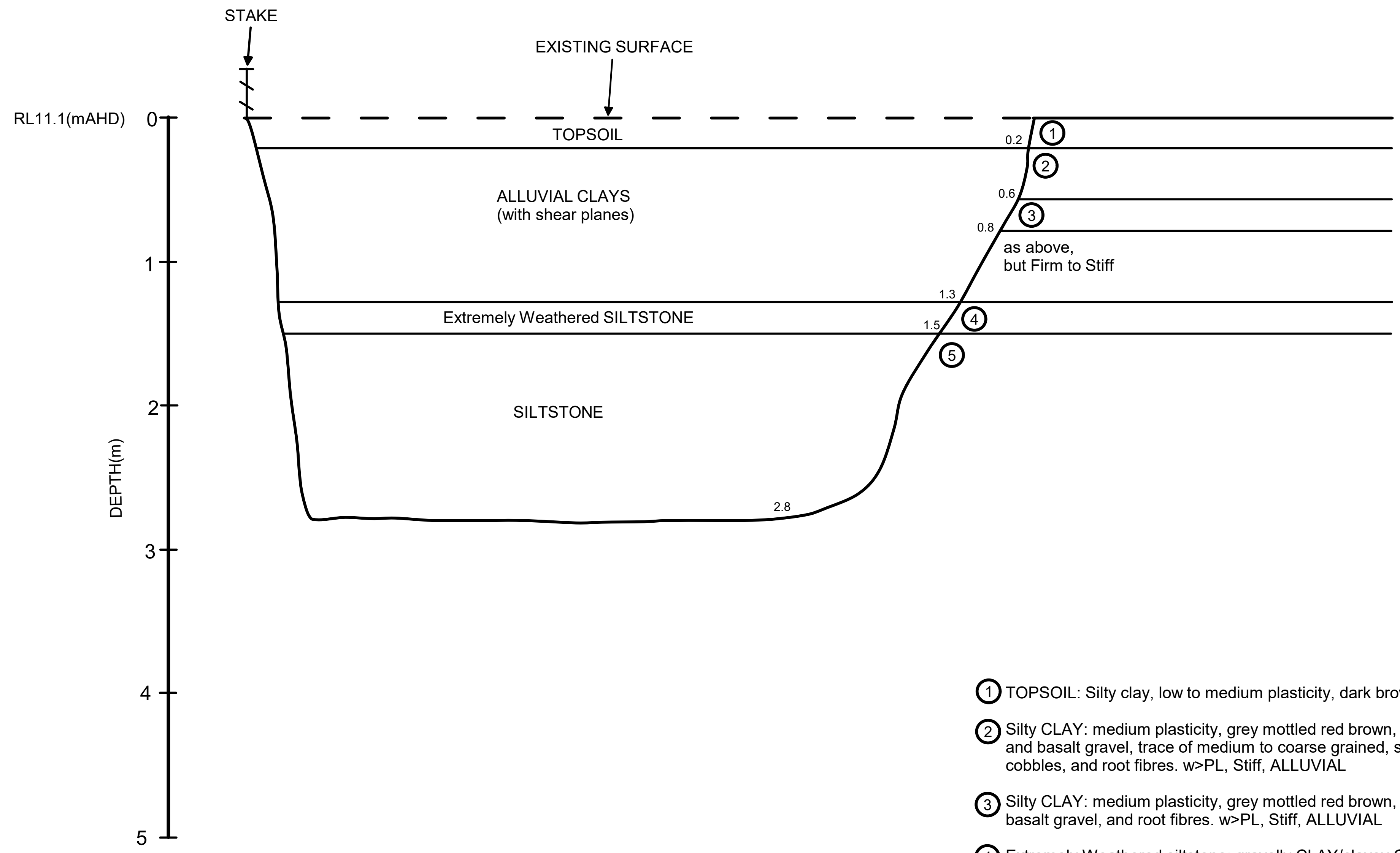
1. TOPSOIL: Clayey silt/Silty clay, low to medium plasticity, dark brown, with root fibres, trace of fine to coarse grained, sub-angular basalt gravel. w>PL
2. Silty CLAY: medium plasticity, dark grey, trace of fine to coarse grained, sub-angular basalt gravel, sub-rounded to sub-angular basalt cobbles, fine grained sand, gravelly clay lenses and root fibres. w>PL, Stiff, RESIDUAL
3. BASALT: grey, with clay bands, highly fractured. Highly Weathered, Low Strength [Moderate Bucket Resistance]
4. BASALT: dark grey, fractured (Blocky). Moderately Weathered, Medium Strength [High Bucket Resistance]

END OF TEST PIT AT 1.3m DEPTH
BUCKET REFUSAL ON SLIGHTLY WEATHERED
HIGH STRENGTH BASALT
'DRY' ON COMPLETION

TEST PIT 206
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics
Report No. 37635UOR Figure No. 8



SAMPLES
CBR: 0.4-0.5
DS: 0.6-0.65
DS: 1.1-1.2
DS: 1.4-1.5
DS: 2.7-2.8

HAND PENETROMETER (kPa)
0.2-0.3: 120, 190, 110, 140, 110, 110
0.4: 140, 120, 140, 120
0.8: 90, 100, 110, 90, 100
1.1: 100, 120, 120, 110

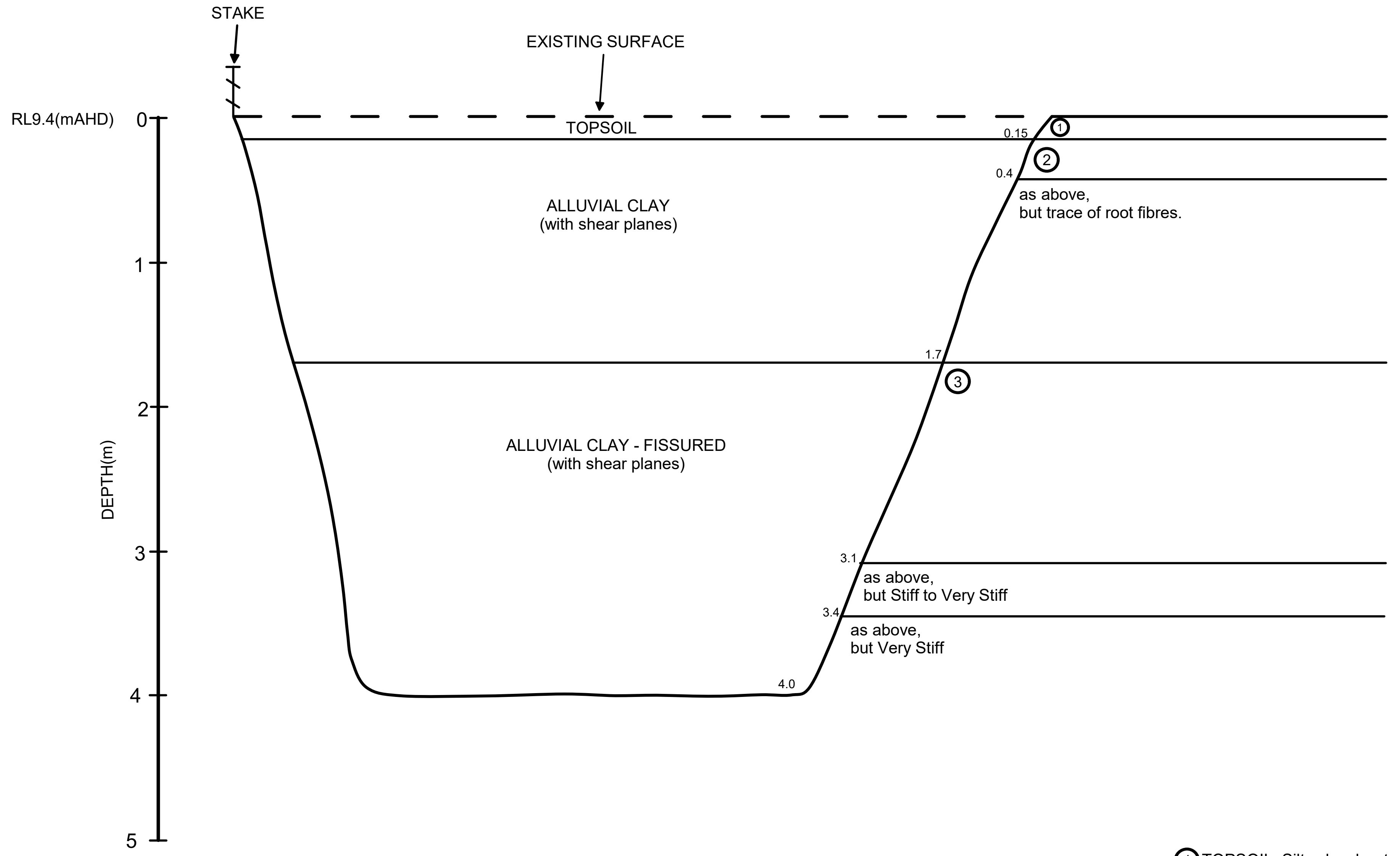
1. TOPSOIL: Silty clay, low to medium plasticity, dark brown, with organics and root fibres. w>PL
2. Silty CLAY: medium plasticity, grey mottled red brown, with fine grained, sub-angular ferricrete and basalt gravel, trace of medium to coarse grained, sub-rounded basalt gravel, sub-rounded basalt cobbles, and root fibres. w>PL, Stiff, ALLUVIAL
3. Silty CLAY: medium plasticity, grey mottled red brown, trace of fine to coarse grained, sub-rounded basalt gravel, and root fibres. w>PL, Stiff, ALLUVIAL
4. Extremely Weathered siltstone: gravelly CLAY/clayey GRAVEL: red brown and grey, fine to coarse grained siltstone gravel, low plasticity, with highly weathered, very low strength and highly fractured ferricrete bands. [Very Low Bucket Resistance]
5. SILTSTONE: red brown, thinly laminated and highly fractured, with high strength ferricrete bands and nodules, trace of extremely weathered bands. Moderately Weathered, Low to Medium Strength [Moderate Bucket Resistance]

END OF TEST PIT AT 2.8m DEPTH
BUCKET REFUSAL ON INFERRED
HIGH STRENGTH FERRICRETE BAND
'DRY' ON COMPLETION

TEST PIT 207
CROSS SECTIONAL SKETCH
LOOKING NORTH-EAST

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics
Report No. 37635UOR Figure No. 9



SAMPLES
CBR: 0.3-0.4
DS: 0.7-0.8
DS:1.3-1.4
DS: 2.3-2.4
DS: 3.0-3.1

HAND PENETROMETER (kPa)
0.2-0.25: 90, 100, 110, 90, 90
0.4-0.5: 110, 100, 110, 100
0.7-0.8: 80, 110, 100, 90, 80
1.1: 90, 110, 100, 90
1.3: 100, 110, 120, 100, 120
1.7: 140, 150, 130, 170
2.3-2.4: 140, 140, 140, 130, 160
3.1-3.3: 200, 210, 240, 200, 210
3.9-4.0: 240, 230, 220, 220

1 TOPSOIL: Silty clay, low to medium plasticity, dark brown, with organics and root fibres. w>PL

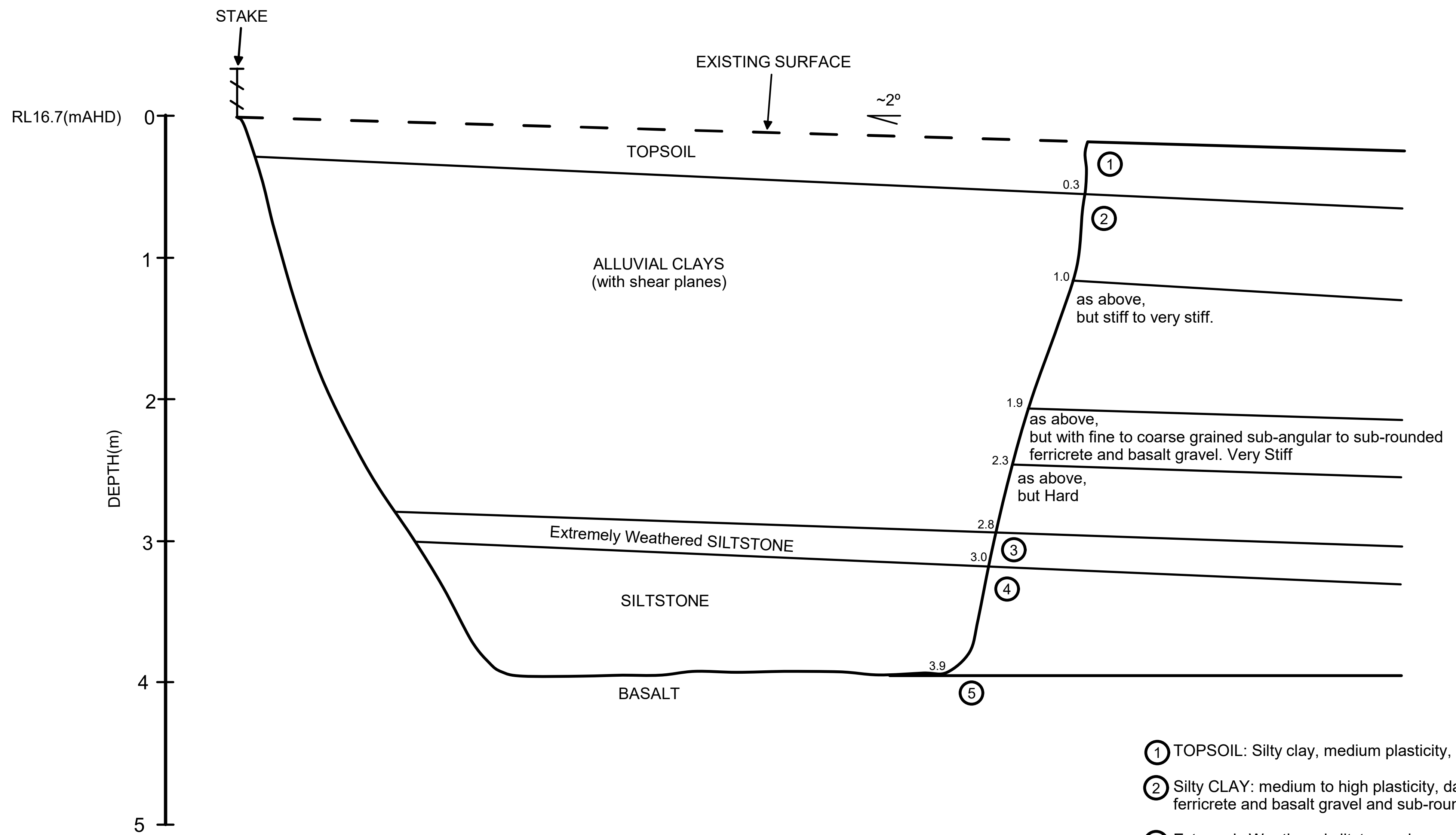
2 Silty CLAY: medium to high plasticity, grey mottled red brown, with root fibres. w>PL, Firm to Stiff, ALLUVIAL

3 Silty CLAY: medium plasticity, grey. w~PL, Stiff, ALLUVIAL

END OF TEST PIT AT 4.0m DEPTH
SOUTHERN AND NORTHERN PIT WALLS
COLLAPSE AT ~2.0m DUE TO
SUB-VERTICAL AND SUB-HORIZONTAL
INTERCONNECTING SMOOTH FISSURES/SHEAR PLANES
'DRY' ON COMPLETION

TEST PIT 208
CROSS SECTIONAL SKETCH
LOOKING NORTH-EAST

0 2.0
Scale 1:40 @A3 Metres



SAMPLES
CBR: 0.4-0.5
DS: 2.3-2.4

HAND PENETROMETER (kPa)
0.2: 90, 80, 100
0.4: 110, 120, 140
1.0-1.1: 210, 170, 200
1.9-2.0: 300, 310, 290, 400
2.3-2.4: 410, 420, 440
2.6-2.8: 410, 450, 420, 410, 430

1 TOPSOIL: Silty clay, medium plasticity, dark brown, with organics and root fibres. w>PL

2 Silty CLAY: medium to high plasticity, dark brown and grey, trace of gine grained, sub-rounded ferricrete and basalt gravel and sub-rounded basalt cobbles. w>PL, Stiff, ALLUVIAL

3 Extremely Weathered siltstone: clayey gravelly SILT: low plasticity, orange brown and grey, fine to medium grained siltstone gravel. w<PL

4 SILTSTONE: red brown, thinly laminated and highly fractured, with medium strength ferricrete bands and nodules. Highly Weathered, Low to Medium Strength [Low to Moderate Bucket Resistance]

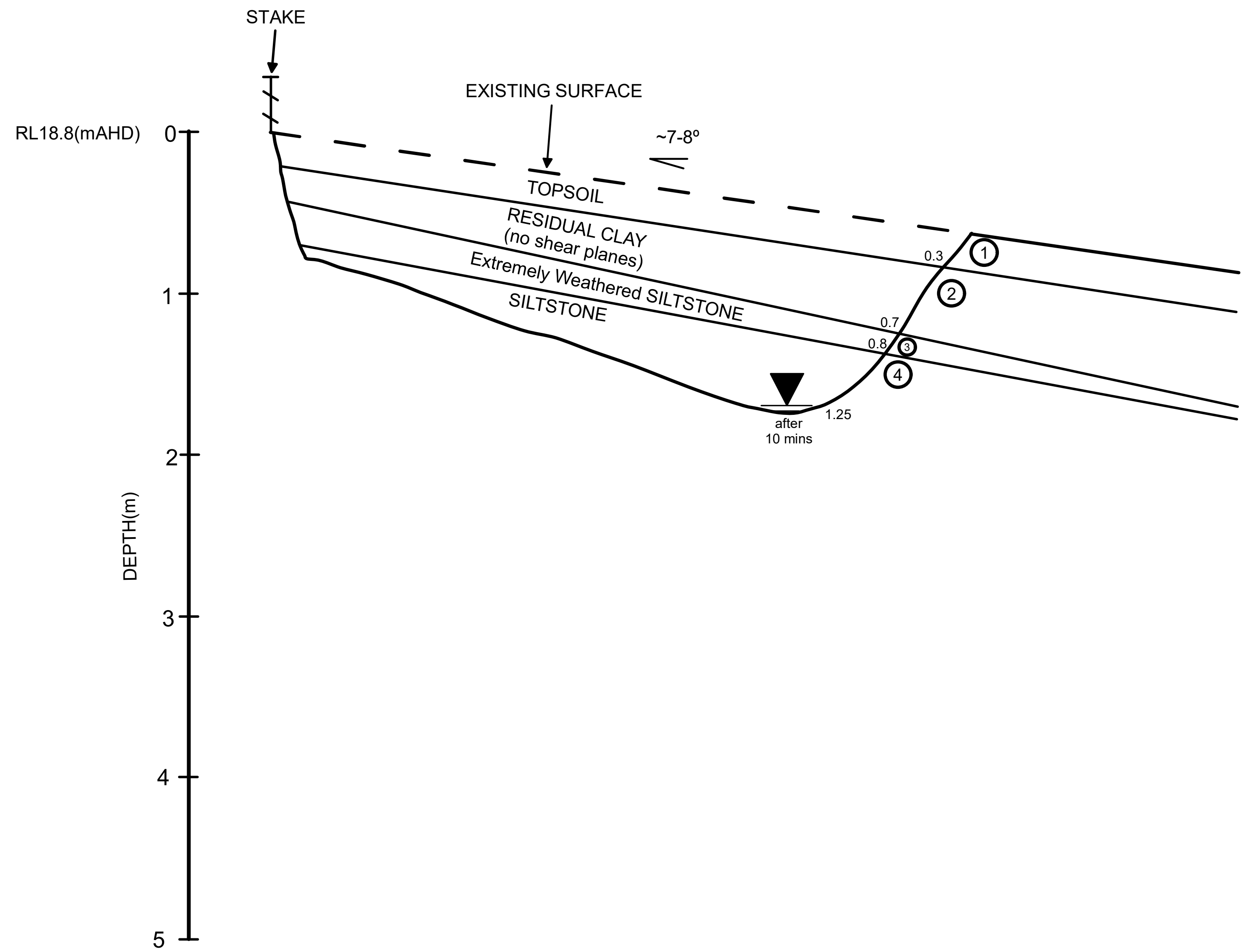
5 BASALT: grey. Slightly Weathered, High Strength [High Bucket Resistance]

END OF TEST PIT AT 3.9m DEPTH
BUCKET REFUSAL ON INFERRED
SLIGHTLY WEATHERED
HIGH STRENGTH BASALT
'DRY' ON COMPLETION

TEST PIT 209
CROSS SECTIONAL SKETCH
LOOKING NORTH-WEST

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics
Report No. 37635UOR Figure No. 11



SAMPLES
DS: 0.2-0.25

HAND PENETROMETER (kPa)
0.2: 170, 180, 190, 170

1 TOPSOIL: Silty clay, low to medium plasticity, dark brown, with organics and root fibres, trace of fine to coarse grained, sub-angular basalt gravel and sub-rounded to sub-angular basalt cobbles. w~PL

2 Silty CLAY: medium plasticity, dark brown, with fine to coarse grained, sub-rounded basalt gravel, sub-rounded basalt cobbles, trace of root fibres. w>PL, Stiff, RESIDUAL

3 Extremely Weathered siltstone: clayey GRAVEL/gravelly CLAY, fine to coarse grained siltstone and ferricrete gravel, medium plasticity, with highly fractured, very low strength bands. [Very Low Bucket Resistance]

4 SILTSTONE: red brown, thinly laminated and highly fractured, with high strength ferricrete bands and nodules, and very low strength bands, bedded tilted to sub-vertical in some locations. Moderately Weathered, Medium Strength [Moderate Bucket Resistance]

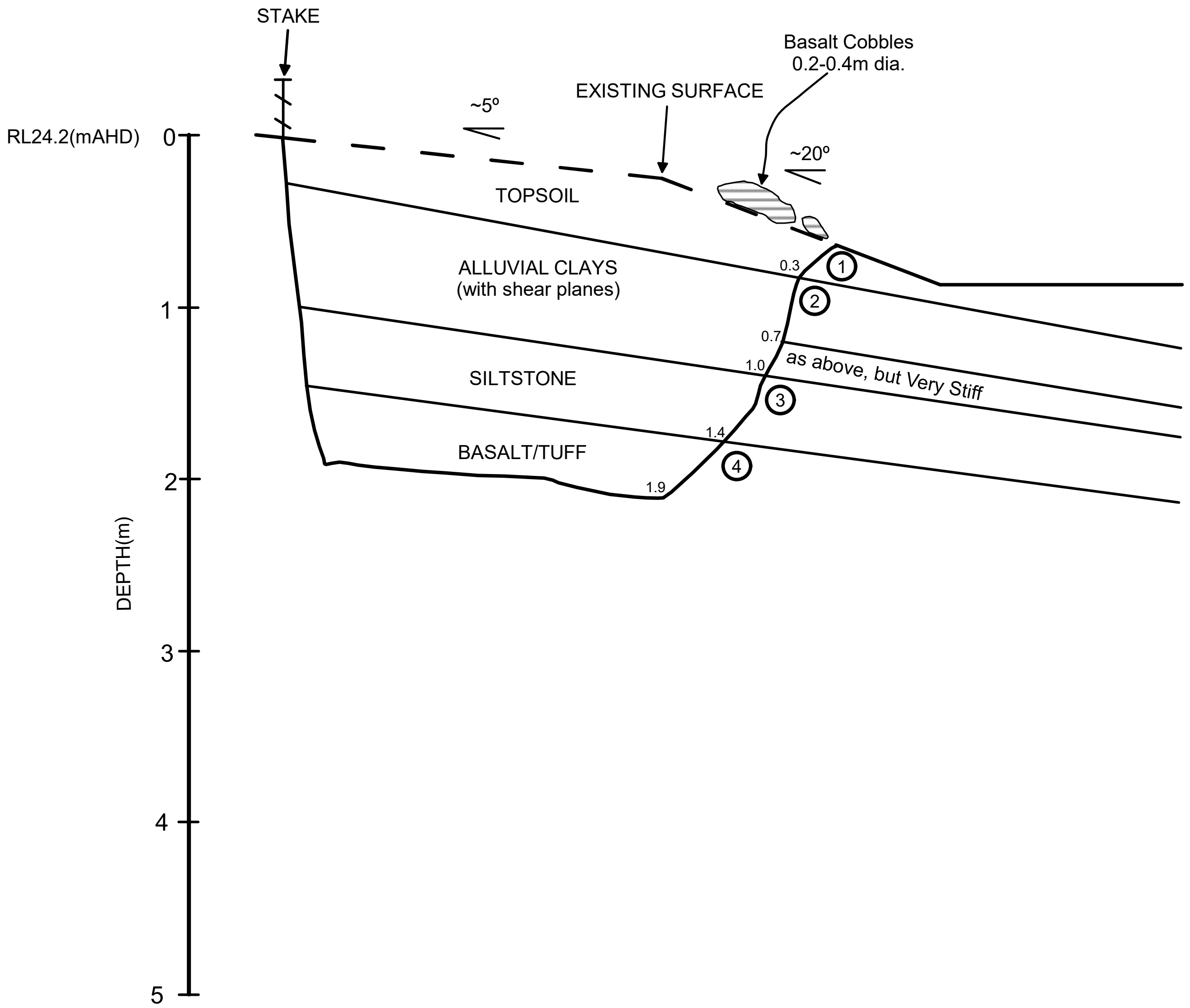
END OF TEST PIT AT 0.8m (high side) to 1.25m (low side) DEPTH
BUCKET REFUSAL ON INFERRED
SLIGHTLY WEATHERED HIGH STRENGTH BASALT
OR HIGH STRENGTH FERRICRETE BAND
SEEPAGE AT 1.2m (low side) DEPTH ON COMPLETION OF EXCAVATION

TEST PIT 210
CROSS SECTIONAL SKETCH
LOOKING NORTH-EAST

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 12



SAMPLES
N/A

HAND PENETROMETER (kPa)
0.1-0.2: 110, 120, 100, 90
0.3-0.4: 120, 120, 110, 130
0.7-0.8: 310, 370, 250, 300
1.0-1.1: >600, >600, >600

1 TOPSOIL: Silty clay, medium plasticity, dark brown, with root fibres.w>PL

2 Silty CLAY: medium plasticity, dark grey, trace of coarse grained, sub-rounded basalt gravel, sub-rounded basalt cobbles and root fibres. w>PL, Stiff, ALLUVIAL

3 SILTSTONE: grey, with extremely weathered bands (gravelly clay) thinly bedded and highly fractured. Highly Weathered, Very Low Strength [Low Bucket Resistance]

4 Interbedded BASALT: grey and red brown, and TUFF: fine to coarse grained, red brown, grey and brown, trace of fine to medium grained vesicles, extremely weathered bands. Highly Weathered, Medium Strength

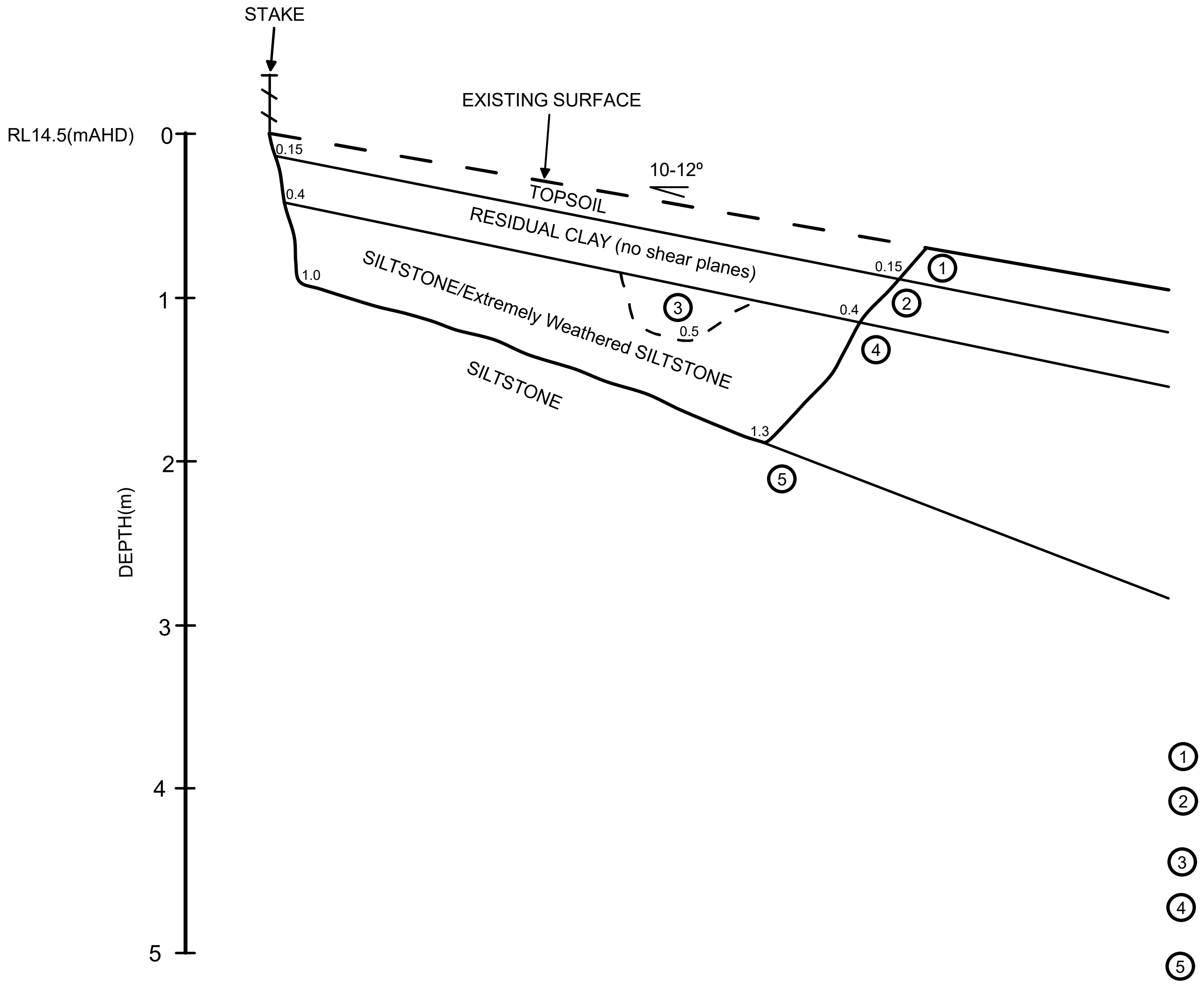
END OF TEST PIT AT 1.9m DEPTH
BUCKET REFUSAL ON INFERRED
SLIGHTLY WEATHERED, HIGH STRENGTH BASALT
'DRY' ON COMPLETION

TEST PIT 216
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 13



SAMPLE:
DS: 0.2-0.3

HAND PENETROMETER (kPa)
0.15-0.4: 140, 200, 140, 170

1. TOPSOIL: Silty clay, medium plasticity, dark brown, with root fibres. w>PL
2. Silty CLAY: medium plasticity, dark brown, with fine to coarse grained, sub-angular basalt gravel, trace of root fibres. w>PL, Stiff, RESIDUAL
3. BASALT: grey, highly fractured with numerous clay bands. Highly Weathered. Low Strength [Low Bucket Resistance]
4. Interbedded SILTSTONE (70%): red brown, highly weathered and very low ro low strength, thinly laminated and highly fractured, and Extremely Weathered siltstone (30%): gravelly CLAY, red brown and brown. [Very Low to Low Bucket Resistance]
5. SILTSTONE: red brown, thinly laminated and highly fractured, with high strength ferricrete bands. Moderately Weathered, Medium Strength [High Bucket Resistance]

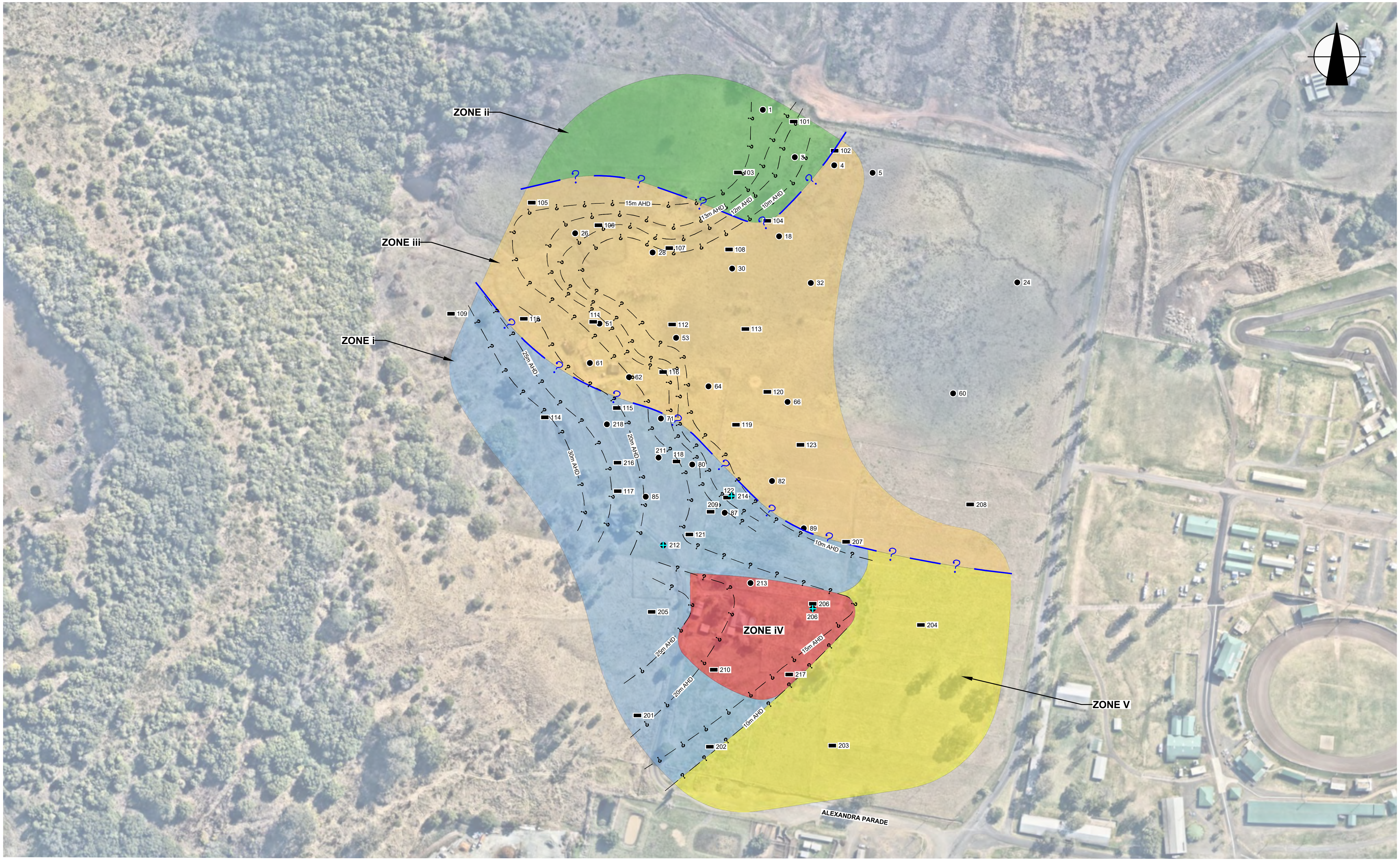
END OF TEST PIT AT 1.0m (high side)
TO 1.3m (low side) DEPTH
BUCKET REFUSAL ON MODERATELY WEATHERED/SLIGHTLY WEATHERED
HIGH STRENGTH FERRICRETE BAND
'DRY' ON COMPLETION

TEST PIT 217
CROSS SECTIONAL SKETCH
LOOKING NORTH-EAST

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 37635UOR Figure No. 14



LEGEND

- JKE/JKG BOREHOLE AND GROUNDWATER MONITORING WELL (MAY AND JUNE 2025)
- JKG BOREHOLE (1, 2, 3 ETC, JKG 2024 INVESTIGATION. 206 ETC, MAY AND JUNE 2025)
- JKG TEST PIT (101, 102 ETC, JKG 2025 INVESTIGATION. 201, 202 ETC, MAY AND JUNE 2025)

0 30 60 90 120 150
SCALE 1:3000 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:	APPROXIMATE BEDROCK SURFACE CONTOURS
Location:	163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
Report No:	37635UOR
Figure No:	15

JKGeotechnics

PLOT DATE: 27/06/2025 8:36:26 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG

LEGEND

- JKE/JKG BOREHOLE AND GROUNDWATER MONITORING WELL (MAY AND JUNE 2025)
- JKG BOREHOLE (1, 2, 3 ETC, JKG 2024 INVESTIGATION. 206 ETC, MAY AND JUNE 2025)
- JKG TEST PIT (101, 102 ETC, JKG 2025 INVESTIGATION. 201, 202 ETC, MAY AND JUNE 2025)

NOTE:
COMPETENT BEDROCK TYPICALLY: MEDIUM TO HIGH (OR HIGHER) STRENGTH BASALT;
OCCASIONALLY MEDIUM TO HIGH STRENGTH TUFF.

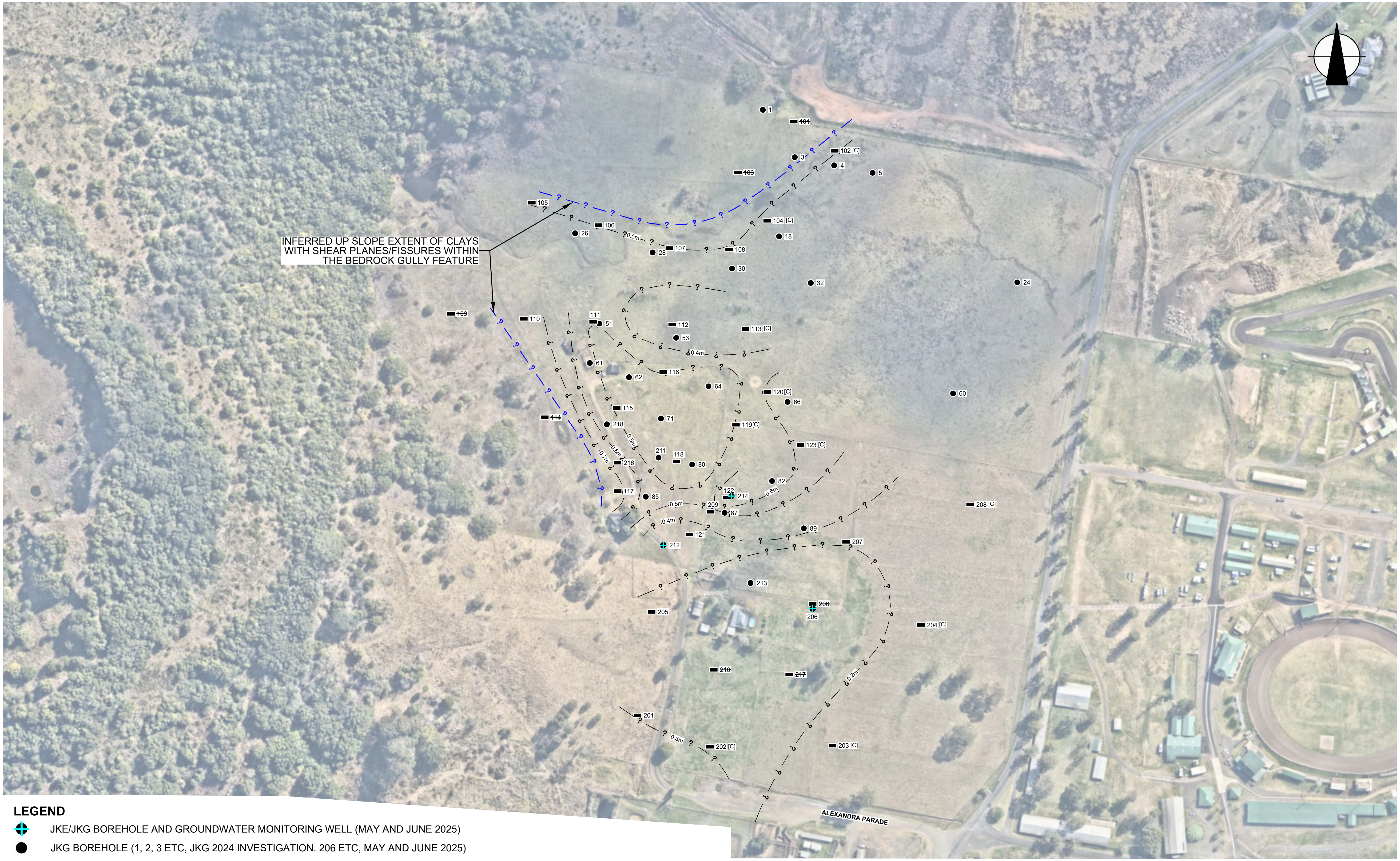
0 30 60 90 120 150
SCALE 1:3000 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:	APPROXIMATE CONTOURS OF COMPETENT BEDROCK
Location:	163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
Report No: 37635UOR	Figure No: 16

JKGeotechnics

PLOT DATE: 27/06/2025 8:36:39 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG



LEGEND

- JKE/JKG BOREHOLE AND GROUNDWATER MONITORING WELL (MAY AND JUNE 2025)
- JKG BOREHOLE (1, 2, 3 ETC, JKG 2024 INVESTIGATION. 206 ETC, MAY AND JUNE 2025)
- JKG TEST PIT (101, 102 ETC, JKG 2025 INVESTIGATION. 201, 202 ETC, MAY AND JUNE 2025)

NOTES:

1. ONLY LOGGING OF TEST PITS USED AS THE SIZE OF EXCAVATION PROVIDES A MORE REPRESENTATIVE SAMPLE OF THE SOIL PROFILE COMPARED TO BOREHOLES.
2. ~~101~~ INDICATES NO SHEAR PLANES/FISSURES ENCOUNTERED.
3. 123[C] INDICATES TEST PIT COLLAPSED IN CLAYS CONTAINING SHEAR PLANES/FISSURES.

0 30 60 90 120 150

SCALE 1:3000 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **APPROXIMATE DEPTH CONTOURS TO FIRST OBSERVED SHEAR PLANES/FISSURES**

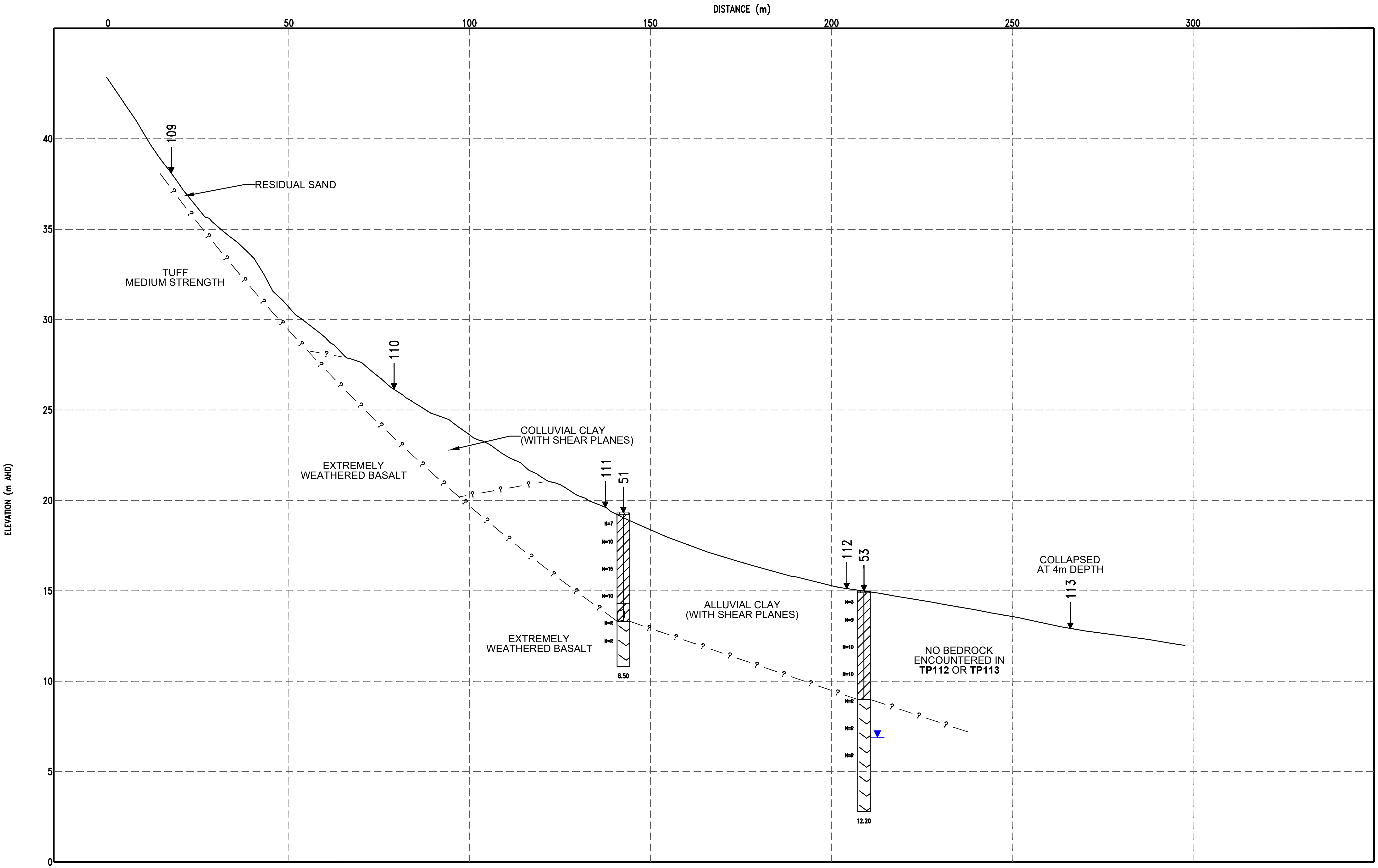
Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Report No: 37635UOR

Figure No: 17

JKGeotechnics

PLOT DATE: 27/06/2025 8:36:50 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG

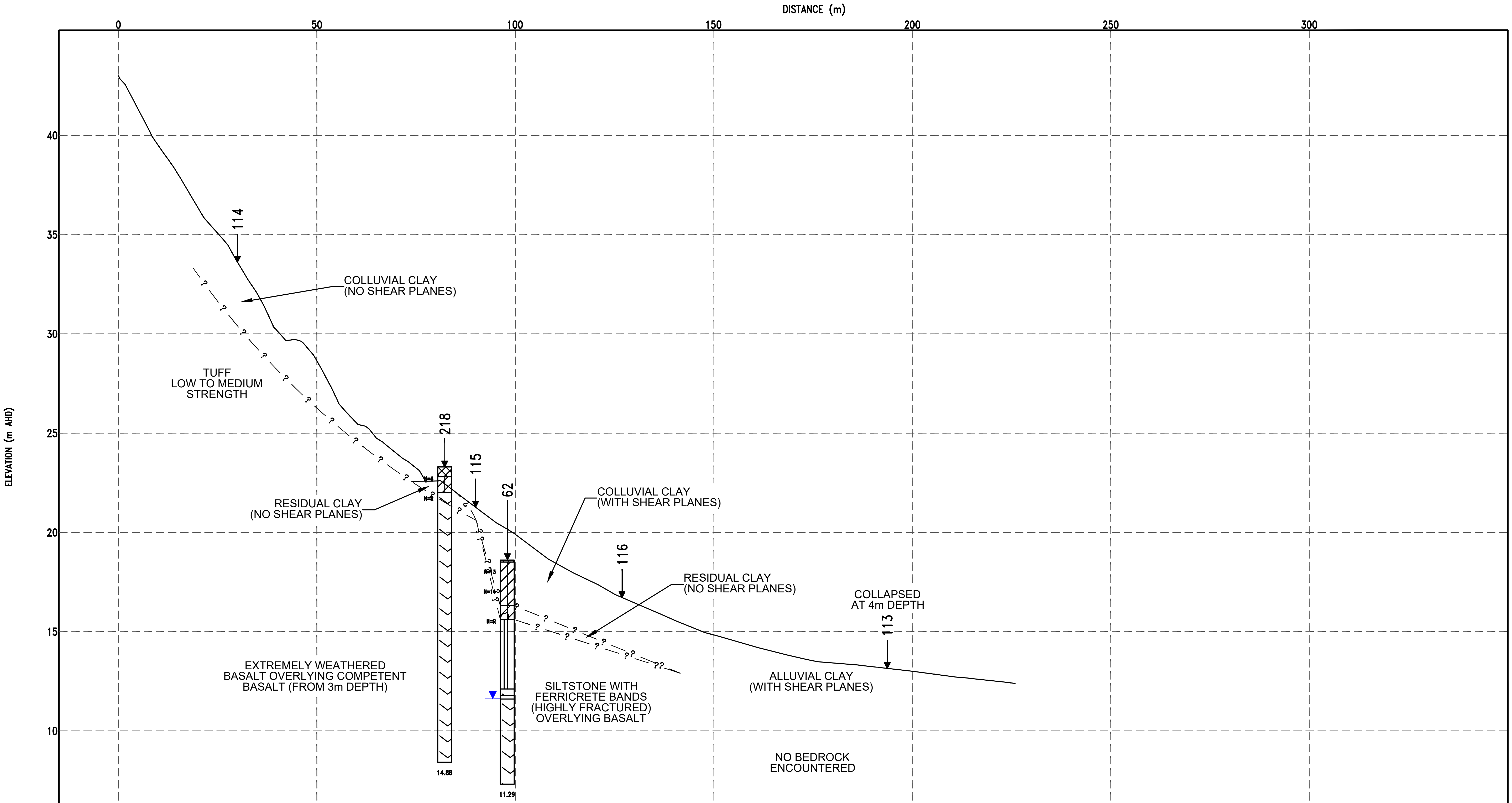


MATERIAL GRAPHIC

- BASALT/ANDESITE
- TOPSOIL
- GRAVELLY SILTY CLAY (CL, CI, CH)
- SILTY CLAY (CL, CI, CH)

H:SCALE 1:1000 @A3 (0 10 20 30 40 50 METRES)	Title: **GEOTECHNICAL SECTION A-A**
V:SCALE 1:200 @A3 (0 2 4 6 8 10 METRES)	Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
This plan should be read in conjunction with the JK Geotechnics report.	Report No: 37635UOR — Figure No: 18

JKGeotechnics



MATERIAL GRAPHIC

- BASALT/ANDESITE
- GRAVELLY SILTY CLAY (CL, CI, CH)
- NO CORE
- SILTY CLAY (CL, CI, CH)
- FILL
- SILTSTONE
- TOPSOIL

0	10	20	30	40	50
H: SCALE		1:1000 @A3			METRES
0	2	4	6	8	10
V: SCALE		1:200 @A3			METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SECTION B-B**

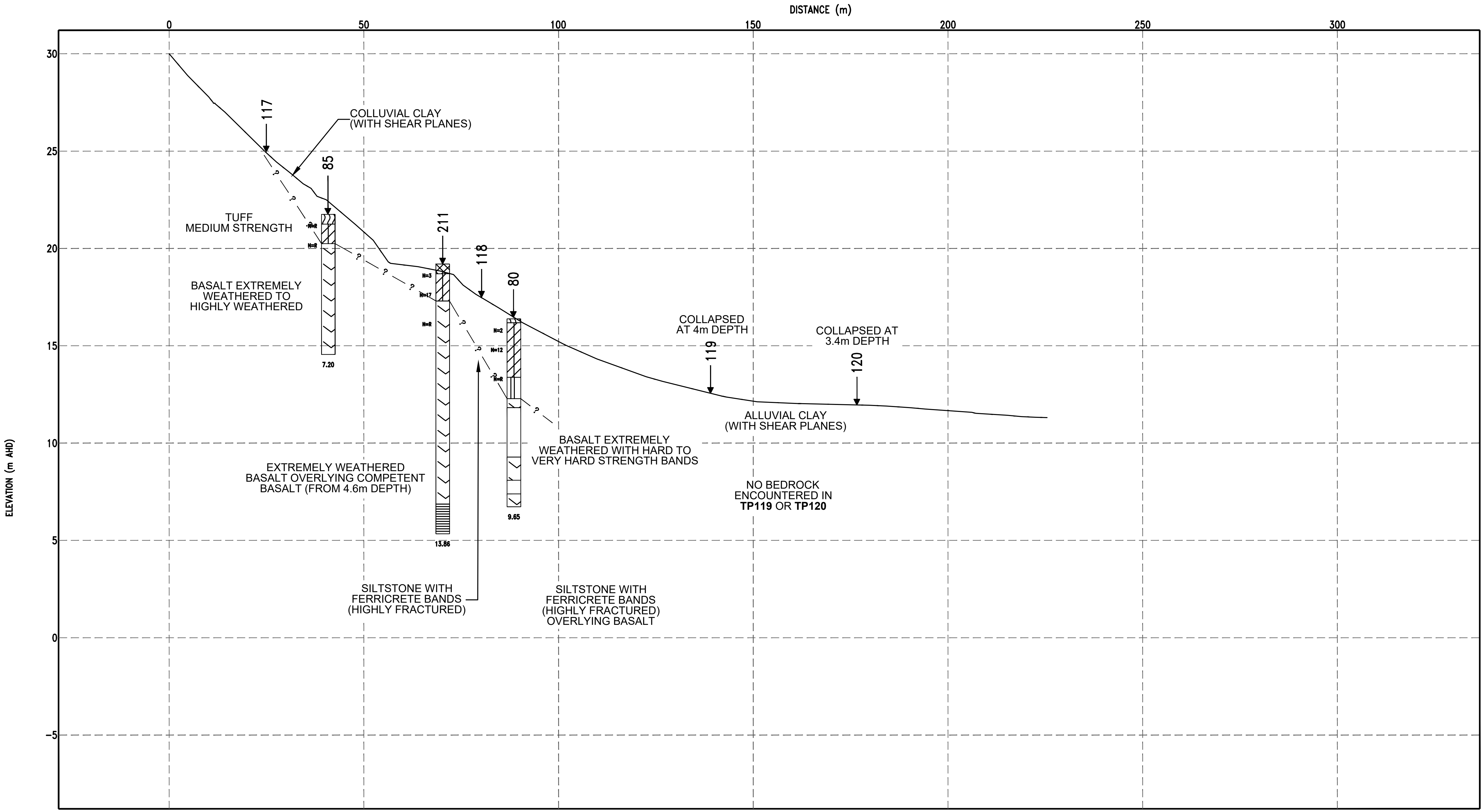
Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Report No: 37635UOR

Figure No: 19

JKGeotechnics

PLOT DATE: 26/06/2025 10:41:07 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG



MATERIAL GRAPHIC

- BASALT/ANDESITE
- NO CORE
- SILTY CLAY (CL, CI, CH)
- FILL
- SILTSTONE
- TOPSOIL
- TUFF

0 10 20 30 40 50
H:SCALE 1:1000 @A3 METRES
0 2 4 6 8 10
V:SCALE 1:200 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SECTION C-C**

Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Report No: 37635UOR

Figure No: 20

JKGeotechnics

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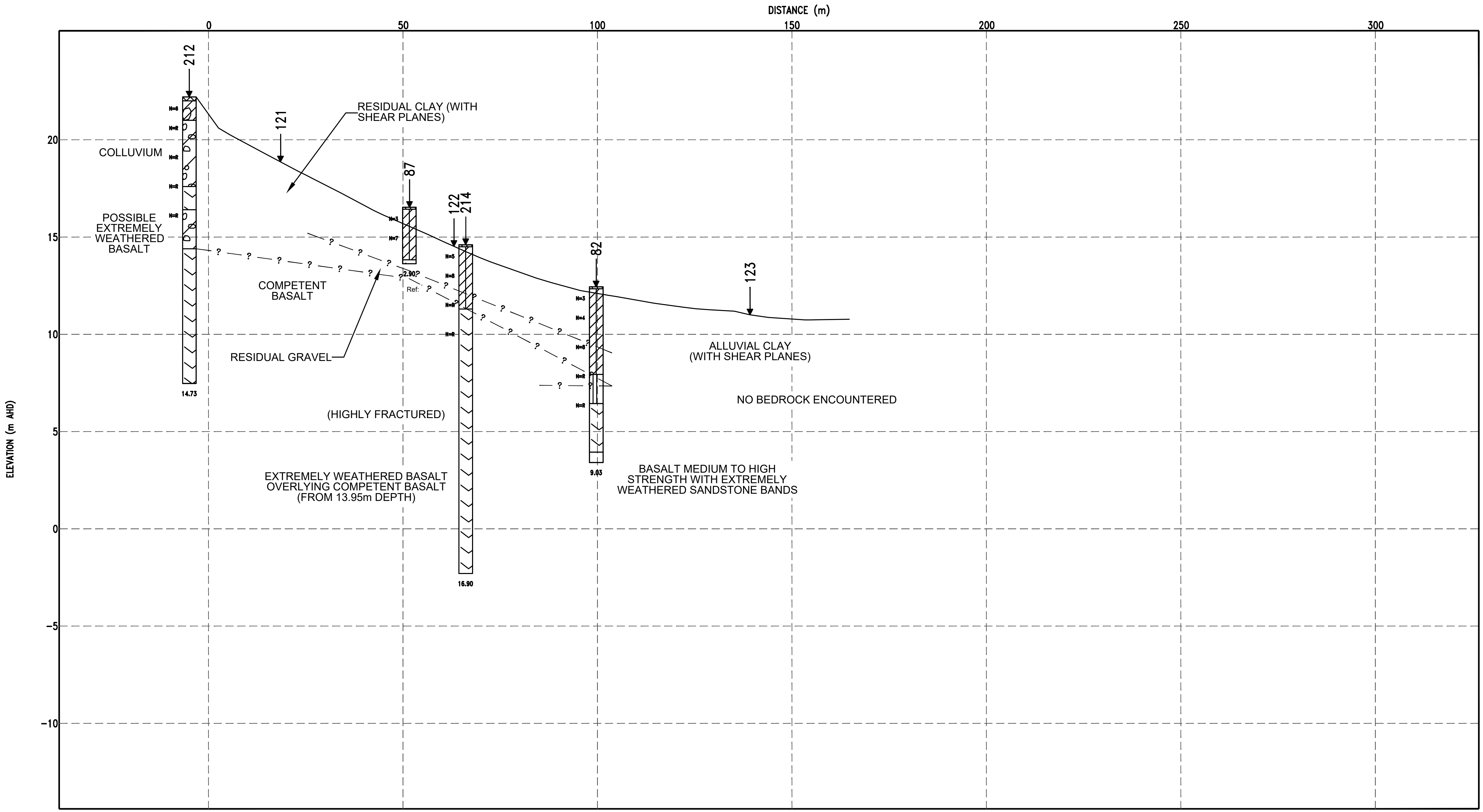


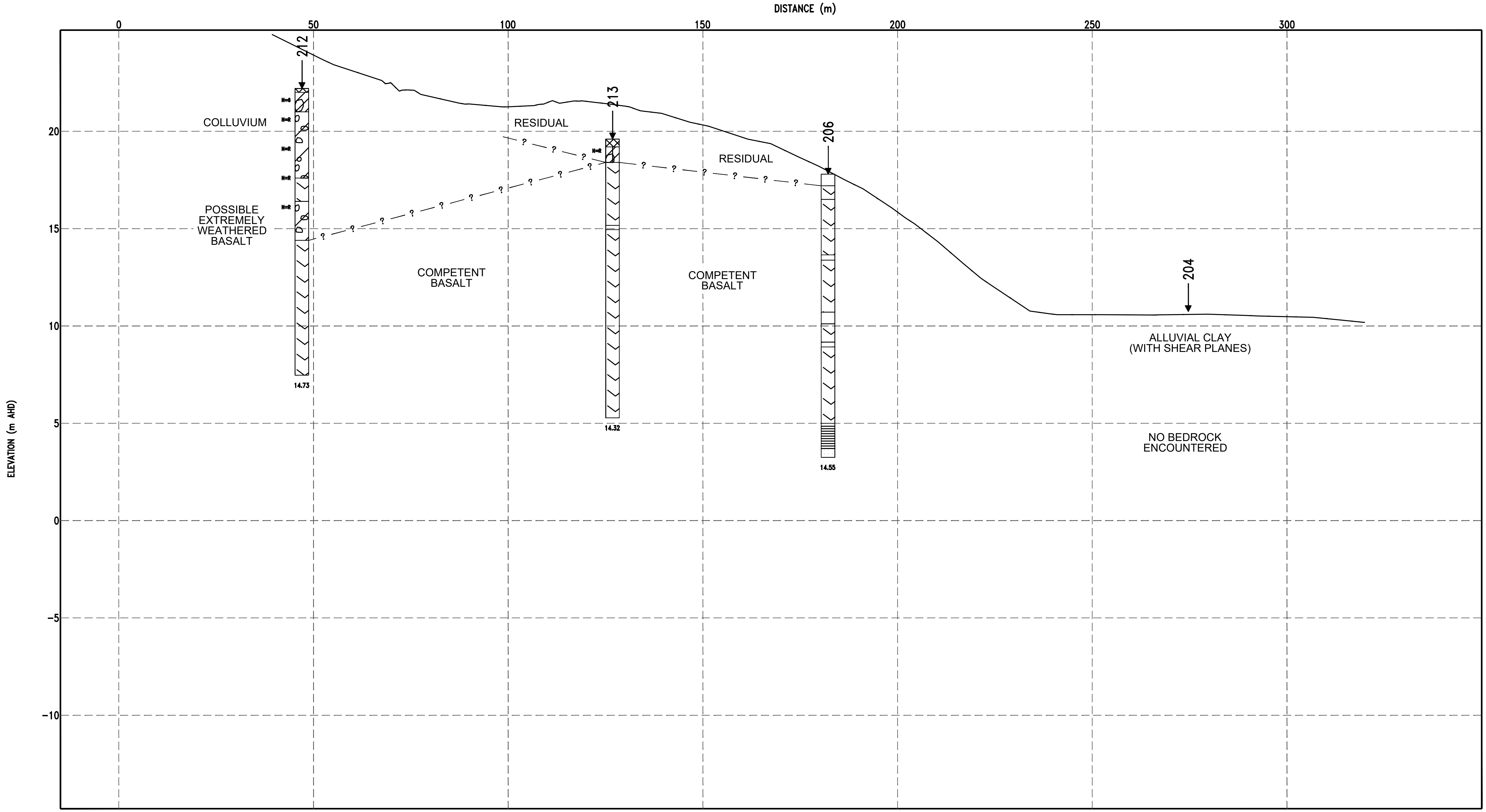
MATERIAL GRAPHIC

- BASALT/ANDESITE
- CLAYEY GRAVEL (GC)
- GRAVELLY CLAY (CL, CI, CH)
- NO CORE
- SILTY CLAY (CL, CI, CH)
- FILL
- SILTSTONE
- TOPSOIL

H:SCALE 1:1000 @A3 METRES (0 10 20 30 40 50)	Title: **GEOTECHNICAL SECTION D-D**
V:SCALE 1:200 @A3 METRES (0 2 4 6 8 10)	Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
This plan should be read in conjunction with the JK Geotechnics report.	Report No: 37635UOR — Figure No: 21

JKGeotechnics

PLOT DATE: 26/06/2025 10:41:35 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG



MATERIAL GRAPHIC

BASALT/ANDESITE
BLANK
CLAYEY GRAVEL (GC)
GRAVELLY CLAY (CL, CI, CH)
GRAVELLY SILTY CLAY (CL, CI, CH)
NO CORE
FILL
SANDSTONE
TUFF

H:SCALE 0 10 20 30 40 50 METRES 1:1000 @A3

V:SCALE 0 2 4 6 8 10 METRES 1:200 @A3

This plan should be read in conjunction with the JK Geotechnics report.

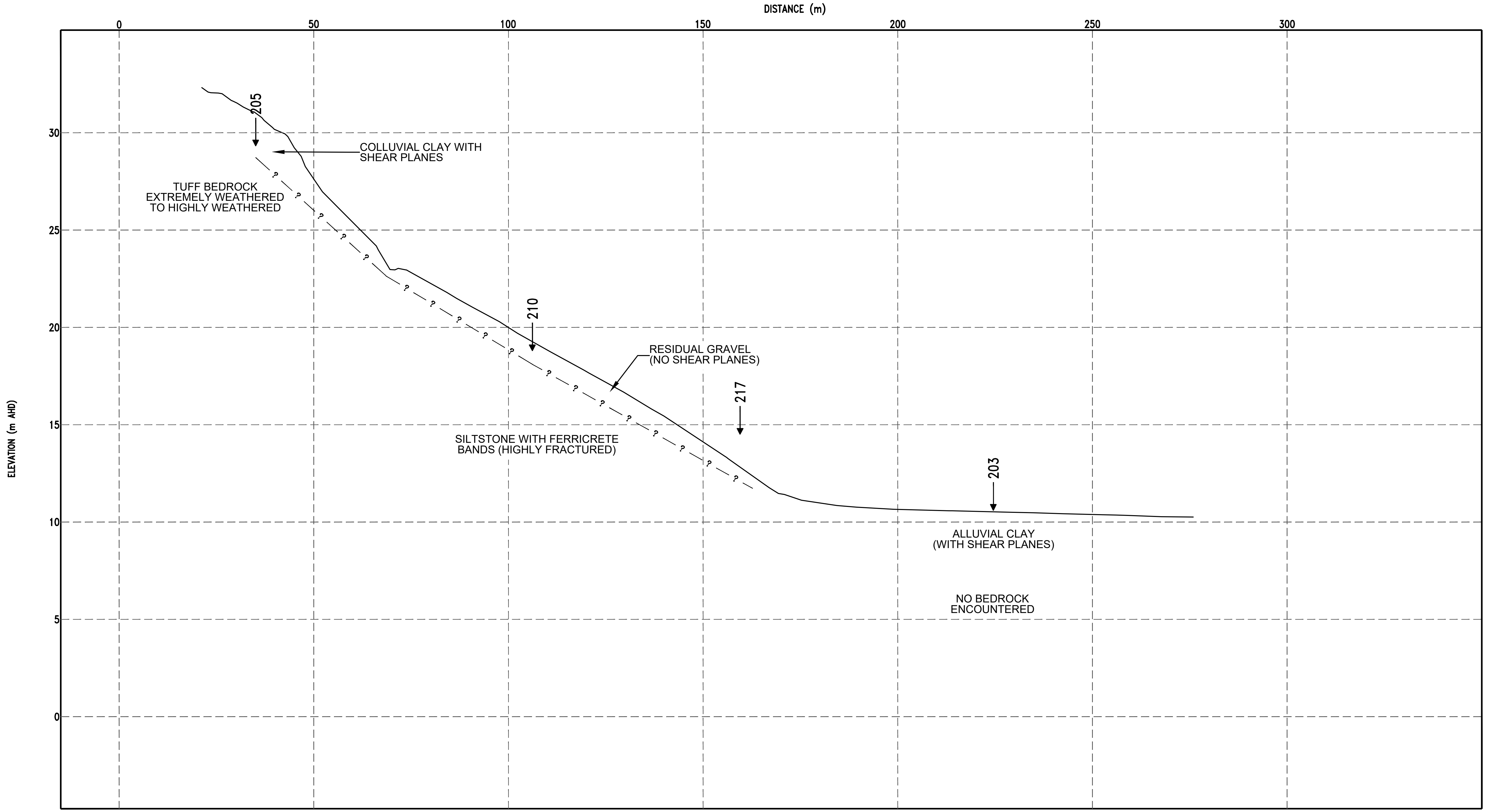
Title: GEOTECHNICAL SECTION E-E

Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Report No: 37635UOR

Figure No: 22

JKGeotechnics



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V: SCALE 1:200 @A3 (0 2 4 6 8 10 METRES)	Location: 163 &170 ALEXANDRA PARADE, NORTH LISMORE, NSW
This plan should be read in conjunction with the JK Geotechnics report.	Report No: 37635UOR — Figure No: 23
	JKGeotechnics

PLOT DATE: 26/06/2025 10:41:55 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37635UOR NORTH LISMORE\CAD\37635UOR.DWG

APPENDIX A

GBG Report (Ref. GBGA2804 Rev.1, dated 25 June 2025)

Sydney
28/7 Salisbury Road
Castle Hill, NSW, 2154
+61 02 9890 2122

Perth
Unit 1, 11 Gympie Way
Willetton, WA, 6155
+61 08 9354 6300
info@gbgoz.com.au

GBGGROUP

Geophysical Consultants

REPORT

North Lismore School Development Geophysical Investigation

Date: 25 June 2025

Job Number: GBGA2804

Photo Credit: Oscar Leon Estacio

DETAILS

Project Number:	GBGA2804
Document Title:	North Lismore School Development
Site Address:	Richmond River High, Campus
Client Details:	Paul Roberts Principal Engineering Geologist JK Geotechnics
Client Address:	Unit 7, 40 Leonard Crescent Brendale QLD 4500
Contact Information:	Tel: +61 7 3012 6339 Email: PRoberts@jkgeotechnics.com.au

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2			
3			

DISTRIBUTION

Revision	Electronic	Paper	Issued to
Draft	1	0	Paul Roberts
1	1	0	Paul Roberts

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1 INTRODUCTION

At the request of JK Geotechnics on behalf of NSW Education School Infrastructure, GBG Australia Pty Ltd (part of GBG Group) carried out a seismic survey near North Lismore NSW. The investigation was conducted on 8th and 9th April 2025.

The geophysical method employed was Seismic Refraction (SR). The objective of this survey was to define the top of rock. The location of survey lines was agreed upon prior to attending site with some minor changes due to field conditions.

This report describes the data collection techniques and presents the findings.

2 INVESTIGATION SITE

The location of the SR lines was agreed upon beforehand with some minor changes discussed on site with the clients representative due to obstacles along the original alignment (see Figure 1). Every effort was made to collect data as close to the original locations as possible.

Figure 1: The survey area and locations of the acquired SR lines.

3 DATA ACQUISITION

3.1 Seismic Refraction

The theory of Seismic Refraction method and its limitations are described in Appendix B.

Seismic Refraction data was acquired using DMT Summit X One seismograph. Seismic records were saved on a Dell laptop computer. Parameters utilised for the measurements are described in Table 1.

Table 1: Acquisition parameters used for SR recordings.

Parameter	Value
Number of geophones	Up to 90
Geophone spacing	2 m
Geophone frequency	10 Hz
Record length	125 ms
Sample interval	0.0625 ms

The number of geophones were chosen in relation to the site constraints (see Table 2). Shot locations were taken at an approximate 5 geophone interval for all lines including offset shots. A sledgehammer impacting a metal plate was used as the seismic source. Between 4 and 10 stacks were performed for each record. Centre shots had fewer stacks than outside shots, with offset shots having 10 stacks. The number of stacks at each location was determined based on data quality. Additional stacks were added until data was acceptable (clear identification of first arrivals) or there was no significant improvement from previous stack.

Table 2: Number of geophones used for each line.

Line	Number of geophones used
Line 1	32
Line 3	50
Line 4	90
Line 5	56
Line 6	48

Figure 2: Data acquisition along Line 3.

3.2 Location and position

All Global Navigation Satellite System data presented in this report is given in MGA2020 zone 56 (GDA2020) and AHD (AusGeoid2020). The coordinates of SRT geophones and shot locations were measured using an Emlid Reach RS2 multi-band, RTK-enabled GNSS receiver. RTK corrections were streamed from the CSNO00AUS0 AUSCORS reference station. The recorded horizontal and vertical RMS errors were 0.013 m and 0.015 m respectively.

Table 3 summarise the coordinates of the measured lines.

Table 3: Locations of SR lines.

	Start		End	
Point	**Easting**	**Northing**	**Easting**	**Northing**
Line 1	526138.718	6814877.319	526171.52	6814824.823
Line 3	526209.316	6814681.428	526189.373	6814585.870
Line 4	526362.379	6814693.666	526187.417	6814720.518
Line 5	526289.364	6814788.641	526237.411	6814692.667
Line 6	526253.085	6814678.708	526289.488	6814593.422

4 GEOPHYSICAL DATA QUALITY AND PROCESSING

4.1 Data processing

Processing of seismic refraction data was conducted using a tomographic approach. Rayfract (V3.35 Intelligent Resources Inc, 2017) software employs a modern approach that relies on computer modelling, specifically tomography, to calculate an interpreted seismic section that matches the travel time graphs. By utilizing Wavefront Eikonal Tomography (WET), Rayfract simulates the movement of seismic waves within an initial seismic model. It then compares the resulting travel time graphs with the actual graphs obtained from seismic refraction fieldwork, iteratively adjusting the seismic model until the best fit is achieved.

Processing steps included:

1. Model Geometry was set including geophone spacing and shot locations, which are set into station numbers. Shot and geophone location elevations are updated. Models are set to adjust the X coordinates to fit the Y coordinates and elevation.

2. The first arrival travel-times (first breaks) for each seismic record were picked where they were clearly identifiable. Where a trace produced too much noise to decern the first break that trace was not picked.

3. A smooth minimum-structure initial model was generated directly from the seismic refraction first break picks using a gradient initial model with velocity increasing with depth. A layer initial model was also developed and compared against the resulting gradient model.

4. The initial model was then refined using both Delta-t-V and gradient methods by calculating the misfit between modelled Wave-path Eikonal travel-time and field travel-times. The inversion algorithm was run for 20 iterations until adequate convergence between modelled data and field occurred.

The Rayfract software outputs Grid files in Surfer version 28 (Golden Software) format. The sections show variations in the modelled P-wave velocity along the profiles and elevation above datum.

4.2 Data quality

The SR data quality across all survey lines was generally good. In most of the records it was possible to clearly identify the first arrivals. However, some data was impacted by noise and the first arrivals could be picked less than 10 channels from the shot location. Temporary display filters on field were applied as needed to ensure data with sufficient signal-to-noise levels were recorded. Where necessary, additional stacks were added to improve data quality until no significant improvement between each stack was observed. The root-mean-square (RMS) errors of the produced P-wave models are relatively low (see **Table 4**). For some of the survey lines there were up to 2 geophones that did not record the data. Attempts were made to solve this issue (re-planting the geophone, change of geophone and/or remote unit), but in some cases the problems persisted. In all cases bad channels were far apart, therefore did not have any significant effect on data quality or the resulting model reliability.

The potential sources of noise in this site were vehicle traffic on the nearby road (~200 m east), regular air traffic, heavy machinery operating nearby (~120 m south) and wind. Where possible, data acquisition was paused, or shots were timed to have the least possible impact from these sources.

Table 4: RMS errors for SR models (using Layer starting model).

Line	RMS (%)
Line 1	1.2
Line 3	1.6
Line 4	1.7
Line 5	1.3
Line 6	1.5

5 RESULTS AND INTERPRETATION

The results of the geophysical investigation carried out for GBGA2804 have been provided in the following drawings attached in Appendix A of this report:

- GBGA2804_01 – Site map
- GBGA2804_02 – Line 1
- GBGA2804_03 – Line 3
- GBGA2804_04 – Line 4
- GBGA2804_05 – Line 5
- GBGA2804_06 – Line 6

5.1 Seismic Refraction results

During SR data processing three models were generated and compared for each of the profiles - Smooth gradient, Delta-t-V and Layered model. Overall, there was no significant difference between all three models. Only the SR results obtained using Layered model are presented in this report, since the P-wave velocities could be relatively clearly identified during the picking of first arrivals. Layer starting model (Layer Model) output maps the boundary at which the refractor occurs to define a layer boundary. The user assigns a velocity to each layer on this boundary, which forms the basis of the starting model. This starting model is then used for the WET inversion algorithm. In the case of this project, it has been interpreted of comprising of 3 separate layers, i.e. 2 refractors were observed.

Based on refractor velocities observed during the processing phase, and the general character of the velocity responses, the SR data has been interpreted to represent 3 layers comprising of 'low velocities (Layer 1)' <750 m/s, 'medium velocities (Layer 2)' between 750 – 2000 m/s, and 'high velocities (Layer 3)' >2000 m/s. The basis of this interpretation mostly relies on seismic data gathered from Line 1, where additional geological information from nearby intrusive tests were available. This interpretation seems to reflect what would be expected from the local geology. However, other interpretations to this dataset are possible and it is likely that the exact geological boundaries these layers represent might be somewhere within the wider velocity range.

Low velocities (Layer 1) ranging from 350 – 750 m/s: This layer is interpreted to be fill/topsoil/alluvial/colluvial sediments and residual material, mostly consisting of silty clay.

Medium velocities (Layer 2) ranging from 750 – 2000 m/s: This layer is interpreted as extremely weathered rock (siltstone or basalt), containing fine to coarse grained basalt and ironstone gravel and ferricrete bands. Since this layer consists of varying materials with different geotechnical properties, it is difficult to attribute precise P-wave velocity for this layer. It is likely that the actual lower boundary is between 500 – 1000 m/s and upper boundary between 1750 – 2250 m/s.

High velocities (Layer 3) of >2000 m/s: This layer is interpreted to be the top of basalt layer (slightly to highly weathered). The typical P-wave velocities of basalts are within the range of 5000 – 6000 m/s (see Appendix B). The much lower observed velocities in this site indicate higher degree of weathering or fracturing. The P-wave velocities within Layer 3 increase with depth, indicating less weathered material (unknown degree of weathering) in depth.

Layer 1 is found along all study area with depths ranging from 1 m in the slopes (Line 4 and 5) up to 3 m in low lying areas (beginning of Line 5, end of Line 6). Such tendencies are expected on slopes due to colluviation (buildup of material at the base of a hillslope). Along Line 3, Layer 1 is not present at the beginning and very end part of the profile. This line was located parallel to the road and locally man-made gravel layer was noted beneath the line. It is likely that along Line 3 chainages 0 - 18 m and 92 - 98 m old asphalt or gravel layer is found beneath the surface, increasing the P-wave velocities observed in this area.

The boundary between Layer 2 and Layer 3, indicated by 2000 m/s contour line, is varying and doesn't necessarily follow the surface topography. Interesting features can be found along Line 1 (chainages 25 – 40 m), Line 3 (chainages 35 – 42 m and 88 to 95 m), Line 4 (chainages 30 – 110 m), Line 5 (chainages 0 – 25 m) and Line 6 (chainages 27 – 40 m). These features indicate potential intrusions or varying weathering patterns within the bedrock layer. Very interesting bench-like feature can be found along the slope of Line 4, where Layer 3 is shallower than in other areas. Contrastingly, along the slope of Line 5 (chainages 25 – 67 m) a depression along 2000 m/s contour line is noted, indicating a thicker weathering layer.

5.2 Correlation with geotechnical results

There are several intrusive geotechnical tests performed at the site, located mostly in the northern part of the study area (see drawing GBGA2804_01). Only 2 of the test locations (Test Pit 115 and BH206) match with the Seismic Refraction profile location (Line 1 and 4, respectively), limiting a precise correlation between geophysical results and site geology. Elevation of the geotechnical investigations were adjusted to the Seismic Refraction profile elevation. It is believed that surfaces of geological boundaries in the area follow the steep topography, therefore, due to being offset from the actual geophysical profiles, use of reported geotechnical investigation elevations would complicate the interpretation. Only boreholes with reasonable proximity to the line (less than 30m away) were plotted over the seismic sections. However, considering the undulated topography and varying geology in the area, it is difficult to correlate these results even with this distance.

Geotechnical investigations generally identify 4 layers within the study area. The upper part (up to 3 m) consists of topsoil and alluvial or colluvial clay. It is followed by less than 0.5 m thick layer of residual clay. Due to the thin vertical extent of residual layer and similar geotechnical properties, it is unlikely to differentiate between residual layer and upper layer in the geophysical data, therefore in the interpretation section (5.1) they have been combined within Layer 1. Below it, 2.5 to 4 m thick extremely weathered siltstone layer can be found. The remainder of the geological section, up to approximately 10 m depth, consists of basalt with varying degrees of weathering (from slightly to highly weathered). At depths of 13 m or more breccia and sandstone was reported below basalt layer.

Test pits indicate thinner extremely weathered siltstone layers and shallower depth to basalt compared to borehole logs. Since test pits only extend up to 10 cm in the basalt layer, it is unlikely to reliably detect the degree of weathering. Additionally, borehole logs indicate basalt gravel within the weathered siltstone layer that might be mistakenly identified as the top of basalt layer.

The seismic results from Line 1 do not correlate well with geotechnical test results. Test pit 115 indicates the boundary between Layer 1 and Layer 2 at 1.3 m depth and boundary between Layer 2 and Layer 3 at 3.85 m depth. The very shallow boundary between Layer 2 and Layer 3 is questionable due to reasons described in the previous paragraph. During the inversion process, the P-wave velocity model is created with smoothly increasing velocities with depth, therefore abrupt velocity changes in the uppermost part of the section are unlikely to be precisely resolved. Inherent limitations of Seismic Refraction method and geophone spacing used restricts the precise identification of 0,8 m thick colluvial clay layer at the surface. This also assumes there is a distinct material property change that is able to be detected and not just a material type change. The boundary between Layer 1 and Layer 2 seems to partially correlate with boundary between residual material and extremely weathered siltstone from borehole logs. All 4 boreholes are offset from the seismic Line 1 and considering the varying geology, precise correlation between geological and geophysical data over this distance is unlikely.

The seismic results from Lines 4 and 5 show good correlation with the interpreted rock surface, represented by the 750 m/s velocity contour. However, there is no clear evidence of a lithological boundary associated with the 2000 m/s contour. This suggests that the transition between Layer 2 and Layer 3 is more likely controlled by variations in physical properties - such as the degree of weathering and rock strength - rather than distinct changes in lithology. This interpretation is supported by borehole logs, which document numerous defects and instances of core loss within the basalt unit, highlighting the complex and heterogeneous geological conditions present across the site.

6 CONCLUSIONS

The geophysical investigation was conducted for a school development project in North Lismore, NSW. The analysis resulted in a three-layer seismic interpretation which is assumed to represent a topsoil/sediment layer, extremely weathered material and slightly to highly weathered basalt based on geophysical results and available geotechnical information.

SR models indicate that the depth to the top of basalt layer is varying in the survey area. It is covered by up to 10 m thick extremely weathered rock layer, containing fine to coarse grained basalt and ironstone gravel and ferricrete bands. The lack of a distinct lithological boundary at the 2000 m/s contour suggests that the transition between Layer 2 and Layer 3 is governed more by changes in physical properties (e.g. weathering and fracturing) than by lithology. Several rising and bench-like features were identified along 2000 m/s contour, indicating potential intrusions or highly varying weathering conditions.

For and on behalf of

GBG Australia

Peteris Dzerins

Senior Geophysicist

APPENDIX A. RESULTS

NORTH LISMORE SCHOOL DEVELOPMENT - GEOPHYSICAL INVESTIGATION SITE MAP

LEGEND:
- Trial pit location
- Borehole location
- Seismic Refraction profile

GBGGROUP

GBG Australia Pty. Ltd.
28/7 Salisbury Road,
Castle Hill, NSW 2154
Telephone: (02) 9890 2122
Email: info@gbgoz.com.au

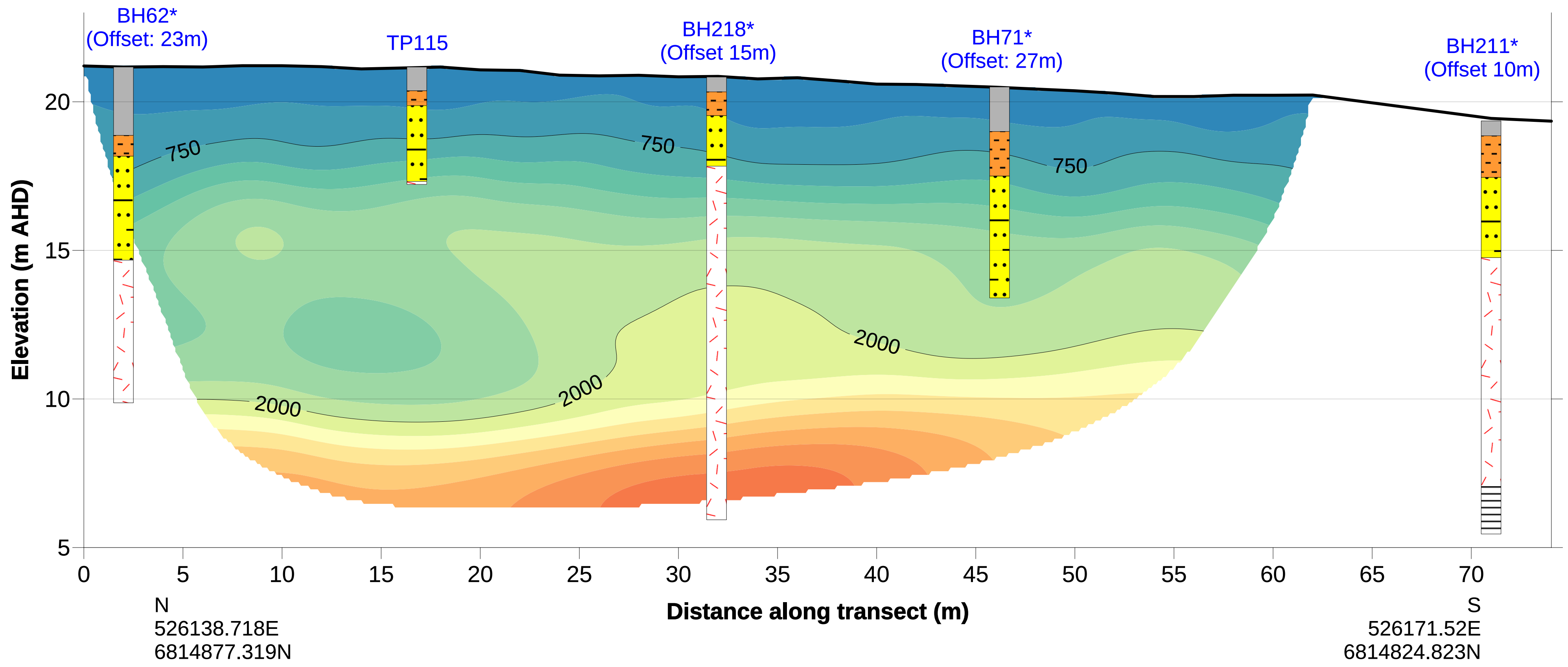
CLIENT: JK Geotechnics

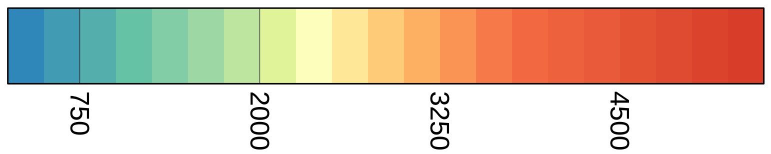
TITLE: NORTH LISMORE SCHOOL DEVELOPMENT

DRAWN: PD	DATE: 25/06/2025	REV: REV 2	SCALE: 1:1250	A3	DATUM: MGA2020 Z56	DRG No: GBGA2804_01

GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT

Line 1 - P-wave velocity model





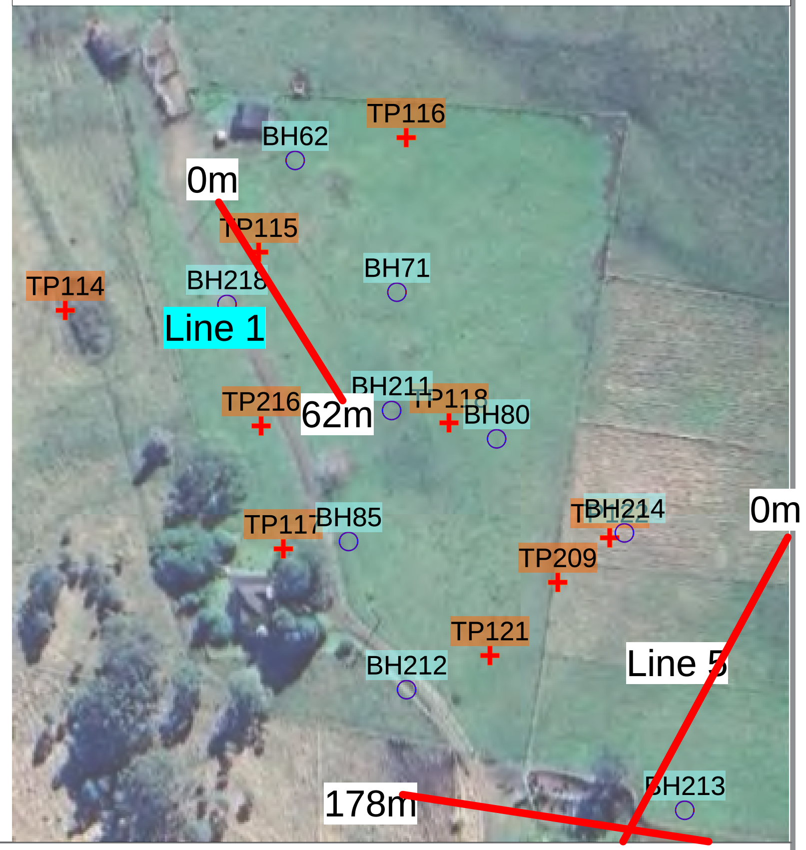
Modelled P-wave Velocity (m/s)

SIMPLIFIED BOREHOLE LEGEND

- Fill/topsoil/alluvial/colluvial sediments
- Residual material
- Extremely weathered rock (siltstone/basalt)
- Basalt (highly to slightly weathered)
- Breccia

MAP LEGEND:

- Borehole location
- Trial pit location
- Seismic Refraction profile



* Borehole elevations are shifted to correspond to geophysical profile elevations

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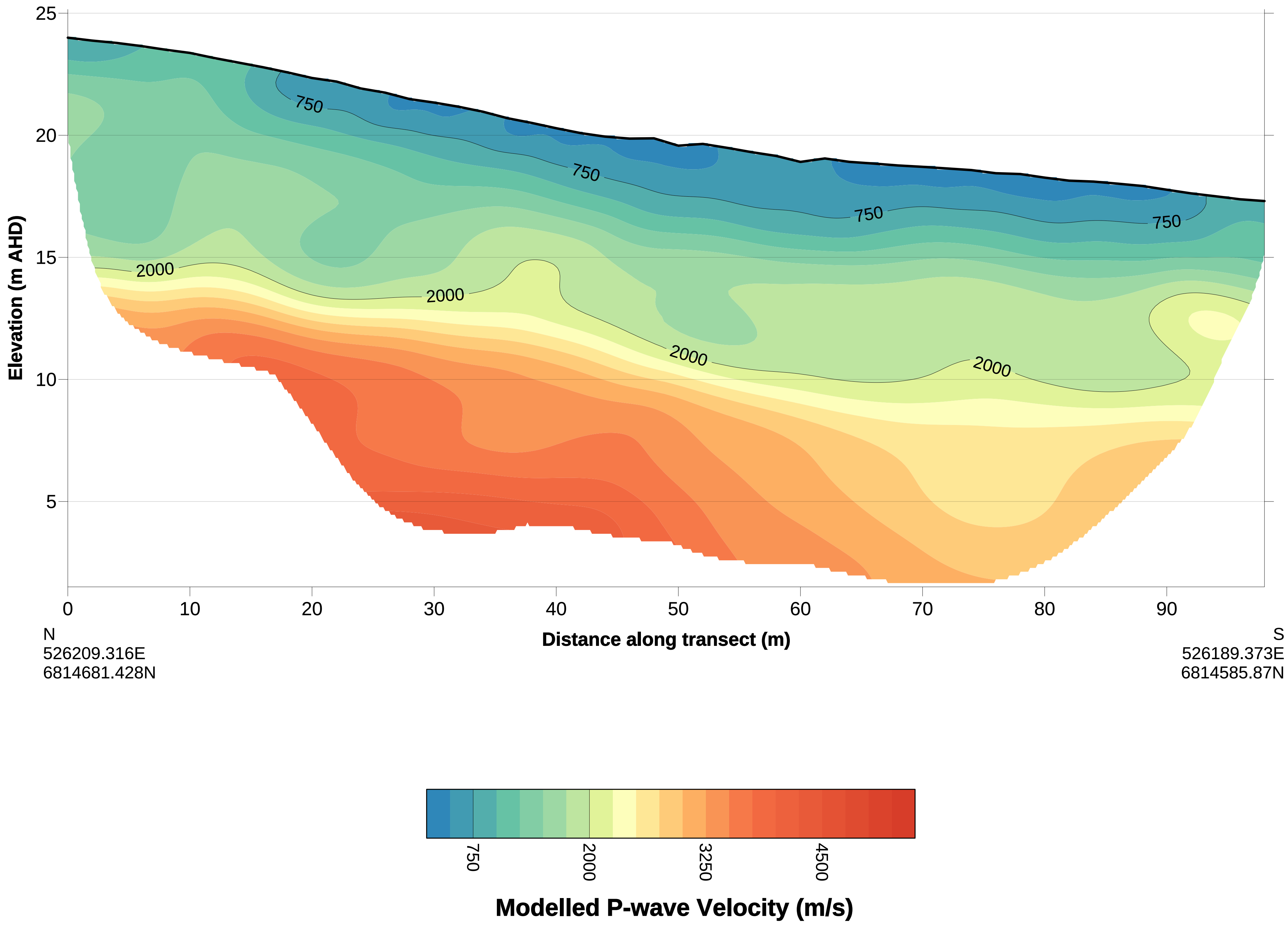
TITLE: GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT	SCALE: X 1:300 Y 1:200	DRAWN: PD
	DRG No: GBGA2804_02	REV: REV 2

GBG GROUP
GBG Australia Pty. Ltd.
28/7 Salisbury Road,
Castle Hill, NSW 2154
Telephone: (02) 9890 2122
Email: info@gbgoz.com.au

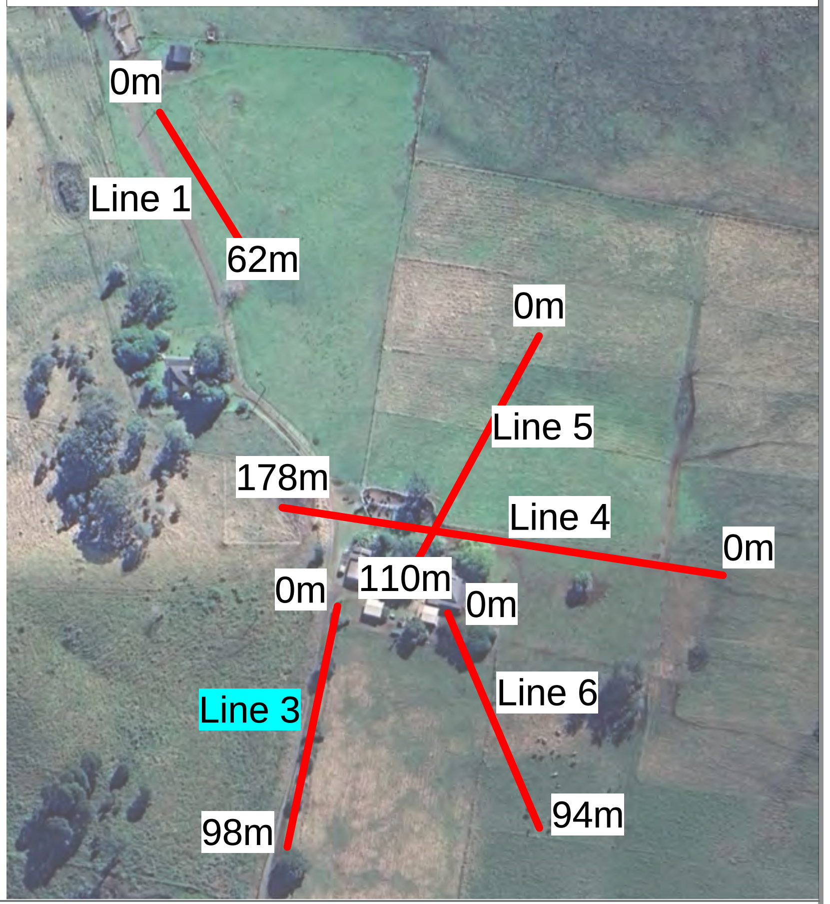
GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT

Line 3 - P-wave velocity model



MAP LEGEND:

Seismic Refraction profile



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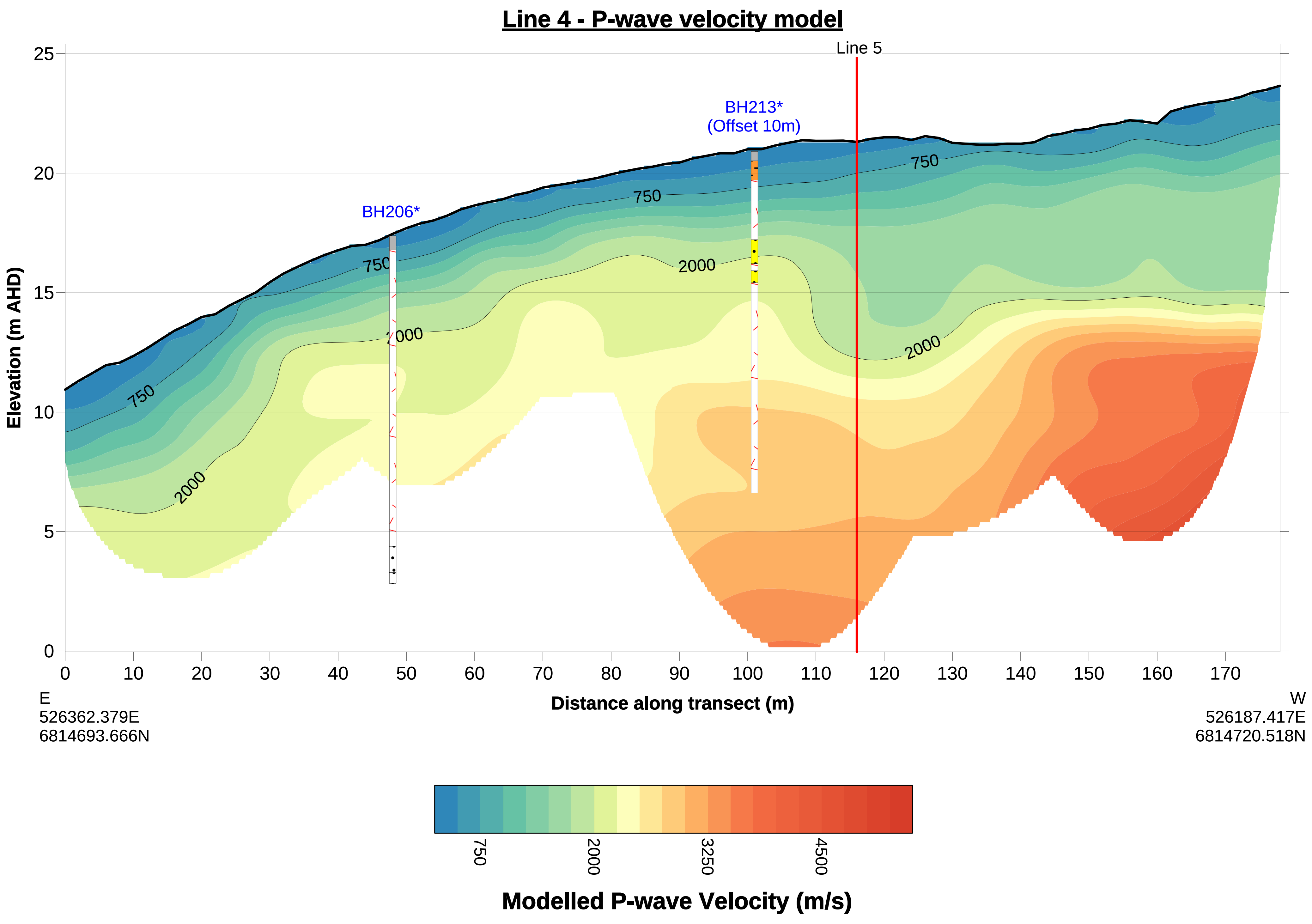
	DRG No: GBGA2804_03	REV: REV 2

GBGGROUP
GBG Australia Pty. Ltd.
28/7 Salisbury Road,
Castle Hill, NSW 2154
Telephone: (02) 9890 2122
Email: info@gbgoz.com.au

GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT

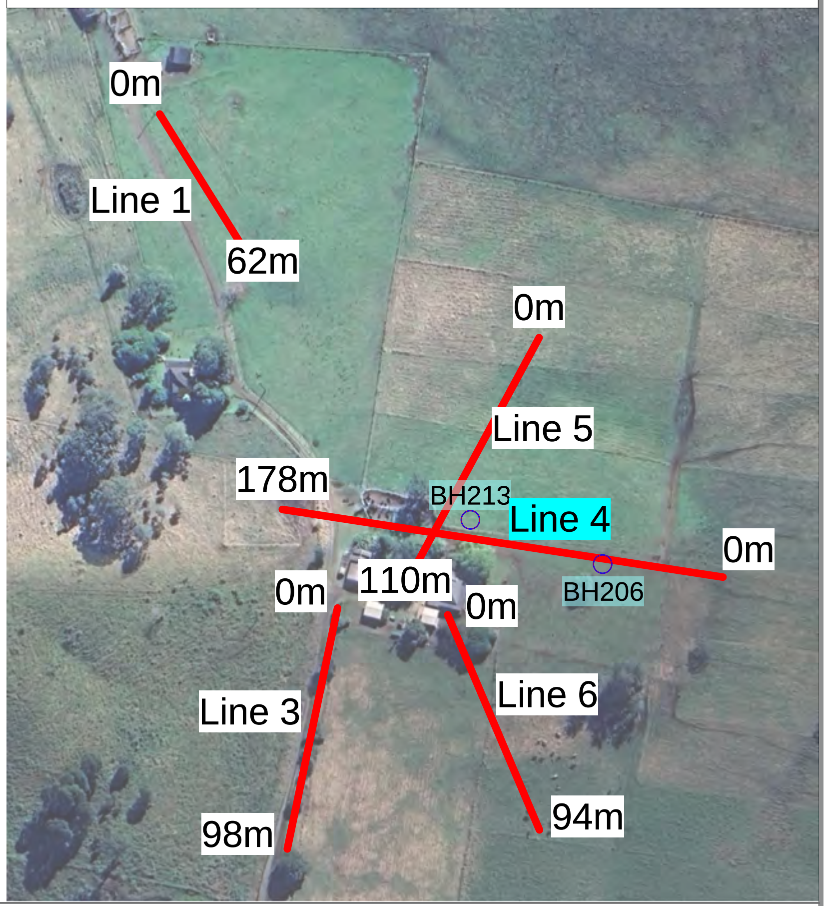


SIMPLIFIED BOREHOLE LEGEND

- Fill/topsoil/alluvial/colluvial sediments
- Residual material
- Extremely weathered rock (siltstone/basalt)
- Basalt (highly to slightly weathered)
- Highly weathered rock (Breccia or Sandstone)

MAP LEGEND:

- Seismic Refraction profile



LEGEND:

= INTERSECTION WITH CROSSING LINE

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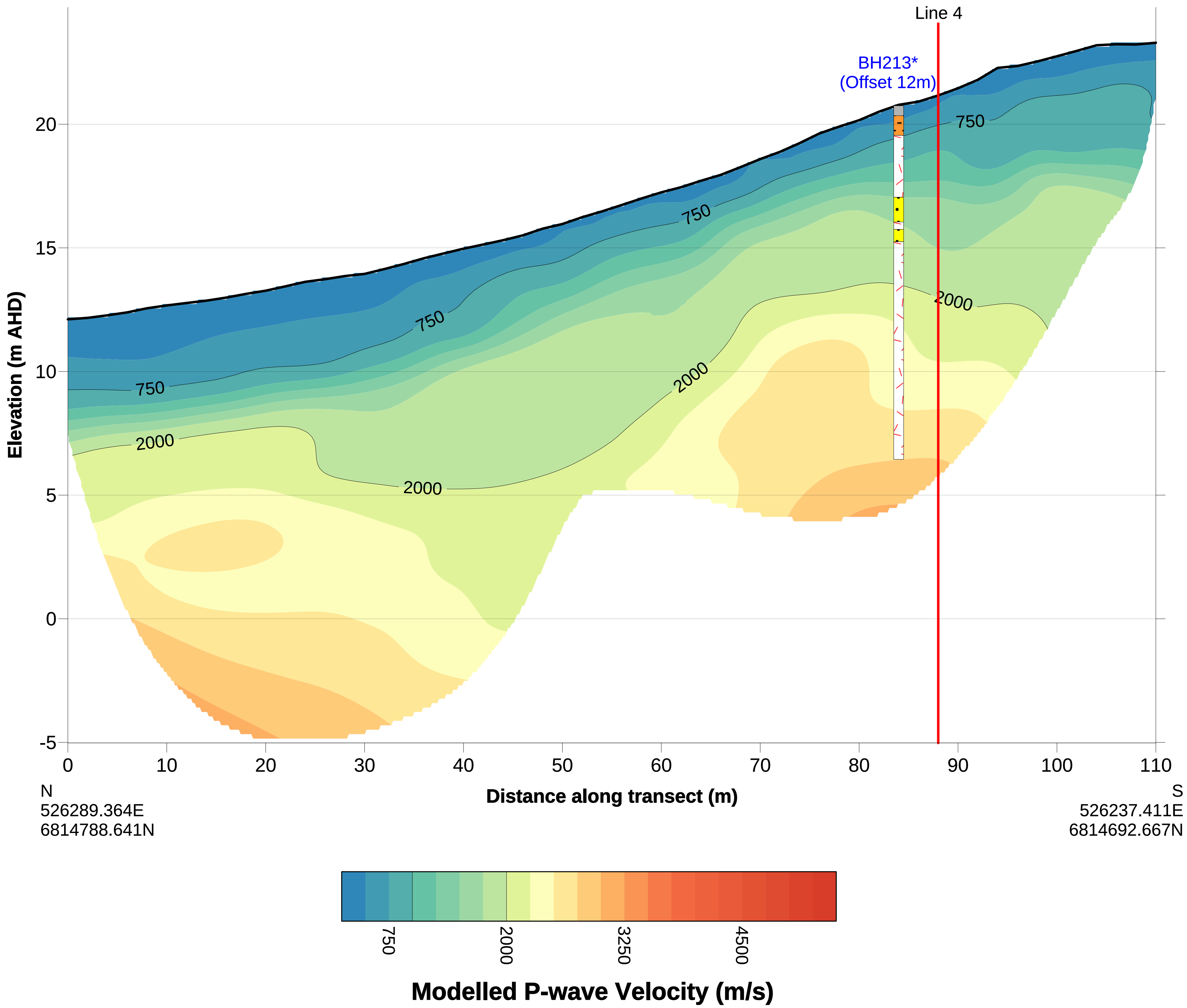
TITLE: GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT	SCALE: X 1:700 Y 1:200	DRAWN: PD
	DRG No: GBGA2804_04	REV: REV 2

GBGGROUP

GBG Australia Pty. Ltd.
28/7 Salisbury Road,
Castle Hill, NSW 2154
Telephone: (02) 9890 2122
Email: info@gbgoz.com.au

GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT

Line 5 - P-wave velocity model

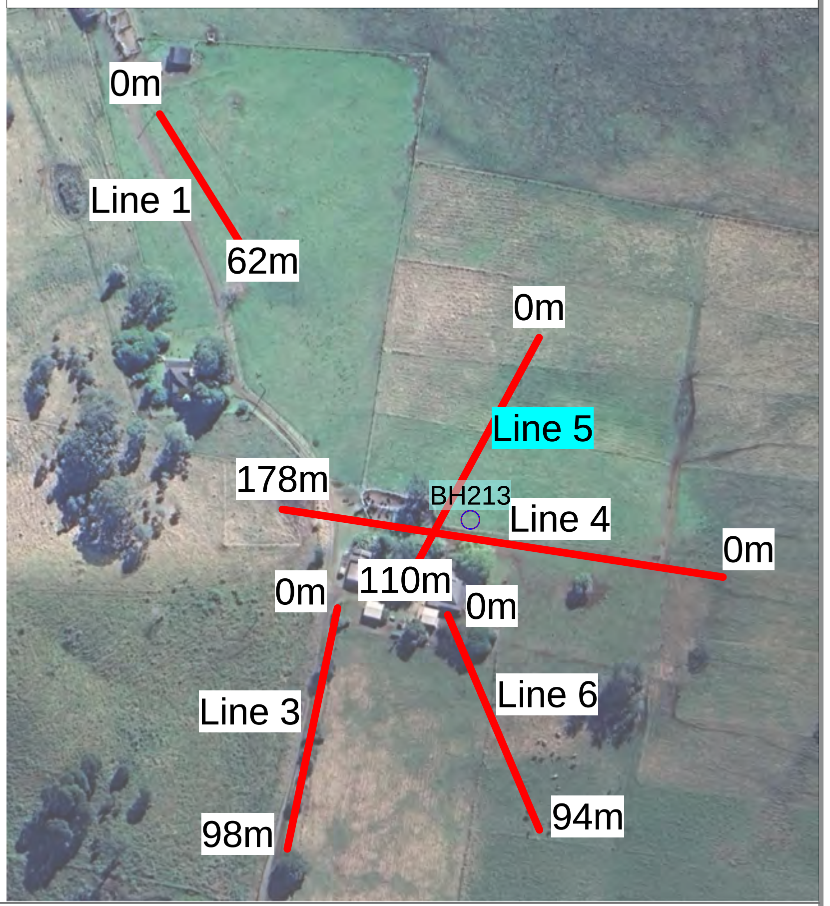


SIMPLIFIED BOREHOLE LEGEND

- Fill/topsoil/alluvial/colluvial sediments
- Residual material
- Extremely weathered rock (siltstone/basalt)
- Basalt (highly to slightly weathered)
- Breccia

MAP LEGEND:

- Seismic Refraction profile



LEGEND:

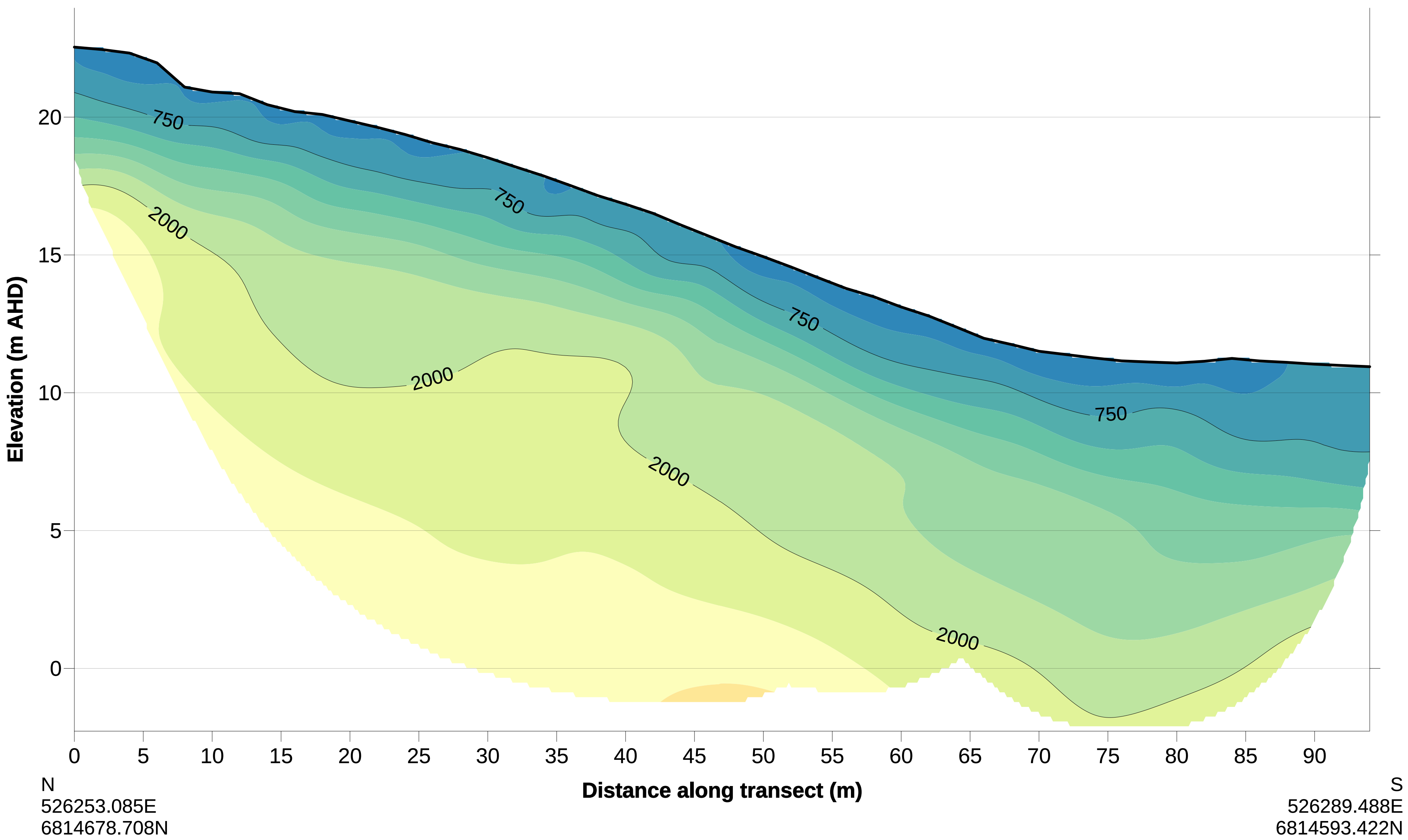
= INTERSECTION WITH CROSSING LINE

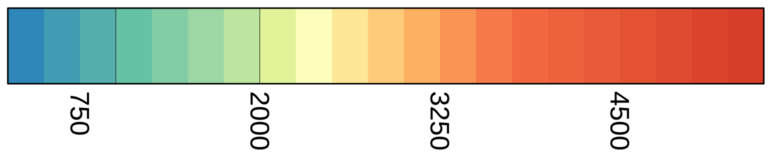
CLIENT: JK Geotechnics	DATE: 25/06/2025	DATUM: GDA2020 Z56	GBGGROUP
TITLE: GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT	SCALE: X 1:500 Y 1:200	DRAWN: PD	
	DRG No: GBGA2804_05	REV: REV 2	

GBG Australia Pty. Ltd.
28/7 Salisbury Road,
Castle Hill, NSW 2154
Telephone: (02) 9890 2122
Email: info@gbgoz.com.au

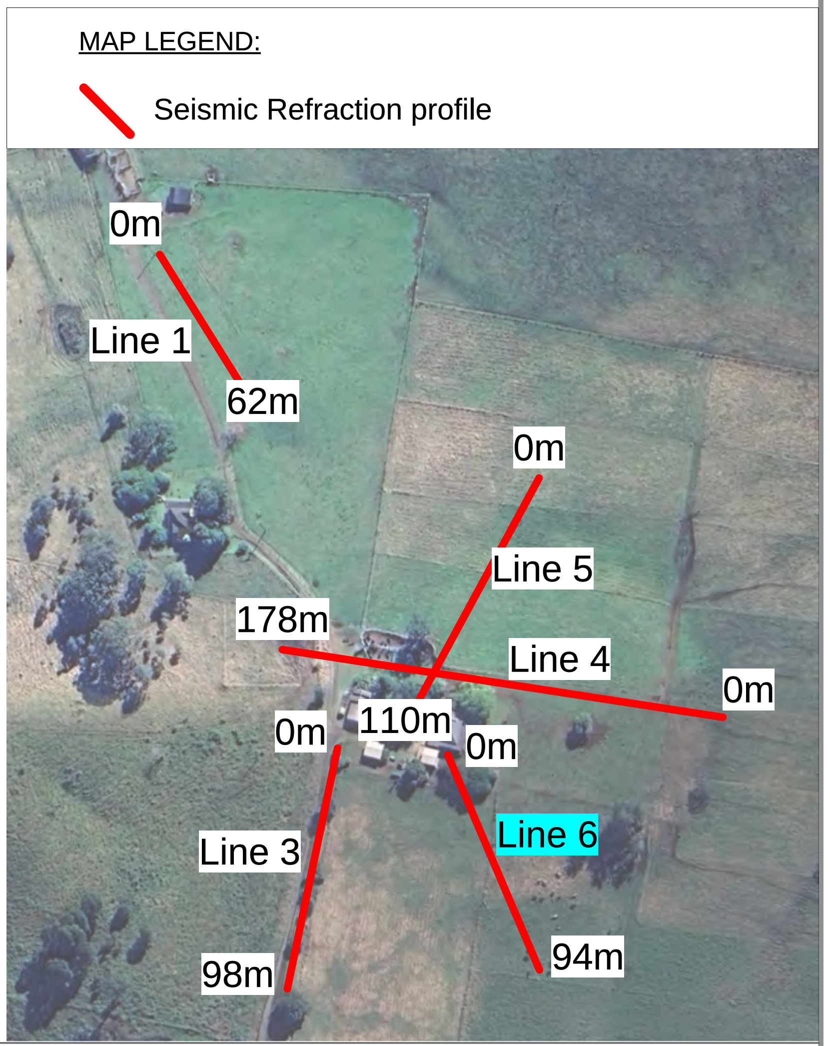
GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT

Line 6 - P-wave velocity model





Modelled P-wave Velocity (m/s)



CLIENT: JK Geotechnics	DATE: 25/06/2025	DATUM: GDA2020 Z56
TITLE: GEOPHYSICAL INVESTIGATION - LISMORE SCHOOL DEVELOPMENT	SCALE: X 1:400 Y 1:200	DRAWN: PD
	DRG No: GBGA2804_06	REV: REV 2

GBGGROUP

GBG Australia Pty. Ltd.
28/7 Salisbury Road,
Castle Hill, NSW 2154
Telephone: (02) 9890 2122
Email: info@gbgoz.com.au

APPENDIX B. SEISMIC REFRACTION THEORY AND LIMITATIONS

APPLICATIONS

- ✓ Bedrock mapping
- ✓ Mapping weathered zones
- ✓ Stratigraphic mapping
- ✓ Indicative material hardness for piling, tunnelling and excavation works
- ✓ Identification of fault / fractured zones

METHOD

The Seismic Refraction method involves the measurement of travel times of seismic compressional waves (P-waves) that are generated at the surface, propagate through the subsurface and return to the surface after being refracted at the interface between layers of contrasting seismic velocity. Seismic wave velocities are controlled by the fundamental parameters of elastic strength and density of the material it propagates through.

SRT is based on the principles of wave propagation and refraction. When seismic energy is introduced into the ground, it travels through subsurface layers at speeds dependent on the physical properties of the material, such as density and elasticity. As these waves encounter boundaries between layers with differing seismic velocities (e.g., unconsolidated soil overlying bedrock), they bend or refract at the interface between the layers. This bending occurs because the wave speed changes as the wave moves from one medium to another, following Snell's Law.

$$sin(\theta r) = v2/v1sin(\theta i)$$

Where:

- θi is the angle of incidence—the angle at which the seismic wave hits the interface.
- θr is the angle of refraction—the angle at which the wave continues through the second material.
- v1 _v2 are the seismic velocities in the first and second material, respectively

The critical angle of incidence, beyond which seismic waves no longer pass into the second medium but instead travel parallel to the interface, is of particular importance. This transition occurs when the angle of refraction reaches 90°, and at this point, the wave is refracted along the boundary, generating head waves (also known as critically refracted waves). These head waves travel along the interface between the two materials. The equation for the critical angle θc is derived from Snell's Law as:

$$\theta^{c} = arcsin(v_1 / v_2)$$

Where:

- θc is the critical angle of incidence.
- v_1 and v_2 are the seismic velocities in the first and second medium, respectively.

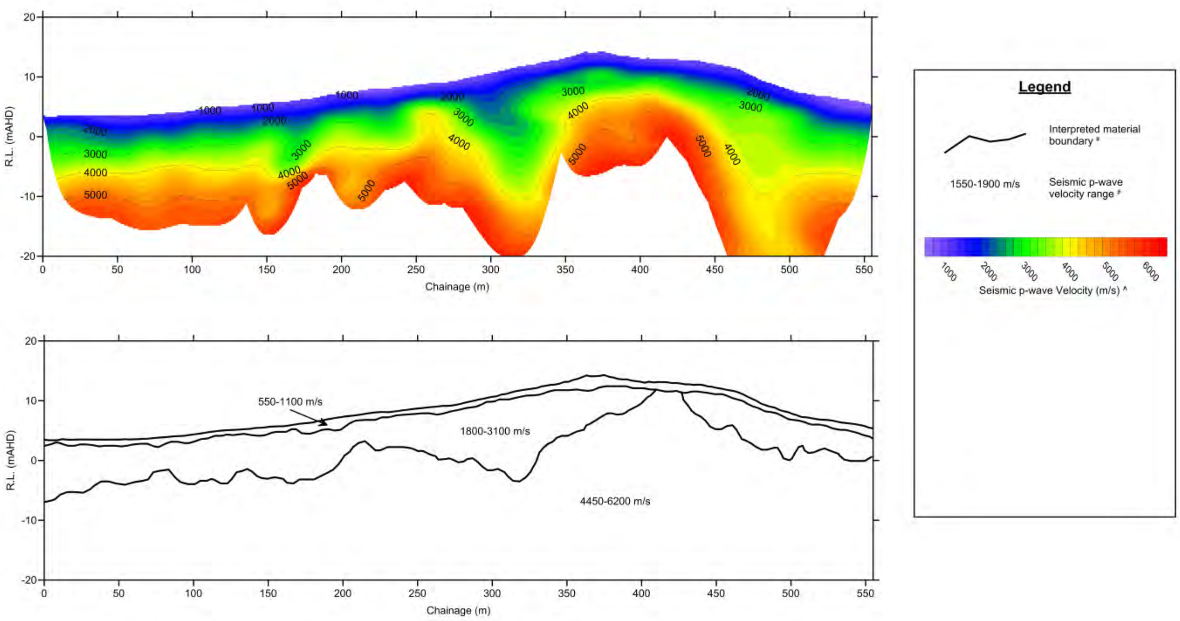
The presence of head waves is a key characteristic in seismic refraction surveys and can be used to map the subsurface layering by analysing the arrival times of seismic waves recorded by geophones placed along a survey line. By recording the times at which seismic waves reach the geophones, it is possible to calculate the seismic velocities of the subsurface layers, which in turn provide valuable information about the geology and material properties beneath the surface. It's important to note that $v2$ must be greater than $v1$ for the method to reliably report depth and velocity of the $v2$ interface.

By measuring the travel times of these refracted waves from multiple source points to multiple receivers, the seismic refraction method can resolve lateral changes in the depth to the top of a refracting interface as well as the seismic velocity within it. Furthermore, being related to elastic strength and density, the velocities calculated from a seismic refraction survey can be a useful guide to the rippability of a rock for excavation.

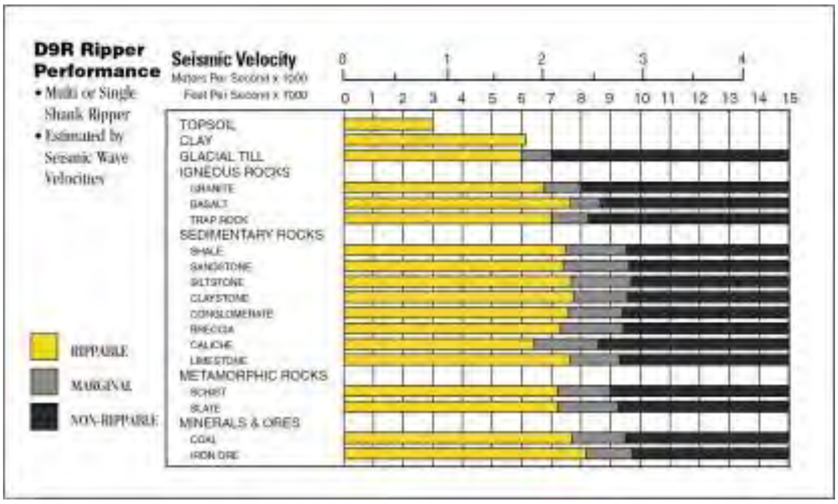
For near surface investigations seismic energy is generated on the surface using a sledgehammer. More powerful sources such as accelerated weight drop (PEG system), down-hole airguns, or explosives are required for deeper investigations.

Processing and analysing seismic refraction data can be carried out using a layered model assuming distinct refractive boundaries or tomographic approach assuming a gradual increase in seismic velocity with depth. Both approaches have benefits and are typically carried out in unison to generate the most detailed geological model possible.

The output is a cross-section showing lateral changes in the depth to the various refracting interfaces and the seismic velocities within them. When correlated with core logs, this information can be related to geological boundaries in the subsurface. This can be particularly useful for planning excavation with the depth to the different layers giving an idea of quantity of rock needed to be removed and the seismic velocities giving an idea of the rock's hardness and hence rippability.



Modelled seismic P-wave velocity section (top) and corresponding layer model section (bottom)



Rippability chart, displays the relationship between rippability and P-wave velocity, taken from Handbook of Ripping, Twelfth Edition, Caterpillar Inc. 2000.

LIMITATIONS

SR data quality is significantly impacted by ambient noise, such as:

- Strong wind and rain (especially if nearby tall grass or trees)
- Vehicle and/or plant traffic. Tracked vehicles are significantly problematic
- Simultaneous operations – drilling, test pitting
- Construction works
- Other sources of vibrations (flow of water, waves etc.)

Sometimes the ambient noise can be avoided, or at least reduced, by planning the field works accordingly (check the weather forecast prior to mobilisation, organise data acquisition in off-peak hours, such as nighttime or weekends). Additionally, some methods can be used to increase the signal-to-noise ratio, such as performing multiple shots at each of the shot locations (stacking) or applying noise filters during processing phase. However, sometimes it’s not possible to manage the impact of noise on data quality.

There are several inherent limitations to SR method that can negatively affect the results:

- Impact source. Different sources can be used for seismic wave generation. The most commonly used for near surface investigations are sledgehammer and accelerated weight drop. Lighter sledgehammer is preferred for generation of higher frequencies. Weight drop system can be used to generate more energy at low frequencies. The use of metallic plate can also increase the frequency of the signal, compared to rubber plate. Ultimately, site conditions and safety considerations can impact the choice of seismic source used.
- Velocity inversions. SR method assumes increase of P-wave velocities with depth. In geological conditions, where that is not the case, for example, soft layer under stiff material, SR results might not solve the P-wave velocities properly and introduce errors.
- First and last shots must be performed at a certain offset distance from the first and last geophone. This needs to be considered when planning survey lines in constrained site conditions.
- Inadequate coupling between the geophones and the ground. This can be caused in areas with very hard or very soft ground, as well as irregular terrain.

- Very shallow, hard bedrock. The abrupt high velocity change presents a challenge for SR method, as conventional principles suggest a depth-related increase in velocity (Sheriff et al., 1995). As a result, P-wave models can show exaggerated thickness of low velocity layer over hard rock in areas where the rock is very shallow or outcropping. This can be partially avoided by using smaller geophone spacing.
- Anisotropy or directional dependence can influence observed P-wave velocities. It can be caused by structural orientations, faults or foliation within rocks or, in some cases, glacial tills and overconsolidated clays. When performing measurements along fault strike, results can indicate higher P-wave velocities compared to measurements perpendicular to it. Such effects cannot be avoided but can be assessed performing perpendicular transects and comparing the measured P-wave velocities at the line crossovers.
- Decreasing resolution with depth. Inverted models are subject to errors, which can have cumulative effect with increasing depth. Therefore, caution should be taken when interpreting deeper layers.
- 3D effects. P-wave models usually are 2D representations and apply to very narrow zone below the traverse, which does not account for lateral variations perpendicular to the traverse. However, such variations could still impact the measurements.
- As can be seen in the figure below, the ranges of characteristic P-wave velocities are not unique and overlap for different materials. Without correlation to intrusive tests, SR results cannot be used to determine subsurface materials.
- Non-uniqueness of the results. The ambiguity arises from using inverse modelling to create P-wave model of the subsurface, which within itself has infinite possible solutions.

REFERENCES

Sheriff, R. E., & Geldart, L. P. (1995). Exploration Seismology (2nd ed.). Cambridge University Press.

Stanford Rock Physics Laboratory - Gary Mavko

Parameters That Influence Seismic Velocity

Type of formation	P wave velocity (m/s)	S wave velocity (m/s)	Density (g/cm^3)	Density of constituent crystal (g/cm^3)
Scree, vegetal soil	300-700	100-300	1.7-2.4	-
Dry sands	400-1200	100-500	1.5-1.7	2.65 quartz
Wet sands	1500-2000	400-600	1.9-2.1	2.65 quartz
Saturated shales and clays	1100-2500	200-800	2.0-2.4	-
Marls	2000-3000	750-1500	2.1-2.6	-
Saturated shale and sand sections	1500-2200	500-750	2.1-2.4	-
Porous and saturated sandstones	2000-3500	800-1800	2.1-2.4	2.65 quartz
Limestones	3500-6000	2000-3300	2.4-2.7	2.71 calcite
Chalk	2300-2600	1100-1300	1.8-3.1	2.71 calcite
Salt	4500-5500	2500-3100	2.1-2.3	2.1 halite
Anhydrite	4000-5500	2200-3100	2.9-3.0	-
Dolomite	3500-6500	1900-3600	2.5-2.9	(Ca, Mg) $CO_3$2.8-2.9
Granite	4500-6000	2500-3300	2.5-2.7	-
Basalt	5000-6000	2800-3400	2.7-3.1	-
Gneiss	4400-5200	2700-3200	2.5-2.7	-
Coal	2200-2700	1000-1400	1.3-1.8	-
Water	1450-1500	-	1.0	-
Ice	3400-3800	1700-1900	0.9	-
Oil	1200-1250	-	0.6-0.9	-

Typical rock velocities, from Bourbié, Coussy, and Zinszner, Acoustics of Porous Media, Gulf Publishing.

GBGGROUP

Sydney
28/7 Salisbury Road
Castle Hill, NSW, 2154
+61 02 9890 2122

Perth
Unit 1, 11 Gympie Way
Willetton, WA, 6155
+61 08 9354 6300
info@gbgoz.com.au

APPENDIX B

Borehole logs, test pit cross sections and laboratory test results from previous JKG reports

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

TABLE A
MOISTURE CONTENT, ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandra Parade, North Lismore, NSW

Report No.: 36314LT - A
Report Date: 5/11/2024

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**	**LIQUID LIMIT %**	**PLASTIC LIMIT %**	**PLASTICITY INDEX %**	**LINEAR SHRINKAGE %**
18	0.50 - 0.95	46.7	87	32	55	21.0*
28	0.50 - 0.95	33.7	81	27	54	20.5**
51	0.50 - 0.95	20.2	69	32	37	16.0**
62	0.20 - 0.40	44.2	79	31	48	20.0**
64	0.50 - 0.95	42.3	104	32	72	25.0* **
85	1.00 - 1.20	23.7	55	29	26	13.5

Notes:

- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample: 24/10/2024.
- Sampled and supplied by client. Samples tested as received.
- * Denotes Linear Shrinkage cracked.
- ** Denotes Linear Shrinkage curled.

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Authorised Signature / Date
(D. Treweek)

115 Wicks Road
Macquarie Park, NSW 2113
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandra Parade, North Lismore, NSW

Report No.: 36314LT - B
Report Date: 12/11/2024
Page 1 of 1

BOREHOLE NUMBER		BH 30	BH 60	BH 61	BH 85	BH 87	BH 89
DEPTH (m)		0.50 - 1.50	0.20 - 1.50	0.50 - 2.00	0.50 - 1.50	0.50 - 2.00	1.00 - 2.00
Surcharge (kg)		4.5	4.5	4.5	4.5	4.5	4.5
Maximum Dry Density (t/m^3)		1.50 STD	1.22 STD	1.47 STD	1.64 STD	1.55 STD	1.95 STD
Optimum Moisture Content (%)		26.3	42.0	29.4	23.6	26.9	12.7
Moulded Dry Density (t/m^3)		1.46	1.20	1.44	1.60	1.52	1.90
Sample Density Ratio (%)		98	98	98	98	98	98
Sample Moisture Ratio (%)		101	100	100	101	101	105
Moisture Contents							
Insitu (%)		33.6	62.5	32.8	28.7	33.3	19.5
Moulded (%)		26.5	42.0	29.5	23.7	27.0	13.3
After soaking and							
After Test, Top 30mm(%)		51.8	72.4	40.8	30.0	39.9	20.3
	Remaining Depth (%)	34.5	49.2	34.3	25.5	27.9	16.8
Material Retained on 19mm Sieve (%)		0	0	4*	0	0	0
Swell (%)		4.5	6.0	2.5	1.0	3.5	0.0
C.B.R. value:	@2.5mm penetration	1.5	1.5	2.5		2.0	
	@5.0mm penetration				7		7

NOTES: Sampled and supplied by client. Samples tested as received.
- Refer to appropriate Borehole logs for soil descriptions
- Test Methods : AS 1289 6.1.1, 5.1.1 & 2.1.1.
- BH's 30, 60, 61, 87 & 89 were all dried back prior to testing as they were too saturated.
- Date of receipt of sample: 24/10/2024.
- * Denotes not used in test sample.

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Macquarie Park, NSW 2113
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North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

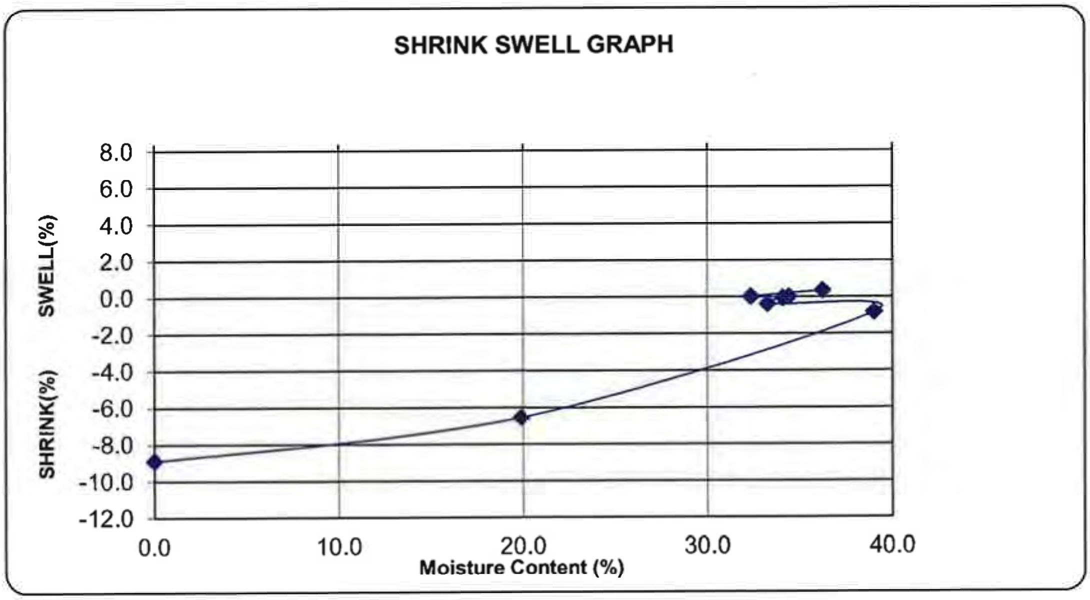
SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandra Parade, North Lismore, NSW

Report No.: 36314LT - C
Report Date: 7/11/2024

Borehole No.: 28		Depth: 0.50 - 0.88m		
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH		
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST	
32.4%	36.2%	220 kPa	140,150 kPa	
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION		SWELL ON SATURATION	SHRINKAGE
25	0.5%		0.3%	8.7%



SHRINK SWELL INDEX
4.90 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

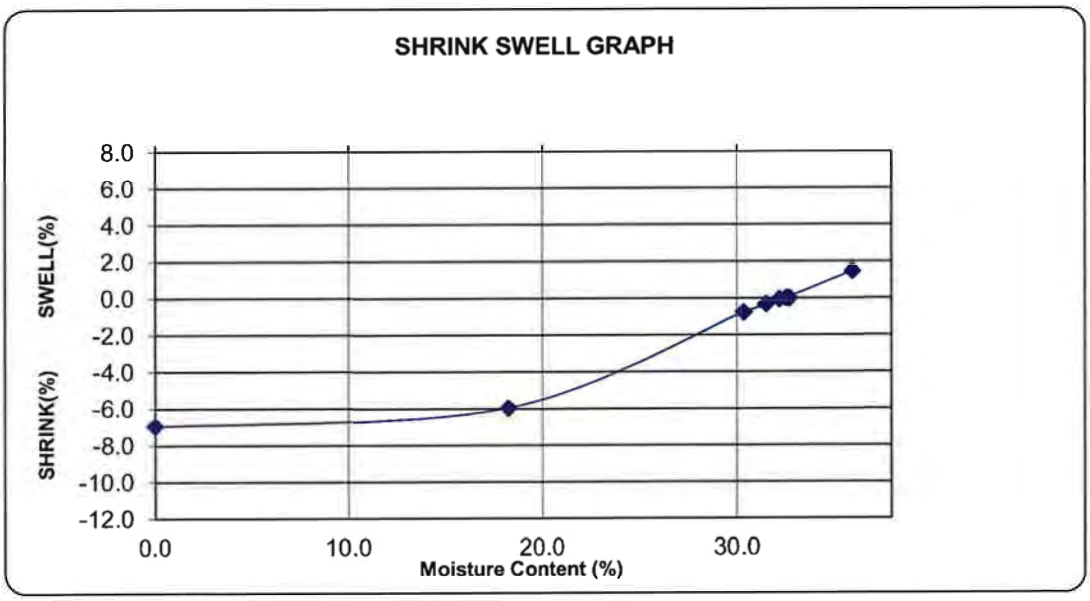
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client:	JK Geotechnics	**Report No.:**	36314LT - C
Project:	Proposed High School	**Report Date:**	7/11/2024
Location:	163-170 Alexandra Parade, North Lismore, NSW	**Page**	2 of 6

Borehole No.: 51		Depth: 1.00 - 1.29m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
32.5%	36.0%	140 kPa	110 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-1.0%	1.5%	6.8%



SHRINK SWELL INDEX
4.21 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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Macquarie Park, NSW 2113
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North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

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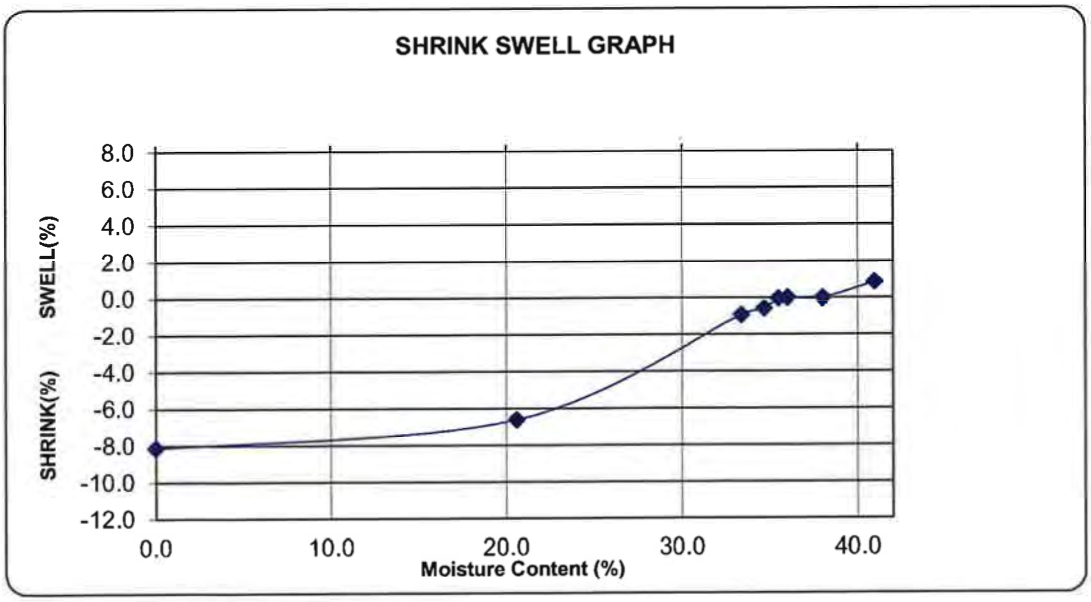
TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandra Parade, North Lismore, NSW

Report No.: 36314LT - C
Report Date: 7/11/2024

Borehole No.: 62		Depth: 0.50 - 0.90m		
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH		
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST	
38.0%	41.0%	160,200 kPa	100,120 kPa	
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION		SWELL ON SATURATION	SHRINKAGE
25	-0.8%		0.9%	8.0%



SHRINK SWELL INDEX
4.66 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

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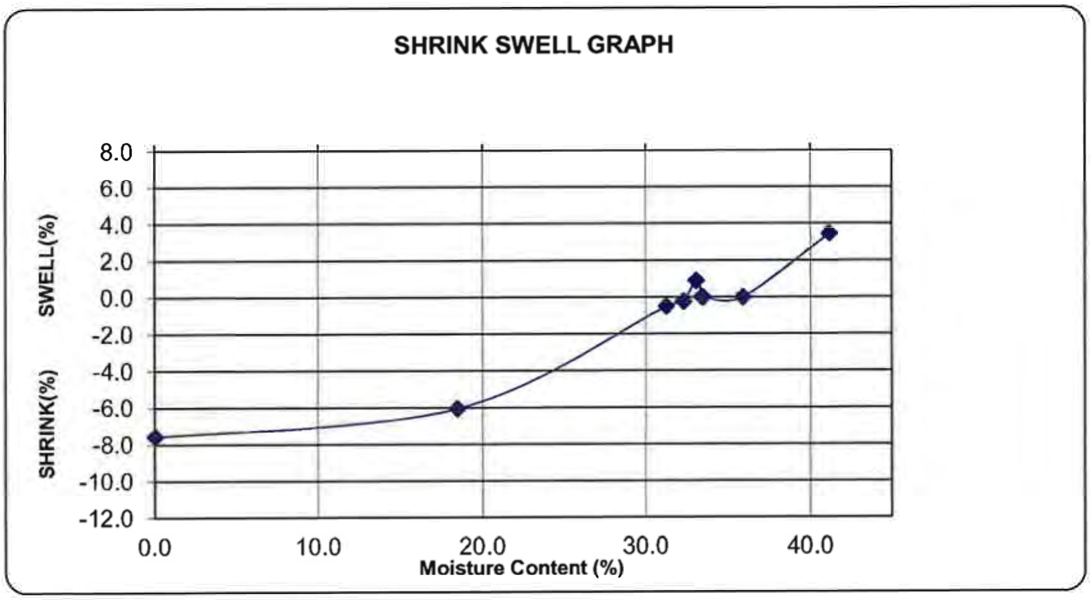
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandra Parade, North Lismore, NSW

Report No.: 36314LT - C
Report Date: 7/11/2024

Borehole No.: 71		Depth: 1.00 - 1.23m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
35.9%	41.1%	210 kPa	130,140 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-1.5%	3.5%	7.3%



SHRINK SWELL INDEX
5.02 %/pF

Notes: Sampled and supplied by client. Sample tested as received.

- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

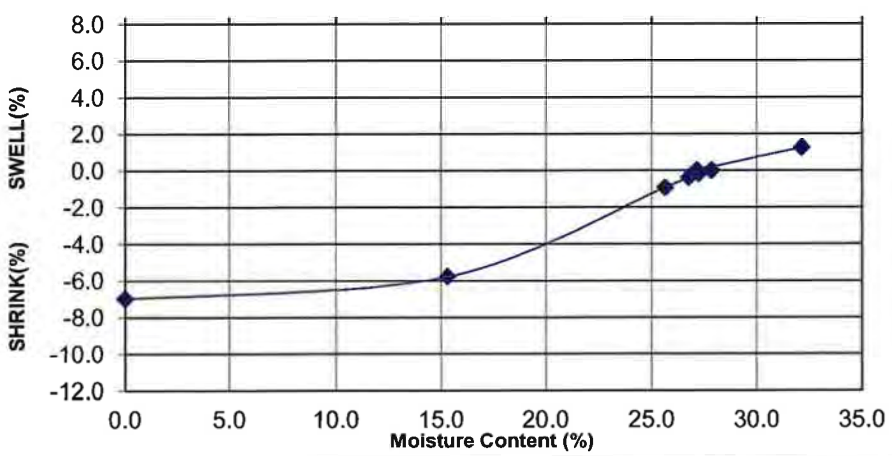
SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client:	JK Geotechnics	**Report No.:**	36314LT - C
Project:	Proposed High School	**Report Date:**	7/11/2024
Location:	163-170 Alexandra Parade, North Lismore, NSW	**Page**	5 of 6

Borehole No.: 80		Depth: 1.00 - 1.30m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
27.1%	32.1%	350,400 kPa	160,200 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.6%	1.2%	6.9%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
4.17 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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(D. Treweek) 7/11/24

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

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ABN 43 002 145 173

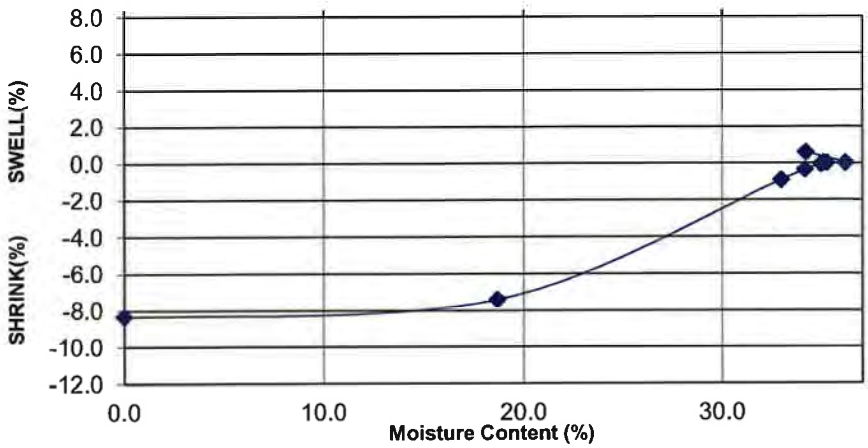
TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed High School
Location: 163-170 Alexandra Parade, North Lismore, NSW

Report No.: 36314LT - C
Report Date: 7/11/2024

Borehole No.: 87		Depth: 0.50 - 0.75m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
36.1%	34.2%	140 kPa	100,110 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.9%	0.6%	8.1%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
4.68 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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TABLE D
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	School Infrastrcutre NSW	**Ref No:**	36314LT
Project:	Proposed School Development	**Report:**	D
Location:	163 - 170 Alexandrea Parade, North Lismore, NSW	**Report Date:**	21/10/24

BOREHOLE NUMBER	DEPTH (m)	$I_{S (50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
28	11.88 - 11.92	0.8	16	A
	12.31 - 12.34	6.2	124	A
	12.84 - 12.88	5.8	116	A
	13.25 - 13.28	6.1	122	A
	14.04 - 14.07	4	80	A
62	7.40 - 7.43	4.2	84	A
	7.77 - 7.80	4.6	92	A
	8.27 - 8.32	3.2	64	A
	8.86 - 8.90	4.3	86	A
	9.26 - 9.30	4	80	A
	9.66 - 9.69	3.5	70	A
	10.35 - 10.38	4.3	86	A
	10.80 - 10.83	5	100	A
	11.21 - 11.24	4.1	82	A
80	4.40 - 4.43	0.2	4	A
	7.35 - 7.39	3.6	72	A
	7.60 - 7.64	3.3	66	A
	8.12 - 8.15	2.1	42	A
	9.19 - 9.23	3.7	74	A
	9.78 - 9.81	5.4	108	A

NOTES

1. In the above table, testing was completed in test direction A for the axial direction, D for the diametral direction, B for the block test and L for the lump test.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa.
5. The estimated Unconfined Compressive Strength was calculated from the Point Load Strength Index based on the correlation provided in AS1726:2017 'Geotechnical Site Investigations' and rounded off to the nearest whole number: U.C.S. = 20 $I_{S(50)}$.

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

CERTIFICATE OF ANALYSIS 364916

Client Details

Client	JK Geotechnics
Attention	Arthur Billingham
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**36314LT, 163-170 Alexandra Parade North Lismore**
Number of Samples	6 Soil
Date samples received	28/10/2024
Date completed instructions received	28/10/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	04/11/2024
Date of Issue	04/11/2024

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		364916-1	364916-2	364916-3	364916-4	364916-5
Your Reference	UNITS	BH26	BH28	BH53	BH71	BH82
Depth		0.5-0.95	9.5-9.7	6.0-6.1	4.0-4.5	4.5-4.65
Date Sampled		11/10/2024	12/10/2024	14/10/2024	11/10/2024	15/10/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	30/10/2024	30/10/2024	30/10/2024	30/10/2024	30/10/2024
Date analysed	-	30/10/2024	30/10/2024	30/10/2024	30/10/2024	30/10/2024
pH 1:5 soil:water	pH Units	6.1	8.1	8.2	8.5	8.8
Chloride, Cl 1:5 soil:water	mg/kg	460	32	89	160	20
Sulphate, SO4 1:5 soil:water	mg/kg	57	25	29	120	20
Resistivity in soil*	ohm m	25	100	85	38	160

Misc Inorg - Soil		
Our Reference		364916-6
Your Reference	UNITS	BH87
Depth		2.7-2.9
Date Sampled		15/10/2024
Type of sample		Soil
Date prepared	-	30/10/2024
Date analysed	-	30/10/2024
pH 1:5 soil:water	pH Units	8.2
Chloride, Cl 1:5 soil:water	mg/kg	330
Sulphate, SO4 1:5 soil:water	mg/kg	140
Resistivity in soil*	ohm m	29

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			30/10/2024	1	30/10/2024	30/10/2024		30/10/2024	[NT]
Date analysed	-			30/10/2024	1	30/10/2024	30/10/2024		30/10/2024	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	6.1	6.1	0	100	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	460	390	16	108	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	57	47	19	110	[NT]
Resistivity in soil*	ohm m	1	Inorg-002	<1	1	25	37	39	98	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Holding time exceedance for PH/EC.

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BOREHOLE LOG

Borehole No. 1

1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 17.50 m
Date: 11/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			0		TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				
		17		CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained, dark brown, angular basalt gravel, and root fibres.	w>PL	St	120 130 100	COLLUVIAL HP TESTING ON REMOULDED SAMPLE
	N > 20 4,11,9/ 100mm REFUSAL		1		Gravelly silty CLAY: high plasticity, brown mottled light brown, fine to medium grained, dark grey basalt gravel, trace of root fibres.		VSt - Hd	300 490 230	BANDED LOW RESISTANCE RESIDUAL POSSIBLY COLLUVIAL
	N=SPT 4/ 0mm REFUSAL	16			as above, but dark brown, fine to coarse grained basalt gravel.	w~PL			LOW 'TC' BIT RESISTANCE TOO FRIABLE FOR HP TESTING
		15	2						
			3	-	BASALT: fine grained, dark grey.	DW	L		HIGH RESISTANCE LOW RESISTANCE
		14			END OF BOREHOLE AT 3.40 m				'TC' BIT REFUSAL ON BASALT
		13	4						
		12	5						
		11	6						

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No. 3

1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 12.15 m
Date: 9/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.				GRASS COVER
		CH	Silty CLAY: high plasticity, dark brown, trace of fine grained ironstone gravel, and root fibres.	w>PL	St	150 140 140	COLLUVIAL
	N = 5 1,1,4		Silty CLAY: high plasticity, dark brown and light brown, with fine to medium grained ironstone gravel.				
	N=SPT 5/ 100mm REFUSAL	-	Extremely Weathered basalt: silty GRAVEL, fine grained, red brown, angular iron indurated, trace of fine grained sand.	XW	VD		LISMORE BASALT VERY LOW 'TC' BIT RESISTANCE
			Extremely Weathered basalt: silty gravelly CLAY, high plasticity, dark brown, fine to medium grained, dark grey, angular basalt gravel.		(Hd)		TOO FRIABLE FOR HP TESTING LOW RESISTANCE
			END OF BOREHOLE AT 5.00 m				

Samples: ES, U50, DB, DS

RL (m AHD): 12, 11, 10, 9, 8, 7, 6

Depth (m): 1, 2, 3, 4, 5, 6

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BOREHOLE LOG

Borehole No.
4
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 11.35 m
Date: 9/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
ON 16/11/24	ES		11	0			TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.	w>PL	St - VSt		GRASS COVER TP EXCAVATED TO 0.1m DEPTH
	ES, DS	N = 11 3,5,6	10	1		CH	Silty CLAY: high plasticity, dark brown, with fine to coarse grained, dark grey, angular igneous gravel.	w>PL	St - VSt	190 220 230	ALLUVIAL
	ES, DS	N = 5 2,2,3	9	2			Silty CLAY: high plasticity, dark grey, trace of fine to coarse grained, rounded ironstone gravel.		St	120 130 170	
	ES, DS		8	3			Silty CLAY: high plasticity, dark grey and brown, trace of fine to medium grained, rounded ironstone gravel.		VSt	220 200 230	
			7, 6	4, 5							GROUNDWATER MONITORING WELL INSTALLED TO 6.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 6.0m. CASING0m TO 3.0m. 2mm SAND FILTER PACK 3.0m TO 6.0m. BENTONITE SEAL 0m TO 3.0m. BACKFILLED WITH BENTONITE TO THE SURFACE. COMPLETED WITH A CONCRETED GALVANISED MONUMENT.
			5	6			END OF BOREHOLE AT 6.00 m				

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BOREHOLE LOG

Borehole No. 5

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 10.69 m
Date: 9/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		0		TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.	w>PL	St		GRASS COVER
	N = 4 0,2,2	0.3	CH	Silty CLAY: high plasticity, dark grey mottled dark brown, trace of fine to coarse grained, dark grey, rounded and angular basalt gravel, fine grained ironstone gravel, and root fibres.	w>PL	St	170 180 180	ALLUVIAL
	N = 3 1,1,2	1.5		Silty CLAY: high plasticity, dark grey, trace of root fibres.			140 180 180	
		2.5		Silty CLAY: high plasticity, grey, trace of fine to medium grained basalt gravel.		St - VSt	190 210 220	
		3		END OF BOREHOLE AT 3.00 m				

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BOREHOLE LOG

Borehole No. 18

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 12.79 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		0		TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.				GRASS COVER
	N = 2 0,1,1		CH	Silty CLAY: high plasticity, dark grey, trace of fine grained ironstone gravel, and root fibres.	w>PL	St VSt	110 110 120 220 230 240 200	ALLUVIAL
	N = 6 2,3,3	1.5		Silty CLAY: high plasticity, dark brown, trace of fine to medium grained, brown and dark grey, sub-angular to sub-rounded basalt gravel and fine grained ironstone gravel.			200 230 240 250 250 230	COLLUVIAL HP TESTING ON REMOULDED SAMPLE
		3.00		END OF BOREHOLE AT 3.00 m				

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BOREHOLE LOG

Borehole No. 24

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 9.65 m
Date: 9/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
ON 16/11/24					TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.	w>PL			GRASS COVER
				CH	Silty CLAY: high plasticity, dark grey mottled dark brown, trace of root fibres.	w>PL	St		ALLUVIAL
	N = 2 0,1,1	9						120 140 140	
			1						
	N = 3 0,1,2	8					VSt	200 220 260	
			2		Silty CLAY: high plasticity, grey and dark grey.				
		7							
			3				St	180 180 180	
		6							
			4						
ON COMPLETION OF AUGERING		5							GROUNDWATER MONITORING WELL INSTALLED TO 6.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 6.0m. CASING 0m TO 3.0m. 2mm SAND FILTER PACK 2.5m TO 6.0m. BENTONITE SEAL 0.2m TO 2.5m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A CONCRETED GATIC COVER.
			5						
		4						120 180 200	
			6		END OF BOREHOLE AT 6.00 m				
		3							

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BOREHOLE LOG

Borehole No.
26
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Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 20.85 m
Date: 11/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		0		TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				
			CH	Silty CLAY: high plasticity, dark brown, trace of fine to coarse grained, dark grey and brown, angular basalt gravel, fine to medium grained ironstone gravel, and basalt boulders.	w>PL	VSt		COLLUVIAL
	N = 23 3,10,13						250 310 320	SLIGHT ORGANIC ODOUR
				Gravelly silty CLAY: high plasticity, dark brown, dark grey and light brown, fine to medium grained, dark grey and brown, angular to sub-rounded basalt and ironstone gravel.	w<PL	Hd	>600 >600 >600	RESIDUAL POSSIBLY COLLUVIAL
	N = 24 5,11,13			Silty CLAY: high plasticity, dark brown, with fine to coarse grained, dark grey, angular to sub-rounded basalt gravel, trace of fine grained ironstone gravel.	w~PL		>600 >600 >600	
								HIGH 'TC' BIT RESISTANCE
		2.60		END OF BOREHOLE AT 2.60 m				BOREHOLE REFUSAL ON BASALT

RL (m AHD) scale: 20, 19, 18, 17, 16, 15, 14. Depth (m) scale: 1, 2, 3, 4, 5, 6.

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BOREHOLE LOG

Borehole No. 28

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 17.15 m
Date: 12/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Depth (m)	Groundwater Record	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
0 – 0.1				TOPSOIL: Silty clay, high plasticity, dark brown, trace of fine grained ironstone gravel, and root fibres.	w>PL	St		GRASS COVER
0.1 – 1.5		N = 7 1,3,4	CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained ironstone gravel, and root fibres.	w>PL	St VSt	140 160 160 270 280 280 220 230 250	COLLUVIAL HP TESTING ON REMOULDED SAMPLE
1.5 – 3.0		N = 12 3,4,8		Silty CLAY: high plasticity, dark brown, with fine grained, dark grey, rounded to sub-angular basalt and ironstone gravel, trace of root fibres.		Hd	420 420 460	
3.0 – 4.5		N = 10 3,5,5		Silty CLAY: high plasticity, dark brown, trace of fine to medium grained, light grey and dark grey, rounded basalt gravel and fine grained ironstone gravel.		VSt - Hd	350 410 430	
4.5 – 5.0		N = 13 4,5,8		as above, but dark brown mottled brown, trace of ash fragments.		VSt	340 360 370	
5.0 – 7.0	ON 16/11/24 ON COMPLETION OF AUGERING	N = 21 6,11,10		Silty CLAY: high plasticity, dark brown mottled light brown and light grey, with fine grained ironstone gravel and fine grained, light grey basalt gravel, trace of fine to medium grained, dark grey, angular to rounded basalt gravel.		Hd	430 440 450	BANDED 'TC' BIT RESISTANCE

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 36314LT NORTH LISMORE.GPJ <<DrawingFile>> 22/11/2024 09:34 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

BOREHOLE LOG

Borehole No.
28

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 17.15 m
Date: 12/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	DS		10			CH	Silty CLAY: high plasticity, dark brown mottled light brown and light grey, with fine grained ironstone gravel and fine grained, light grey basalt gravel, trace of fine to medium grained, dark grey, angular to rounded basalt gravel.	w>PL	Hd		
		N=SPT 8/ 50mm REFUSAL	9	8			Silty CLAY: high plasticity, dark brown and brown, with fine to coarse grained, dark grey, angular basalt gravel, trace of fine grained ironstone gravel.		VSt	250 260 290	HP TESTING ON REMOULDED SAMPLE RESIDUAL POSSIBLY COLLUVIAL
	DS	N=SPT 9/ 50mm REFUSAL	8, 7, 6	9, 10, 11			as above, but brown, trace of fine to medium grained igneous gravel.			220 270 270	NO RESISTANCE HP TESTING ON REMOULDED SAMPLE
			5, 4	12, 13			REFER TO CORED BOREHOLE LOG				HIGH RESISTANCE GROUNDWATER MONITORING WELL INSTALLED TO 9.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 9.0m. CASING 0m TO 3.0m. 2mm SAND FILTER PACK 2.5m TO 9.0m. BENTONITE SEAL 0.2m TO 2.5m. BACKFILLED WITH BENTONITE. COMPLETED WITH A CONCRETED GALVANISED MONUMENT.

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CORED BOREHOLE LOG

Borehole No.
28

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT	**Core Size:** NMLC	**R.L. Surface:** 17.15 m
Date: 12/10/24	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK309	**Bearing:** N/A	**Logged/Checked By:** A.G./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness — Specific / General	Formation
		6			START CORING AT 11.40m						
90% RETURN		5	12		BASALT: fine grained, dark grey.	MW	M - H	0.80		(11.70m) J, 90°, Ir, R, Fe Sn (11.79m) J, 20°, P, R, Fe Sn (11.84m) J, 70°, P, R (12.03m) J, 90°, P, R, Fe Sn (12.17m) XWS, 0°, 5 mm.t	Lismore Basalt
		4	13			SW	VH	6.2 5.8 6.1 4.0		(12.21m) J, 30°, Ir, R, Fe Sn (12.26m) J x 4, 20°, P, R, Fe Sn (12.36m) J, 30°, P, R, Fe Sn (12.51m) J, 20°, Ir, R, Fe Sn (12.65m) J, 40°, P, S, Fe Sn (12.71m) XWS, 30°, 50 mm.t (12.87m) XWS, 0°, 20 mm.t (13.13m) XWS, 0°, 10 mm.t (13.20m) J, 45°, C, R, Fe Sn (13.34m) J, 40°, P, S, Fe Sn (13.50m) Cr, 0°, 10 mm.t (13.56m) XWS, 0°, 40 mm.t (13.65m) J, 90°, Ir, R, Fe Sn (13.89m) J, 20°, P, R, Fe Sn (13.91m) J, 15°, P, S, Cn (13.93m) XWS, 0°, 10 mm.t ~~(14.06m) Cr, 30°, 50 mm.t~~	
		3	14		NO CORE 0.24m						
		2 1 0	15 16 17		END OF BOREHOLE AT 14.36 m				600 200 60 20		

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 36314LT
Borehole No: BH28
Depth: 11.40m to 14.36m
KODAK Gray Scale
KODAK Color Control Patches
36314LT BH28 START CORING AT 11.4m
11
12
13
14
NO CORE 0.24m.t
END OF BH AT 14.36m

JKGeotechnics

BOREHOLE LOG

Borehole No.
30
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 14.54 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION					FILL: Silty clay, high plasticity, dark brown, with root fibres, trace of ceramic fragments.	w>PL			GRASS COVER
	N = 3 0,1,2	14		CH	Silty CLAY: high plasticity, dark brown, trace of fine to coarse grained, dark grey and dark red brown, sub-angular to sub-rounded basalt gravel, fine grained basalt gravel, and root fibres.	w>PL	St	170 170 170 130 160 160	COLLUVIAL POSSIBLE SLIDE PLANE WITHIN SPT SAMPLE AT 0.5-0.95m
	N = 8 2,4,4	13	1 / 2		as above, but trace of fine grained igneous and ironstone gravel, and root fibres.		VSt	230 250 250	
	N = 8 3,3,5	12	3		as above, but without root fibres.			230 270 300	
		11 / 10 / 9 / 8	4 / 5 / 6		END OF BOREHOLE AT 3.45 m				

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BOREHOLE LOG

Borehole No.
32
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 12.05 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			12	0			TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.				GRASS COVER
		N = 2 1,1,1				CH	Silty CLAY: high plasticity, dark grey, trace of fine to medium grained, dark grey and brown, sub-angular to sub-rounded basalt gravel, fine grained ironstone gravel, and root fibres.	w>PL	St	150 160 190	ALLUVIAL
										110 120 130	HP TESTING ON REMOULDED SAMPLE
			11	1							
		N = 5 1,2,3							St - VSt	190 200 210	
			10	2					VSt		
										240 240 230	HP TESTING ON REMOULDED SAMPLE
			9	3			END OF BOREHOLE AT 3.00 m				
			8	4							
			7	5							
			6	6							

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BOREHOLE LOG

Borehole No.
51
1 / 2

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 19.31 m
Date: 12/10/24 TO 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		0		TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				GRASS COVER
	N = 7 2,3,4		CH	Silty CLAY: high plasticity, dark brown mottled brown, trace of fine to medium grained, dark brown, rounded basalt gravel, fine grained ironstone gravel, ash fragments and root fibres.	w<PL	St	190 120 130	COLLUVIAL
	N = 10 2,5,5			Silty CLAY: high plasticity, dark brown, with fine to medium grained ironstone gravel, trace of fine grained, light grey igneous gravel.	w>PL	VSt	260 310 320	
	N = 15 5,7,8	3				Hd	520 530 520	
	N = 10 4,4,6					VSt	350 390 360	POSSIBLE SLIDE PLANE WITHIN SPT SAMPLE AT 4.5-4.95m
		5		Gravelly silty CLAY: high plasticity, brown, fine to coarse grained, dark grey, angular basalt gravel, trace of fine grained ironstone gravel.			300 250 260	HP TESTING ON REMOULDED SAMPLES RESIDUAL POSSIBLY COLLUVIAL
	N=SPT 5/ 50mm REFUSAL	6	-	Extremely Weathered basalt: silty CLAY, high plasticity, brown, with fine to coarse grained, dark grey, angular basalt gravel, trace of fine grained ironstone gravel.	XW	(Hd)		LISMORE BASALT VERY LOW 'TC' BIT RESISTANCE

RL (m AHD) scale: 19, 18, 17, 16, 15, 14, 13. Depth (m) scale: 1, 2, 3, 4, 5, 6.

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BOREHOLE LOG

Borehole No.
51

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 19.31 m
Date: 12/10/24 TO 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
				■	N=SPT 7/ 100mm REFUSAL	12 11	8		-	Extremely Weathered basalt: silty CLAY, high plasticity, brown, with fine to coarse grained, dark grey, angular basalt gravel, trace of fine grained ironstone gravel. *(continued)*	XW	(Hd)		NO RESISTANCE TOO FRIABLE FOR HP TESTING
						10 9 8 7 6	9 10 11 12 13			END OF BOREHOLE AT 8.50 m				'TC' BIT REFUSAL ON BASALT

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BOREHOLE LOG

Borehole No.
53
1 / 2

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 14.99 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
			0		TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.	w>PL			GRASS COVER
	N = 3 1,1,2 N = 9 3,3,6	14 13	1 2	CH	Silty CLAY: high plasticity, dark grey, trace of fine to medium grained, dark grey, angular to sub-angular basalt gravel, fine grained ironstone gravel, and root fibres.		St VSt - Hd	120 120 110 150 160 170 350 400 400	COLLUVIAL
					as above, but dark brown, without root fibres.				BANDED VERY LOW 'TC' BIT RESISTANCE
ON COMPLETION OF AUGERING	N = 10 3,5,5	12 11	3 4		as above, but brown and dark grey basalt gravel.		Hd	450 440 460	
	N = 10 3,3,7	10	5		as above, but trace of fine grained, light grey to translucent igneous crystals.		VSt	300 300 350	POSSIBLE SLIDE PLANE WITHIN SPT SAMPLE AT 4.5-4.95m
					Silty CLAY: high plasticity, brown, with fine to coarse grained igneous gravel, and fine grained ironstone gravel.	w<PL			BANDED VERY LOW RESISTANCE RESIDUAL
	N=SPT 10/ 100mm REFUSAL	9	6	-	Extremely Weathered basalt: silty CLAY, high plasticity, brown and light brown, with fine to coarse grained igneous gravel, and fine grained ironstone gravel.	XW	Hd		POSSIBLY COLLUVIAL LISMORE BASALT TOO FRIABLE FOR HP TESTING

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 36314LT NORTH LISMORE.GPJ <<DrawingFile>> 22/11/2024 09:35 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

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BOREHOLE LOG

Borehole No.
53

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 14.99 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	DS					-		XW	Hd		
▶	DS	N=SPT 5/ 50mm REFUSAL	7	8			Extremely Weathered basalt: silty GRAVEL, fine grained, red brown, angular, iron indurated basalt.		(D)		POSSIBLY HIGHLY WEATHERED BASALT
	DS	N=SPT 4/ 10mm REFUSAL	6	9			BASALT: brown.	HW	VL - L		LOW RESISTANCE
			5	10							MODERATE RESISTANCE
			4	11							
			3	12			BASALT: dark grey.	SW - FR	VH		
			2	13			END OF BOREHOLE AT 12.20 m				'TC' BIT REFUSAL ON BASALT BEDROCK

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BOREHOLE LOG

Borehole No.
60
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 10.42 m
Date: 9/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
ON 16/11/24		0		TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.	w>PL			GRASS COVER
			CH	Silty CLAY: high plasticity, dark grey, trace of root fibres.	w>PL	St		ALLUVIAL
	N = 2 0,1,1						130 130 150	
		1		as above, but dark grey mottled brown.				
	N = 4 0,2,2			Silty CLAY: high plasticity, grey and dark grey.			120 120 110 120	
		3					150 120 140	
ON COMPLETION OF AUGERING								GROUNDWATER MONITORING WELL INSTALLED TO 6.0m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 6.0m. CASING 0m TO 3.0m. 2mm SAND FILTER PACK 2.5m TO 6.0m. BENTONITE SEAL 0.2m TO 2.5m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A GALVANISED MONUMENT.
		6		END OF BOREHOLE AT 6.00 m				

RL (m AHD) scale: 10, 9, 8, 7, 6, 5, 4

Samples: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No. 61

1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~21.0 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			0		FILL: Silty clay, high plasticity, dark brown, trace of fine to coarse grained igneous gravel, fine grained ironstone gravel, glass fragments and root fibres.	w>PL			
	N > 10 3,10/ 100mm REFUSAL			CH	Silty CLAY: high plasticity, dark brown, trace of fine to coarse grained, dark grey, angular basalt gravel, fine grained ironstone gravel, basalt boulder and root fibres.	w>PL	St	130 140 140 150 150 160	COLLUVIAL
		20	1		as above, but without basalt boulders.				
	N = 13 6,6,7	19	2				St - VSt	100 230 270	
					Silty CLAY: light brown, trace of brown and dark grey, rounded basalt gravel.				
		18	3		END OF BOREHOLE AT 3.00 m				
		17	4						
		16	5						
		15	6						

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BOREHOLE LOG

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 18.61 m
Date: 11/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record: DRY ON COMPLETION OF AUGERING

Depth (m)	RL (m AHD)	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
0–0.1				TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.	w>PL			
0.1–1.0	18	N = 13 3,5,8	CH	Silty CLAY: high plasticity, dark brown, with fine grained, brown and dark grey, rounded basalt gravel, fine grained ironstone gravel, fine grained, grey to light grey quartz gravel, and root fibres.	w>PL	St	110 120 140	COLLUVIAL HP TESTING ON REMOULDED SAMPLE
1.0–2.3	17	N = 14 4,7,7				Hd	440 400 500 600 590 >600	ORGANIC ODOUR HP TESTING ON REMOULDED SAMPLE
2.3–6.5	16, 15, 14, 13	N=SPT 10/ 150mm REFUSAL		Gravelly silty CLAY: high plasticity, light brown, fine to coarse grained, dark grey, rounded to sub-rounded basalt gravel, trace of fine grained ironstone gravel.	w<PL		>600 >600 >600	RESIDUAL POSSIBLY COLLUVIAL VERY LOW 'TC' BIT RESISTANCE GROUNDWATER MONITORING WELL INSTALLED TO 11.29m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 7.0m TO 11.29m. CASING 0m TO 7.0m. 2mm SAND FILTER PACK 6.0m TO 11.29m. BENTONITE SEAL 0m TO 6.0m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A CONCRETED GALVANISED MONUMENT.
6.5–6.75	12		-	BASALT: fine grained, dark grey.	SW	H		LISMORE BASALT HIGH RESISTANCE
				REFER TO CORED BOREHOLE LOG				

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CORED BOREHOLE LOG

Borehole No. 62

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT	**Core Size:** NMLC	**R.L. Surface:** 18.61 m
Date: 11/10/24	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK309	**Bearing:** N/A	**Logged/Checked By:** A.G./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS DESCRIPTION Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness — Specific	General	Formation
		12			START CORING AT 6.75m							
					BASALT: fine grained, dark grey.	SW	VH					
			7		NO CORE 0.18m							
ON 16/11/24		11			BASALT: fine grained, dark grey.	HW	VH	4.2		(7.05m) J, 30°, P, R, Fe Sn (7.18m) XWS, 30°, 150 mm.t (7.25m) Jh, 90°, Un, Sn (7.32m) J, 20°, P, S, Fe Sn (7.34m) J, 90°, Ir, R, Fe Sn (7.45m) XWS, 20°, 2 mm.t (7.52m) XWS, 20°, 50 mm.t (7.62m) J, 20°, P, S, Fe Sn (7.70m) J, 20°, Un, R, Fe Sn (7.74m) J, 45°, C, S, Fe Sn		Lismore Basalt
						SW		4.6		(7.93m) XWS, 50°, 6 mm.t (7.98m) XWS, 0°, 4 mm.t		
			8			HW	VL - L			(8.07m) Cr, 0°, 40 mm.t (8.10m) J, 70°, P, S, Fe Sn		
90% RETURN		10				FR	VH	3.2 4.3 4.0		(8.21m) Cr, 0 - 50°, 50 mm.t (8.25m) J, 50°, P, S, Fe Sn (8.40m) J, 70°, P, S, Fe Sn (8.52m) Cr, 0°, 115 mm.t (8.63m) XWS, 0°, 6 mm.t (8.67m) XWS, 0°, 6 mm.t (8.79m) J, 70°, P, S, Fe Sn (8.95m) XWS, 0°, 50 mm.t (9.12m) J, 20°, P, R, Fe Sn (9.22m) J, 45°, P, R, Fe Sn (9.27m) XWS, 5°, 3 mm.t (9.54m) J, 20°, Ir, R, Fe Sn (9.58m) XWS, 5°, 2 mm.t		
		9	9			MW		3.5				
			10			FR		4.3 5.0 4.1		(9.85m) J, 40°, Ir, R, Fe Sn (9.88m) XWS, 0°, 4 mm.t (9.93m) J, 70 - 90°, C, S, Cn (10.18m) XWS, 0°, 40 mm.t (10.27m) XWS, 10°, 1 mm.t (10.44m) XWS, 5°, 4 mm.t (10.64m) XWS, 5°, 10 mm.t (10.80m) XWS, 0°, 3 mm.t (11.06m) XWS, 0°, 15 mm.t (11.12m) XWS, 0°, 5 mm.t		
		8	11									
		7			END OF BOREHOLE AT 11.29 m							
			12									
		6										

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 36314LT
Borehole No: BH62
Depth: 6.75m to 11.29m
KODAK Gray Scale
KODAK Color Control Patches
36314LT BH62 START CORING AT 6.75m
6
NO CORE 0.18m.t
7
8
9
10
11
END OF BH AT 11.29m

JKGeotechnics

BOREHOLE LOG

Borehole No. **64**

1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~13.4 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Samples	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION				0.0–0.3		TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				
	ES		13	0.3	CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained, dark grey, sub-angular basalt gravel, fine grained ironstone gravel, and root fibres.	w>PL	F	50 90 190	COLLUVIAL
	DS, ES	N = 3 0,1,2		0.5–0.95				St	150 160 180	HP IN TEST PIT SIDE WALL
			12	1						
	ES	N = 7 3,3,4		1.5–1.95				St - VSt	130 170 200	NO SPT RETURN HP READINGS ON DISTURBED AUGER SAMPLES
			11	2						
	DS, ES			2.8–3.0				VSt	310 230 290	
			10	3		END OF BOREHOLE AT 3.00 m				
			9	4						
			8	5						
			7	6						

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BOREHOLE LOG

Borehole No.
66
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~11.8 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION							TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.				GRASS COVER
						CH	Silty CLAY: high plasticity, dark grey, trace of fine to medium grained dark grey, sub-rounded basalt gravel, fine grained ironstone gravel, and root fibres.	w>PL	St	110 140 140	ALLUVIAL HP TESTING ON REMOULDED SAMPLES
		N = 3 0,1,2	11							140 130 150	
				1							
		N = 4 1,2,2	10							180 200	
				2							
			9							180 180 190	HP TESTING ON REMOULDED SAMPLES
				3			END OF BOREHOLE AT 3.00 m				
			8	4							
			7	5							
			6	6							
			5								

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BOREHOLE LOG

Borehole No.
71

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 16.97 m
Date: 11/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION					TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				GRASS COVER
	N = 9 2,4,5	16	1	CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained, brown, rounded basalt gravel, fine grained ironstone gravel, and root fibres.	w>PL	Hd	550 530 560	COLLUVIAL
					Silty CLAY: high plasticity, light grey and light brown mottled dark brown, with fine to medium grained ironstone gravel.	w<PL			
	N > 15 10,15/ 100mm REFUSAL	15	2		Gravelly silty CLAY: high plasticity, light brown and brown, fine to medium grained, dark grey, angular basalt gravel.			>600 >600 >600	BANDED VERY LOW 'TC' BIT RESISTANCE RESIDUAL POSSIBLY COLLUVIAL
	N=SPT 7/ 50mm REFUSAL	14	3						
		13	4						LOW RESISTANCE
		12	5						
		11	6						

Samples columns: ES, U50, DB, DS. Graphic Log column.

JKGeotechnics

BOREHOLE LOG

Borehole No. 71

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 16.97 m
Date: 11/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
				■						Gravelly silty CLAY: high plasticity, light brown and brown, fine to medium grained, dark grey, angular basalt gravel.	w<PL	Hd		HIGH RESISTANCE
										END OF BOREHOLE AT 7.10 m				'TC' BIT REFUSAL ON BASALT
						9	8							
						8	9							
						7	10							
						6	11							
						5	12							
						4	13							

JKGeotechnics

BOREHOLE LOG

Borehole No.
80
1 / 2

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 16.38 m
Date: 10/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING		0		TOPSOIL: Silty clay, high plasticity, dark brown, trace of fine grained igneous and quartz gravel, and root fibres.	w>PL			GRASS COVER
	N = 2 0,0,2		CH	Silty CLAY: high plasticity, dark brown, trace of fine to medium grained, dark grey basalt gravel.	w>PL	St	170 180 190	COLLUVIAL
	N = 12 3,4,8	1		Silty CLAY: high plasticity, brown and dark brown, with fine to medium grained ironstone gravel, trace of fine to medium grained, brown and dark grey, angular basalt gravel, and fine grained quartz gravel.		Hd	460 440 420	POSSIBLE SLIDE PLANE IN SPT SAMPLE AT 1.5-1.95m
	N=SPT 9/ 50mm REFUSAL	3	-	Extremely Weathered basalt: silty clayey GRAVEL, fine grained, red brown and brown, angular, iron indurated basalt.	XW	Hd		LISMORE BASALT TOO FRIABLE FOR HP TESTING HIGH 'TC' BIT RESISTANCE
		4		REFER TO CORED BOREHOLE LOG				

RL (m AHD) scale: 16, 15, 14, 13, 12, 11, 10. Depth (m) scale: 1, 2, 3, 4, 5, 6.

SAMPLES: ES, U50, DB, DS

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 36314LT NORTH LISMORE.GPJ <<DrawingFile>> 22/11/2024 09:35 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
80

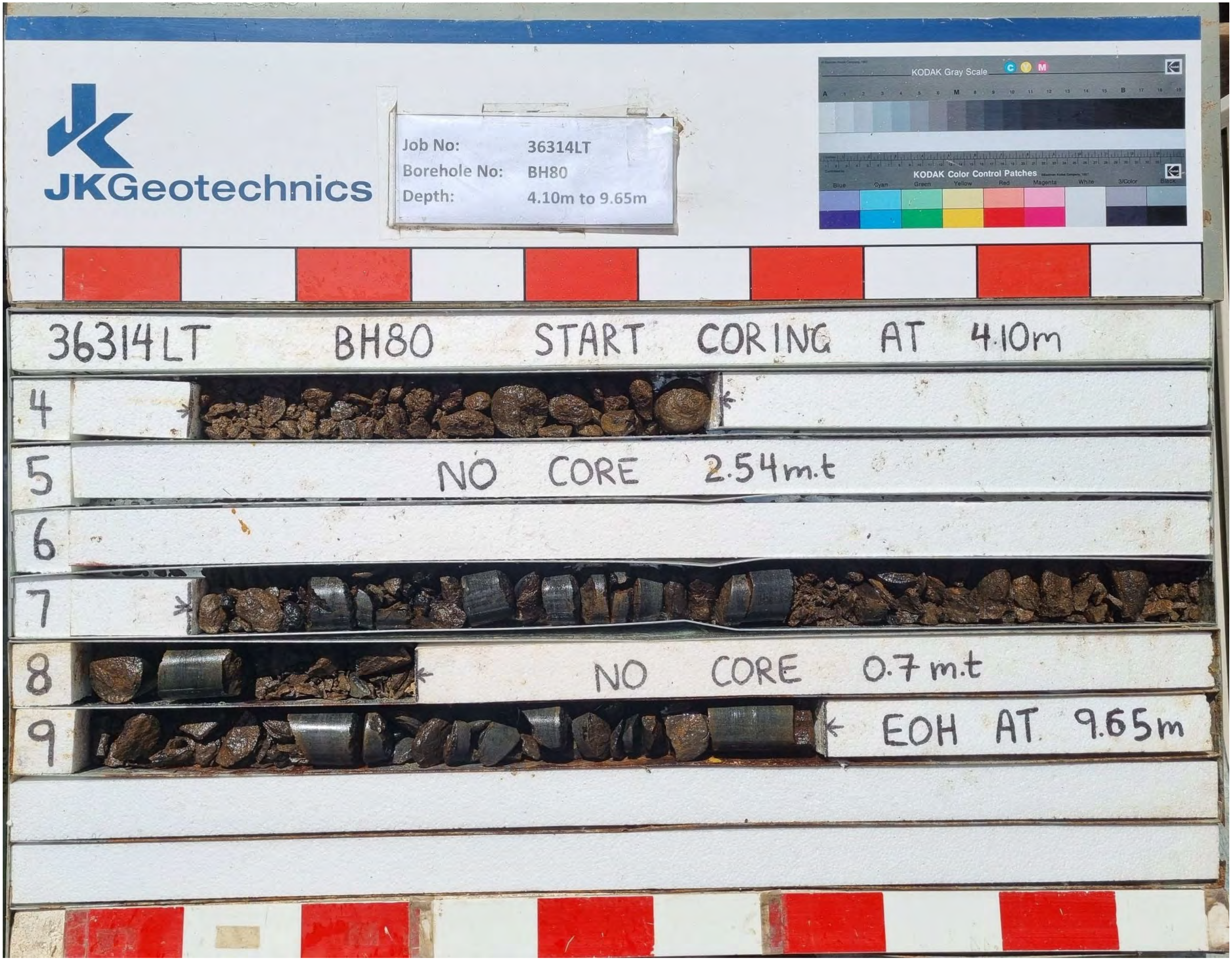
Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT | **Core Size:** NMLC | **R.L. Surface:** 16.38 m
Date: 10/10/24 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK309 | **Bearing:** N/A | **Logged/Checked By:** A.G./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components (START CORING AT 4.10m)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – Specific	DEFECT DETAILS – General	Formation
50% RETURN		12			Extremely Weathered basalt: gravelly silty CLAY, medium to high plasticity, brown, fine grained gravel, with low strength basalt bands up to 35mm.t.	XW	(Hd)	0.20		CLAY WASHED AWAY, JUST LEAVING SILTY GRAVEL	
		11, 10	5, 6, 7		NO CORE 2.54m						
80% RETURN		9			BASALT: fine grained, dark grey.	SW	VH	3.6, 3.3	(7.24m) J, 0°, P, S, Fe Sn (7.32m) J, 90°, P, R, Fe Sn (7.40m) J, 0°, P, S, Fe Sn (7.44m) Be, 0°, P, S, Fe Sn	(7.34-7.64m) Joints generally bedded at 0-30° with iron staining	Lismore Basalt
					Extremely Weathered basalt: clayey GRAVEL, fine to coarse grained, dark grey and brown, basalt gravel.	XW	(D)		(7.93m) J, 45°, St, R, Fe Sn		
			8		BASALT: fine grained, dark grey.	SW	H	2.1	(8.08m) J, 10°, P, R, Fe Sn		
		8			Extremely Weathered basalt: clayey GRAVEL, fine to coarse grained, dark grey and brown, basalt gravel.	XW	(D)				
					NO CORE 0.70m						
			9		Extremely Weathered basalt: clayey GRAVEL, fine to coarse grained, dark grey and brown, basalt gravel.	XW	(D)				
		7			BASALT: fine grained, dark grey.	SW	VH	3.7	(9.20m) J, 25°, P, R, Fe Sn (9.25m) XWS, 0°, 8 mm.t (9.35m) J, 90°, P, R, Fragmented (9.45m) J, 40°, P, R, Fe Sn (9.57m) Jh, 90°, Ir, R, Fe Sn		
		6	10		END OF BOREHOLE AT 9.65 m						

Point load strength scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH. Spacing (mm): 600, 200, 60, 20.

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS



JKGeotechnics
Job No: 36314LT
Borehole No: BH80
Depth: 4.10m to 9.65m
KODAK Gray Scale
KODAK Color Control Patches
36314LT BH80 START CORING AT 4.10m
4
5 NO CORE 2.54m.t
6
7
8 NO CORE 0.7m.t
9 EOH AT 9.65m

JKGeotechnics

BOREHOLE LOG

Borehole No.
82

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~12.2 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
					TOPSOIL: Silty clay, high plasticity, dark grey, with root fibres.				GRASS COVER
	N = 3 0,1,2	12 11	1	CH	Silty CLAY: high plasticity, dark grey, trace of fine grained ironstone gravel, and root fibres.	w>PL	St	100 120 130	ALLUVIAL TP EXCAVATED TO 0.3m.
ON COMPLETION OF AUGERING	N = 4 1,2,2	10	2		as above, but dark grey and dark brown, trace of fine to medium grained dark grey, angular basalt gravel, and fine grained ironstone gravel.			130 140 170	
	N = 8 3,3,5	9	3		Silty CLAY: high plasticity, brown, trace of fine to medium grained basalt gravel.	w<PL	St - VSt	170 210 210	RESIDUAL POSSIBLY COLLUVIAL
		8	4		as above, but light grey and brown, with fine to coarse grained basalt gravel.		VSt	270 300 300	VERY LOW 'TC' BIT RESISTANCE
	N=SPT 24/ 150mm REFUSAL	7	5	-	Extremely Weathered basalt: silty CLAY, high plasticity, light brown and brown, with iron indurated bands.	XW	Hd		LISMORE BASALT BANDED LOW RESISTANCE
	N=SPT 7/ 50mm REFUSAL	6	6		BASALT: fine grained, dark grey.	DW	M - H		HIGH RESISTANCE MODERATE RESISTANCE

JKGeotechnics

BOREHOLE LOG

Borehole No.
82

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~12.2 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
						5			-	BASALT: fine grained, dark grey. *(continued)*	DW	H		
						4, 3, 2, 1, 0, -1	8, 9, 10, 11, 12, 13			REFER TO CORED BOREHOLE LOG				

JKGeotechnics

CORED BOREHOLE LOG

Borehole No. 82

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT | **Core Size:** NMLC | **R.L. Surface:** ~12.2 m
Date: 15/10/24 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK309 | **Bearing:** N/A | **Logged/Checked By:** A.G./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness — Specific / General	Formation
		5			START CORING AT 7.65m						
90% RETURN			8		BASALT: fine grained, dark grey.	HW	H			Defects likely comprise closely spaced joints infilled with extremely weathered material.	Lismore Basalt
10% RETURN		4			Extremely Weathered basalt: sandy silty CLAY, low plasticity, brown and yellow brown.	XW	(Hd)				
					NO CORE 0.53m						
		3	9		END OF BOREHOLE AT 9.03 m						
		2	10								
		1	11								
		0	12								
		-1	13								

JK 9.02.4 LIB.GLB Log JK CORED BOREHOLE - MASTER 36314LT NORTH LISMORE.GPJ <<DrawingFile>> 22/11/2024 09:38 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 36314LT
Borehole No: BH82
Depth: 7.65m to 9.03m
KODAK Gray Scale
KODAK Color Control Patches
36314LT BH82 START CORING AT 7.65m
7
8
NO CORE 0.53m.t.
9
END OF BH AT 9.03m

JKGeotechnics

BOREHOLE LOG

Borehole No.
85

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 21.75 m
Date: 10/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION AND ON 16/11/24					TOPSOIL: Silty clay, high plasticity, dark brown, trace of root fibres.	w>PL			GRASS COVER
	N=SPT 16/ 150mm REFUSAL	21	1	CH	Silty CLAY: high plasticity, dark red brown, with fine to coarse grained basalt gravel.	w>PL	St	100 180 100	COLLUVIAL
	N=SPT 2/ 10mm REFUSAL	20, 19, 18, 17, 16, 15	2, 3, 4, 5, 6	-	BASALT: brown and dark brown, with high strength, dark grey core stones and bands.	XW - HW	Hd / VL		LISMORE BASALT LOW 'TC' BIT RESISTANCE WITH HIGH RESISTANCE BANDS LOW TO MODERATE RESISTANCE

Samples columns: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No.
85
2 / 2

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** 21.75 m
Date: 10/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
									-	BASALT: brown and dark brown, with high strength, dark grey core stones and bands.	XW - HW			HIGH RESISTANCE
										END OF BOREHOLE AT 7.20 m				'TC' BIT REFUSAL ON INFERRED BASALT BEDROCK GROUNDWATER MONITORING WELL INSTALLED TO 7.2m. CLASS 18 MACHINE SLOTTED 3.0m TO 7.2m. CASING 0m TO 3.0m. 2mm SAND FILTER PACK 2.5m TO 7.2m. BENTONITE SEAL 0m TO 2.5m. COMPLETED WITH A CONCRETED GALVANISED MONUMENT.
						14	8							
						13	9							
						12	10							
						11	11							
						10	12							
						9	13							
						8								

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 36314LT NORTH LISMORE.GPJ <<DrawingFile>> 22/11/2024 09:35 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

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BOREHOLE LOG

Borehole No.
87
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~15.8 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			0		TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				GRASS COVER
				CH	Silty CLAY: high plasticity, dark brown, trace of fine grained ironstone gravel, and root fibres.	w>PL	St	120 120 100	COLLUVIAL
	N = 3 1,1,2	15	1					150 180 170	
	N = 7 2,2,5	14	2		as above, but fine to medium grained ironstone and basalt gravel.		VSt	260 250 300	
		13		GC	Clayey GRAVEL: fine to coarse grained, dark grey gravel in a light brown matrix, angular, igneous.	D			RESIDUAL POSSIBLY COLLUVIAL
			3		END OF BOREHOLE AT 2.90 m				'TC' BIT REFUSAL ON BASALT
		12	4						
		11	5						
		10	6						
		9							

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No. 89

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED HIGH SCHOOL
Location: 163-170 ALEXANDRA PARADE, NORTH LISMORE, NSW

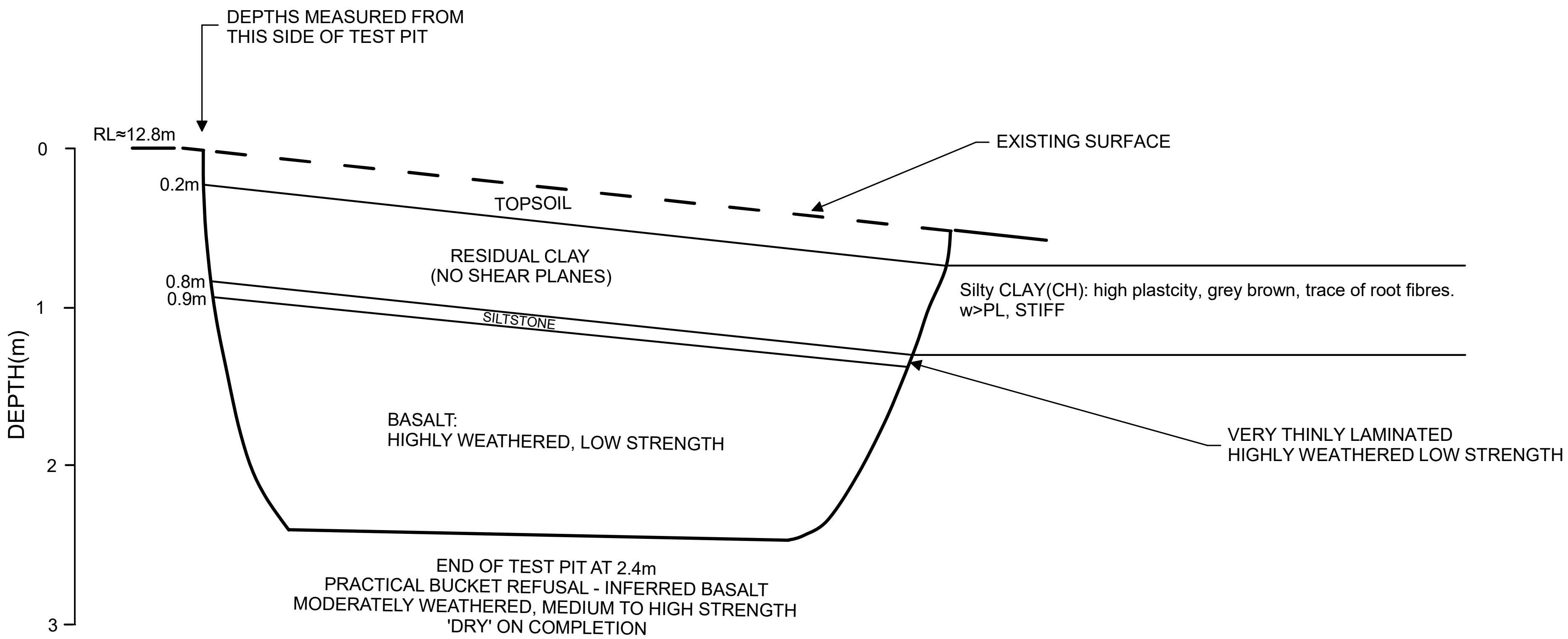
Job No.: 36314LT **Method:** SPIRAL AUGER **R.L. Surface:** ~13.7 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK309 **Logged/Checked By:** A.G./A.B.

Groundwater Record: DRY ON COMPLETION

Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
		TOPSOIL: Silty clay, high plasticity, dark brown, with root fibres.				GRASS COVER
N = 22 0,7,15	CH	Silty CLAY: high plasticity, dark brown, trace of root fibres.	w>PL	St - VSt	210 210 250	TEST PIT EXCAVATED TO 0.5m COLLUVIAL
		Silty CLAY: high plasticity, dark brown mottled grey, trace of fine to medium grained ironstone gravel, and root fibres.			120	
N=SPT 7/ 50mm REFUSAL N=SPT 8/ 50mm REFUSAL	-	Extremely Weathered basalt: gravelly silty CLAY, low plasticity, brown and dark brown, fine to coarse grained, dark grey basalt gravel.	XW	(Hd)	130 150	LISMORE BASALT VERY LOW 'TC' BIT RESISTANCE
		END OF BOREHOLE AT 4.50 m				

RL (m AHD): 13, 12, 11, 10, 9, 8, 7

Depth (m): 1, 2, 3, 4, 5, 6



TEST PIT 101
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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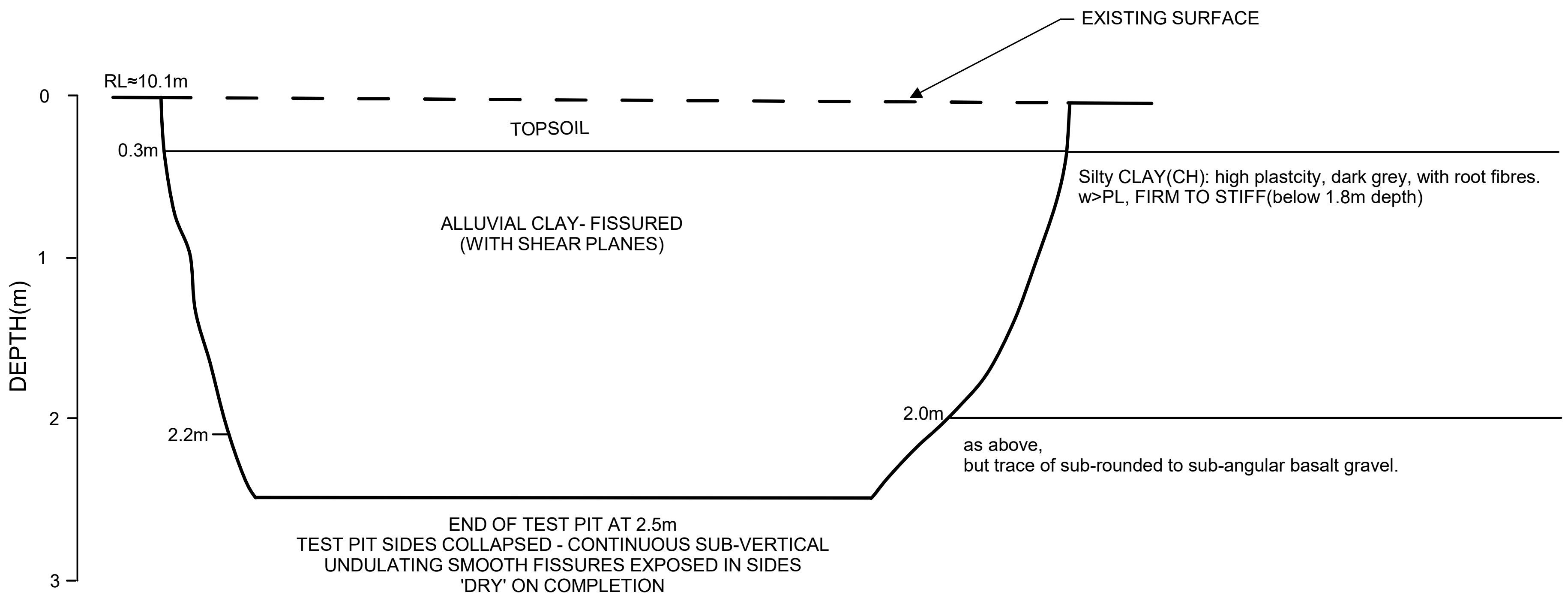
Report No. 36314LT Figure No. 12



TEST PIT 102
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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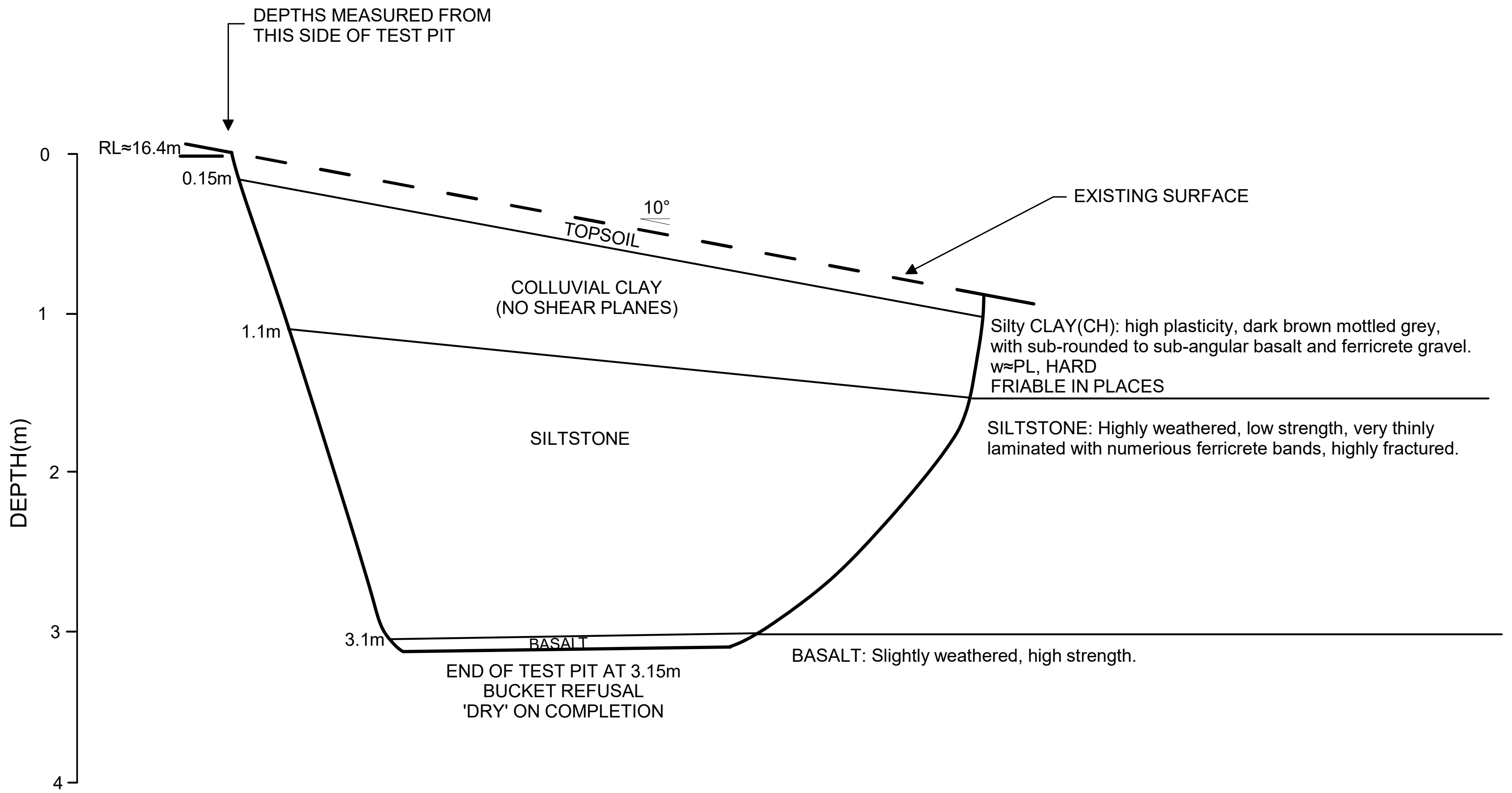
Report No. 36314LT Figure No. 13



TEST PIT 103
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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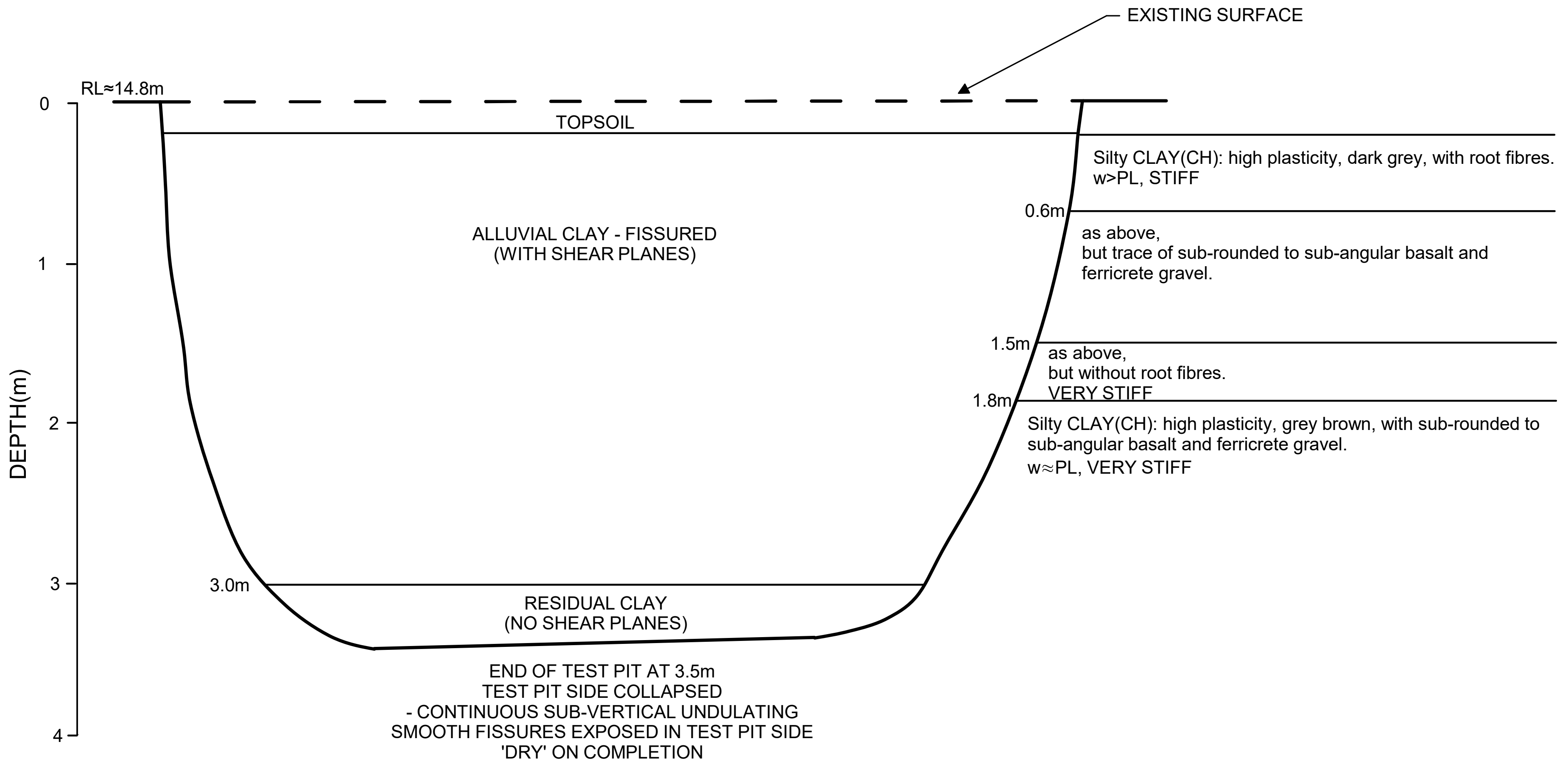
Report No. 36314LT Figure No. 14



TEST PIT 104
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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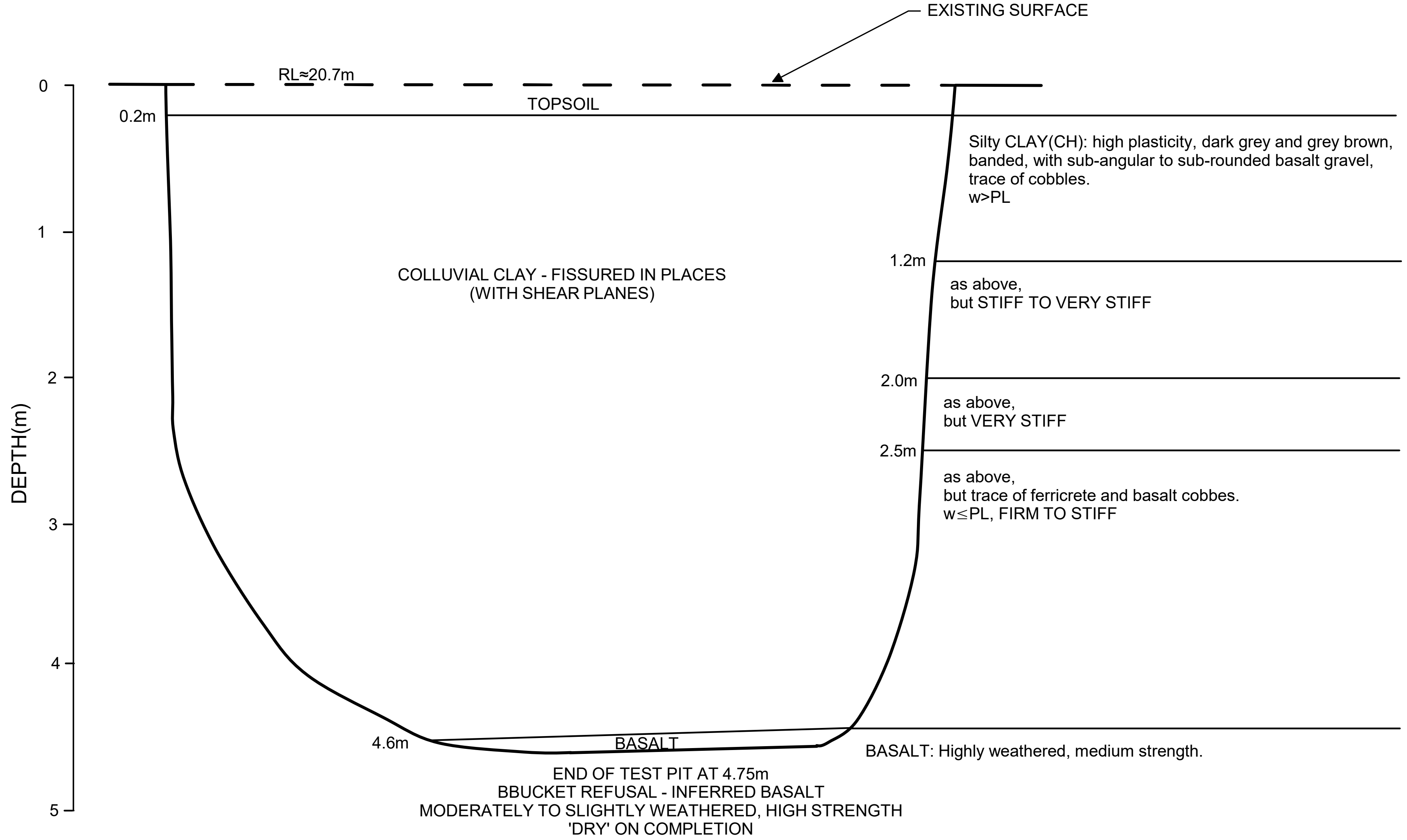
Report No. 36314LT Figure No. 15



TEST PIT 105
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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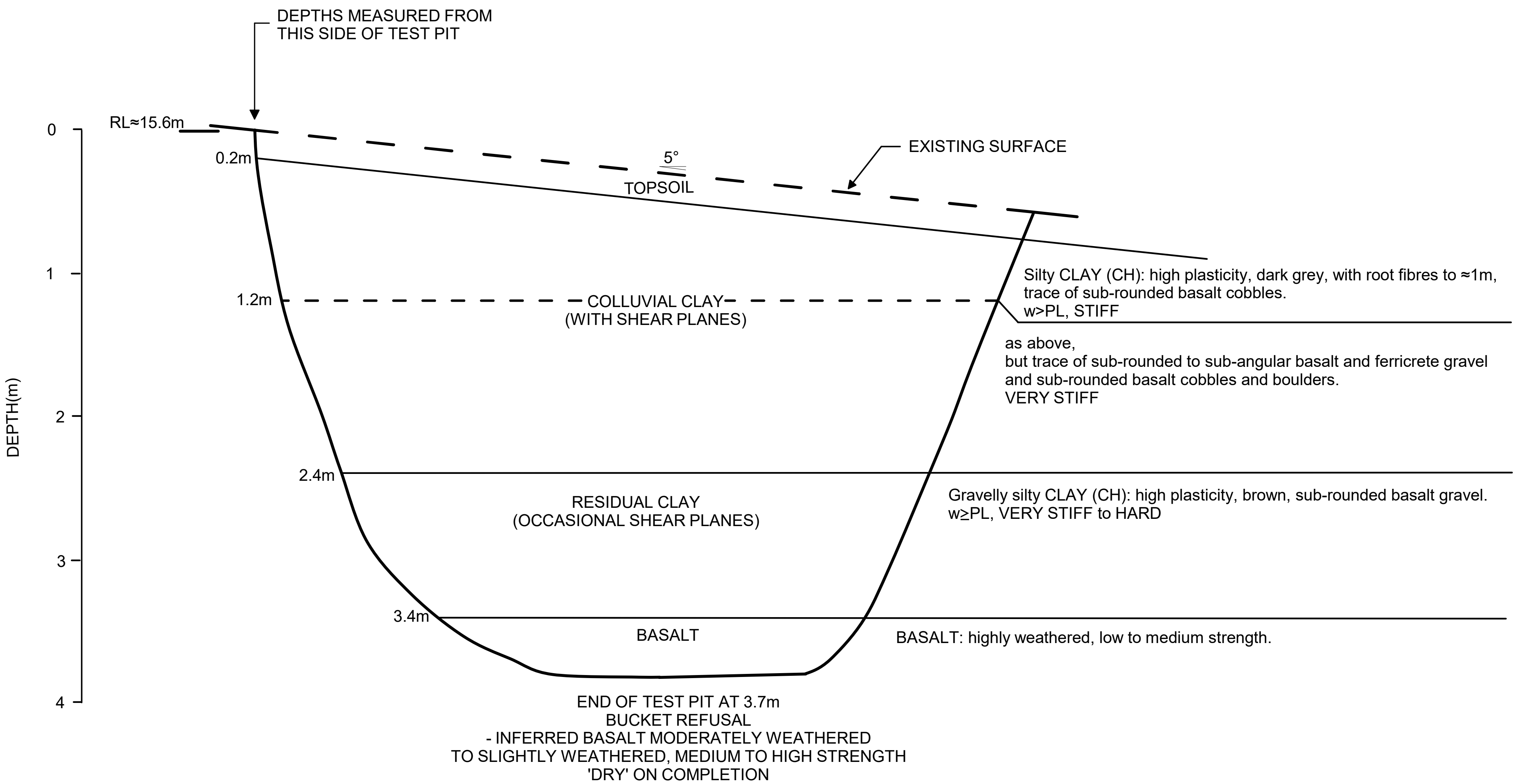
Report No. 36314LT Figure No. 16



TEST PIT 106
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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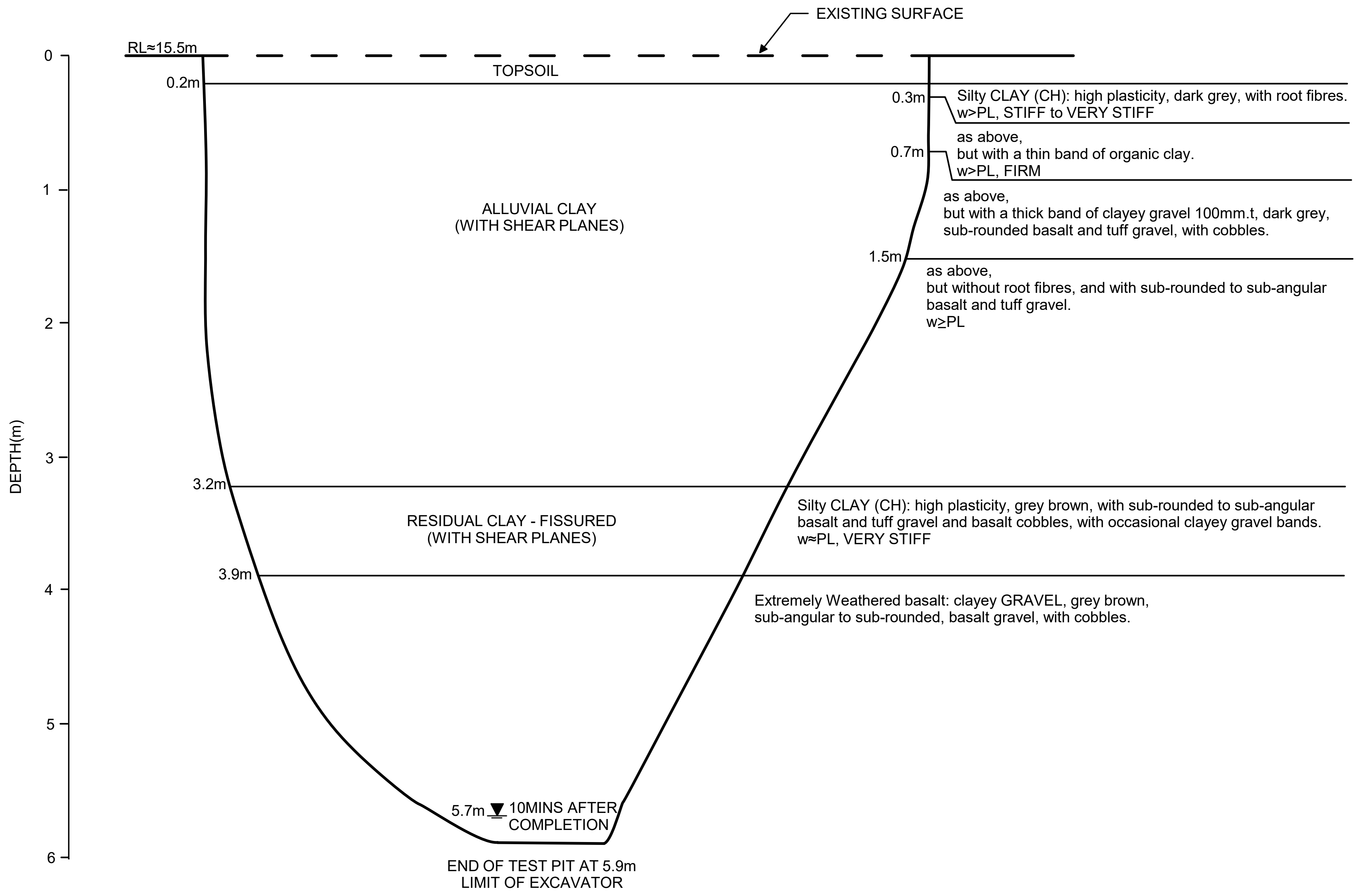
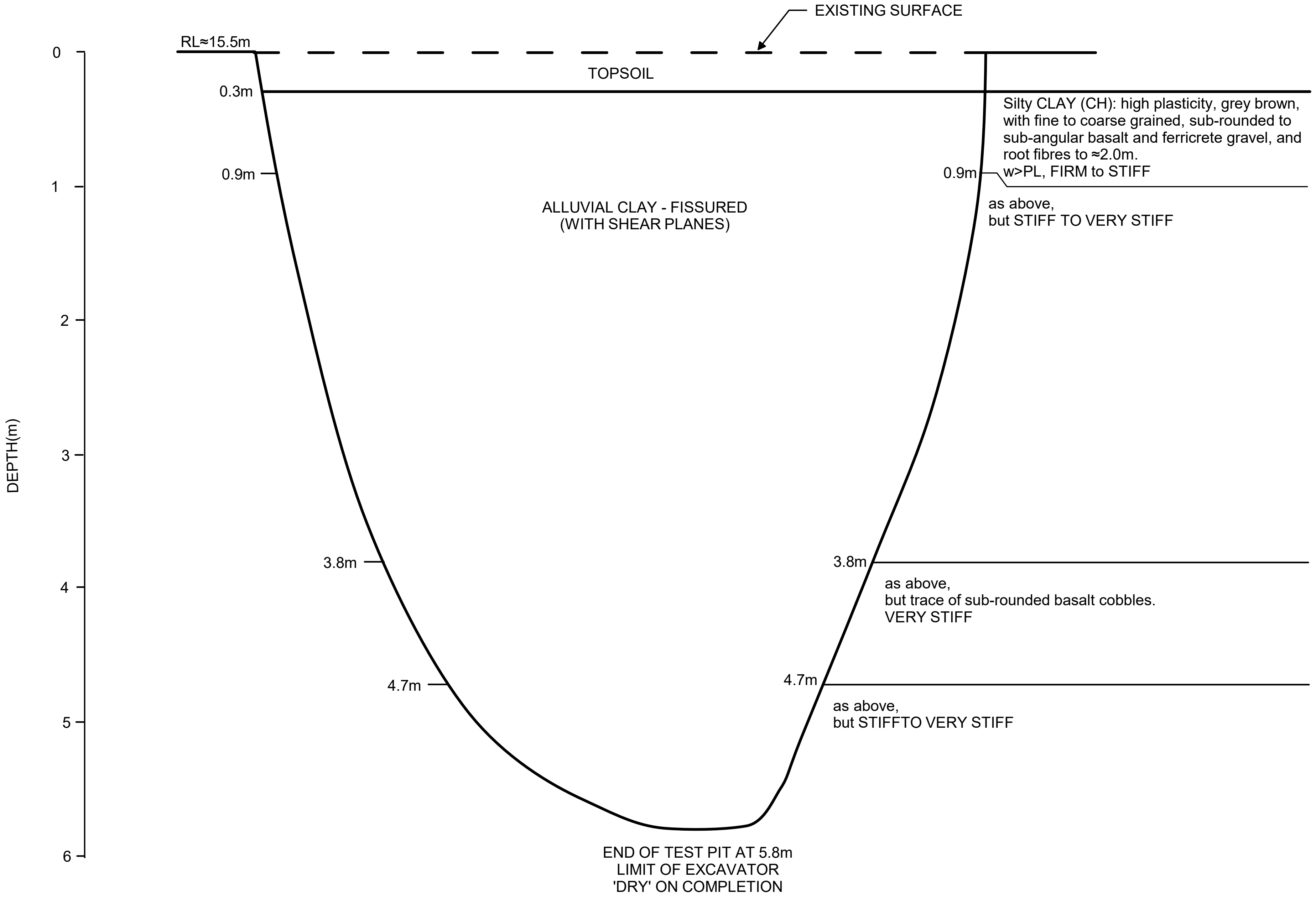
Report No. 36314LT Figure No. 17



TEST PIT 107
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

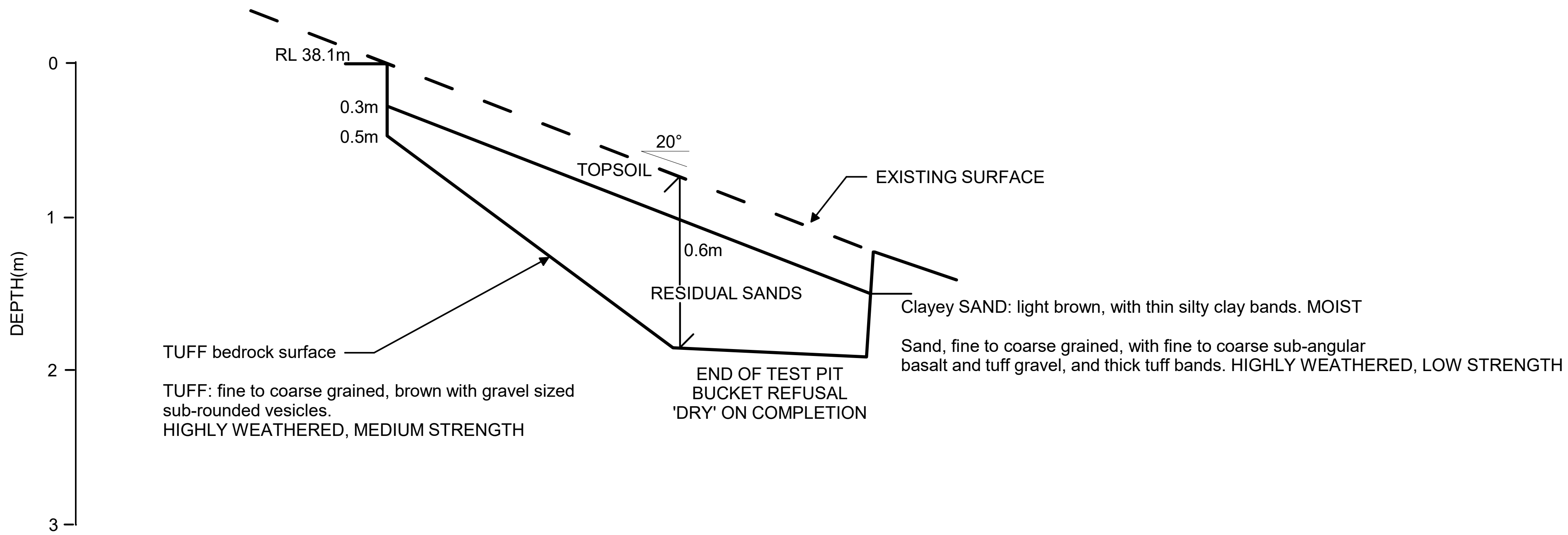


TEST PIT 108
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 19



TEST PIT 109
CROSS SECTIONAL SKETCH
LOOKING SOUTH

0 — 2.0
Scale 1:40 @A3 Metres

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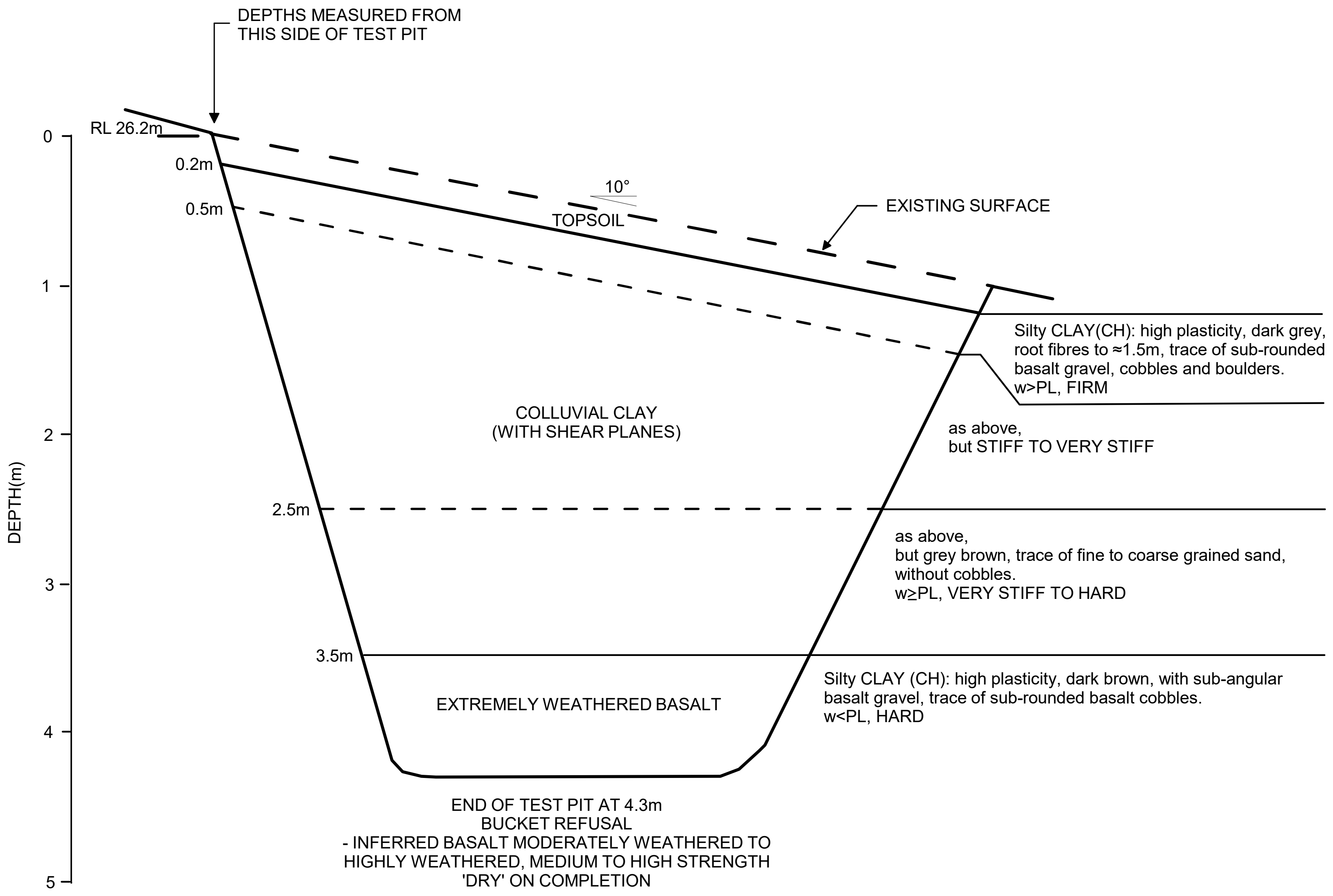
Report No. 36314LT Figure No. 20



TEST PIT 110
CROSS SECTIONAL SKETCH
LOOKING SOUTH

0 2.0
Scale 1:40 @A3 Metres

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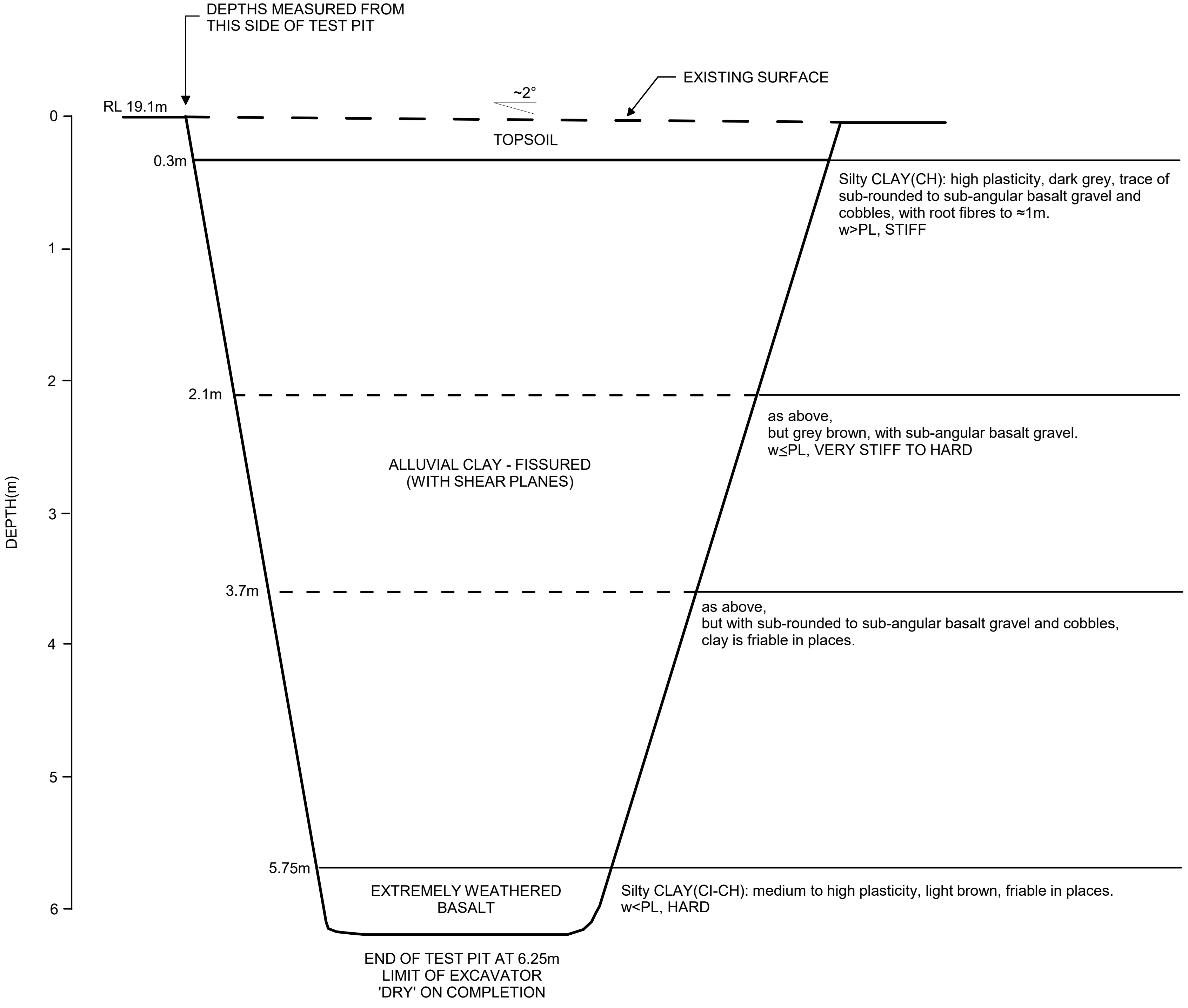
Report No. 36314LT Figure No. 21

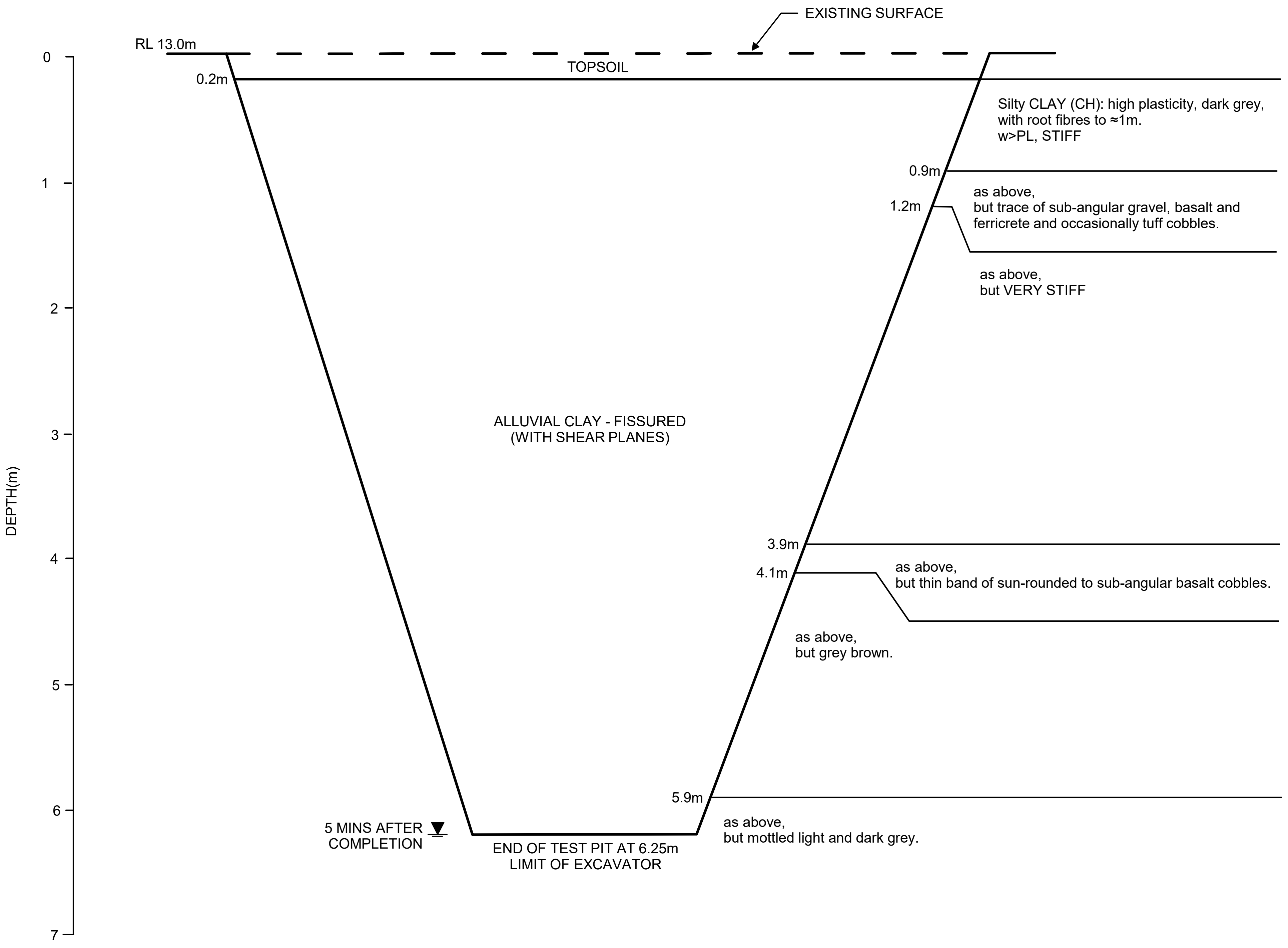


TEST PIT 111
CROSS SECTIONAL SKETCH
LOOKING SOUTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 22



TEST PIT 112
CROSS SECTIONAL SKETCH
LOOKING SOUTH

0 2.0
Scale 1:40 @A3 Metres

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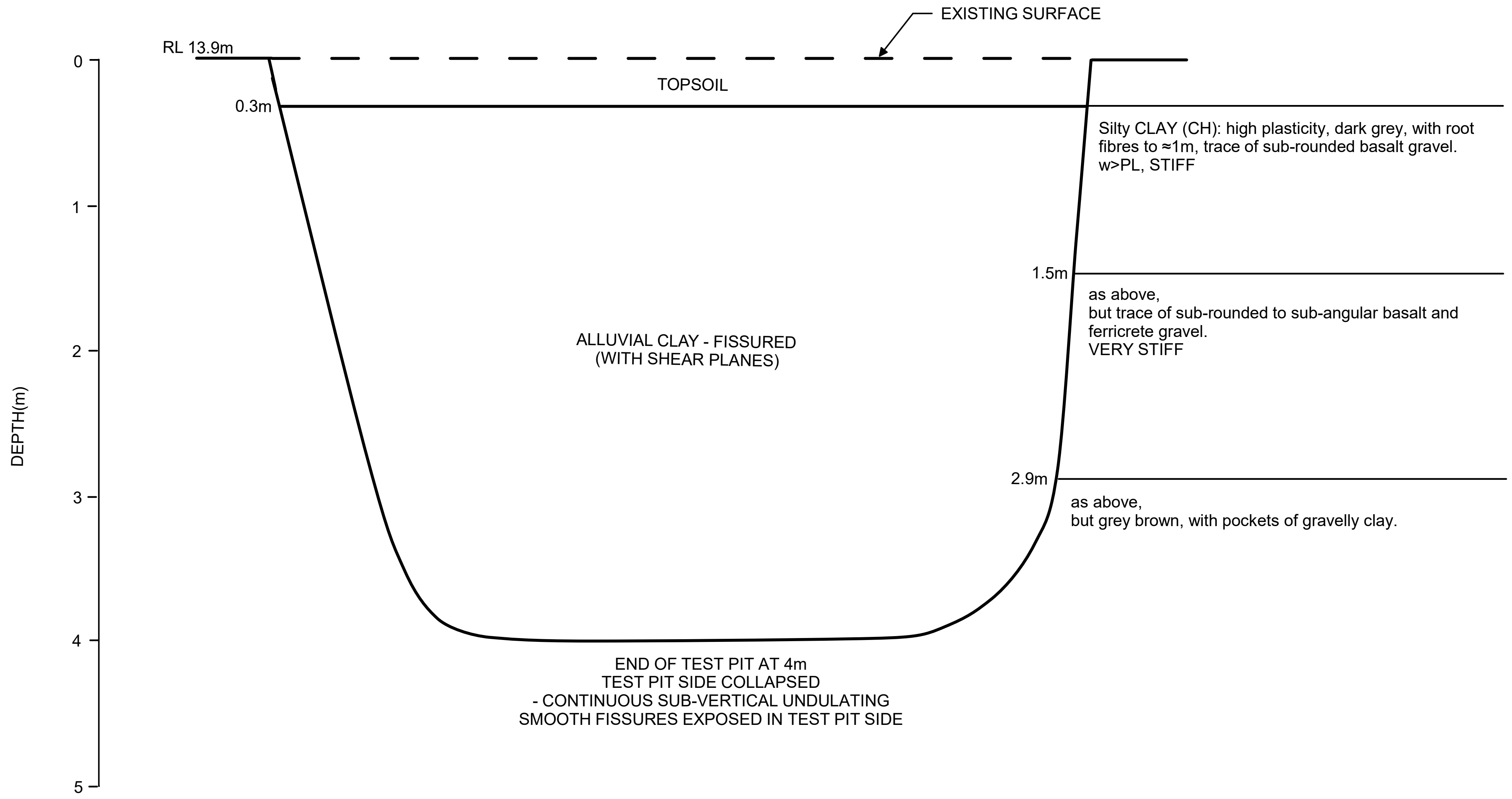
Report No. 36314LT Figure No. 23



TEST PIT 113
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

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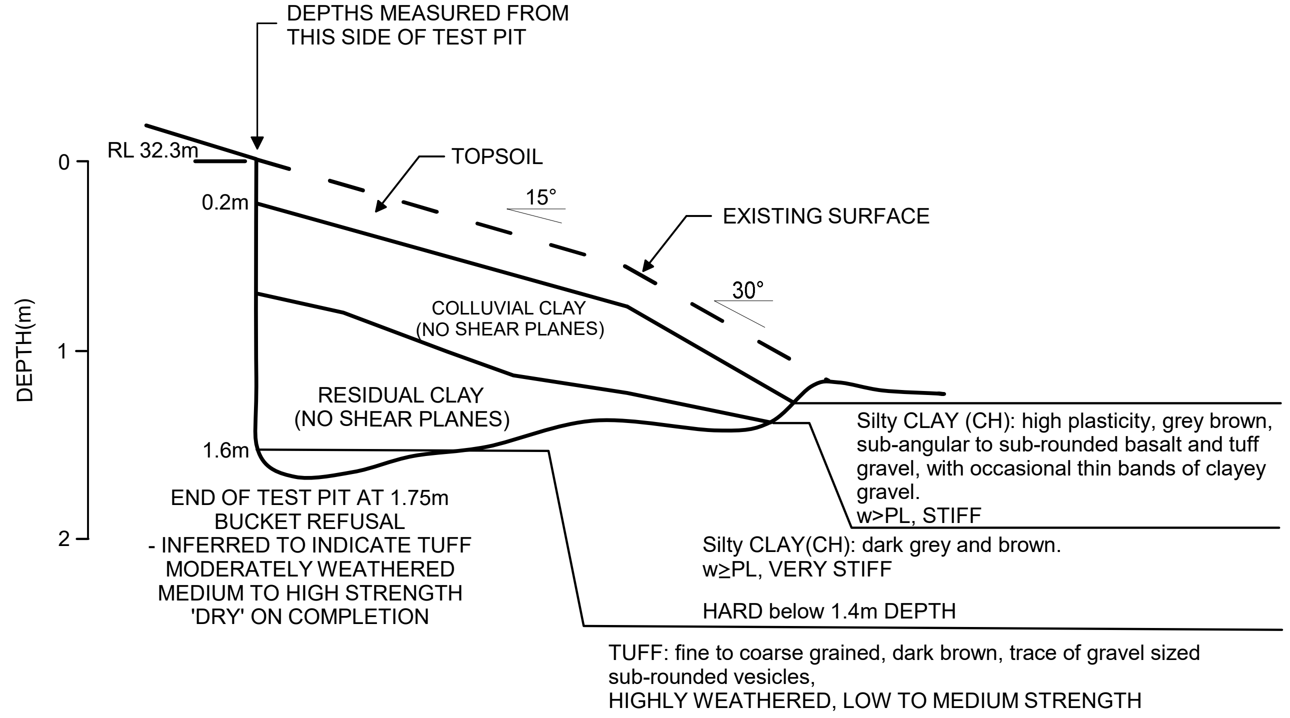
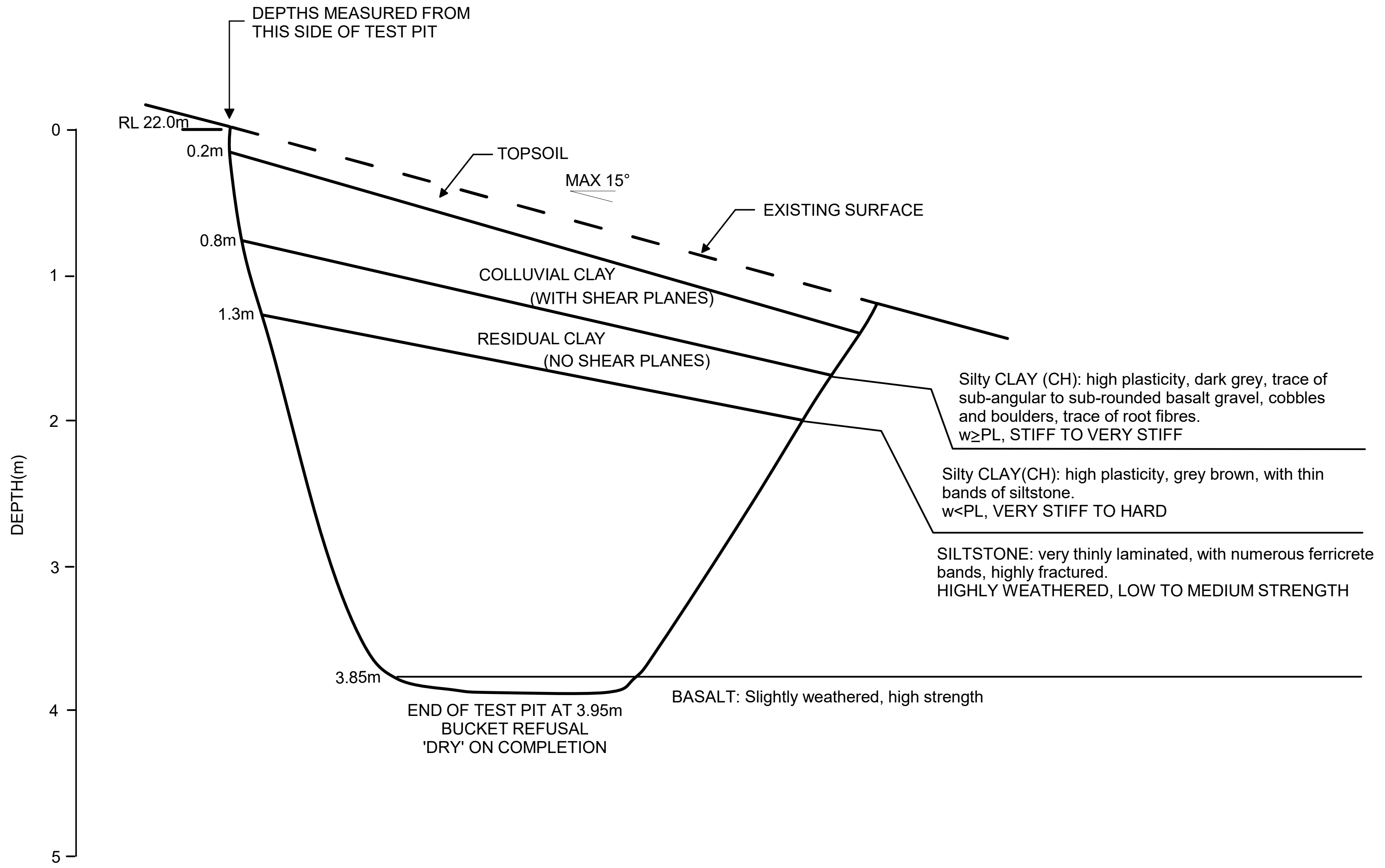
Report No. 36314LT Figure No. 24



TEST PIT 114
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

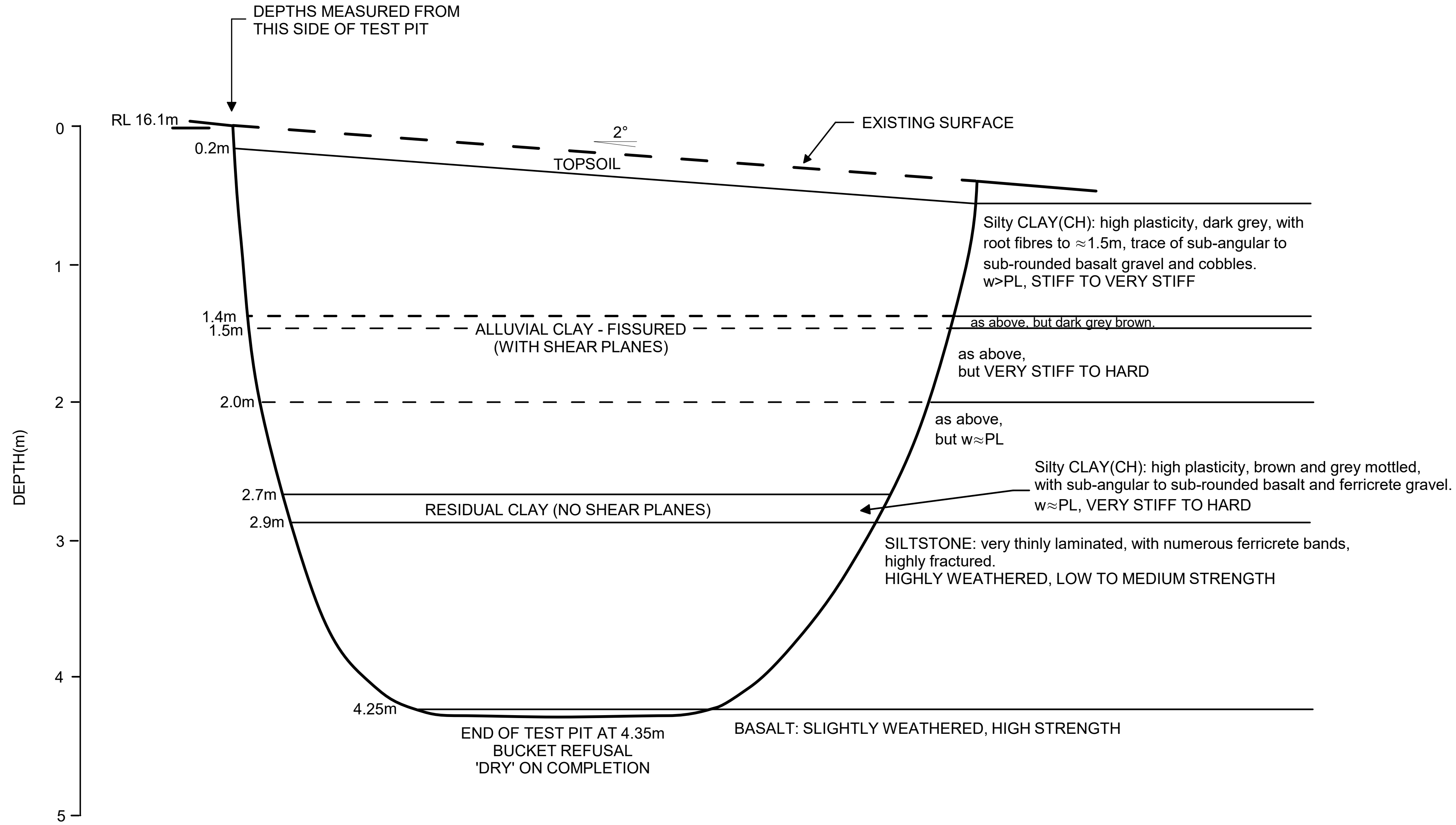


TEST PIT 115
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 26

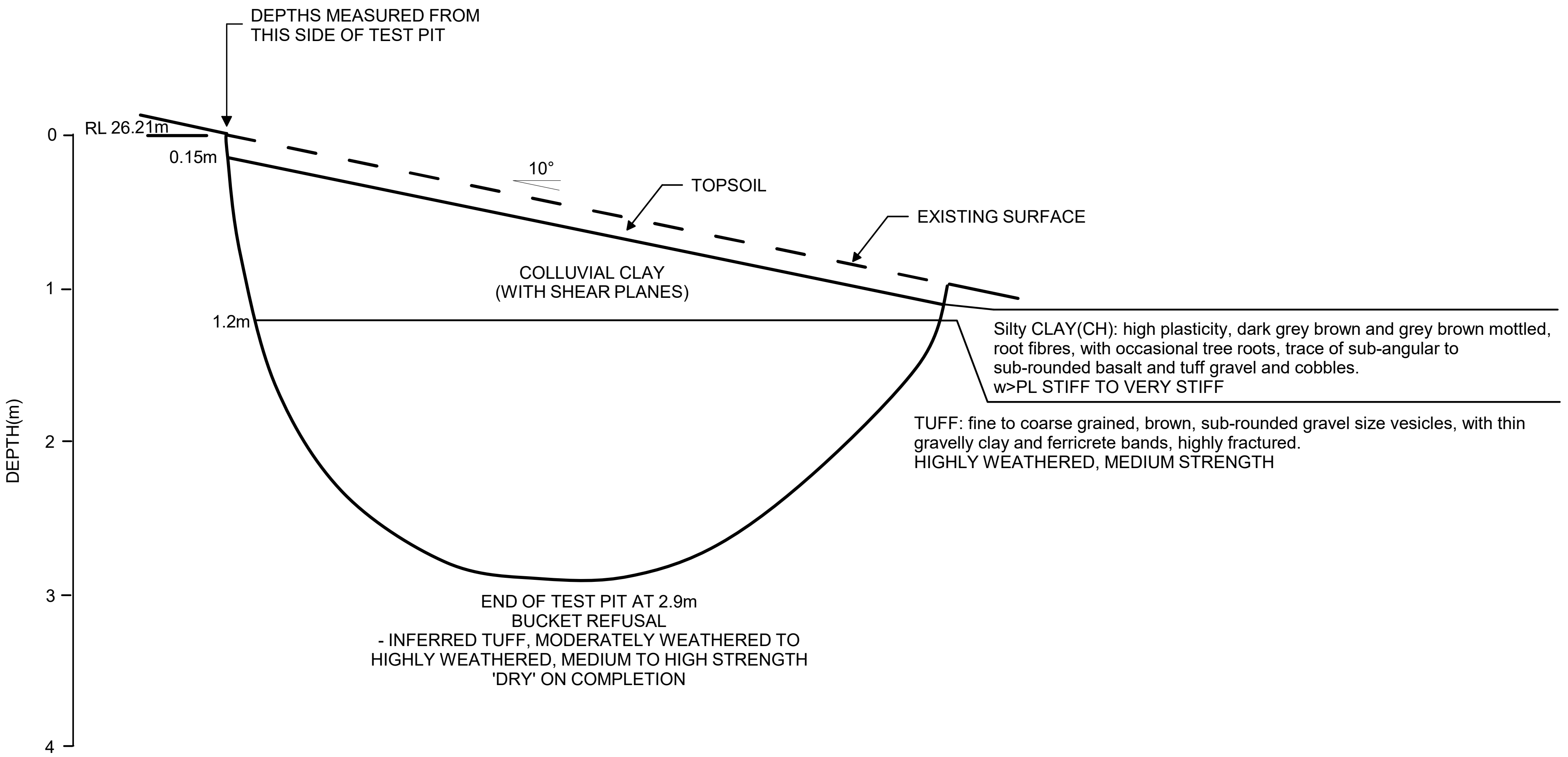


TEST PIT 116
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 27

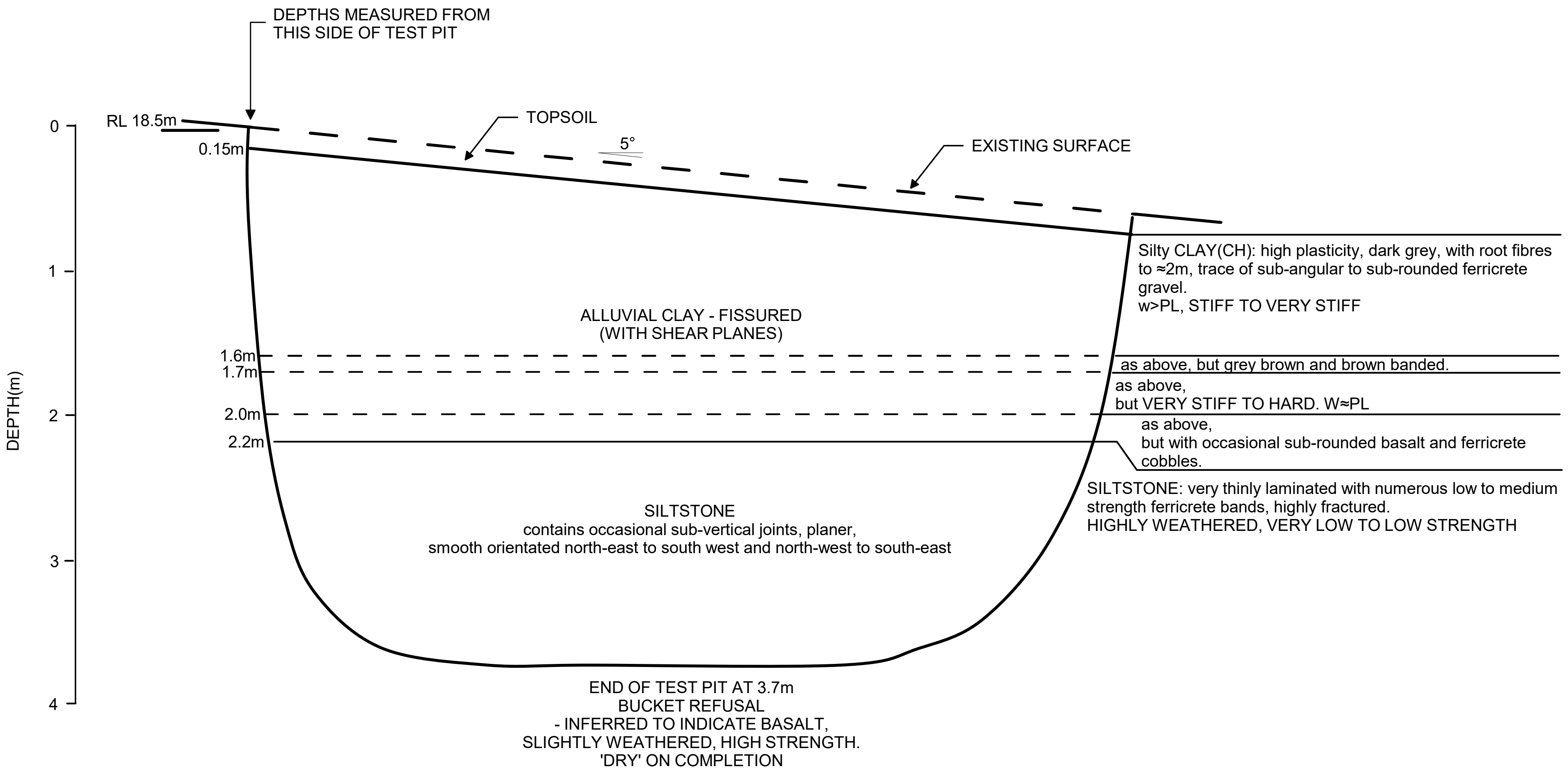


TEST PIT 117
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 28

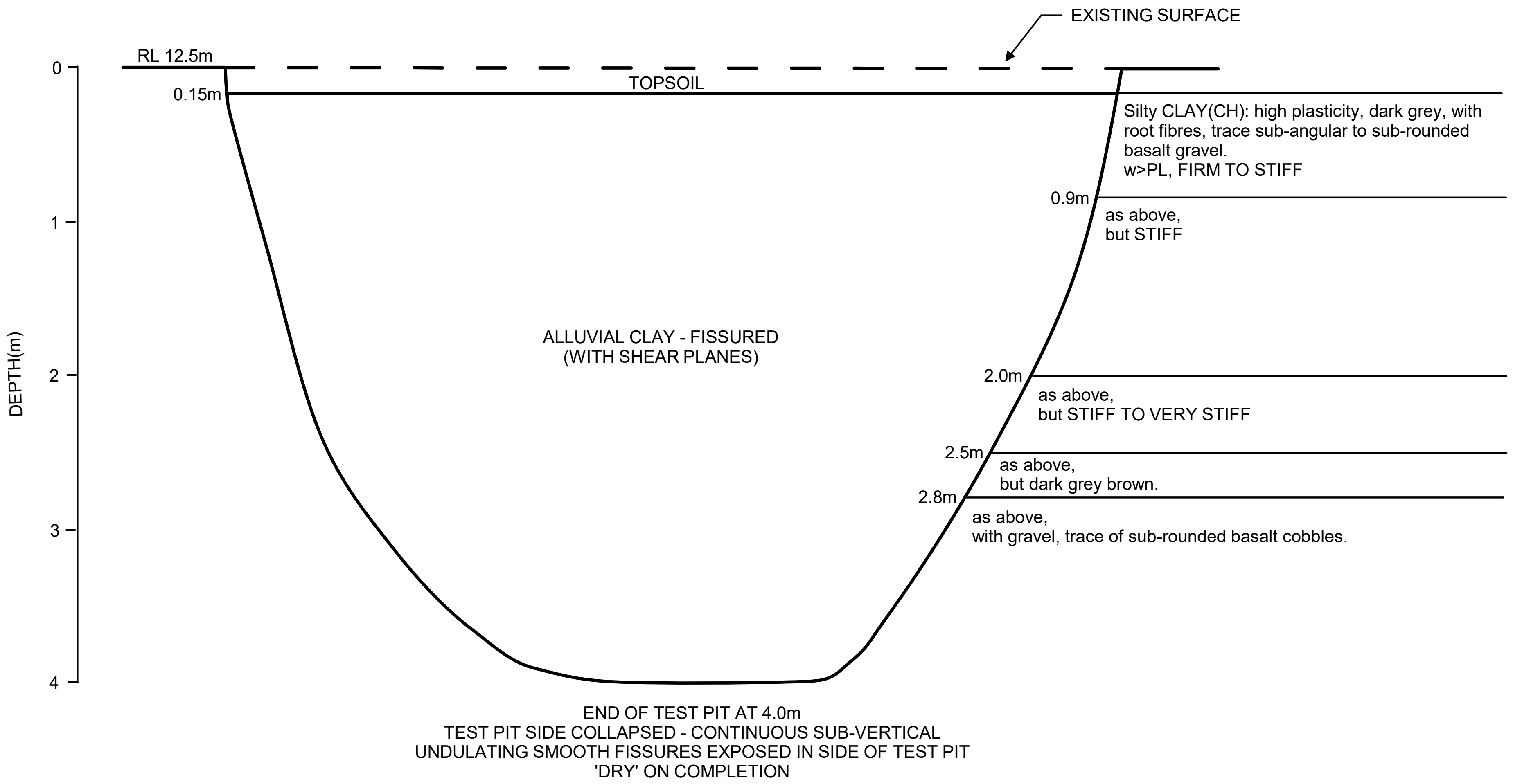


TEST PIT 118
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 29



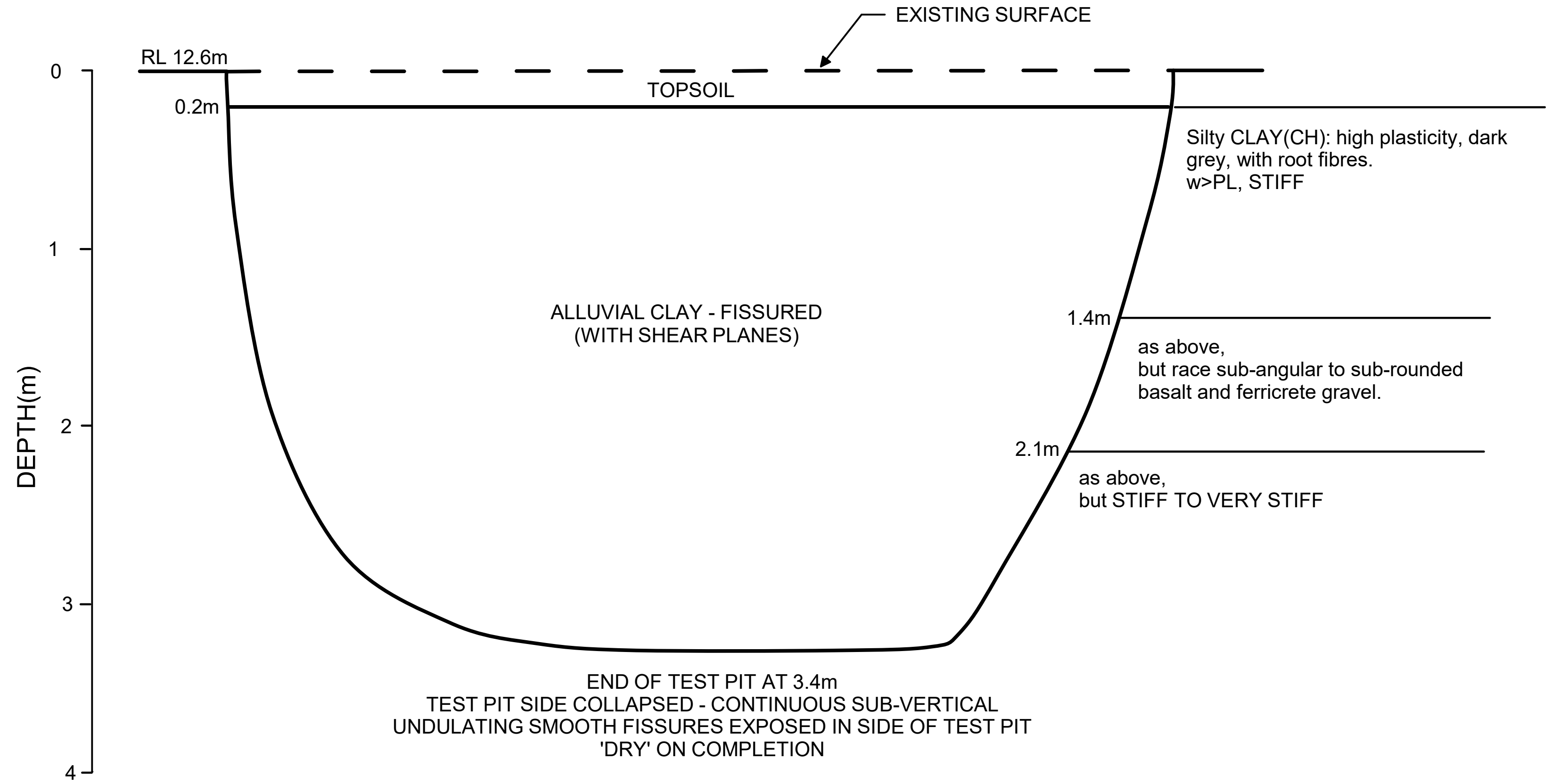
TEST PIT 119
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0

Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 30

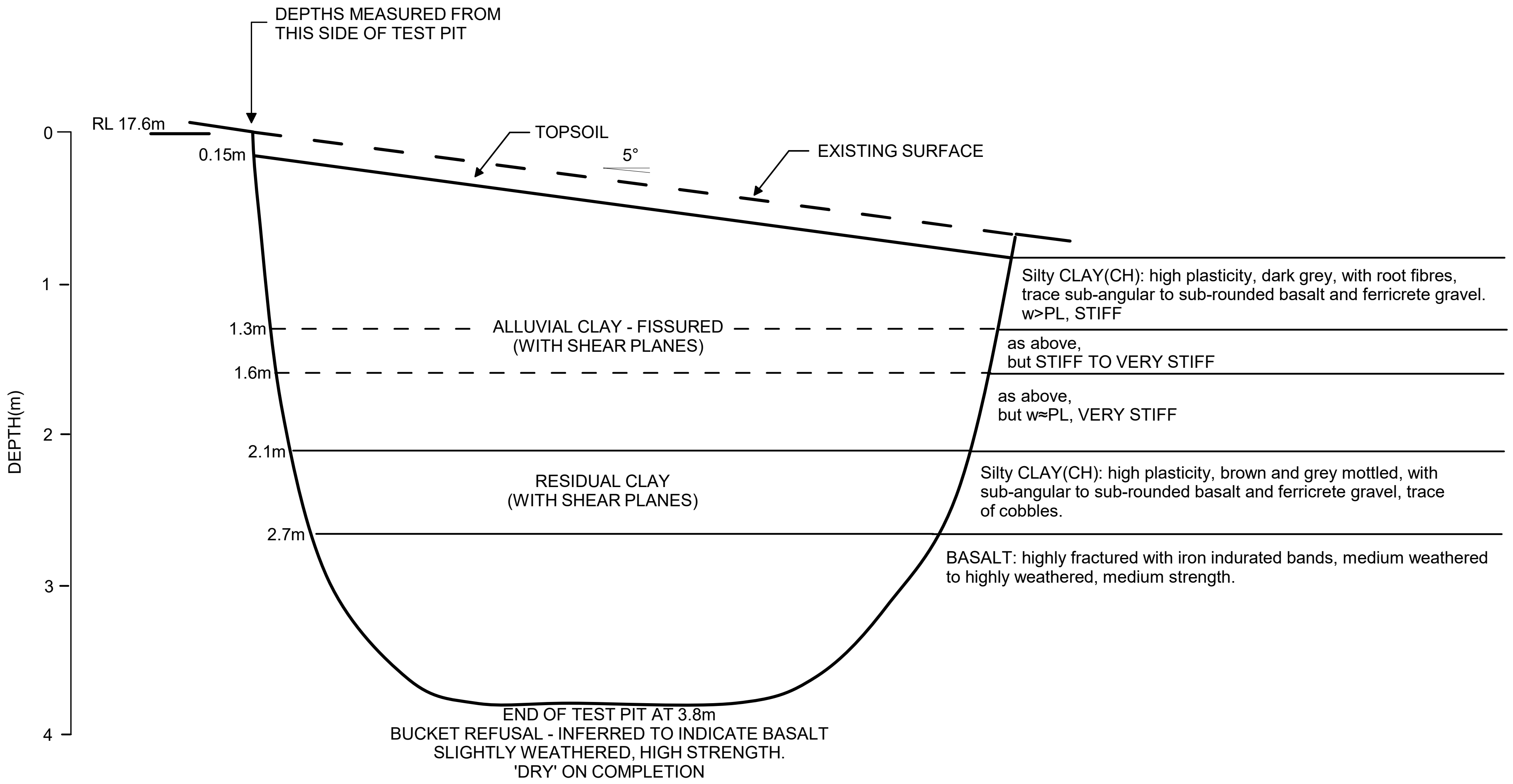


TEST PIT 120
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 31

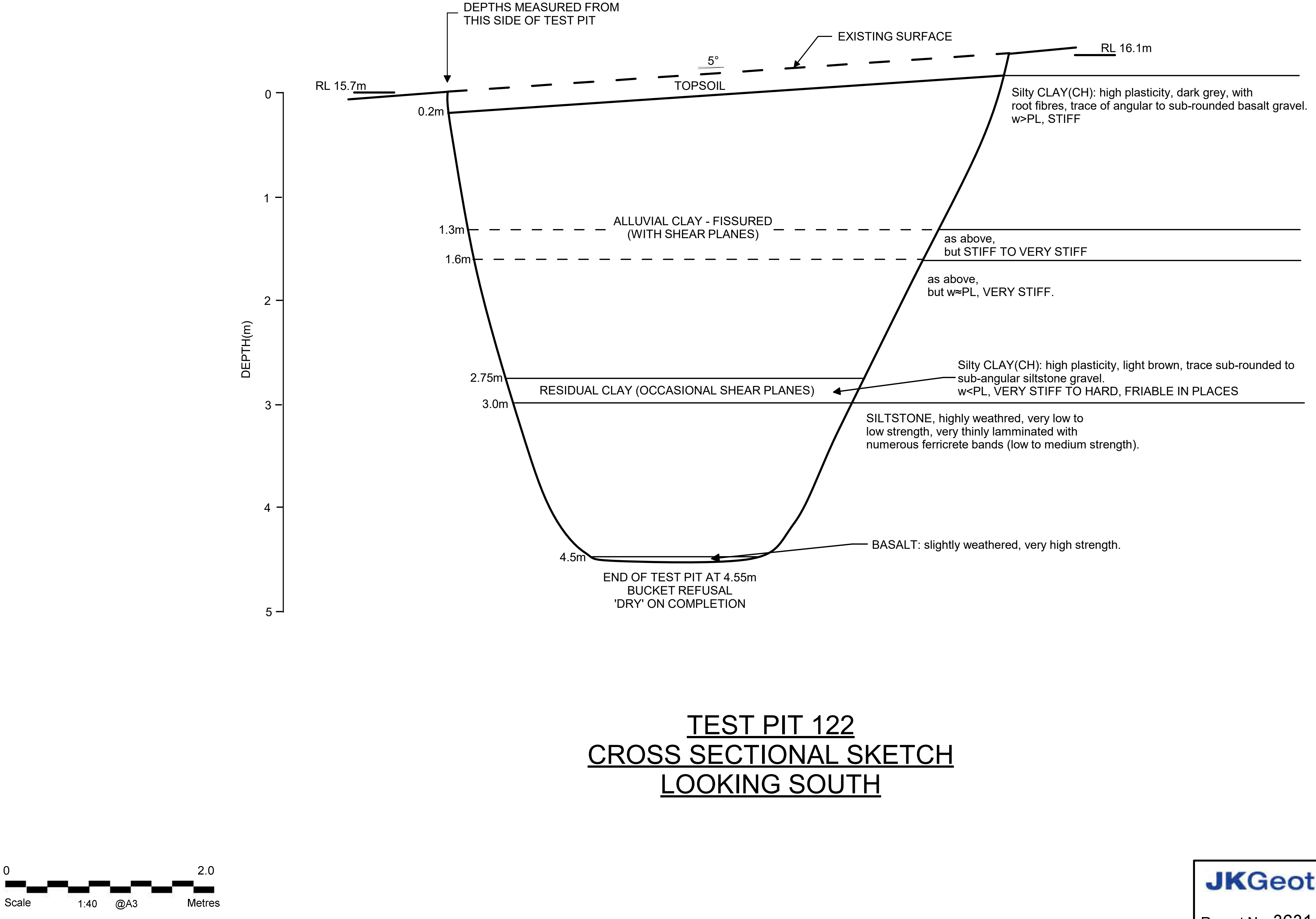


TEST PIT 121
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 32

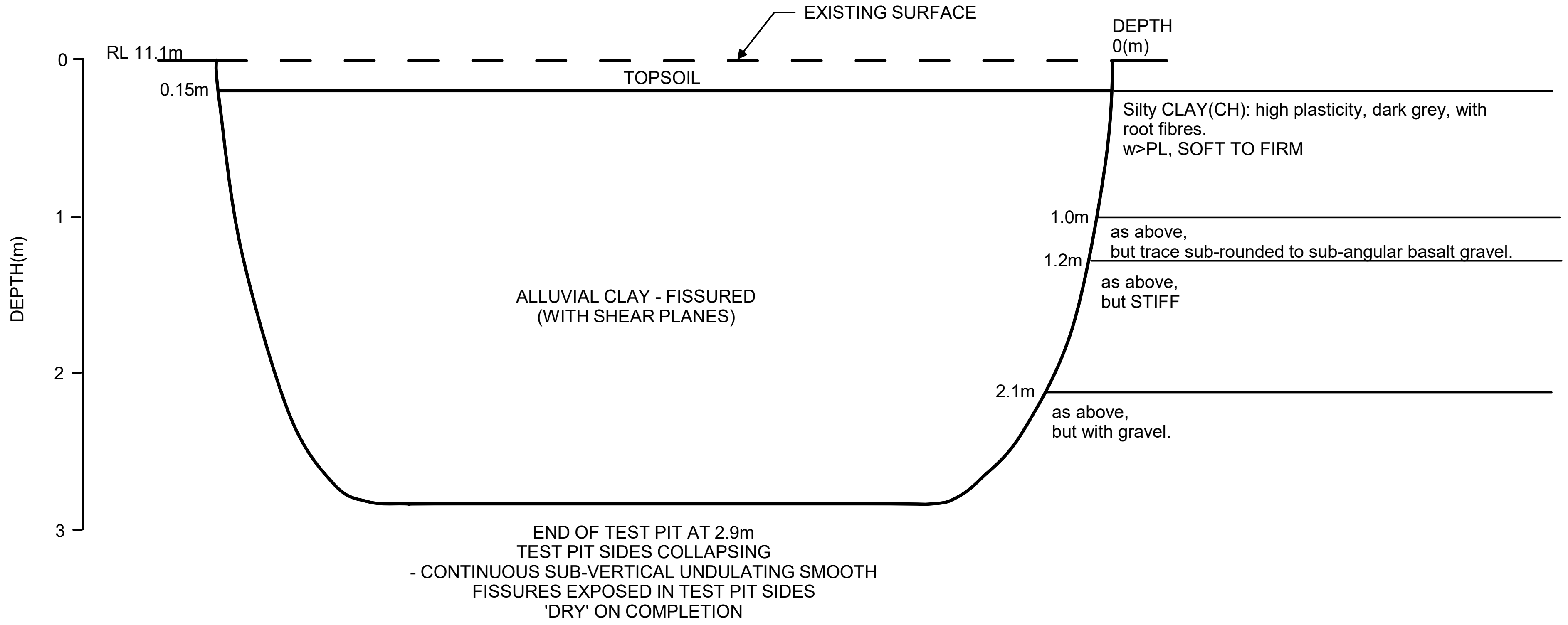


TEST PIT 122
CROSS SECTIONAL SKETCH
LOOKING SOUTH

JKGeotechnics

Report No. 36314LT

Figure No. 33



TEST PIT 123
CROSS SECTIONAL SKETCH
LOOKING NORTH

0 2.0
Scale 1:40 @A3 Metres

JKGeotechnics

Report No. 36314LT Figure No. 34

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 1726:2017 *'Geotechnical Site Investigations'*. 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 soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

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 (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

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

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	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 fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) is referred to as 'laminite'.

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 shrink-swell behaviour, 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 methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock 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 a large 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. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, 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 limited 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 cuttings. 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 assessed 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. 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, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, 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 NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom 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 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

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 63.5kg 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.

A modification to the SPT 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.

Cone Penetrometer Testing (CPT) and Interpretation: The cone penetrometer is sometimes referred to as a Dutch Cone. The test is described in Australian Standard 1289.6.5.1–1999 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Static Cone Penetration Resistance of a Soil – Field Test using a Mechanical and Electrical Cone or Friction-Cone Penetrometer'*.

In the tests, a 35mm or 44mm 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 a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm 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. The CPT does not provide soil sample recovery.

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. There are two scales presented for the cone resistance. The lower scale has a range of 0 to 5MPa and the main scale has a range of 0 to 50MPa. For cone resistance values less than 5MPa, the plot will appear on both scales.
- 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 CPT and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of CPT 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.

There are limitations when using the CPT in that it may not penetrate obstructions within any fill, thick layers of hard clay and very dense sand, gravel and weathered bedrock. Normally a 'dummy' cone is pushed through fill to protect the equipment. No information is recorded by the 'dummy' probe.

Flat Dilatometer Test: The flat dilatometer (DMT), also known as the Marchetti Dilometer comprises a stainless steel blade having a flat, circular steel membrane mounted flush on one side.

The blade is connected to a control unit at ground surface by a pneumatic-electrical tube running through the insertion rods. A gas tank, connected to the control unit by a pneumatic cable, supplies the gas pressure required to expand the membrane. The control unit is equipped with a pressure regulator, pressure gauges, an audio-visual signal and vent valves.

The blade is advanced into the ground using our CPT rig or one of our drilling rigs, and can be driven into the ground using an SPT hammer. As soon as the blade is in place, the membrane is inflated, and the pressure required to lift the membrane (approximately 0.1mm) is recorded. The pressure then required to lift the centre of the membrane by an additional 1mm is recorded. The membrane is then deflated before pushing to the next depth increment, usually 200mm down. The pressure readings are corrected for membrane stiffness.

The DMT is used to measure material index (I_D), horizontal stress index (K_D), and dilatometer modulus (E_D). Using established correlations, the DMT results can also be used to assess the 'at rest' earth pressure coefficient (K_o), over-consolidation ratio (OCR), undrained shear strength (C_u), friction angle (ϕ), coefficient of consolidation (C_h), coefficient of permeability (K_h), unit weight (γ), and vertical drained constrained modulus (M).

The seismic dilatometer (SDMT) is the combination of the DMT with an add-on seismic module for the measurement of shear wave velocity (V_s). Using established correlations, the SDMT results can also be used to assess the small strain modulus (G_o).

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod with a 20mm diameter cone end with a 9kg hammer dropping 510mm. The test is described in Australian Standard 1289.6.3.2–1997 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – 9kg Dynamic Cone Penetrometer Test'*.

The results are used to assess the relative compaction of fill, the relative density of granular soils, and the strength of cohesive soils. Using established correlations, the DCP test results can also be used to assess California Bearing Ratio (CBR).

Refusal of the DCP can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Vane Shear Test: The vane shear test is used to measure the undrained shear strength (C_u) of typically very soft to firm fine grained cohesive soils. The vane shear is normally performed in the bottom of a borehole, but can be completed from surface level, the bottom and sides of test pits, and on recovered undisturbed tube samples (when using a hand vane).

The vane comprises four rectangular blades arranged in the form of a cross on the end of a thin rod, which is coupled to the bottom of a drill rod string when used in a borehole. The size of the vane is dependent on the strength of the fine grained cohesive soils; that is, larger vanes are normally used for very low strength soils. For borehole testing, the size of the vane can be limited by the size of the casing that is used.

For testing inside a borehole, a device is used at the top of the casing, which suspends the vane and rods so that they do not sink under self-weight into the 'soft' soils beyond the depth at which the test is to be carried out. A calibrated torque head is used to rotate the rods and vane and to measure the resistance of the vane to rotation.

With the vane in position, torque is applied to cause rotation of the vane at a constant rate. A rate of 6° per minute is the common rotation rate. Rotation is continued until the soil is sheared and the maximum torque has been recorded. This value is then used to calculate the undrained shear strength. The vane is then rotated rapidly a number of times and the operation repeated until a constant torque reading is obtained. This torque value is used to calculate the remoulded shear strength. Where appropriate, friction on the vane rods is measured and taken into account in the shear strength calculation.

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 terms and symbols used in preparation of the logs are defined in the following pages.

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 reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised 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 assess 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 Soils for Engineering Purposes'* or appropriate NSW Government Roads & Maritime Services (RMS) test methods. 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.

Reasonable 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.
- Details of the development that the Company could not reasonably be expected to anticipate.

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 rather than at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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. Licence to use the documents may be revoked without notice if the Client is in breach of any obligation to make a payment to us.

REVIEW OF DESIGN

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

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:

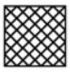
i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

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

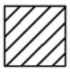
iii) full time engineering presence on site.

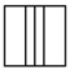
SYMBOL LEGENDS

SOIL

 FILL

 TOPSOIL

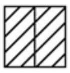
 CLAY (CL, CI, CH)

 SILT (ML, MH)

 SAND (SP, SW)

 GRAVEL (GP, GW)

 SANDY CLAY (CL, CI, CH)

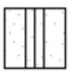
 SILTY CLAY (CL, CI, CH)

 CLAYEY SAND (SC)

 SILTY SAND (SM)

 GRAVELLY CLAY (CL, CI, CH)

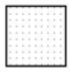
 CLAYEY GRAVEL (GC)

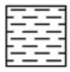
 SANDY SILT (ML, MH)

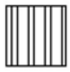
 PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

 CONGLOMERATE

 SANDSTONE

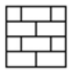
 SHALE/MUDSTONE

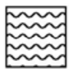
 SILTSTONE

 CLAYSTONE

 COAL

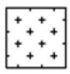
 LAMINITE

 LIMESTONE

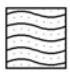
 PHYLLITE, SCHIST

 TUFF

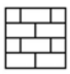
 GRANITE, GABBRO

 DOLERITE, DIORITE

 BASALT, ANDESITE

 QUARTZITE

OTHER MATERIALS

 BRICKS OR PAVERS

 CONCRETE

 ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

$$C_U = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

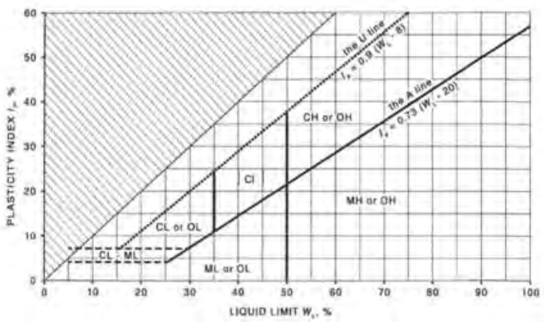
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

2 Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.

3 Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.

4 The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



LOG SYMBOLS

Log Column	Symbol	Definition
Groundwater Record	▼	Standing water level. Time delay following completion of drilling/excavation may be shown.
	C	Extent of borehole/test pit collapse shortly after drilling/excavation.
	►	Groundwater seepage into borehole or test pit noted during drilling or excavation.
Samples	ES U50 DB DS ASB ASS SAL	Sample taken over depth indicated, for environmental analysis. Undisturbed 50mm diameter tube sample taken over depth indicated. Bulk disturbed sample taken over depth indicated. Small disturbed bag sample taken over depth indicated. Soil sample taken over depth indicated, for asbestos analysis. Soil sample taken over depth indicated, for acid sulfate soil analysis. 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. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	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° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25 PID = 100	Vane shear reading in kPa of undrained shear strength. Photoionisation detector reading in ppm (soil sample headspace test).
Moisture Condition (Fine Grained Soils)	w > PL $w \approx$ PL w < PL $w \approx$ LL w > LL	Moisture content estimated to be greater than plastic limit. Moisture content estimated to be approximately equal to plastic limit. Moisture content estimated to be less than plastic limit. Moisture content estimated to be near liquid limit. Moisture content estimated to be wet of liquid limit.
(Coarse Grained Soils)	D M W	DRY – runs freely through fingers. MOIST – does not run freely but no free water visible on soil surface. WET – free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS S F St VSt Hd Fr ( )	VERY SOFT – unconfined compressive strength ≤ 25kPa. SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa. FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa. STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa. VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa. HARD – unconfined compressive strength > 400kPa. FRIABLE – strength not attainable, soil crumbles. Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.
Density Index/ Relative Density (Cohesionless Soils)	VL L MD D VD ( )	**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)** VERY LOOSE ≤ 15 / 0 – 4 LOOSE > 15 and ≤ 35 / 4 – 10 MEDIUM DENSE > 35 and ≤ 65 / 10 – 30 DENSE > 65 and ≤ 85 / 30 – 50 VERY DENSE > 85 / > 50 Bracketed symbol indicates estimated density based on ease of drilling or other assessment.
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.

Log Column	Symbol	Definition
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as:
		RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock.
		EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock.
		ALLUVIAL – soil deposited by creeks and rivers.
		ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents.
		MARINE – soil deposited in a marine environment.
		AEOLIAN – soil carried and deposited by wind.
		COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description 'slopewash' is used for thinner surficial deposits.
		LITTORAL – beach deposited soil.

Classification of Material Weathering

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered (Note 1)</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Guide to Strength	
			Point Load Strength Index $Is_{(50)}$ (MPa)	Field Assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Abbreviations Used in Defect Description

Cored Borehole Log Column		Symbol Abbreviation	Description
Point Load Strength Index		• 0.6	Axial point load strength index test result (MPa)
		x 0.6	Diametral point load strength index test result (MPa)
Defect Details	– Type	Be	Parting – bedding or cleavage
		CS	Clay seam
		Cr	Crushed/sheared seam or zone
		J	Joint
		Jh	Healed joint
		Ji	Incipient joint
		XWS	Extremely weathered seam
	– Orientation	Degrees	Defect orientation is measured relative to normal to the core axis (ie. relative to the horizontal for a vertical borehole)
	– Shape	P	Planar
		C	Curved
		Un	Undulating
		St	Stepped
		Ir	Irregular
	– Roughness	Vr	Very rough
		R	Rough
		S	Smooth
		Po	Polished
		Sl	Slickensided
	– Infill Material	Ca	Calcite
		Cb	Carbonaceous
		Clay	Clay
		Fe	Iron
		Qz	Quartz
		Py	Pyrite
	– Coatings	Cn	Clean
		Sn	Stained – no visible coating, surface is discoloured
		Vn	Veneer – visible, too thin to measure, may be patchy
		Ct	Coating ≤ 1mm thick
		Filled	Coating > 1mm thick
	– Thickness	mm.t	Defect thickness measured in millimetres