# ARO INDUSTRIES

## DON RIVER STREAMBANK GEOTECHNICAL REPORT

# DOCUMENT CONTROL SHEET

**Title:** Don River Streambank Geotechnical Report

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**Client:** Banana Shire Council

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**Client Reference:** Don River Streambank

**Purpose:** A geotechnical assessment of the site stability and proposed stabilization of Don River Streambank at Kelly's Road, Banana Shire.

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## EXECUTIVE SUMMARY

At the request of Orion Project Consulting (Orion) ARO Industries Pty Ltd (ARO) has undertaken a geotechnical assessment for the proposed remediation works to the scour damage that occurred along 160m of the Don River Streambank affecting Kellys Road, Dixalea. The scour damage is visible along the toe of the batter indicating potential for instability.

A site investigation was undertaken by Douglas Partner Pty Ltd (Douglas) involving the drilling of two boreholes to approximately 20m below ground level. Stability modelling was undertaken based on the stratigraphy encountered during the investigation and inferred parameters were assumed based on these results. Modelling indicates that the existing batter does not meet the minimum batter stability requirements and that remediation of the batter would is required. Various remediation methods were considered, however, the recommended remediation for the site involves a combination of rock protection and soil nails.

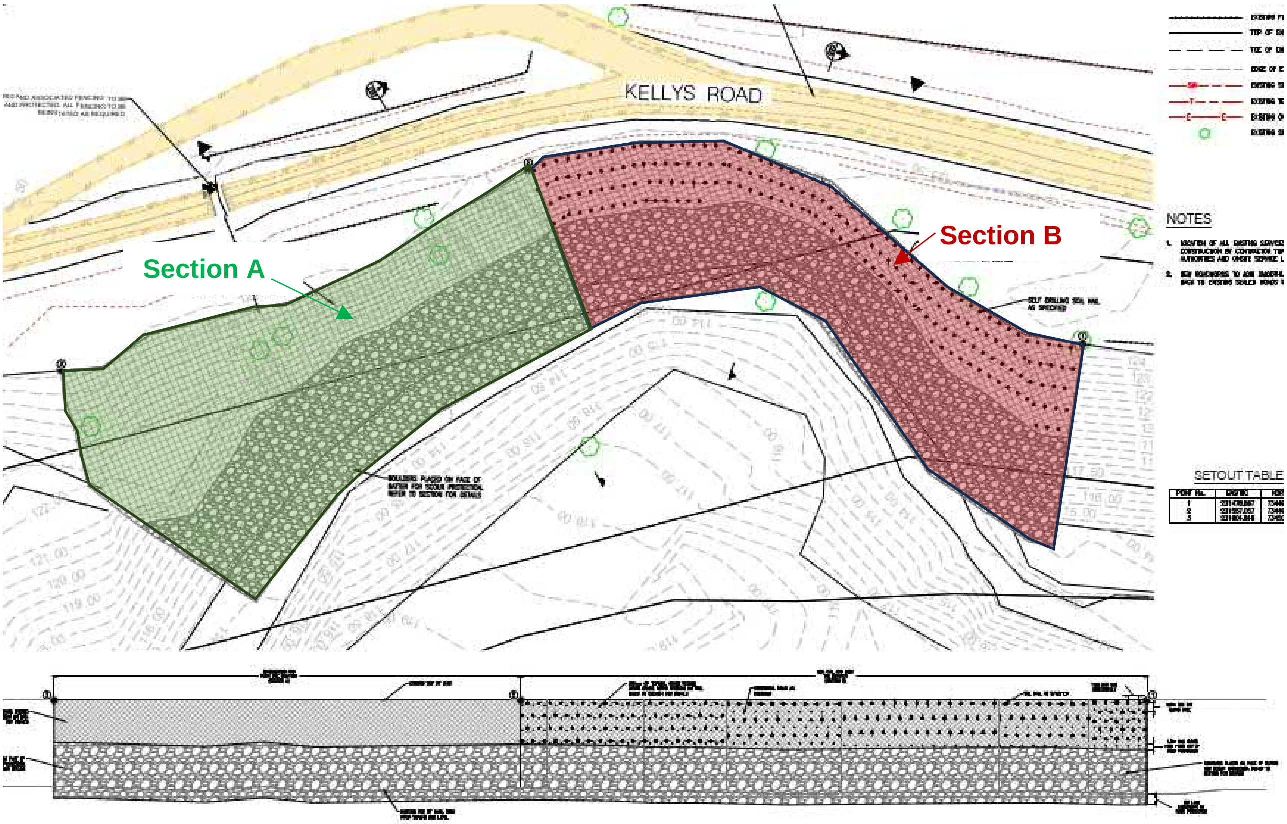

Figure 1: Overall Schematic of bank stabilisation works

It is proposed to stabilise the green shaded portion (Section A), with rock protection at the base of the bank up to approximately 6m in height. The top portion will be revegetated. The red section of the bank (Section B) will have the same rock protection works on the lower portion of the site, but soil nails are recommended to the upper portion of the batter. The soil nails were required in the red Section B, to ensure that the batter stability met factor of safety requirements for dry and saturated conditions.

The report details the process undertaken to reach the recommended solution.

# 1. INTRODUCTION

This report has been prepared as supporting information for the proposed remediation to Don River Streambank scour damage affecting Kelly's Road, Dixalea. Orion Project Consulting (Orion) Pty Ltd. have commissioned the report on behalf of Banana Shire Council.

The report outlines the geotechnical stability assessment of the site and investigates alternative remediation options that could be used to stabilise the site. Figures 1 and 2 show the location and extent of the slip.

*Figure 1 – Locality Plan of Site (source: Queensland Globe)*

*Figure 2 – Plan view of site showing extent of the erosion*

# 2. SITE UNDERSTANDING

## 2.1. Site Overview

The Don River originates in the Calliope Range in the Don River State Forest and flows in westerly direction until it joins with the Dawson River at Gainsford. The site is located approximately 15 km upstream of its confluence point with Callide Creek, a major tributary of the Don River, and approximately 86 km upstream of the Dawson River. The landslide is located on the outside of the low flow channel and is approximately 12m high and 160m in length located on the south-eastern side of Don River streambank. The batter failure is evidenced by the vertical scarp which has formed at the crest of the batter, which is located adjacent to the road as illustrated in Figure 4.

*Figure 3 – Active erosion of the toe of the batter*

*Figure 4 – Photo showing the geotechnical failure of the batter immediately adjacent to Kelly's Road*

## 2.2. Previous Reports

The author is aware of the following previous reports for the site.

1) An Options Assessment Report (by ARO, dated 8 May 2023).
2) A geotechnical investigation factual report (Douglas Partners, dated 8 November 2023.

Copies of each of the reports are provided in Appendix B.

## 2.3. Site Geology

The Geological Survey of Queensland's detailed surface geology mapping indicates the site is underlain by Quaternary aged floodplain alluvium described as typically comprising "Clay, silt, sand and gravel". The floodplain alluvium is expected to be underlain at depth by Eocene aged Biloela Formation. An extract of the maps from Queensland Globe is shown in Figure 5.

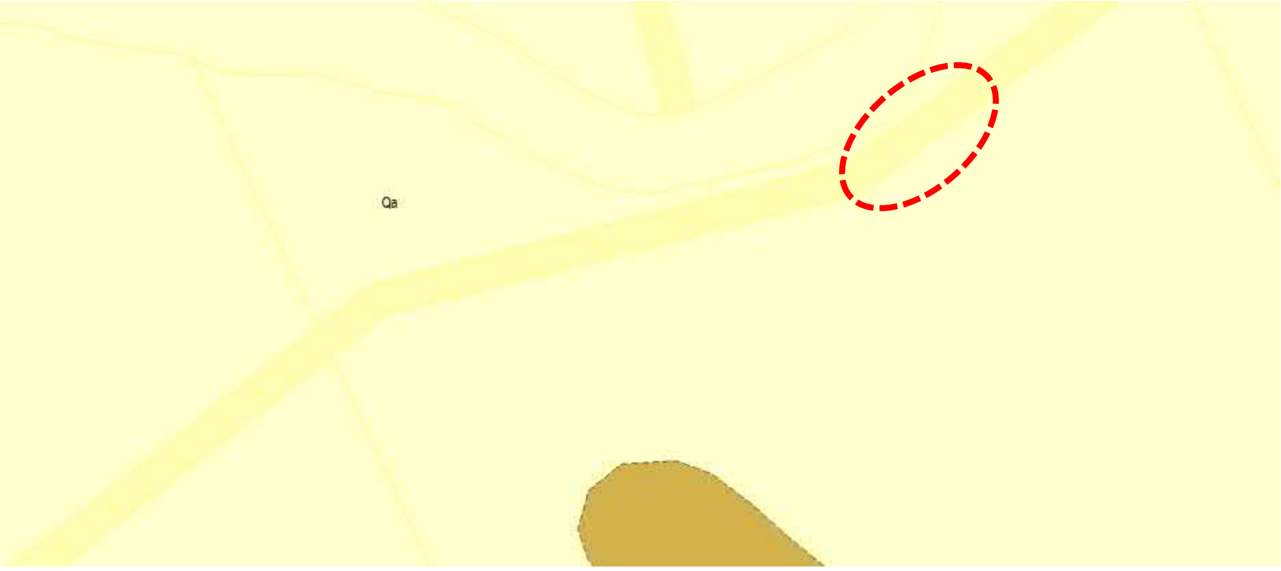

*Figure 5 - Geological Survey of Queensland's 1:100,000 Series Map*

## 2.4. Tenure

The location of the landslip relative to the council tenure is illustrated in Figure 6 and Figure 7. Based on available information - Queensland Globe and Digital Cadastral Database (DCDB) survey, (refer to Figure 6 and Figure 7 respectively), it is important to note the following:

- Generally, the crest of the slip lies within Lot 10/RN1393 (shaded pale blue) with the batter and toe of the slip in the road reserve (shaded yellow).
- Kelly's Road currently lies outside the perimeter of the council road reserve.
- The location of the landslip is within an existing waterway (Don River).

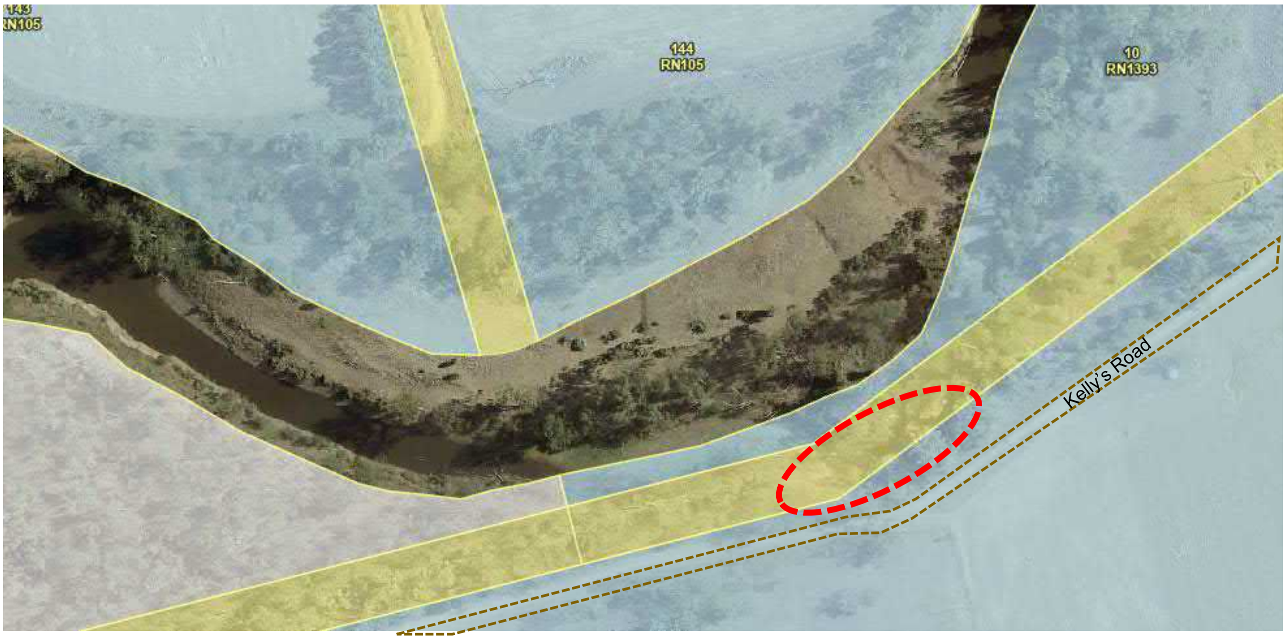

*Figure 6 – Tenure of Landslip on Don River Streambank*

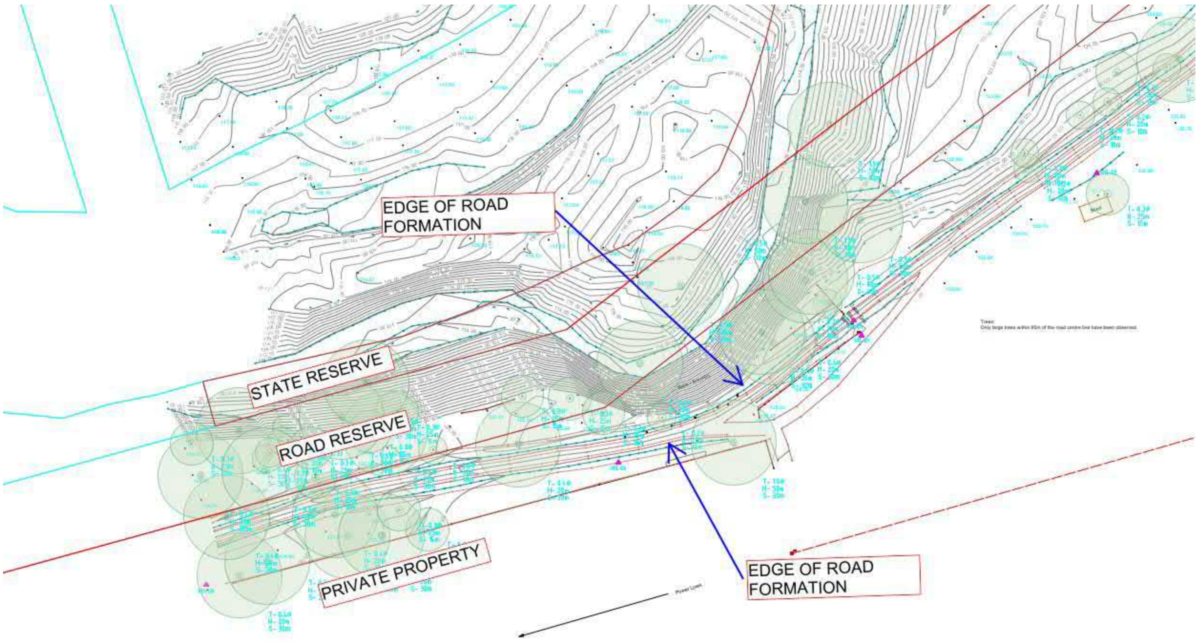

*Figure 7 – Digital Cadastral Database (DCDB) Engineering survey*

A cadastral survey is recommended to confirm lot/road reserve boundaries.

## 3. SITE CONSTRAINTS

A site constraint analysis was provided in the options assessment report (Appendix B). A brief overview of the primary constraints is provided below.

### 3.1. Planning Overlays

### 3.1.1. Native Vegetation Mapping

The site has been identified as containing vegetation which is a matter of State Environmental Significance (MSES). The site is identified as containing vegetation in Category B on the regulated. vegetation management map (Figure 8).

*Figure 8 – Regulated Vegetation management Map highlighting category B (Remnant Vegetation*

Figure 9 illustrates Category X the area which are typically exempt from clearing restrictions under the *Vegetation Management Act 1999*.

*Figure 9 – Regulated Vegetation management map highlighting category X.*

### 3.1.2. Fish Habitat Areas

Don River is s declared fish habitat area (FHA) and is identified as a purple category waterway by the Department of Agriculture and Fisheries (DAF).

Fish Habitat Areas (FHA) are areas protected from physical disturbance associated with coastal development and declared under Queensland's *Fisheries Act 1994*. They are part of Australia's Nationally Representative System of Marine Protected Areas and fit within the International Union for the Conservation of Nature and Natural Resources (IUCN) Protected Area Management Category VI - 'Managed Resource Protected Area'.

Development works in declared FHAs require application for a resource allocation authority under the *Fisheries Act 1994* and a development approval under the *Planning Act 2016*, unless the works comply with the accepted development requirements. Development assessment in declared FHAs is provided by the Department of Agriculture and Fisheries on behalf of the department.

The DAF manages these waterways and provide guidelines to what works are allowable to be undertaken. The proposed remediation will involve remediation on the exiting bank and therefore within a waterway.

When any work is undertaken within a fish habitat area (FHA), then the works must be: -

i) Be classified as excepted works [1] OR

ii) Comply with the Accepted Development Requirements[2], OR

iii) Apply for a development approval which meets the requirements of the State Development Assessment Provisions (SDAP) Code 18 – Constructing or raising of waterway barrier works[3].

Based on information provided by Queensland Government Department of Agriculture and Fisheries (https://www.daf.qld.gov.au/business-priorities/fisheries/habitats/policies-guidelines/factsheets/what-is-not-a-waterway-barrier-work), several works and types of structures have been excluded from consideration as waterway barrier works based on their minimal impact to fisheries productivity. Below is an excerpt of works **not** considered waterway barrier works include:

- *Bank revetment or another bank stabilisation works when they:*
    - *fill minor erosion pockets to regularise the bank of the waterway.*
    - *in waterways less than 50m wide at the main channel width, do not extend into the waterway beyond the toe of the bank, or raise the bed level of the waterway above its natural profile.*

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[1] https://www.business.qld.gov.au/industries/farms-fishing-forestry/fisheries/development/waterways/barriers

[2] https://www.publications.qld.gov.au/dataset/fisheries-development-activities/resource/011a916e-30ad-4f52-87e9-f9c5a6b2532f

[3] https://planning.statedevelopment.qld.gov.au/planning-framework/state-assessment-and-referral-agency/state-development-assessment-provisions-sdap

- *in waterways greater than 50m wide at the main channel width, do not extend beyond 10% of the width of the waterway (main channel width), or raise the bed level of the waterway above its natural profile (both maintenance and new works).*

The proposed remediation falls within these guidelines, they are not considered waterway barrier works. This is an important finding.

### 3.1.3. Engineering Constraints

Several engineering factors were considered in the proposed remediation. These include:

- Geotechnical Stability and scour protection to the batter
- Road location – it is understood that the preference is not relocate the road away from the existing alignment.
- Budget
- Constructability – considering accessibility, local civil construction resource, specialisation of the works.
- Ongoing Maintenance – preference for a low maintenance and durable remediation option, which can be maintained within the council's existing workforce and skill set.

# 4. SITE CHARACTERISATION

## 4.1. Subsurface Conditions

A fieldwork investigation was undertaken by Douglas Partners on 8 November 2023 which involved the drilling of two boreholes to depths ranging from 19.45m to 19.95m below ground level (BGL) with standard Penetration Testing (SPT) conducted at 1.5m intervals.

Test locations are shown in Figure 10 and a detailed description of the investigation findings is presented in the Douglas Partners geotechnical report provided in Appendix B.

*Figure 10 – Test location plan (Douglas Partners)*

Based on the conditions encountered at the boreholes the embankment is underlain by at least 20 m of alluvial sediments comprising of interbedded sequences of silty clay, sandy clay, and clayey sandy gravel. Note, rock was not intercepted within the boreholes and the depth of alluvial sediments within the profile is not known.

Results from laboratory testing that was undertaken on selected samples from the site is included in Appendix B.

### 4.2. Groundwater Conditions

Groundwater was not encountered during investigation activities due to the introduction of drilling fluid at 2.5m depth in both boreholes. It is anticipated that groundwater conditions would fluctuate depending on prevailing weather conditions and groundwater seepage may develop in more permeable horizons in the soil.

## 5. GEOTECHNICAL ASSESSMENT OF PROPOSED SLOPE STABILISATION OPTIONS

### 5.1. Methodology

The approach to modelling the risk of slope stability for the site was undertaken in a two-stage process:

i) The existing and proposed slopes were assessed using the Landslide Risk Assessment Framework as outlined by the Australian Geomechanics Society (2007).

ii) The detailed assessment of slope stability was undertaken using a limit state equilibrium analysis, using the proprietary software Rocscience SLIDE 2.

### 5.2. Risk Assessment (AGS 2007)

A risk assessment of the site was undertaken in accordance with the Australian Geomechanics Society (AGS) 2007 Guidelines for landslide risk assessment and results are summarised in Table 1.

*Table 1 - Qualitative assessment of risk to property due to future site works*

| | Potential Hazard | Risk to | Condition | WITHOUT Engineering Controls | | | Engineering Controls to Reduce Risk | WITH Engineering Controls | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Consequence | Likelihood | Qualitative Risk | | Consequence | Likelihood | Qualitative Risk |
| Existing | Earth slides in 1V:3H to 1V:2.5H (18-22 degree) slopes on site | Road (Roadway) | Dry | Minor | Rare | Very Low | Provide adequate drainage and erosion protection, including lined drains at the crest of batters. Vegetate existing, exposed batter slopes with deep rooted, native species. Use vegetation matting (or approved equivalent) to assist with seeding/ germination/ establishment and erosion protection. | Minor | Rare | Very Low |
| | | | Wet | Minor | Unlikely | Low | | Minor | Rare | Very Low |
| | Earth slides in 1V:1.5H to 1V:1H (34-45 degree) slopes on site | Road (Roadway) | Dry | Medium | Likely | High | Positive retention of the slope is recommended to reduce risk of slope failure | Refer to Future/ Proposed | | |
| | | | Wet | Medium | Almost Certain | Very High | | | | |
| Future/ Proposed | Earth slide in future cut batters less than 1V:3H to 1V:2.5H (18-22 degree) | Road (Roadway) | Dry | Minor | Rare | Very Low | Provide adequate drainage and erosion protection, including lined drains at the crest of batters. Vegetate existing, exposed batter slopes with deep rooted, native species. Use vegetation matting (or approved equivalent) to assist with seeding/ germination/ establishment. | Minor | Rare | Very Low |
| | | | Wet | Minor | Unlikely | Low | | Minor | Rare | Very Low |
| | Earth slide in future cut batters greater than1V:2.5H (~22 degrees) | Road (Roadway) | Dry | Medium | Unlikely | Low | Limit batter/bench heights to appropriate heights or provide positive support/retention. Stable batter profiles should be designed and certified by a suitably qualified and experienced RPEQ.<br>Provide adequate drainage and erosion protection, including lined drains at the crest and toe of batters. Vegetate existing, exposed batter slopes with deep rooted, native species. Use vegetation matting (or approved equivalent) to assist with seeding/ germination/ establishment and erosion protection. | Medium | Rare | Low |
| | | | Wet | Medium | Possible | Moderate | | Medium | Rare | Low |
| | Earth slides in future fill batters | Road (Roadway) | Dry | | | | Not applicable - No fill batters proposed for future works | | | |
| | | | Wet | | | | | | | |
| | Failure of future retention structure and resulting earth slide | Road (Roadway) | Dry | Major | Barely Credible | Very Low | Suitably designed and certified retention systems to be installed - Provide adequate drainage and erosion protection, including lined drains at the crest and toe of batters. | Major | Barely Credible | Very Low |
| | | | Wet | Major | Rare | Low | Vegetate existing, exposed batter slopes with deep rooted, native species. Use vegetation matting (or approved equivalent) to assist with seeding/ germination/ establishment and erosion protection. | Major | Rare | Low |
| | Degradation of earth batters | Road (Roadway) | Dry | Minor | Likely | Moderate | Provide adequate drainage and erosion protection, including lined drains at the crest of batters<br>Vegetate existing, exposed batter slopes with deep rooted, native species. Use vegetation matting (or approved equivalent) to assist with seeding/ germination/ establishment and erosion protection.<br>Provide erosion control at locations of high erosion potential (riverbanks, creek banks, stormwater outlets and/ or flow paths.) | Minor | Rare | Very Low |
| | | | Wet | Minor | Almost Certain | High | | Minor | Unlikely | Low |

The qualitative risk to property of the existing slopes at less than 1V:2.5H was assessed as between “Very Low” to “Low” without engineering controls. Normally regulators accept risk levels of “Low” or “Very Low” when assessed in accordance with AGS (2007). Where risks levels are assessed to be above these limits, engineering controls are typically introduced to reduce the risks to acceptable levels.

The survey of the existing sites indicate that the batters are steeper and are between 1V:2.5H. The assessment of risk for these slopes indicated a high - very high level of risk. In such circumstances engineering controls are required to reduce the risk levels to acceptable levels.

A limit state analysis of the existing condition and proposed solution was undertaken to confirm the suitability of the preferred option.  Section 6.3 describes the process and findings of the modelling.

### 5.3. Limit State Analysis

Limit State Analysis of the sites was undertaken using the proprietary software Rocscience Slide. The type and extent of engineering controls required were determined by modelling the existing conditions and then applying increasing levels of support until the required factors of safety have been reached.

#### 5.3.1. Geotechnical Model

For geotechnical characterization of the site, a geotechnical model was formulated based on the stratigraphy encountered during the geotechnical investigation activities carried out by Douglas Partners, 2023 (Appendix B).  The existing slope geometry was adopted from the DCDB survey information. The locations of the sections analysed are presented in Figure 11.  Figure 12 and Figure 13 illustrate the interpolated ground conditions based on the geotechnical units encountered during the investigation. A 15 kN/m$^2$ loading was applied to account for any live (vehicular) loads.

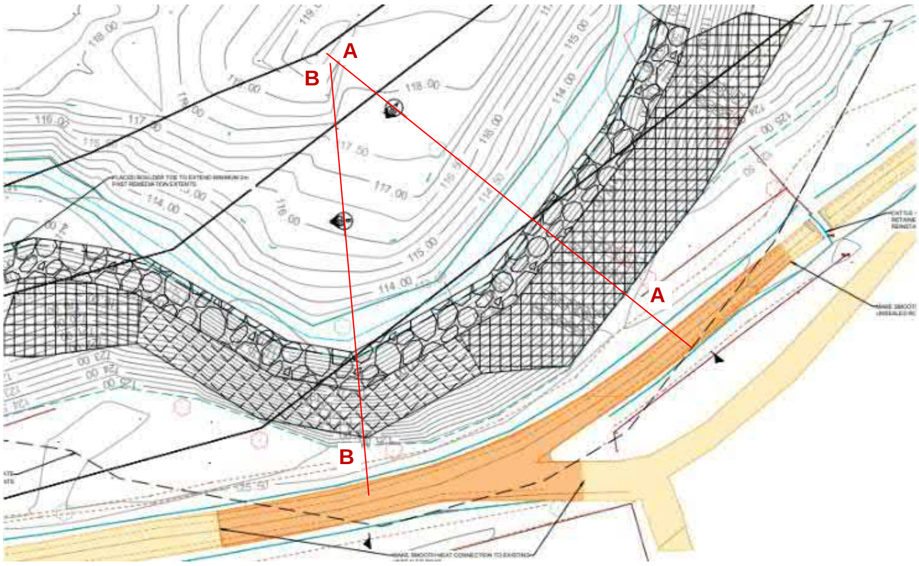

Figure 11 – Plan illustrating location of sections A-A’ and B-B’

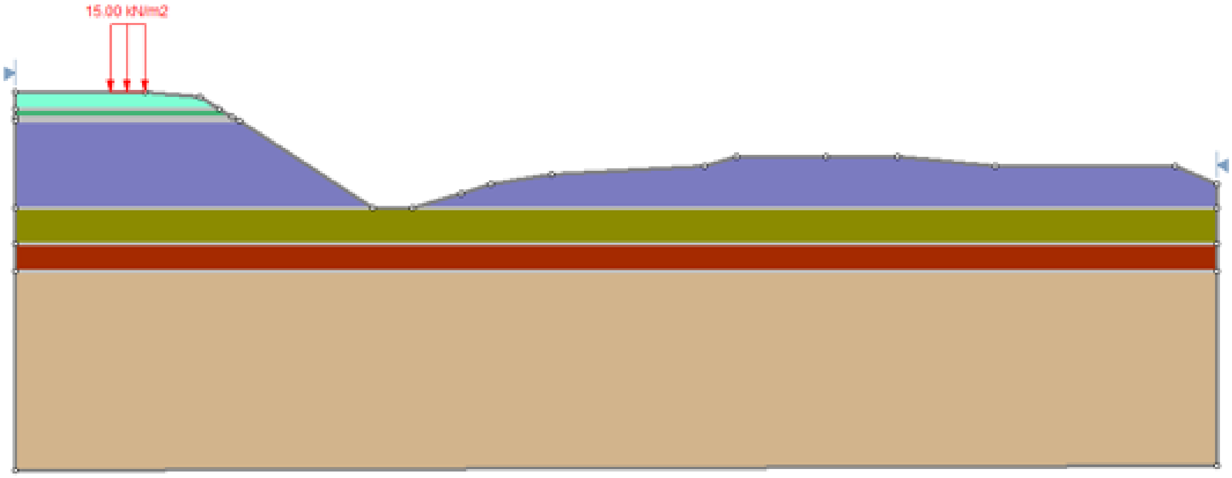

Figure 12 – Section A-A’ with interpreted ground conditions based on report provided by Douglas Partners

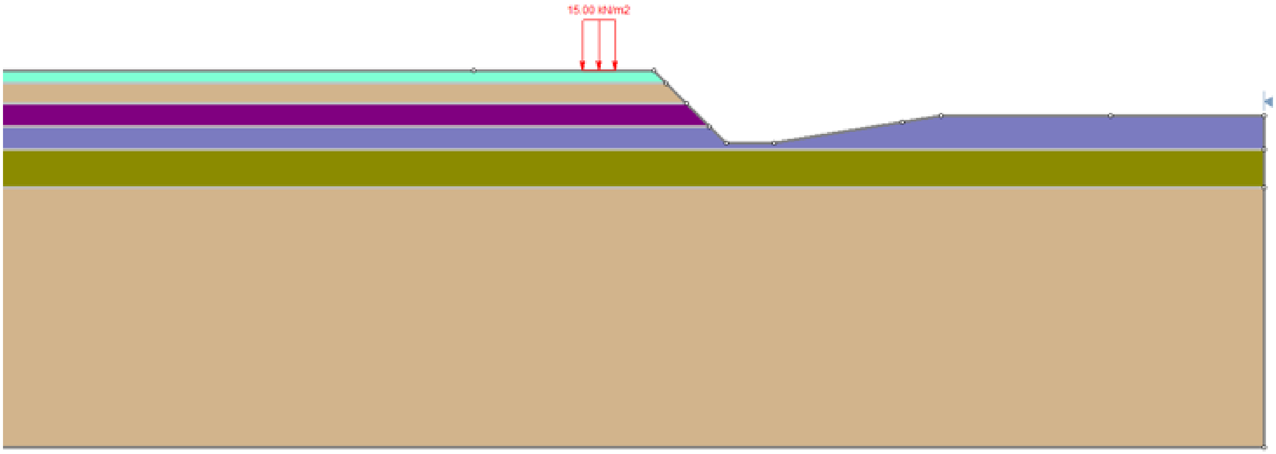

*Figure 13 – Section B-B’ with interpreted ground conditions based on report provided by Douglas Partners*

### 5.3.2. Material Properties (Mohr Coulomb)

Geotechnical design parameters adopted in the design has been formulated based on the geological origin as well as stratigraphic units identified during investigation activities. The geotechnical parameters adopted for each unit type are based on a combination of in situ test results, laboratory test results, and correlations and estimations based on descriptions from the boreholes logs and experience. A summary of the parameters adopted in the geotechnical assessment are provided in Table 2.

*Table 2 - Material Parameters*

| Material Description<br>Strength Type / Mohr Coulomb | Bulk Density $\gamma_b$ (kN/m$^3$) | Drained (“Effective”) Soil Parameters | | Undrained (Total) Soil Parameters |
|---|---|---|---|---|
| | | Cohesion c’ (kPa) | Friction angle $\phi$’ (degrees) | Undrained Shear Strength , $S_u$ (kPa) |
| Sandy Clay<br>(Stiff) | 18 | 3 | 22 | 25 |
| Clayey SAND *1<br>(Medium Dense) | 20 | 2 | 30 | - |
| Silty CLAY<br>(Very Stiff) | 19 | 5 | 28 | 150 |
| Silty CLAY<br>(hard) | 20 | 10 | 28 | 200 |
| Clayey Sandy GRAVEL<br>(Dense) | 20 | 4 | 35 | - |
| Sandy Gravelly CLAY*1<br>(Very Stiff-Hard) | 20 | 8.5 | 30 | 175 |
| Sandy CLAY<br>(hard) | 20 | 10 | 30 | 200 |

*1 Material only encountered in Section A-A

The shear strength of rockfill is dependent on the effective confining stress (or effective stress normal to the shear surface). This is evident by the ability of rockfill to stand at steep angles without ravelling due to interlocking of large particles at low effective stresses. Research has shown that the angle of shearing resistance ($\emptyset'$) for rockfill is significantly higher under low effective stresses (i.e. near the surface) than it is at higher effective stresses due to dilatant behaviour during shearing. The Barton model has been adopted as a material strength for the rockfill with parameters detailed in Table 3.

*Table 3 - Material properties (Strength Type – Barton-Bandis)*

| Material Description<br>Strength Type – Barton-Bandis | Bulk Density (kN/m$^3$) | Joint Roughness Coefficient<br>JRC | Joint Wall Compressive strength JCS (kPa) | Residual Friction Angle (degrees) |
|---|---|---|---|---|
| Rock Fill (Scour Protection) | 20 | 6 | 40000 | 30 |

### 5.3.3. Slope Stability Assessment

*Condition States*

The stability analysis for the selected profiles were performed for.

- **Dry** ("normal") conditions and
- Two variants of the (2) wet ("extreme") conditions. These are referred to as ***saturated drained*** and ***saturated undrained***.

The drained and undrained conditions refer to the rate of loads being applied to the soil matrix and the consequential ability of water to drain from the same matrix.

In the undrained condition loads are applied quickly. The loads are transferred into the soil-water matrix. The load is transferred into the water, which is trapped in the soil matrix, thus increasing the water (pore) pressure. Once the water pressure exceeds the pressure carried by the soil matrix, the water "pushes" the soil particles apart, and failure occurs. This is like what happens in quicksand or in mud-rushes. This is referred to as the ***saturated-undrained*** condition.

In the drained conditions, the load is applied more slowly. In the soil-water matrix, the load is transferred from the water to the soil matrix – as the water can drain (i.e. leaves the soil matrix). This is referred to as the ***saturated drained*** condition. To know at what stage this occurs is more complex. To make a rationalised assumption of how this occurs, the saturated drained conditions were modelled by assuming a fully saturated profile, then solving the groundwater conditions to a steady state solution. This is to understand where the phreatic surface (i.e., groundwater) is likely to be in a saturated – steady state condition. This would represent a likely soil profile that would exist after a prolonged period of rain, such as in the monsoonal condition. Once this has been determined, it is used as an input to the slope stability assessment for the saturated drained condition.

*Factors of Safety*

For the purposes of assessing stability the following is provided which are considered appropriate to the site:

- A calculated factor of safety[4] > 1.5 indicates that the profile is likely to be stable.
- A calculated factor of safety from 1.0 – 1.5 indicates a marginally stable profile.
- A calculated factor of safety < 1.0 indicates a marginally stable profile.

Generally, for normal operating conditions a long-term factor of safety of 1.5 is acceptable. For short term or "extreme" conditions, it may be acceptable to design for a reduced factor of safety of 1.2. The two cross-sections analysed were based on the geotechnical models illustrated in Figure 10 and Figure 11. The results of the analysis are summarised in Table 3.

*Loading*

A 15kPa surcharge loading was applied to the embankment slope for the 'during construction' design slope stability analysis to simulate the loading generated by machinery / vehicular movements during construction.

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[4] In general terms, the factor of safety (Fos) is calculated by dividing the forces resisting instability (i.e. strength of the soil) by the forces driving instability (i.e. the weight of the soil, groundwater, and loads on the slope).

*Groundwater Conditions*

The site is located at an embankment adjacent to Don River and is affected with annual rainfall. Slope stability analysis has assumed ‘dry, conditions within Don River. i.e. no running water within the river. This is a more conservative assumption as the addition of water within the creek would likely improve the factor of safety in the stability analysis.

*Table 4 - Factor of Safety for Existing Batters*

| **Site** | **Calculated Factor of Safety**[5] | | |
|---|---|---|---|
| | **Dry Conditions** | **Wet Conditions** | |
| | | **Undrained** | **Drained**<br>(Steady State Groundwater) |
| A-A’ | **<1.5** | **>1.2** | **<1.2** |
| B-B’ | **<1.5** | **>1.2** | **<1.2** |

The results of the stability analyses show that the factors of safety are not within the acceptable limits during both wet and dry conditions. These results indicate instability of the batters which is consistent with the failures observed on site. The site is still considered unstable and requires retention or other remediation works to strengthen and stabilise the batters to achieve the required factor of safety. These may include:

1. Reducing batter steepness to a stable profile, or
2. Various forms of Positive retention or reinforcement
    a. These can take the form of soil nails, soil anchors or geosynthetic reinforced structures. These forms of reinforcement act by confining the soil to function as a single mass by increasing the resistive forces along the slip plane. Other types of reinforcement include gravity retaining (bulk rock fill/ rock buttressing) and cantilever retaining walls (sheet piles), These are passive reinforcement. They provide an inertial resistive force due to self-weight or converts horizontal pressures from behind the wall to vertical pressures on the ground below respectively.

## 6 OPTIONS ASSESSMENT

Multiple remedial options were considered to stabilise the failure. These have been summarised in Table 5.

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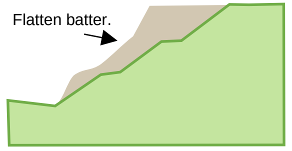
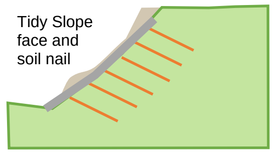
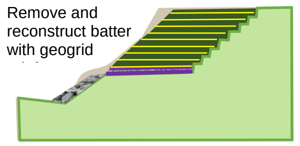
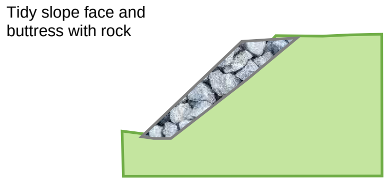
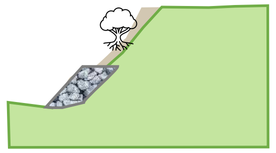
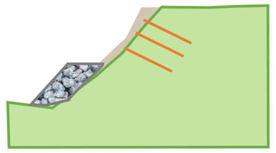
[5] Factors of safety recorded within the report were calculated assuming circular slip surface analysis.

*Table 5 - Proposed Solutions*

| | **Proposed Solution** | | | | | |
|---|---|---|---|---|---|---|
| | **Option 1:**<br>**Batter back slope (decrease angle)**<br><br> | **Option 2:**<br>**Soil nailing of batter**<br><br> | **Option 3:**<br>**Reinforced Earth**<br><br> | **Option 4:**<br>**Placed Rock**<br><br> | **Option 5:**<br>**Rock Protection of the toe, Revegetation of upper batter**<br> | **Option 6:**<br>**Rock Protection of the toe, Soil Nails for upper batter**<br> |
| **Summary of proposed remediation** | Reprofile streambank to 1V:3.5H providing rock toe protection and revegetation to upper portions of bank | Tidy slope face and install soil nails. Add rock to protection. Preliminary stability analysis indicates > 10km soil nails required to stabilize | Stabilize streambank by excavating zone behind embankment (approx. 17.5m and replace with interbedded layers of won material at specified compaction and layers of geogrid. Install grassroots erosion matting | Based on preliminary stability analysis an 8 – 10m width of rock armor required along entire face of slope.<br>Significant earthworks and costs | Leave embankment as is with addition of some rock toe protection to prevent further erosion, revegetation of upper batter. | Add rock for toe protection to prevent further erosion, install soil nails along upper slope. (Stability analysis indicates length of soil nails required to reach the required factor of safety as 9m (section A) to 12m (section B). |
| **Cost** | Medium | High | High | High | Low | Medium |
| **Constructability** | Simple construction. Will require working platforms to be created within the batter to allow for removal of material at the bottom of the batter. | Complex construction requiring specialist machinery, operators, and expert input. This will require a working platform to be created within the batter to allow for installation. | Simple construction. Can be constructed by removing the bank in a top-down manner by ramping longitudinally with the road. Earthworks exercise. | Simple construction. | Simple construction | Soil nailing required for upper slope requires complex construction requiring specialist machinery, operators, and expert input. It is anticipated that soil nailing on the upper slope could be undertaken using a long-arm excavator to install soil nails from the road level. |
| **Approvals/ Environmental** | • All existing vegetation on batter to be removed as part of proposed remediation solution.<br>• Potential risk of erosion on the upper portions of the batter until vegetation establishes.<br>• Requires Environmental investigations and application to SARA.<br>• Anticipated that bank revetment/stabilization works for option 1 fall outside DAF's definition of works not considered waterway barrier works and therefore it is anticipated that permit/approval would be required.<br>• Would need to resume land from adjacent farmland. | • All existing vegetation on batter to be removed as part of the proposed remediation solution.<br>• May need approvals for in stream works from DAF and/or Department of Environment and Sciences<br>• Requires Environmental investigations and application to SARA.<br>• Would need to discuss options with landowner regarding easement and/or resumption of land to install soil nails. Once remediated, Kelly's Road can be reinstated. | • All existing vegetation on batter to be removed as part of the proposed remediation solution.<br>• Likely will not need approval for the geotechnical solution for any proposed scour protection.<br>• May need approvals for in stream works from DAF and/or Department of Environment and Sciences<br>• Requires Environmental investigations and application to SARA.<br>• Would need to discuss options with landowner regarding easement and/or resumption of land to construct geosynthetic reinforced structure. Once installed, Kelly's Road can be reinstated. | • All existing vegetation on batter to be removed as part of the proposed remediation solution.<br>• Require approvals from DAF and/or Department of Environment and Science for bank revetment works as quantity of rockfill required exceeds guidelines regarding altering width of channel.<br>• Requires Environmental investigations and application to SARA.<br>• Would need to discuss options with landowner regarding easement and/or resumption of land to place rockfill as within their lot. | • Limited Environmental Approvals required.<br>• Fits into an exemption for waterway barrier works.<br>• Longer Term stability for batter is increased by the establishment of vegetation.<br>• Short Term: risk of further failures, until vegetation establishes. | • All existing vegetation on batter to be removed as part of the proposed remediation solution.<br>• May need approvals for in stream works from DAF and/or Department of Environment and Sciences<br>• Requires Environmental investigations and application to SARA.<br>• Would need to discuss options with landowner regarding easement and/or resumption of land to install soil nails. Once remediated, Kelly's Road can be reinstated. |

Based on preliminary stability assessment of the above options and considering site constraints, the following options were not considered further:

- Option 1
  - If we adopt the worst-case scenario (Section B-B) and reduce the existing batter angle approximately 1V:3.5H, the stability modelling indicates that adequate factors of safety can be achieved in all condition states (Dry, Saturated Undrained, Saturated Drained).
  - To apply this over the entire site would require large scale earthworks (60,000m3+), and significant environment assessments and approvals., potentially quarrying permits (resource entitlement etc.) would be required.
  - Resumption of land from the adjacent landowner would be required. Modelling suggests the road would need to be moved approximately 25m back and into private property.

- Option 3 and Option 4
  - Similar to Option 1, statutory requirements and would likely be required to implement the solutions. i.e. the solution would require large scale earthworks and significant environment assessments and approvals., potentially quarrying permits (resource entitlement etc.)

Remedial options two, five and six were modelled to assess the stability of each section of the site (A-A) and (B-B).

## 6.1 Summary of Stability Assessments

The results of the stability analysis are summarised in Table 5. The outputs from the modelling are contained in Appendices B and C.

***Table 5: Summary of stability analysis (FOS) for primary modelling cases***

| **Section** | **Factors of Safety** | | |
|---|---|---|---|
| | **Dry** | **Saturated undrained** | **Saturated Drained** |
| **EXISTING CONDITION** | | | |
| **Section A-A’** | **1.32** | **0.86** | **2.43** |
| **Section B-B’** | **1.00** | **0.66** | **2.61** |
| ***OPTION 2: Soil Nails (18m)*** | | | |
| **Section A-A’** | **2.54** | **1.43** | **2.81** |
| **Section B-B’** | **2.87** | **1.62** | **2.71** |
| ***OPTION 5: Rock Protection of the toe to a height of 6m up the slope*** *– 4m thickness at base grading to a 3m thickness at height 6m, with 0.5m embedment in creek, maintain the road in the existing location*. | | | |
| **Section A-A’** | **1.57** | **1.20** | **1.38** |
| **Section B-B’** | **1.16** | **1.07** | **1.54** |
| ***OPTION 6: Rock Protection of the toe, soil nails on upper slope*** *(A-A: 4 rows of 9m long soil nails at 3m spacing along boundary; B-B 3 rows of 12m long soil nails at 3m spacing along boundary), maintain the road in the existing location.* | | | |
| **Section A-A’** | **1.75** | **1.31** | **1.67** |
| **Section B-B’** | **1.51** | **1.31** | **1.51** |

Table five (5) shows that the existing bank is unstable, in the dry and saturated undrained cases and is likely to continue to fail, without the intervention of some form of remediation on the site. Options two, five and six were all modelled

Option 2 included the installation of long soil nails (18m). over the full length and height of the location. It is stable in all conditions.

Option 5 included rock protection of the toe to approximately 6m up the slope. In this assessment Section A-A of the slope remains stable, however Section B-B is not. Section B-B is the steeper section of the batter and the section of the batter closest to the existing road. It also occurs on the bend which is likely to induce more turbulent flows, and erosion.

Option 6 is option 5 (toe rock protection) plus soil nailing on the top portion of the batter. This was modelled along the full length of the site.

Based on the results of modelling it is considered prudent to include an additional option (Option 7) – which is rock protection along the toe of the full site (as per option 5). It also includes soil nails but applied to section B-B only.

***Table 6: Summary of stability analysis (FOS) for secondary/ combined modelling cases***

| **Section** | **Factors of Safety** | | |
|---|---|---|---|
| | **Dry** | **Saturated undrained** | **Saturated Drained** |
| ***OPTION 7: Rock Protection of the toe (full length), soil nails on upper slope (B-B) only. Upper Section of Section A-A remains as per current vegetation.***<br>*Note: Section B-B 3 includes: rows of 12m long soil nails at 3m spacing along boundary), maintain the road in the existing location.* | | | |
| **Section A-A’** | **1.57** | **1.20** | **1.38** |
| **Section B-B’** | **1.51** | **1.31** | **1.51** |

## 6.2 Assumptions

It should be noted that the classical engineering approach to stability modelling includes a number of assumptions, including:

1. The stability of the site must include the assessment of the three (3) critical design cases:
    - Dry.
    - Saturated-Drained[6], and
    - Saturated Undrained[7]

    These design cases represent “Extreme” conditions.
2. The proposed solution needs to meet the accepted factors of safety (FOS) for
    - Dry : FOS >1.5
    - Saturated /Temporary : FOS >1.2
3. The critical saturated design case was after a rapid drawdown
4. The effect of vehicles using the road above the embankment have been modelled using a distributed load of 15kPa across the road width
5. The geotechnical model has been constructed based on the results from the in-field investigations. The stratigraphy between the two (2) test locations have been interpolated. There may be localised deviations from the model. In cases where this is identified, the designer should be contacted to ensure that the identified field conditions do not compromise the design integrity.
6. Temporary batters/ works are to be the responsibility of the Contractor and meet the requirements of their construction methodology and Workplace health and safety management plan

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[6] The *Saturated Drained* Condition– is where the soil mass is full saturated (the voids in the soil matrix are filled with water), and a load is applied slowly, such that the water is able to escape from the soil matrix without increasing in pressure (excess pore pressure). This applied load in the saturated soil matrix is absorbed by the soil particles.

[7] The *Saturated Undrained* Condition– is where the soil mass is full saturated (the voids in the soil matrix are filled with water), and a load is applied quickly. In this case, the water is not able to escape from the soil matrix without increasing in pressure (excess pore pressure). This applied load in the saturated soil matrix is absorbed by the water particles. The consequence of generating excess pore (water) pressure in the soil is it pushes the soil particles apart with the same amount of water pressure. In the most extreme cases, when the water (pore) pressure in the soil matrix exceeds the pressure applied from particle to particle, the soil mass liquefies. This is known as liquefaction; Quicksand is an example of a liquefied soil (A soil where the pore pressure exceeds the pressure applied from soil particle to soil particle).

## 6.3 Estimate of Construction Costs

An estimate of costs has been made for each of the options and Summarised in Table 7.

*Table 7: Cost Estimate for Remediation Options*

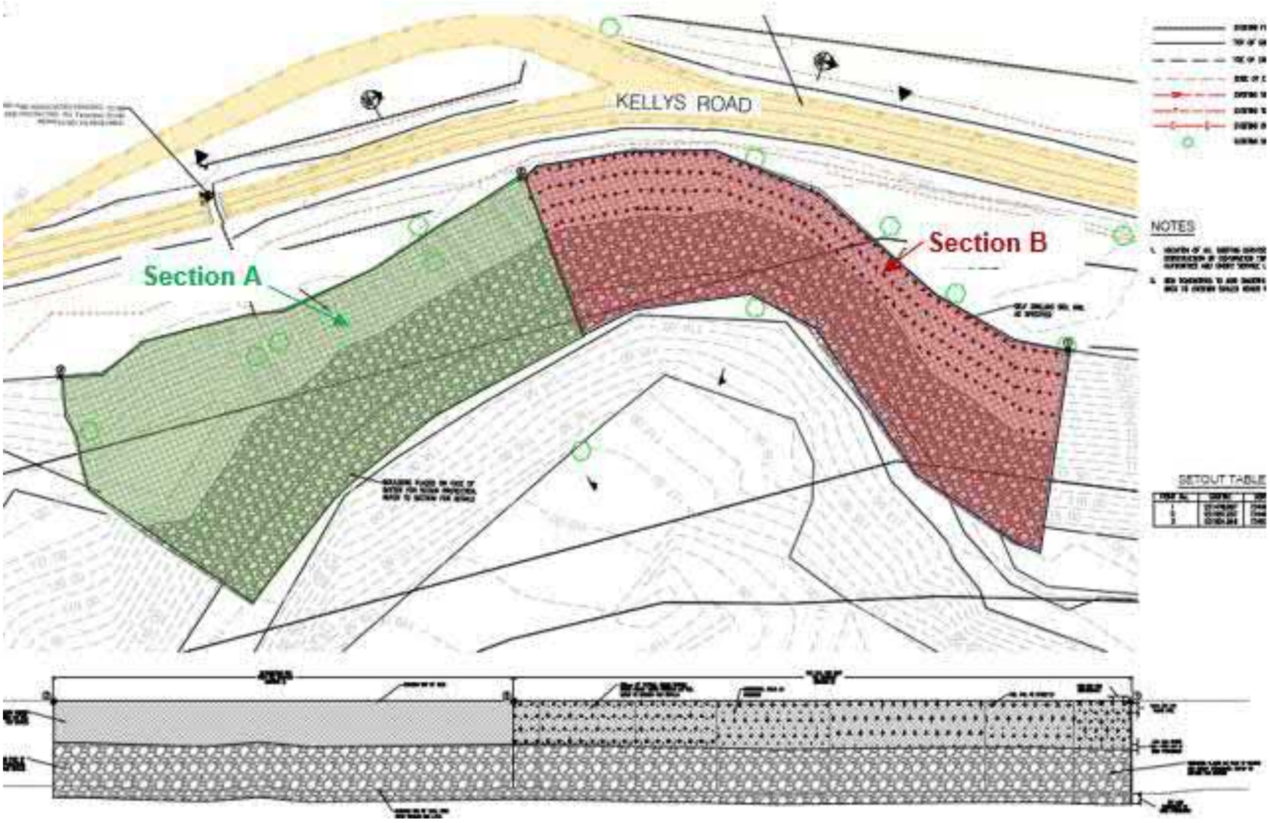
| | Option 2 – Soil Nails (18m) | Option 6 – Rock Protection to 6m, Soil Nails above | Option 7– Rock Protection to 6m, Soil Nails above in Section B-B only |
|---|---|---|---|
| Estimate of Construction Cost (ex-GST) | | | |
| GST | | | |
| Estimate of Construction Cost (incl-GST) | | | |

## 6.4 Recommended Option

Option 7 is the recommended remedial option for the Dom Riverbank Stabilisation. This includes:

- Rock protection along the toe of the full length of the failure to a height of 6m,
- Soil nails (12m long) installed in Section B only (*Red Section below).
- Revegetation of the upper portion of the banks (above the rock protection) using locally sourced native species.

Detailed Design drawings for the proposed remediation options are provided in Appendix A.



Option 7 is the preferred remediation, based on technical suitability and cost effectiveness. Option 7 provides the greatest value for money solution.

## 7 CONSTRUCTION INSPECTIONS

Through the construction of the proposed reconstruction work, inspections by a suitably qualified and experienced geotechnical engineer are required to undertaken to confirm design assumptions. Localised landslips may occur during construction activities. All works should aim to minimise disturbance of the natural slope outside of the immediate earthworks zone. Where possible, all earthworks should be completed in the dry season. Construction activities should not take place in heavy or prolonged rainfall due the potential reduction of slope stability. Works should be protected prior to forecast rainfall.

## 8 SUMMARY AND RECOMMENDATIONS

It is recommended that Banana Shire Regional Council consider the findings and suggested remediation works described in this geotechnical report and detailed in ARO Industries Engineering Drawings ARO0388-C00, ARO0388-C01, ARO0388-C02, ARO0388-C03, ARO0388-C04 and ARO0388-C05, refer Appendix A. The proposed remediation works ensure that the batter will remain geotechnically stable.

# APPENDIX A

*Previous Reports*

Douglas Partners
Geotechnics / Environment / Groundwater

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Kunda Park QLD 4556
Phone (07) 5351 0400

# Investigation Summary Report

| | | | |
|---|---|---|---|
| **Client** | ARO Industries Pty Ltd | **Project No.** | 224488.00 |
| **Project** | Don River Stabilisation | **Date** | 08 Nov 2023 |
| **Address** | Don River, Kellys Road, Dixalea | **Doc No.** | R.001.Rev0 |

**Introduction:** This report presents the results of a factual geotechnical investigation undertaken by Douglas Partners Pty Ltd (DP) for the proposed stabilisation of a streambank failure on the Don River, at Kellys Road, Dixalea.

The investigation was undertaken at the request of ARO Industries Pty Ltd in general accordance with DP's proposal 224488.00.P.001.Rev0 dated 8 August 2023 and following authorisation to proceed received on 23 August 2023.

The investigation comprised the drilling of two bores, followed by laboratory testing on selected samples. Details of the field work and laboratory testing are presented in this report.

This report must be read in conjunction with the attached notes entitled *"About This Report"* along with any other explanatory notes and should be kept in its entirety without separation of individual pages or sections.

**Regional Geology:** The Geological Survey of Queensland's detailed surface geology mapping indicates the site is underlain by Quaternary aged floodplain alluvium described as typically comprising *"Clay, silt, sand and gravel"*. The floodplain alluvium is expected to be underlain at depth by Eocene aged Biloela Formation

**Description of Site:** The streambank failure on the Don River is located adjacent to Kellys Road, Dixalea (refer to Drawing 1 attached).

The riverbank (backscarp of streambank failure) was very steep and estimated to be approximately 15 m in height. The crest of the riverbank was relatively flat and level, covered with grass and vegetated with mature gum trees. The existing unsealed gravel road (Kellys Road) was setback between 2 m and 20 m from the crest of the riverbank. Photographs of typical site conditions at the time of investigation are shown in Figures 1.

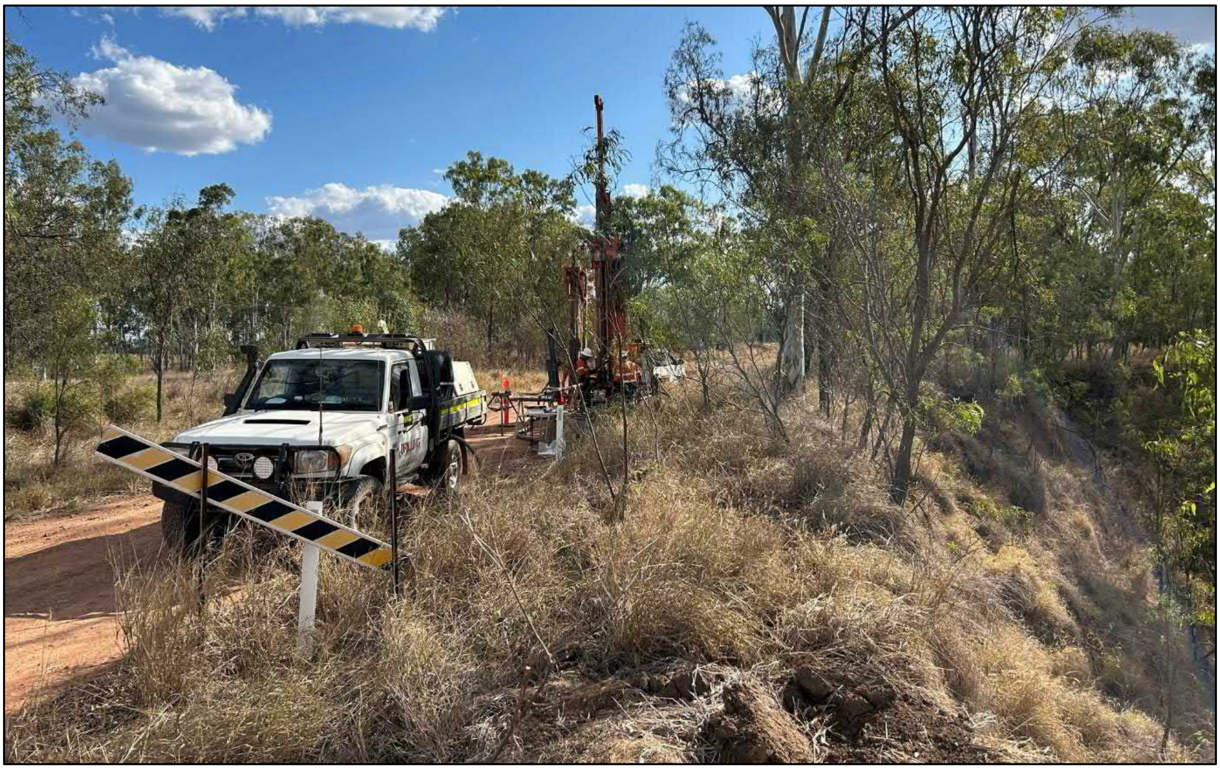

Figure 1:  View of drill rig set up at Bore 2.

Figure 2:  View of riverbank failure

**Field Work Methods:** The field work was carried out between 11 and 14 September 2023 and comprised the drilling of two bores (designated as Bores 1 and 2) to 19.95 m and 19.45 m depth respectively. The nominated bore locations were set out with reference to site features by an experienced geotechnical engineer. The bore locations and surface level were recorded afterwards using a real-time DGPS device. The approximate bore locations are indicated on Drawing 1 attached.

The bores were drilled with a track mounted Hanjin 8D drilling rig using solid flight augers fitted with a tungsten carbide (TC) bit to 2.5 m depth and then advanced using rotary washboring to termination depth. Standard penetration tests (SPTs) were carried out at regular depth intervals where possible to assess the relative density and strength consistency of the soils, as well as to recover samples for subsequent laboratory testing. Details of the SPT procedure are given in the accompanying notes with the penetration 'N' values recorded on the borehole logs. On completion, the bores were backfilled with drill spoil.

The drilling was undertaken by experienced geotechnical personnel under the supervision of an experienced geotechnical engineer from DP who logged the bores, and collected samples for visual and tactile assessment and subsequent laboratory testing. Strata identification was undertaken through observation of cutting returns and recovered samples.

**Field Work Results:** The subsurface conditions encountered in the bores are described in detail on the attached borehole logs, together with accompanying notes which define the classification methods and descriptive terms used. The depths were measured below existing surface levels at the time of investigation.

In summary, the subsurface conditions encountered in the bores typically comprised localised gravel fill overlying natural clayey sand, sandy and silty clays, clayey/sandy gravel, and sandy gravelly clay. The subsurface conditions encountered are further described below:

- **Fill:** Surficial silty sandy gravel fill was encountered to 0.1 m depth in Bore 2.
- **Sandy Clay:** From the surface in Bore 1, and underlying the surficial fill in Bore 2, natural sandy clay was encountered in the bores to 1.8 m and 5.4 m depth respectively. The strength consistency of the sandy clay was initially stiff, grading hard below 2.1 m depth in Bore 2. Hard sandy clay was encountered between 9.4 m and 12.6 m depth in Bore 1.
- **Clayey Sand:** Underlying the upper sandy clay in Bore 1, medium dense clayey sand was encountered between 1.8 m and 2.7 m depth.
- **Silty Clay:** Underlying the clayey sand in Bore 1, and the sandy clay in Bore 2, silty clay was encountered. The strength consistency of the silty clay was initially very stiff, grading hard below 3.2 m depth in Bore 1, and very stiff grading very stiff to hard with depth in Bore 2.
- **Clayey/Sandy Gravel:** Underlying the silty clay, clayey/sandy gravel was encountered at 12.6 m and 13.0 m depth in Bores 1 and 2 respectively. The relative density of sandy gravel was typically dense. The sandy gravel continued to 16.4 m depth in Bore 1 and to termination of Bore 2 at 19.45 m depth.
- **Sandy Gravelly Clay:** Underlying the sandy gravel in Bore 1, very stiff to hard sandy gravelly clay was encountered and continued to bore termination at 19.95 m depth.

No groundwater seepage was encountered in the bores during augering. Water introduced for drilling below 2.5 m depth prevented any further groundwater observation. No water return during washbore drilling occurred below 12.6 m and 6.8 m depth in Bores 1 and 2 respectively.

It should be noted however, that groundwater depths and ground moisture conditions are affected by climatic conditions, drainage conditions and soil permeability, as well as human influences, and will therefore vary with time.

**Laboratory Testing:** Samples recovered from the bores were tested in the laboratory for engineering properties of plasticity and particle size distribution for classification purposes. The results of this testing are summarised in Table 1 with detailed material test reports attached.

**Table 1: Results of Plasticity and Particle Size Distribution Testing**

| Bore No. | Depth (m) | Material | FMC (%) | Plasticity | | | | Particle Size Distribution (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | LL (%) | PL (%) | PI (%) | LS (%) | Gravel | Sand | Silt/Clay |
| 1 | 0.0-0.4 | Sandy CLAY | 6.4 | 26 | 17 | 9 | 6.5 | 1 | 43 | 56 |
| 1 | 2.5-2.95 | Silty CLAY | 11.7 | 39 | 20 | 19 | 12.0 | 0 | 18 | 82 |
| 1 | 5.5-5.95 | Silty CLAY | 16.5 | 47 | 17 | 30 | 16.0 | 0 | 11 | 89 |
| 1 | 8.5-8.95 | Silty CLAY | 17.1 | 39 | 16 | 23 | 13.0 | 0 | 20 | 80 |
| 1 | 14.5-14.95 | Sandy GRAVEL | 14.8 | - | - | - | - | 62 | 29 | 9 |
| 2 | 4.0-4.45 | Sandy CLAY | 16.0 | 39 | 15 | 24 | 12.5 | 0 | 26 | 74 |
| 2 | 7.0-7.45 | Silty CLAY | 25.5 | 45 | 17 | 28 | 13.5 | 0 | 4 | 96 |
| 2 | 10.0-10.45 | Silty CLAY | 19.7 | 58 | 17 | 41 | 18.0 | 0 | 5 | 95 |
| 2 | 13.0-13.27 | Clayey Sandy GRAVEL | 13.4 | - | - | - | - | 58 | 23 | 19 |

Where FMC = Field Moisture Content, LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index, LS = Linear Shrinkage

Standard compaction and single point soaked California bearing ratio (CBR) tests were undertaken on a bulk sample recovered from Bore 1. The sample was first screened over the 19 mm sieve, as required by the test standard, and then compacted to 97% Standard dry density ratio at near to optimum moisture content (OMC). The sample was soaked for four days under a 4.5 kg surcharge.

The results of the compaction and CBR testing are summarised in Table 2 with detailed material test reports attached.

**Table 2: Results of Compaction and Soaked CBR Testing**

| Bore No. | Depth (m) | Material | FMC (%) | Standard Compaction | | CBR | |
|---|---|---|---|---|---|---|---|
| | | | | MDD (t/m$^3$) | OMC (%) | Swell (%) | CBR (%) |
| 1 | 0.0-0.4 | Sandy CLAY | 6.5 | 1.79 | 13.0 | 0.5 | 11 |

Where FMC = Field moisture content, MDD = Maximum Dry Density, OMC = Optimum moisture content

**Limitations:** Douglas Partners Pty Ltd (DP) has prepared this report for the Don River stabilisation near Kellys Road, Dixalea. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of ARO Industries Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the subsurface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Subsurface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

**Douglas Partners Pty Ltd**

**Brett Egen (RPEQ8597)**
Principal

| | |
|---|---|
| Attachments: | About this Report |
| | Drawing 1 - Test Location Plan |
| | Sampling, Testing and Excavation Methodology |
| | Soil Descriptions |
| | Borehole Logs |
| | SPT Photographs |
| | Laboratory Test Results |

# About this Report

November 2020

## Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

## Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

## Borehole and Test Pit Logs

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

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

## Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole 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. They may not be the same at the time of construction as are indicated in the report; and
- 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 first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or 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 a perched water table.

## Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

continued next page

### 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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

### Information for Contractual Purposes

Where information obtained from this report 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. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

### Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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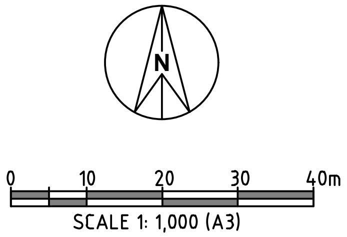
## Location Plan



SCALE 1: 1,000 (A3)

**LEGEND:-**

| | |
|---|---|
| ⌖ | Bore Location and Number |

**NOTE:-**

1. Test locations are approximate only and are shown with reference to existing site features.
2. Image obtained from Google Earth Pro. Date of imagery 20-06-2023.

**Douglas Partners**
*Geotechnics | Environment | Groundwater*

CLIENT: ARO Industries Pty Ltd

OFFICE: Sunshine Coast DRAWN BY: JST

SCALE: As shown DATE: September 2023

TITLE: **Test Location Plan**
**Don River Stabilisation**
**Don River, Dixalea**

PROJECT No: 224488.00

DRAWING No: 1

REVISION: 0

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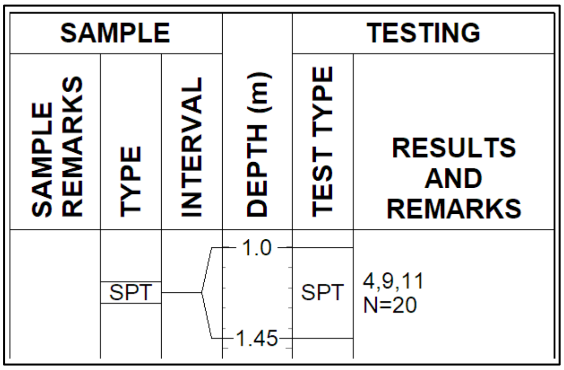
# Sampling, Testing and Excavation Methodology

September 2023

## Sampling and Testing

A record of samples retained, and field testing performed is usually shown on a Douglas Partners' log with samples appearing to the left of a depth scale, and selected field and laboratory testing (including results, where relevant) appearing to the right of the scale, as illustrated below:



### *Sampling*

The type or intended purpose for which a sample was taken is indicated by the following abbreviation codes.

| Sample Type | Code |
|---|---|
| Auger sample | `A` |
| Bulk sample | `B` |
| Core sample | `C` |
| Disturbed sample | `D` |
| Sample from SPT test | `SPT` |
| Environmental sample | `ES` |
| Gas sample | `G` |
| Undisturbed tube sample | `U`[1] |
| Water sample | `W` |
| Piston sample | `P` |
| Core sample for unconfined compressive strength testing | `UCS` |
| Material Sample | `MT` |

[1] – numeric suffixes indicate tube diameter/width in mm

The above codes only indicate that a sample was retained, and not that testing was scheduled or performed.

### *Field and Laboratory Testing*

A record that field and laboratory testing was performed is indicated by the following abbreviation codes.

| Test Type | Code |
|---|---|
| Pocket penetrometer (kPa) | `PP` |
| Photo ionisation detector (ppm) | `PID` |
| Standard Penetration Test<br>`x/y` =*x* blows for *y* mm penetration<br>`HB` = hammer bouncing<br>`HW` = fell under weight of hammer | `SPT` |
| Shear vane (kPa) | `V` |
| Unconfined compressive strength, (MPa) | `UCS` |
| Point load test, (MPa), axial `(A)`, diametric `(D)`, irregular `(I)` | `PLT(_)` |
| Dynamic cone penetrometer, followed by blow count penetration increment in mm (cone tip, generally in accordance with AS1289.6.3.2) | `DCP/150` |
| Perth sand penetrometer, followed by blow count penetration increment in mm (flat tip, generally in accordance with AS1289.6.3.3) | `PSP/150` |

## Groundwater Observations

| | |
|---|---|
| ▷ | seepage/inflow |
| ▽ | standing or observed water level |
| `NFGWO` | no free groundwater observed |
| `OBS` | observations obscured by drilling fluids |

## Drilling or Excavation Methods/Tools

The drilling/excavation methods used to perform the investigation may be shown either in a dedicated column down the left-hand edge of the log, or stated in the log footer. In some circumstances abbreviation codes may be used.

| Method | Abbreviation Code |
|---|---|
| Toothed bucket | `TB`[1] |
| Mud/blade bucket | `MB`[1] |
| Ripping tyne/ripper | `R` |
| Rock breaker/hydraulic hammer | `RB` |
| Hand auger | `HA`[1] |
| NMLC series coring | `NMLC` |
| HMLC series coring | `HMLC` |
| NQ coring | `NQ3` |
| HQ coring | `HQ3` |
| PQ coring | `PQ3` |
| Push tube | `PT`[1] |
| Rock roller | `RR`[1] |
| Solid flight auger. Suffixes:<br>`/T` = tungsten carbide tip,<br>`/V` = v-shaped tip | `AD`[1] |
| Sonic drilling | `SON`[1] |
| Vibrocore | `VC`[1] |
| Wash bore (unspecified bit type) | `WB`[1] |
| Existing exposure | `X` |
| Hand tools (unspecified) | `HAND` |
| Predrilled | `PD` |
| Diatube | `DT`[1] |
| Hollow flight auger | `HSA`[1] |
| Vacuum excavation | `VE` |

[1] – numeric suffixes indicate tool diameter/width in mm

# Soil Descriptions

Terminology
Symbols
Abbreviations

September 2023

## Introduction

All materials which are not considered to be "in-situ rock" are described in general accordance with the soil description model of AS 1726-2017 Part 6.1.3, and can be broken down into the following description structure:

The "classification" comprises a two character "group symbol" providing a general summary of dominant soil characteristics. The "name" summarises the particle sizes within the soil which most influence its behaviour. The detailed description presents more information about composition, condition, structure, and origin of the soil.

Classification, naming and description of soils require the relative proportion of particles of different sizes within the whole soil mixture to be considered.

### *Particle size designation and Behaviour Model*

Solid particles within a soil are differentiated on the basis of size.

The engineering behaviour properties of a soil can subsequently be modelled to be either "fine grained" (also known as "cohesive" behaviour) or "coarse grained" ("non cohesive" behaviour), depending on the relative proportion of fine or coarse fractions in the soil mixture.

| **Particle Size Designation** | **Particle Size (mm)** | **Behaviour Model** | |
|---|---|---|---|
| | | **Behaviour** | **Approximate Dry Mass** |
| Boulder | >200 | Excluded from particle behaviour model as "oversize" | |
| Cobble | 63 - 200 | | |
| Gravel[1] | 2.36 - 63 | Coarse | >65% |
| Sand[1] | 0.075 - 2.36 | | |
| Silt | 0.002 - 0.075 | Fine | >35% |
| Clay | <0.002 | | |

[1] – refer grain size subdivision descriptions below

The behaviour model boundaries defined above are not precise, and the material behaviour should be assumed from the name given to the material (which considers the particle fraction which dominates the behaviour, refer "component proportions" below), rather than strict observance of the proportions of particle sizes. For example, if a material is named a "Sandy CLAY", this is indicative that the material exhibits fine grained behaviour, even if the dry mass of coarse grained material may exceed 65%.

### *Component proportions*

The relative proportion of the dry mass of each particle size fraction is assessed to be a "primary", "secondary", or "minor" component of the soil mixture, depending on its influence over the soil behaviour.

| **Component Proportion Designation** | **Definition[1]** | **Relative Proportion** | |
|---|---|---|---|
| | | **In Fine Grained Soil** | **In Coarse Grained Soil** |
| Primary | The component (particle size designation, refer above) which dominates the engineering behaviour of the soil | The clay/silt component with the greater proportion | The sand/gravel component with the greater proportion |
| Secondary | Any component which is not the primary, but is significant to the engineering properties of the soil | Any component with greater than 30% proportion | Any granular component with greater than 30%; or<br>Any fine component with greater than 12% |
| Minor[2] | Present in the soil, but not significant to its engineering properties | All other components | All other components |

[1] As defined in AS1726-2017 6.1.4.4

[2] In the detailed material description, minor components are split into two further sub-categories. Refer "identification of minor components" below.

### *Composite Materials*

In certain situations, a lithology description may describe more than one material, for example, collectively describing a layer of interbedded sand and clay. In such a scenario, the two materials would be described independently, with the names preceded or followed by a statement describing the arrangement by which the materials co-exist. For example, "INTERBEDDED Silty CLAY AND SAND".

## Classification

The soil classification comprises a two character group symbol. The first character identifies the primary component. The second character identifies either the grading or presence of fines in a coarse grained soil, or the plasticity in a fine grained soil. Refer AS1726-2017 6.1.6 for further clarification.

### Soil Name

For most soils, the name is derived with the primary component included as the noun (in upper case), preceded by any secondary components stated in an adjective form. In this way, the soil name also describes the general composition and indicates the dominant behaviour of the material.

| Component[1] | Prominence in Soil Name |
|---|---|
| Primary | Noun (eg "CLAY") |
| Secondary | Adjective modifier (eg "Sandy") |
| Minor | No influence |

[1] – for determination of component proportions, refer component proportions on previous page

For materials which cannot be disaggregated, or which are not comprised of rock or mineral fragments, the names "ORGANIC MATTER" or "ARTIFICIAL MATERIAL" may be used, in accordance with AS1726-2017 Table 14.

Commercial or colloquial names are not used for the soil name where a component derived name is possible (for example "Gravelly SAND" rather than "CRACKER DUST").

Materials of "fill" or "topsoil" origin are generally assigned a name derived from the primary/secondary component (where appropriate). In log descriptions this is preceded by uppercase "FILL" or "TOPSOIL". Origin uncertainty is indicated in the description by the characters `(?)`, with the degree of uncertainty described (using the terms "probably" or "possibly" in the origin column, or at the end of the description).

### Identification of minor components

Minor components are identified in the soil description immediately following the soil name. The minor component fraction is usually preceded with a term indicating the relative proportion of the component.

| Minor Component Proportion Term | Relative Proportion | |
|---|---|---|
| | In Fine Grained Soil | In Coarse Grained Soil |
| With | All fractions: 15-30% | Clay/silt: 5-12%<br>sand/gravel: 15-30% |
| Trace | All fractions: 0-15% | Clay/silt: 0-5%<br>sand/gravel: 0-15% |

The terms "with" and "trace" generally apply only to gravel or fine particle fractions. Where cobbles/boulders are encountered in minor proportions (generally less than about 12%) the term "occasional" may be used. This term describes the sporadic distribution of the material within the confines of the investigation excavation only, and there may be considerable variation in proportion over a wider area which is difficult to factually characterise due to the relative size of the particles and the investigation methods.

### Soil Composition

Plasticity

| Descriptive Term | Laboratory liquid limit range | |
|---|---|---|
| | Silt | Clay |
| Non-plastic materials | Not applicable | Not applicable |
| Low plasticity | ≤50 | ≤35 |
| Medium plasticity | Not applicable | >35 and ≤50 |
| High plasticity | >50 | >50 |

Note, Plasticity descriptions generally describe the plasticity behaviour of the whole of the fine grained soil, not individual fine grained fractions.

Grain Size

| Type | | Particle size (mm) |
|---|---|---|
| Gravel | Coarse | 19 - 63 |
| | Medium | 6.7 - 19 |
| | Fine | 2.36 – 6.7 |
| Sand | Coarse | 0.6 - 2.36 |
| | Medium | 0.21 - 0.6 |
| | Fine | 0.075 - 0.21 |

Grading

| Grading Term | Particle size (mm) |
|---|---|
| Well | A good representation of all particle sizes |
| Poorly | An excess or deficiency of particular sizes within the specified range |
| Uniformly | Essentially of one size |
| Gap | A deficiency of a particular size or size range within the total range |

Note, AS1726-2017 provides terminology for additional attributes not listed here.

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## Soil Condition

### *Moisture*

The moisture condition of soils is assessed relative to the plastic limit for fine grained soils, while for coarse grained soils it is assessed based on the appearance and feel of the material. The moisture condition of a material is considered to be independent of stratigraphy (although commonly these are related), and this data is presented in its own column on logs.

| Applicability | Term | Tactile Assessment | Abbreviation code |
|---|---|---|---|
| Fine | Dry of plastic limit | Hard and friable or powdery | `w<PL` |
| | Near plastic limit | Can be moulded | `w=PL` |
| | Wet of plastic limit | Water residue remains on hands when handling | `w>PL` |
| | Near liquid limit | “oozes” when agitated | `w=LL` |
| | Wet of liquid limit | “oozes” | `w>LL` |
| Coarse | Dry | Non-cohesive and free running | `D` |
| | Moist | Feels cool, darkened in colour, particles may stick together | `M` |
| | Wet | Feels cool, darkened in colour, particles may stick together, free water forms when handling | `W` |

The abbreviation code `NDF`, meaning “not-assessable due to drilling fluid use” may also be used.

Note, observations relating to free ground water or drilling fluids are provided independent of soil moisture condition.

### *Consistency/Density/Compaction/Cementation/Extremely Weathered Material*

These concepts give an indication of how the material may respond to applied forces (when considered in conjunction with other attributes of the soil). This behaviour can vary independent of the composition of the material, and on logs these are described in an independent column and are generally mutually exclusive (i.e it is inappropriate to describe both consistency and compaction at the same time). The method by which the behaviour is described depends on the behaviour model and other characteristics of the soil as follows:

- In fine grained soils, the “consistency” describes the ease with which the soil can be remoulded, and is generally correlated against the materials undrained shear strength;
- In granular materials, the relative density describes how tightly packed the particles are, and is generally correlated against the density index;
- In anthropogenically modified materials, the compaction of the material is described qualitatively;
- In cemented soils (both natural and anthropogenic), the cemented “strength” is described qualitatively, relative to the difficulty with which the material is disaggregated; and
- In soils of extremely weathered material origin, the engineering behaviour may be governed by relic rock features, and expected behaviour needs to be assessed based the overall material description.

Quantitative engineering performance of these materials may be determined by laboratory testing or estimated by correlated field tests (for example penetration or shear vane testing). In some cases, performance may be assessed by tactile or other subjective methods, in which case investigation logs will show the estimated value enclosed in round brackets, for example `(VS)`.

Consistency (fine grained soils)

| Consistency Term | Tactile Assessment | Undrained Shear Strength (kPa) | Abbreviation Code |
|---|---|---|---|
| Very soft | Extrudes between fingers when squeezed | <12 | `VS` |
| Soft | Mouldable with light finger pressure | >12 - ≤25 | `S` |
| Firm | Mouldable with strong finger pressure | >25 - ≤50 | `F` |
| Stiff | Cannot be moulded by fingers | >50 - ≤100 | `St` |
| Very stiff | Indented by thumbnail | >100 - ≤200 | `VSt` |
| Hard | Indented by thumbnail with difficulty | >200 | `H` |
| Friable | Easily crumbled or broken into small pieces by hand | - | `Fr` |

Relative Density (coarse grained soils)

| Relative Density Term | Density Index | Abbreviation Code |
|---|---|---|
| Very loose | <15 | `VL` |
| Loose | >15 - ≤35 | `L` |
| Medium dense | >35 - ≤65 | `MD` |
| Dense | >65 - ≤85 | `D` |
| Very dense | >85 | `VD` |

Note, tactile assessment of relative density is difficult, and generally requires penetration testing, hence a tactile assessment guide is not provided.

Compaction (anthropogenically modified soil)

| Compaction Term | Abbreviation Code |
|---|---|
| Well compacted | `WC` |
| Poorly compacted | `PC` |
| Moderately compacted | `MC` |
| Variably compacted | `VC` |

Cementation (natural and anthropogenic)

| Cementation Term | Abbreviation Code |
|---|---|
| Moderately cemented | `MOD` |
| Weakly cemented | `WEK` |

### *Extremely Weathered Material*

AS1726-2017 considers weathered material to be soil if the unconfined compressive strength is less than 0.6 MPa (i.e. less than very low strength rock). These materials may be identified as “extremely weathered material” in reports and by the abbreviation code `XWM` on log sheets. This identification is not correlated to any specific qualitative or quantitative behaviour, and the engineering properties of this material must therefore be assessed according to engineering principles with reference to any relic rock structure, fabric, or texture described in the description.

## Soil Origin

| Term | Description | Abbreviation Code |
|---|---|---|
| Residual | Derived from in-situ weathering of the underlying rock | `RS` |
| Extremely weathered material | Formed from in-situ weathering of geological formations. Has strength of less than ‘very low’ as per as1726 but retains the structure or fabric of the parent rock. | `XWM` |
| Alluvial | Deposited by streams and rivers | `ALV` |
| Estuarine | Deposited in coastal estuaries | `EST` |
| Marine | Deposited in a marine environment | `MAR` |
| Lacustrine | Deposited in freshwater lakes | `LAC` |
| Aeolian | Carried and deposited by wind | `AEO` |
| Colluvial | Soil and rock debris transported down slopes by gravity | `COL` |
| Slopewash | Thin layers of soil and rock debris gradually and slowly deposited by gravity and possibly water | `SW` |
| Topsoil | Mantle of surface soil, often with high levels of organic material | `TOP` |
| Fill | Any material which has been moved by man | `FILL` |
| Littoral | Deposited on the lake or seashore | `LIT` |
| Unidentifiable | Not able to be identified | `UID` |

## Cobbles and Boulders

The presence of particles considered to be “oversize” may be described using one of the following strategies:

- Oversize encountered in a minor proportion (when considered relative to the wider area) are noted in the soil description; or
- Where a significant proportion of oversize is encountered, the cobbles/boulders are described independent of the soil description, in a similar manner to composite soils (described above) but qualified with “MIXTURE OF”.

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# BOREHOLE LOG

**CLIENT:** ARO Industries Pty Ltd
**PROJECT:** Don River Stabilisation
**LOCATION:** Don River, Dixalea, QLD

**SURFACE LEVEL:** 125.2 AHD
**COORDINATE:** E:231571.6, N:7345000.7
**DATUM/GRID:** MGA2020 Zone 56
**DIP/AZIMUTH:** 90°/---°

**LOCATION ID:** 1
**PROJECT No:** 224488.00
**DATE:** 11/09/23
**SHEET:** 1 of 3

## CONDITIONS ENCOUNTERED

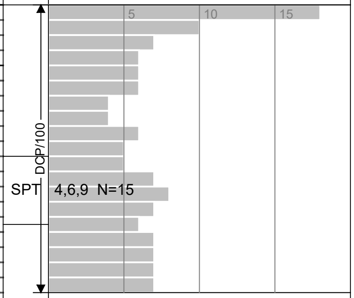
| GROUNDWATER | DEPTH (m) | DESCRIPTION OF STRATA | ORIGIN(#) | CONSIS.(*) / DENSITY.(*) | MOISTURE |
|---|---|---|---|---|---|
| | | Sandy CLAY (CL): dark brown; low plasticity; fine sand. | ALV | St | w<PL |
| | 1.80 | Clayey SAND (SC): brown streaked grey; fine to medium. | ALV | MD | D to M<br>NDF |
| | 2.70 | Silty CLAY (CI): grey streaked brown and orange; medium plasticity.<br>3.20m:<br>6.90m: brown streaked orange<br>8.10m: pale brown streaked orange and grey | ALV | VSt<br>H | NDF |
| | 9.40 | Sandy CLAY (CH): grey streaked orange and brown; high plasticity; fine sand. | ALV | H | NDF |

## SAMPLE

| REMARKS | TYPE | INTERVAL |
|---|---|---|
| | B | 0.40 |

## TESTING AND REMARKS

| TEST TYPE | RESULTS AND REMARKS |
|---|---|
| DCP/100 | |
| SPT | 4,6,9 N=15 |
| SPT | 5,12,15 N=27 |
| PP | >600kPa |
| SPT | 10,12,20 N=32 |
| SPT | 11,14,19 N=33 |
| SPT | 11,14,24 N=38 |
| SPT | 10,16,26 N=42 |



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

**PLANT:** Hanjin 8D
**METHOD:** AD to 2.5m, then WB to 19.95m
**REMARKS:** No groundwater seepage observed during auger drilling.

**OPERATOR:** MK Drilling
**CASING:** HWT to 2.5m, then HQ to 16.3m

**LOGGED:** MDH

Generated with CORE-GS by Geroc - Soil Log - 8/11/2023 11:05:36 AM

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

# BOREHOLE LOG

**CLIENT:** ARO Industries Pty Ltd
**PROJECT:** Don River Stabilisation
**LOCATION:** Don River, Dixalea, QLD

**SURFACE LEVEL:** 125.2 AHD
**COORDINATE:** E:231571.6, N:7345000.7
**DATUM/GRID:** MGA2020 Zone 56
**DIP/AZIMUTH:** 90°/---°

**LOCATION ID:** 1
**PROJECT No:** 224488.00
**DATE:** 11/09/23
**SHEET:** 2 of 3

| CONDITIONS ENCOUNTERED | | | | | | | | SAMPLE | | | | TESTING AND REMARKS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GROUNDWATER | RL (m) | DEPTH (m) | DESCRIPTION OF STRATA | GRAPHIC | ORIGIN(#) | CONSIS.(*) ▨ DENSITY.(*) ▨ | MOISTURE | REMARKS | TYPE | INTERVAL | DEPTH (m) | TEST TYPE | RESULTS AND REMARKS |
| | 115 | | [CONT] Sandy CLAY (CH): grey streaked orange and brown; high plasticity; fine sand. | | ALV | H | NDF | | | | | SPT | 10,16,23 N=39 |
| | 114 | 11 | | | | | | | | | 11 | | |
| | | | | | | | | | | | | SPT | 8,12,21 N=33 |
| | 113 | 12 | | | | | | | | | 12 | | |
| ◁ | | 12.60 | Sandy GRAVEL (GW): brown grey; fine to coarse; fine to coarse sand. | | ALV | D | NDF | | | | | | |
| | 112 | 13 | | | | | | | | | 13 | SPT | 16,16,26 N=42 |
| | 111 | 14 | | | | | | | | | 14 | | |
| | | | | | | | | | | | | SPT | 13,14,17 N=31 |
| | 110 | 15 | | | | | | | | | 15 | | |
| | 109 | 16 | | | | | | | | | 16 | SPT | 30/110 |
| | | | | | | | | | | | | SPT | 30/80 |
| | | 16.40 | Sandy Gravelly CLAY (CI-CH): orange brown; medium to high plasticity; fine to coarse sand; fine to coarse gravel; trace of cobbles. | | ALV | VSt to H | NDF | | | | | | |
| | 108 | 17 | | | | | | | | | 17 | SPT | 12,23,30/90 |
| | 107 | 18 | | | | | | | | | 18 | | |
| | | | | | | | | | | | | SPT | 30/120 |
| | 106 | 19 | | | | | | | | | 19 | | |
| | | | | | | | | | | | | SPT | 5,10,10 N=20 |

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

**PLANT:** Hanjin 8D
**METHOD:** AD to 2.5m, then WB to 19.95m
**REMARKS:** No groundwater seepage observed during auger drilling.

**OPERATOR:** MK Drilling
**CASING:** HWT to 2.5m, then HQ to 16.3m

**LOGGED:** MDH

Refer to explanatory notes for symbol and abbreviation definitions

# BOREHOLE LOG

**CLIENT:** ARO Industries Pty Ltd
**PROJECT:** Don River Stabilisation
**LOCATION:** Don River, Dixalea, QLD

**SURFACE LEVEL:** 125.2 AHD
**COORDINATE:** E:231571.6, N:7345000.7
**DATUM/GRID:** MGA2020 Zone 56
**DIP/AZIMUTH:** 90°/---°

**LOCATION ID:** 1
**PROJECT No:** 224488.00
**DATE:** 11/09/23
**SHEET:** 3 of 3

| CONDITIONS ENCOUNTERED | | | | | | | | SAMPLE | | | | TESTING AND REMARKS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GROUNDWATER | RL (m) | DEPTH (m) | DESCRIPTION OF STRATA | GRAPHIC | ORIGIN(#) | CONSIS.(*) ■ DENSITY.(*) ▨ | MOISTURE | REMARKS | TYPE | INTERVAL | DEPTH (m) | TEST TYPE | RESULTS AND REMARKS |
| | | 19.95 | Borehole discontinued at 19.95m depth.<br>Limit of Investigation. | | | | | | | | | | |

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

**PLANT:** Hanjin 8D
**METHOD:** AD to 2.5m, then WB to 19.95m
**REMARKS:** No groundwater seepage observed during auger drilling.

**OPERATOR:** MK Drilling
**CASING:** HWT to 2.5m, then HQ to 16.3m

**LOGGED:** MDH

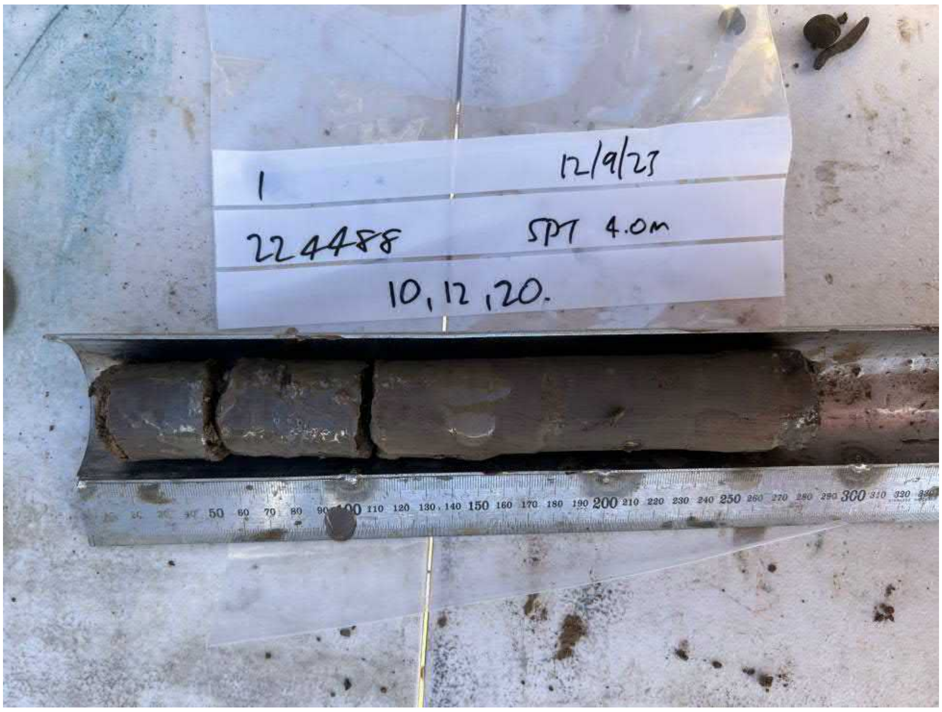

1
12/9/23
224488
SPT 1.0m
4,6,9.

Bore 1 – SPT 1.0m

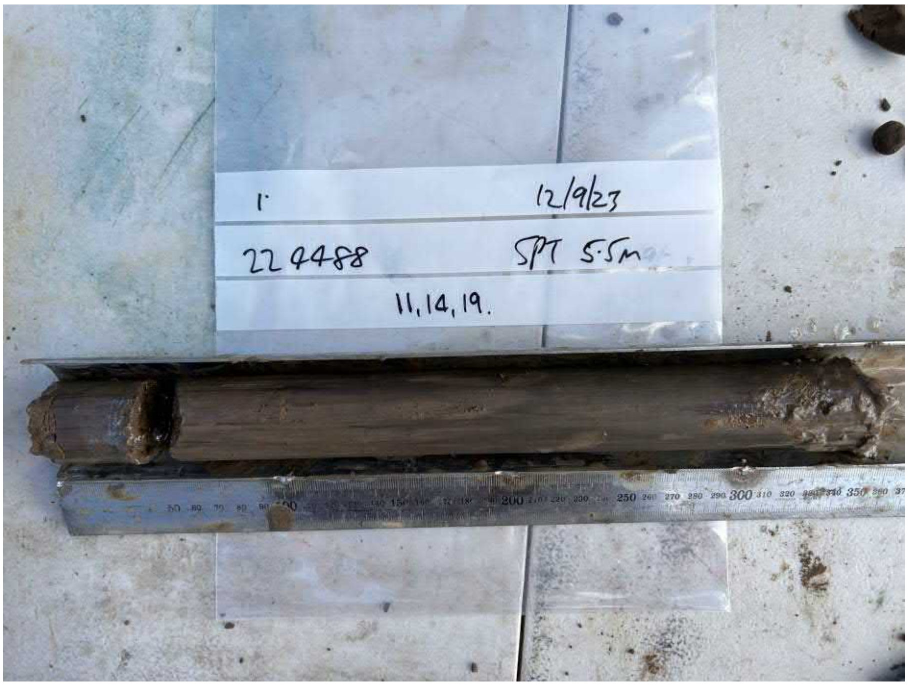

1
12/9/23
224488
SPT 2.5m
5,12,15.

Bore 1 – SPT 2.5m

| | | | |
|---|---|---|---|
| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
| | **Don River Stabilisation** | PLATE No: | 1 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |



Bore 1 – SPT 4.0m



Bore 1 – SPT 5.5m

Douglas Partners
Geotechnics / Environment / Groundwater

**SPT Photographs**

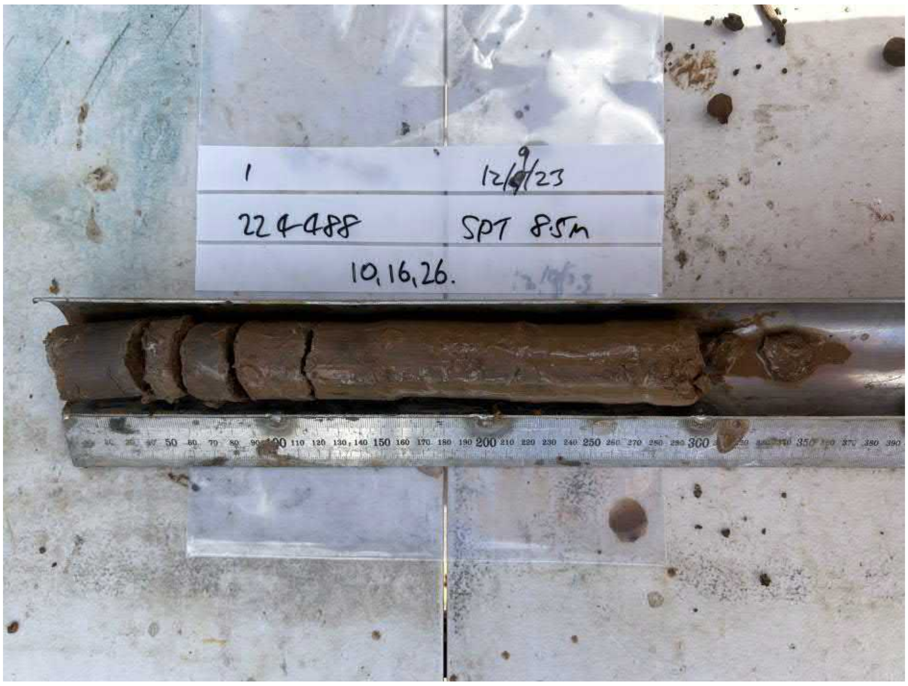
**Don River Stabilisation**

**Don River, Dixalea**

CLIENT: ARO Industries Pty Ltd

| | |
|---|---|
| PROJECT: | 224488.00 |
| PLATE No: | 2 |
| REV: | 0 |
| DATE: | Nov-23 |

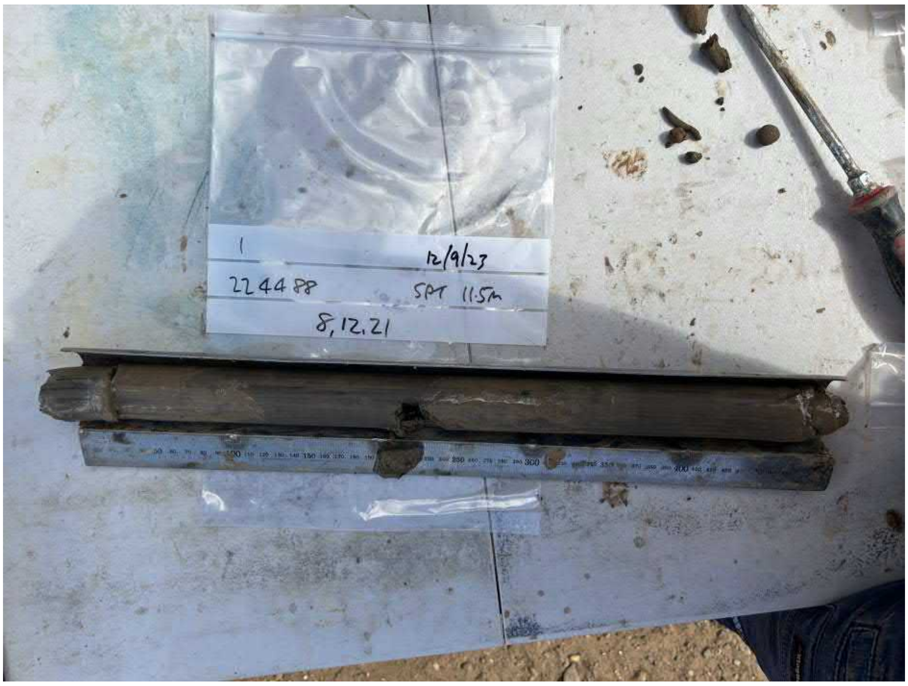
Bore 1 – SPT 7.0m



Bore 1 – SPT 8.5m

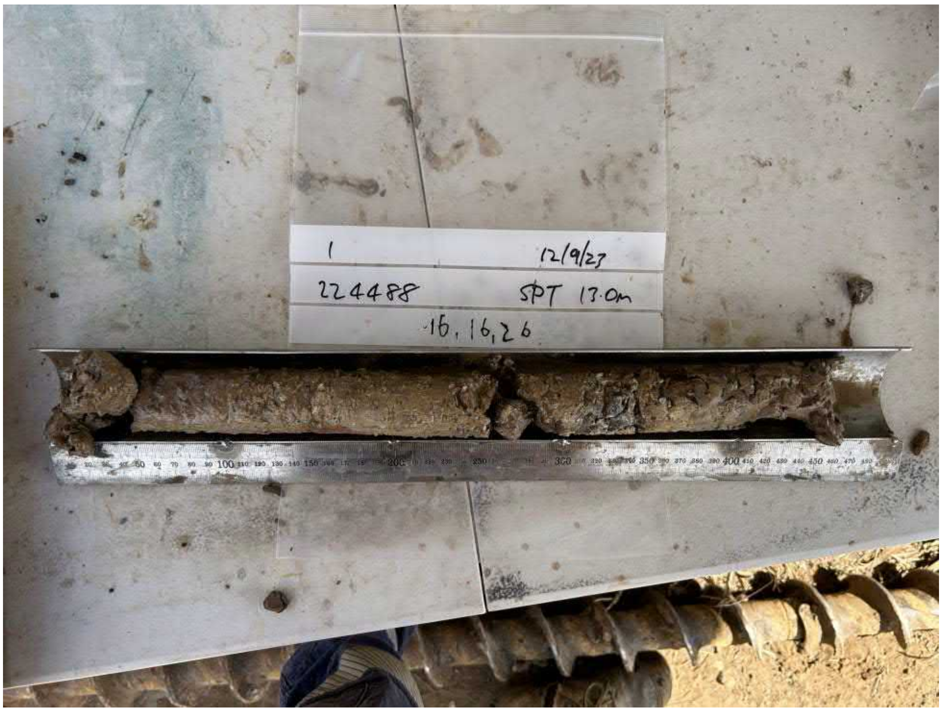
| | | | |
|---|---|---|---|
| **Douglas Partners**<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
| | **Don River Stabilisation** | PLATE No: | 3 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |

Bore 1 – SPT 10.0m

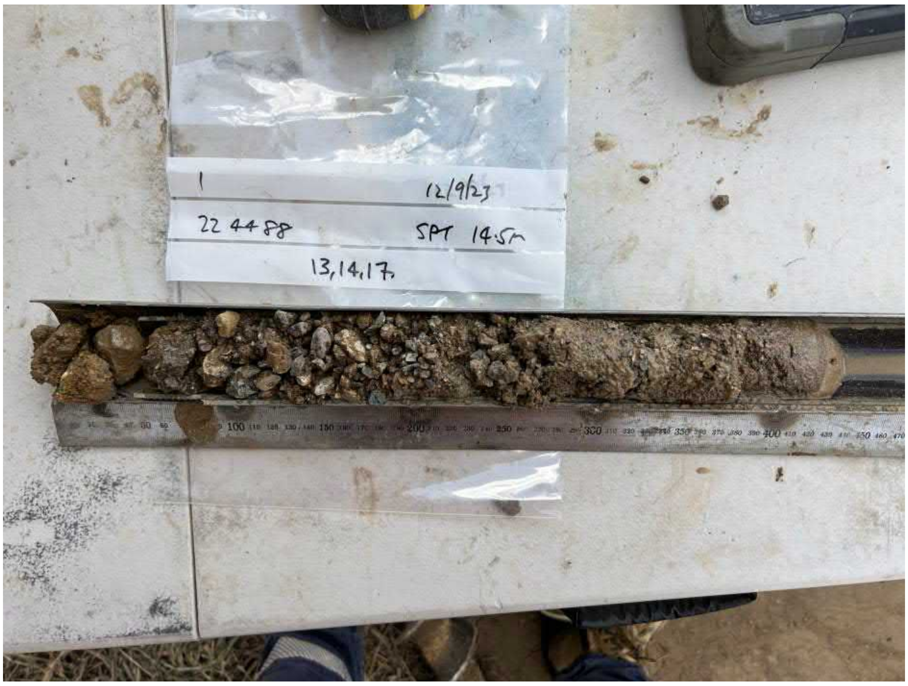


Bore 1 – SPT 11.5m

| | | | |
|---|---|---|---|
| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
| | **Don River Stabilisation** | PLATE No: | 4 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |



Bore 1 – SPT 13.0m



Bore 1 – SPT 14.5m

| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs**<br>**Don River Stabilisation**<br>**Don River, Dixalea** | PROJECT: | 224488.00 |
|---|---|---|---|
| | | PLATE No: | 5 |
| | | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |

# BOREHOLE LOG

**CLIENT:** ARO Industries Pty Ltd
**PROJECT:** Don River Stabilisation
**LOCATION:** Don River, Dixalea, QLD

**SURFACE LEVEL:** 125.1 AHD
**COORDINATE:** E:231524.3, N:7344975.9
**DATUM/GRID:** MGA2020 Zone 56
**DIP/AZIMUTH:** 90°/---°

**LOCATION ID:** 2
**PROJECT No:** 224488.00
**DATE:** 13/09/23
**SHEET:** 1 of 2

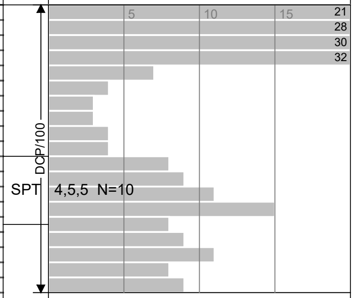
## CONDITIONS ENCOUNTERED

| DEPTH (m) | DESCRIPTION OF STRATA | ORIGIN(#) | CONSIS.(*) / DENSITY.(*) | MOISTURE |
|---|---|---|---|---|
| 0.10 | FILL / Silty Sandy GRAVEL (GM): grey-pale brown; fine to medium, with cobbles; fine to coarse sand. | FILL | VD | D |
| 2.10 | Sandy CLAY (CL): dark brown; low plasticity; fine sand. | ALV | St | w<PL |
| 5.40 | Sandy CLAY (CI): brown streaked grey and pale grey; medium plasticity; fine to medium sand. | ALV | H | w=PL<br>NDF |
|  | Silty CLAY (CI): grey brown streaked dark grey; medium plasticity.<br>7.00m: grey streaked pale brown | ALV | VSt | NDF |

RL (m): 125, 124, 123, 122, 121, 120, 119, 118, 117, 116

## TESTING AND REMARKS

| TEST TYPE | RESULTS AND REMARKS |
|---|---|
| DCP/100 |  |
| SPT | 4,5,5 N=10 |
| SPT | 7,13,19 N=32 |
| SPT | 8,14,16 N=30 |
| PP | >600kPa |
| SPT | 7,8,11 N=19 |
| SPT | 3,6,11 N=17 |
| SPT | 4,5,11 N=16 |



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

**PLANT:** Hanjin 8D
**METHOD:** AD to 2.5m, then WB to 19.45m
**REMARKS:** No groundwater seepage observed during auger drilling.

**OPERATOR:** MK Drilling
**CASING:** HWT to 2.5m, then HQ to 19m

**LOGGED:** MDH

Refer to explanatory notes for symbol and abbreviation definitions

# BOREHOLE LOG

**CLIENT:** ARO Industries Pty Ltd
**PROJECT:** Don River Stabilisation
**LOCATION:** Don River, Dixalea, QLD

**SURFACE LEVEL:** 125.1 AHD
**COORDINATE:** E:231524.3, N:7344975.9
**DATUM/GRID:** MGA2020 Zone 56
**DIP/AZIMUTH:** 90°/---°

**LOCATION ID:** 2
**PROJECT No:** 224488.00
**DATE:** 13/09/23
**SHEET:** 2 of 2

**CONDITIONS ENCOUNTERED**

| GROUNDWATER | RL (m) | DEPTH (m) | DESCRIPTION OF STRATA | GRAPHIC | ORIGIN(#) | CONSIS.(*) / DENSITY.(*) | MOISTURE | REMARKS | TYPE | INTERVAL |
|---|---|---|---|---|---|---|---|---|---|---|
| | 115 | 9.99 | Silty CLAY (CH): grey streaked brown; high plasticity. | | ALV | VSt to H | NDF | | | |
| | 112 | 13.00 | Clayey Sandy GRAVEL (GW-GC): brown grey; fine to coarse, with cobbles; fine to coarse sand; low plasticity. | | ALV | D | NDF | | | |
| | | 19.45 | Borehole discontinued at 19.45m depth.<br>Limit of Investigation. | | | | | | | |

**TESTING AND REMARKS**

| DEPTH (m) | TEST TYPE | RESULTS AND REMARKS |
|---|---|---|
| | SPT | 6,12,19 N=31 |
| | SPT | 5,9,12 N=21 |
| 13 | SPT | 27,30/120 |
| | SPT | 25,30/80 |
| 16 | SPT | 12,20,30/140 |
| | SPT | 30/150 |
| 19 | SPT | 17,26,27 N=53 |

Generated with CORE-GS by Geroc - Soil Log - 8/11/2023 11:05:47 AM

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

**PLANT:** Hanjin 8D
**METHOD:** AD to 2.5m, then WB to 19.45m
**REMARKS:** No groundwater seepage observed during auger drilling.

**OPERATOR:** MK Drilling
**CASING:** HWT to 2.5m, then HQ to 19m

**LOGGED:** MDH

Refer to explanatory notes for symbol and abbreviation definitions

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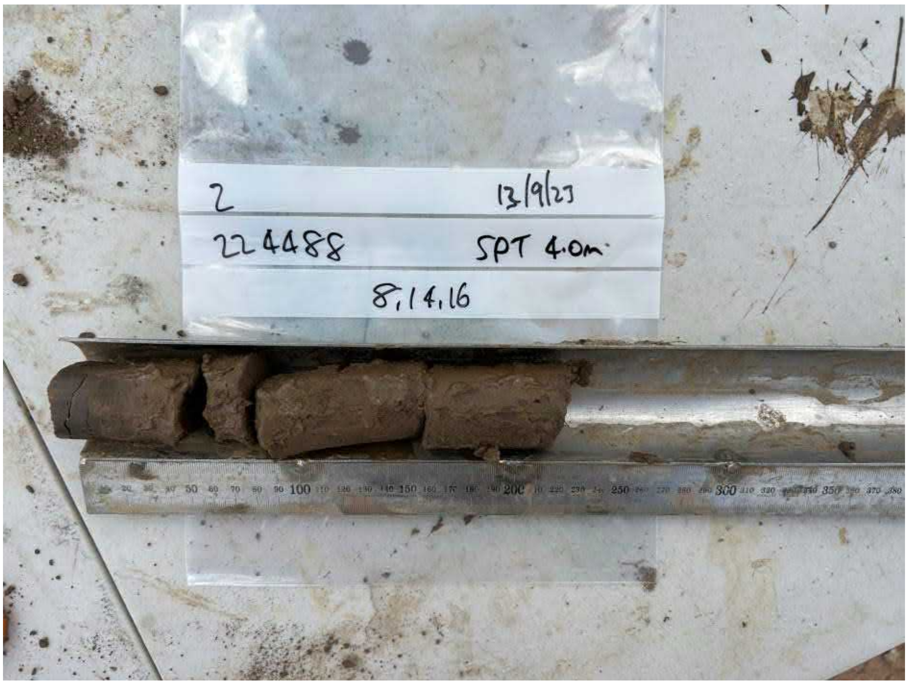
Bore 2 – SPT 2.5m



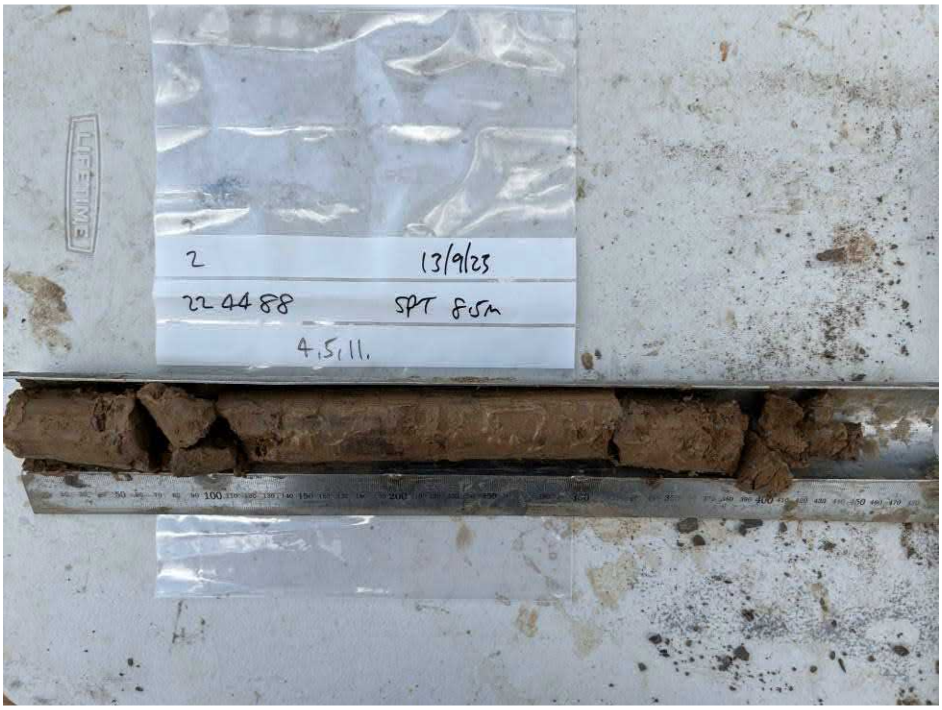
Bore 2 – SPT 4.0m

| | | | |
|---|---|---|---|
| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
| | **Don River Stabilisation** | PLATE No: | 6 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |

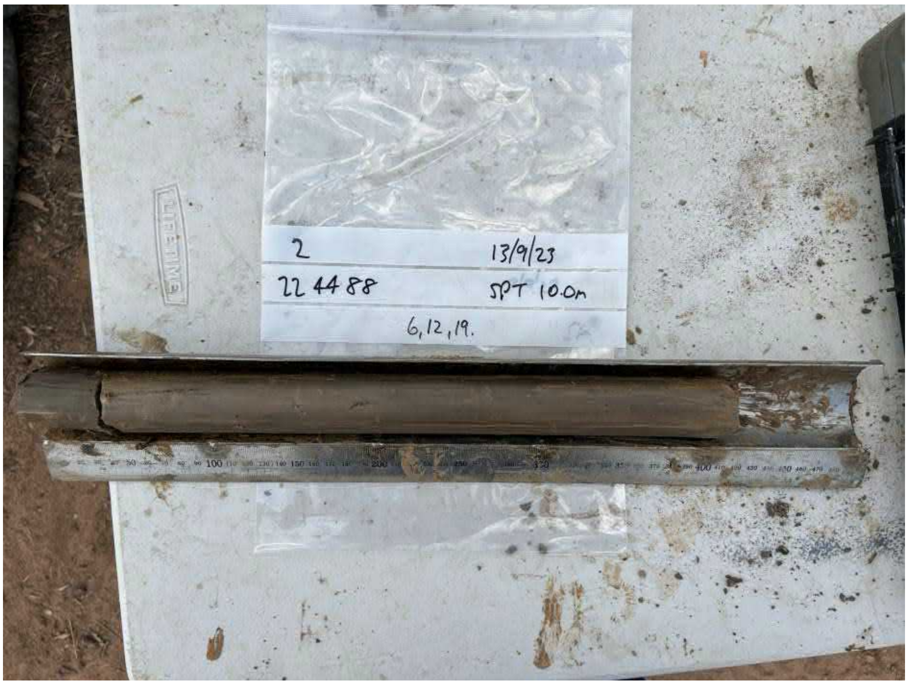
Bore 2 – SPT 5.5m

Bore 2 – SPT 7.0m

| | | | |
|---|---|---|---|
| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
| | **Don River Stabilisation** | PLATE No: | 7 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |



Bore 2 – SPT 8.5m



Bore 2 – SPT 10.0m

| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
|---|---|---|---|
| | **Don River Stabilisation** | PLATE No: | 8 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |

Bore 2 – SPT 11.5m

Bore 2 – SPT 13.0m

**Douglas Partners**
Geotechnics | Environment | Groundwater

**SPT Photographs**
**Don River Stabilisation**
**Don River, Dixalea**

CLIENT: ARO Industries Pty Ltd

| | |
|---|---|
| PROJECT: | 224488.00 |
| PLATE No: | 9 |
| REV: | 0 |
| DATE: | Nov-23 |

Bore 2 – SPT 14.5m

Bore 2 – SPT 16.0m

**SPT Photographs**

**Don River Stabilisation**

**Don River, Dixalea**

CLIENT: ARO Industries Pty Ltd

| | |
|---|---|
| PROJECT: | 224488.00 |
| PLATE No: | 10 |
| REV: | 0 |
| DATE: | Nov-23 |

Bore 2 – SPT 17.5m

Bore 2 – SPT 19.0m

| | | | |
|---|---|---|---|
| Douglas Partners<br>Geotechnics / Environment / Groundwater | **SPT Photographs** | PROJECT: | 224488.00 |
| | **Don River Stabilisation** | PLATE No: | 11 |
| | **Don River, Dixalea** | REV: | 0 |
| | CLIENT: ARO Industries Pty Ltd | DATE: | Nov-23 |

# Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sunshine Coast Laboratory
1/28 Kessling Avenue Kunda Park QLD 4556
Phone: (07) 5351 0400
Email: martin.cook@douglaspartners.com.au

**Report Number:** **224488.00-1**
**Issue Number:** 1
**Date Issued:** 01/11/2023
**Client:** ARO Industries Pty Ltd
44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106I
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 25/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 1 , Depth: 0.0 - 0.4 m**

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

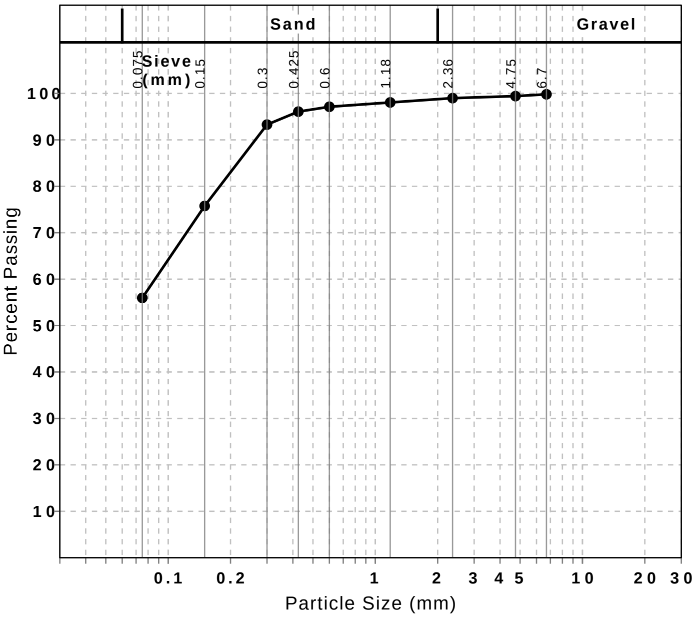
| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 6.7 mm | **100** | | |
| 4.75 mm | **99** | | |
| 2.36 mm | **99** | | |
| 1.18 mm | **98** | | |
| 0.6 mm | **97** | | |
| 0.425 mm | **96** | | |
| 0.3 mm | **93** | | |
| 0.15 mm | **76** | | |
| 0.075 mm | **56** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 26 | | |
| Plastic Limit (%) | 17 | | |
| **Plasticity Index (%)** | **9** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **6.5** | | |
| Cracking Crumbling Curling | None | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 6.4 | | |

Particle Size Distribution



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*Results relate only to the items tested/sampled.*

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Assistant Laboratory Manager
Laboratory Accreditation Number: 828

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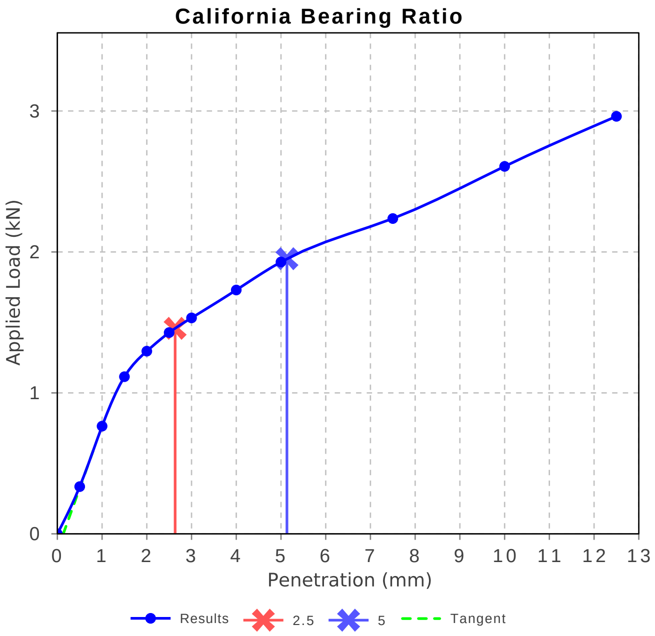
**Date Issued:** 01/11/2023
**Client:** ARO Industries Pty Ltd
44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106I
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 17/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 1 , Depth: 0.0 - 0.4 m**

| California Bearing Ratio (AS 1289 6.1.1 & 2.1.1) | | Min | Max |
|---|---|---|---|
| CBR taken at | 2.5 mm | | |
| CBR % | **11** | | |
| Method of Compactive Effort | Standard | | |
| Method used to Determine MDD | AS 1289 5.1.1 & 2.1.1 | | |
| Method used to Determine Plasticity | AS1289 3.1.2 | | |
| Maximum Dry Density (t/m$^3$) | 1.79 | | |
| Optimum Moisture Content (%) | 13.0 | | |
| Laboratory Density Ratio (%) | 97.5 | | |
| Laboratory Moisture Ratio (%) | 98.5 | | |
| Dry Density after Soaking (t/m$^3$) | 1.73 | | |
| Field Moisture Content (%) | 6.5 | | |
| Moisture Content at Placement (%) | 12.9 | | |
| Moisture Content Top 30mm (%) | 17.2 | | |
| Moisture Content Rest of Sample (%) | 17.3 | | |
| Mass Surcharge (kg) | 4.5 | | |
| Soaking Period (days) | 4 | | |
| Curing Hours (h) | 24.0 | | |
| Swell (%) | 0.5 | | |
| Oversize Material (mm) | 19 | | |
| Oversize Material Included | Excluded | | |
| Oversize Material (%) | 0.0 | | |



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Email: martin.cook@douglaspartners.com.au

**Report Number:** **224488.00-1**
**Issue Number:** 1
**Date Issued:** 01/11/2023
**Client:** ARO Industries Pty Ltd
44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106E
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 25/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 1 , Depth: 2.5 - 2.95 m**

Accredited for compliance with ISO/IEC 17025 - Testing

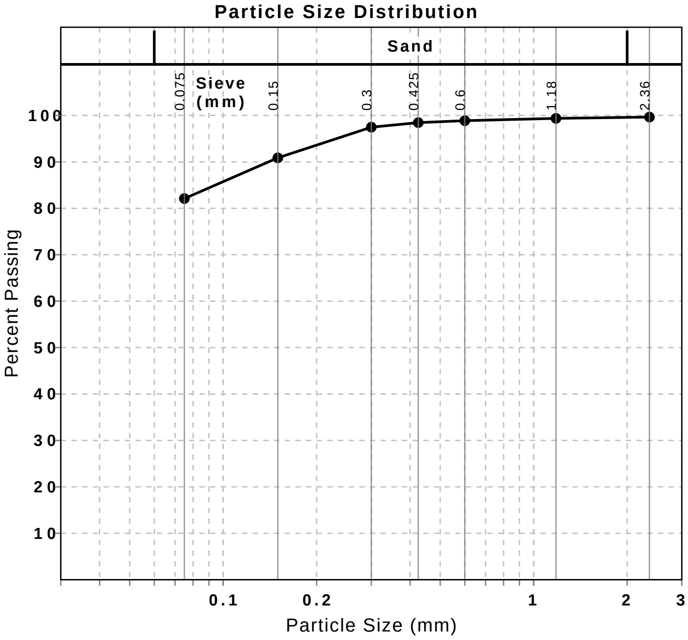
Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 2.36 mm | **100** | | |
| 1.18 mm | **99** | | |
| 0.6 mm | **99** | | |
| 0.425 mm | **98** | | |
| 0.3 mm | **97** | | |
| 0.15 mm | **91** | | |
| 0.075 mm | **82** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 39 | | |
| Plastic Limit (%) | 20 | | |
| **Plasticity Index (%)** | **19** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **12.0** | | |
| Cracking Crumbling Curling | None | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 11.7 | | |



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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

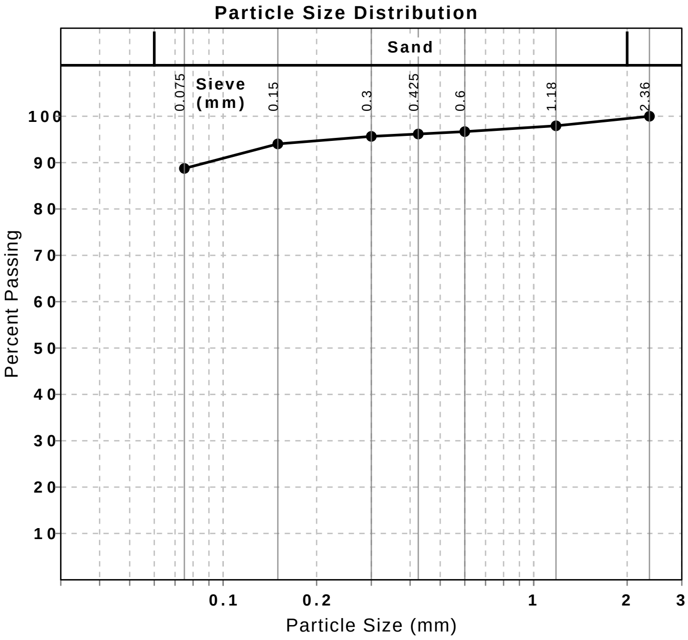
**Report Number:** **224488.00-1**
**Issue Number:** 1
**Date Issued:** 01/11/2023
**Client:** ARO Industries Pty Ltd
44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106F
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 25/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 1 , Depth: 5.5 - 5.95 m**

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 2.36 mm | **100** | | |
| 1.18 mm | **98** | | |
| 0.6 mm | **97** | | |
| 0.425 mm | **96** | | |
| 0.3 mm | **96** | | |
| 0.15 mm | **94** | | |
| 0.075 mm | **89** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 47 | | |
| Plastic Limit (%) | 17 | | |
| **Plasticity Index (%)** | **30** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **16.0** | | |
| Cracking Crumbling Curling | None | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 16.5 | | |



# Material Test Report

| | |
|---|---|
| **Report Number:** | **224488.00-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 01/11/2023 |
| **Client:** | ARO Industries Pty Ltd<br>44 McLeod Street, Cairns QLD 4870 |
| **Contact:** | Jarrod Williams |
| **Project Number:** | 224488.00 |
| **Project Name:** | Don River Stabilisation |
| **Project Location:** | Don River, Dixalea QLD |
| **Work Request:** | 26106 |
| **Sample Number:** | SS-26106G |
| **Date Sampled:** | 12/09/2023 |
| **Dates Tested:** | 11/10/2023 - 25/10/2023 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **Bore 1 , Depth: 8.5 - 8.95 m** |

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Accredited for compliance with ISO/IEC 17025 - Testing

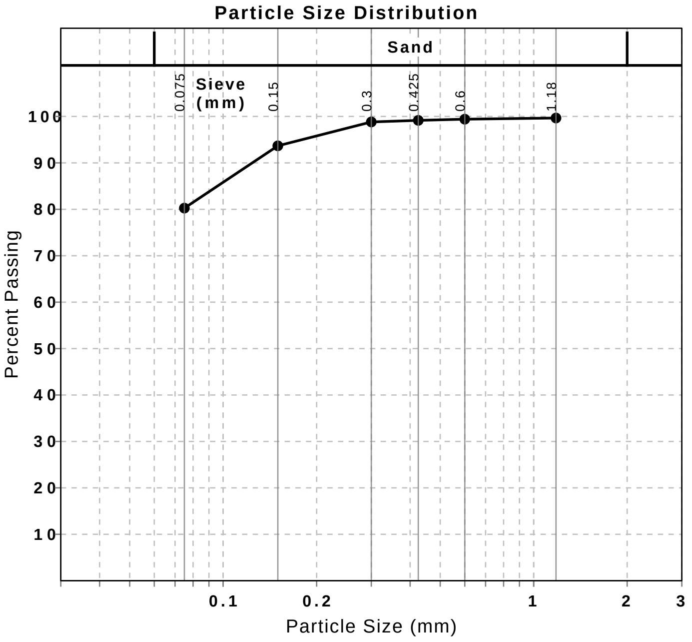
Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 1.18 mm | **100** | | |
| 0.6 mm | **99** | | |
| 0.425 mm | **99** | | |
| 0.3 mm | **99** | | |
| 0.15 mm | **94** | | |
| 0.075 mm | **80** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 39 | | |
| Plastic Limit (%) | 16 | | |
| **Plasticity Index (%)** | **23** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **13.0** | | |
| Cracking Crumbling Curling | Cracking | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 17.1 | | |



# Material Test Report

**Report Number:** **224488.00-1**
**Issue Number:** 1
**Date Issued:** 01/11/2023
**Client:** ARO Industries Pty Ltd
44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106H
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 13/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 1 , Depth: 14.5 - 14.95 m**

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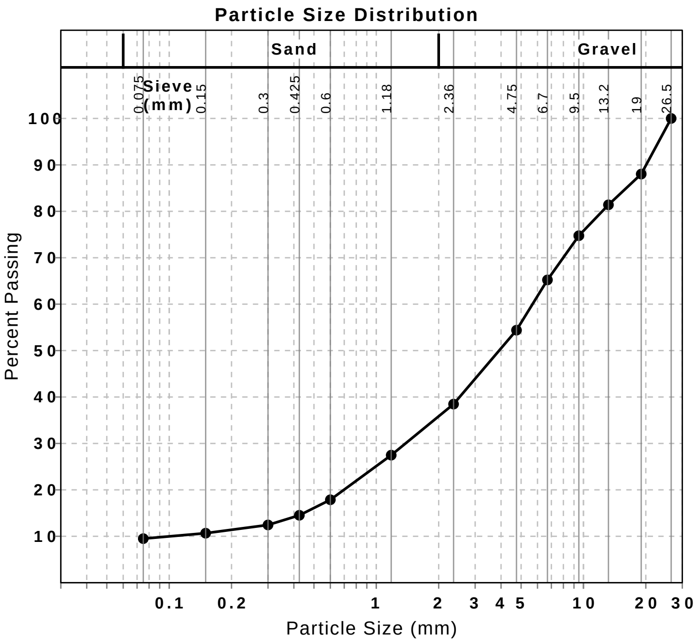
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 26.5 mm | **100** | | |
| 19 mm | **88** | | |
| 13.2 mm | **81** | | |
| 9.5 mm | **75** | | |
| 6.7 mm | **65** | | |
| 4.75 mm | **54** | | |
| 2.36 mm | **38** | | |
| 1.18 mm | **27** | | |
| 0.6 mm | **18** | | |
| 0.425 mm | **15** | | |
| 0.3 mm | **12** | | |
| 0.15 mm | **11** | | |
| 0.075 mm | **9** | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 14.8 | | |



# Material Test Report

**Douglas Partners**
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| | |
|---|---|
| **Report Number:** | **224488.00-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 01/11/2023 |
| **Client:** | ARO Industries Pty Ltd<br>44 McLeod Street, Cairns QLD 4870 |
| **Contact:** | Jarrod Williams |
| **Project Number:** | 224488.00 |
| **Project Name:** | Don River Stabilisation |
| **Project Location:** | Don River, Dixalea QLD |
| **Work Request:** | 26106 |
| **Sample Number:** | SS-26106A |
| **Date Sampled:** | 12/09/2023 |
| **Dates Tested:** | 11/10/2023 - 25/10/2023 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **Bore 2 , Depth: 4.0 - 4.45 m** |

Accredited for compliance with ISO/IEC 17025 - Testing

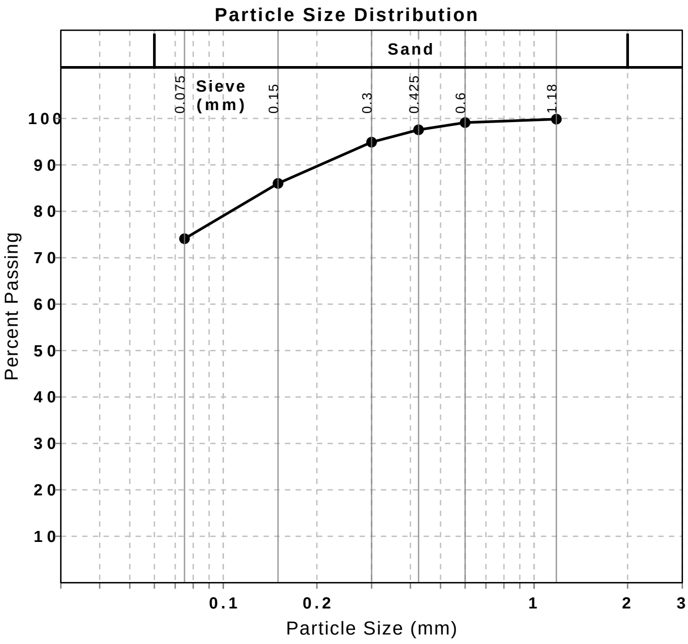
Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 1.18 mm | **100** | | |
| 0.6 mm | **99** | | |
| 0.425 mm | **98** | | |
| 0.3 mm | **95** | | |
| 0.15 mm | **86** | | |
| 0.075 mm | **74** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 39 | | |
| Plastic Limit (%) | 15 | | |
| **Plasticity Index (%)** | **24** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **12.5** | | |
| Cracking Crumbling Curling | None | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 16.0 | | |



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44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106B
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 25/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 2 , Depth: 7.0 - 7.45 m**

Accredited for compliance with ISO/IEC 17025 - Testing

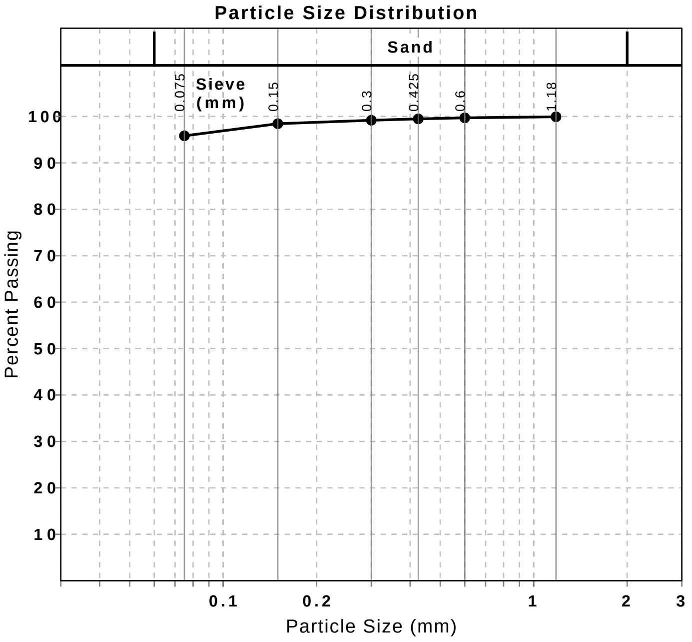
Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 0.6 mm | **100** | | |
| 0.425 mm | **99** | | |
| 0.3 mm | **99** | | |
| 0.15 mm | **98** | | |
| 0.075 mm | **96** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 45 | | |
| Plastic Limit (%) | 17 | | |
| **Plasticity Index (%)** | **28** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **13.5** | | |
| Cracking Crumbling Curling | None | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 25.5 | | |



# Material Test Report

Douglas Partners Pty Ltd
Sunshine Coast Laboratory
1/28 Kessling Avenue Kunda Park QLD 4556
Phone: (07) 5351 0400
Email: martin.cook@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

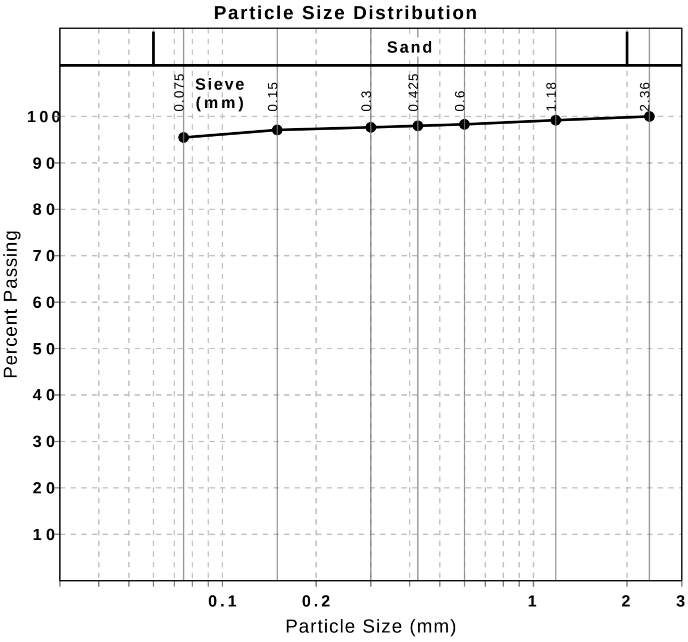
**Report Number:** **224488.00-1**
**Issue Number:** 1
**Date Issued:** 01/11/2023
**Client:** ARO Industries Pty Ltd
44 McLeod Street, Cairns QLD 4870
**Contact:** Jarrod Williams
**Project Number:** 224488.00
**Project Name:** Don River Stabilisation
**Project Location:** Don River, Dixalea QLD
**Work Request:** 26106
**Sample Number:** SS-26106C
**Date Sampled:** 12/09/2023
**Dates Tested:** 11/10/2023 - 25/10/2023
**Sampling Method:** Sampled by Engineering Department
*The results apply to the sample as received*
**Sample Location:** **Bore 2 , Depth: 10.0 - 10.45 m**

| Particle Size Distribution (AS1289 3.6.1) | | | |
|---|---|---|---|
| Sieve | Passed % | Passing Limits | |
| 2.36 mm | **100** | | |
| 1.18 mm | **99** | | |
| 0.6 mm | **98** | | |
| 0.425 mm | **98** | | |
| 0.3 mm | **98** | | |
| 0.15 mm | **97** | | |
| 0.075 mm | **95** | | |

| Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1) | | Min | Max |
|---|---|---|---|
| Sample History | Oven Dried | | |
| Preparation Method | Dry Sieve | | |
| Liquid Limit (%) | 58 | | |
| Plastic Limit (%) | 17 | | |
| **Plasticity Index (%)** | **41** | | |

| Linear Shrinkage (AS1289 3.4.1) | | Min | Max |
|---|---|---|---|
| Moisture Condition Determined By | AS 1289.3.1.2 | | |
| Linear Shrinkage (%) | **18.0** | | |
| Cracking Crumbling Curling | Cracking & Curling | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 19.7 | | |



# Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Sunshine Coast Laboratory
1/28 Kessling Avenue Kunda Park QLD 4556
Phone: (07) 5351 0400
Email: martin.cook@douglaspartners.com.au

| | |
|---|---|
| **Report Number:** | **224488.00-1** |
| **Issue Number:** | 1 |
| **Date Issued:** | 01/11/2023 |
| **Client:** | ARO Industries Pty Ltd<br>44 McLeod Street, Cairns QLD 4870 |
| **Contact:** | Jarrod Williams |
| **Project Number:** | 224488.00 |
| **Project Name:** | Don River Stabilisation |
| **Project Location:** | Don River, Dixalea QLD |
| **Work Request:** | 26106 |
| **Sample Number:** | SS-26106D |
| **Date Sampled:** | 12/09/2023 |
| **Dates Tested:** | 11/10/2023 - 13/10/2023 |
| **Sampling Method:** | Sampled by Engineering Department<br>*The results apply to the sample as received* |
| **Sample Location:** | **Bore 2 , Depth: 13.00 - 13.27 m** |

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Approved Signatory: Martin Cook
Assistant Laboratory Manager
Laboratory Accreditation Number: 828

## Particle Size Distribution (AS1289 3.6.1)

| Sieve | Passed % | Passing Limits | |
|---|---|---|---|
| 26.5 mm | **100** | | |
| 19 mm | **89** | | |
| 13.2 mm | **79** | | |
| 9.5 mm | **71** | | |
| 6.7 mm | **63** | | |
| 4.75 mm | **56** | | |
| 2.36 mm | **42** | | |
| 1.18 mm | **37** | | |
| 0.6 mm | **29** | | |
| 0.425 mm | **26** | | |
| 0.3 mm | **24** | | |
| 0.15 mm | **21** | | |
| 0.075 mm | **19** | | |

| Moisture Content (AS 1289 2.1.1) | | Min | Max |
|---|---|---|---|
| Moisture Content (%) | 13.4 | | |