Hattah North SDL

Geotechnical Report

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Contents

Executive Summary

Jacobs have been engaged by Goulburn-Murray Water (GMW) to undertake detailed design for proposed environmental regulator structures in Murray-Kulkyne National Park. The Hattah Lakes wetland system is located within the Hattah-Kulkyne National Park, about 100 km south-east of Mildura. The system comprises approximately 20 lakes which receive water from the Murray River, via Chalka and Cantala Creek. Geotechnical investigations were undertaken at the location of the proposed K10 Regulator on the River Track, and a nearby borrow area which is proposed to supply earth fill for the project. The K10 regulator will control environmental flows within Chalka and Cantala Creeks. These works form part of the northern extension to the Hattah Lakes Water infrastructure project.

A geotechnical Investigation was undertaken at Chalka Creek at the proposed K10 regulator site, and at the nearby Kulkyne borrow site proposed to be the source of fill material for the structure, and nearby associated levees.

Ground conditions at the site were characterised by CPT testing, and generally comprise stiff desiccated clays and silty sands overlying fine to medium grained, relatively clean sand.

Geotechnical design parameters have been provided in this report for the site, along with a review of conditions at the borrow site. Borrow material is found to be moderately dispersive but otherwise suitable for embankment construction, assuming it is adequately moisture conditioned. The Kulkyne borrow area is also expected to provide a suitable source of sand for filter zones. Borrow material at the existing Bitterang borrow site is also considered acceptable for use in the augmentation of the adjacent Bitterang levees.

The geometry proposed at concept design stage is considered to be acceptable from a seepage point of view. Sheet pile cut-offs are recommended to extend to 20m either side of the structure with a reworked clay cut-off used beyond the sheet-pile.

Important note about your report

It is important that the user of this report be aware of the limitations associated with the data presented. Guidance on these limitations is presented in this section.

The information presented in this report is considered appropriate to assist in the detailed design for the proposed regulator structure at Hattah Lakes. It should be noted that the information may not be appropriate for other uses.

The data presented in this report is based on the site specific data available. The information in this report is therefore based on limited data, and should not be extrapolated to any location or depth which is not specifically addressed in the report. All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the available information. No study can completely eliminate risk, and even a rigorous assessment and/or sampling program may not detect all problem areas within a site.

The content of this report is based solely upon the Jacobs agreed scope of work for technical services to GMW. Jacobs has not performed any additional work not specifically set out or required under the scope of work, and is therefore not liable for the existence of any condition the discovery of which would have required the performance of such additional work.

Unless specifically so stated in this report, Jacobs has not attempted to independently verify the accuracy or completeness of any information received from the Client or third parties during the performance of the Services, and cannot therefore be liable for any inaccuracies or incompleteness in any such information.

The Services in this project have been performed by Jacobs with the skill and care ordinarily exercised by a reasonable geotechnical specialist, in particular, taking into account the limits of the Scope of Work requested by the Client, the timescale involved and the resources, including financial and manpower resources, agreed between Jacobs and the Client.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

1. Introduction

Jacobs have been engaged by Goulburn-Murray Water (GMW) to undertake detailed design for proposed environmental regulator structures in Murray-Kulkyne National Park. The Hattah Lakes wetland system is located within the Hattah-Kulkyne National Park, about 100 km south-east of Mildura. The system comprises approximately 20 lakes which receive water from the Murray River, via Chalka and Cantala Creek. Geotechnical investigations were undertaken at the location of the proposed K10 Regulator on the River Track, and a nearby borrow area which is proposed to supply earth fill for the project. The K10 regulator will control environmental flows within Chalka and Cantala Creeks. These works form part of the northern extension to the Hattah Lakes Water infrastructure project.

Jacobs undertook a field investigation on November 8 and 9th, 2015 which included the excavation of 11 test pits at the Kulkyne borrow site and 5 Cone Penetration Tests (CPTu) at the K10 Regulator site.

This investigation supplemented previous works undertaken at Advanced Concept stage by GHD. In addition, previous works completed by GHD at Bitterang Levee have been reviewed to inform the augmentation of the existing structure at that site. The purpose of this report is to document the findings of the geotechnical investigation and to summarise geotechnical advice associated with the proposed regulator structure.

2. Site Description

The location of the K10 Regulator site and borrow area can be seen in the site map in **Figure 1**. The boundaries of Chalka Creek across which the K10 Regulator will be constructed were evident at the time of the investigation, but the creek itself was dry. The Kulkyne borrow area is located on private property south of the proposed regulator site. The Bitterang levee is located further south.

The site is located within an extensive alluvial plane associated with the Hattah lakes system and nearby Murray River. The terrain is gently undulating with low lying areas generally comprising alluvial deposits, and higher elevations comprising sand dunes which are stabilised by vegetation growth. Vegetation comprises grasses, small shrubs and trees. At the time of the investigation, the terrain was dry and no water was present in the creek. The nearest standing water was several kilometres away. **Photo 1** and **Photo 2** illustrate the conditions at the site.

Photo 1: K10 regulator location

Photo 2: Borrow area

Lake Bitterang is located further south, and is fed predominantly by flows from Chalka Creek North. The Bitterang Levee is located north of Lake Bitterang, and is used to control inundation to the surrounding area. The levee is to be widened, and culvert-style regulators added. Extensive investigations have been previously undertaken at Bitterang (GHD, 2009), and these form the basis for assessments discussed in this report.

3. Geological Setting

3.1 Regional Geology

The geology of the project area comprises Aeolian and fluvially deposited sediment associated with the Murray River and its billabongs and tributaries. The Geological Survey of Victoria, Mildura Map Sheet (1:250 000 scale) describes the surface geology within the site. An extract from the Mildura Map sheet is shown (not to scale) in **Figure 3.1** below, and shows the approximate extent of the site.

The area is overlain by various Quarternary aged deposits, namely:

- Coonambidgal Formation (Qc): Fluvial, lacustrine deposts, clay, sand and sandy clays
- Lowan Formation (Ql): Aeolian: dune sand, fine to medium grained
- Blanchetown Clay (Qb): Fluvial: clayey sand, sandstone and sand.

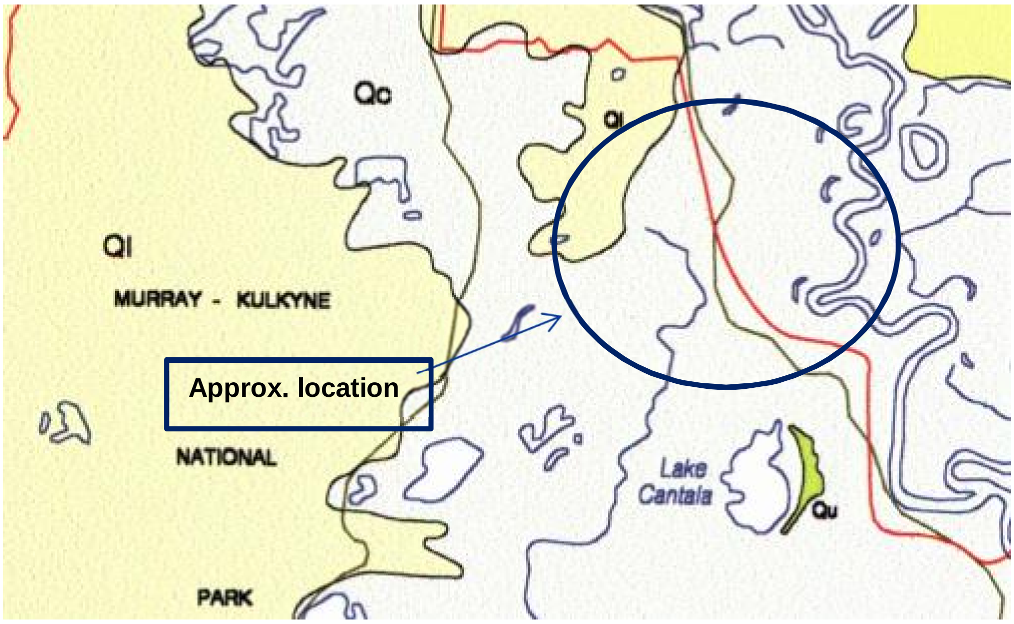


Figure 3.1 : Extract from Geological Map of Mildura (Geological Survey of Victoria, 1997)

The findings of the field investigation are consistent with the expected geology.

3.2 Previous Studies

Previous geotechnical investigations were conducted by GHD to assess foundation conditions at the proposed sites. At the site of the K10 regulator, the GHD report dated February 2015 details the site walkover and geotechnical investigation which included the drilling of 2 boreholes to a depth of approximately 15m at the K10 Regulator structure, 9 shallow solid flight augers (up to 3.95m deep) at selected locations spread across the proposed regulator, causeway and embankment locations, 4 CPT tests at four locations along the alignment of the K10 regulator, and DCP and SPT testing as part of the drilling and excavation.

The report interprets the results of the investigation and summarises the ground profile in the area. The conditions at the K10 Regulator site generally comprise:

- **Fill** at surface, generally consisting of gravelly material (noting that boreholes were drilled through the existing unsealed roadway); overlying
- **Medium to high plasticity clay** with interbedded minor sand and fine gravel component, of a stiff to hard consistency and dry to moist condition to a depth of approximately 3 to 4m; overlying
- **Loose to medium dense sand** within traces of silt and gravel to a depth of between 11.6 and 13m; overlying
- **Stiff clay and clay with sand** to depths of greater than 20m below ground level.

The report provides recommendations of parameters for use in design, as well as design recommendations for foundation options and sheet pile wall cut-off in regards to the seepage underneath the regulator. The report also provides recommendations on settlements and commentary around the characteristics of the borrow material, noting that it is likely to be dispersive. The recommendations made by GHD have been reviewed and taken into consideration in this report.

At Bitterang, investigation works undertaken by GHD in April 2009 comprised 8 test pits along the extent of the levee. The report identifies sandy clay and clayey sands to a depth of up to 4.2m below natural ground level. Works undertaken in 2010 by GHD describe the borrow material at the site (which was ultimately used in the levee's construction) as comprising similar material to the founding strata of the levee itself.

3.3 Seismic Hazard

Reference to Australian Standard AS1170.4 indicates that the site is located in an area of low seismicity, with a site hazard factor (Z) of 0.03, and a site classification of C_e. Seismicity is not expected to govern design.

4. Subsurface Conditions

4.1 General

Subsurface conditions at the K10 regulator site and nearby Kulkyne borrow are described in Sections 4.2 to 4.4, below. Subsurface conditions at Bitterang are described in Section 3, based on reports by GHD.

4.2 Field Investigation

The geotechnical investigation was carried out on the 8th and 9th of November, 2015. Eleven (11) test pits were excavated at the borrow site. Five (5) CPTu tests were performed at the K10 Regulator Site. A sample was obtained at CPTu location J1 at a depth of 4 to 4.5m using a Vertek sampler. **Table 4.1** provides a summary of the test pits and CPTs conducted during the field investigation. An interpretative long section through the K10 regulator site is provided in **Appendix A** and includes relevant CPT data from both the recent Jacobs investigation and the previous GHD investigation. A site plan showing the location of test pits excavated at the borrow area is included in **Figure 2.** **Figure 2** has been annotated with the approximate thicknesses of suitable borrow material at each test location. Test pit and CPTu logs are provided in **Appendix B.** Further details for each location are provided in **Section 4.2** and **Section 4.3**.

Test locations have been assessed using a hand-held GPS device at the time of testing, with nominal accuracy of +/- 10m. Surface elevations have been estimated from existing survey data. No surface elevation data is available at the borrow site.

Table 4.1 : Summary of test pits and CPTs conducted during the geotechnical investigation

Hole ID	Easting	Northing	Inferred Surface RL (mAHD)	Termination depth (m bgl)
K10 Regulator Site				
J-CPT1	630784	6170271	39.9	15.4
J-CPT2	630790	6170257	40.15	8.7
J-CPT3	630798	6170241	40.5	20.4
J-CPT4	630791	6170286	40.7	17.35
J-CPT5	630777	6170308	42.1	21.35
Borrow Area				
J-TP1	632744	6168968	N/A	2.9
J-TP2	632782	6168971		3.0
J-TP3	632836	6168988		3.0
J-TP4	632846	6168904		3.0
J-TP5	632909	6169054		2.9
J-TP6	632809	6169039		3.2
J-TP7	632725	6169025		3.0
J-TP8	632669	6168849		3.2
JTP9	632825	6168680		3.15
J-TP10	632629	6168951		3.2
J-TP11	632313	6168944		1.3

4.3 K10 Regulator Site

Ground conditions at the K10 regulator site are illustrated in the long section provided in **Appendix A**. In general, ground conditions comprise:

Unit 1: Dry, very dense **Clayey Sand and Sandy Clay** of low to intermediate plasticity at the surface, typically fissured and with negligible top soil thickness; overlying

Unit 2: Very stiff and dry **Clay with interbedded dense sand** of low plasticity; overlying

Unit 3: Medium Dense to Dense **Sand**, fine to medium grained, sub-rounded to sub-angular; overlying

Unit 4: Stiff to Very Stiff **Silty Clay**.

The depths of each unit type are summarised in **Table 4.2** below. A Vertek sample of the Unit 3 sand material was obtained at CPT J-1, in the middle of the creek-bed, at a depth of approximately 4 to 4.5m below ground surface level. A photograph of this sample is provided in **Figure 4.2**, giving an indication of its composition. A dissipation test in this material was attempted by could not be undertaken due to the rapid draining of pore water pressure around the CPT cone, which suggests that this layer is of very high permeability (and can therefore be assumed to be free-draining for the purposes of geotechnical strength and stiffness assessments). A subsequent dissipation test was attempted at 7.0m depth in Unit 4. This test ran for approximately 2 hours with less than 25% excess pore water pressure dissipation during this time, which suggests a very low permeability of this material. The permeability observations are consistent with the inferred sandy and clayey nature of these two units respectively.

Table 4.2 : Summary of units and depths encountered – K10 Regulator site

Unit	Material type	Depths Encountered in each CPT (mbgl)				
		J1	J2	J3	J4	J5
1	Clayey Sand / Sandy Clay	0 to 1	0 to 0.5	0 to 1	0 to 0.5	0 to 1.5
2a	Very stiff Sand/very stiff Clayey Sand	1 to 2	0.5 to 2	1 to 2	0.5 to 1.5	1.5 to 2.5
2b	Very stiff clay to stiff silty clay	2 to 3	2 to 3	2 to 3	1.5 to 3	2.5 to 3
3	Medium dense to dense sand	3 to 9	3 to 10	3 to 10	3 to 10	3 to 12
4	Stiff to very stiff clay	9 to 14	N/A	10 to 20	10 to 15	12 to 17

N/A – not applicable – unit not encountered

Photo3: Vertek sample taken from CPT J1, 4.0 to 4.5m bgl

4.4 Kulkyne Borrow Area

The borrow area, directly south of the K10 regulator site, has previously been used to supply fill material for the construction of nearby structures. Test pits were excavated immediately north and to the west of the footprint of the previously disturbed borrow. The ground conditions at the site generally comprised:

Unit 1: Dark brown and dark grey **Silty Clay** of low to intermediate plasticity; overlying

Unit 2: Light brown and orange-brown **Silty Clay** of low plasticity; overlying

Unit 3: Pale brown **Sand**, fine grained, with some silt.

The depths at which these units were encountered are summarised in **Table 4.3**. A marker layer of weakly cemented sand, up to 200mm thick, exists at the interface between Unit 2 and Unit 3. This band was generally difficult to excavate through.

No groundwater was encountered in any of the excavated test pits.

Test Pit J11 was excavated within the footprint of the previously disturbed and backfilled borrow area, to ascertain the material which has been placed there. The **FILL** material in this area generally comprised a mix of fine grained, pale grey and light brown sands, and low plasticity silts and clays, and is generally considered to be unsuitable for reuse in levee or regulator construction. It is likely this material is waste-spoil excavated from river banks for other nearby regulators built using borrow material from Kulkyne.

Table 4.3 : Summary of Units and depths encountered – Borrow area

Unit	Depths encountered (mbgl)
1	0 to 1.0
2	0.5 to 3.2
3	Below 2.2 m

4.5 Groundwater

At the K10 regulator site, groundwater levels were inferred from observed u_2 pore pressure readings taken from the CPT tests. These were then validated by hand measurement of the water level in the CPT hole at the completion of the test. Ground water levels were observed to be approximately **5m** below natural ground level. Owing to the desiccated and fissured nature of the surface clays, it is reasonable to assume that when the area is in flood, the groundwater table will be hydraulically connected to surface water, and therefore effectively at ground surface level. A high degree of variability in the groundwater table during the design life of the regulator can therefore be assumed.

No groundwater was encountered in any of the test pits at the borrow site.

5. Laboratory Testing

5.1 General

Samples from the Kulkyne borrow area investigation were consigned for laboratory testing by Civil Geotechnical Services (CGS) based in Croydon, Victoria. **Table 5.1** summarises the results of the laboratory testing, and further discussion is provided in subsequent sections below. Test certificates are provided in **Appendix C**.

Table 5.1 : Summary of Laboratory Test Results

Test Pit	Depth	Natural Moisture Content	Liq. Limit	Pl Limit	PI	Linear Shrinkage	Clay	Silt	Emerson Class	Std Max Dry Density	Opt. Moisture Content
	(m)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(-)	(t/m^3)	(%)
J-TP1	1.6	11.3	38	19	19	9	26	62.5	2		17.0
J-TP1	2.9	4.9	24	21	3	1	4.5	36.7	3		
JTP-2	2.9	5.9	25	22	3	1				1.54	
JTP-3	1.2	16.9	55	21	34	15	42.9	42.1	3	1.68	
J-TP4	1.2	19	46	21	25	12	37.8	53.9			20
JTP-6	3.2	14.4	35	21	14	7.5	20.3	56	2	1.55	
JTP-8	0.6-1.6	11.7	35	18	17	9					15.5

5.2 Moisture Content and Atterberg Limits

Figure 3 presents a plot of moisture content and Atterberg Limit versus depth at the borrow site, and **Figure 4** presents a Casagrande Chart showing the plasticity of the data. Figure 3 also shows the measured optimum moisture content available for the site, relative to the natural moisture content. It can be seen from these figures that the available soils in Unit 2 at the site are generally of low to medium plasticity, and are within the recommended Plasticity Index and Liquid Limit bounds recommended by Fell (2005). Figure 3 does however suggest that the soil in its natural state is significantly dry of optimum, by up to 5%. This is consistent with GHD's earlier findings (GHD, 2014; GHD, 2010).

5.3 Dispersivity

Emerson class dispersivity testing indicates a classification of 2 or 3 for the borrow soil in distilled water. Unfortunately it was not possible to test in river water given that Chalka creek was dry at the time of sampling. These test results suggest the material is moderately dispersive, but may be used as fill material provided it is carefully compacted and treated. The relatively high silt contents of the material validate the Emerson Class values obtained.

6. Summary of Geotechnical Design Parameters

Table 6.1 summarises inferred geotechnical design parameters for the natural, in situ material at the K10 regulator site. These parameters are based on interpretation of the CPT results using the methods described by Robertson et al (2012).

Table 6.1 : Summary of preliminary design parameters

Unit	Bulk unit weight (kN/m^3)	Effective cohesion, c' (kPa)	Effective angle of internal friction, f' (deg)	Undrained shear strength, s_u (kPa)	Effective modulus of elasticity, E' (kPa)
1	18	0	37	N/A	11,200
2a	17	0	N/A	80	17,700
2b	17	0	33	N/A	28,900
3	18	0	40	N/A	54,500
4	17	0	N/A	70	34,400

7. Discussion and Recommendations

7.1 K10 Regulator Site - Seepage

The surficial clays and silty sands (Units 1, 2a, 2b) at the site are expected to be permeable due to the presence of desiccation cracking and gilgai features at the surface. These surficial clays will tend to percolate water downwards when flooded, and will soften slightly on wetting due to swelling of the clay. This softened strength has been taken into account in the design parameters nominated in **Section 6**. Groundwater levels at the time of investigation were approximately 5m below ground level. Given the permeability of the ground, it is reasonable to assume that the groundwater will be hydraulically connected to the nearby river and any surface water in Chalka Creek. For design purposes, groundwater at surface level should be assumed.

An assessment of seepage beneath the regulator has been made using the Weighted Creep Method (Lane, 1935). Results are summarised in **Table 7.1**. The assessment assumes a central sheet pile cut-off extending 4.5m below the base of the structure, and an upstream and downstream sheet pile cut-off to 3.0m below structure invert.

Table 7.1 : Lane's Weighted Creep – summary of preliminary seepage assessment

Analysis Case	Description	Critical Head assumed (m)	Weighted Creep Ratio (c_w)
1	Flow around central cutoff only	2.72	7.7
2	Flow around all three cutoffs (Centre cutoff at 4.5m depth, u/s and d/s cut offs at 3m depth	2.72	12.2
3	Minimum head height for no cutoff	0.75	8.5
4	Intermediate height embankment – 1.5m	1.5	9.9

The values presented in **Table 7.1** may be compared with a critical creep ratio (c_w) of 8.5 recommended by Lane for silty sands and clays, and a value of 6.0 for medium to coarse sands. The subgrade profile at the site comprises interbedded sands and clays near the contact with the structure, and therefore the actual critical c_w value is likely to be in between these two values. The results suggest that if only a central cut-off is provided, the creep ratios would be marginal. In this scenario, a deeper cut off may need to be provided OR the embankment should be widened.

The analysis also suggests that no sheet pile cut-off needs be provided when the retained water height on the upstream side of the K10 regulator is less than **0.75m**. This critical depth should be considered when assessing the lateral extent of sheet piles at the site; for piping control purposes, the sheet piles will not be required when the upstream ponded water height is below this threshold depth.

It is noted that CPT J1 refused at a relatively shallow depth of 8.7m below ground level, within Unit 3. Some earlier GHD CPTs also refused at relatively shallow depths, within a few metres of the natural ground surface. It is likely that refusal occurred in the cemented sand material identified at the borrow site, which occurred within 3m of the surface. As a general rule of thumb, any ground which causes refusal of the CPT cone is likely to result in difficult driving of sheet piles, and therefore there is a risk that isolated sheets may refuse at a shallower depth than design.

Shallow refusal of sheetpiles would need to be assessed during the construction phase on a case by case basis, as it will depend on the quantity of sheets and the extent to which they have refused prematurely.

7.2 Geometry of levee and extent of cut-offs

The geometry and cut-off depths proposed in the concept design appear are considered to be reasonable to provide adequate stability and seepage resistance for the proposed structure. Given the strength of the underlying soil, the proposed 3H:1V batters are considered by inspection to be stable for the global slope stability of the structure and levees. Lane's method assumes that horizontal flow paths have 1/3 of the effectiveness of vertical flow paths in resisting seepage and piping, and therefore consideration was given to reducing the depth of the cut-off sheet piles. For every one metre in which the sheet piles are shortened, the embankment would need to be widened by a minimum of 3m at its base. Notwithstanding this, the cut offs would still need to extend at least to the base of the desiccated surface clay layer (ie 3m below ground level).

Provided that the embankment material is placed as discussed in **Section 7.3**, and filter zones are included in the embankment as described in **Section 7.4**, sheet piles extending to the full height of the structure are not considered to be mandatory for the structure to function adequately. However given that the regulator may go for several years between inundation events, and is therefore subject to extended dry periods which may increase the likelihood of desiccation cracking around the structure, extended sheetpiles to above the full service level of the regulator have been incorporated into the design as an additional safety measure.

The concept design recommends that sheet piles extend under the levee 20m either side of the regulator structure itself. Jacobs agree with this recommendation. Beyond this zone, a clay cut-off formed by digging a trench to minimum 1m depth and reworking and recompacting the existing clay to remove any fissures or gilgai features is considered sufficient. This approach is considered valid since away from the structure, (where Lane's method no longer applies) hydraulic gradients are less than 0.1, assuming horizontal flow along the base of the levee. The greatest seepage risk is therefore associated with water percolating into the foundation materials via dessication cracks or sandy zones in the surficial clays. The provision of a compacted clay cut-off beneath the levee (along with the filters proposed in Section 7.4) is therefore considered to be sufficient.

7.3 Fill selection and placement

7.3.1 K10 Regulator

The Kulkyne borrow area is assumed to be the preferred source of material for the K10 regulator and associated levee construction works. Material described as "Unit 2" at the borrow area is considered suitable for use as general impermeable fill for the regulator and levee structure. The approximate thickness of this material is shown for each test pit on **Figure 2**. The material has an average thickness of approximately 2.1m in the northern part of the borrow site, and 2.3m in the western part. Assuming typical bulking factors, the approximate volume of available borrow material can be estimated depending on the extents of the borrow available at the time of construction. In excess of 100,000m^3 of suitable material is expected to be available at the site.

Fill material should be placed at a moisture content of between Optimum and 3% wet of optimum moisture content, and compacted to 98% standard maximum dry density. This level of moisture content and density will minimise the risk of dispersion of the material, as recommended by Fell et al, 2005.

Scour protection is recommended at both the upstream and downstream toe of the levee in the vicinity of the regulator structure itself. Gabions are recommended, as they are easy to construct and shape to suit the local topography and geometry of the structure. In particular, at the downstream toe where pore pressure relief for the downstream filter zone is required, gabions are expected to provide a better solution to tie in than the use of riprap, which may also require a coarsely graded filter for transition.

It is noted that Unit 2 material at the borrow site is up to 5% dry of optimum moisture content and will therefore require significant moisture conditioning before placement. It is not known how much groundwater levels fluctuate at the borrow site over the course of the year, and depending on when the borrow material is excavated, may be wetter or drier than noted in this report. A field wetting trial is therefore recommended at the commencement of construction to optimise the moisture conditioning process.

7.3.2 Bitterang Levee

For augmentation of the Bitterang Levee, material sourced from the existing Bitterang borrow area as described by GHD (2010) is considered to be acceptable for use in the currently proposed phase of works. GHD note that the plasticity index (PI) of this material is slightly lower than what is normally considered acceptable for water retaining embankments however is acceptable given the relatively low height of the structure. Jacobs agree and consider this material to be acceptable for augmentation works for the levee for the following reasons:

- The material was used for the existing Bitterang Levee, which appears to have had acceptable performance to-date;
- For widening of water-retaining embankments, it is generally preferable to adopt material with similar linear shrinkage characteristics as the original embankment, to ensure shrink-swell and strain compatibility between old and new fills.

7.4 Filter zones

Sand filters are recommended at the following locations in the embankments:

- A filter drain should be provided at the downstream toe to control the phreatic surface through the embankment;
- At the regulator structure-embankment interface (minimum 0.5m wide) extending the full height of the embankment, if sheet piles are terminated at foundation level;
- Beneath any revetment adjacent to the regulator structure on the upstream face.

If full-height sheet piles are incorporated into the design, then filter zones alongside the structure-embankment interface may be omitted, as the sheet piles will provide a physical barrier to seepage and piping.

A recommended filter envelope is provided in **Figure 5**, which has been designed to be compatible with the grading curves of the Unit 2 borrow material which are also shown in the figure. This filter envelope is consistent with that nominated by GHD for other nearby regulators, including Messengers and Oatey's. Also shown in the figure is a reference grading curve from filter sand used for the construction of the earlier regulators (GHD, 2010). This material is therefore considered suitable for use as filter sand for the K10 structure.

7.5 Bearing Capacity

The 4m high regulator structure, together with live load surcharge is expected to result in a bearing pressure of 100 to 150kPa under ultimate limit state conditions. The very stiff surface clays underlain by medium dense to dense sands suggests a bearing capacity in excess of 200kPa will be achievable at the site. Settlement is expected to be negligible and will be 'built out' during the construction phase.

Foundation conditions at Bitterang comprise very stiff clays and dense sands. These ground conditions are similarly expected to provide suitable bearing capacity for the proposed levee augmentation.

8. Summary and Conclusions

A geotechnical Investigation was undertaken at Chalka Creek at the proposed K10 regulator site, and at the nearby Kulkyne borrow site proposed to be the source of fill material for the structure, and nearby associated levees.

Ground conditions at the site were characterised by CPT testing, and generally comprise stiff desiccated clays and silty sands overlying fine to medium grained, relatively clean sand.

Geotechnical design parameters have been provided in this report for the site, along with a review of conditions at the borrow site. Borrow material is found to be moderately dispersive but otherwise suitable for embankment construction, assuming it is adequately moisture conditioned. Borrow material at the existing Bitterang borrow site is also considered acceptable for use in the augmentation of the adjacent Bitterang levees.

The geometry proposed at concept design stage is considered to be acceptable from a seepage point of view. Sheet pile cut-offs are recommended to extend to 20m either side of the structure with a reworked clay cut-off used beyond the sheet-pile.

A seepage assessment using the Weighted Creep Method by Lane (1935) has been undertaken and results suggest that if a central cut-off is provided under the structure, the result is likely to be satisfactory. A cut-off is necessary for any water depths in excess of 0.75m. Sand filters are recommended at the downstream toe of the structure, and at the structure embankment interface. Sand sourced from the Kulkyne borrow area is considered to be appropriate for use in the proposed filter zones.

9. References

- Fell R, MacGregor P, Stapledon D, Bell G (2005), Geotechnical Engineering of Dams, Taylor & Francis Group, London.

- Geological Survey of Victoria (1997), 1:250,000 Mildura Map sheet.

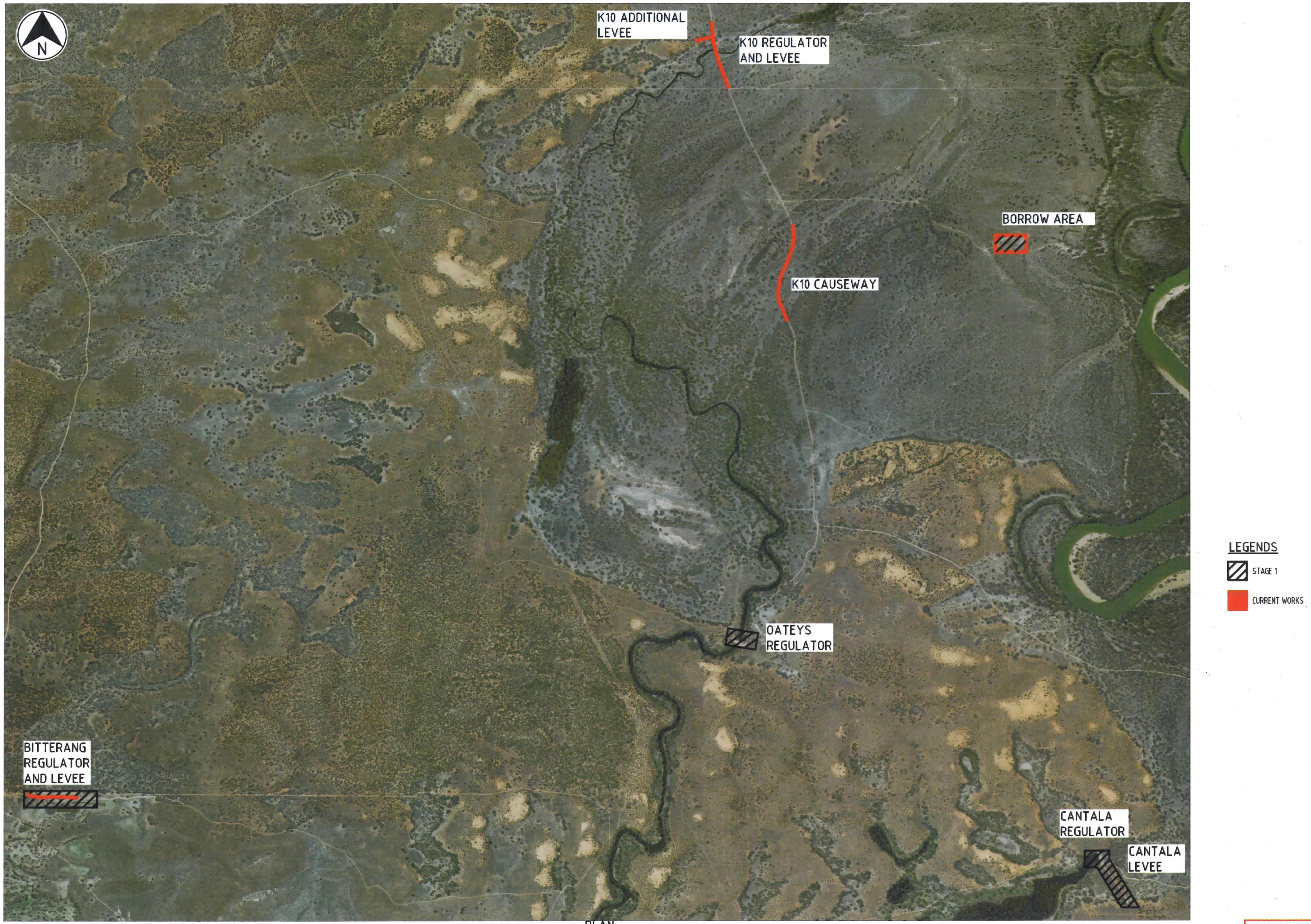
- GHD (2014), Report for Mallee Catchment Authority, Hattah Lakes SDL Adjustment Supply Measures – Geotechnical Investigation

- GHD (2010), Report for Goublurn Murray Water, Hattah Lakes Floodplain Management Project, Hattah Lakes Borrow Pit Assessment, GHD report ref. 31/21413/188158

- GHD (2009), Report for Goulburn Murray Water, Hattah Lakes Flood Management Project – Geotechnical Investigations Report, GHD report ref. 31/21413/165795

- Lane, EW (1935) “Security from under-seepage – masonary dams on earth foundations”, Trans. ASCE, 100, pp. 1235-1351.

Figures



PLAN
SCALE NTS

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
B			KM		ISSUED FOR APPROVAL
A	18/02/16		KM		ISSUED FOR REVIEW - 85%

REV.	PLAN NO.	REFERENCE PLAN TITLE

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Job No: IS129400

GOULBURN-MURRAY WATER
MANAGER ASSETS SERVICE

DETAILED DESIGN OF HATTAH NORTH SDL INFRASTRUCTURE
LOCATION OF WORKS

FIGURE 1

GMW CORR. NO.

GOULBURN MURRAY RURAL WATER AUTHORITY
40 CASEY STREET (PO BOX 165), TATURA VIC. 3616
Telephone (03) 5833 5500 Fax (03) 5833 5501

CAD DRAWING INDEX
SHEET NUMBER OF
DRAWING NUMBER 487513-0002
REVISION B

A1

BOREHOLE COORDINATE TABLE

BORROW PIT		
HOLE ID	EASTING	NORTHING
J TP1	632744	6168968
J-TP2	632836	6168986
J-TP3	632878	6168994
J-TP4	632932	6169004
J-TP5	632909	6169054
J-TP6	632809	6169039
J-TP7	632725	6169025
J-TP8	632669	6168849
J-TP9	632743	6168747
J-TP10	632658	6168907
J-TP11	632813	6168917

NOTE:
COORDINATES ARE APPROXIMATE ONLY AND BASED ON HAND-HELD GPS AND ON-SITE MEASUREMENTS.

LEGENDS

✚ TEST PIT - JACOBS

PLAN

SCALE 1:1000

SCALE 1:1000 (A1) 20 10 0 20 40 60 80 100m

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
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A	18/02/16		KM		ISSUED FOR REVIEW - 85%

REV.	PLAN NO.	REFERENCE PLAN TITLE

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PROJECT DIRECTOR

GOULBURN-MURRAY WATER

MANAGER ASSETS SERVICE

DETAILED DESIGN OF HATTAH NORTH SDL INFRASTRUCTURE

GEOTECHNICAL INVESTIGATION PLAN

KULKYNE BORROW AREA

FIGURE 2

GMW CORR. NO.

GOULBURN MURRAY RURAL WATER AUTHORITY
40 CASEY STREET (PO BOX 165), TATURA VIC. 3616
Telephone (03) 5833 5500 Fax (03) 5833 5501

CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
	OF	487513-0006	B

A1

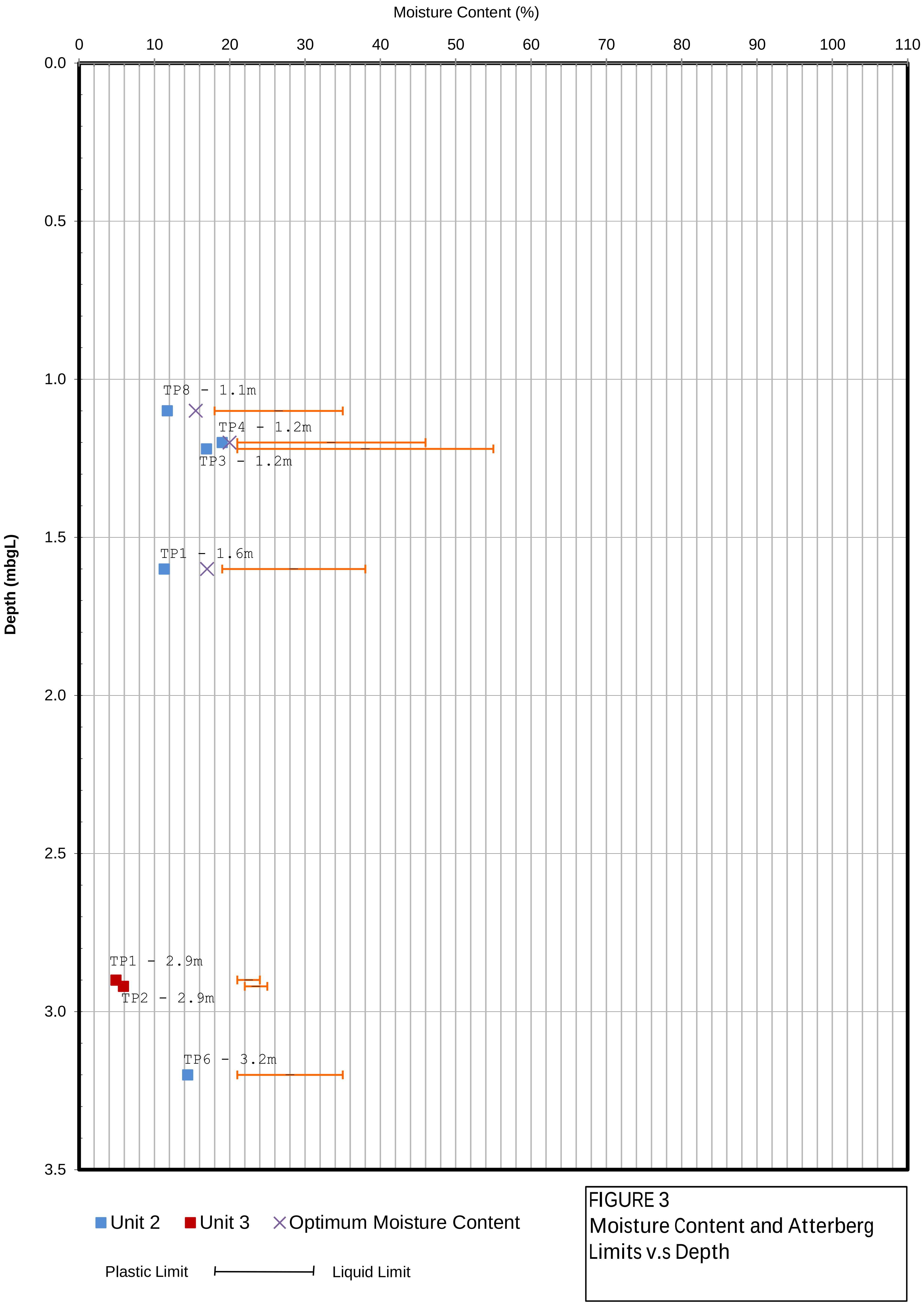


FIGURE 3
Moisture Content and Atterberg
Limits v.s Depth

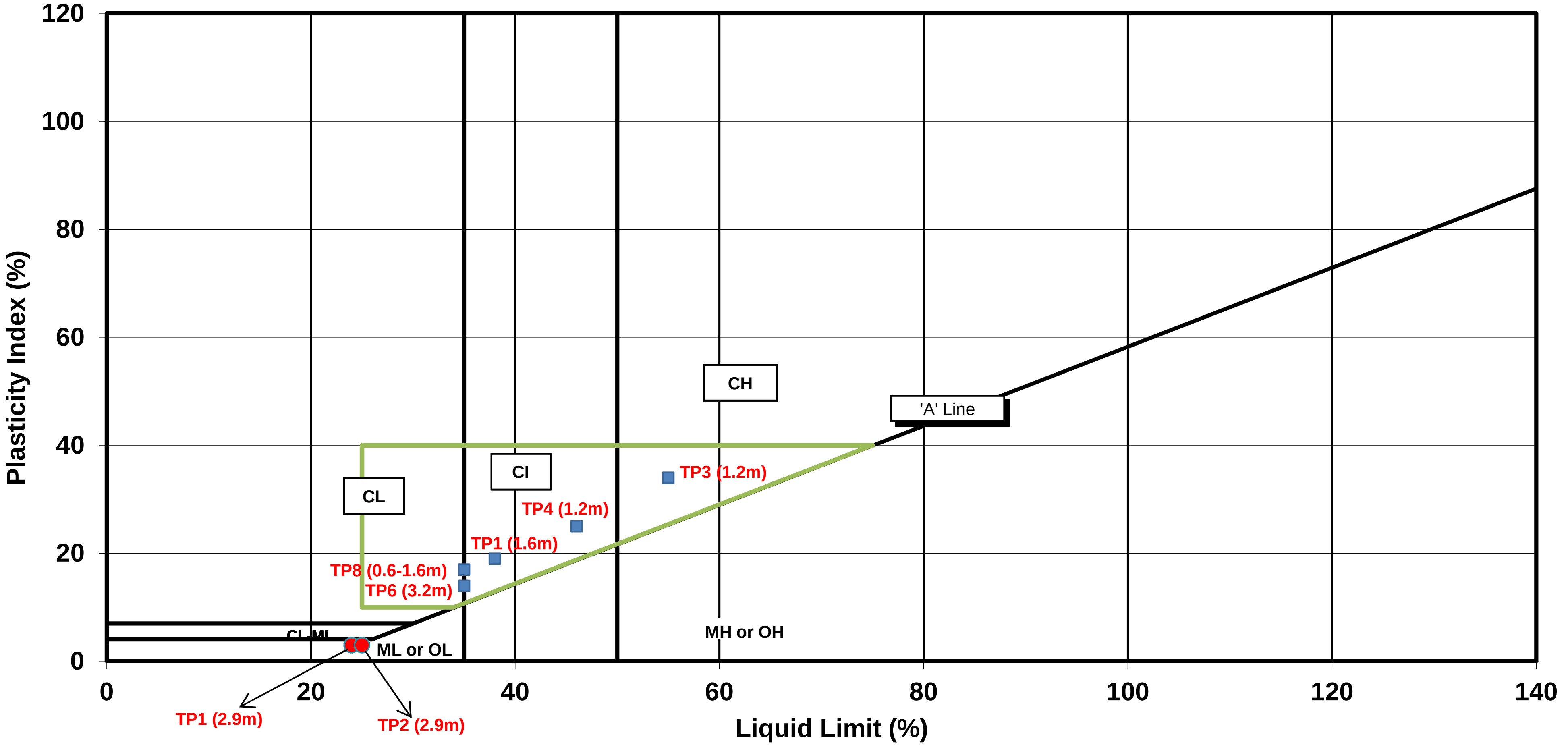


FIGURE 4
Casagrande Chart

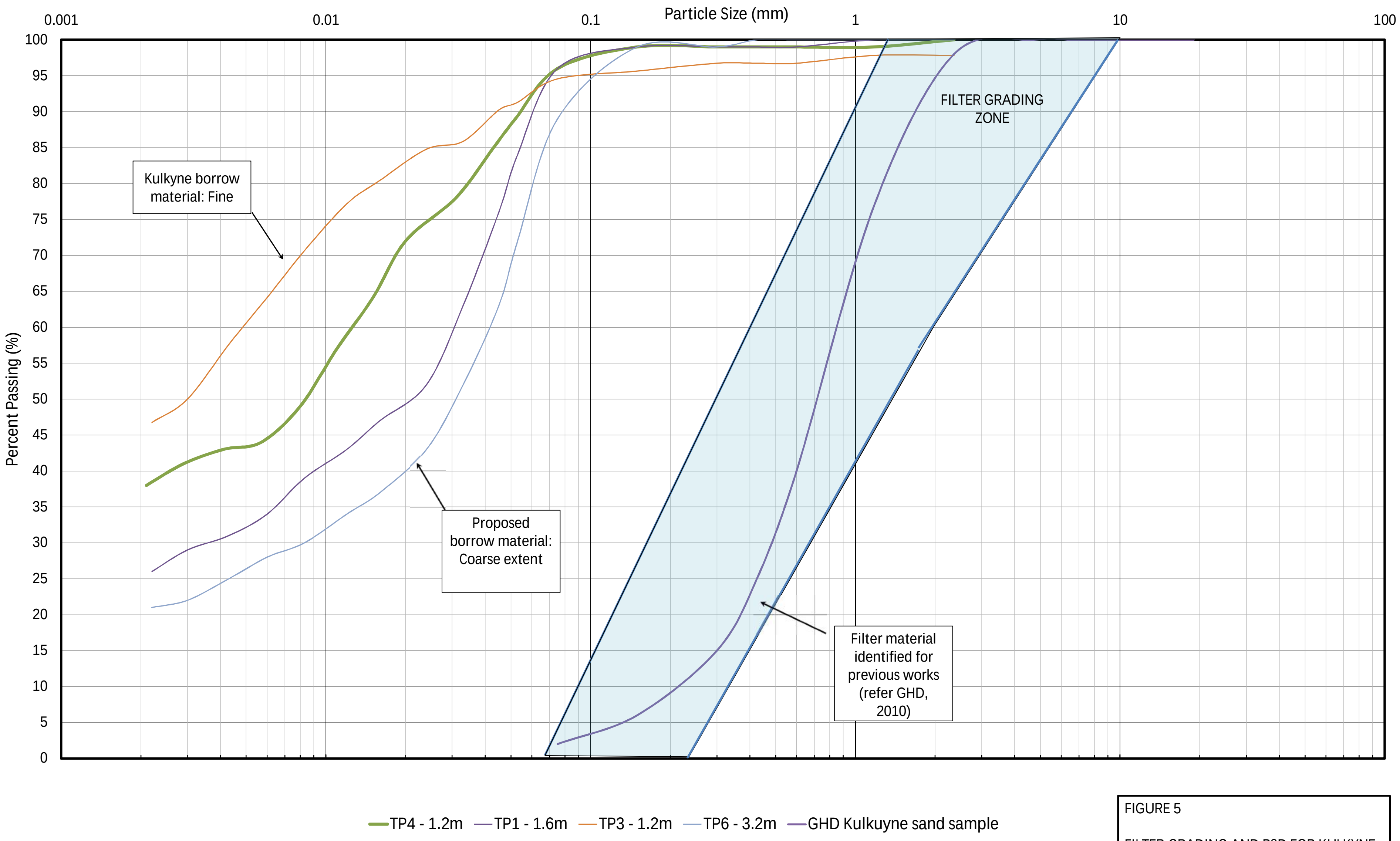


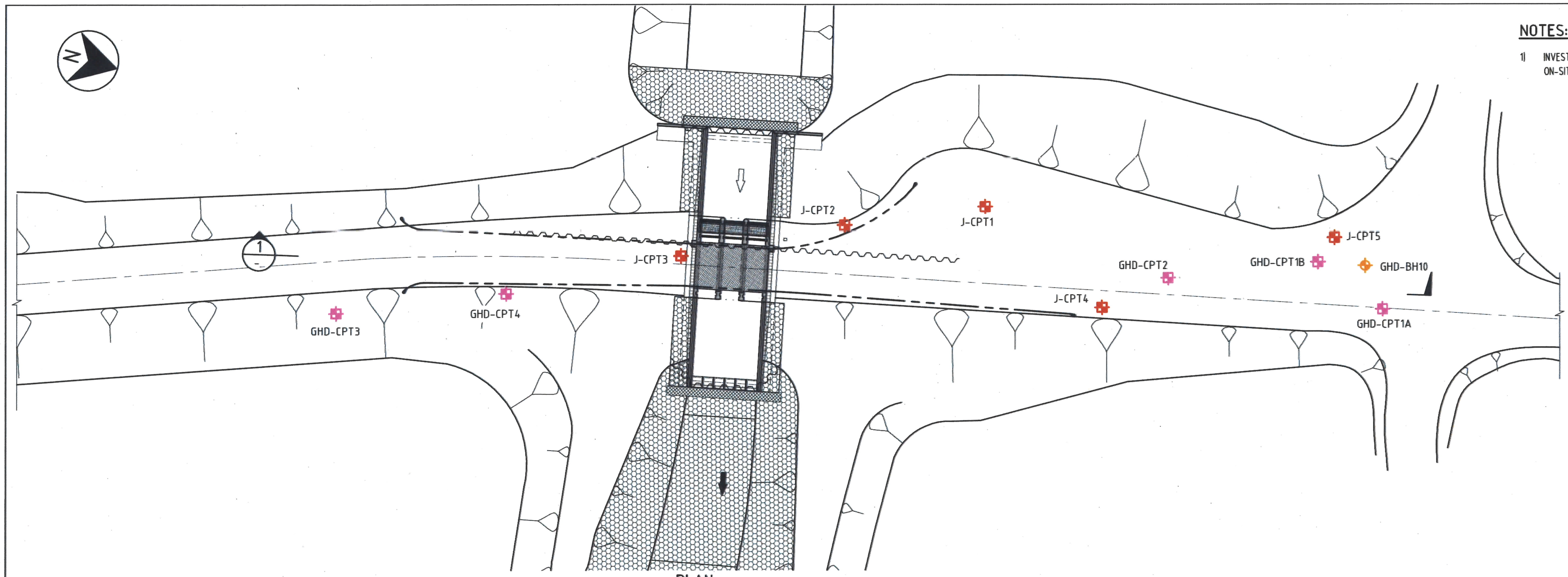
FIGURE 5

FILTER GRADING AND PSD FOR KULKYNE BORROW AREA

Appendix A. Interpretative Long Section

NOTES:

1) INVESTIGATION LOCATIONS ARE APPROXIMATE AND BASED ON HAND-HELD GPS AND ON-SITE SETOUT. REFER TO GEOTECHNICAL REPORT.

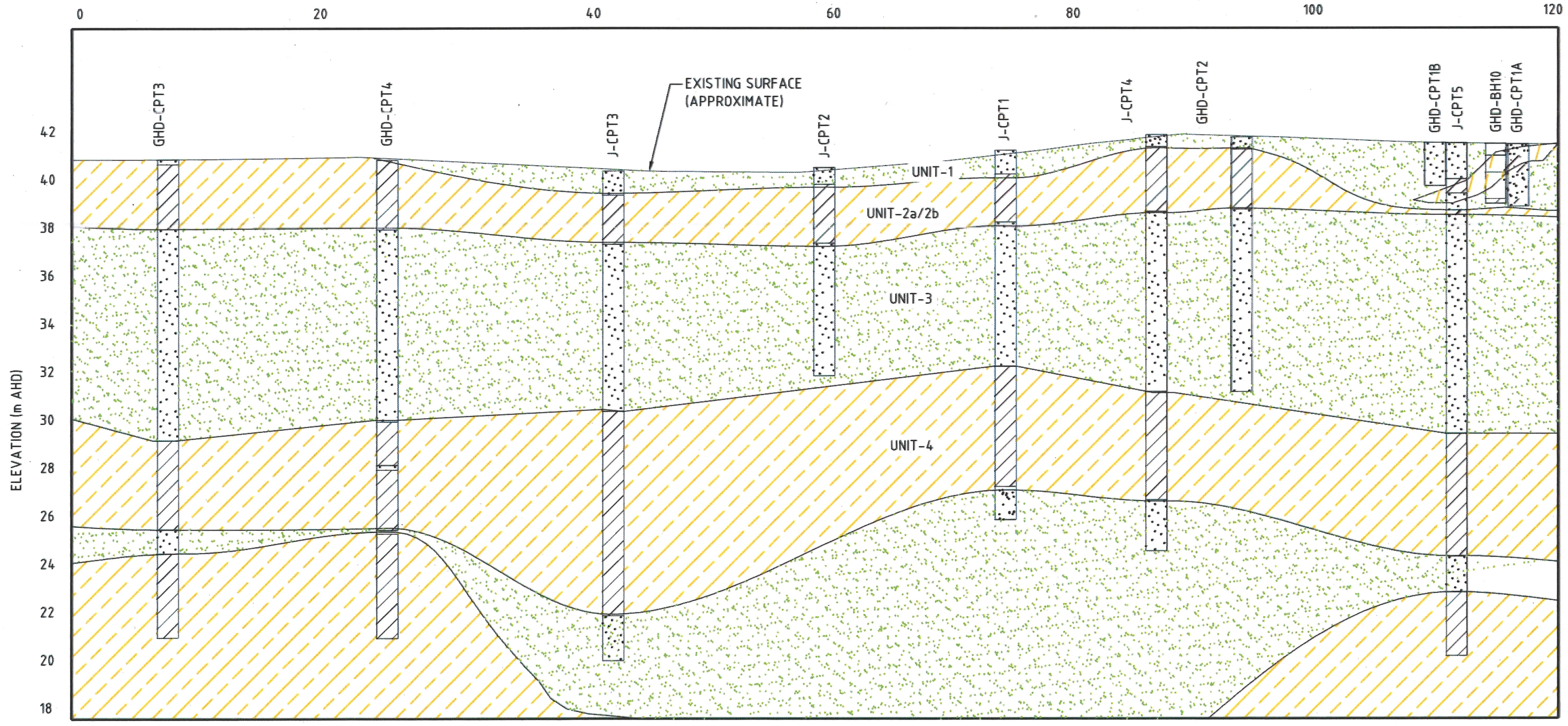


PLAN

SCALE 1:250

BOREHOLE CO-ORDINATE TABLE

K10 REGULATOR		
HOLE ID	EASTING	NORTHING
J-CPT1	630784	6170271
J-CPT2	630790	6170257
J-CPT3	630798	6170241
J-CPT4	630791	6170286
J-CPT5	630777	6170308
GHD-CPT1A	630783	6170315
GHD-CPT1B	630780	6170307
GHD-CPT2	630786	6170292
GHD-CPT3	630814	6170207
GHD-CPT4	630807	6170224
GHD-BH10	630779	6170312
GHD-BH11	630812	6170212



LEGENDS

- ░ SAND, SILTY SAND
- ▨ STIFF TO VERY STIFF CLAY
- ▨ SAND/ CLAY MIXERS
- ✦ BORE HOLES - GHD
- ✦ CPT - JACOBS
- ✦ CPT - GHD

SECTION ① GEOTECHNICAL LONG SECTION

HOR SCALE 1:250, VER 1:125

SCALE 1:250 (A1)

0 5 10 15 20 25m
5 4 3 2 1

NOT FOR CONSTRUCTION

REV	DATE	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	REVISIONS
B			KM		ISSUED FOR APPROVAL
A	18/02/16		KM		ISSUED FOR REVIEW - 85%

REV.	PLAN NO.	REFERENCE PLAN TITLE

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PROJECT DIRECTOR

GOULBURN-MURRAY WATER

MANAGER ASSETS SERVICE

DETAILED DESIGN OF HATTAH NORTH SDL INFRASTRUCTURE

GEOTECHNICAL INVESTIGATION PLAN

K10 REGULATOR

GMW CORR. NO.	GOULBURN MURRAY RURAL WATER AUTHORITY 40 CASEY STREET (PO BOX 165), TATURA VIC. 3616 Telephone (03) 5833 5500 Fax (03) 5833 5501	CAD DRAWING INDEX	SHEET NUMBER	DRAWING NUMBER	REVISION
			OF	487513-0005	B

4/14/2016 11:31:22 AM A1

Appendix B. CPT and test pit logs

TEST PIT LOG

HOLE NO: **J-TP1**

PROJECT : K10 Regulator Hattah Lakes	JOB NO : IS129400	PAGE : 1 OF 1
POSITION : E: 632744.000, N: 6168968.000 (MGA94)	SURFACE ELEVATION :	LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator	CONTRACTOR : Ashley Shirnack	BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15	LOGGED BY : AK CHECKED BY : RK	STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA Moisture Content	Dry Density	% Fines	Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
E								Silty CLAY (CI) grey-brown, trace hard nodules, trace fine sand	D	St to VSt		
					0.50m D		0.5	grades to yellow brown				0.50: increased silt content? (CL-ML)
							1.0					
					1.20m D							
							1.5					
	11.3		96	LL=38 PI=19 LS=9	1.60m B							
							2.0					2.00: retrieved as cobble-sized clumps
					2.20m D			2.20m grading to weakly cemented sand Silty CLAY (CL) grey-brown, trace fine sand, black nodules in matrix		H		
							2.5					
								2.80m 2.90m Silty SAND (SM) fine to medium grain, low plasticity fines				
	4.9		53	LL=24 PI=3 LS=1	2.90m D		3.0	Test pit terminated at target depth at 2.9m				2.90: Consistecy is Hard with inferred extremely low strength
							3.5					
							4.0					
							4.5					

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS

▼ = Water level (static)

▽ = Water level (during drilling)

► = Water inflow

◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)

SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION

D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

JACOBS AGS REV04 (WORKING).GLB Log TEST PIT LOG - PHOTO HATTAH LAKE TEST PITS.GPJ <<DrawingFile>> 03/12/2015 16:49

TEST PIT LOG

HOLE NO: J-TP10

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632629.000, N: 6168951.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA: Moisture Content	LAB DATA: Dry Density	LAB DATA: % Fines	LAB DATA: Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									Silty CLAY (CL) brown, grey-brown	D	VSt		
							0.5	0.50m	Silty CLAY (CL) light brown, orange-brown, friable, trace fine sand				
							3.0	3.00m	Clayey SAND (SC) mottled orange-grey, fine grained, weakly cemented in places				
								3.20m	Test Pit terminated at target depth at 3.2m				

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS

- ▼ = Water level (static)
- ▽ = Water level (during drilling)
- ►— = Water inflow
- —◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION

D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

JACOBS AGS REV04 (WORKING).GLB Log TEST PIT LOG - PHOTO HATTAH LAKE TEST PITS.GPJ <<DrawingFile>> 03/12/2015 16:49

TEST PIT LOG

HOLE NO: **J-TP11**

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632313.000, N: 6168944.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA Moisture Content	LAB DATA Dry Density	LAB DATA % Fines	LAB DATA Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									FILL: Sand (SP) pale grey, fine grained	D	D		
					1.00m		0.80m		Silty CLAY (CL) orange brown, light brown		St		
					2.00m		1.20m		SAND (SP) light brown, fine grained				1.10: trace woods, roots and rootlets
									Test pit terminated at target depth at 1.3m				

EXCAVATION			
N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
► = Water inflow
◄ = Water outflow

SAMPLES & FIELD TESTS			
B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY	
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)		
VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

TEST PIT LOG

HOLE NO: J-TP2

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632782.000, N: 6168971.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA Moisture Content	Dry Density	% Fines	Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									Silty Clay (CI-CL) dark brown	D	VSt		
							0.5		grading to light brown				
							1.0						
					1.40m D		1.40m 1.5		Silty CLAY (CL) orange-brown, trace fine sand		St		
							2.0		orange-brown, increasing sand content				
							2.5						
	5.9			LL=25 PI=3 LS=1	2.90m B		2.90m 3.00m 3.0		Silty SAND (SM) pale brown, fine to medium grained, fines of low plasticity		VD		
									Test Pit terminated at target depth at 3m				
							3.5						
							4.0						
							4.5						

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
►— = Water inflow
—◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

TEST PIT LOG

HOLE NO: **J-TP3**

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632836.000, N: 6168988.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA: Moisture Content	LAB DATA: Dry Density	LAB DATA: % Fines	LAB DATA: Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
							0.5 1.0	▨	Silty CLAY (CL) grey, brown-grey, trace fine grained sand	D	VSt		
	16.9		87	LL=55 PI=34 LS=15	1.20m D		1.20m 1.5 2.0 2.5	▨	Silty CLAY (CH) brown, grey brown, trace fine to coarse grained sand, trace fine to medium grained gravel	D to M	VSt		
					2.90m D					D			2.90: getting sandy with depth, excavator noted was getting hard, starting to hit sand
							3.00m 3.0 3.5 4.0 4.5		Test Pit terminated at refusal at 3m		VSt to VD		

EXCAVATION			
N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
►— = Water inflow
—◄ = Water outflow

SAMPLES & FIELD TESTS			
B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY	
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)		
VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

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JACOBS

TEST PIT LOG

HOLE NO: **J-TP4**

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632846.000, N: 6168904.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA Moisture Content	 Dry Density	 % Fines	 Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									Silty CLAY (CL) dark brown	M	VSt		
							0.5						
							1.0		1.00m Silty CLAY (CI) grey, light brown, trace fine sand				1.00: increasing plasticity with depth
	19		96	LL=46 PI=25 LS=12	1.20m B								
							1.5						
							2.0						
									becoming moist				
							2.5						
					2.90m D					D to M			2.90: becoming hard
							3.0		3.00m trace fine sand		H		
									Test pit terminated at target depth at 3m				
							3.5						
							4.0						
							4.5						

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
► = Water inflow
◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

JACOBS

TEST PIT LOG

HOLE NO: **J-TP5**

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632909.000, N: 6169054.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA				SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
	Moisture Content	Dry Density	% Fines	Atterberg Limits									
					1.40m D 2.20m D				Silty CLAY (CL) grey brown grading to orange-brown	D	St		
							2.20m		SAND (SP) pale brown, light brown, fine grained becoming orange-brown, weakly cemented sand becoming mottled brown-light brown				
							2.90m		Test pit terminated at refusal at 2.9m				2.90: some moisture noted

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
► = Water inflow
◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

TEST PIT LOG

HOLE NO: **J-TP6**

PROJECT : K10 Regulator Hattah Lakes	JOB NO : IS129400	PAGE : 1 OF 1
POSITION : E: 632809.000, N: 6169039.000 (MGA94)	SURFACE ELEVATION :	LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator	CONTRACTOR : Ashley Shirnack	BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15	LOGGED BY : AK CHECKED BY : RK	STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA Moisture Content	Dry Density	% Fines	Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									Silty CLAY (CL) dark brown	D	VSt		
					2.10m D		0.50m		Silty CLAY (CL-CI) mottled orange-brown, grey, friable				
	14.4		89	LL=35 PI=14 LS=7.5	3.20m D		3.10m		Silty CLAY (CL-CI) pale-brown, friable, trace fine sand				
							3.20m		Test pit terminated at target depth at 3.2m				

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS

- ▼ = Water level (static)
- ▽ = Water level (during drilling)
- ►— = Water inflow
- —◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION

D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

TEST PIT LOG

HOLE NO: **J-TP7**

PROJECT : K10 Regulator Hattah Lakes	JOB NO : IS129400	PAGE : 1 OF 1
POSITION : E: 632725.000, N: 6169025.000 (MGA94)	SURFACE ELEVATION :	LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator	CONTRACTOR : Ashley Shirnack	BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15	LOGGED BY : AK CHECKED BY : RK	STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA: Moisture Content	LAB DATA: Dry Density	LAB DATA: % Fines	LAB DATA: Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									Silty CLAY (CL) dark grey, friable	D	VSt to H		
							0.5	0.50m	Silty CLAY (CL) light brown, friable, trace fine sand				0.60: retrieved as hard coarse gravel sized pieces
					1.00m B		1.0						
							1.5						
							2.0						
							2.5	2.60m	Clayey SAND (SC) light brown-orange, weakly cemented in places		H		
								2.90m 3.00m	SAND (SP) pale brown, fine grained				
							3.0		Test Pit terminated at target depth at 3m				
							3.5						
							4.0						
							4.5						

EXCAVATION

N	Natural/Existing cutting	B	Buldozer
E	Excavator	R	Ripper
BH	Backhoe Bucket		

GROUNDWATER SYMBOLS

▼ = Water level (static)
▽ = Water level (during drilling)
►— = Water inflow
—◄ = Water outflow

SAMPLES & FIELD TESTS

B	Bulk Sample	U	Undisturbed Tube Sample
D	Small Disturbed Sample	W	Water Sample
ES	Env Soil Sample		
EW	Env Water Sample		

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense
CO	Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

JACOBS

TEST PIT LOG

HOLE NO: **J-TP8**

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632669.000, N: 6168849.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA Moisture Content	Dry Density	% Fines	Atterberg Limits	SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
									Silty CLAY (CL) dark grey, low plasticity, friable, trace organic material	D	VSt		
	11.7			LL=35 PI=17 LS=9	0.80m B 1.60m		0.5 1.0 1.5 2.0 2.5	0.50m	Silty CLAY (CL-CI) pale brown, trace fine sand, friable grading to mottled red-brown				2.50: becoming sandier (some cemented sand)
							3.0	2.90m	Clayey SAND (SC) light brown, yellow brown, fine grained, friable		VD		2.90: weakly cemented in places
							3.5 4.0 4.5	3.20m	Test pit terminated at target depth at 3.2m				

EXCAVATION
N Natural/Existing cutting
E Excavator
BH Backhoe Bucket
B Buldozer
R Ripper

GROUNDWATER SYMBOLS
▼ = Water level (static)
▽ = Water level (during drilling)
►— = Water inflow
—◄ = Water outflow

SAMPLES & FIELD TESTS
B Bulk Sample
D Small Disturbed Sample
ES Env Soil Sample
EW Env Water Sample
U Undisturbed Tube Sample
W Water Sample
PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense
CO Compact

MOISTURE CONDITION
D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)

TEST PIT LOG

HOLE NO: **J-TP9**

PROJECT : K10 Regulator Hattah Lakes
JOB NO : IS129400
PAGE : 1 OF 1
POSITION : E: 632825.000, N: 6168680.000 (MGA94)
SURFACE ELEVATION :
LOCATION : Kulkyne-Hattah National Park, Mi
EQUIPMENT TYPE : 4t Excavator
CONTRACTOR : Ashley Shirnack
BUCKET WIDTH : 0.6m
DATE EXCAVATED : 9/11/15 to 9/11/15
LOGGED BY : AK
CHECKED BY : RK
STANDARD : AS1726-1993

EXCAVATION & WATER DETAIL	LAB DATA				SAMPLES & FIELD DATA	RL (m)	DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE	CONSISTENCY/ DENSITY	DCP (blows/100mm) 5 10 15 20	COMMENTS Field Test Data & Other Observations
	Moisture Content	Dry Density	% Fines	Atterberg Limits									
							0.5 1.0 1.5 2.0 2.5		Silty CLAY (CL) pale grey grading to light brown, yellow brown 2.60m	D	VSt		
					2.60m D		3.0		SAND (SP) light brown, fine grained 3.15m		MD		
							3.5 4.0 4.5		Test pit terminated at target depth at 3.15m				

EXCAVATION

N Natural/Existing cutting
E Excavator
BH Backhoe Bucket
B Buldozer
R Ripper

GROUNDWATER SYMBOLS

▼ = Water level (static)
▽ = Water level (during drilling)
►— = Water inflow
—◄ = Water outflow

SAMPLES & FIELD TESTS

B Bulk Sample
D Small Disturbed Sample
ES Env Soil Sample
EW Env Water Sample
U Undisturbed Tube Sample
W Water Sample

PP Hand Penetrometer (UCS result)
SV Hand Vane Shear (P: Peak Su, R: Residual Su)

PHOTOGRAPHS NOTES ☒ YES ☐ NO

DENSITY

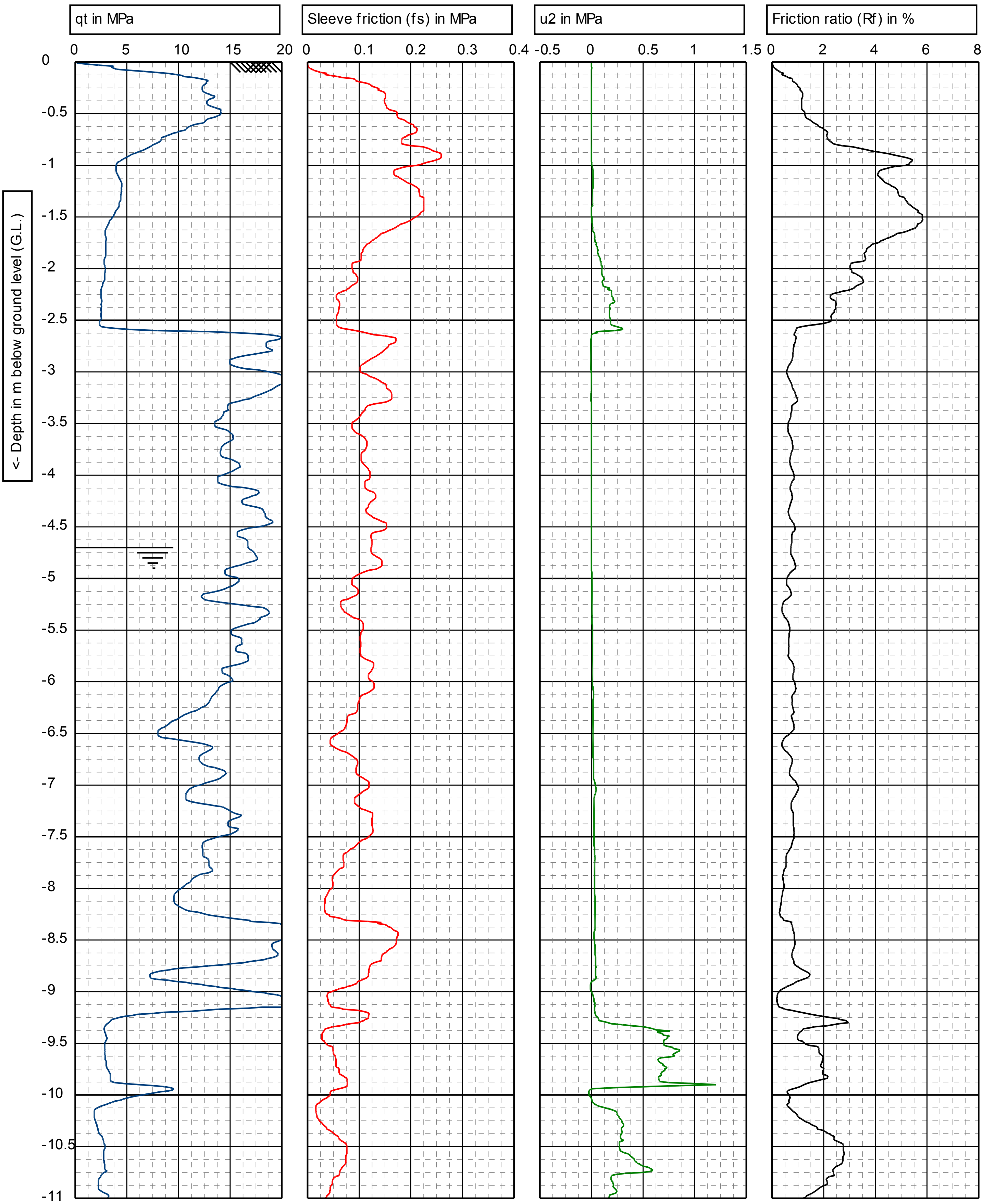
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense
CO Compact

MOISTURE CONDITION

D = Dry M = Moist W = Wet

CONSISTENCY (Su)

VS	Very Soft	(0-12.5kPa)
S	Soft	(12.5-25kPa)
F	Firm	(25-50kPa)
St	Stiff	(50-100kPa)
VSt	Very Stiff	(100-200kPa)
H	Hard	(>200kPa)



BLACK
INSITU TESTING

u2
150 cm²
10 cm²

Client: Jacobs

G.L.: **0.00 m**

W.L.: **-4.70 m**

Project: **Hattah Lakes K10 Regulator**

Location: **Chalka Creek**

Position: **630784, 6170271**

Predrill: **0.00 m Predrilled**

Date: **10/11/2015**

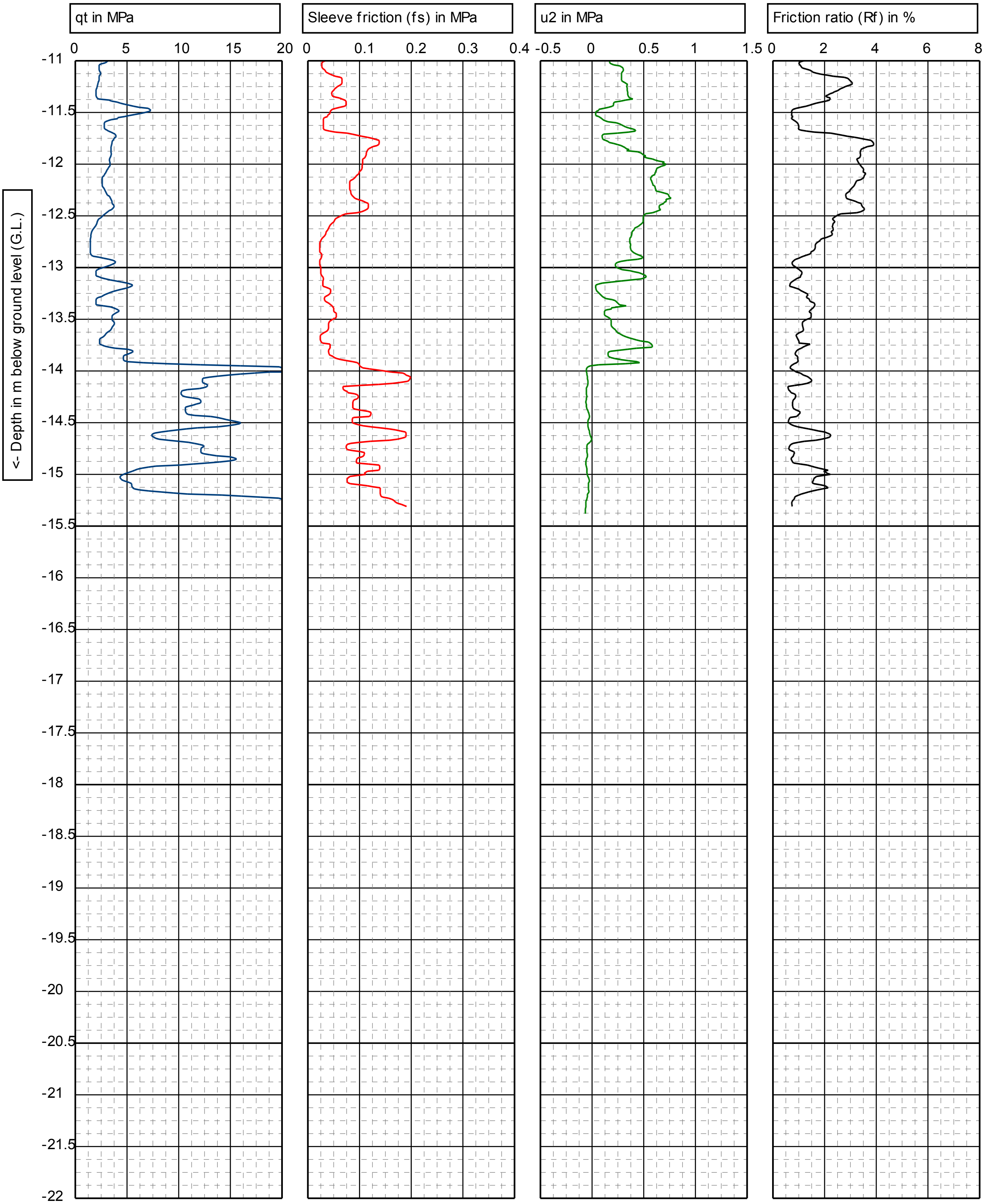
Cone no.: **C10CFIIP.C14058**

Project no.: **E032**

CPT no.: **CPT_J1** **1/2**

1.44

Processed : RB Checked: DRAFT



Test complete at 15.38m qc>25MPa

Hole closed at 4.7m w et at 4.7m

BLACK INSITU TESTING

u2
150 cm²
10 cm²

Client: Jacobs

G.L.: **0.00 m**

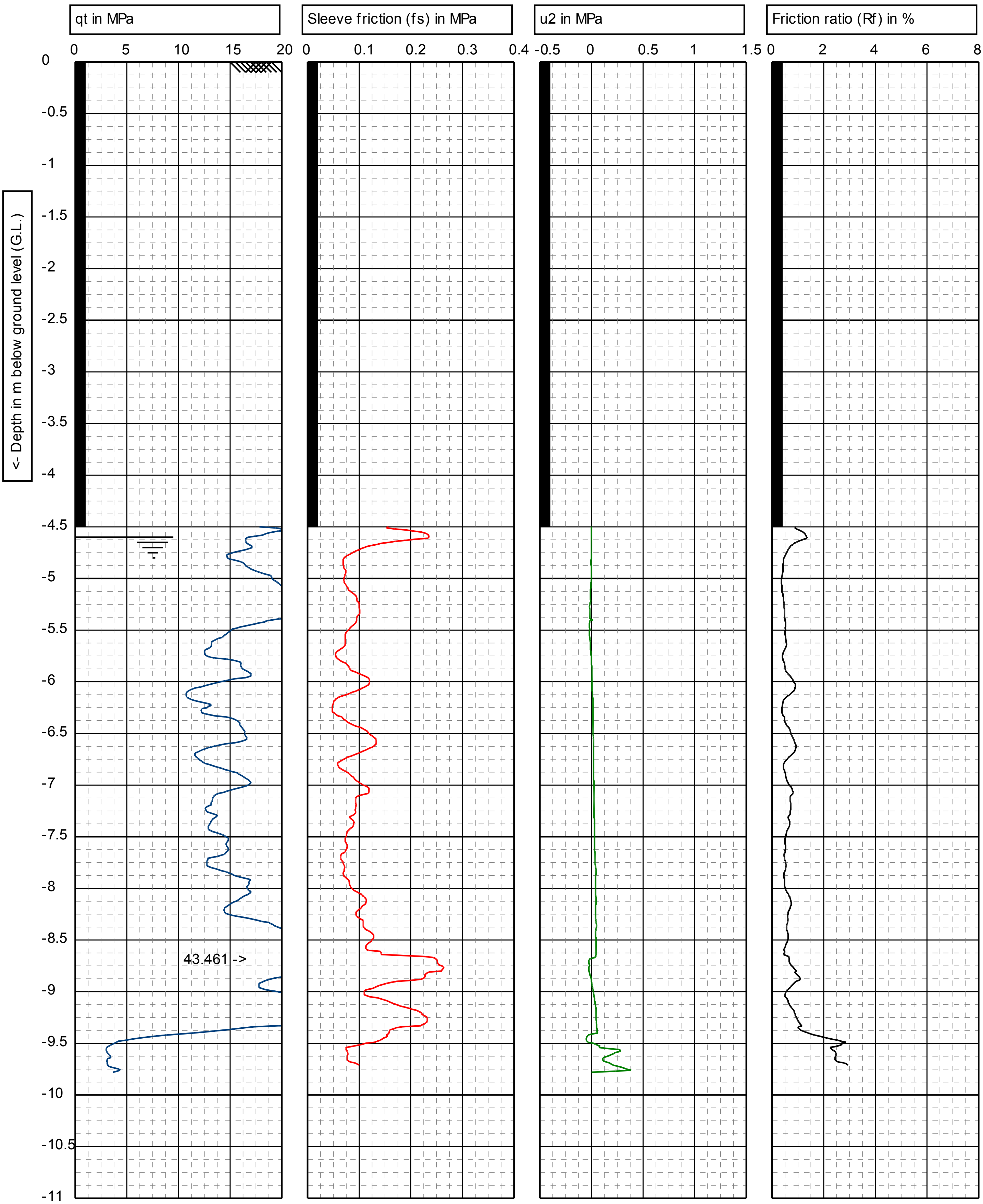
W.L.: **-4.70 m**

Project: **Hattah Lakes K10 Regulator**
Location: **Chalka Creek**
Position: **630784, 6170271**

Predrill: **0.00 m Predrilled**
Date: **10/11/2015**
Cone no.: **C10CFIIP.C14058**
Project no.: **E032**
CPT no.: **CPT_J1** **2/2**

1.44

Processed : RB Checked: DRAFT



Test complete at 9.78m qc>5MPa

Hole closed at 4.6m wet at 4.6m

BLACK INSITU TESTING

u2 150 cm² 10 cm²	Client: Jacobs		Predrill:	**4.50 m Predrilled**
	G.L.: **0.00 m**	W.L.: **-4.60 m**	Date:	**10/11/2015**
Project:	**Hattah Lakes K10 Regulator**		Cone no.:	**C10CFIIP.C14058**
Location:	**Chalka Creek**		Project no.:	**E032**
Position:	**630784, 6170271**		CPT no.:	**CPT_J1A** 1/1

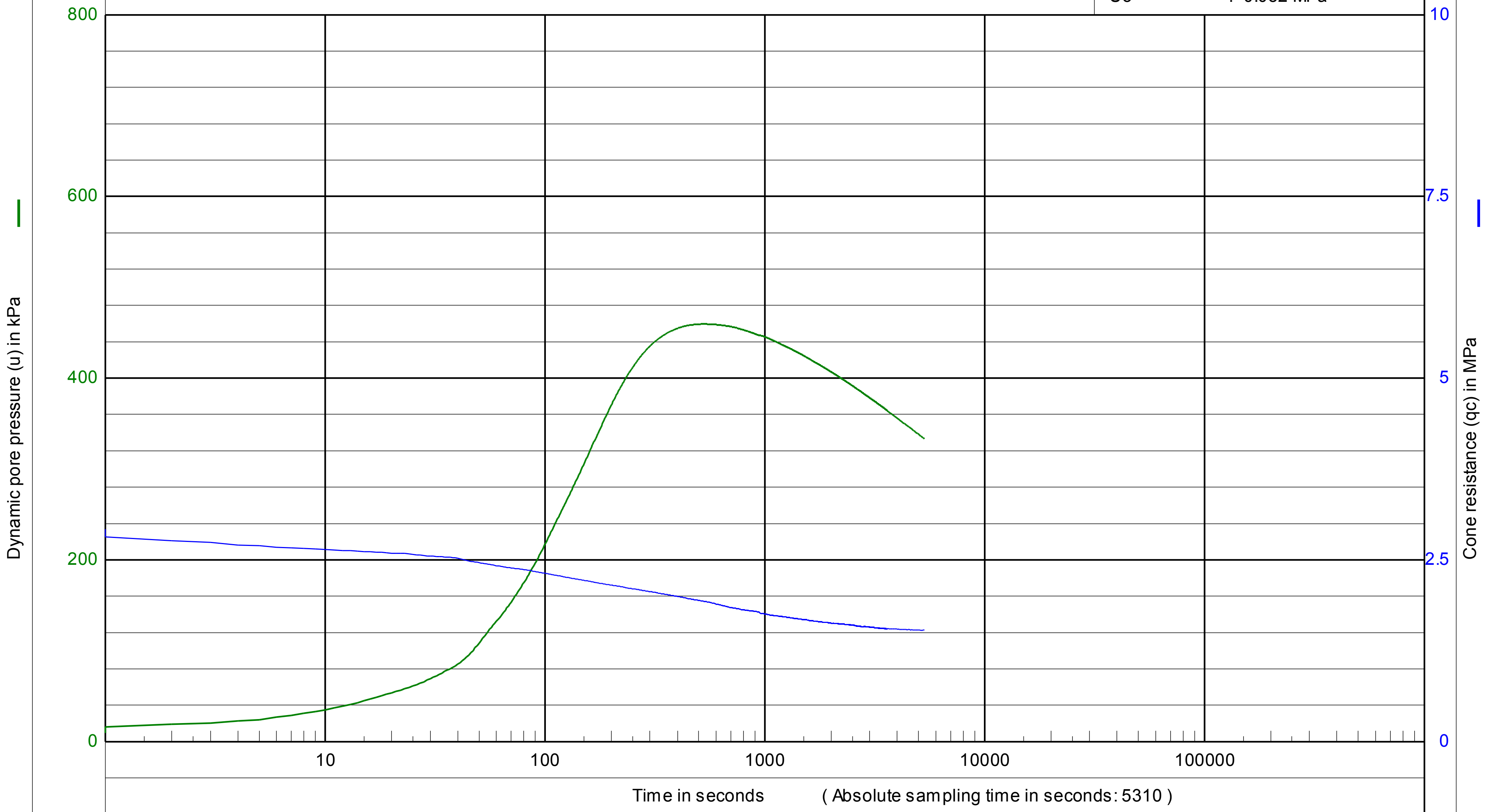
1.44

Processed : RB Checked: DRAFT

Test number 2

Ubegin : 0.009 MPa

Uo : 0.052 MPa



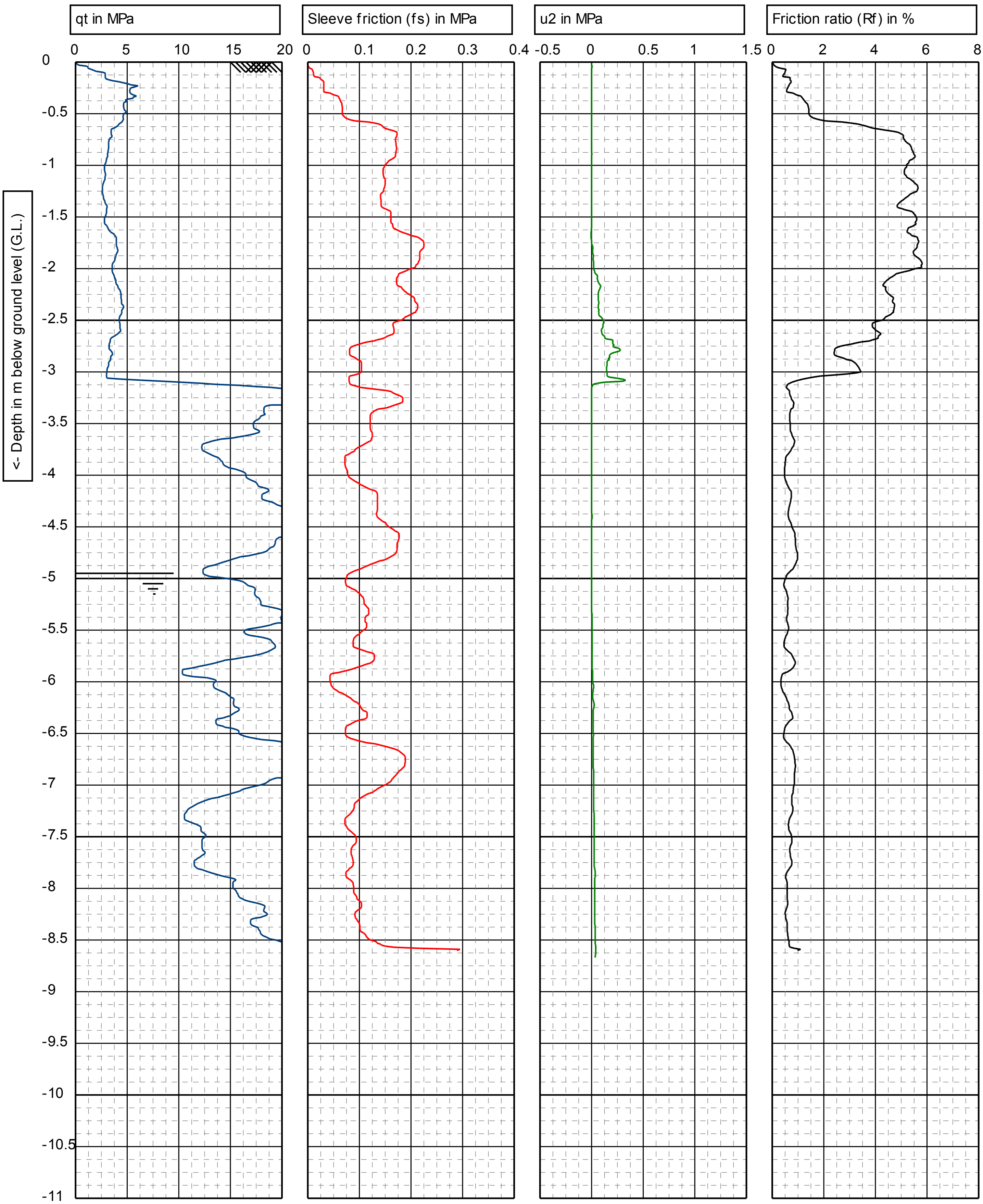
BLACK INSITU TESTING

Client: Jacobs

Project : Hattah Lakes K10 Regulator

Location : Chalka Creek

Date	:	10/11/2015	
Project no.	:	E032	
CPT no.	:	CPT_J1A	
Test depth	:	9.78	[m] - G.L.
Water level	:	-4.60	[m] - G.L.



Refusal at 8.67m qc>60MPa

Hole closed at 4.95m w et at 4.95m

BLACK INSITU TESTING

u2
150 cm²
10 cm²

Client: Jacobs

G.L.: **0.00 m**

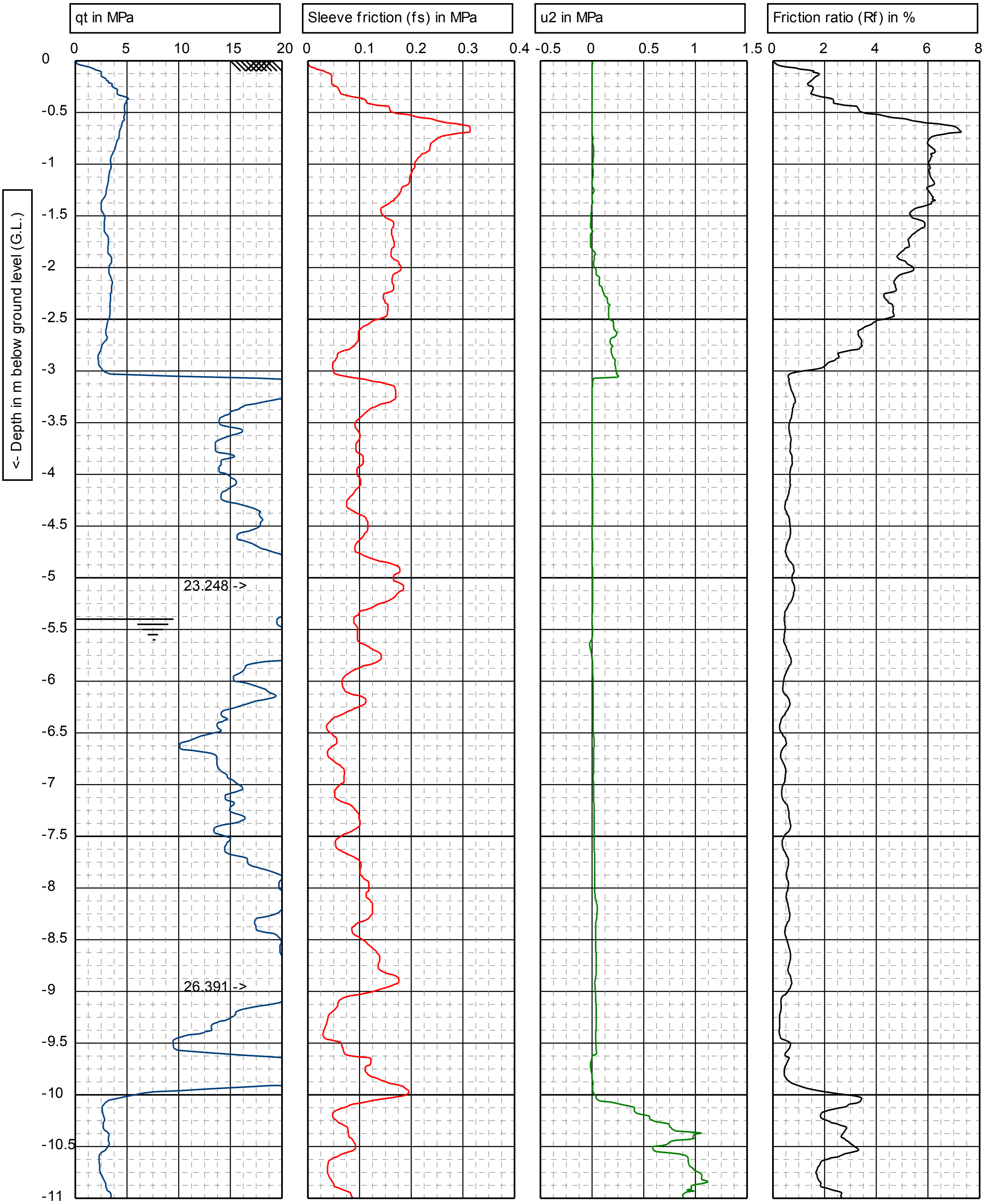
W.L.: **-4.95 m**

Project: **Hattah Lakes K10 Regulator**
Location: **Chalka Creek**
Position: **630790, 6170257**

Predrill: **0.00 m Predrilled**
Date: **10/11/2015**
Cone no.: **C10CFIIP.C14058**
Project no.: **E032**
CPT no.: **CPT_J2** **1/1**

1.44

Processed : RB Checked: DRAFT



BLACK
INSITU TESTING

u2
150 cm²
10 cm²

Client: Jacobs

G.L.: **0.00 m**

W.L.: **-5.40 m**

Predrill: **0.00 m Predrilled**

Date: **10/11/2015**

Cone no.: **C10CFIIP.C14058**

Project no.: **E032**

CPT no.: **CPT_J3** **1/2**

Project: **Hattah Lakes K10 Regulator**

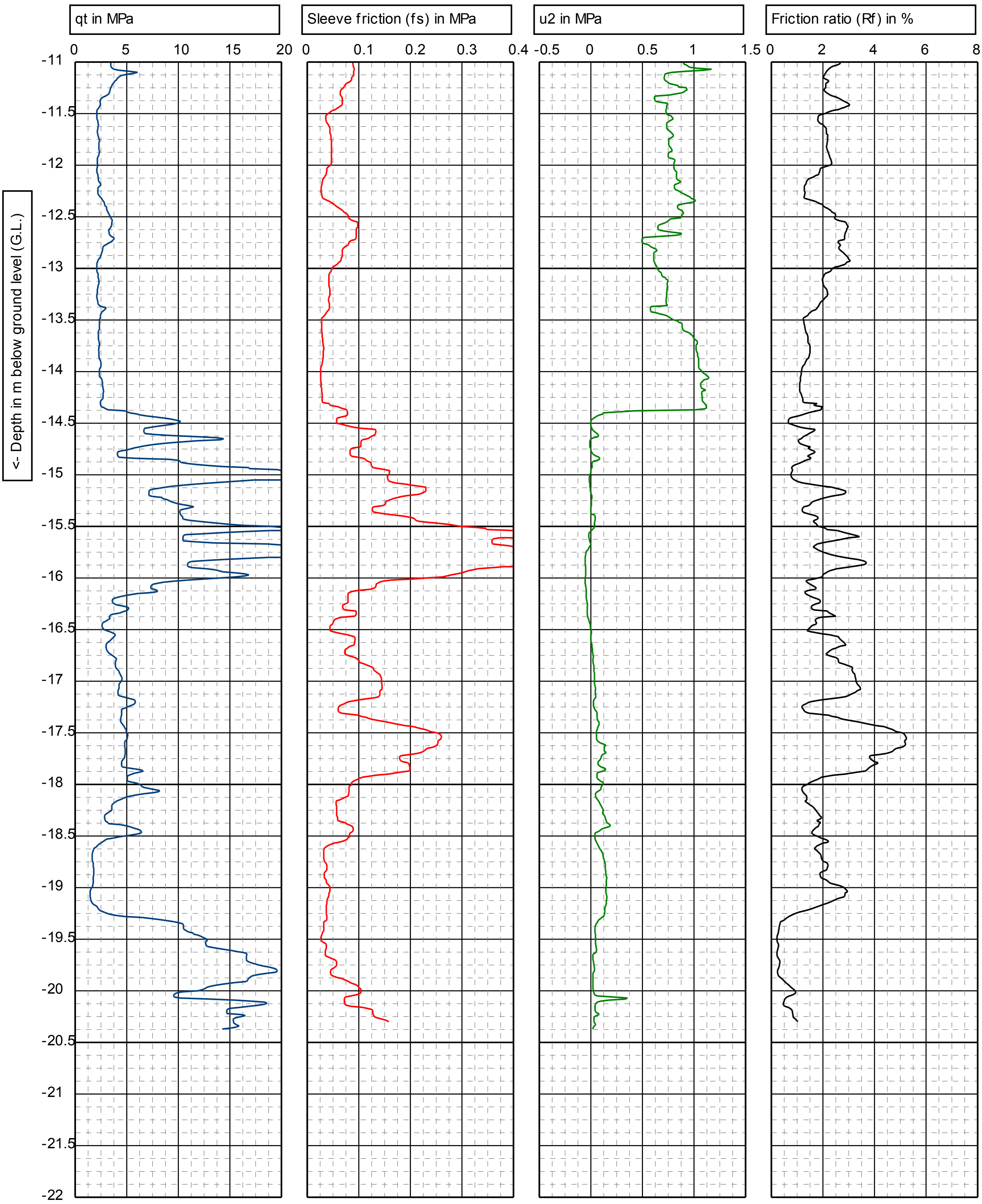
Location: **Chalka Creek**

Position: **640798, 6170241**

1.44

Processed : RB

Checked: DRAFT



Test complete at 20.37m qc>15MPa

Hole closed at 5.4m wet at 5.4m

BLACK INSITU TESTING

u2
150 cm²
10 cm²

Client: Jacobs

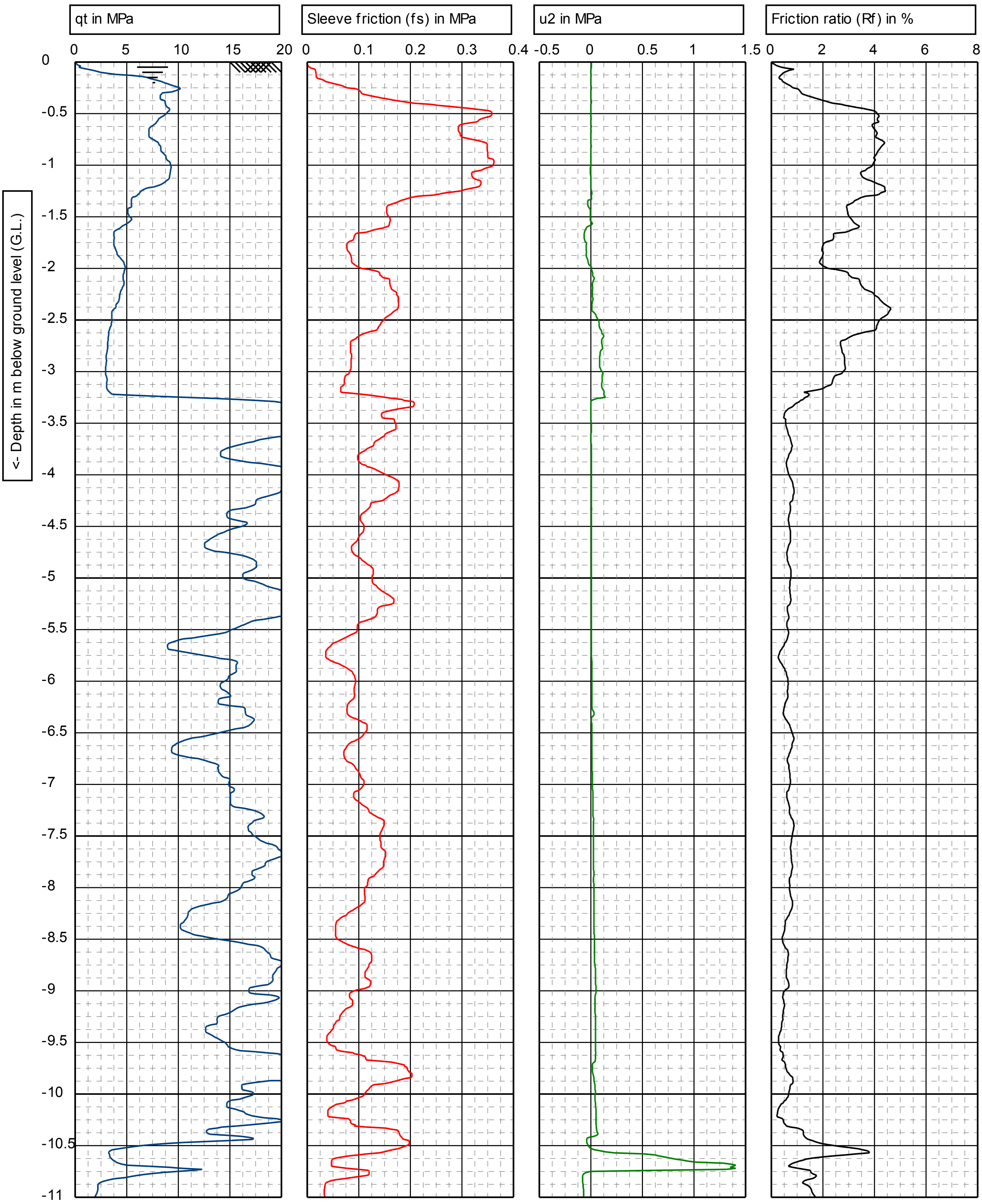
G.L.: **0.00 m**
W.L.: **-5.40 m**

Predrill: **0.00 m Predrilled**
Date: **10/11/2015**
Cone no.: **C10CFIIP.C14058**
Project no.: **E032**
CPT no.: **CPT_J3** **2/2**

Project: **Hattah Lakes K10 Regulator**
Location: **Chalka Creek**
Position: **640798, 6170241**

1.44

Processed : RB Checked: DRAFT



u2
150 cm²
10 cm²

Client: Jacobs

G.L.: **0.00 m**

W.L.: **0.00 m**

Predrill: **0.00 m Predrilled**

Date: **10/11/2015**

Cone no.: **C10CFIIP.C14058**

Project no.: **E032**

CPT no.: **CPT_J4** **1/2**

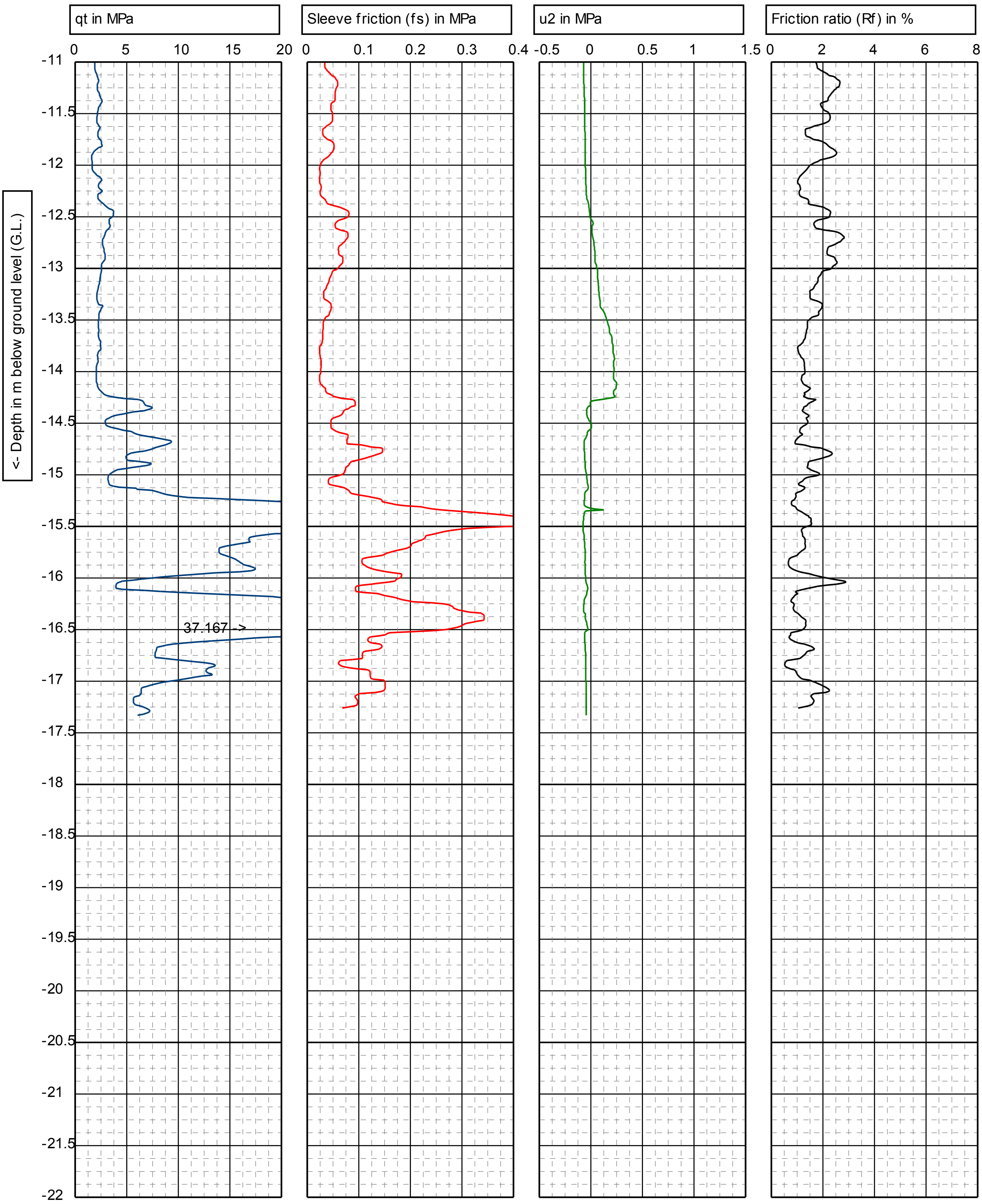
Project: **Hattah Lakes K10 Regulator**

Location: **Chalka Creek**

Position: **630791, 6170275**

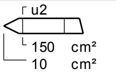
1.44

Processed : RB Checked: DRAFT



Test complete at 17.33m qc>qc>5MPa

Hole closed at 5.35m dry



Client: Jacobs

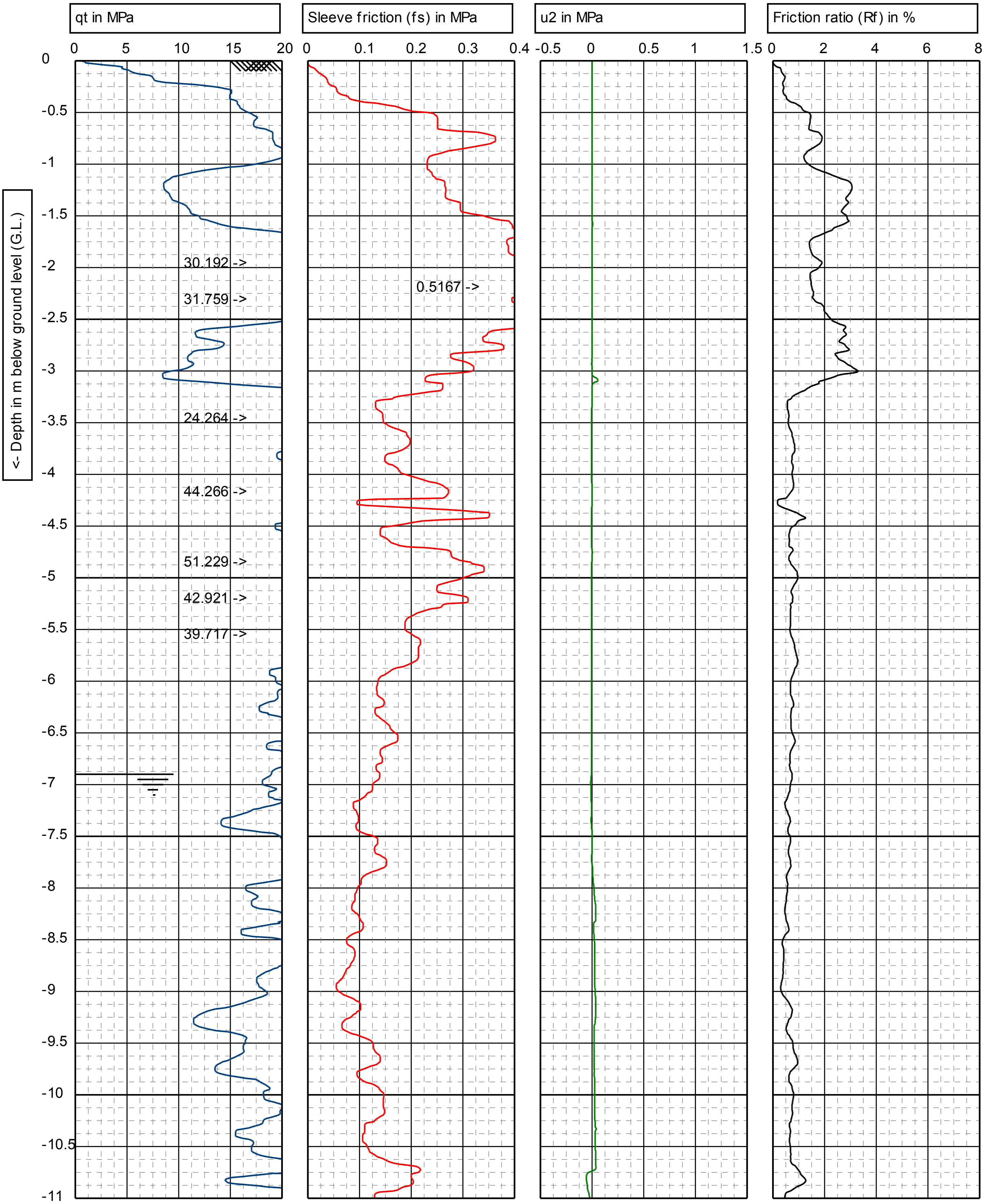
G.L.: **0.00 m**
W.L.: **0.00 m**

Project: **Hattah Lakes K10 Regulator**
Location: **Chalka Creek**
Position: **630791, 6170275**

Predrill: **0.00 m Predrilled**
Date: **10/11/2015**
Cone no.: **C10CFIIP.C14058**
Project no.: **E032**
CPT no.: **CPT_J4** **2/2**

1.44

Processed : RB Checked: DRAFT



BLACK
INSITU TESTING

u2
150 cm²
10 cm²

Client: Jacobs

G.L.: **0.00 m**

W.L.: **-6.90 m**

Project: **Hattah Lakes K10 Regulator**

Location: **Chalka Creek**

Position: **630777, 6170308**

Predrill: **0.00 m Predrilled**

Date: **10/11/2015**

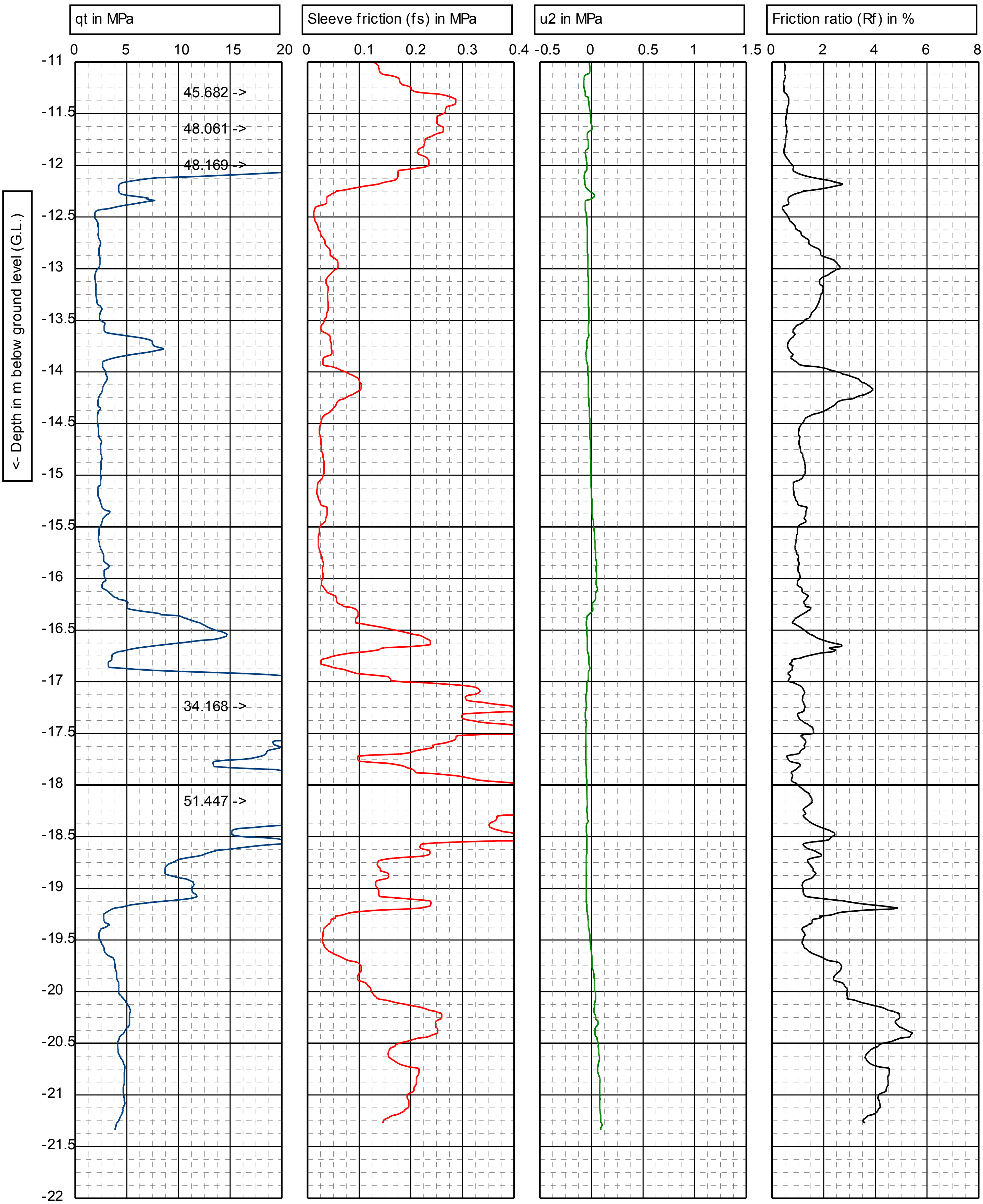
Cone no.: **C10CFIIP.C14058**

Project no.: **E032**

CPT no.: **CPT_J5** **1/2**

1.44

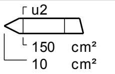
Processed : RB Checked: DRAFT



Test complete at 21.34m qc>4MPa

Hole closed at 7.0m w et at 6.9m

BLACK
INSITU TESTING



Client: Jacobs

G.L.: **0.00 m**

W.L.: **-6.90 m**

Project: **Hattah Lakes K10 Regulator**

Location: **Chalka Creek**

Position: **630777, 6170308**

Predrill: **0.00 m Predrilled**

Date: **10/11/2015**

Cone no.: **C10CFIIP.C14058**

Project no.: **E032**

CPT no.: **CPT_J5** **2/2**

1.44

Processed : RB Checked: DRAFT

Appendix C. Laboratory test certificates

PARTICLE SIZE DISTRIBUTION

CIVIL GEOTECHNICAL SERVICES		*Job No*	15018
		Report No	15018/R094
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	27/11/15
Client	JACOBS SKM (MELBOURNE)	*Tested by*	ANR
Project	IS129400 HATTAH LAKES	*Date tested*	25/11/15
Location	VIA VICTORIA	*Checked by*	ANR

Sample Identification J-TP1 @ 1.6m

Sample No 15018080

Sample Description

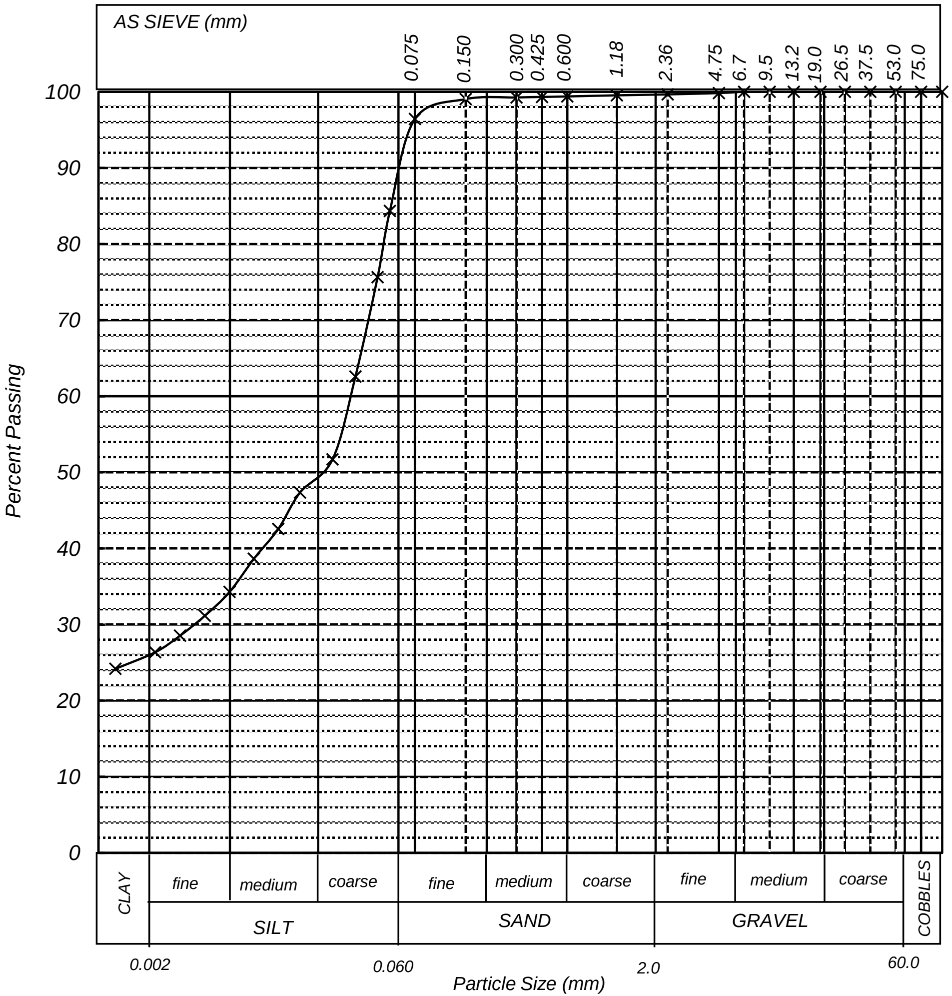
CLAY, medium plasticity, pale brown, trace of fine sand.

Assumed soil particle density 2.65 *g/cm³*

AS 1289.3.6.1 and 3.6.3 - Particle Size Distribution - Standard method of fine analysis using a Hydrometer

Method of dispersion	Mechanical	*Loss in pretreatment*	0%
Hydrometer type	g/l	*Variation to method*	-

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	100
1.18	100
0.600	99
0.425	99
0.300	99
0.150	99
0.075	96
0.053	84
0.045	76
0.033	63
0.024	52
0.016	47
0.012	43
0.0083	39
0.0060	34
0.0043	31
0.0030	29
0.0022	26
0.0013	24



Gravel		*Sand*		*Silt*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	0.2%	*coarse*	38.8%	*Gravel*	0.4%
medium	0.1%	*medium*	0.3%	*medium*	15.4%	*Sand*	11.1%
fine	0.3%	*fine*	10.6%	*fine*	8.3%	*Silt*	62.5%
Total	0.4%	*Total*	11.1%	*Total*	62.5%	*Clay*	26.0%
						Total	100.0%

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PARTICLE SIZE DISTRIBUTION

CIVIL GEOTECHNICAL SERVICES
6 - 8 Rose Avenue, Croydon 3136

Job No	15018
Report No	15018/R095
Date of Issue	27/11/15

Client	JACOBS SKM (MELBOURNE)	Tested by	ANR
Project	IS129400 HATTAH LAKES	Date tested	26/11/15
Location	VIA VICTORIA	Checked by	ANR

Sample Identification J-TP1 @ 2.9m

Sample No 15018081

Sample Description

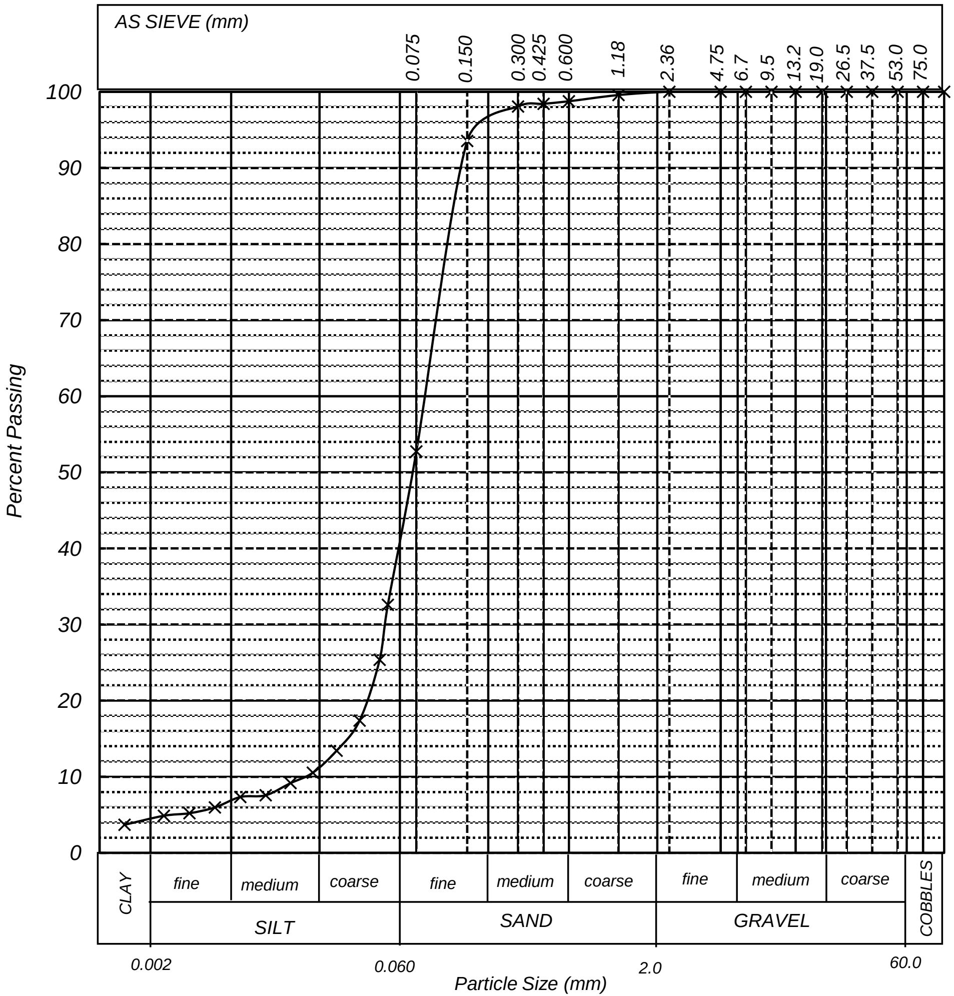
silty SAND, fine to medium, pale brown, fines of low plasticity.

Assumed soil particle density 2.65 g/cm³

AS 1289.3.6.3 - Particle Size Distribution - Standard method of fine analysis using a Hydrometer

Method of dispersion	Mechanical	Loss in pretreatment	0%
Hydrometer type	g/l	Variation to method	-

Particle Size (mm)	Percent Passing
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	100
1.18	100
0.600	99
0.425	98
0.300	98
0.150	94
0.075	53
0.051	33
0.045	25
0.035	17
0.025	13
0.018	11
0.013	9
0.0096	8
0.0068	7
0.0048	6
0.0034	5
0.0024	5
0.0014	4



Gravel		Sand		Silt		Cobbles	0.0%
coarse	0.0%	coarse	1.1%	coarse	29.8%	Gravel	0.1%
medium	0.0%	medium	3.3%	medium	4.5%	Sand	58.7%
fine	0.1%	fine	54.3%	fine	2.4%	Silt	36.7%
Total	0.1%	Total	58.7%	Total	36.7%	Clay	4.5%
						Total	100.0%

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PARTICLE SIZE DISTRIBUTION

CIVIL GEOTECHNICAL SERVICES
6 - 8 Rose Avenue, Croydon 3136

Job No 15018
Report No 15018/R096
Date of Issue 27/11/15

Client JACOBS SKM (MELBOURNE)
Project IS129400 HATTAH LAKES
Location VIA VICTORIA

Tested by ANR
Date tested 25/11/15
Checked by ANR

Sample Identification J-TP3 @ 1.2m
Sample No 15018083

Sample Description

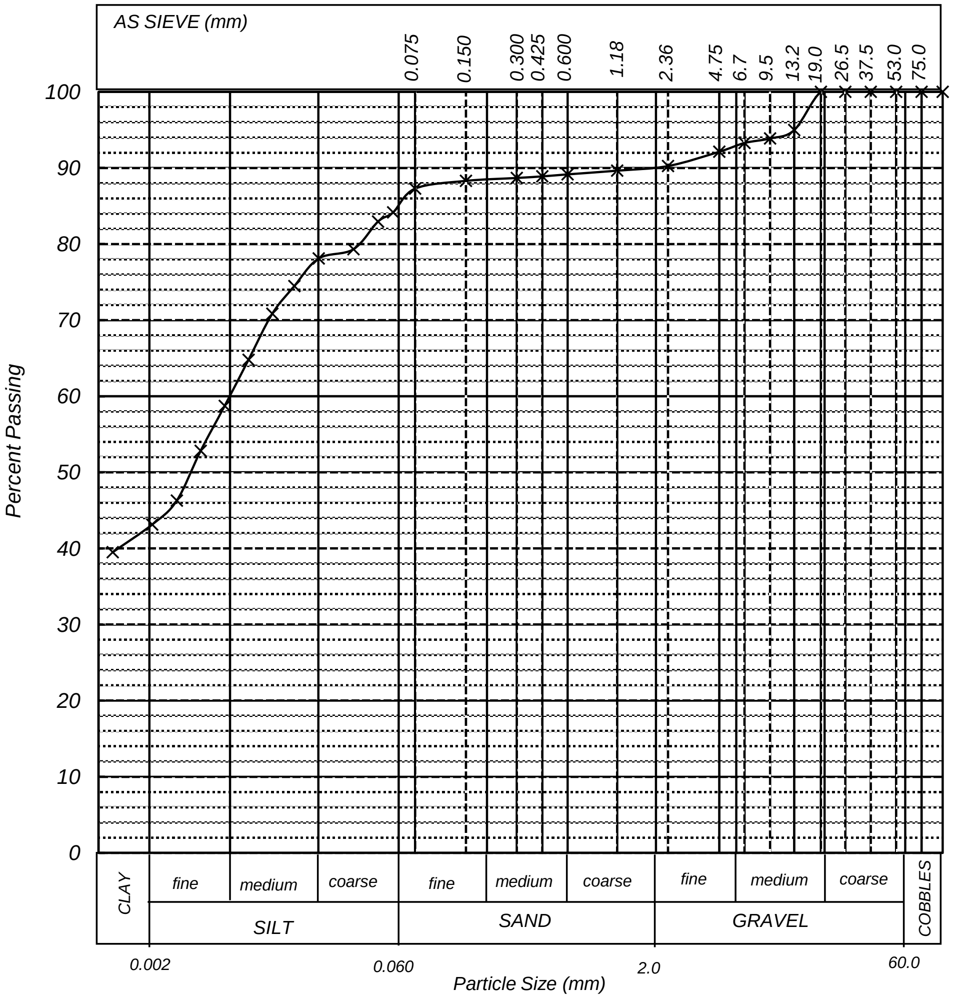
CLAY, high plasticity, grey-brown, trace of fine to medium gravel, trace of fine to coarse sand.

Assumed soil particle density 2.65 *g/cm³*

AS 1289.3.6.1 and 3.6.3 - Particle Size Distribution - Standard method of fine analysis using a Hydrometer

Method of dispersion	Mechanical	*Loss in pretreatment*	0%
Hydrometer type	g/l	*Variation to method*	-

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	95
9.5	94
6.7	93
4.75	92
2.36	90
1.18	90
0.600	89
0.425	89
0.300	89
0.150	88
0.075	87
0.056	84
0.045	83
0.032	79
0.020	78
0.014	74
0.011	71
0.0077	65
0.0056	59
0.0040	53
0.0029	46
0.0021	43
0.0012	40



Gravel		*Sand*		*Silt*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	0.9%	*coarse*	6.9%	*Gravel*	9.9%
medium	7.1%	*medium*	0.7%	*medium*	18.0%	*Sand*	5.1%
fine	2.8%	*fine*	3.5%	*fine*	17.2%	*Silt*	42.1%
Total	9.9%	*Total*	5.1%	*Total*	42.1%	*Clay*	42.9%
						Total	100.0%

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PARTICLE SIZE DISTRIBUTION

CIVIL GEOTECHNICAL SERVICES
6 - 8 Rose Avenue, Croydon 3136

Job No	15018
Report No	15018/R097
Date of Issue	27/11/15

Client	JACOBS SKM (MELBOURNE)	*Tested by*	ANR
Project	IS129400 HATTAH LAKES	*Date tested*	25/11/15
Location	VIA VICTORIA	*Checked by*	ANR

Sample Identification	J-TP4 @ 1.2m	*Sample No*	15018084

Sample Description

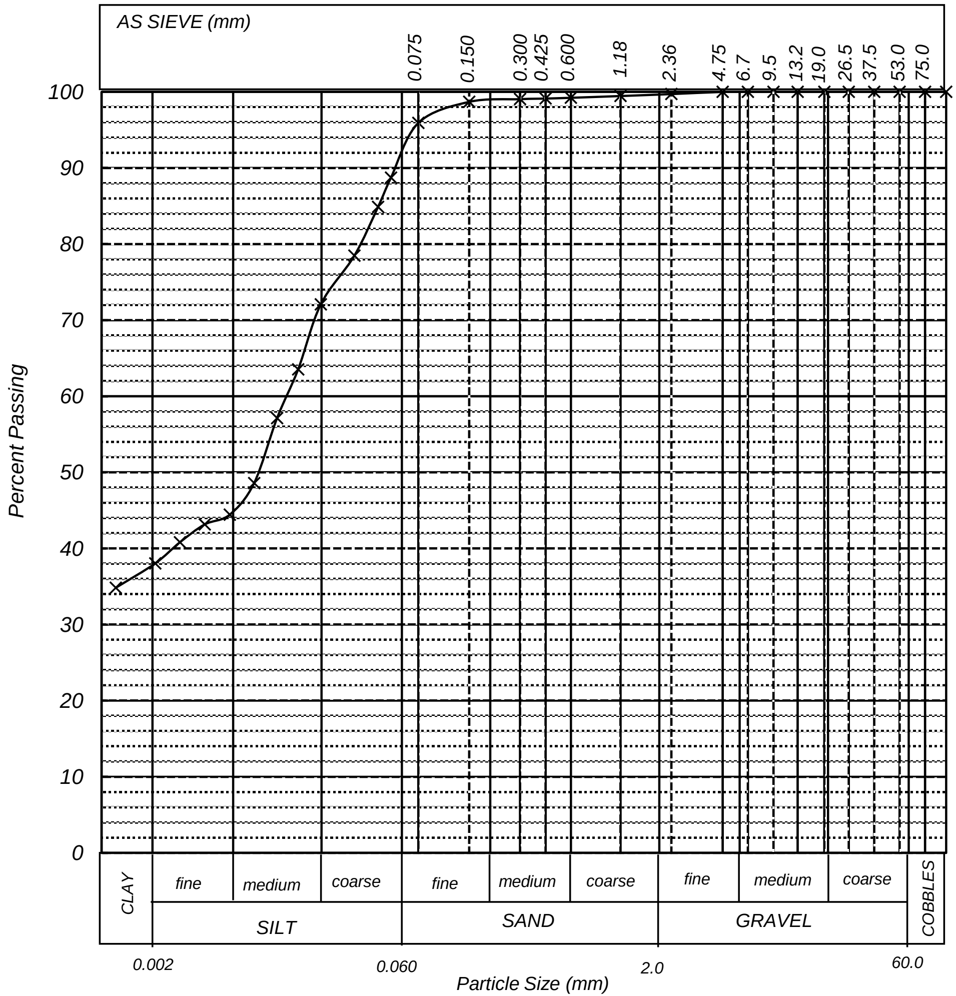
CLAY, medium plasticity, grey and brown, trace of fine sand.

Assumed soil particle density 2.65 *g/cm³*

AS 1289.3.6.3 - Particle Size Distribution - Standard method of fine analysis using a Hydrometer

Method of dispersion	Mechanical	*Loss in pretreatment*	0%
Hydrometer type	g/l	*Variation to method*	-

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	100
1.18	99
0.600	99
0.425	99
0.300	99
0.150	99
0.075	96
0.052	89
0.043	85
0.031	78
0.020	72
0.015	64
0.011	57
0.0080	49
0.0057	44
0.0041	43
0.0029	41
0.0021	38
0.0012	35



Gravel		*Sand*		*Silt*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	0.4%	*coarse*	19.4%	*Gravel*	0.3%
medium	0.0%	*medium*	0.4%	*medium*	27.2%	*Sand*	8.0%
fine	0.3%	*fine*	7.2%	*fine*	7.3%	*Silt*	53.9%
Total	0.3%	*Total*	8.0%	*Total*	53.9%	*Clay*	37.8%
						Total	100.0%

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PARTICLE SIZE DISTRIBUTION

		Job No	15018
CIVIL GEOTECHNICAL SERVICES		*Report No*	15018/R098
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	27/11/15
Client	JACOBS SKM (MELBOURNE)	*Tested by*	ANR
Project	IS129400 HATTAH LAKES	*Date tested*	25/11/15
Location	VIA VICTORIA	*Checked by*	ANR

Sample Identification J-TP6 @ 3.2m

Sample No 15018085

Sample Description

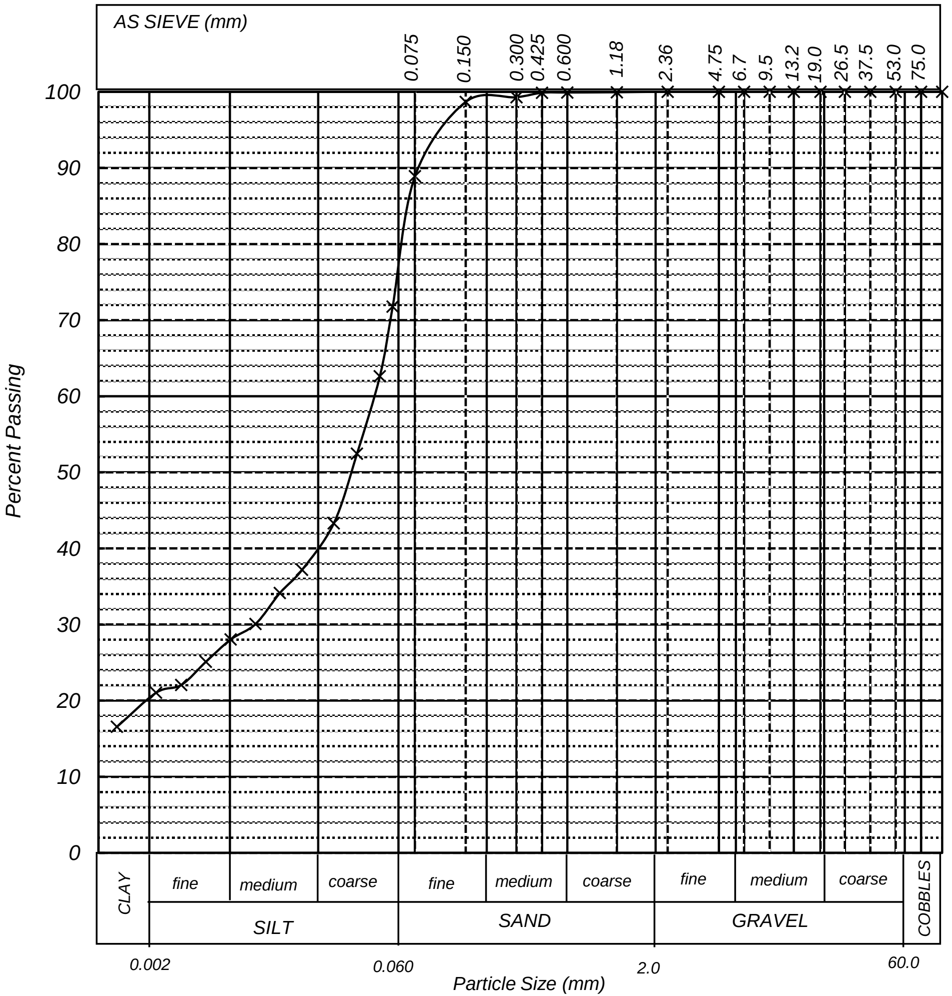
CLAY, medium plasticity, pale brown, with fine sand.

Assumed soil particle density 2.65 *g/cm³*

AS 1289.3.6.3 - Particle Size Distribution - Standard method of fine analysis using a Hydrometer

Method of dispersion	Mechanical	*Loss in pretreatment*	0%
Hydrometer type	g/l	*Variation to method*	-

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	100
1.18	100
0.600	100
0.425	100
0.300	99
0.150	99
0.075	89
0.055	72
0.046	63
0.034	52
0.025	43
0.016	37
0.012	34
0.0085	30
0.0061	28
0.0043	25
0.0031	22
0.0022	21
0.0013	17



Gravel		*Sand*		*Silt*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	0.1%	*coarse*	36.1%	*Gravel*	0.0%
medium	0.0%	*medium*	1.0%	*medium*	12.3%	*Sand*	23.7%
fine	0.0%	*fine*	22.6%	*fine*	7.6%	*Silt*	56.0%
Total	0.0%	*Total*	23.7%	*Total*	56.0%	*Clay*	20.3%
						Total	100.0%

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STANDARD COMPACTION

AS 1289.5.1.1

Job No 15018

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon, Vic 3136

Report No 15018/R099

Date of Issue 27/11/15

Client JACOBS SKM (MELBOURNE)

Project IS129400 HATTAH LAKES

Location VIA VICTORIA

Tested by AG

Date tested 18/11/15

Checked by ANR

Sample Identification J-TP1 @ 1.6m

Sample No 15018080

Sample Description

CLAY, medium plasticity, pale brown, trace of fine sand.

Sampled by Client

Sampling date 2015

Oversize material retained on 19.0mm sieve = 0 %

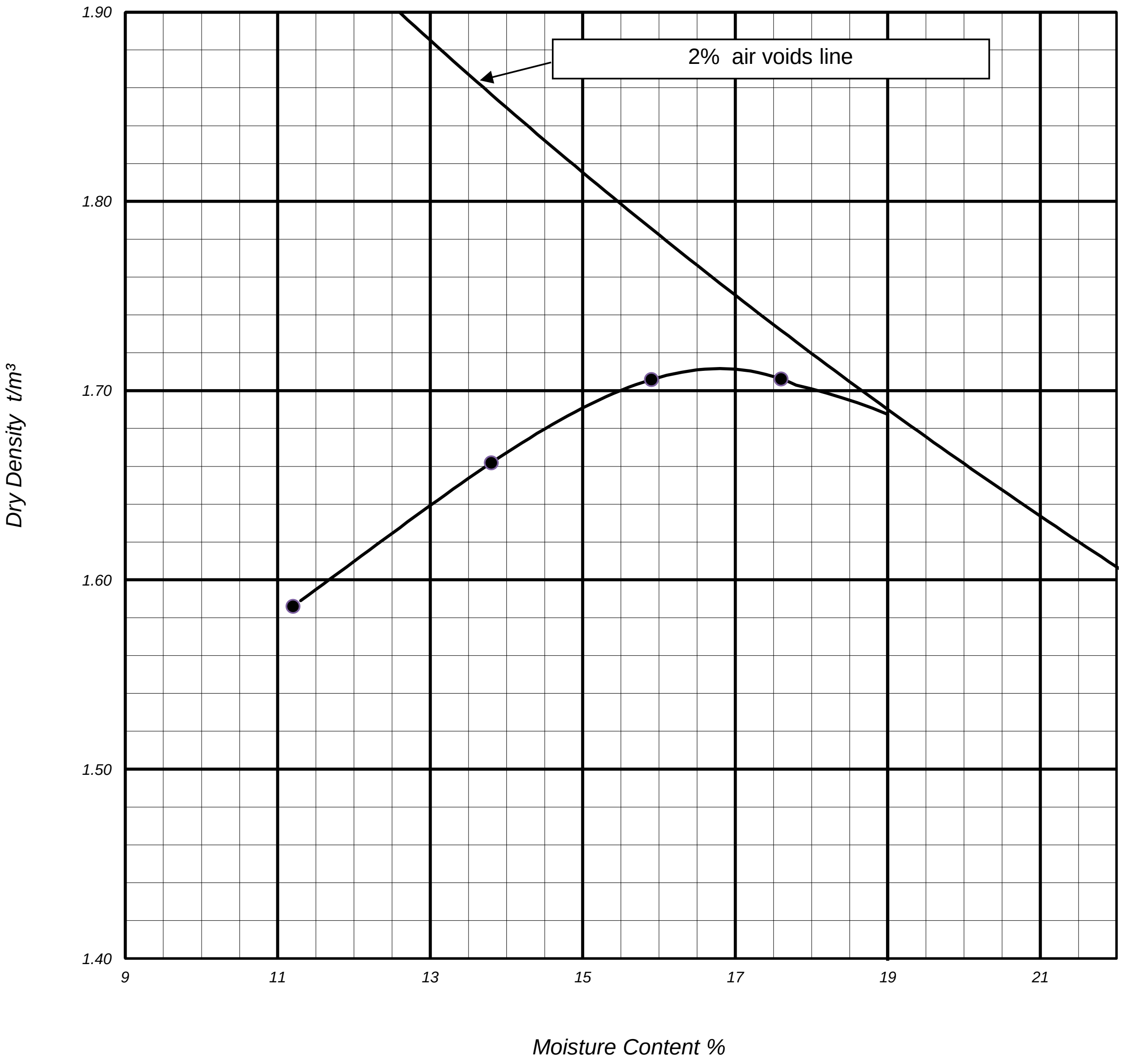
Mould Type A

Maximum Dry Density 1.71 *t/m³*

Optimum Moisture Content 17.0 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.57 *t/m³*



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STANDARD COMPACTION

AS 1289.5.1.1

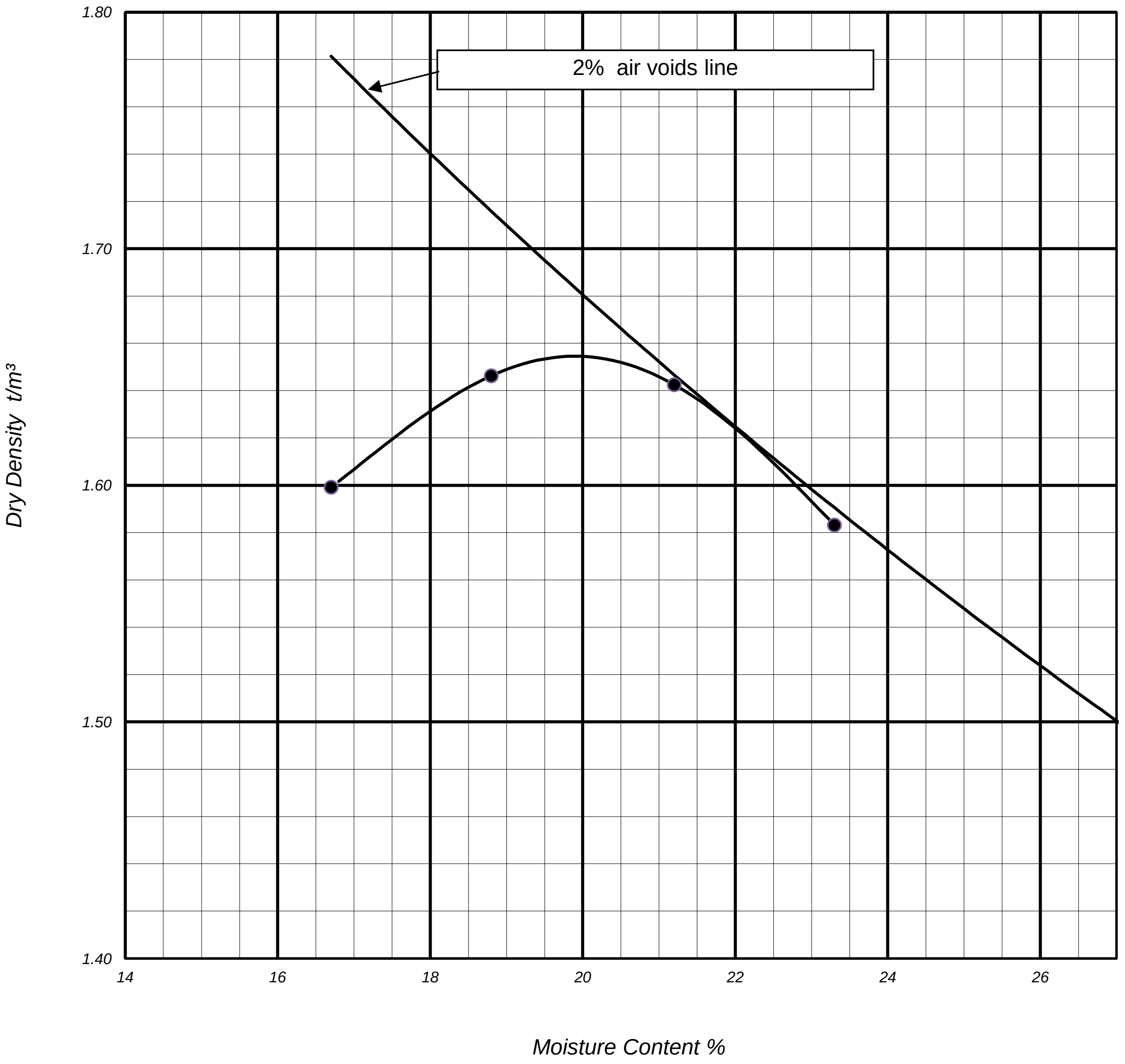
Job No	15018
Report No	15018/R100
Date of Issue	27/11/15

CIVIL GEOTECHNICAL SERVICES
6 - 8 Rose Avenue, Croydon, Vic 3136

Client	JACOBS SKM (MELBOURNE)	*Tested by*	AG
Project	IS129400 HATTAH LAKES	*Date tested*	19/11/15
Location	VIA VICTORIA	*Checked by*	ANR
Sample Identification	J-TP4 @ 1.2m	*Sample No*	15018084
Sample Description		*Sampled by*	Client
CLAY, medium plasticity, grey and brown, trace of fine sand.		*Sampling date*	2015
Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.65 *t/m³*	*Optimum Moisture Content*	20.0 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.61 *t/m³*



AS512-R7-OCT 09

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STANDARD COMPACTION

AS 1289.5.1.1

Job No	15018
Report No	15018/R101
Date of Issue	27/11/15

CIVIL GEOTECHNICAL SERVICES

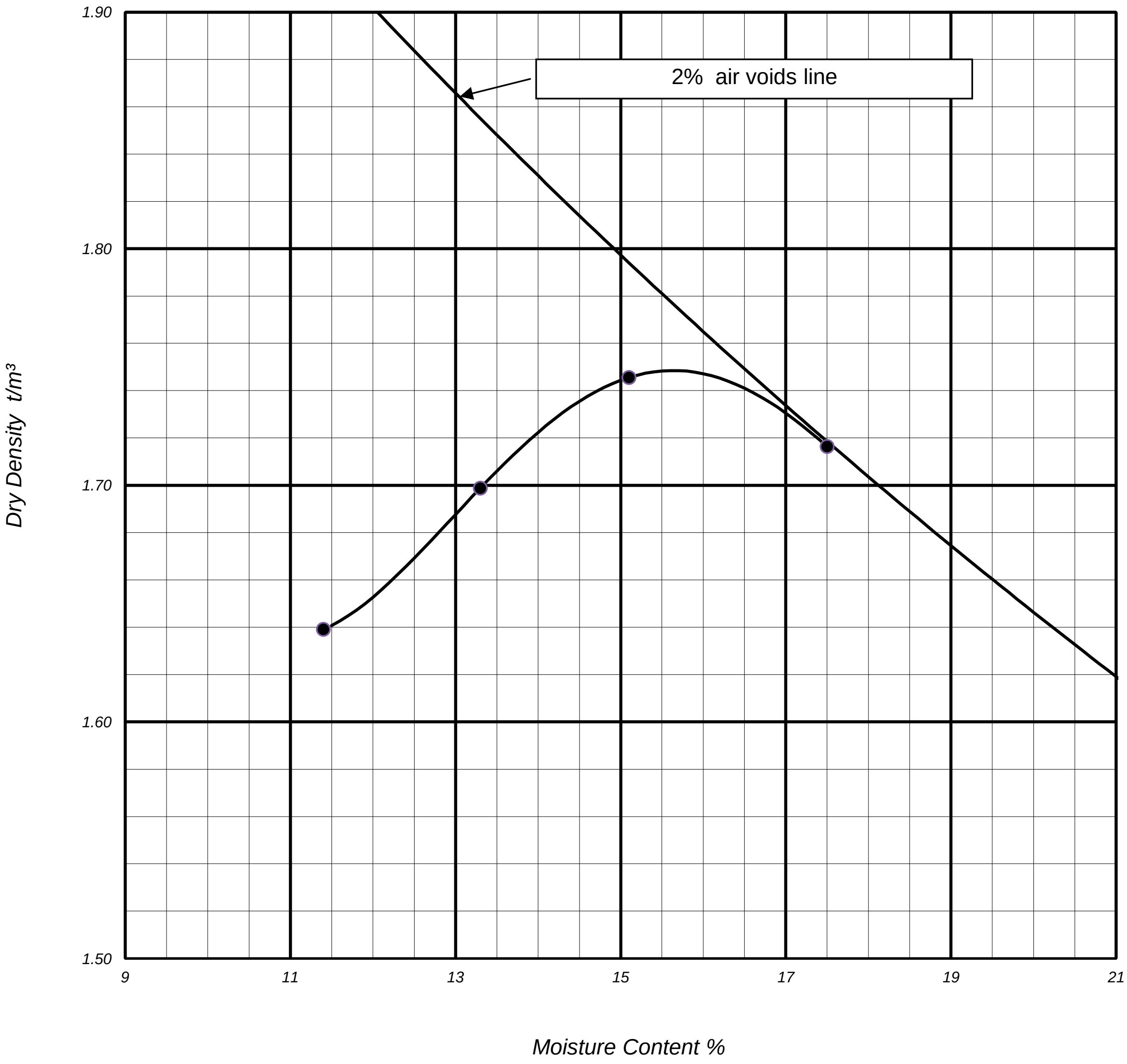
6 - 8 Rose Avenue, Croydon, Vic 3136

Client	JACOBS SKM (MELBOURNE)	*Tested by*	AG
Project	IS129400 HATTAH LAKES	*Date tested*	20/11/15
Location	VIA VICTORIA	*Checked by*	ANR
Sample Identification	J-TP8 0.6 - 1.6m	*Sample No*	15018086
Sample Description	CLAY, medium plasticity, pale brown, with fine sand.	*Sampled by*	Client
		Sampling date	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.75 *t/m³*	*Optimum Moisture Content*	15.5 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.53 *t/m³*



AS512-R7-OCT 09

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TEST RESULTS

AS 1289.2.1.1, 3.1.1, 3.2.1, 3.3.1, 3.4.1, 3.6.1 & 3.8.1

CIVIL GEOTECHNICAL SERVICES
6 - 8 Rose Avenue, Croydon 3136

Job No	15018
Report No	15018/R102
Date of Issue	27/11/15
Client	JACOBS SKM (MELBOURNE)
Project	IS129400 HATTAH LAKES
Location	VIA VICTORIA
Tested by	SK
Date tested	18-26/11/15
Checked by	ANR

Sample Identification	*Soil Description*	*Field Moisture Content* %	*Liquid Limit* %	*Plastic Limit* %	*Plasticity Index* %	*Linear Shrinkage* %	*% Passing 75µm sieve*	*Emerson Class No**
15018080 J-TP1 @ 1.6m	CLAY, medium plasticity, pale brown, trace of fine sand.	11.3	38	19	19	9.0	96	2
15018081 J-TP1 @ 2.9m	silty SAND, fine to medium, pale brown, fines of low plasticity.	4.9	24	21	3	1.0	53	3
15018082 J-TP2 @ 2.9m	silty SAND / SAND, fine to medium pale brown, trace of low plastic fines	5.9	25	22	3	1.0	-	-
15018083 J-TP3 @ 1.2m	CLAY, high plasticity, grey-brown, trace of fine to medium gravel, trace of fine to coarse sand.	16.9	55	21	34	15.0	87	3
15018084 J-TP4 @ 1.2m	CLAY, medium plasticity, grey and brown, trace of fine sand.	19.0	46	21	25	12.0	96	-
15018085 J-TP6 @ 3.2m	CLAY, medium plasticity, pale brown, with fine sand.	14.4	35	21	14	7.5	89	2
15018086 J-TP8 0.6 - 1.6m	CLAY, medium plasticity, pale brown, with fine sand.	11.7	35	18	17	9.0	-	-

Notes

AS 1289.3.1.1,3.2.1,3.4.1	*Method of drying:*	Oven dried	*AS 1289.3.8.1**	*Water used:*	Distilled water
	Dry/Wet sieve:	Dry		*Temperature:*	20.2 °C
	Curing time:	>24hrs		*Date sampled:*	2015

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