Transport for NSW

Byrons Lane Slip Stage V

Review of Environmental Factors

October 2022

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Acknowledgement of Country

Transport for NSW acknowledges the Yaegl People, the traditional custodians of the land on which the Byrons Lane Slip Stage V project is proposed.

We pay our respects to their Elders past and present and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters of NSW.

Many of the transport routes we use today – from rail lines, to roads, to water crossings – follow the traditional Songlines, trade routes and ceremonial paths in Country that our nation's First Peoples followed for tens of thousands of years.

Transport for NSW is committed to honouring Aboriginal peoples' cultural and spiritual connections to the land, waters and seas and their rich contribution to society.

Approval and authorisation

Title	Byrons Lane Slip Stage V - Review of Environmental Factors
Accepted on behalf of Transport for NSW by:	Ian Drinkwater Project Manager, Project Services Northern
Signed	Ian Drinkwater
Date:	28/10/2022

Document review tracking

Draft No.	Date	Comments
Draft 1	23/02/2022	First draft issued to TfNSW
Draft 2	24/03/2022	ECF - First draft report transferred into new TfNSW Project REF template
Draft 2	25/03/2022	AK - Proof newly formatted word doc; PDF
Draft 3	04/04/2022	ECF – Third draft (v3) responding to TfNSW comments
Draft 4	17/05/2022	ECF - Fourth draft (v4) responding to TfNSW comments and version for s199 referral
Draft 5	04/08/2022	ECF (v5) updates after REF finalization meeting, include s199 referral response
Draft 6	17/10/2022	SDS (v6) updates after TfNSW review and comments

Executive summary

The proposal

Transport for NSW ('Transport') proposes to carry out remediation works on the South Arm River (south arm of the Clarence River) embankment to repair the riverbank profile in response to a slip as a result of significant rainfall event (declared natural disaster) in March 2021. The South Arm River is located adjacent to the Big River Way (Old Pacific Highway) and the eastern riverbank forms the western embankment for the Big River Way at the proposed remediation site. The slip is located approximately 33.44km north of Grafton in the Clarence Valley Council (CVC) local government area and is located approximately 540m north-east of Byrons Lane.

The scope of works is broadly summarised as implementing a structural piled wall solution for slope remediation in combination with remediation of the riverbank profile.

Key features of the proposal include:

Initial Project Set up

- Establishing a site compound and stockpile site within road reserve on eastern side of Big River Way approximately 700m north of the proposed works. A potential pile stockpile site may be established within land (owner to be confirmed) on the opposite (north-western) side of the riverbank.
- Establishing traffic control management in vicinity of the site.
- Establishing sedimentation and erosion controls on South Arm River embankment and within waterway as required.
- Clearing and disturbance of vegetation (consisting of trees, weeds and native vegetation) alongside the South Arm River to facilitate works (up to a total area of 0.84ha). The slip site consists of removal of approximately 0.27ha of plant community type (PCT) 1235 and 4 swamp oak trees over 10cm diameter at breast height (DBH).
- Vegetation mulched onsite and either temporarily stockpiled for reuse on site or taken to an alternative site for re-use or disposed of at a licenced waste facility.

Piling Works and Slope Remediation

- Proposed shear piles and rock fill construction methodology which seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower riverbank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

Restoration of Big River Way Pavement

- Repair areas of pavement shoulder impacted by loss of formation support.
- Repair/extend existing concrete safety barriers.

Construction was expected to commence in September 2022 and be completed by September 2023, however there is some flexibility around start of construction (which may not commence until 2023) to accommodate the construction procurement process and potential for programming of work around predicted wet periods.

Need for the proposal

The subject site at Clarence riverbank adjacent to Big River Way was inspected on 9 March 2021 by Transport Geotechnical Officers after the slope subsidence was initially identified by Road Maintenance inspections. Observations identified embankment subsidence and increase cracking mechanisms within the road shoulder. This site is located within an area where previous riverbank slope stability treatments have been required. An initial slip occurred at the site as a result of floods in mid-June 2009. The site has been subject to various stages (I-IV) of restoration works to rehabilitate the original slip and prevent further collapse of the riverbank to ensure highway safety was maintained.

Big River Way provides an important transport route which carries low volumes of traffic for a variety of vehicle types (regional freight vehicles, large passenger vehicles, light passenger vehicles and local traffic). The proposal is required to restore the riverbank, prevent further slips and improve safety for road users.

The proposal is funded by a state road and natural disaster program and is expected to cost approximately $4M for delivery.

Proposal objectives

The primary objective of the proposal is to ensure that Big River Way remains a safe and trafficable transport route by preventing further degradation of the road surface from subsidence risk associated with the ALR1 risk rating slope.

Other objectives of the proposal are to:

- Stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way.
- Restoration of the riverbank profile.
- Restore the pavement to the shoulder of Big River Way.
- Undertake works to minimise traffic, environmental, social impacts.

Options considered

The 100% Geotechnical Interpretive and Design Options report outlines 4 possible options and construction sequences. The following options for the proposal were assessed.

Option 1A: Cantilever Sheet Pile Wall

Concept Option 1A seeks to retain the road embankment by installing a row of cantilevered steel sheet piles along the alignment of the existing slip headscarp. The approximate length of the wall is 42m and comprises AZ46-700N sheet piles, at least 16m in length, embedded within the stiff clays.

Option 1B: Anchored Sheet Pile Wall

Concept Option 1B seeks to retain and regain the failed embankment by installing a row of sheet piles on the riverside of the headscarp, through the slip. In this location, the sheet piles are supporting weak, slumped slip materials and are expected to require a row of anchors of tie bars to control displacements.

The concept design is a 40m long sheet piled retaining wall comprising approximately 12m long sheet piles. A second row of deadman sheet piles (5m long) are proposed to be located on the opposite side of the road, positioned to avoid buried services (Telstra and water main). A row of steel tie bars anchors the retaining wall to the deadman via horizontal water beams.

Option 2: Contiguous Pile Wall

Concept Option 2 seeks to retain the embankment by installing a row of contiguous piles. The piles are proposed to be installed using continuous flight auger (CFA) drilling rig. Alternatively driven steel tubular piles (possibly interlocked) may be installed and the upper 7m to 10m could be excavated and replaced with reinforced concrete for durability.

The approximate length of the wall is 42m and comprises 750mm diameter piles at close (1200mm to 1400mm) centres. The piles are supposed to be positioned approximately 1.5m back from the existing headscarp, primarily to allow the piles to be installed without further temporary stability or casing requirements. The headscarp is proposed to be battered and rock armoured.

Option 3: Shear Piles and Rock Fill

Concept Option 3 is similar to the adjacent, previous slip remediation. It seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower riverbank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

Option 4: Gabion Wall and Piled Foundation

Concept Option 4 seeks to retain the road embankment with a gabion basket retaining wall founded on a piled raft footing. Two rows of precast, driven, reinforced concrete piles are proposed to be installed and connected to a reinforced concrete pad footing. The gabion baskets to be founded on the concrete raft footing construction on top of the piles. Temporary battered excavations are required to facilitate the construction of the reinforced concrete footing and gabion baskets.

A 'do nothing' option involves leaving the existing slip in place. This option does not maintain road safety, a key responsibility of Transport. Furthermore, the 'do nothing' option would not address slope remediation works required alongside Big River Way which in the longer term would risk further damage to the road asset.

Option 3 was selected as the preferred option as it scored the highest when evaluated using weighted multi-criteria analysis (Design, Construction, Environment, Community and Costing Components). Option 3 satisfies the objectives of the proposal and is expected to achieve the highest design life. While the construction method is considered a relatively higher risk option due to working over water, the proposal is considered to have positive environmental impacts as it seeks to restore lost riverbank.

Statutory and planning framework

The proposal is for a road and road infrastructure facilities and is to be carried out by Transport for NSW and can therefore be assessed under Division 5.1 of the *Environmental Planning and Assessment Act 1979 (NSW)*. Development consent from council is not required.

State Environmental Planning Policy (Transport and Infrastructure) 2021 (TISEPP) (previously *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP)) aims to facilitate the effective delivery of infrastructure across the State, including roads and road infrastructure facilities. Section 2.108 of TISEPP (previously Clause 94 ISEPP) permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

The proposal is not located on land reserved under the *National Parks and Wildlife Act 1974* and does not require development consent or approval under *State Environmental Planning Policy (Resilience and Hazards) 2021, State Environmental Planning Policy (Planning Systems) 2021* or *State Environmental Planning Policy (Precincts - Regional) 2021.*

Part 2.2 of TISEPP (previously Part 2 of ISEPP) contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Consultation, including consultation as required by TISEPP (where applicable), is discussed in chapter 5 of this REF.

Community and stakeholder consultation

Preliminary consultation with affected stakeholders, landowners, Council and government agencies has been undertaken and has informed the proposal.

The Transport Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI) has been undertaken for the proposal. Transport for NSW's Cultural and Heritage Officer advised that the proposal was unlikely to have an impact on Aboriginal cultural heritage. Consultation has also been undertaken under the *Native Title Act*.

Formal consultation has been initiated with Clarence Valley Council (CVC) and State Emergency Services (SES) and internal notification has been provided to Transport – Maritime as per the requirements of TISEPP. NSW Department of Primary Industries (DPI) - Fisheries have also been consulted in accordance with the Fisheries Management Act 1994. Advice received from Transport – Maritime and NSW DPI Fisheries as part of this consultation has been addressed in this REF. No other comments have been received as part of this consultation.

Consultation with key stakeholders affected by the proposal will be ongoing.

Environmental impacts

The main environmental impacts of the proposal are:

Biodiversity Impact

- The proposal involves removing weeds and native growth along the proposed river embankment along the South Arm River as required to facilitate riverbank stabilisation and repair to the road shoulder. A Biodiversity Assessment Report (BAR) has been prepared to assess biodiversity matters relevant to the proposal.
- The BAR concluded that the proposal is unlikely to significantly affect any species, communities or their habitat listed under the BC Act of the EPBC Act. A Species Impact Statement is not required, nor is the proposal subject to the EPBC Act Strategic Assessment. The works do not trigger the Transport offset guidelines.

- Safeguards and mitigation measures detailed in the BAR have been recommended to manage potential impacts relating to biodiversity. Refer to the Biodiversity Assessment Report prepared to accompany this report (**Appendix A**).

Heritage Impact

- The proposal is unlikely to have any impact on Indigenous or Non-Indigenous heritage.

Socio-economic Impact

- Potential short-term impacts including increased traffic, noise and vibration associated with the works can be managed by safeguards and management measures presented in the REF. Overall, while the short-term impacts cannot be avoided completely, no significant or long-term adverse impacts are likely.
- The proposed repair works will have positive long term socio-economic benefits by providing an improved road safety environment with reduced risk of further slips/collapse as a result of restoration of the riverbank.

Soil and Water Quality Impact

- Potential environmental impacts associated with erosion and sediment, including disturbance of the riverbed and riverbank causing sediment to mobilise, would be suitably managed through effective implementation of safeguards of this REF.

Traffic Impact

- Users of Big River Way would experience traffic delays during the proposed work. Traffic delays may also occur along South Arm Road (on Woodford Island) associated with delivery of piles to the proposed pile storage location on the north-western bank of the Clarence River (with owner approval), which would lessen impacts on Big River Way. An alternative option may include use of an additional barge for temporary storage of piles to avoid impacts on local roads during cane haul season (July to December).

Construction Noise levels

- Predicted noise levels for the works are expected to exceed the established EPAs construction noise management levels for various affected receivers depending on hours of work. Letterbox drops to residents are recommended for sensitive receivers within certain distances from the works site depending on working hours.

No significant impacts to any Matters of National Environmental Significance (MNES) listed in the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) will occur as a result of the proposal.

Other potential environmental impacts would be generally minor in nature. A variety of safeguards have been developed to minimise the risk and potential magnitude of potential impacts posed by the proposal to the environment. The proposal would have a number of positive environmental impacts, including improvements to road safety and prevention of future slips and further degradation of road surface.

Justification and conclusion

The remediation works on the South Arm River embankment are required to improve road safety.

With effective implementation of the safeguards and management measures of this REF, environmental impacts associated with undertaking the work would be minor. Unavoidable impacts required for the work are temporary and not substantial and would not significantly affect the local environment. Overall, the environment would benefit from the proposed restoration and remediation of the riverbank as road safety would be improved.

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1. Introduction

1.1 Proposal identification

Transport proposes to carry out remediation works to the shoulder and riverbank that has eroded away on a section of Big River Way (Old Pacific Highway), Tyndale (the Site). The site is located approximately 33.44km north of Grafton. The project site is approximately 100m in length and extends from the Big River Way into the Clarence River. The section of the roadside shoulder to be repaired is approximately 40m in length on the northbound lane, adjacent to the South Arm of the Clarence River. The works are required to stabilise the riverbank and improve safety along this section of Big River Way.

Key features of the proposal would include:

- Project set up including establishment of site compound and stockpile locations within close proximity to the site.
- Establish traffic controls in vicinity of site (to accommodate temporary restricted/closed lanes of Big River Way).
- Establish sedimentation and erosion controls on riverbank and within the waterway as required.
- Clearing of slip area including clearing of vegetation along slip restoration site to facilitate works.
- Piling works (from road and/or river) to stabilise slope area (detailed below).
- Repair/restoration of pavement shoulder of Big River Way.

The selected construction option seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower riverbank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

The following construction sequence is anticipated:

1. Set out piles in river.
2. Mobilise barge with a large excavator and displace existing rock fill and rock armour from the proposed pile footprint and obstructions to barge.
3. Mobilise a barge with pile driving rig to install the row of sheet piles or precast concrete piles. The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration would be given to hydraulic impacts (use of hammers rather than vibratory hammers).
4. Clear vegetation from riverbank to excavate terraces.
5. Lay and secure heavy duty geotextile.
6. Place rock fill and rock armour to slope commencing from behind the piles. Likely to require some rock fill to be placed from barge and/or a long reach excavator.
7. Extend concrete safety barrier.

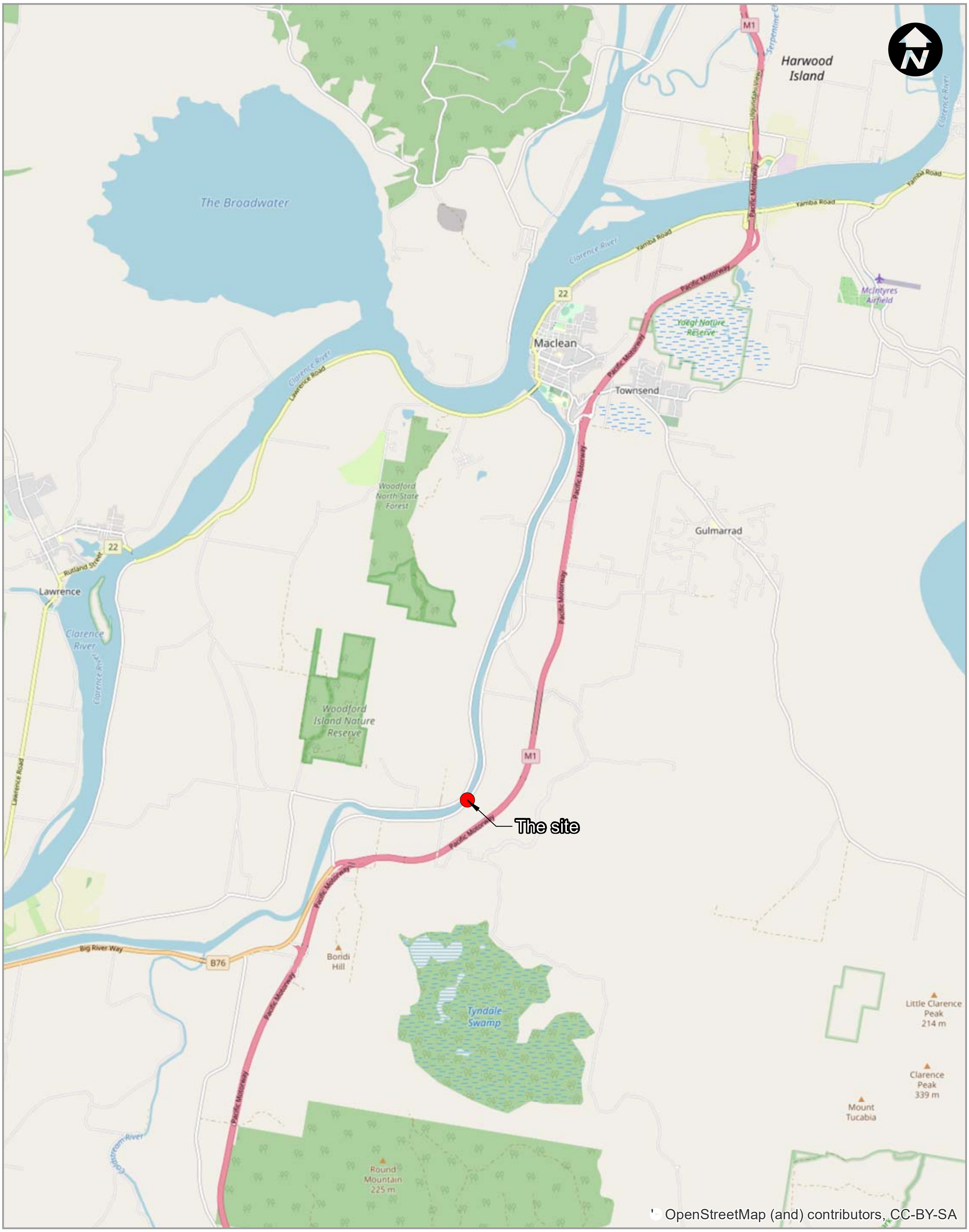
Construction was expected to commence in September 2022 and be completed by September 2023, however there is some flexibility around start of construction (which may not commence until 2023) to accommodate the construction procurement process and potential for programming of work around predicted wet periods.

On site facilities for workers and stockpile sites will be provided, including use of an existing site compound established within the road reserve on the eastern side of Big River Way approximately 700 m north of the proposed works. A potential stockpile site for piles may be established within land on the opposite side (north-western) riverbank (land owner and approval to be confirmed).

The location of the proposal is shown in Figure 1.1 and an overview of the proposal is provided in Figure 1.2. Chapter 3 describes the proposal in more detail.

Plate 1.1: Existing slip viewed from southern extent of the site showing headscarp profile

Plate 1.2: Existing slip viewed from the northern extent of the site showing headscarp profile



0 2 Km

Location Of The Proposal - Illustration 1.1

GeoLINK environmental management and design

Byron's Lane Slip Stage V
4099-1009

Information shown is for illustrative purposes only
Drawn by: AB Checked by: RE Reviewed by: ECF
Source of base data: OpenStreet Map
Date: 20/10/2021

LEGEND

- Survey limit
- New Byron Lane stage V slip
- Cadastre

0 30 Meters

The Proposal - Illustration 1.2

GeoLINK environmental management and design

Byron's Lane Slip Stage V
4099-1016

Information shown is for illustrative purposes only
Drawn by: AB Checked by: RE Reviewed by: ECF
Source of base data: Department of Customer Services
Date: 06/04/2022
Revision: A

1.2 Purpose of the report

This review of environmental factors (REF) has been prepared by GeoLINK on behalf of Transport Northern Region. For the purposes of these works, Transport is the proponent and determining authority under Division 5.1 of the *Environmental Planning and Assessment Act 1979 (NSW) (EP&A Act)*.

The purpose of the REF is to describe the proposal, to document the likely impacts of the proposal on the environment, and to detail mitigation and management measures to be implemented.

The description of the proposed work and assessment of associated environmental impacts has been undertaken in the context of Section 171 of the Environmental Planning and Assessment Regulation 2021, the factors in *Is an EIS Required? Best Practice Guidelines for Part 5 of the EP&A Act* (*Is an EIS required?* guidelines) (DUAP, 1995/1996), *Roads and Related Facilities EIS Guideline* (DUAP 1996), the *Biodiversity Conservation Act, 2016 (BC Act*), the *Fisheries Management Act 1994* (FM Act), and the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)*.

In doing so, the REF helps to fulfil the requirements of:

- Section 5.5 of the EP&A Act including that Transport examine and take into account, to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity.

The findings of the REF would be considered when assessing:

- Whether the proposal is likely to have a significant impact on the environment and therefore the necessity for an environmental impact statement to be prepared and approval sought from the Minister for Planning under Division 5.2 of the EP&A Act.
- The significance of any impact on threatened species as defined by the BC Act and/or FM Act, in section 1.7 of the EP&A Act and therefore the requirement for a Species Impact Statement or a Biodiversity Development Assessment Report
- The significance of any impact on nationally-listed biodiversity matters under the EPBC Act, including whether there is a real possibility that the activity may threaten long-term survival of these matters, and if offsets are required and able to be secured.

The potential for the proposal to significantly impact any other matters of national environmental significance or Commonwealth land and the need, subject to the *EPBC Act* strategic assessment approval, to make a referral to the Australian Government Department of Agriculture, Water and the Environment for a decision by the Commonwealth Minister for the Environment on whether assessment and approval is required under the *EPBC Act.*

2. Need and options considered

2.1 Strategic need for the proposal

The proposed works occur along Big River Way, a state classified road, which provides an important transport route. It carries low volumes of traffic for a variety of vehicle types (regional freight vehicles, large passenger vehicles, light passenger vehicles and local traffic). A risk to road users exists as a result of the slip, which occurred after a significant rainfall event (declared natural disaster) in March 2021. Remediation works are required to repair the current slip, prevent further slips and improve road safety. Delaying the proposed remediation works may result in further slips and additional damage to the road pavement. This may then require major rehabilitation that is likely to involve a higher risk of negative environmental impacts, greater financial cost and lengthy delays for motorists.

The proposal is funded by a state road and natural disaster program and is expected to cost approximately $4M for delivery.

Transport are responsible for managing road related transport infrastructure and providing safe and efficient access for the road network for the people of NSW. The proposal incorporates Transport's environment policy (2012), which states that:

Transport is committed to carrying out its business in an environmentally responsible manner by effectively identifying and managing any risks which may potentially impact the environment. Transport will take all reasonably practical steps to ensure there is continuous improvement in environmental performance, including ongoing communication and awareness raising, active reporting of environmental incidents and continuous learning from experience.

The proposal will be undertaken with low environmental impacts, and construction activities would be guided by the safeguards described in this REF.

2.2 Limitations of existing infrastructure

The slip along the riverbank means the shoulder along the edge of Big River Way is in a deteriorated condition and poses a risk to road safety. The proposed remediation works along the riverbank are required to stabilise the site and allow restoration of the pavement to the shoulder of Big River Way to meet current safety standards.

This section of the riverbank has a history of slip remediation projects and riverbank slope stability treatments have been required. This includes:

<u>Initial Slip</u>: approximately 60m of the riverbank including road verge, shoulder and 300mm of the north bound lane of the Pacific Highway (now Big River Way) slumped and fell into the Clarence River as a result of floods in mid-June 2009.

<u>Stage I</u>: the south bound lane of the Pacific Highway was moved to the east away from the existing slip site.

<u>Stage II</u>: restoration works to rehabilitate the original slip were completed in August 2009 however upon completion, the works slumped for a second time into the Clarence River.

<u>Stage III:</u> works involved sheet piling along the face of the slip in December 2009 to prevent further collapse of the riverbank and ensure that highway safety was maintained for the travelling public.

<u>Stage IV:</u> works involved installing 11m long timber piles along the toe of the slip scar and reinstating the riverbank between the piles and the slip with rock fill.

The last repairs completed were carried out in 2017. The current slip site (approximately 40m long) is located directly north (downstream) of the stage IV rock fill and piling work slip site.

When first investigated the slip headwall scarp was up to 2.5m high and about 6m from the edge line. A formed concrete barrier is between the scarp and the edge line of the Big River Way for part of the slip. The scarp is about 1m inside the guard rail/edge of formation. The slip scarp is continuing to increase in height as the slip creeps (daily showers are likely contributing to continued slip movement).

The rock fill for the original slip extends about 6m into the river channel from the riverbank. The failed slope adjacent to the original Byrons Lane slip has angular rock on the surface. The riverbank was either covered in rock for scour protection or rock fill has been placed at some time in the past. The tree and vegetation cover suggests this pre-dates the rock fill for the original Byrons Lane Slip. The current slip site consists of approximately 0.27ha of PCT 1235 and 4 swamp oak trees over 10cm diameter at breast height (DBH).

The riverbank that has not failed downstream of the current site has a near vertical riverbank about 1.5-2m high with leaning trees and local undermining from river scour and tidal action. At the top of the bank is a 3-4m wide low angle terrace. From the terrace, the riverbank rises about 3-4m at 20-30 degrees to the road level. This is likely part fill and part natural slope. Guardrail is at the top of the slope. The shoulder is wide, up to 6m, due to shifting of the road as part of work for the original Byrons Lane Slip.

At low tide, there appears to be some rock at the toe of the riverbank. There appears to be a small shelf. It is assumed the riverbank drops steeply offshore of the riverbank based on the channel morphology in front of the original Byrons Lane Slip.

2.3 Proposal objectives and development criteria

2.3.1 Proposal objectives

The objectives of the proposal include:

- Stabilise the bank of the South Arm River associated with the proposal to prevent further erosion along the edge of Big River Way;
- Restore the riverbank profile;
- Restore the pavement to the shoulder of Big River Way;
- Undertake works to minimise traffic, environmental, social impacts; and
- Ensure Big River Way remains a safe and trafficable transport route.

2.3.2 Development criteria

The development criteria for the proposal include:

- Transport Technical Directions and Specifications.

2.3.3 Urban design objectives

Transport is committed to adopting an urban design approach suitable for all TfNSW transport infrastructure. Urban design has been integrated into the process of developing and designing the proposal with the following objectives:

- Contribute to the accessibility and connectivity of communities.
- Contribute to the overall quality of the public domain for the community.
- Promote road safety through integrated urban design.

2.4 Alternatives and options considered

2.4.1 Methodology for selection of preferred option

Four concept slope remediation options were designed to achieve a minimum design life of 50 years, a long-term slope stability factor of safety of at least 1.3 and short-term slope stability factor of safety of at least 1.2.

These options were considered against the following weighted criteria:

A. Technical Merit/Design (30%)
B. Construction (20%)
C. Environment (20%)
D. Community Impacts During Construction (10%)
E. Price/Costing components (20%)

2.4.2 Identified options

Option 1A: Cantilever Sheet Pile Wall

Concept Option 1A seeks to retain the road embankment by installing a row of cantilevered steel sheet piles along the alignment of the existing slip headscarp. The approximate length of the wall is 42m and comprises AZ46-700N sheet piles, at least 16m in length, embedded within the stiff clays.

Option 1B: Anchored Sheet Pile Wall

Concept Option 1B seeks to retain and regain the failed embankment by installing a row of sheet piles on the riverside of the headscarp, through the slip. In this location, the sheet piles are supporting weak, slumped slip materials and are expected to require a row of anchors of tie bars to control displacements.

The concept design is a 40m long sheet piled retaining wall comprising approximately 12m long sheet piles. A second row of deadman sheet piles (5m long) are proposed to be located on the opposite side of the road, positioned to avoid buried services (Telstra and water main). A row of steel tie bars anchors the retaining wall to the deadman via horizontal water beams.

Option 2: Contiguous Pile Wall

Concept Option 2 seeks to retain the embankment by installing a row of contiguous piles. The piles are proposed to be installed using continuous flight auger (CFA) drilling rig. Alternatively driven steel tubular piles (possibly interlocked) may be installed and the upper 7m to 10m could be excavated and replaced with reinforced concrete for durability.

The approximate length of the wall is 42m and comprises 750mm diameter piles at close (1200mm to 1400mm) centres. The piles are supposed to be positioned approximately 1.5m back from the existing headscarp, primarily to allow the piles to be installed without further temporary stability or casing requirements. The headscarp is proposed to be battered and rock armoured.

Option 3: Shear Piles and Rock Fill

Concept Option 3 is similar to the adjacent, previous slip remediation. It seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower riverbank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

Option 4: Gabion Wall and Piled Foundation

Concept Option 4 seeks to retain the road embankment with a gabion basket retaining wall founded on a piled raft footing. Two rows of precast, driven, reinforced concrete piles are proposed to be installed and connected to a reinforced concrete pad footing. The gabion baskets to be founded on the concrete raft footing construction on top of the piles. Temporary battered excavations are required to facilitate the construction of the reinforced concrete footing and gabion baskets.

2.4.3 Analysis of options

A weighted multi-criteria assessment was undertaken to compare the four concept slip remediation options within the Geotechnical Interpretive and Design Options Report (refer to **Appendix B**). The assessment criteria and weightings were adopted from other TfNSW slope remediation projects and include design, construction, environmental, community and costing components. The criteria weightings range from 10% to 30% and the criteria score range from 1 (Very poor) to 5 (Excellent).

Table 2.1 presents a summary of the comparative assessment.

Table 2.1: Weighted multi-criteria assessment

Criteria		Technical Merit		Construction		Environment		Community		Price	Total
Descriptions	Score (1-5)	Design Life/ Durability (15%)	Stability (15%)	Risks to life and Other Risks (10%)	Construct-ability (10%)	Impacts/ Footprint (10%)	Long term including visual (10%)	Duration (5%)	Road Closures (5%)	Relative Construction Cost (Estimate) (20%)	
Option 1A – Cantilever Sheet Pile Wall	Score	3	5	4	5	2	2	5	4	3	-
	% of Score	0.45	0.75	0.4	0.5	0.2	0.2	0.25	0.2	0.6	**3.55**
Option 1B – Anchored Sheet Pile Wall	Score	3	5	3	4	3	2	3	2	2	-
	% of Score	0.45	0.75	0.3	0.4	0.3	0.2	0.15	0.1	0.4	**3.05**
Option 2 – Contiguous Pile Wall	Score	5	5	3	4	2	3	3	3	3	-
	% of Score	0.75	0.75	0.2	0.4	0.2	0.3	0.15	0.15	0.6	**3.5**
Option 3 – Shear Piles and Rock Fill	Score	4	5	2	3	4	4	2	3	4	-
	% of Score	0.6	0.75	0.2	0.3	0.4	0.4	0.1	0.15	0.8	**3.7**
Option 4 – Gabion Wall and Piled Foundation	Score	4	5	2	2	3	3	2	3	1	-
	% of Score	0.6	0.75	0.2	0.2	0.3	0.3	0.1	0.15	1	**3.6**

2.5 Preferred option

The preferred Option 3 – The Proposal – has been selected to meet the proposal objectives whilst best balancing the impacts of the Proposal.

Option 3 was selected as the preferred option as it scored the highest when evaluated using weighted multi-criteria analysis. Option 3 satisfies the objectives of the proposal and is expected to achieve the highest design life, with 50 – 100-year design life expected depending on type of shear piles. The construction method requires both overwater and land-based construction. Option 3 is considered a relatively higher risk option due to working over water, and has identified other risks including; existing rock fill in the river obstructing pile driving; excavation in the riverbed; maneuvering the barge to enable installation of piles above high tide level and environmental contamination from earthworks. Although the proposal will have a relatively large disturbance footprint associated with rock fill and rock armour treatment, it is considered to have positive environmental impacts as it seeks to restore lost riverbank. Community impacts are relatively minor with single northbound lane closure expected for estimated 4 weeks. The relative construction cost estimate has Option 3 as the second cheapest option.

The objectives of the EP&A Act encourage Ecologically Sustainable Development (ESD). The 'integration' principle of ESD requires the integration of economic, social development and environmental considerations into the decision-making process for all developments. These factors are consistent with the preferred options for the proposal.

2.6 Design refinements

The 80% Geotechnical Detailed Design Report prepared by SMEC considered the detailed design for the preferred shear pile and rock fill solution. The detailed design considered alternate shear pile options comprising of either steel or precast concrete, and was assessed in relation to durability and constructability. Transport advised SMEC of the preferred steel pile type. The 100% Geotechnical Detailed Design Report was prepared (refer to **Appendix B**) which provided the structural detailing and finalisation of construction drawings.

3. Description of the proposal

3.1 The proposal

Transport proposes to carry out remediation works on the Clarence River embankment to repair the slip that occurred as a result of a significant rainfall event (declared natural disaster) in March 2021. The site is located approximately 33.44km north of Grafton. The location of the proposal is shown in Figure 1.1 and an overview of the proposal is shown in Figure 1.2.

Key features of the proposal include:

- Project set up including establishment of site compound and stockpile locations within close proximity to the site.
- Establish traffic controls in vicinity of site (to accommodate temporary restricted/closed lanes of Big River Way).
- Establish sedimentation and erosion controls on riverbank and within waterway (i.e. silt boom) as required.
- Clearing of slip area including clearing of vegetation along slip restoration site to facilitate works.
- Piling works (from road and/or river) to stabilise slope area.
- Repair/restoration of pavement shoulder of Big River Way.

The selected construction option seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower riverbank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

The following construction sequence is anticipated:

1. Set out piles in river.
2. Mobilise barge with a large excavator and displace existing rock fill and rock armour from the proposed pile footprint and obstructions to barge.
3. Loading of piles from opposite riverbank onto ferry and transportation of piles to barge. Mobilise a barge with pile driving rig to install the row of sheet piles or precast concrete piles. The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration should be given to hydraulic impacts (e.g. hammers rather than vibratory hammers).
4. Clear vegetation from riverbank to excavate terraces.
5. Lay and secure heavy-duty geotextile.
6. Place rock fill and rock armour to slope commencing from behind the piles. Likely to require some rock fill to be placed from barge and/or a long reach excavator.
7. Extend concrete safety barrier.

Construction was expected to commence in September 2022 and be completed by September 2023, however there is some flexibility around start of construction (which may not commence until 2023) to accommodate the construction procurement process and potential for programming of work around predicted wet periods.

On site facilities for workers and stockpile sites will be provided, including use of an existing site compound established within the road reserve on the eastern side of Big River Way approximately 700 m north of the proposed works. A potential stockpile site for piles may be established within land (owner to be confirmed) on the opposite side (north-western) riverbank.

3.2 Design

3.2.1 Design criteria

The works would be carried out in accordance with:

- Transport Technical Directions and Specifications

3.2.2 Engineering constraints

The main engineering constraints related to the proposal are:

- Potential acid sulfate soils.

- Flooding impacts (during and post construction).
- Working within waterways (Clarence River).
- Minimising disruptions to motorists, residents and local businesses.

3.2.3 Major design features

Major design feature 1 - Reinforced concrete shear piles with rock fill and armour

The proposal seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower river bank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

3.3 Construction activities

3.3.1 Work methodology

The proposal would involve the following indicative methodology:

The sequence of construction steps may change, however, will generally be as follows:

Initial Project set-up and cleaning of slip area

- Locate all services (including communication and potentially life-threatening services such as electrical, gas, fuel, etc.) and have current dial before you dig (DBYD) plans on site at all times.
- Establish on site facilities and a site compound within the road reserve on the eastern side of the Pacific Highway approximately 700 m north of the proposed works. Potential stockpile site for piles may be established land (owner and approval to be confirmed) on the opposite side (north-western) riverbank.
- Establish traffic control management in accordance with an approved traffic control guidance plan.
- Establish sedimentation and erosion controls on river embankment as required.
- Remove weeds and native regrowth along the proposed slip restoration site.
- Poison weeds at identified sites prior to removal and mulching to ensure mulch material reused at site is inert.
- Cut select trees to stump level as required for access for riverbank remediation using a cut and grab excavator located on the temporary closed road travel lane. This is to reduce weight on the batter and gain access to the slope.
- Vegetation will be placed in the tree mulcher located on the closed travel lane and either temporarily stockpiled for reuse onsite or taken to an alternative site for re-use or disposed of at a licenced waste facility. Any mulch reused on site would be to aid regeneration of the top of the bank; the mulch is to be spread at no more than 100mm thick across the top of the bank.
- Loose material and slip debris to be removed from slip (no excavation below current surface level). This material is to be taken to the site compound/temporary stockpile area for treatment if required and then disposed of at a licensed waste facility.

Piling Construction Sequence

- Set out piles in river.
- Assemble and launch a barge from closest suitable external site to be ferried to site with a large excavator to excavate and displace existing rock fill and rock armour from the proposed pile footprint and obstructions to barge.
- Float barge to work zone by towing behind a suitable boat and anchored in place.
- Ensure navigation lights and waterway markers are in place and operational.
- Establish a floating sedimentation and control boom and attached silt curtain around barge and proposed area of disturbance to isolate the works site. The silt curtain would be weighted to the bed and secured to accommodate tidal flow.
- Mobilise a barge with pile driving rig to install the row of sheet piles or precast concrete piles. Loading of piles from opposite riverbank onto ferry and transportation of piles to barge. The stability of the site and adjacent

riverbanks may be sensitive to vibrations and consideration should be given to hydraulic impact hammers rather than vibratory hammers.

- Clear vegetation from riverbank and excavate terraces.
- Lay and secure heavy-duty geotextile.

Restoration of Riverbank profile

- Install access from road (existing disturbed areas) to the lower bank and river adjacent to the identified slip area.
- Assemble and launch a barge from closest suitable external boat ramp site approved by the Transport Local Environmental Officer, float to slip area and anchor.
- Install floating boom(s) around slip area within river.
- Place rock fill and rock armour to slope commencing from behind the piles. Likely to require some rock fill to be placed from barge and/or a long reach excavator. Rock material to be stockpiled and washed for fines at site compound (or on opposite riverbank) before being delivered directly for use and placed on site. There would be no stockpiling of incoming rock material on site. As required, establish northbound lane closure of Big River Way with approved traffic control management plan.

Restoration of Big River Way Pavement

- Patch out/repair areas of pavement shoulder that have suffered distress due to the loss of formation support.
- Repair and/or extend existing concrete safety barriers.

Site Disestablishment

- Remove onsite facilities and disestablish site compound/stockpiles located 700m north of site and potential stockpile area on opposite side of the riverbank.
- Site remediation to remove waste, compounds and conduct rehabilitation of areas impacted.

3.3.2 Construction workforce

The proposed works would take approximately 14 months and over that time the workforce required for construction of the project is likely to fluctuate through the various phases of the project depending on the activities. The workforce would likely consist of a combination of Transport employees and various contractors/subcontractors. This will not result in a significant influx of workers to the local area, however it could provide some modest short term economic stimulus for the locality.

3.3.3 Construction hours and duration

Construction was expected to commence in September 2022 and be completed by September 2023, however there is some flexibility around start of construction (which may not commence until 2023) to accommodate the construction procurement process and potential for programming of work around predicted wet periods.

The proposed works would generally be undertaken during the hours detailed below:

Monday – Friday	7:00 am to 6:00 pm
Saturday:	7:00 am to 6:00 pm (note extended working hours)
Sunday and Public Holidays:	No work

However, work may be undertaken outside of the working hours on weekends or nights to minimise traffic impacts on the community. If it is determined that work outside the nominated hours is required, an assessment would be undertaken to determine the safeguards and mitigations required.

Noisy works will be undertaken in accordance with RMS "Construction Noise and Vibration Guideline" (August 2016).

3.3.4 Plant and equipment

The main equipment and plant that would be used for the proposal would include, but is not limited to, the following:

- Low loader.
- Excavators.
- Tipper trucks.
- Light vehicles for staff movement to and from site.
- Traffic control devices.
- Small plant items (chain saw, mulch head, chipper, and generators).
- Concrete agitator trucks and pump.
- Earthworks heavy plant items.
- Construction rollers.
- Road broom.
- Bitumen spray truck.
- Punt/boat to ferry staff to riverbank/check environmental controls
- Tree mulcher

Additional items dependent on Geotechnical Engineering Design include:

- Piling rig (to be determined)
    - Continuous flight auger (CFA) drilling rig
    - Sheet pile
- Barges (to be determined)
- Cranes (to be determined)

3.3.5 Earthworks

Earthworks would include:

- Riverbank disturbance when burying barge anchor points for restoration of riverbank profile;
- Remove slumped rock materials from riverbed and replace into slip area; and
- Place rock and fill for restoration of slip area.

3.3.6 Source and quantity of materials

Rock within the vicinity of the slip would be retrieved and reused onsite. Road base, gravel or rock would be sourced locally from licensed bulk landscape suppliers or quarries where possible. Timber concrete, steel and all other materials would be commercially sought, certified uncontaminated and environmentally safe.

3.3.7 Traffic management and access

Traffic will be managed according to the Transport *Traffic Control at Work Sites Manual Version 6.1* (TfNSW February 2022). A site-specific Traffic Management Plan (TMP) will be prepared detailing the specifics of the site and any hazards and constraints. Work would not begin until the plan is approved and strategies to manage traffic within and around the work site are in place.

Access to and from the site occurs primarily along Big River Way, with additional access gained by boat or barge from the South Arm of the Clarence River. The proposed works would generate increased traffic associated with road closure, work crews and material delivery within the locality during standard construction hours. Over the construction period, minor delays would be experienced by traffic along this stretch of Big River Way.

Traffic impacts may also occur on South Arm Road on Woodford Island as a result of deliveries of piles made to the potential pile stockpile site located on the north-western bank of the Clarence River (with owner approval). Piles would then be ferried across the river to the site.

These roads are used by trucks hauling harvested cane during cane haul season (July to December), and the Traffic Control Plan will need to take this into consideration. As an alternative, an additional barge may be used as temporary storage of piles to avoid impacts on the local roads during cane haul season.

The piling works will occur along the bank of the South Arm of the Clarence River associated with the site and would be undertaken from the roadway and from a barge. There may be some impacts on maritime traffic in this waterway but should be easily managed with appropriate safeguards given the width of the navigable channel in this location.

Traffic management issues identified include:

- Single northbound land closure expected.

Traffic control measures would include:

- Temporary lowering of speed limit to 40km/hour;
- Temporary stop/go controls; and
- Temporary one lane alternating flow (periodically).

3.4 Ancillary facilities

On site facilities for workers will be provided and a site compound/stockpile area would be established within the road reserve on the eastern side of Big River Way approximately 700m north of the proposed works on Lot 182 DP 808610 (refer to Plate 3.1 and **Figure 3.1**). The subject lot including the hardstand is a Transport Admin site (usage – 'stockpile site'). This area has been used for a site compound during previous maintenance work undertaken by Transport. No native vegetation clearing would be required to establish/operate this ancillary facility.

Plate 3.1: Designated site compound/stockpile site 700m north of works site

Possible stockpiling at this compound site may be undertaken of the following materials:

- Vegetation/mulch (small amounts).
- Excavated material (small amounts).
- Construction materials.
- Rock material
- Untreated and treated Acid Sulfate Soils.

As the compound site is located on flood liable land, the site would be vacated when floods are forecast and a flood contingency plan detailing how materials would be removed in the event of a flood would be included in the Construction Environmental Management Plan (CEMP).

This compound site is currently being used for Transport's Culvert upgrade project at Lee's Drain. If the Lee's Drain project is still requiring use of this compound when construction for the Byrons Slip Stage V project commences, an alternative site compound can be established in an area of road reserve on the northbound side of Big River Way, approximately 1km north of the slip site, and 150m south of Norley's Lane (refer to Plate 3.2 and **Figure 3.1**).

Plate 3.2: Alternative site compound available approximately 1km north of slip site within road reserve of Big River Way

An additional stockpile site for piles may be established on land on the opposite (north-western) side of the riverbank to allow the piles to be ferried across the river to site (refer to Plate 3.3 and **Figure 3.1**). Land owner details and approval is to be confirmed.

Plate 3.3: Potential stockpile site for piles within land (owner to be confirmed and consent required) on western riverbank adjacent to South Arm Road, opposite slip site.

Stockpiles would be managed in accordance with Transport's Stockpile Site Management Guideline (EMS-TG-10) and the QA Specification R44 – Earthwork. Ancillary sites may be required for up to fourteen months from the commencement of construction.

LEGEND

- Survey limit
- New Byron Lane stage V slip
- Cadastre
- Site compound alternative location
- Stockpile alternative area
- Preferred site compound and stockpile location

0 120 Meters

Ancillary Facilities - Illustration 3.1

GeoLINK environmental management and design

Byron's Lane Slip Stage V
4099-1025

Information shown is for illustrative purposes only
Drawn by: AB Checked by: SDS Reviewed by: DGH
Source of base data: Department of Customer Services
Date: 18/10/2022

3.5 Public utility adjustment

The following utilities are associated with the site:

- Overhead powerlines.
- Underground water main.
- Underground communications (Telstra).

Prior to construction commencing, pot holing of underground utilities would be undertaken and location of all services. Public utilities would be adjusted where necessary prior to construction commencing.

The proposed works are not likely to impact on Council's active water main located along the eastern side of Big River Way. An old water main may be contained in the slumped material within the slip area on the eastern side, which will need to be removed from site and disposed of to a licensed facility. Clarence Valley Council has advised the old water main is a 150mm pipe containing asbestos.

The proposed works relating to the slip are not expected to impact on existing overhead powerline infrastructure located on the eastern side of Big River Way.

3.6 Property acquisition

No property acquisition is required for the proposal.

4. Statutory and planning framework

This chapter provides the statutory and planning framework for the proposal and considers the provisions of relevant state environmental planning policies, local environmental plans and other legislation.

4.1 Environmental Planning and Assessment Act 1979

4.1.1 State Environmental Planning Policies

State Environmental Planning Policy (Transport and Infrastructure) 2021

State Environmental Planning Policy (Transport and Infrastructure) 2021 (*TISEPP*) (previously *State Environmental Planning Policy (Infrastructure) 2007 (ISEPP))* aims to facilitate the effective delivery of infrastructure across the State, including roads and road infrastructure facilities.

Section 2.108 of TISEPP (previously Clause 94 of *ISEPP 2007)* permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

As the proposal is appropriately characterised as development for the purposes of road or road infrastructure facilities and is to be carried out by or on behalf of Transport for NSW, it can be assessed under Division 5.1 of the Environmental Planning and Assessment Act 1979 (NSW). Development consent from council is not required.

The proposal is not located on land reserved under the *National Parks and Wildlife Act 1974* and does not require development consent or approval under *State Environmental Planning Policy (Resilience and Hazards) 2021, State Environmental Planning Policy (Planning Systems) 2021 or State Environmental Planning Policy (Precincts - Regional) 2021.*

Part 2.2 of TISEPP (previously Part 2 of *ISEPP)* contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Consultation, including consultation as required by *TISEPP* (where applicable), is discussed in chapter 5 of this REF.

State Environmental Planning Policy (Biodiversity and Conservation) 2021 - Chapter 3 Koala habitat protection (previously State Environmental Planning Policy - Koala Habitat Protection (2020)

Chapter 3 of State Environmental Planning Policy (Biodiversity and Conservation) 2021 aims to encourage the conservation and management of natural vegetation areas that provide habitat for Koalas, to ensure permanent free-living populations would be maintained over their present range. Section 3.5 states this Part applies to land 'in relation to which a development application has been made'. However, Section 2.108 of TISEPP (previously Clause 94 of ISEPP) precludes the proposal from requiring consent therefore this part of the SEPP does not apply to the proposal. It is Transport policy, however, to consider environmental issues relating to their work to the fullest extent possible, including impacts on Koalas.

This chapter defines potential koala habitat as areas of native vegetation where trees of the types listed in Schedule 1 constitute at least 15 per cent of the total number of trees in the upper or lower strata of the tree component. Forest Red Gum and Tallowwood are both Schedule 2 trees (total of five trees). However, these tree species make up well below <15% of trees at the site. Furthermore, given that only a very small area of fragmented habitat occurs at the site and that Koala records in the study area are scarce the site is not considered to be core Koala Habitat. No further consideration of the policy is required.

State Environmental Planning Policy (Primary Production) 2021 - Chapter 2 Primary production and rural development (previously State Environmental Planning Policy (Primary Production and Rural Development) 2019)

Chapter 2 of State Environmental Planning Policy (Primary Production) aims to facilitate the orderly and economic use and development of rural lands for rural and primary production purposes. Part of the objectives relates to the maintenance of the social, economic and environmental welfare of the state and the reduction of land use conflicts and support for primary production.

The proposal would not impose any significant impacts to local agricultural land or primary production.

4.1.2 Local Environmental Plans

Clarence Valley Local Environmental Plan 2011

The proposal is located on land governed by the Clarence Valley Local Environmental Plan (LEP) 2011, where the following zones apply:

- RU1 Primary Production.
- SP2 Infrastructure.
- W2 Recreational Waterways.

The proposal is not inconsistent with, nor would it hinder the objectives of these zones.

The proposal is precluded from requiring development consent under Section 2.108 of TISEPP (previously Clause 94 of the ISEPP).

In addition, the Clarence Valley LEP 2011 includes a mapping layer which indicates the site is in a flood planning area. The potential impacts and safeguards for flooding are discussed further in Section 6.2 of this REF. The Clarence Valley LEP 2011 includes a mapping layer which indicates the site contains acid sulfate soils. The potential impacts and safeguards for acid sulfate soils are discussed further in Section 6.3 of this REF.

4.2 Other relevant NSW legislation

Table 4.1 lists other NSW legislation relevant to the assessment of the proposal and provides comment on implications for the proposal.

Table 4.1: Other relevant NSW legislation

Legislation	Section(s)	Comment
Crown Lands Management Act 2016		The South Arm of the Clarence River is Crown reserve. Transport's use and occupation of Crown reserve within the project footprint and the full width of the river from the slip site to the north western embankment for access to pile storage area, can proceed with notification to DPI's Crown Land Division under s175 Roads Act 1993. Notification (at least 7 days written notice prior to start of activity) should include environmental approvals/the determined REF. A copy of landowner's consent to be provided with s199 referral request (below).
Fisheries Management Act 1994	Sections 199	The proposed slope remediation and piling works will occur within the South Arm of the Clarence River. The installation will be done from land and over water (using a barge). The proposal consists of works within a waterway (including dredging and reclamation works) and as such written notification (s199 referral request) which will include a copy of the final REF, to the Minister for Agriculture and Western NSW is required, a minimum of 28 days prior to the start of work. A s199 referral request was made on 9 June 2022. A response with comments was received from NSW DPI Fisheries on 20 July 2022 (refer to **Appendix C**), which are to be included in the construction environmental management plan (CEMP).
Fisheries Management Act 1994	Schedules 4, 4A, 5 and 6	The proposal is considered unlikely to have a significant impact on any threatened aquatic species or communities listed under Schedules 4, 4A, 5 and 6 of the FM Act.
Heritage Act 1977		There are no heritage items at or near the site. The proposal is considered unlikely to have any impact on the nearest heritage item, which is a locally listed 'Pioneers Memorial' (Item 350) situated approximately 1.5 km away to the east.
National Parks and Wildlife Act 1974	Sections 87(1), 90	The provisions of the Act are unlikely to be triggered by the proposal. Aboriginal heritage investigations found that the proposal is unlikely to have an impact on Aboriginal heritage.

Legislation	Section(s)	Comment
		Work would cease if an artefact or place of significance is disturbed or encountered during the proposal and the appropriate Local Aboriginal Land Council (LALC) and OEH Cultural Heritage Division notified immediately.
Biosecurity Act 2015		In NSW, the administration of weed control is the responsibility of the Minister for Primary Industries under the *Biosecurity Act 2015.* The Act is implemented and enforced by the Local Control Authority for the area, usually local government or NSW Agencies. Transport are therefore required to control declared weeds on land under their control. A search of the WeedWise database (30/09/2021) within the Clarence Valley LGA control area identified 137 priority weed species. Two of these were observed on-site (Fireweed and Lantana). The mitigation measures in place as part of this REF are consistent with the aims and objectives of the Biosecurity Act. With the adoption of standard hygiene measures for plant and associated equipment (including barges) during construction, it is unlikely that pathogens or diseases (terrestrial and aquatic) would be introduced to the site.
Protection of the Environment Operations Act 1997		No Protection of the Environment Policies (PEPs) are relevant to the proposal. No licenses would be required pursuant to the *Protection of the Environment Operations Act 1997*. Transport and/or contractors working on behalf of Transport are required to notify NSW Environment Protection Authority (EPA) when a 'pollution incident' occurs that causes or threatens material harm to the environment.
Protection of the Environment Operations Act 1997	Section 115	It is an offence to negligently dispose of waste in a manner that harms the environment. Waste would be managed in accordance with the *Waste Avoidance and Resource Recovery Act 2001*. The proposal would aim to reduce the environmental impact of dumping waste and include mechanisms to recover resources and reduce the production of waste where possible.
Protection of the Environment Operations Act 1997	Section 120	It is an offence to pollute any waters of the State. The REF includes safeguard and mitigations measures to ensure that the proposal does not result in pollution of waters.
Protection of the Environment Operations Act 1997	Section 143	A signed s.143 Notice must be submitted prior to transporting waste generated by or for Transport to a place that is not owned or managed by Transport and is not a licensed landfill or resource recovery facility. Any stockpiling of material generated from the construction works within private property requires a section 143 notice under the POEO Act. This does not apply to the temporary storage of materials that are purchased for construction purposes (e.g. piles, clean rock, etc.) The proposal does not require disposal of waste to a place that is not owned or managed by Transport or is not a licensed landfill or resource recovery facility.
Biodiversity Conservation Act 2016	Section 7.8	For Part 5 activities, the Biodiversity Offset Scheme (BOS) thresholds of the BC Act do not apply. Proponents must instead apply the test of significance (as required). If this results in a decision that the activity will significantly affect threatened species, then: • a Species Impact Statement is required (with concurrence from OEH); or • the proponent may instead 'opt in' to the BOS.

Legislation	Section(s)	Comment
	Schedules 1, 1A, 2 and 3	Section 7.3 of the BC Act requires a test of significance ('five-part test') for determining whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats. Schedules of threatened species and communities were reviewed and are unlikely to be significantly impacted upon by the proposal (refer to Section 6.1). An Assessment of Significance (Five-part test) was completed (refer to **Appendix A**) for relevant species. The proposal would incrementally contribute to the Key Threatening Process (KTP) of Anthropogenic Climate Change, through the generation of carbon dioxide during operation of machinery and vehicles and associated fuel consumption.
Water Management Act 2000	Section 91 (2)	Work within water lands or those comprising of extraction or management of water may be subject to approval if they constitute a 'controlled activity'. Transport is, however, exempt from the need to obtain a Controlled Activity Approval. The proposal is located within water lands and does not involve the extraction or management of water. If Transport decide to extract water from waterways, a permit under S56 of the Act would be required.
State Environmental Planning Policy (Biodiversity and Conservation) 2021 - Chapter 2 *(previously State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017)*	Part 2.2 Clearing vegetation in non-rural areas (previously Part 2 Authority to clear vegetation in non-rural areas)	This SEPP applies (as applicable) to clearing vegetation in non-rural areas/zones of the State, including environmental zones, not associated with a Development Application. Section 2.7 (previously Clause 8) outlines clearing that does not require authority under this Policy, including: *(1) A permit or approval to clear vegetation is not required under this Chapter if it is clearing of a kind that is authorised under the Local Land Services Act 2013, section 60O or Part 5B.* On this basis and according to Clause 60O of the LLS Act (refer below), and given the Proposal is Part 5 Activity, any vegetation clearing is authorised by way of compliance with that part of the EP&A Act and authority under the Vegetation SEPP is not required.
Local Land Services Act 2013	Part 5A Land Management (native vegetation)	Provisions of the Act apply to clearing native vegetation in rural parts of the State and also contains provisions with regard to clearing that is authorised under other legislation. Pursuant to Section 60O (*Clearing authorised under other legislation*) the following is applicable: *(b) Other planning authorisation - The clearing was:* *(ii) an activity carried out by a determining authority within the meaning of Part 5 of that Act after compliance with that Part, or* *(iii) authorised by an approval of a determining authority within the meaning of Part 5 of that Act granted after compliance with that Part.* As the Proposal is a Part 5 Activity, vegetation clearing is authorised by way of compliance with that part of the EP&A Act.

4.3 Commonwealth legislation

4.3.1 Environment Protection and Biodiversity Conservation Act 1999

Under the *EPBC Act*, a referral is required to the Australian Government for proposed actions that have the potential to significantly impact on matters of national environmental significance or the environment of Commonwealth land. These are considered in **Appendix D** and chapter 6 of the REF.

A referral is not required for proposed road activities that may affect nationally-listed threatened species, endangered ecological communities and migratory species. This is because requirements for considering impacts to these biodiversity matters are the subject of a strategic assessment approval granted under the *EPBC Act* by the Australian Government in September 2015.

Potential impacts to these biodiversity matters are also considered as part of chapter 6 of the REF and **Appendix A**.

Findings - matters of national environmental significance (refer to **Appendix D**)

The assessment of the proposal's impact, on matters of national environmental significance and the environment of Commonwealth land, found that there is unlikely to be a significant impact on relevant matters of national environmental significance or on Commonwealth land. Accordingly, the proposal has not been referred to the Australian Government Department of Agriculture, Water and the Environment under the *EPBC Act*.

4.3.2 Other relevant Commonwealth legislation

Native Title Act 1993

The *Native Title Act 1993* recognises and protects native title. The Act covers actions affecting native title and the processes for determining whether native title exists and compensation for actions affecting native title. It establishes the Native Title Registrar, the National Native Title Tribunal, the Register of Native Title Claims and the Register of Indigenous Land Use Agreements, and the National Native Title Register. Under the Act, a future act includes proposed public infrastructure on land or waters that affects native title rights or interest.

A search of the Native Title Tribunal Native Title Vision website was undertaken, with one Native Title holders/claimants identified. South Arm is within the determination area of Yaegl People #2 (Tribunal File No NCD2015/003).

The portion of the project area which falls west of the mean high tide level (i.e. the river) is within the determined Native Title Claim for the Yaegl People. The remainder of the project area to the east is within the road reserve where Native Title has been extinguished.

Transport for NSW provided a notice of the proposal to NTSCorp under Section 24KA of the Act on 16 May 2022. A response from NTSCorp was provided on 15 June 2022 (see **Appendix E**). The letter notes the land and waterways within the Yaegl Native Title Determination Area are of immense cultural significance to Yaegl People, and members of the Yaegl Traditional Owners Aboriginal Corporation RNTBC (YTOAC) hold significant concerns about the location of the proposed works. In particular, the proposed works are within extremely close proximity to known cultural and spiritual sites. A further site visit is required between YTOAC and Transport to discuss the location and nature of works before they occur.

Transport provided a response to NTSCORPs letter on 29 July 2022 (refer to **Appendix E**) to proceed with arrangements for the project team to connect with YTOAC on Country to gain an appreciation of their native title rights and interests relating to the project location and how they might be best considered during project development and delivery.

The Project team will continue to liaise with the Transport's Aboriginal Cultural Heritage Team to inform ongoing processes of consultation throughout the project, which are likely to involve on-site meetings with knowledge holders present at specific points of the work program (i.e. at vegetation clearing and piles installation stages).

4.4 Confirmation of statutory position

The proposal is categorised as development for the purpose of a road and road infrastructure facilities and is being carried out by or on behalf of a public authority. Under Section 2.108 of TISEPP the proposal is permissible without consent. The proposal is not State significant infrastructure or State significant development. The proposal can be assessed under Division 5.1 of the *EP&A Act*.

Transport for NSW is the determining authority for the proposal. This REF fulfils Transport's obligation under section 5.5 of the *EP&A Act* including to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the activity.

5. Consultation

This chapter discusses the consultation undertaken to date for the proposal and the consultation proposed for the future.

5.1 Consultation strategy

A communications officer has been appointed to the proposal. A project-specific consultation strategy will be developed and implemented in accordance with the Transport Community Involvement - Practice Notes and Resource Manual and Transport Minor Project procedure, Communications for minor projects (ILC-MP-TP0-301).

The key aim of the consultation strategy will be:

- To inform the local community and other key stakeholders about the proposal in an effective and timely manner
- To keep the local community and other key stakeholders regularly updated with relevant information
- To encourage participation from the community and other stakeholders, and enable effective feedback on the proposal
- To increase stakeholder understanding of the project and its objectives

5.2 Community involvement

The project team will consult with community stakeholders in relation to the project. Consultation with the community will continue throughout the project.

5.3 Aboriginal community involvement

The Transport Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI – Stage 1) was undertaken in 2022 by the Transport Aboriginal Cultural and Heritage Officer who advised that the proposal was unlikely to have an impact on Aboriginal cultural heritage (refer to **Appendix E**).

As discussed previously a search of the Native Title Tribunal Native Title Vision website was undertaken, with one Native Title holders/claimants identified. South Arm is within the determination area of Yaegl People #2 (Tribunal File No NCD2015/003). A section 24KA notice was issued, details of correspondence between Transport and NTSCORP is provided in Section 4.3.2 of this report and copies of the letters can be found in **Appendix E**.

The Project team will liaise with the Transport's Aboriginal Cultural Heritage Team about continued consultation and aboriginal community involvement throughout the project.

5.4 TISEPP (previously ISEPP) consultation

A statutory consultation checklist is included in **Appendix F**. As per the requirements of the State Environmental Planning Policy (Transport and Infrastructure) 2021 (previously ISEPP 2007), consultation with the following organisations has occurred.

Clarence Valley Council (CVC) have been consulted as per the requirements of Section 2.10 and 2.12 of TISEPP (previously clause 13 and 15 of the ISEPP) due to the potential impacts on *'Council related infrastructure or services'* and '*development with impacts on flood liable land'.*

The NSW State Emergency Service have also been consulted as per the requirements of Section 2.13 of TISEPP (previously clause 15AA of the ISEPP) due to the Activity occurring on flood liable land.

Transport – Maritime Division have been consulted as per the requirements of Section 2.15 of TISEPP (previously clause 16 of the ISEPP) due to the possible use of a *fixed or floating structure in or over navigable waters.*

Key findings of the consultation informed the proposal, the potential impacts and required impact avoidance or mitigation measures. A summary of the results of TISEPP consultation is included in **Table 5.1** with records of TISEPP consultation included in **Appendix F**.

Issues that have been raised as a result of this consultation are outlined below in **Table 5.1**.

Table 5.1: Issues raised through TISEPP consultation

Group	Issue raised	Response / where addressed in REF
Clarence Valley Council	Consultation letter sent 23 Nov 2021 No response received	N/A
NSW SES	Consultation letter sent 23 Nov 2021 No response received	N/A
Transport Roads and Maritime – Maritime Division	Consultation letter sent 23 Nov 2021 Response received 14 Dec 2021. No objections. The proposal has been assessed as having minimal impact on the safety of navigation under the Marine Safety Act 1998. NSW Maritime requests conditions (provided) to be considered in preparation of the REF: 1. Any works impacting on navigation during the construction phase must seek TfNSW Maritime support. 2. A full scope of works relating to on-water operations including dates is to be provided to *navigationadvicenorth@transport.nsw.gov.au* 21 days prior to works commencing so a Marine Notice can be prepared and published on the Maritime website. 3. Any work vessels associated with the project must comply with the relevant NSW marine legislation. 4. Any work vessels and crew associated with the project must comply with the Marine Safety (Domestic Commercial Vessels) National Law Act 2012. 5. Any submerged hazards, cables, wires, silt curtains etc. must be marked with yellow aqua buoys (sign written – "Warning – Submerged Hazard). These aqua buoys must be lit with a yellow flashing light if hazards are present before sunrise and after sunset.	Section 6.4.2 Maritime Traffic During Construction.

5.5 Government agency and stakeholder involvement

Consultation has been undertaken with the NSW (Department of Primary Industries – DPI) Fisheries regarding the proposal as the following relevant matters would occur:

- Construction works within a waterway (including dredging and reclamation works) are required and as such, written notification to the Minister for Agriculture and Western NSW is required. The proposed piling works will be undertaken from within the South Arm of the Clarence River.

A consultation letter was sent on 23 November 2021. A response was received on 9 December 2021 (refer to **Appendix C**), including the following comments:

The proposal should first aim to avoid impacts to fisheries resources, particularly key fish habitats. Where impacts to key fish habitats cannot be avoided, the preference is to impact less sensitive key fish habitats over more highly sensitive key fish habitats. Mangroves and other marine vegetation, as well as riparian vegetation should be avoided where possible. This is relevant both during construction and operation of the structure.

The design should incorporate 'soft' engineering options where possible, and where harder engineering options are required, an integrated approach using planting in combination with natural materials (logs, live stakes, live brush bundles etc.) is preferred. Where possible, rock voids above the tidal limit should be planted with Lomandras, and existing riparian vegetation at the top of the bank behind the proposed revetment should be augmented with additional plantings of native grasses, shrubs and trees. Components of the wall that provide minimal fish habitat, should be minimised.

A written notification (s199 referral request) to the Minister for Agriculture and Western NSW was subsequently sent to NSW DPI Fisheries on 9 June 2022 and further information on 23 June 2022, which included a copy of the near final REF (refer to **Appendix C**). A response was received on 20 July 2022. Fisheries noted they have no objection to the proposed works and provided matters to be taken into consideration and incorporated into the construction environmental management plan (CEMP) to ensure impacts to key fish habitats are avoided or minimized.

The matters for consideration under s199 of the *Fisheries Management Act 1994* are provided below:

Administration

1. DPI Fisheries recommend that a copy of relevant approval documentation be carried by the proponent or their contractor operating on-site. Reason – A DPI Fisheries Compliance Officer may wish to check that the works are being undertaken in accordance with relevant approvals.

2. The subject works, including the final built design, should be consistent with the proposal outlined in the s199 referral to DPI Fisheries by Transport for NSW on 9 June 2022 and additional information provided 23 June 2022. Any proposed changes to the final design should be discussed with DPI Fisheries prior to implementation. Reason – This s199 consultation has been prepared following an assessment of the potential impacts of the described works upon the aquatic and neighbouring environments. Other works, which were not described in the referral have not been assessed and may have significant adverse impacts.

Erosion and sediment control

3. Sediment entering into waterways can directly impact on key fish habitats. DPI Fisheries recommend that Transport for NSW ensures that: - Erosion and sediment mitigation devices are erected and managed in accordance with all applicable requirements of the Blue Book (i.e. Landcom [2004], Managing Urban Stormwater: Soils and Construction [4th Edition]) (www.landcom.nsw.gov.au/news/publications-and-programs/the-blue-book.aspx); - A floating boom and attached silt curtain are used and maintained to isolate the work site and minimise the impacts of turbidity and mobilised sediment during the construction; and - Stockpiles are located away from adjacent on water land1, and riparian and aquatic vegetation2. Reason – To ensure that sediment generated by the exposure of soil is not transported into the aquatic environment.

Timing of works for low flows and low tides

4. Appropriately timing the works for periods of low flow can assist erosion and sediment control at the site. DPI Fisheries recommend that Transport for NSW ensures that works are undertaken during periods of low flows in the waterway and when Bureau of Metrological forecast for the Northern Rivers district forecast region (available at: www.bom.gov.au/nsw/forecasts/map.shtml) indicates several days of clear, dry weather. Reason – Timing the works for appropriate conditions can reduce delays and minimise impacts on the aquatic environments.

Instream works

5. Instream works can impact on key fish habitats. DPI Fisheries recommend that Transport for NSW ensures: - The avoidance of machinery entering or working from the waterway unless in accordance best management practice; - That machinery is appropriately cleaned, degreased and serviced prior to use at the site and entry into the waterway; and - That Emergency Spill Kits appropriate for containing and cleaning up petroleum and solvent product spills within waterways be available on site at all times during works. Reason – To reduce the threat of an unintended pollution incident impacting upon the aquatic environment.

Armouring works

6. Poorly designed or constructed bank protection works can have an immediate and lasting impact on key fish habitats. DPI Fisheries recommend that Transport for NSW ensures that: - Only clean rock is used at the site; - Rock forming bank armouring is placed into position using a rock grab or excavator; and - The rock used for bank armouring be underlaid by geotextile fabric. Reason – To avoid fines, clay and other sediment un-necessarily entering the waterway and ensure rock armouring is constructed using Best Management Practice techniques.

Post works rehabilitation of site

7. DPI Fisheries recommend that Transport for NSW ensures that the site is rehabilitated and stabilised at the completion of the works including: - Removal of surplus construction materials and temporary structures from the site (other than silt fences and other erosion and sediment control devices); - Undertaking plantings of Lomandra hystrix along the toe and top of the banks of the waterway for 5 metres upstream and downstream of the work footprint; and - Appropriate maintenance of erosion and sediment control devices until the vegetation has successfully established and the site has stabilised. Reason – To ensure that habitats are restored as quickly as possible, public safety is not compromised, aesthetic values are not degraded and sediment inputs into the waterway are reduced.

Fish kill contingency

8. DPI Fisheries maintains a fish kill database. To limit the potential of a fish kill incident, DPI Fisheries recommends that the proponent be advised to undertake a visual inspection of the waterway for dead or distressed fish (indicated by fish gasping at the water surface, fish crowding in pools or at the creek's banks) twice daily during the works. Observations of dead or distressed fish should be immediately reported to the Contact Officer by Transport for NSW. If a fish kill occurs, DPI Fisheries recommend works cease until the issue causing the kill is rectified. Reason – Fish kills are also potentially contentious incidents from the public perspective. DPI Fisheries needs to be aware of fish kills so that it can assess the cause and recommend ways to mitigate further incidents in consultation with relevant authorities. Work practices may need to be modified to reduce the impacts upon the aquatic environment.

The matters raised above can mostly be incorporated into the CEMP. However, the recommendation regarding undertaking plantings of Lomandra hystrix along the toe and top of the banks of the waterway for 5m upstream and downstream of the work footprint is most likely unfeasible. While attempts for post works rehabilitation of the site will be made, this proposal is unable to commit to this outcome.

Consultation requirements under the *Native Title Act 1993* have been undertaken and are discussed in Section 4.3.2 and 5.3 of this report.

5.6 Ongoing or future consultation

As indicated above, community consultation is proposed regarding the scope of work and proposed traffic disruptions. Planned traffic disruptions during the proposed work will be advised through advertising using the Transport Traffic Alert system, as well as other means identified via the Consultation Strategy developed for the proposal.

Ongoing stakeholder and community consultation would be undertaken in accordance with the Transport Communication Toolkit during the development and implementation of the project. Consultation would include:

- NSW DPI Fisheries.
- NSW DPI Crown Lands and Water Division.
- Transport (Maritime).
- Clarence Valley Council.
- Native Title representatives (Yaegl LALC).
- Residents and businesses within a minimum of one kilometre of the proposal.
- Emergency services.
- Bus operators.
- NSW Sugar Cane industry and/or Harwood Mill and/or Clarence Cane Growers Association Inc (as required in response to cane haul season traffic impacts).

6. Environmental assessment

This section of the REF provides a detailed description of the potential environmental impacts associated with the construction and operation of the proposal. All aspects of the environment, potentially impacted upon by the proposal, are considered. This includes consideration of:

- Potential impacts on matters of national environmental significance under the EPBC Act.
- The factors specified in the Is an EIS required? (DUAP 1995/1996) and as required under section 171 of the Environmental Planning and Assessment Regulation 2021 and the *Roads and Related Facilities EIS Guideline (DUAP 1996*). The factors specified in section 171 of the Environmental Planning and Assessment Regulation 2021 are also considered in **Appendix D**.

Site-specific safeguards and management measures are provided to mitigate the identified potential impacts.

6.1 Biodiversity

6.1.1 Methodology

A specialist Biodiversity Assessment Report (BAR) was completed for the proposal by GeoLINK and is provided at **Appendix A**. The methodology used for the biodiversity assessment included:

- Searches of relevant databases.
- Literature review.
- Field survey utilising the following methodology:
  - Mapping vegetation communities on the site and assigning NSW Plant Community Type (PCT) where possible, in accordance with the DPIE/BCD BioNet Vegetation Classification database;
  - Random meander searching for threatened flora and completing a general flora inventory;
  - Targeted survey for Threatened Ecological Communities (TECs);
  - Recording the occurrence and extent of any priority weeds listed in the Biosecurity Act 2016 (Clarence Valley Council Local Control Area); and
  - Opportunistic survey of all fauna based on visual and aural observations.

Areas assessed included all vegetation within the proposal footprint with broader consideration of adjoining vegetation outside this area.

6.1.2 Existing environment

Vegetation

Vegetation alongside the Big River Way comprises patches of regrowth native trees including Swamp Oak (*Casuarina glauca*), Forest Red Gum (*Eucalyptus tereticornis*), Tallowwood (*Eucalyptus* microcorys) Tuckeroo (*Cupaniopsis anacardioides*), Cheese Tree (*Glochidion ferdinandi*), Smooth Clerodendrum (*Clerodendrum floribundum*), Brush Ironbark Wattle (*Acacia disparrima*) and Foambark Tree (*Jagera pseudorhus*). The midstorey comprises immature regrowth of the aforementioned species, banks of Lantana (*Lantana camara**), Mickey Mouse Plant (*Ochna serrulata**), Cottonwood (*Hibiscus tiliaceus*) Coffee Bush (*Breynia oblongifolia*), Burny Vine (*Trophis scandens subsp. scandens*), Snake Vine (*Stephania japonica*) and Coastal Morning Glory (*Sansevieria trifasciata**).

Groundcover within this vegetation is scarce and confined to patches of Common Reed (*Phragmites australis*) occurring along the riverbank and roadside grasses and weeds occurring on the periphery of treed vegetation including Blady Grass (*Imperata cylindrica*), Rhodes Grass (*Chloris gayana*), Guinea Grass (*Panicum maximum**), (Blue Billygoat Weed (*Ageratum houstonianum**), Annual Ragweed (*Ambrosia artemisiifolia**) and Cobbler's Peg (*Bidens pilosa**).

Native vegetation at the site is characteristic of PCT 1235 *Swamp Oak swamp forest of the coastal lowlands of the NSW North Coast Bioregion.* Removal of vegetation at the slip area consists of approximately 0.27ha of PCT 1235, with potential clearing and disturbance of vegetation (consisting of trees, weeds and native vegetation) of the broader site (up to a total area of 0.84ha) to facilitate works.

The proposed pile storage area on the opposite/western riverbank along South Arm Road does not fit with PCT due to lack of native species and structure. While four isolated Forest Red Gums occur within this area, the remainder is cleared and dominated with Kikuyu Grass, and appears to be in relatively poor condition due to past disturbance from agriculture and grazing.

Weeds

Environmental and agricultural weeds are common along the disturbed roadside environment of the Big River Way throughout the study area. Priority Weeds for the North Coast Local Land Services Region occurring on the site and relevant duty are included below in **Table 6.1.**

Table 6.1: Priority weeds within the site and relevant duty

Common Name	Species	Duty
Fireweed	*Senecio madagascariensis*	**Prohibition on certain dealings** *Must not be imported into the state, sold, bartered, exchanged or offered for sale.*
Lantana	*Lantana camara*	**Prohibition on certain dealings** *Must not be imported into the state, sold, bartered, exchanged or offered for sale.*

The works are unlikely to result in the spread of weeds provided that relevant mitigation measures relating to machinery hygiene protocols are effectively implemented.

Threatened Flora

No threatened flora species listed under the BC Act or EPBC Act were recorded in the study area during the site assessment. Potentially occurring threatened flora species were readily identifiable at the time the site survey was conducted and therefore were assigned a low likelihood of occurrence on the basis that they were not recorded in the site survey.

Fauna Habitat Values

The site occurs within an area known to be utilised by the Coastal Emu Population which is listed as an endangered population under the BC Act. The Yuraygir sub-population occurring south of the Clarence River is known to occupy the coastal strip of Yuraygir National Park as well as surrounding contiguous areas in the Sandon and Brooms Head area in the north to Minnie Water and Red Rock in the south and Tucabia, Tyndale and Shark Creek to Pillar Valley and the lower Clarence River wetlands in the west.

Threatened Fauna

No threatened fauna was observed onsite. There was no evidence of Koala activity within the site (scratching on trees and scats in leaf litter).

A detailed review of the movements and range of the Yuraygir sub-population of Coastal Emus was undertaken as part of the Coastal Emu Management Plan for the Woolgoolga to Ballina (W2B) Pacific Highway Upgrade project (RMS, 2017). Emus are known to forage within sugar cane land located within the surrounding area, which is separated from the site by Big River Way.

Several other threatened fauna species were identified as having moderate potential to occur at the site. These species were not subjected to sufficient survey (i.e. not in accordance with the guidelines) and were therefore presumed to occur. Potential habitat for these threatened fauna species is associated with small areas of PCT 1235, and surrounding areas of agricultural land. No hollow-bearing trees occur at the site.

Aquatic Habitat

The subject site occurs alongside the South Arm of the Clarence River and is mapped as Key Fish Habitat for the Clarence Valley LGA.

Waterways at the site are unlikely to provide any habitat for FM Act listed threatened aquatic species. A review of the fisheries spatial data portal did not indicate any potential habitat for threatened fish species in any waterways in the study area. The fisheries spatial data portal lists the adjacent section of the South Arm River as having 'fair' freshwater fish community status.

6.1.3 Potential impacts

Removal of vegetation

The proposal would require clearing of a small area of approximately 0.27ha of native vegetation alongside the South Arm River and the Big River Way to facilitate sheet piling, riverbank stability and repair to the road shoulder. This area consists of PCT 1235 and 4 swamp oak trees over 10cm DBH .

A larger area of vegetation of up to approximately 0.84ha may be subject to clearing and disturbance to facilitate the works. This area consists of PCT 1235, weeds, annual ragweed and lantana and a variety of tree species identified in the biodiversity mapping including; acacia (2), camphor laurel (4), cheese tree (1), forest red gum (3), grey gum (1), swamp oak (35), tallow wood (1) and tuckeroo (15).

While the proposed vegetation removal constitutes the Key Threatening Process (KTP) Clearing of Native Vegetation (as listed in the BC Act), the magnitude to which the proposal contributes to this KTP is negligible. Mitigation measures to reduce the risk of direct impacts to native vegetation adjacent to the site are outlined below.

Removal of threatened fauna habitat

The proposal would remove approximately 0.02 hectares of PCT 1235. This vegetation and the subject section of Big River Way, the South Arm River and surrounds provides potential habitat for potentially occurring threatened fauna species, including:

- Potential foraging habitat for a number of threatened bird species
- Potential foraging habitat for Grey-headed Flying-fox

The construction footprint generally comprises degraded habitats with only limited threatened fauna habitat value. There are a limited number of mature trees present (>50 cm DBH) and hollow-bearing trees are absent. The fauna habitat directly affected by the proposal is negligible in a local context.

Imjury and mortality

The proposal may result in a minor risk of fauna injury/mortality through:

- Vegetation removal if the impacted vegetation is occupied at the time of clearing. This is mainly a risk to nesting or non-flying species.
- Vehicle strike during construction for a range of fauna species including Coastal Emus which have potential to occur at the site.

Conclusion on significance of impacts

The proposal is not likely to significantly impact threatened species or ecological communities or their habitats, within the meaning of the *Biodiversity Conservation Act, 2016* or *Fisheries Management Act 1994* and therefore a *Species Impact Statement* is not required.

The proposal is not likely to significantly impact threatened species, ecological communities or migratory species, within the meaning of the *EPBC Act*.

6.1.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Biodiversity	A Flora and Fauna Management Plan will be prepared in accordance with Transport for NSW's *Biodiversity Guidelines: Protecting and Managing Biodiversity on Projects (RMS, 2011)* and implemented as part of the CEMP. It will include, but not be limited to: • plans showing areas to be cleared and areas to be protected, including exclusion zones, protected habitat features and revegetation areas	Contractor	Detailed design / pre-construction	Section 4.8 of QA G36 Environment Protection

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• requirements set out in the *Landscape Guideline (RMS, 2008)* • pre-clearing survey requirements • procedures for unexpected threatened species finds and fauna handling • procedures addressing relevant matters specified in the DPI *Policy and guidelines for fish habitat conservation and management (2013)* • protocols to manage weeds and pathogens			
Biodiversity	Measures to further avoid and minimise the construction footprint and native vegetation or habitat removal will be investigated during detailed design and implemented where practicable and feasible.	Contractor	Detailed design / pre-construction	
Removal of native vegetation	Native vegetation removal will be minimised throughout the project.	Transport Project Manager/ Contractor	Prior to construction and during construction	
	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	Prior to construction	
	Vegetation removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bush rock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
	Native vegetation will be re-established in accordance with *Guide 3: Re-establishment of native vegetation* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011). Note: this will be considered for bank stability in areas where it will not compromise the structural integrity of the asset and outside access areas for maintenance. Also, it's noted there is little to no opportunity to re-establish native vegetation at the slip remediation site due to the narrow road reserve with rock revetment, unless natural vegetation was to naturally colonise the area over time (which is unlikely due to the amount of rock fill to be placed.)	Transport Project Manager/ Contractor	Post construction	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened ecological communities, not assessed in the biodiversity assessment, are identified in the proposal site.	Transport Project Manager/ Contractor	During construction	
Removal of threatened species habitat and	Habitat removal will be minimised throughout the project.	Transport Project Manager/ Contractor	Prior to construction and during construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
habitat features	Habitat removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bush rock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
Removal of threatened plants	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	Prior to construction	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened flora species, not assessed in the biodiversity assessment, are identified in the proposal site.	Transport Project Manager/ Contractor	During construction	
Aquatic impacts	Aquatic habitat will be protected in accordance with *Guide 10: Aquatic habitats and riparian zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) and Section 3.3.2 *Standard precautions and mitigation measures* of the *Policy and guidelines for fish habitat conservation and management Update 2013* (DPI (Fisheries NSW) 2013).	Transport Project Manager/ Contractor	During construction	
	All activities are to minimise disturbance to shallow water habitats under, and in the immediate vicinity of water based structures, including disturbance of seabed sediments and smothering habitats from propeller strike or excessive propeller wash.			
	All activities are to be carried out to avoid spreading aquatic/marine pests including: • Removal of weeds, animals or sediment from equipment and disposal to an appropriate waste receptacle or facility • Disposal of sewage and bilge water at an approved pump out facility			
Groundwater dependent ecosystems	Interruptions to water flows associated with groundwater dependent ecosystems will be minimised.	Transport Project Engineer/ Contractor	Prior to construction and during construction	
Changes to hydrology	Changes to existing surface water flows will be minimised.	Transport Project Engineer/ Contractor	Prior to construction and during construction	
Edge effects on adjacent native vegetation and habitat	Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	During construction	
	Fauna will be managed in accordance with *Guide 9: Fauna handling* of the *Biodiversity*	Transport Project	During construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
Injury and mortality of fauna	*Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Manager/ Contractor		
	Pre-clearing surveys will be undertaken in accordance with Guide 1: Pre-clearing process of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (RTA 2011).	Transport Project Manager/ Contractor	Prior to construction	
Invasion and spread of weeds	Weed species will be managed in accordance with *Guide 6: Weed management* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
Invasion and spread of pests	If vegetation is to be mulched, pest species will be managed within the proposal site in accordance with the TfNSW Technical Procedure: Mulch Management	Contractor	During construction	
Invasion and spread of pathogens and disease	Pathogens will be managed in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
Noise, light and vibration	Shading and artificial light impacts will be minimised.	Transport Project Manager/ Contractor	Prior to construction and during construction	
Tree and Hollow replacement	Tree and hollows that require replacement will be identified in accordance with the Tree and Hollow replacement guideline. Where trees and hollows will be replaced within the project boundary prepare a Tree and Hollow Replacement Plan to address the impacts described in Table 7-2 prior to commencement of works. Alternatively, where tree and hollow replacement cannot be accommodated locally or can only be partially accommodated, payment must be made to the TfNSW Conservation fund prior to the commencement of works in accordance with the Tree and Hollow Replacement Guideline.	Transport Project Manager	Prior to construction	

6.1.5 Transport Biodiversity Policy 2022: Biodiversity offset Strategy/Tree and hollow replacement guidelines

The Transport Biodiversity Policy 2022 provides the framework to protect and enhance biodiversity across TfNSW with the goal of achieving no net loss of biodiversity. The Policy commits TfNSW to replace individual trees and hollows removed by TfNSW activities subject to certain exemptions for low-risk activities.

Where tree removal cannot be avoided, the number of native and amenity trees and individual hollows to be removed must be counted and used to calculate the number of replacement trees and hollows (refer to **Table 6.2** below). The site features no amenity trees; therefore, they have been disregarded for the required tree replacement calculation.

This tree replacement is only calculated for the definite slip works as part of the proposal, where known tree removal within the footprint is required. If additional tree removal is required additions to tree replacement calculations will need to be undertaken.

A safeguard has been included in relation to a Tree and Hollow Replacement Plan, which is to be prepared prior to commencement of works for inclusion in the CEMP.

Table 6.2: Summary of tree and hollow replacement

Category	Number impacted	Replacement required	Number to be replaced
			Native Trees
Very Large Tree (DBH greater than 100cm)	0	Plant minimum 16 trees	0
Large Tree (DBH greater than 50cm but less than 100cm)	0	Plant minimum 8 trees	0
Medium Tree (DBH greater than 20cm but less than 50cm)	12	Plant minimum 4 trees	48
Small Tree (DBH greater than 5cm but less than 20cm)	11	Plant minimum 2 trees	22
Hollows	No hollow-bearing trees occur at the site.	Provide 3 artificial hollows for every occupied hollow removed	N/A

6.2 Hydrology and flooding (surface water and groundwater)

6.2.1 Existing environment

The proposed works are located on the eastern bank of the South Arm of the Clarence River and includes the use of the opposite western bank as a pile storage area, with works likely to encroach into the river. The South Arm joins the Clarence River at Maclean approximately 9km downstream and disembogues into the Pacific Ocean at Yamba approximately 25km downstream. The proposed works would occur over a 100m length of the Big River Way, the river, and its banks. The area is steeply sloping and unstable.

As indicated in **Table 6.3**, the mean annual rainfall is approximately 1305.1mm. Typically the highest rainfall occurs in March, with a pronounced dry season between August and October. The latter six months of the year experiences less rainfall than the first six months. The site has potential to be impacted by flooding.

Table 6.3: Rainfall Data for Harwood Island (Harwood Island Sugar Mill) (1915-2022)

Month	Mean Monthly Rainfall (mm)
January	144.7
February	166.4
March	174.0
April	133.5
May	126.3
June	111.3
July	70.3
August	55.1
September	47.8
October	72.8
November	95.8
December	111.8
Annual	**1305.1**

6.2.2 Potential impacts

Construction

Potential types and impacts of pollution or water quality degradation that could arise from the proposed works include disturbance of the riverbed through barge anchoring or removal of slumped rock materials and excavation, the entry of soil into the water resulting in the sedimentation of, and increased water turbidity in, the South Arm of the Clarence River. Actions that could result in sedimentation and turbidity increases include:

- Removal of vegetation (weeds and native growth) along the proposed slip restoration site;
- Disturbance to soils associated with pedestrian and machinery access;
- Access to the site by barge(s);
- Movement of the barge(s) and anchorage of the barge(s) on site at slip area;
- Removal of slumped rock materials from riverbed to slip area;
- Piling works as specified by Geotechnical design requirements to stabilise the slope;
- Securing of heavy duty geotextile;
- Run off from stockpile locations; and
- Dust or air-borne particles generated during construction works.

A variety of dispersible liquid materials may be used in proximity to, and within, the river and pose a potential pollutant threat to local water quality. These liquids include, but are not limited to, diesel, unleaded petrol, machinery oils and lubricants. The nature of these liquids and their ability to disperse away from the work site means that they could have a negative impact on ground or surface water on or adjacent to the site if not contained, especially during rain.

Flood events within the catchment have the potential to impact the site and potential acid sulfate soils (PASS). And there is potential for water entering the compound site to become contaminated. This is likely to occur if waste, vehicles and machinery and any fuels stored at the compound sites are not removed from the compound site should flood waters breach the Clarence River or Lees Drain (which is adjacent to the compound site).

The above impacts have the potential to cause environmental harm. However, with the implementation of the management measures and safeguards contained herein, the risk associated with such impacts is considered low.

Overall, with the safeguards and management measure described in Section 6.2.3 water quality, hydrology and flooding impacts for the proposal are not expected.

Operation

Following completion of the proposal, stabilisation of the riverbank profile and restoration of Big River Way should result in positive impacts for the surrounding area in relation to water quality, hydrology and flooding impacts by preventing further degradation of the road surface and risk of further slip movements.

6.2.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Hydrological impacts	A CEMP must be prepared in accordance with the specifications set out in the *QA Specification G36 - Environmental Protection (Management) System* to guide the implementation of environmental impact mitigation measures, identify key roles and responsibilities for environmental monitoring and methods of reporting incidents.	Transport Project Manager	Pre-construction	
Erosion sedimentation	A site-specific Erosion and Sediment Control Plan is to be prepared and implemented as part of the CEMP. The plan is to identify detailed measures and controls to be applied to minimise erosion and sediment control risks including (where relevant), but not limited to: runoff, diversion	Transport Project Manager	Pre-construction, construction	Section 2.2 of QA G38 *Soil and Water Management*

Impact	Environmental safeguards	Responsibility	Timing	Reference
	and drainage points, sumps, scour protection; stabilising disturbed areas as soon as possible; check dams, fencing and swales and staged implementation arrangements. The plan is to also include arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather. Work in areas where soil may be disturbed is to only commence once all relevant erosion and sediment controls have been established. The controls are to be maintained in place until the work is complete and all exposed erodible materials are stable.			
	Erosion and sedimentation controls must be checked and maintained (including clearing of sediment from behind barriers) on a regular basis (including after any precipitation events) and records kept and provided on request.	Transport Project Engineer	Pre-construction, construction	
	An Environmental Work Method Statement (EWMS) is required for proposed instream works and dewatering of any areas prior to commencement of those activities. The EWMS would include measures to avoid or minimise risks from erosion, sedimentation, ASS and PASS to water quality and biodiversity. The EWMS would be approved by the TfNSW Environment Officer and form part of the Construction Environment Management Plan. Dewatering would be undertaken in accordance with TfNSW Environmental Fact Sheet 10: *Dewatering* and the EWMS.	Transport Project Manager	Pre-construction, construction	
	For all works likely to generate sediment within the waterway or on the adjacent banks of the Clarence River (including piling), a full depth sediment/silt curtain and floating hydrocarbon boom will be placed in the adjacent Clarence River to isolate the work area, weighted to the bed and secured to accommodate tidal flow. The hydrocarbon boom will be installed inside of the silt curtain when both are in operation. Install the curtain prior to commencement of instream works and retain until works that risk mobilising sediment are completed. This will remain in place until the completion of sediment generating activities. Silt curtains/floating booms are to be installed, monitored and maintained as needed to contain any sediment. If sediment plumes are observed outside the containment system, then the activity will stop until the containment system has been repositioned to encompass the area of disturbance.	Transport Project Engineer	Pre-construction, construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	Disturbance of natural sediments and vegetation must be minimised.	Transport Project Engineer	Pre-construction, construction	
	Erosion and sediment control measures must not be removed until the work is complete or disturbed areas are stabilised.	Transport Project Engineer	Construction, post-construction	
	Maintenance of site compounds must be in accordance with the TfNSW Stockpile Site Management Guideline (EMS-TG-10).	Transport Project Engineer	Pre-construction, construction	
	All rocks will be washed to remove fines.	Transport Project Engineer	Construction	
	Cleaning of tools and equipment must occur within a designated wash-down bay. The wash-down bay must be bunded and placed so that water does not flow directly into the Clarence River but is captured and contained or filtered and allowed to soak into the ground.	Transport Project Engineer	Construction	
	Water utilised for cleaning of tools must be minimised and obtained from a licensed location or town water supply.	Transport Project Engineer	Construction	
	Clean equipment and vehicles must be used, with equipment being cleaned down before being brought to the site	Transport Project Engineer	Pre-construction, construction	
	A site-specific emergency spill plan will be developed and include spill management measures in accordance with the TfNSW *Code of Practice for Water Management* (RTA, 1999) and relevant EPA guidelines. The plan will address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including TfNSW and EPA officers).	Transport Project Manager	Detailed design/ Pre-construction	Section 4.3 of QA *G36 Environment Protection*
	A spill containment kit for aquatic and terrestrial spills must be available at all times. The spill kit must be appropriately sized for the volume of substances at the work site. All personnel must be made aware of the location of the kit and trained in its effective deployment.	Transport proposal Manager	Pre-construction, construction	
Reduced water quality	If a spill occurs, the Transport Environmental Incident Classification and Reporting Procedure must be followed, and the Transport Project Manager notified as soon as practicable.	Transport Project Manager/ Project Engineer	Pre-construction, construction	
	Potential or actual acid sulphate soils are to be managed in accordance with the Roads and Maritime Services Guidelines for the Management of Acid Sulphate Materials 2005.	Transport Project Manager	Construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	Locate stockpiles of dispersible material away from areas of concentrated overland flow.	Transport Project Manager/ Project Engineer	Construction	
	Required fuels and other liquids must be stored in self-safe chemical storage containers.	Transport Project Manager/ Project Engineer	Pre-construction, construction	
	Unnecessary storage of fuels, lubricants or other compounds on-site must be avoided.	Transport Project Manager/ Project Engineer	Pre-construction, construction	
	Refuelling of plant and equipment is to occur in impervious bunded areas located a minimum of 50 metres from drainage lines or waterways otherwise a double bund is required.	Transport Project Manager/ Project Engineer	Construction	
	All equipment must be maintained in good working order and operated according to manufacturer's specifications.	Transport Project Engineer	Pre-construction, construction	
	Visual monitoring of local water quality (i.e. turbidity, hydrocarbon spills/slicks) is to be undertaken on a regular basis to identify any potential spills or deficient silt curtains or erosion and sediment controls.	Transport Project Engineer	Construction	
	Construction vessels (including barges) are only to be used at suitable tides when no less than 600mm clearance is available between the underside of the vessel and the bed of the waterway.	Transport Project Engineer	Construction	
	Prepare an emergency response plan for flood events for the proposed work. Include a procedure for rapid removal in the emergency response plan and location for the material.	Transport Project Manager	Pre-construction	
	Establish the compound site in such a way to limit potential impacts from flooding (e.g. on as high a ground as possible and that are readily removed in the event of a flood).	Transport Project Manager	Construction	
Flooding	Include a Work Method Statement (WMS) in CEMP on compound site evacuation procedure. Issues to be addressed in the WMS include: • Responsibility for monitoring flood threat/flood warning information and how it is to be done • Training for staff on evacuation • Demonstrate that specific equipment for evacuation is readily available Detail where compound site equipment, waste, materials, site sheds etc.	RMS Project Manager	Pre-construction	

6.3 Soils

6.3.1 Methodology

The following methodology was undertaken:

- Review of Mitchell Landscape Mapping (2002).
- Review of the NSW EPA contaminated land database and DPI cattle dip site locator (www.epa.nsw.gov.au/prclmapp/aboutregister.aspx) (https://www.dpi.nsw.gov.au/animals-and-livestock/beef-cattle/health-and-disease/parasititic-and-protozoal-diseases/ticks/cattle-dip-site-locator) (both accessed 27 October 2021).
- Review of Department of Planning, Industry and Environment (eSPADE) Soil and Land Information - Acid Sulfate Soil (ASS) risk mapping (accessed in October 2021).

6.3.2 Existing environment

One Mitchell Landscape occurs within the study area and is described as follows:

Clarence – Richmond Alluvial Plains: wide valleys, channels, floodplains, terraces and estuaries of the Clarence and Richmond Rivers and other coastal streams on Quaternary alluvium, general elevation 0 to 50 metres, local relief 15 metres. Deep brown earths and structured brown clay on floodplains. Terrace with yellow texture-contrast soil containing ironstone concretions.

The remediation site for the proposed works is located on the eastern bank of the South Arm of the Clarence River, and includes the slip area as well as the bed of the river, with potential disturbance to the riverbed as a result of the works. The proposed site compound is located within an alluvial floodplain comprising of low-lying erosional sediments.

Acid Sulfate Soils (ASS) risk mapping identifies the site as having a high probability (Class 4) of ASS material within the soil profile greater than 2 metres below the natural ground surface. The Geotechnical Report (**Appendix B**) details an acid sulfate test carried out on a soil sample where the results show Net Acidity exceeds recommended guidelines. Accordingly, as soil disturbance is proposed, a precautionary approach to management is required, and the need for an acid sulfate management plan is triggered. Noting, disturbance to acid sulfate soils may also influence corrosion rates.

No records of contaminated land within close proximity to the site are recorded in the EPA contaminated land database (accessed October 2021). The cattle dip site locator identifies five cattle dip sites within the Tyndale locality. The proposal does not occur in proximity to any of these sites.

An old water main may be contained in the slumped material within the slip area on the eastern side, which will need to be removed from site and disposed of to a licensed facility. Clarence Valley Council has advised the old water main is a 150mm pipe containing asbestos.

6.3.3 Potential impacts

Construction

Earthworks required as part of the proposal include:

- Riverbank disturbance when burying barge anchor points for restoration of riverbank profile;
- Remove slumped rock materials from riverbed and replace into slip area; and
- Place rock fill and rock armour for restoration of slip area.

Potential impacts related to soils from the proposal include:

- Erosion and sedimentation impacts which could affect receiving environments such as the Clarence River. The impacts and relevant safeguards are detailed in Section 6.2.
- The presence of Acid Sulfate Soils (ASS) has the potential to result in water quality impacts including acidification of waterways, fish kills and sedimentation. Given that the site is mapped as having ASS material at 2 metres below surface level the risk of encountering ASS during excavation is considered moderate to high. ASS (including any stockpiling of this material) will be managed in accordance with an Acid Sulfate Soil Management Plan (ASSMP) to be included in the CEMP.
- The disturbance of contaminated land (potential presence of asbestos from old water main) has the potential to cause impacts to humans and pollutions to nearby environments.

Acid Sulfate Soil (ASS) Management

- An ASS treatment area for the project will likely need to be provided. It is unlikely there is room within the project worksite for a treatment area to be established. Transport's Lee's Drain Project footprint was able to accommodate a treatment area and treated ASS stockpile area. As this is located in close proximity to the works area (approximately 600m north of the subject site) there may be an option to utilise this existing area. There does not appear to be an opportunity to place treated soils back onsite, and it is likely treated soils will be directed to a licenced waste facility. This will be investigated as part of the ASSMP to be included in the CEMP.

Operation

Following completion of the proposal it is expected that stabilisation of the riverbank profile and associated roadworks would have improved impact on soils by preventing risk of future slips at the site and further degradation of the road surface.

6.3.4 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Contaminated land	If contaminated areas are encountered during construction, appropriate control measures will be implemented to manage the immediate risks of contamination. All other works that may impact on the contaminated area will cease until the nature and extent of the contamination has been confirmed and any necessary site-specific controls or further actions identified in consultation with the Transport for NSW Environment Manager and/or EPA.	Contractor	Detailed design / Pre-construction	Section 4.2 of QA *G36 Environment Protection*
Accidental spill	A site-specific emergency spill plan will be developed and include spill-management measures in accordance with the Transport *Code of Practice for Water Management (RTA, 1999)* and relevant EPA guidelines. The plan will address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including Transport EPA officers).	Contractor	Detailed design / Pre-construction	Section 4.3 of QA *G36 Environment Protection*
Acid sulfate soils	Potential or actual acid sulfate soils are to be managed in accordance with the *TfNSW Services Guidelines for the Management of Acid Sulfate Materials 2005.* An Acid Sulfate Management Plan (ASSMP) will be prepared by Transport and approved by the Environment Officer before the commencement of any activities likely to expose ASS/PASS and at a minimum, the plan will include: • Management measures for the safe excavation and timing to cover excavation, isolated storage and treatment area, neutralisation and re-use or disposal of neutralised soils • Requirements for additional testing to determine predicted liming rates of excavated spoil once quantities are determined. Specific controls to be implemented will include:	Transport Project Manager	Pre-construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• Capping exposed surfaces with clean fill to prevent oxidation • Placing excavated ASS separately in a lined, bunded and covered area • Neutralising ASS for reuse on site (where appropriate) by using additives such as lime • Disposal at a licensed waste facility. The ASSMP will be included in the CEMP.			
Asbestos	An Unexpected Contaminated Land and Asbestos Finds procedure must be prepared prior to the commencement of construction and must be followed should unexpected contaminated land or asbestos (or suspected contaminated land or asbestos) be excavated or otherwise discovered during construction.	Transport Project Manager	Pre-construction	

6.4 Traffic and transport

6.4.1 Existing environment

Road Traffic

The subject section of Big River Way is a two-lane section of road with a 100 km/hour speed limit providing a link between the Tyndale and Maclean areas. This route is often used by travellers and local residents to access the coastal villages of Maclean, Tyndale and Ulmarra, and is sometimes used as an alternative to the Pacific Highway or as a tourist route for vehicles travelling north or south. Big River Way represents a valued traffic route option used by travellers, local residents and farmers to access surrounding areas.

Traffic impacts may also occur along South Arm Road (on Woodford Island) associated with the delivery of piles to the proposed pile storage site located on the north-western bank of the Clarence River (with owner approval). Piles would then be ferried across the river to the site.

These roads are used by trucks hauling harvested cane during cane haul season (July to December) so traffic impacts and delays will need to be taken into consideration for the Traffic Management Plan (TMP).

Traffic would be managed according to TfNSW's Traffic Control at Work Sites Manual Version 6 (TfNSW, 2020). A site-specific TMP will be prepared detailing the specifics of the work and any hazards and constraints. Work would not begin until the plan is approved and strategies to manage traffic within and around the work site are in place. During times of traffic disruptions, liaison with local road users would occur through standard Transport communication protocols (e.g. Transport website postings using the Traffic Alert system).

Maritime Traffic

The South Arm of the Clarence River is used by a variety of vessels including trawlers and large and small recreational watercraft. Smaller vessels mostly access this waterway from a boat ramp in Maclean (Ferry Street).

6.4.2 Potential impacts

Road traffic during construction

Single northbound lane closure is expected adjacent to the slip location. The closure would be required for an estimated 12 weeks to allow the works to be undertaken. Speed limits for the subject section of road would be reduced to 40 km/hour during the project.

Potential traffic management impacts include:

- Reduction in speed limits to 40 km/hour.
- Increased construction traffic locally.
- Short delays for road users during the project as a result of the above.

The long duration of construction works for the project (12 months+) means there is likely to be some disruptions to traffic along Big River Way and South Arm Road during cane harvesting season (July to December), with impacts on cane haulage to and from the Harwood Sugar Mill. Consultation with the NSW Sugar Cane Industry, Clarence Cane Growers Association and/or Harwood Island Mill may be required as necessary depending on staging of works coinciding with harvesting season.

The works are required to improve road safety. Without the work and associated construction delays being undertaken, the slip remediation works could not be undertaken. Consequently, the short-term disruptions to traffic are justifiable.

Maritime traffic during construction

Piling works would be undertaken along the bank of the South Arm of the Clarence River associated with the site. This would not impact maritime traffic in this waterway given the large width of the navigable channel in this location.

The proposal was referred to Transport - Maritime Division who were consulted as per the requirements of Section 2.15 of the TISEPP (previously clause 16 of the ISEPP) due to the use of a fixed or floating structure in or over navigable waters. Transport advised the proposal was assessed as having minimal impact on the safety of navigation under the Marine Safety Act 1998 and have no objections. However, NSW Maritime requests the following conditions be considered:

1. Any works impacting on navigation during the construction phase must seek TfNSW Maritime support.
2. A full scope of works relating to on-water operations including dates is to be provided to navigationadvicenorth@transport.nsw.gov.au 21 days prior to works commencing so a Marine Notice can be prepared and published on the Maritime website.
3. Any work vessels associated with the project must comply with the relevant NSW marine legislation.
4. Any work vessels and crew associated with the project must comply with the Marine Safety (Domestic Commercial Vessels) National Law Act 2012.
5. Any submerged hazards, cables, wires, silt curtains etc must be marked with yellow aqua buoys (sign written – "Warning – Submerged Hazard). These aqua buoys must be lit with a yellow flashing light if hazards are present before sunrise and after sunset.

Operation

The proposal would have no negative impacts on road or maritime traffic post-construction with positive impacts including improved road safety, reduced future maintenance and associated reduced delays and detours on the subject section of Big River Way.

6.4.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Traffic and transport	A Traffic Management Plan (TMP) will be prepared and implemented as part of the CEMP. The TMP will be prepared in accordance with the Transport *Traffic Control at Work Sites Manual* (RTA, 2010) and *QA Specification G10 Control of Traffic* (Transport for NSW, 2008). The TMP will include: • confirmation of haulage routes • measures to maintain access to local roads and properties • site-specific traffic control measures (including signage) to manage and regulate traffic movement • measures to maintain pedestrian and cyclist access • requirements and methods to consult and inform the local community of impacts on the local road network • access to construction sites including entry and exit locations and measures to	Transport Project Manager	Detailed design / Pre-construction	Section 4.8 of QA *G36 Environment Protection*

Impact	Environmental safeguards	Responsibility	Timing	Reference
	prevent construction vehicles queuing on public roads. • a response plan for any construction traffic incident • consideration of other developments that may be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic • monitoring, review and amendment mechanisms.			
	Where possible, current traffic movements must be maintained during the work. Any disturbance must be minimised to prevent unnecessary traffic delays.	Transport Project Engineer	Construction	
	A project-specific consultation strategy must be developed and implemented in accordance with the TfNSW *Community Involvement – Practice Notes and Resource Manual* and *TfNSW Minor Project procedure, Communications for minor projects (ILC-MP-TP0-301).*	Transport Project Manager	Pre-construction	
Maritime	Twenty-Eight (28) days prior to works commencing the applicant must provide Transport Maritime with a full scope of works including maps noting all obstructions to navigation associated with the proposed works, (vessel/barge anchoring, scaffolding and silt curtain locations etc.) so a Marine Notice can be prepared and advertised.	Transport Project Manager	Pre-construction	
	Transport Maritime will prepare and advertise the Marine Notice online. The Marine Notice may be required to be placed in the local press and to be advertised at local boat ramps.	Transport Project Manager RMS (Maritime)	Pre-construction	
	Consultation will be required throughout the duration of the works to develop forward plans for the on-water traffic management whilst the works are carried out and as plant and structures are deployed in different locations.	Transport Project Manager RMS (Maritime)	Pre-construction, construction	
	Approved navigational marks, signage and Marine Notices to be implemented and updated during the period of works.	Transport Project Manager/ TfNSW Project Engineer	Pre-construction, construction	
	All navigation aids and traffic management plans must be approved by Transport Maritime.	Transport Project Manager RMS (Maritime)	Pre-construction, construction	
	Any work vessels involved in the project must comply with the relevant NSW Marine Legislation (i.e. day shapes, lights etc.).	Transport Project Manager	Construction	
	Barges, work vessels and crew involved with the project must comply with the *Marine Safety (Domestic Commercial Vessels) National Law Act 2012*.	Transport Project Manager	Construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	A minimum of one navigable channel span (at least 6 m) must be open to navigation at all times unless approved by TfNSW Maritime.	Transport Project Manager	Construction	
	A 4-knot lit Special Mark buoyage OR signage is to be installed at an appropriate distance (200 m) from the structure/s.	Transport Project Manager	Construction	
	Any submerged hazards must be marked with yellow aqua buoys sign written “Warning Submerged Hazard”. These aqua buoys must be lit with yellow flashing lights if hazards are present before sunrise and after sunset.	Transport Project Manager	Construction	

6.5 Noise and vibration

6.5.1 Existing environment

Big River Way provides an important transport route and experiences low volumes of traffic for a variety of vehicle types (regional freight vehicles, large passenger vehicles, light passenger vehicles and local traffic), which results in some noise and vibration impacts. The small township of Tyndale is located about 5 kilometres south-west of the site and Maclean approximately 7.9 kilometres north. The nearest sensitive receivers to the work are listed in **Table 6.4**.

Table 6.4: Noise sensitive receivers located within the affected distance (760m) of project footprint

Lot	DP	Distance of residential receiver from project footprint (m)	Direction of residential receiver from project footprint
16	877827	80	East
1	1012109	200	South-west
23	1007618	450	North-east
1	995518	490	West
1	995519	180	North
55	751392	630	North
1	1024565	680	South-west
525	1118832	740	North-west

6.5.2 Potential impacts

Construction

The following are considered to be the highest noise emitting activities to be undertaken as part of the proposal:

- Driving/ vibrating for piling works.
- Saw cutting existing pavement.
- Jack hammering concrete.
- Excavation/ profiling existing pavement.
- Tree mulching.

Noise and vibration would be associated with the construction phase and not endure for the long-term. Noise and vibration are expected from construction activity and the use of a variety of construction vehicles and machinery as part of the Activity (typical construction plant have been outlined previously in the description of the Proposal). The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration should be given to hydraulic impact hammers rather than vibratory hammers.

Noise from the general site compound would be generated by localised sources within the works area, such as a delivery truck or item of mobile plant or works personnel and their vehicles. Noting the scale of the works, these sources would be infrequent and generally have a limited duration. Noise from the compound is likely to be perceived as general construction noise by surrounding receivers.

The proposed works would be undertaken during the following working hours:

- Monday to Friday: 7.00am to 6.00pm
- Saturday: 7.00am to 6.00pm (note extended working hours)
- Sunday and Public Holidays: No work

A distance-based nosiest plant noise assessment was undertaken for this construction site using a bored piling rig as a selected representative for the works, refer to the TfNSW Construction and Maintenance Noise Estimator (**Appendix H**).

The representative noise environment was assessed as category R0 using the 'Representative Noise Environ' tab from RMS Construction Noise Estimator.xlsm as per section 6.2 of RMS 'Construction Noise and Vibration Guideline' (August

2016). Background noise levels during the day, evening and night periods are estimated to be 30, 30 and 30 dB (A) respectively.

The Environmental Protection Authority's (EPA) construction noise management levels for the day, day (Out of Hours Work), evening and night are 40, 35, 35 and 35dB (A) respectively.

The noise assessment related to two scenarios; working during the day (OOWH) period and working during the day (Standard hours).

Working during the day (OOHW)

The noise estimator identifies an affected distance of 760m for nearby residents for the day (OOHW) time period. (The affected distance is the distance up to which noise levels are expected to exceed the Noise Management Level (NML) as defined by the EPA Interim Construction Noise Guidelines). Eight residents are located within this affected distance, listed in **Table 6.1** above.

Five of the eight receivers are located less than 525m from the site and are recommended mitigation measures including notification and respite periods.

The predicted noise level at the nearest receiver can be up to 60dB (A) when works are being undertaken, which is 25 dB(A) above the NML of 35 dB(A) and may require specific notification.

Working during the day (standard hours)

Five residents located less than 525m from the work are identified as impacted by construction noise, three of these are less than 250m from the works and are likely to be impacted by construction noise to a high degree and should be notified.

The predicted noise level at the nearest receiver can be up to 60dB (A) when works are being undertaken, which is 20 dB(A) above the NML of 40 dB(A).

Consultation with sensitive receivers is outlined in **Table 6.5**, below.

Table 6.5: Consultation with sensitive receivers

Lot	DP	Distance of dwelling from project footprint (m)	Day (standard construction hours)	Day (out of hours work (OOHW))
16	877827	80	Notification	Notification Respite period (R1) Duration respite Phone calls Specific Notification
1	995519	180	Notification	Notification Respite period (R1) Duration respite
1	1012109	200	Notification	Notification Respite period (R1) Duration respite
23	1007618	450	-	Notification Respite period (R1) Duration respite
1	995518	490	-	Notification Respite period (R1) Duration respite

Work would predominantly be undertaken during standard day time construction hours, except for Saturdays where extended working hours will occur. However, extended construction hours outside of working hours on weekend or night works to minimise traffic impacts on the community may be undertaken. Before any such work proceeds, these impacts would need to be considered and assessed and any additional/ particular management measures need to be determined and implemented by Transport or the contractor as required.

Overall, it is considered unlikely that local residents would be significantly impacted by noise and/or vibration generated by the Activity due to separation distances and with the implementation of recommended measures to safeguard or mitigate against this.

Noise generated by the works would not significantly impact on the surrounding habitat. Noise from piling is unlikely to significantly impact any aquatic organisms as disturbance will be intermittent and temporary but may result in aquatic fauna moving/swimming away from the site area.

If works are undertaken outside of working hours on weekends or nights to minimise traffic impacts on the community, an assessment would be undertaken to determine any safeguards and mitigations required.

Operation

The works would not alter the alignment of the road or lead to an increase in the number of vehicle movements. As such there is unlikely to be any change to the traffic noise level post construction.

6.5.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Noise and vibration	A Noise and Vibration Management Plan (NVMP) will be prepared and implemented as part of the CEMP. The NVMP will generally follow the approach in *the Interim Construction Noise Guideline (ICNG) (DECC, 2009*) and identify: • all potential significant noise and vibration generating activities associated with the activity • feasible and reasonable mitigation measures to be implemented, taking into account Beyond the Pavement: urban design policy, process and principles (Transport, 2014). • a monitoring program to assess performance against relevant noise and vibration criteria • arrangements for consultation with affected neighbours and sensitive receivers, including notification and complaint handling procedures • contingency measures to be implemented in the event of non-compliance with noise and vibration criteria.	Contractor	Detailed design / Pre-construction	Section 4.6 of QA *G36 Environment Protection*
Noise and vibration	All sensitive receivers (e.g. local residents) likely to be affected will be notified at least 21 days prior to commencement of any works associated with the activity that may have an adverse noise or vibration impact. The notification will provide details of: • the project • the construction period and construction hours	Contractor	Detailed design / Pre-construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• contact information for project management staff • complaint and incident reporting • how to obtain further information.			
Airborne noise/ground-borne vibration	• Provide phone calls or specific notification for nearby sensitive receivers located less than 120 m from the project footprint, particularly relating to driving/vibrating in piling activities and activities scheduled outside standard construction hours • Periodic notification of all receivers (monthly letterbox drop or equivalent) • Website (if required) • Project info line • Construction Response Line • Email distribution list.	Transport Project Manager	Pre-construction, construction	
	All employees, contractors and subcontractors will receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.	Transport Project Manager/Transport Project Engineer	Pre-construction, construction	
	• No swearing or unnecessary shouting or loud stereos/radio on site. • No dropping of materials from height, throwing of metal items and slamming of doors.	Project team	Construction	
	Verification noise monitoring is required to be undertaken for driven sheet piling. Verification noise monitoring is required for noisy activities outside standard construction hours. An environmental noise monitor would be suitable for verification noise monitoring, noting the anticipated emergence of construction noise above the ambient noise environment and also the remoteness of the site. This monitoring could be undertaken by Transport, the construction contractor or a third party.	Transport Project Manager	Construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	Monitoring of noise and vibration should be undertaken upon receipt of complaints.			
	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods. The periods 6:00 am – 7:00 am Monday to Friday and 1:00 pm – 6:00 pm Saturday and all of Sunday and public holidays are outside standard construction hours. Scheduling noisy activities during these periods should be avoided where practical. It is noted that work during these periods will be required on occasion.	Transport Project Manager	Construction	
	Respite should be negotiated with nearby sensitive receivers located within 525 m of the project footprint during driven piling and other high noise and vibration generating activities outside of standard construction hours. Respite agreed by negotiation may vary from the typical respite period detailed below (i.e. more or less respite may be agreed with impacted residents). In general, the following respite is provided unless otherwise agreed with the relevant receivers. High noise and vibration generating activities – e.g. driven piling – may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour in between each block. For longer duration projects, it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite. Support may be demonstrated from surveys, online feedback, contact phone numbers and community events.	Transport Project Engineer/Transport Project Manager	Construction	
	Use quieter and less vibration emitting construction methods where feasible and reasonable.	Transport Project Engineer	Construction	
	The noise levels of plant and equipment will have operating Sound Power or Sound Pressure Levels compliant with the criteria in Table F.1 of the CNVG.	Transport Project Engineer	Pre-construction, construction	
	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used	Transport Project Manager	Pre-construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	on site unless compliant with the criteria in Table F.1 of the CNVG.			
	Simultaneous operation of noisy plant within discernible range of a sensitive receiver will be avoided.	Transport Project Engineer	During work	
	The offset distance between noisy plant and adjacent sensitive receivers will be maximised. Plant used intermittently will be throttled down or shut down when not in use. Noise-emitting plant will be directed away from sensitive receivers.	Transport Project Engineer	During work	
	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.	Transport Project Engineer/ RMS Project Manager	During work	
	Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.	Transport Project Engineer	During work	
	Loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas will be shielded if close to sensitive receivers. Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible.	Transport Project Engineer	During work	
	Stationary noise sources will be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of *AS 2436: 2010* lists materials suitable for shielding.	Transport Project Engineer	During work	
	For works to be completed during OOHW day periods: • Phone calls and specific notification for residents less than 120m from the works. • Notification to all residents located within the rural area less than 525m from the works and offer respite.	Transport Project Manager	During work	
	For works to be completed during standard working hours: • Notification to all residents located less than 250m from the works.	Transport Project Manager	During work	

6.6 Aboriginal cultural heritage

6.6.1 Existing environment

Transport's Procedure for Aboriginal Cultural Heritage Consultation and Investigation (PACHCI) was undertaken by Transport's Aboriginal Cultural and Heritage Officer (refer to **Appendix E**). The results of the PACHCI are summarised as follows:

The project, as described in the Stage 1 assessment checklist, was assessed as being unlikely to have an impact on Aboriginal cultural heritage.

The assessment is based on the following due diligence considerations:

- The project works are within the existing road corridor and disturbed areas (disturbed zones).
- The project is unlikely to harm known Aboriginal objects or places (AHIMS sites).
- The AHIMS search indicated that there are no recorded Aboriginal sites within the study area.
- The study area does contain landscape features that indicate the presence of Aboriginal objects, based on the Office of Environment and Heritage's Due diligence Code of Practice for the Protection of Aboriginal objects in NSW and the Roads and Maritime Services' procedure, however, the cultural heritage potential of the study area appears to be reduced due to past disturbances in the form of the construction of the current road corridor and seasonal flood events.
- There is an absence of sandstone rock outcrops likely to contain Aboriginal art.
- No artefacts or other items of cultural significance were identified during the physical site inspection.

The project may proceed in accordance with the environmental impact assessment process, as relevant, and all other relevant approvals.

As discussed previously a search of the Native Title Tribunal Native Title Vision website was undertaken, with one Native Title holders/claimants identified. South Arm is within the determination area of Yaegl People #2 (Tribunal File No NCD2015/003). The portion of the project area which falls west of the mean high tide level (i.e. the river) is within the determined Native Title Claim for the Yaegl People. The remainder of the project area to the east is within the road reserve where Native Title has been extinguished. Consultation requirements under the *Native Title Act 1993* have been undertaken and are discussed in Section 4.3.2 and 5.3 of this report.

6.6.2 Potential impacts

Construction

Minor excavation required at the site has potential to uncover unexpected Aboriginal objects (including skeletal remains). Safeguards are provided.

Operation

It is not expected that following completion of the proposal the operation of Big River Way and subject remediation works area would have any impact on Aboriginal heritage.

6.6.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Aboriginal heritage	The *Standard Management Procedure - Unexpected Heritage Items* (Transport, 2015) will be followed in the event that an unknown or potential Aboriginal object/s, including skeletal remains, is found during construction. This applies where Transport does not have approval to disturb the object/s or where a specific safeguard for managing the disturbance (apart from the Procedure) is not in place.	Contractor	Detailed design / Pre-construction	Section 4.9 of QA *G36 Environment Protection*

Impact	Environmental safeguards	Responsibility	Timing	Reference
	Work will only re-commence once the requirements of that Procedure have been satisfied.			
	All personnel working on site must be advised of their responsibilities under the NPW Act.	All personnel on site	Pre-construction	

6.7 Non-Aboriginal heritage

6.7.1 Methodology/ Existing environment

Searches were made of relevant Commonwealth, State and local heritage resisters on which historical heritage places are entered on 27 October 2021. Results are as follows:

- NSW State Heritage Register: no items on the register occur in proximity to the site.
- Clarence Valley Local Environment Plan: The nearest heritage item listed on the LEP is a 'Pioneers Memorial' (Item 350) situated approximately 1.5 km away to the east of the site. This item would not be impacted by the proposal.
- Commonwealth Heritage List: no results were returned within the Clarence Valley LGA.
- National Trust heritage list: no results were returned within 10 kilometres of the site.

6.7.2 Potential impacts

Construction

Given no known Non-Aboriginal heritage items occur at the site it is unlikely that the proposal would have any impacts on such items. There is always potential that the proposal may locate unexpected heritage items, archaeological remains or potential relics of Non-Aboriginal origin, however the likelihood of this is low for the site given its previous disturbance history associated with road works (the Big River Way) and previous remediation works.

Operation

In the operational stage there is unlikely to be any impacts to Non-Aboriginal Heritage items.

6.7.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Non-Aboriginal heritage	The *Standard Management Procedure - Unexpected Heritage Items* (Transport for NSW, 2015) will be followed in the event that any unexpected heritage items, archaeological remains or potential relics of non-Aboriginal origin are encountered. Work will only re-commence once the requirements of that Procedure have been satisfied.	Contractor	Detailed design / Pre-construction	Section 4.9 of QA *G36 Environment Protection*

6.8 Landscape character and visual impacts

6.8.1 Existing environment

The proposed works occur along a modified road reserve and rural landscape setting, comprising a slip on the bank of the South Arm of the Clarence River and Big River Way. The subject site comprises the river embankment and associated riparian vegetation while the broader area is dominated by agricultural lands, predominantly sugar cane.

Local road and river users are most likely to be impacted by changes to the visual setting. The visual amenity of the following landholders may also be impacted:

- Dwelling – approximately 80 east of the site
- Dwelling – approximately 200m southwest of the site
- Dwelling – approximately 180m north of the site

6.8.2 Potential impacts

Construction

Some minor amenity impacts to nearby properties and local road/river users are possible during construction. These could include:

- Noise and vibration.
- Air quality.
- Water quality.
- Habitat/vegetation removal.
- Visual impacts.

While the work and associated sites would be obvious to road users, this impact would be minor.

Operation

The proposal has potential to create adverse visual impacts for local residents via changes to the landscape character of the site. The selected Option 3 was higher scoring than other options in relation to its environmental impacts, including long term visual impacts, as the proposal is seeking to restore lost riverbank. Visually, the shear piles and rock fill are exposed, which will have a similar visual appearance to the adjacent slip remediation site.

In general, the aesthetic qualities and value of the locality are not expected to be impacted by the proposal as the character of the general area would largely remain the same post construction.

6.8.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Landscape character and visual impact	All working areas will be maintained, kept free of rubbish and cleaned up at the end of each working day.	Transport Project Engineer	Construction	
	Soil disturbance will be minimised where possible.	Transport Project Engineer	Construction	

6.9 Socio-economic

6.9.1 Existing environment

Big River Way provides a valued transport route used by travellers, local residents and farmers to access surrounding areas and the coastal villages of Maclean, Tyndale and Ulmarra. This section of the road is sometimes used as an alternative to the Pacific Highway or as a tourist route for vehicles travelling north or south. The proposal is required to restore the riverbank and the deteriorated road surface of Big River Way which is imperative to the safety and integrity of the road to prevent further slips and additional damage to the road pavement.

6.9.2 Potential impacts

Construction

During construction, some traffic delays may be experienced by local road users due to traffic as a result of single northbound lane closure although these are likely to be minor given the low volume of traffic that typically uses the subject section of Big River Way. Accordingly impacts on local residents, businesses and services in the local area are unlikely to be affected by the changed road conditions.

Traffic impacts may also be experienced on South Arm Road on Woodford Island as a result of deliveries of piles made to the potential pile stockpile site located on the north-western bank of the Clarence River (with owner approval). These roads are used by trucks hauling harvested cane during cane haul season (July to December). Planned traffic delays of Big River Way and South Arm Road would be mindful of needs of the local community and cane harvesting businesses.

Whilst some visual amenity and noise and vibration impacts are expected during the works these can largely be managed with recommended safeguards outlined in the REF.

Operation

The repair works of the Big River Way pavement would improve the safety of the road environment and the proposed restoration of the riverbank will reduce risk of further slips/collapse. This would have a positive socio-economic impact by reducing risk of additional damage and degradation to the road surface as a result of future slips or slope subsidence.

6.9.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Socio-economic	Communication Plan (CP) will be prepared and implemented as part of the CEMP to help provide timely and accurate information to the community during construction. The CP will include (as a minimum): • mechanisms to provide details and timing of proposed activities to affected residents, including changed traffic and access conditions • contact name and number for complaints. The CP will be prepared in accordance with the *Community Involvement and Communications Resource Manual* (RTA, 2008).	Contractor	Detailed design / Pre-construction	
Notification	All businesses, residential properties and other key stakeholders (e.g. schools, council, bus operators) affected by the activity would be notified at least 10 working days prior to commencement of the activity. Project/community updates would be provided throughout the duration of works as relevant. Notification would utilise both digital and conventional (non-digital) modes of communication (e.g. media release, letter box drops, newsletters and regular updates to a project website). Notification would include an information package, including contact name and number for enquiries or complaints, the expected timeframe of works and any planned or potential disruptions to utilities/services and changed road and traffic conditions.	Transport project manager and communications officer	Pre-construction and during construction	
Consultation	Ongoing stakeholder and community consultation would be undertaken in accordance with the *Roads & Maritime Communication Toolkit*. Consultation would include: • Clarence Valley Shire Council.	Transport project manager and communications officer	Pre-construction and during construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	• Residents and businesses within a minimum of 2 kilometres of the proposal. • Emergency services. • Bus operators. • Local schools. • Transport Maritime for on water traffic management. • Sugar Cane Industry, Clarence Cane Growers Association and/or Harwood Sugar Mill (as necessary depending on staging of works coinciding with cane harvesting season)			
Noise and vibration specific notification and consultation	Implement notification and community consultation measures with regard to airborne noise and ground-borne vibration impacts from the works, including: • Periodic notification of all identified receivers (letterbox drop or equivalent). • Website. • Project info line. • Construction Response Line. • Email distribution list. For highly noise emitting activities and activities scheduled outside of standard construction hours, provide phone calls or specific notification for each of the identified receivers (this is an additional measure as per noise assessment).	Transport project manager and communications officer	Pre-construction and during construction	
Traffic	As per the notification process, advanced warning signage would be established prior to and during the work to ensure road users are made aware of changed traffic conditions and detour directions. Excluding the required detours, where possible, current traffic movements and property accesses would be maintained during the work. Any disturbance would be minimised to prevent unnecessary traffic delays.	Transport project engineer and work supervisor	Pre-construction and during construction	
Waterway	Advanced warning signage and/or beacons (appropriate for any applicable day and night-time maritime requirements) would be established prior to and during the work to ensure any users of the Clarence River nearby are aware of changed navigational conditions or hazards within the work area and waterway.	Transport project engineer and work supervisor	Pre-construction and during construction	
School bus services	Maintain ongoing consultation and cooperation between Transport and School Bus Services prior to and for the duration of the project, to ensure no adverse or unmanageable impact to important services. Any anticipated traffic disruptions would need to be communicated to the affected School Bus Service.	Transport project manager, communications officer, project engineer and work supervisor	Pre-construction and during construction	
Complaints	A complaint handling procedure and register would be included in the CEMP and would	Transport project manager	During construction	

Impact	Environmental safeguards	Responsibility	Timing	Reference
	include that all complaints would be responded to within 24 hours.	and communications officer		
Health and safety	Suitable site induction relating to site specific hazards would be undertaken for all contractor and Transport staff. The work would be undertaken in accordance with all NSW health and safety legislative requirements and relevant Australian Standards.	Transport project engineer and work supervisor	Pre-construction and during construction	

6.10 Air quality

6.10.1 Existing environment

The proposed works are located within an agricultural setting, predominantly used for sugarcane production. There are no OEH air quality records for Northern NSW. However, it would be expected that low volumes of vehicle emissions would occur on a regular ongoing basis from the traffic along Big River Way, and dust emission are likely to be very low. Ambient air quality at the site is generally good.

6.10.2 Potential impacts

The proposed works may adversely affect air quality through:

- Exhaust emissions from machinery and associated transportation;
- Dust generated through transport and application of rock and fill; and
- Dust generated from stockpiling materials.

The works would result in elevated emissions during construction from plant and equipment, however, it is unlikely this would be significant when compared to background emissions from regular vehicle movements.

6.10.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Air quality	An Air Quality Management Plan (AQMP) will be prepared and implemented as part of the CEMP. The AQMP will include, but not be limited to: • potential sources of air pollution • air quality management objectives consistent with any relevant published EPA and/or Office of Environment and Heritage (OEH) guidelines • mitigation and suppression measures to be implemented • methods to manage work during strong winds or other adverse weather conditions • a progressive rehabilitation strategy for exposed surfaces.	Transport Project Engineer	Pre-construction/ construction	Section 4.4 of *QA G36 Environment Protection*
	Vegetation, garbage or other combustible waste materials are not to be burnt on site.	Transport Project Engineer	Construction	
	Vehicles transporting waste or other materials that may produce odours or dust are to be covered during transportation.	Transport Project Engineer	Construction	

	Stockpile areas that may generate dust are to be managed to suppress dust emissions in accordance with the TfNSW Stockpile Site Management Guideline (EMS-TG-10).	Transport Project Engineer	Construction	
	Measures (including watering or covering exposed areas) would be used to minimise or prevent air pollution and dust	Transport Project Engineer	Construction	
	Works would not be carried out during strong winds or in weather conditions where high levels of dust or air borne particulates are likely	Transport Project Engineer	Construction	
	Vehicles, machinery and equipment would be maintained in accordance with manufacturer's specifications in order to meet the requirements of the POEO Act and associated regulations	Transport Project Engineer	Construction	
	Vehicles and equipment would be switched off when not required to be operational	Transport Project Engineer	Construction	
	Debris and waste would be removed from the works and compound areas as soon as practicable to ensure light-weight material is not dispersed by wind gusts.	Transport Project Engineer	Construction	

6.11 Waste and resources

6.11.1 Existing environment

The works site occurs adjacent to the South Arm of the Clarence River which has potential to be polluted and transport pollution to areas away from the site.

6.11.2 Potential impacts

Uncontained waste has the potential to disperse into the surrounding environment and cause visual impacts and potential harm to aquatic flora and fauna. Waste products may also transport contaminants that may degrade local water quality (e.g. fuels and oils).

Waste generated from the proposal is expected to include:

- Removed weeds and vegetation mulch.
- Packaging materials (e.g. machinery oil/lubricant packaging etc), off-cuts, etc.
- Liquid waste from portable toilets.

Poisoned weeds and removed vegetation are to be mulched in the tree mulcher and may follow different management options, including:

- Transport the material to Harwood Sugar Mill compost system, or
- Transport and dispose of at a licenced waste facility.

A Mulch Management Plan is to be developed for the project to form part of the CEMP.

If weeds can be separated from trees prior to mulching, the mulch can be used on landscape garden beds within Transport for NSW rest areas.

A site has been identified by Transport's Far North Coast District team for reuse of excavated spoil material. The site is within the road reserve adjacent to Coldstream Bridge, south bound lane of Big River Way located approximately 6km south-west of the project area (refer to **Figure 6.1**). This hard stand area can be extended with no additional clearing or disturbance required and can accept this material.

The proposal would be undertaken to ensure minimal impacts are generated from waste material produced on site by ensuring that all waste collected and disposed of or recycled is in accordance with Transport waste disposal protocols and EPA guidelines. No materials would be used in a manner that poses a risk to public safety.

Hazardous waste would be separated from other waste on site which would subsequently reduce the risk of contamination of non-hazardous waste streams. Separation on site also reduces the volume of waste to be stored on site and assists with secure storage of waste, which in turn reduces the risk of contamination of the surrounding environment due to loss of containment of waste. To further reduce risks associated with waste, the volume of waste stored on site would be limited to an amount which could be removed from site within a short timeframe; thereby allowing for complete removal of all waste in the event of a flood warning.

6.11.3 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Waste	A Waste Management Plan (WMP) will be prepared and implemented as part of the CEMP. The WMP will include but not be limited to: • measures to avoid and minimise waste associated with the project • classification of wastes and management options (re-use, recycle, stockpile, disposal) • statutory approvals required for managing on- and off-site waste, or application of any relevant resource recovery exemptions • procedures for storage, transport and disposal • monitoring, record keeping and reporting. The WMP will align with the *Environmental Procedure - Management of Wastes on Transport for NSW Land* (Transport, 2014) and relevant Transport Waste fact sheets.	Contractor	Detailed design / Pre-construction	Section 4.2 of *QA G36 Environment Protection*
	If vegetation is to be mulched and transported off site for beneficial reuse, it is to be assessed for the presence of weeds, pest, and other disease and a Mulch Management Plan prepared in accordance with the Transport Technical Procedure: Mulch Management. Note that there may be restrictions to applying mulch to land outside the road reserve.	Transport Project Engineer	Construction	
	Potentially contaminated waste/ hazardous waste is to be stored separately from other waste streams generated at the site.	Transport Project Engineer	Construction	
	To minimise the risk of impacts from flooding, the quantity of waste stored on site is not to exceed the volume of waste that can be removed in one to two days.	Transport Project Engineer	Construction	
	Potentially contaminated waste/ hazardous waste is to be stored separately from other waste streams generated at the site.	Transport Project Engineer	Construction	
	Resource management hierarchy principles are to be followed: • Avoid unnecessary resource consumption as a priority • Avoidance is followed by resource recovery (including reuse of materials, reprocessing, recycling and energy recovery) • Disposal is undertaken as a last resort. (in accordance with the *Waste Avoidance & Resource Recovery Act 2001*).	Transport Project Engineer	Pre – Construction, Construction	

	There is to be no disposal or re-use of construction waste on to other land.	Transport Project Engineer	Construction	
	Waste is not to be burnt on site.	Transport Project Engineer	Construction	
	All wastewater from vessels is to be discharged at an approved vessel wastewater disposal facility. No vessel wastewater is to be discharged (i.e. pumped out) directly into the water or onto any land adjacent.	Transport Project Engineer	Construction	
	Waste material is not to be left on site once the work has been completed.	Transport Project Engineer	Construction	
	Non-recyclable wastes are to be collected and disposed of at licensed waste facilities only.	Transport Project Engineer	Construction	
	Temporary storage of contaminated waste at the site compound is to be in sealed containers within a self safe storage container and double bunded and sign posted as contaminated waste.	Transport Project Engineer	Construction	
	Storage of hazardous waste (i.e. removed lead paint flakes and dust), restricted solid waste or liquid waste (or a combination of these) on site at any time is not to exceed five tonnes otherwise an Environment Protection Licence under the POEO Act is required.	Transport Project Engineer	Construction	
	Any contaminated waste generated by the proposal is to be disposed of in accordance with the EPA approved methods of waste disposal.	Transport Project Engineer	Construction	
	Bulk project waste (e.g. fill) sent to a site not owned by Roads and Maritime (excluding Office and Environment and Heritage licensed landfills) for land disposal is to have prior formal written approval from the landowner, in accordance with Environmental Direction No. 20 – Legal Off-site disposal of Bulk RTA Project Wastes and Section 143 of the POEO Act.	Transport Project Engineer	Construction	

GDA 1994 MGA Zone 56

LEGEND

Cadastre

Byrons Lane Slip: Excavated Material Reuse Area

0 10 Meters

Excavated Material Reuse Area - Illustration 6.1

GeoLINK environmental management and design

Byron's Lane Slip Stage V
4099-1026

Information shown is for illustrative purposes only
Drawn by: AB Checked by: SDS Reviewed by: DGH
Source of base data: Department of Customer Services
Date: 18/10/2022

6.12 Other impacts

6.12.1 Existing environment and potential impacts

Environmental factor	Existing environment	Potential impacts
Utilities	The following utilities are associated with the site: • Overhead powerlines. • Underground watermain. • Underground communications (Telstra). Prior to construction commencing identification of underground utilities would be undertaken. Public utilities would be adjusted where necessary prior to construction commencing.	Damage to utilities in the vicinity of the proposal.

6.12.2 Safeguards and management measures

Impact	Environmental safeguards	Responsibility	Timing	Reference
Utilities	Prior to the commencement of works: • the location of existing utilities and relocation details will be confirmed following consultation with affected utility owners • further assessment will be undertaken if the scope or location of proposed utility relocation works falls outside of the assessed proposal scope and footprint.	Transport Project Manager	Detailed design / Pre-construction	
Hazards and risk management	A Hazard and Risk Management Plan (HRMP) will be prepared and implemented as part of the CEMP. The HRMP will include, but not be limited to: • details of hazards and risks associated with the activity • measures to be implemented during construction to minimise these risks • record keeping for materials present on the site, material safety data sheets, and personnel trained and authorised to use such materials • a monitoring program to assess performance in managing identified risks • contingency measures to be implemented in the event of unexpected hazards, risks arising and emergency situations. The HRMP will be prepared in accordance with relevant guidelines and standards, including relevant Safe Work Australia Codes of Practice, and EPA or OEH publications.	Contractor	Detailed design / Pre-construction	

6.13 Cumulative impacts

6.13.1 Study area

The study area for the purposes of assessing cumulative impacts is the Clarence Valley LGA.

6.13.2 Other projects and developments

Table 6.6: Past, present and future projects

Project	Construction impacts	Operational impacts
Transport currently have another project in close proximity to the subject site: Culvert at Lees Drain (500m north of the site) • Improved drainage of Shark Creek cane drainage system to protect road assets in the locality and improved stability along a section of Clarence River associated with the outlet of Lees Drain • Construction expected to commence late 2021 and be completed early 2022. This project will likely be finished before the subject project commences as there will be shared utilisation of stockpile sites and compounds.	Construction impacts of the Culvert at Lees Drain may include: • Construction noise exceeding the noise criteria for residences in the surrounding areas. • Traffic congestion affecting Big River Way for the duration of the works.	Operational impacts of the Lees Drain project may include: • An increase in traffic on Big River Way and associated road traffic noise. Although these projects are not part of the same program of work, the timing of these projects has been staggered in order to minimise cumulative impacts.

6.13.3 Potential impacts

The proposal has potential to add a number of cumulative impacts (to a minor extent) during construction including resource consumption, disruption to traffic, noise impacts and generation of greenhouse gas emissions (through operation of vehicles and equipment). In order to minimise the cumulative impacts of the Lees Drain project and the proposal on the immediate surrounding area the timing of the projects have been planned so the Lees Drain project will near completion before works begin for Byrons Lane Slip Stage V. This will help manage potential impacts as well as the extensive mitigation measures stated within Section 6 which aim to minimise the extent to which the proposal contributes to cumulative adverse environmental impacts.

7. Environmental management

This chapter describes how the proposal will be managed to reduce potential environmental impacts during detailed design, construction and operation. A framework for managing potential impacts is provided. A summary of site-specific environmental safeguards is provided and the licence and/or approval requirements required prior to construction are listed.

7.1 Environmental management plans (or system)

Safeguards and management measures have been identified in the REF in order to minimise adverse environmental impacts, including social impacts, which could potentially arise as a result of the proposal. Should the proposal proceed, these safeguards and management measures would be incorporated into the detailed design and applied during the construction and operation of the proposal.

A Construction Environmental Management Plan (CEMP) will be prepared to describe the safeguards and management measures identified. The CEMP will provide a framework for establishing how these measures will be implemented and who would be responsible for their implementation.

The CEMP will be prepared prior to construction of the proposal and must be reviewed and certified by the Transport for NSW Environment Officer, Northern region, prior to the commencement of any on-site works. The CEMP will be a working document, subject to ongoing change and updated as necessary to respond to specific requirements. The CEMP would be developed in accordance with the specifications set out in the *QA Specification G36 - Environmental Protection (Management System)*, *QA Specification G38 - Soil and Water Management (Soil and Water Plan)*, *QA Specification G40 - Clearing and Grubbing, QA Specification G10 - Traffic Management*].

7.2 Summary of safeguards and management measures

Environmental safeguards and management measures outlined in this REF will be incorporated into the detailed design phase of the proposal and during construction and operation of the proposal, should it proceed. These safeguards and management measures will minimise any potential adverse impacts arising from the proposed works on the surrounding environment. The safeguards and management measures are summarised in **Table 7.1**.

Table 7.1: Summary of safeguards and management measures

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
GEN1	General - minimise environmental impacts during construction	A CEMP will be prepared and submitted for review and endorsement of the Transport for NSW Environment Manager prior to commencement of the activity. As a minimum, the CEMP will address the following: • any requirements associated with statutory approvals; • details of how the project will implement the identified safeguards outlined in the REF; • issue-specific environmental management plans; • roles and responsibilities; • communication requirements; • induction and training requirements; • procedures for monitoring and evaluating environmental performance, and for corrective action; • reporting requirements and record-keeping; • procedures for emergency and incident management; and • procedures for audit and review. The endorsed CEMP will be implemented during the undertaking of the activity.	Contractor / Transport for NSW project manager	Pre-construction / detailed design	
GEN2	General - notification	All businesses, residential properties and other key stakeholders (e.g. schools, local councils) affected by the activity will be notified at least five days prior to commencement of the activity.	Contractor / Transport for NSW project manager	Pre-construction	
GEN3	General – environmental awareness	All personnel working on site will receive training to ensure awareness of environment protection requirements to be implemented during the project. This will include up-front site induction and regular "toolbox" style briefings. Site-specific training will be provided to personnel engaged in activities or areas of higher risk. These include: • threatened species habitat. • adjoining residential areas requiring particular noise management measures.	Contractor / Transport for NSW project manager	Pre-construction / detailed design	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
1	Biodiversity	A Flora and Fauna Management Plan will be prepared in accordance with Transport for NSW's *Biodiversity Guidelines: Protecting and Managing Biodiversity on Projects (RMS, 2011)* and implemented as part of the CEMP. It will include, but not be limited to: • plans showing areas to be cleared and areas to be protected, including exclusion zones, protected habitat features and revegetation areas • requirements set out in the *Landscape Guideline (RMS, 2008)* • pre-clearing survey requirements • procedures for unexpected threatened species finds and fauna handling • procedures addressing relevant matters specified in the DPI *Policy and guidelines for fish habitat conservation and management (2013)* • protocols to manage weeds and pathogens	Contractor	Detailed design / pre-construction	Section 4.8 of QA G36 Environment Protection
	Biodiversity	Measures to further avoid and minimise the construction footprint and native vegetation or habitat removal will be investigated during detailed design and implemented where practicable and feasible.	Contractor	Detailed design / pre-construction	
	Removal of native vegetation	Native vegetation removal will be minimised throughout the project.	Transport Project Manager/ Contractor	Prior to construction and during construction	
		Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	Prior to construction	
		Vegetation removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bush rock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
		Native vegetation will be re-established in accordance with *Guide 3: Re-establishment of native vegetation* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011). Note: this will be considered for bank stability in areas where it will not compromise the structural integrity of the asset and outside access areas for maintenance. Also, it's noted there is little to no opportunity to re-establish native vegetation at the slip remediation site due to the narrow road reserve with rock revetment, unless natural vegetation was to naturally colonise the area over time (which is unlikely due to the amount of rock fill to be placed.)	Transport Project Manager/ Contractor	Post construction	
		The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened ecological communities, not assessed in the biodiversity assessment, are identified in the proposal site.	Transport Project Manager/ Contractor	During construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
	Removal of threatened species habitat and habitat features	Habitat removal will be minimised throughout the project.	Transport Project Manager/ Contractor	Prior to construction and during construction	
		Habitat removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bush rock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
	Removal of threatened plants	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	Prior to construction	
		The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened flora species, not assessed in the biodiversity assessment, are identified in the proposal site.	Transport Project Manager/ Contractor	During construction	
	Aquatic impacts	Aquatic habitat will be protected in accordance with *Guide 10: Aquatic habitats and riparian zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) and Section 3.3.2 *Standard precautions and mitigation measures* of the *Policy and guidelines for fish habitat conservation and management Update 2013* (DPI (Fisheries NSW) 2013).	Transport Project Manager/ Contractor	During construction	
		All activities are to minimise disturbance to shallow water habitats under, and in the immediate vicinity of water based structures, including disturbance of seabed sediments and smothering habitats from propeller strike or excessive propeller wash.			
		All activities are to be carried out to avoid spreading aquatic/marine pests including: • Removal of weeds, animals or sediment from equipment and disposal to an appropriate waste receptacle or facility Disposal of sewage and bilge water at an approved pump out facility			
	Groundwater dependent ecosystems	Interruptions to water flows associated with groundwater dependent ecosystems will be minimised.	Transport Project Engineer/ Contractor	Prior to construction and during construction	
	Changes to hydrology	Changes to existing surface water flows will be minimised.	Transport Project Engineer/ Contractor	Prior to construction and during construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
	Edge effects on adjacent native vegetation and habitat	Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	During construction	
	Injury and mortality of fauna	Fauna will be managed in accordance with *Guide 9: Fauna handling* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Transport Project Manager/ Contractor	During construction	
		Pre-clearing surveys will be undertaken in accordance with Guide 1: Pre-clearing process of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (RTA 2011).	Transport Project Manager/ Contractor	Prior to construction	
	Invasion and spread of weeds	Weed species will be managed in accordance with *Guide 6: Weed management* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
	Invasion and spread of pests	If vegetation is to be mulched, pest species will be managed within the proposal site in accordance with the TfNSW Technical Procedure: Mulch Management	Contractor	During construction	
	Invasion and spread of pathogens and disease	Pathogens will be managed in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Contractor	During construction	
	Noise, light and vibration	Shading and artificial light impacts will be minimised.	Transport Project Manager/ Contractor	Prior to construction and during construction	
	Tree and Hollow replacement	Tree and hollows that require replacement will be identified in accordance with the Tree and Hollow replacement guideline. Where trees and hollows will be replaced within the project boundary prepare a Tree and Hollow Replacement Plan to address the impacts described in Table 7-2 prior to commencement of works. Alternatively, where tree and hollow replacement cannot be accommodated locally or can only be partially accommodated, payment must be made to the TfNSW Conservation fund prior to the commencement of works in accordance with the Tree and Hollow Replacement Guideline.	Transport Project Manager	Prior to construction	
2	Hydrological impacts	A CEMP must be prepared in accordance with the specifications set out in the *QA Specification G36 - Environmental Protection (Management) System* to guide the implementation of environmental impact mitigation measures, identify key roles and responsibilities for environmental monitoring and methods of reporting incidents.	Transport Project Manager	Pre-construction	
	Erosion sedimentation	A site-specific Erosion and Sediment Control Plan is to be prepared and implemented as part of the CEMP. The plan is to identify detailed measures and controls to be applied to minimise erosion and sediment control risks including (where relevant), but not limited to: runoff, diversion and drainage points, sumps, scour protection; stabilising disturbed areas as soon as possible; check dams, fencing and swales and staged implementation arrangements.	Transport Project Manager	Pre-construction, construction	Section 2.2 of QA G38 *Soil and Water Management*

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		The plan is to also include arrangements for managing wet weather events, including monitoring of potential high-risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather. Work in areas where soil may be disturbed is to only commence once all relevant erosion and sediment controls have been established. The controls are to be maintained in place until the work is complete and all exposed erodible materials are stable.			
		Erosion and sedimentation controls must be checked and maintained (including clearing of sediment from behind barriers) on a regular basis (including after any precipitation events) and records kept and provided on request.	Transport Project Engineer	Pre-construction, construction	
		An Environmental Work Method Statement (EWMS) is required for proposed instream works and dewatering of any areas prior to commencement of those activities. The EWMS would include measures to avoid or minimise risks from erosion, sedimentation, ASS and PASS to water quality and biodiversity. The EWMS would be approved by the TfNSW Environment Officer and form part of the Construction Environment Management Plan. Dewatering would be undertaken in accordance with TfNSW Environmental Fact Sheet 10: *Dewatering* and the EWMS.	Transport Project Manager	Pre-construction, construction	
		For all works likely to generate sediment within the waterway or on the adjacent banks of the Clarence River (including piling), a full depth sediment/silt curtain and floating hydrocarbon boom will be placed in the adjacent Clarence River to isolate the work area, weighted to the bed and secured to accommodate tidal flow. The hydrocarbon boom will be installed inside of the silt curtain when both are in operation. Install the curtain prior to commencement of instream works and retain until works that risk mobilising sediment are completed. This will remain in place until the completion of sediment generating activities. Silt curtains/floating booms are to be installed, monitored and maintained as needed to contain any sediment. If sediment plumes are observed outside the containment system, then the activity will stop until the containment system has been repositioned to encompass the area of disturbance.	Transport Project Engineer	Pre-construction, construction	
		Disturbance of natural sediments and vegetation must be minimised.	Transport Project Engineer	Pre-construction, construction	
		Erosion and sediment control measures must not be removed until the work is complete or disturbed areas are stabilised.	Transport Project Engineer	Construction, post-construction	
		Maintenance of site compounds must be in accordance with the TfNSW Stockpile Site Management Guideline (EMS-TG-10).	Transport Project Engineer	Pre-construction, construction	
		All rocks will be washed to remove fines.	Transport Project Engineer	Construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		Cleaning of tools and equipment must occur within a designated wash-down bay. The wash-down bay must be bunded and placed so that water does not flow directly into the Clarence River but is captured and contained or filtered and allowed to soak into the ground.	Transport Project Engineer	Construction	
		Water utilised for cleaning of tools must be minimised and obtained from a licensed location or town water supply.	Transport Project Engineer	Construction	
		Clean equipment and vehicles must be used, with equipment being cleaned down before being brought to the site	Transport Project Engineer	Pre-construction, construction	
		A site-specific emergency spill plan will be developed and include spill management measures in accordance with the TfNSW *Code of Practice for Water Management* (RTA, 1999) and relevant EPA guidelines. The plan will address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including TfNSW and EPA officers).	Transport Project Manager	Detailed design/ Pre-construction	Section 4.3 of QA *G36 Environment Protection*
		A spill containment kit for aquatic and terrestrial spills must be available at all times. The spill kit must be appropriately sized for the volume of substances at the work site. All personnel must be made aware of the location of the kit and trained in its effective deployment.	Transport proposal Manager	Pre-construction, construction	
	Reduced water quality	If a spill occurs, the Transport Environmental Incident Classification and Reporting Procedure must be followed, and the Transport Project Manager notified as soon as practicable.	Transport Project Manager/ Project Engineer	Pre-construction, construction	
		Potential or actual acid sulphate soils are to be managed in accordance with the Roads and Maritime Services Guidelines for the Management of Acid Sulphate Materials 2005.	Transport Project Manager	Construction	
		Locate stockpiles of dispersible material away from areas of concentrated overland flow.	Transport Project Manager/ Project Engineer	Construction	
		Required fuels and other liquids must be stored in self-safe chemical storage containers.	Transport Project Manager/ Project Engineer	Pre-construction, construction	
		Unnecessary storage of fuels, lubricants or other compounds on-site must be avoided.	Transport Project Manager/ Project Engineer	Pre-construction, construction	
		Refuelling of plant and equipment is to occur in impervious bunded areas located a minimum of 50 metres from drainage lines or waterways otherwise a double bund is required.	Transport Project Manager/ Project Engineer	Construction	
		All equipment must be maintained in good working order and operated according to manufacturer's specifications.	Transport Project Engineer	Pre-construction, construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		Visual monitoring of local water quality (i.e. turbidity, hydrocarbon spills/slicks) is to be undertaken on a regular basis to identify any potential spills or deficient silt curtains or erosion and sediment controls.	Transport Project Engineer	Construction	
		Construction vessels (including barges) are only to be used at suitable tides when no less than 600mm clearance is available between the underside of the vessel and the bed of the waterway.	Transport Project Engineer	Construction	
		Prepare an emergency response plan for flood events for the proposed work. Include a procedure for rapid removal in the emergency response plan and location for the material.	Transport Project Manager	Pre-construction	
		Establish the compound site in such a way to limit potential impacts from flooding (e.g. on as high a ground as possible and that are readily removed in the event of a flood).	Transport Project Manager	Construction	
	Flooding	Include a Work Method Statement (WMS) in CEMP on compound site evacuation procedure. Issues to be addressed in the WMS include: • Responsibility for monitoring flood threat/flood warning information and how it is to be done • Training for staff on evacuation • Demonstrate that specific equipment for evacuation is readily available Detail where compound site equipment, waste, materials, site sheds etc.	RMS Project Manager	Pre-construction	
3	Contaminated land	If contaminated areas are encountered during construction, appropriate control measures will be implemented to manage the immediate risks of contamination. All other works that may impact on the contaminated area will cease until the nature and extent of the contamination has been confirmed and any necessary site-specific controls or further actions identified in consultation with the Transport for NSW Environment Manager and/or EPA.	Contractor	Detailed design / Pre-construction	Section 4.2 of QA *G36 Environment Protection*
	Accidental spill	A site-specific emergency spill plan will be developed and include spill-management measures in accordance with the Transport *Code of Practice for Water Management (RTA, 1999)* and relevant EPA guidelines. The plan will address measures to be implemented in the event of a spill, including initial response and containment, notification of emergency services and relevant authorities (including Transport EPA officers).	Contractor	Detailed design / Pre-construction	Section 4.3 of QA *G36 Environment Protection*
	Acid sulfate soils	Potential or actual acid sulfate soils are to be managed in accordance with the *TfNSW Services Guidelines for the Management of Acid Sulfate Materials 2005*. An Acid Sulfate Management Plan (ASSMP) will be prepared by Transport and approved by the Environment Officer before the commencement of any activities likely to expose ASS/PASS and at a minimum, the plan will include: • Management measures for the safe excavation and timing to cover excavation, isolated storage and treatment area, neutralisation and re-use or disposal of neutralised soils • Requirements for additional testing to determine predicted liming rates of excavated spoil once quantities are determined. Specific controls to be implemented will include: • Capping exposed surfaces with clean fill to prevent oxidation	Transport Project Manager	Pre-construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		• Placing excavated ASS separately in a lined, bunded and covered area • Neutralising ASS for reuse on site (where appropriate) by using additives such as lime • Disposal at a licensed waste facility. The ASSMP will be included in the CEMP.			
	Asbestos	An Unexpected Contaminated Land and Asbestos Finds procedure must be prepared prior to the commencement of construction and must be followed should unexpected contaminated land or asbestos (or suspected contaminated land or asbestos) be excavated or otherwise discovered during construction	Transport Project Manager	Pre-construction	
4	Traffic and transport	A Traffic Management Plan (TMP) will be prepared and implemented as part of the CEMP. The TMP will be prepared in accordance with the Transport *Traffic Control at Work Sites Manual* (RTA, 2010) and *QA Specification G10 Control of Traffic* (Transport for NSW, 2008). The TMP will include: • confirmation of haulage routes • measures to maintain access to local roads and properties • site-specific traffic control measures (including signage) to manage and regulate traffic movement • measures to maintain pedestrian and cyclist access • requirements and methods to consult and inform the local community of impacts on the local road network • access to construction sites including entry and exit locations and measures to prevent construction vehicles queuing on public roads. • a response plan for any construction traffic incident • consideration of other developments that may be under construction to minimise traffic conflict and congestion that may occur due to the cumulative increase in construction vehicle traffic monitoring, review and amendment mechanisms.	Transport Project Manager	Detailed design / Pre-construction	Section 4.8 of QA *G36 Environment Protection*
		Where possible, current traffic movements must be maintained during the work. Any disturbance must be minimised to prevent unnecessary traffic delays.	Transport Project Engineer	Construction	
		A project-specific consultation strategy must be developed and implemented in accordance with the TfNSW *Community Involvement – Practice Notes and Resource Manual* and *TfNSW Minor Project procedure, Communications for minor projects (ILC-MP-TP0-301).*	Transport Project Manager	Pre-construction	
	Maritime	Twenty-Eight (28) days prior to works commencing the applicant must provide Transport Maritime with a full scope of works including maps noting all obstructions to navigation associated with the proposed works, (vessel/barge anchoring, scaffolding and silt curtain locations etc.) so a Marine Notice can be prepared and advertised.	Transport Project Manager	Pre-construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		Transport Maritime will prepare and advertise the Marine Notice online. The Marine Notice may be required to be placed in the local press and to be advertised at local boat ramps.	Transport Project Manager RMS (Maritime)	Pre-construction	
		Consultation will be required throughout the duration of the works to develop forward plans for the on-water traffic management whilst the works are carried out and as plant and structures are deployed in different locations.	Transport Project Manager RMS (Maritime)	Pre-construction, construction	
		Approved navigational marks, signage and Marine Notices to be implemented and updated during the period of works.	Transport Project Manager/ TfNSW Project Engineer	Pre-construction, construction	
		All navigation aids and traffic management plans must be approved by Transport Maritime.	Transport Project Manager RMS (Maritime)	Pre-construction, construction	
		Any work vessels involved in the project must comply with the relevant NSW Marine Legislation (ie day shapes, lights etc.).	Transport Project Manager	Construction	
		Barges, work vessels and crew involved with the project must comply with the *Marine Safety (Domestic Commercial Vessels) National Law Act 2012*.	Transport Project Manager	Construction	
		A minimum of one navigable channel span (at least 6 m) must be open to navigation at all times unless approved by TfNSW Maritime.	Transport Project Manager	Construction	
		A 4-knot lit Special Mark buoyage OR signage is to be installed at an appropriate distance (200 m) from the structure/s.	Transport Project Manager	Construction	
		Any submerged hazards must be marked with yellow aqua buoys sign written "Warning Submerged Hazard". These aqua buoys must be lit with yellow flashing lights if hazards are present before sunrise and after sunset.	Transport Project Manager	Construction	
5	Noise and vibration	A Noise and Vibration Management Plan (NVMP) will be prepared and implemented as part of the CEMP. The NVMP will generally follow the approach in *the Interim Construction Noise Guideline (ICNG) (DECC, 2009*) and identify: • all potential significant noise and vibration generating activities associated with the activity • feasible and reasonable mitigation measures to be implemented, taking into account Beyond the Pavement: urban design policy, process and principles (Transport, 2014). • a monitoring program to assess performance against relevant noise and vibration criteria • arrangements for consultation with affected neighbours and sensitive receivers, including notification and complaint handling procedures contingency measures to be implemented in the event of non-compliance with noise and vibration criteria.	Contractor	Detailed design / Pre-construction	Section 4.6 of QA *G36 Environment Protection*

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		All sensitive receivers (e.g. local residents) likely to be affected will be notified at least 21 days prior to commencement of any works associated with the activity that may have an adverse noise or vibration impact. The notification will provide details of: • the project • the construction period and construction hours • contact information for project management staff • complaint and incident reporting how to obtain further information.	Contractor	Detailed design / Pre-construction	
	Airborne noise/ground-borne vibration	• Provide phone calls or specific notification for nearby sensitive receivers located less than 120 m from the project footprint, particularly relating to driving/vibrating in piling activities and activities scheduled outside standard construction hours • Periodic notification of all receivers (monthly letterbox drop or equivalent) • Website (if required) • Project info line • Construction Response Line Email distribution list.	Transport Project Manager	Pre-construction, construction	
		All employees, contractors and subcontractors will receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) Environmental incident procedures.	Transport Project Manager/Transport Project Engineer	Pre-construction, construction	
		No swearing or unnecessary shouting or loud stereos/radio onsite. No dropping of materials from height, throwing of metal items and slamming of doors.	Project team	Construction	
		Verification noise monitoring is required to be undertaken for driven sheet piling. Verification noise monitoring is required for noisy activities outside standard construction hours. An environmental noise monitor would be suitable for verification noise monitoring, noting the anticipated emergence of construction noise above the ambient noise environment and also the remoteness of the site. This monitoring could be undertaken by Transport, the construction contractor or a third party. Monitoring of noise and vibration should be undertaken upon receipt of complaints.	Transport Project Manager	Construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods. The periods 6:00 am – 7:00 am Monday to Friday and 1:00 pm – 6:00 pm Saturday and all of Sunday and public holidays are outside standard construction hours. Scheduling noisy activities during these periods should be avoided where practical. It is noted that work during these periods will be required on occasion.	Transport Project Manager	Construction	
		Respite should be negotiated with nearby sensitive receivers located within 525 m of the project footprint during driven piling and other high noise and vibration generating activities outside of standard construction hours. Respite agreed by negotiation may vary from the typical respite period detailed below (i.e. more or less respite may be agreed with impacted residents). In general, the following respite is provided unless otherwise agreed with the relevant receivers. High noise and vibration generating activities – e.g. driven piling – may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour in between each block. For longer duration projects, it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite. Support may be demonstrated from surveys, online feedback, contact phone numbers and community events.	Transport Project Engineer/Transport Project Manager	Construction	
		Use quieter and less vibration emitting construction methods where feasible and reasonable.	Transport Project Engineer	Construction	
		The noise levels of plant and equipment will have operating Sound Power or Sound Pressure Levels compliant with the criteria in Table F.1 of the CNVG.	Transport Project Engineer	Pre-construction, construction	
		The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table F.1 of the CNVG.	Transport Project Manager	Pre-construction	
		Simultaneous operation of noisy plant within discernible range of a sensitive receiver will be avoided.	Transport Project Engineer	During work	
		The offset distance between noisy plant and adjacent sensitive receivers will be maximised. Plant used intermittently will be throttled down or shut down when not in use. Noise-emitting plant will be directed away from sensitive receivers.	Transport Project Engineer	During work	
		Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.	Transport Project Engineer/ RMS Project Manager	During work	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.	Transport Project Engineer	During work	
		Loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas will be shielded if close to sensitive receivers. Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible.	Transport Project Engineer	During work	
		Stationary noise sources will be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of *AS 2436: 2010* lists materials suitable for shielding.	Transport Project Engineer	During work	
		For works to be completed during OOHW day periods: • Phone calls and specific notification for residents less than 120m from the works. • Notification to all residents located within the rural area less than 525m from the works and offer respite.	Transport Project Manager	During work	
		For works to be completed during standard working hours: Notification to all residents located less than 250m from the works.	Transport Project Manager	During work	
6	Aboriginal heritage	The *Standard Management Procedure - Unexpected Heritage Items* (Transport, 2015) will be followed in the event that an unknown or potential Aboriginal object/s, including skeletal remains, is found during construction. This applies where Transport does not have approval to disturb the object/s or where a specific safeguard for managing the disturbance (apart from the Procedure) is not in place. Work will only re-commence once the requirements of that Procedure have been satisfied.	Contractor	Detailed design / Pre-construction	Section 4.9 of QA *G36 Environment Protection*
		All personnel working on site must be advised of their responsibilities under the NPW Act.	All personnel on site	Pre-construction	
7	Non-Aboriginal heritage	The *Standard Management Procedure - Unexpected Heritage Items* (Transport for NSW, 2015) will be followed in the event that any unexpected heritage items, archaeological remains or potential relics of non-Aboriginal origin are encountered. Work will only re-commence once the requirements of that Procedure have been satisfied.	Contractor	Detailed design / Pre-construction	Section 4.9 of QA *G36 Environment Protection*
8	Landscape character and visual impact	All working areas will be maintained, kept free of rubbish and cleaned up at the end of each working day.	Transport Project Engineer	Construction	
		Soil disturbance will be minimised where possible.	Transport Project Engineer	Construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
9	Socio-economic	Communication Plan (CP) will be prepared and implemented as part of the CEMP to help provide timely and accurate information to the community during construction. The CP will include (as a minimum): • mechanisms to provide details and timing of proposed activities to affected residents, including changed traffic and access conditions • contact name and number for complaints. The CP will be prepared in accordance with the *Community Involvement and Communications Resource Manual* (RTA, 2008).	Contractor	Detailed design / Pre-construction	
	Notification	All businesses, residential properties and other key stakeholders (e.g. schools, council, bus operators) affected by the activity would be notified at least 10 working days prior to commencement of the activity. Project/community updates would be provided throughout the duration of works as relevant. Notification would utilise both digital and conventional (non-digital) modes of communication (e.g. media release, letter box drops, newsletters and regular updates to a project website). Notification would include an information package, including contact name and number for enquiries or complaints, the expected timeframe of works and any planned or potential disruptions to utilities/services and changed road and traffic conditions.	Transport project manager and communications officer	Pre-construction and during construction	
	Consultation	Ongoing stakeholder and community consultation would be undertaken in accordance with the *Roads & Maritime Communication Toolkit*. Consultation would include: • Clarence Valley Shire Council. • Residents and businesses within a minimum of 2 kilometres of the proposal. • Emergency services. • Bus operators. • Local schools. • Transport Maritime for on water traffic management. Sugar Cane Industry, Clarence Cane Growers Association and/or Harwood Sugar Mill (as necessary depending on staging of works coinciding with cane harvesting season)	Transport project manager and communications officer	Pre-construction and during construction	
	Noise and vibration specific notification and consultation	Implement notification and community consultation measures with regard to airborne noise and ground-borne vibration impacts from the works, including: • Periodic notification of all identified receivers (letterbox drop or equivalent). • Website. • Project info line. • Construction Response Line. • Email distribution list.	Transport project manager and communications officer	Pre-construction and during construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		For highly noise emitting activities and activities scheduled outside of standard construction hours, provide phone calls or specific notification for each of the identified receivers (this is an additional measure as per noise assessment).			
	Traffic	As per the notification process, advanced warning signage would be established prior to and during the work to ensure road users are made aware of changed traffic conditions and detour directions. Excluding the required detours, where possible, current traffic movements and property accesses would be maintained during the work. Any disturbance would be minimised to prevent unnecessary traffic delays.	Transport project engineer and work supervisor	Pre-construction and during construction	
	Waterway	Advanced warning signage and/or beacons (appropriate for any applicable day and night-time maritime requirements) would be established prior to and during the work to ensure any users of the Clarence River nearby are aware of changed navigational conditions or hazards within the work area and waterway.	Transport project engineer and work supervisor	Pre-construction and during construction	
	School bus services	Maintain ongoing consultation and cooperation between Transport and School Bus Services prior to and for the duration of the project, to ensure no adverse or unmanageable impact to important services. Any anticipated traffic disruptions would need to be communicated to the affected School Bus Service.	Transport project manager, communications officer, project engineer and work supervisor	Pre-construction and during construction	
	Complaints	A complaint handling procedure and register would be included in the CEMP and would include that all complaints would be responded to within 24 hours.	Transport project manager and communications officer	During construction	
	Health and safety	Suitable site induction relating to site specific hazards would be undertaken for all contractor and Transport staff. The work would be undertaken in accordance with all NSW health and safety legislative requirements and relevant Australian Standards.	Transport project engineer and work supervisor	Pre-construction and during construction	
10	Air quality	An Air Quality Management Plan (AQMP) will be prepared and implemented as part of the CEMP. The AQMP will include, but not be limited to: • potential sources of air pollution • air quality management objectives consistent with any relevant published EPA and/or Office of Environment and Heritage (OEH) guidelines • mitigation and suppression measures to be implemented • methods to manage work during strong winds or other adverse weather conditions	Transport Project Engineer	Pre-construction/ construction	Section 4.4 of *QA G36 Environment Protection*

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		a progressive rehabilitation strategy for exposed surfaces.			
		Vegetation, garbage or other combustible waste materials are not to be burnt on site.	Transport Project Engineer	Construction	
		Vehicles transporting waste or other materials that may produce odours or dust are to be covered during transportation.	Transport Project Engineer	Construction	
		Stockpile areas that may generate dust are to be managed to suppress dust emissions in accordance with the TfNSW Stockpile Site Management Guideline (EMS-TG-10).	Transport Project Engineer	Construction	
		Measures (including watering or covering exposed areas) would be used to minimise or prevent air pollution and dust	Transport Project Engineer	Construction	
		Works would not be carried out during strong winds or in weather conditions where high levels of dust or air borne particulates are likely	Transport Project Engineer	Construction	
		Vehicles, machinery and equipment would be maintained in accordance with manufacturer's specifications in order to meet the requirements of the POEO Act and associated regulations	Transport Project Engineer	Construction	
		Vehicles and equipment would be switched off when not required to be operational	Transport Project Engineer	Construction	
		Debris and waste would be removed from the works and compound areas as soon as practicable to ensure light-weight material is not dispersed by wind gusts.	Transport Project Engineer	Construction	
11	Waste	A Waste Management Plan (WMP) will be prepared and implemented as part of the CEMP. The WMP will include but not be limited to: • measures to avoid and minimise waste associated with the project • classification of wastes and management options (re-use, recycle, stockpile, disposal) • statutory approvals required for managing on- and off-site waste, or application of any relevant resource recovery exemptions • procedures for storage, transport and disposal • monitoring, record keeping and reporting. The WMP will align with the *Environmental Procedure - Management of Wastes on Transport for NSW Land* (Transport, 2014) and relevant Transport Waste fact sheets.	Contractor	Detailed design / Pre-construction	Section 4.2 of *QA G36 Environment Protection*
		If vegetation is to be mulched and transported off site for beneficial reuse, it is to be assessed for the presence of weeds, pest, and other disease and a Mulch Management Plan prepared in accordance with the Transport Technical Procedure: Mulch Management. Note that there may be restrictions to applying mulch to land outside the road reserve.	Transport Project Engineer	Construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		Potentially contaminated waste/ hazardous waste is to be stored separately from other waste streams generated at the site.	Transport Project Engineer	Construction	
		To minimise the risk of impacts from flooding, the quantity of waste stored on site is not to exceed the volume of waste that can be removed in one to two days.	Transport Project Engineer	Construction	
		Potentially contaminated waste/ hazardous waste is to be stored separately from other waste streams generated at the site.	Transport Project Engineer	Construction	
		Resource management hierarchy principles are to be followed: • Avoid unnecessary resource consumption as a priority • Avoidance is followed by resource recovery (including reuse of materials, reprocessing, recycling and energy recovery) • Disposal is undertaken as a last resort. (in accordance with the *Waste Avoidance & Resource Recovery Act 2001*).	Transport Project Engineer	Pre – Construction, Construction	
		There is to be no disposal or re-use of construction waste on to other land.	Transport Project Engineer	Construction	
		Waste is not to be burnt on site.	Transport Project Engineer	Construction	
		All wastewater from vessels is to be discharged at an approved vessel wastewater disposal facility. No vessel wastewater is to be discharged (i.e. pumped out) directly into the water or onto any land adjacent.	Transport Project Engineer	Construction	
		Waste material is not to be left on site once the work has been completed.	Transport Project Engineer	Construction	
		Non-recyclable wastes are to be collected and disposed of at licensed waste facilities only.	Transport Project Engineer	Construction	
		Temporary storage of contaminated waste at the site compound is to be in sealed containers within a self safe storage container and double bunded and sign posted as contaminated waste.	Transport Project Engineer	Construction	
		Storage of hazardous waste (i.e. removed lead paint flakes and dust), restricted solid waste or liquid waste (or a combination of these) on site at any time is not to exceed five tonnes otherwise an Environment Protection Licence under the POEO Act is required.	Transport Project Engineer	Construction	
		Any contaminated waste generated by the proposal is to be disposed of in accordance with the EPA approved methods of waste disposal.	Transport Project Engineer	Construction	
		Bulk project waste (e.g. fill) sent to a site not owned by Roads and Maritime (excluding Office and Environment and Heritage licensed landfills) for land disposal is to have prior formal	Transport Project Engineer	Construction	

No.	Impact	Environmental safeguards	Responsibility	Timing	Reference
		written approval from the landowner, in accordance with Environmental Direction No. 20 – Legal Off-site disposal of Bulk RTA Project Wastes and Section 143 of the POEO Act.			
12	Utilities	Prior to the commencement of works: • the location of existing utilities and relocation details will be confirmed following consultation with affected utility owners further assessment will be undertaken if the scope or location of proposed utility relocation works falls outside of the assessed proposal scope and footprint.	Transport Project Manager	Detailed design / Pre-construction	
	Hazards and risk management	A Hazard and Risk Management Plan (HRMP) will be prepared and implemented as part of the CEMP. The HRMP will include, but not be limited to: • details of hazards and risks associated with the activity • measures to be implemented during construction to minimise these risks • record keeping for materials present on the site, material safety data sheets, and personnel trained and authorised to use such materials • a monitoring program to assess performance in managing identified risks • contingency measures to be implemented in the event of unexpected hazards, risks arising and emergency situations. The HRMP will be prepared in accordance with relevant guidelines and standards, including relevant Safe Work Australia Codes of Practice, and EPA or OEH publications.	Contractor	Detailed design / Pre-construction	

7.3 Licensing and approvals

Table 7.2: Summary of licensing and approvals required

Instrument	Requirement	Timing
Fisheries Management Act 1994 (s199)	Notification to the Minister for Agriculture and Western NSW prior to any dredging or reclamation works. [Note exemption under s263A of the Fisheries Management (General) Regulation 2010] Address comments from NSW DPI Fisheries s199 response (refer to Section 5.5 of this report) to TfNSW notification in CEMP	A minimum of 28 days prior to the start of work. Notification (s199 referral) provided 9 June 2022 (refer to Appendix C)
Crown Land Management Act 2016 (Division 3.4, 5.5 and 5.6)	Lease or licence to occupy areas of Crown land.	Prior to start of the activity. Notification (at least 7 days written notice prior to start of activity) should include environmental approvals/the determined REF. A copy of landowner's consent to be provided with s199 referral request.
Transport and Infrastructure SEPP (TISEPP)	Given the presence of the project on flood liable land, notification of the proposal is required to the local branch of the State Emergency Services (SES), email: erm@ses.nsw.gov.au; mcl.ops@ses.nsw.gov.au; ulm.ops@ses.nsw.gov.au	21 days prior to construction.

8. Conclusion

This chapter provides the justification for the proposal taking into account its biophysical, social and economic impacts, the suitability of the site and whether or not the proposal is in the public interest. The proposal is also considered in the context of the objectives of the *EP&A Act*, including the principles of ecologically sustainable development as defined in Section 193 of the Environmental Planning and Assessment Regulation 2021.

8.1 Justification

The remediation works on the South Arm River embankment are required to improve road safety and ensure that Big River Way remains a safe and trafficable transport route by restoring the riverbank, preventing further slips and degradation of the road surface and improve safety for road users.

General objectives of the proposal are to:

- Stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way.
- Restoration of the riverbank profile.
- Restore the pavement to the shoulder of Big River Way.

With effective implementation of the safeguards and management measures of this REF, environmental impacts associated with undertaking the work would be minor. Unavoidable impacts required for the work are temporary and not substantial and would not significantly affect the local environment. Overall, the environment would benefit from the proposed restoration and remediation of the river bank as road safety would be improved.

8.2 Objects of the *EP&A Act*

Instrument	Requirement
1.3(a) To promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources.	Factored into the design of the proposal.
1.3(b) To facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment.	Ecologically sustainable development is considered in Sections 8.2.1 below
1.3(c) To promote the orderly and economic use and development of land.	Not relevant to the proposal.
1.3(d) To promote the delivery and maintenance of affordable housing.	Not relevant to the project.
1.3(e) To protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats.	This REF provides a thorough assessment of the environment and recommends extensive safeguards to minimise impacts to the environment with a focus on reducing the impacts of the project.
1.3(f) To promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage).	This REF provides a thorough assessment of the environment and recommends extensive safeguards to minimise impacts to the environment.
1.3(g) To promote good design and amenity of the built environment.	Factored into the design of the proposal.
1.3(h) To promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants.	Not relevant to the project.

Instrument	Requirement
1.3(i) To promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State.	Not relevant to the project.
1.3(j) To provide increased opportunity for community participation in environmental planning and assessment.	The public will be consulted about the project.

8.2.1 Ecologically sustainable development

Ecologically sustainable development (ESD) is development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. The principles of ESD have been an integral consideration throughout the development of the project.

ESD requires the effective integration of economic and environmental considerations in decision-making processes. The four main principles supporting the achievement of ESD are discussed below.

The precautionary principle

The precautionary principle deals with reconciling scientific uncertainty about environmental impacts with certainty in decision-making. It provides that where there is a threat of serious or irreversible environmental damage, the absence of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation.

This principle was considered during route options development (refer to Chapter 2) and was applied as part of the Environmental Assessment (Chapter 6). The precautionary principle has guided the assessment of environmental impacts for this REF and the development of mitigation measures.

Intergenerational equity

Social equity is concerned with the distribution of economic, social and environmental costs and benefits. Inter-generational equity introduces a temporal element with a focus on minimising the distribution of costs to future generations.

The proposal would not significantly affect the viability of local or threatened species or any TECs. Therefore, local biodiversity values would not be substantially adversely affected by the proposal and would be maintained for future generations. Without the works proceeding, traffic safety and efficiency would rapidly decline. Overall, the socio-economic, safety and environmental safety benefits of the proposal would occur only at limited minimal potential environmental expense.

Conservation of biological diversity and ecological integrity

The conservation of biological diversity and ecological integrity should be a fundamental consideration in shaping the project.

The impacts to ecological integrity and conservation of biological diversity at the site have been thoroughly assessed as part of this REF. No threatened species or communities are likely to be significantly affected by the proposal. No populations of native species are likely to be made locally rare or unviable as a result of the proposal. Consequently, the ecological integrity and biological diversity would be maintained at the site.

Improved valuation, pricing and incentive mechanisms

The principle of internalising environmental costs into decision making requires consideration of all environmental resources that may be affected by the carrying out of a project, including air, water, land and living things.

It is difficult to assign a monetary value to the environment of a locality or to environmental resources not considered for commercial use. Transport has taken an approach to manage the potential environmental impacts of the proposal by identifying appropriate safeguards (this REF) to mitigate adverse environmental effects with financial support for implementation.

8.3 Conclusion

The proposed remediation works and riverbank restoration at Clarence River embankment, adjcant to Big River Way is subject to assessment under Division 5.1 of the *EP&A Act*. The REF has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity.

This has included consideration (where relevant) of conservation agreements and plans of management under the NPW Act, biodiversity stewardship sites under the *BC Act*, wilderness areas, areas of outstanding value, impacts on threatened species and ecological communities and their habitats, and other protected fauna and native plants. It has also considered potential impacts to matters of national environmental significance listed under the *EPBC Act*.

A number of potential environmental impacts from the proposal have been avoided or reduced during the concept design development and options assessment. The proposal, as described in the REF, best meets the project objectives but would still result in some impacts on biodiversity, traffic, soils and noise. Safeguards and management measures as detailed in this REF would ameliorate or minimise these expected impacts. The proposal would also improve road safety and prevent future slips and degradation of the road surface. On balance, the proposal is considered justified and the following conclusions are made.

Significance of impact under NSW legislation

The proposal would be unlikely to cause a significant impact on the environment. Therefore, it is not necessary for an environmental impact statement to be prepared nor approval to be sought from the Minister for Planning under Division 5.2 of the *EP&A Act*. A Biodiversity Development Assessment Report or Species Impact Statement is not required, however a BAR has been provided for the project. The proposal is subject to assessment under Division 5.1 of the *EP&A Act*. Consent from Council is not required.

Significance of impact under Australian legislation

The proposal is not likely to have a significant impact on matters of national environmental significance nor the environment of Commonwealth land within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*. A referral to the Australian Department of Agriculture, Water and the Environment is not required.

9. Certification

This review of environmental factors provides a true and fair review of the proposal in relation to its potential effects on the environment. It addresses to the fullest extent possible all matters affecting or likely to affect the environment as a result of the proposal.

Name:	David Havilah
Position:	Senior Ecologist
Company name:	GeoLINK
Date:	6 September 2022

I have examined this review of environmental factors and accept it on behalf of Transport for NSW.

Name:	Ian Drinkwater
Position:	Project Manager - Project Services Northern
Transport region/program:	Maintenance and Delivery North Regional and Outer Metropolitan
Date:	October 2022

10. References

Department of Urban Affairs and Planning [DUAP] (1995/1996). *Is an EIS required?* Department of Urban Affairs and Planning.

Terms and acronyms used in this REF

Term / Acronym	Description
AusLink	Mechanism to facilitate cooperative transport planning and funding by Commonwealth and state and territory jurisdictions
BC Act	*Biodiversity Conservation Act 2016 (NSW)*
CEMP	Construction environmental management plan
CM SEPP	State Environmental Planning Policy (Coastal Management) 2018
EIA	Environmental impact assessment
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*. Provides for the protection of the environment, especially matters of national environmental significance, and provides a national assessment and approvals process
ESD	Ecologically sustainable development. Development which uses, conserves and enhances the resources of the community so that ecological processes on which life depends, are maintained and the total quality of life, now and in the future, can be increased
FM Act	*Fisheries Management Act 1994 (NSW)*
Heritage Act	*Heritage Act 1977 (NSW)*
ISEPP	State Environmental Planning Policy (Infrastructure) 2007
LALC	Local Aboriginal Land Council
LEP	Local Environmental Plan. A type of planning instrument made under Part 3 of the *EP&A Act*.
LoS	Level of Service. A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers
MNES	Matters of national environmental significance under the *Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*
NPW Act	*National Parks and Wildlife Act 1974 (NSW)*
OEH	*Office of Environment and Heritage* within the *Department of Planning and Environment*
PEA Act	*Protection of the Environment Administration Act 1991*
QA Specifications	Specifications developed by Transport for use with road work and bridge work contracts let by Transport
RMS	NSW Roads and Maritime Services, now Transport for NSW
SEPP	State Environmental Planning Policy. A type of planning instrument made under Part 3 of the *EP&A Act*
Transport	Transport for NSW

Appendix A

Biodiversity Assessment Report

Byrons Lane Slip Stage V

Biodiversity Assessment Report

Transport for NSW | February 2022

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Byrons Lane Slip Stage V

Biodiversity Assessment Report

Transport for NSW | February 2022

Prepared by GeoLINK

Executive summary

Transport for NSW (TfNSW) propose to carry out remediation works on the South Arm River (south arm of the Clarence River) embankment in response to a significant rainfall (declared natural disaster) event in March 2021. The South Arm River is located adjacent to the Big River Way (Old Pacific Highway) and the easter riverbank forms the western embankment for the Big River Way at the proposed remediation site. The slip is located approximately 33.44 km north of Grafton within the Clarence Valley Council (CVC) local government area and is located approximately 540 m north-east of Byron's Lanes

The objectives of the proposed works are to:

- Stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way.
- Restoration of the riverbank profile.
- Restore the pavement to the shoulder of Big River Way.
- Undertake works to minimise traffic, environmental, social impacts.
- Ensure Big River Way remains a safe and trafficable transport route.

Based on the site assessment and consideration of the work required, the following biodiversity matters are relevant to the proposal:

- The study area comprises mostly disturbed land lacking native vegetation as a result of historical agricultural pursuits and the construction of Big River Way. Pockets of native vegetation subject to weed incursions are associated with the study area, mainly as riparian vegetation occurring alongside the South Arm River.
- The proposal would result in disturbance of approximately up to 0.84 ha of vegetation (including 0.27 ha of PCT 1235). No hollow-bearing trees would be removed.
- The TEC '*Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions* occurs at the site. The proposal would result in the disturbance and/ or removal of approximately up to 0.27 ha of this TEC.
- No threatened flora species were detected at the site and habitat for such species is poor.
- No threatened fauna species were detected at the site.
- Short-term and localized minor impacts aquatic impacts due to sedimentation and erosion, minor disturbance to aquatic flora and fauna.
- There is potential for several threatened fauna species to occur based on available site habitats.
- A number of mitigation measures have been recommended to manage potential impacts relating to biodiversity.
- It was determined that the proposal is unlikely to significantly affect any species, communities or their habitat listed under the BC Act of the EPBC Act. Therefore, a Species Impact Statement is not required, nor is the proposal subject to the EPBC Act Strategic Assessment.
- The works do not trigger the TfNSW offset guidelines.

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Glossary of terms

Definitions	
Biodiversity offsets	Management actions that are undertaken to achieve a gain in biodiversity values on areas of land in order to compensate for losses to biodiversity values from the impacts of development (Office of Environment and Heritage [OEH] 2017).
Construction footprint	The area to be directly impacted by the proposal during construction activities. Analogous with subject land (see definition for subject land).
Cumulative impact	The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Refer to Clause 228(2) of the Environmental Planning and Assessment Regulation 2000 for cumulative impact assessment requirements.
Direct impact	Direct impacts on biodiversity values include those related to clearing native vegetation and threatened species habitat and impacts on biodiversity values prescribed by the Biodiversity Conservation Regulation 2017 (the BC Regulation) (BAM 2017).
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component.
Indirect impact	Indirect impacts include but not limited to: (a) indirect impacts on adjacent vegetation and habitat during construction (b) indirect impacts on adjacent vegetation and habitat during operation (c) impacts on adjacent vegetation and habitat arising from a change in land-use patterns (BAM 2017).
Local population	The population that occurs in the study area. In cases where multiple populations occur in the study area or a population occupies part of the study area, impacts on each subpopulation must be assessed separately (OEH 2017).
MNES	A matter of national environmental significance (MNES) protected by a provision of Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999*.
Mitchell landscape	Landscapes with relatively homogeneous geomorphology, soils and broad vegetation types, mapped at a scale of 1:250,000 (OEH 2014).
Mitigation	Action to reduce the severity of an impact (OEH 2014).
Mitigation measure	Any measure that facilitates the safe movement of wildlife and/or prevents wildlife mortality or injury.

Definitions	
Native vegetation	(a) trees (including any sapling or shrub or any scrub), (b) understorey *plants*, (c) groundcover (being any type of herbaceous vegetation), (d) *plants* occurring in a wetland. A *plant* is native to New South Wales if it was established in New South Wales before European settlement (*Biodiversity Conservation Act 2016*).
OEH BAM Calculator	An online application of the Biodiversity Assessment Method (BAM). The calculator uses the rules and calculations outlined in the BAM and allows the user to apply the BAM at a site and observe the results of the assessment.
Operational footprint	The area that will be subject to ongoing operational impacts from the proposal. This includes the road, surrounding safety verges and infrastructure, fauna connectivity structures and maintenance access tracks and compounds.
Population	A group of organisms, all of the same species, occupying a particular area (BAM 2017).
Proposal area/ proposal site/ development footprint	The area of land that is directly impacted on by the proposal that is being assessed under the EP&A Act, including access roads, and areas used to store construction materials (OEH 2014). It includes the construction and operational areas for the proposal.
Study area	The area directly affected by the development and any additional areas likely to be affected by the development, either directly or indirectly (OEH 2014).
Target species	A species has been identified within the study area or is considered to have a moderate to high likelihood of occurrence and may be impacted by the proposal.

Acronyms

Abbreviations	
BC Act	*Biodiversity Conservation Act 2017*
BCD	Biodiversity Conservation Division
BOS	Biodiversity Offset Scheme under the BC Act
CEEC	Critically Endangered Ecological Community
CEMP	Construction Environmental Management Plan
DAWE	Department of Agriculture, Water and the Environment

Abbreviations	
DPIE	Department of Planning, Industry and Environment
DPI	Department of Primary Industries
EEC	Endangered ecological community
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FM Act	*Fisheries Management Act 1994* (NSW)
GDE	Groundwater dependent ecosystems
IBRA	Interim Biogeographic Regionalisation of Australia
MNES	Matters of National Environmental Significance
PCT	Plant Community Type
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy
TECs	Threatened Ecological Communities
TBDC	Threatened Biodiversity Data Collection
VEC	Vulnerable Ecological Community
VIS	Vegetation information system

1. Introduction

1.1 Proposal background

Transport for NSW (TfNSW) propose to carry out remediation works to the shoulder and riverbank that has eroded away on a section of Big River Way (Old Pacific Highway), Tyndale (‘the site’). The section of the roadside shoulder to be repaired is approximately 40 m in length on the northbound lane, adjacent to the South Arm of the Clarence River. The works are required to improve safety along this section of Big River Way.

The objectives of the proposed works are to:

- Stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way.
- Restoration of the riverbank profile.
- Restore the pavement to the shoulder of Big River Way.
- Undertake works to minimise traffic, environmental, social impacts.
- Ensure Big River Way remains a safe and trafficable transport route.

The site comprises agricultural lands and disturbed habitats associated with Big River Way. Past disturbances include vegetation clearing (for road construction and agricultural pursuits), weed incursion, and structural modification to vegetation through regular roadside maintenance (e.g. slashing). Adjacent land use predominantly consists of agriculture (sugar cane).

1.2 The proposal

Key features of the proposal include:

- Establishment of on-site crib facilities during the works.
- Establishment of stockpile locations on an existing hardstand area.
- Establishment of traffic controls in vicinity of site.
- Establish sedimentation and erosion controls on the South Arm River as required.
- Clearing of vegetation alongside the South Arm River to facilitate work.
- Vegetation mulched onsite and either temporarily stockpiled for reuse onsite or taken to a co-generation plant for re-use or disposed of at a licenced waste facility.

<u>Piling Works Option 1 – Piling works with access from road</u>

- Establish road travel lane restriction to Big River Way with an approved traffic control management plan.
- Construct a platform within the closed lanes of the Big River Way to support a piling rig.
- Establish a piling rig on site.
- Undertake piling works as specified by Geotechnical design requirements to stabilise slope area.

<u>Piling Works Option 2 – Piling works with access from River</u>

- Install access to the lower bank and river adjacent to the identified slip area.
- Assemble and launch a barge at an external boat ramp site approved by the TfNSW Local Environmental Officer, float to slip area and anchor (launched from opposite site from the banks of South Arm Road side of The South Arm River).

- Float barge to work zone by towing behind a suitable boat and anchored in place.
- Ensure navigation lights and waterway markers are in place and operational.
- Establish a floating sedimentation and control boom and attached silt curtain around barge and proposed area of disturbance to isolate the works site. The silt curtain would be weighted to the bed and secured to accommodate tidal flow.
- Undertake piling works as specified by Geotechnical design requirements to stabilise slope area.

Restoration of Riverbank profile

- Install access to the lower bank and river adjacent to the identified slip area.
- Assemble and launch a barge at an external boat ramp site approved by the TfNSW Local Environmental Officer, float to slip area and anchor.
- Install floating boom(s) around slip area within river.
- Rock to be delivered directly to river embankment within the proposed work zone and then immediately placed onto the slope. This would be completed by excavator located on the temporary closed road travel lane or using the barge-mounted excavator. There would be no stockpiling of incoming rock material.

On site facilities for workers and stockpile sites will be provided on an existing hardstand area north of the proposal footprint.

The location of the proposal is shown **Illustration 1.1** and an overview of the proposal is provided in **Illustration 1.2**.

1.3 Legislative context

A Review of Environmental Factors (REF) is to be prepared to satisfy TfNSW duties under s.5.5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to *"examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity"* and s.5.7 in making decisions on the likely significance of any environmental impacts. This biodiversity impact assessment forms part of the REF being prepared for the project and assesses the biodiversity impacts of the proposal to meet the requirements of the EP&A Act.

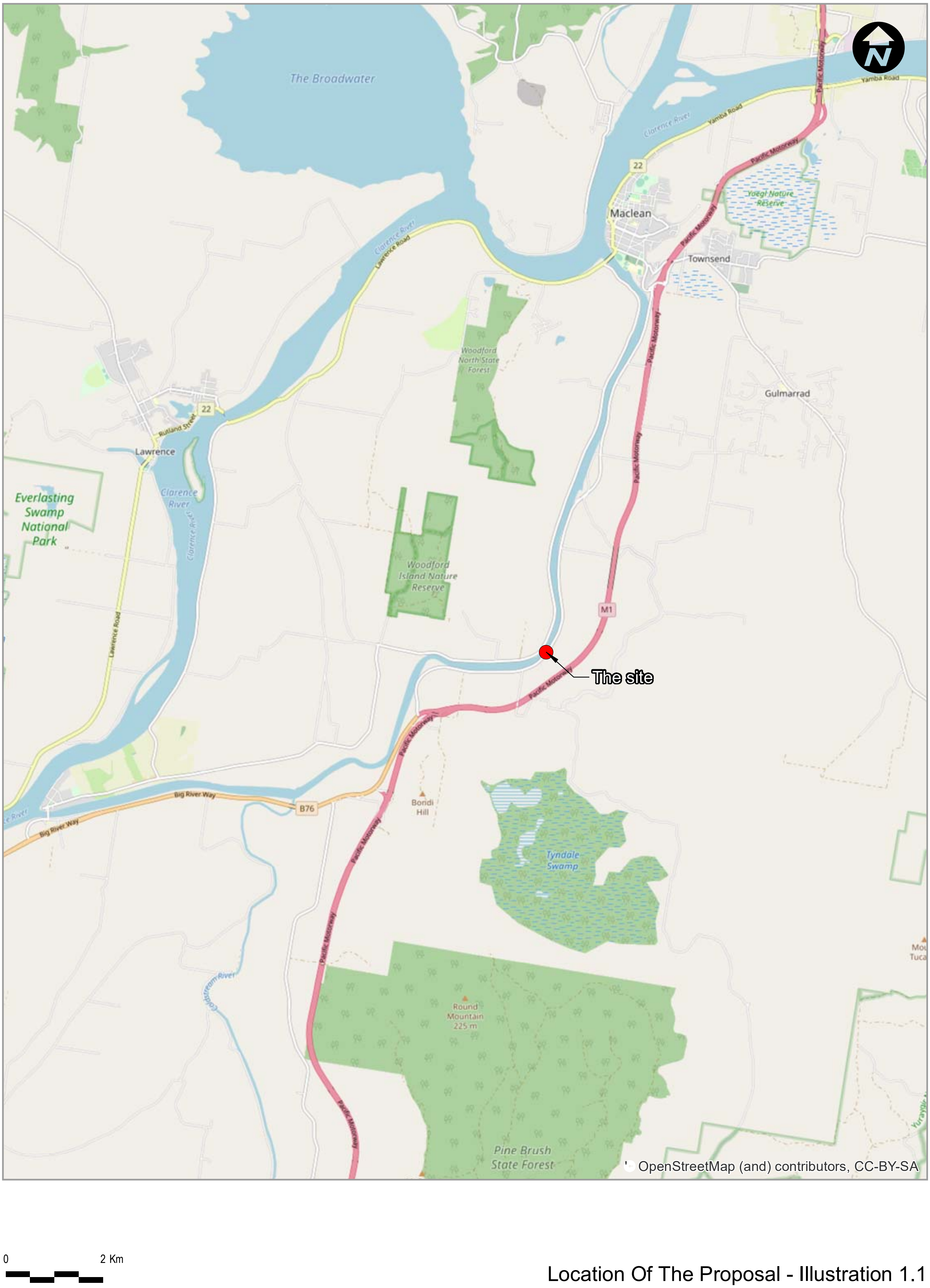
Sections 7.2 A of the *Biodiversity Conservation Act 2016* (BC Act) and Part 7A of the *Fisheries Management Act 1994* (FM Act) require that the significance of the impact on threatened species and endangered ecological communities is assessed using a test of significance. Where a significant impact is likely to occur, a species impact statement (SIS) must be prepared in accordance with the Director-General's requirements or a Biodiversity Development Assessment Report (BDAR) must be prepared by an accredited assessor in accordance with the Biodiversity Assessment Method (BAM).

In September 2015, a "strategic assessment" approval was granted by the Federal Minister in accordance with the EPBC Act. The approval applies to TfNSW activities being assessed under Part 5.1 (formerly Part 5) of the EP&A Act with respect to potential impacts on nationally listed threatened species, ecological communities and migratory species.

As a result, TfNSW proposals assessed via a REF:

- must address and consider potential impacts on nationally listed threatened species, populations, ecological communities and migratory species, including application of the "avoid, minimise, mitigate and offset" hierarchy; and
- do not require referral to the Federal Department of Agriculture, Water and the Environment for these matters, even if the activity is likely to have a significant impact.

To assist with this, assessments are required in accordance with the *Matters of National Environmental Significance: Significant impact guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999* (DoE 2013).



Location Of The Proposal - Illustration 1.1

GeoLINK environmental management and design

Byron Lane Stage V Slip Biodiversity Report
4099-1005

Information shown is for illustrative purposes only
Drawn by: AB Checked by: RE Reviewed by: SDS
Source of base data: OpenStreet Map
Date: 06/10/2021

LEGEND

- Survey limit
- New Byron Lane stage V slip
- Cadastre

0 30 Meters

The Proposal - Illustration 1.2

GeoLINK environmental management and design

Byron Lane Stage V Slip Biodiversity Report
4099-1017

Information shown is for illustrative purposes only
Drawn by: AB Checked by: RE Reviewed by: SDS
Source of base data: Department of Customer Services
Date: 07/04/2022
Revision: A

2. Methods

2.1 Personnel

Qualifications and experience of personnel involved in the assessment is provided in **Table 2.1**.

Table 2.1: Qualifications and experience of personnel

Name	Qualifications	Years of Experience	Role
Samuel Smith	B.Env.Sc.	5	Field surveys and BAR content
David Havilah	B.Sc (Biology).	14	Field surveys and BAR content

2.2 Background research

To guide targeted field surveys, searches of the databases listed in Table 2.2 were completed. Database search results are provided at **Annexure A**.

Table 2.2: Summary of database searches undertaken

Source	Database name	Accessed	Search areas	Date conducted
DPIE/OEH	BioNet	*http://www.bionet.nsw.gov.au/*	10 km x 10 km grid centred on the site	23/09/2021
	Areas of Outstanding Biodiversity Value	*https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity*	Clarence Valley LGA	23/09/2021
	Vegetation Information System	*http://www.environment.nsw.gov.au/NSWVCA20PRapp/LoginPR.aspx*	Clarence lowlands subregion	24/09/2021
NSW Department of Primary Industries (DPI)	Fisheries Spatial Data Portal	*https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal*	Clarence Valley LGA	30/09/2021
	Key Fish habitat mapping	*https://www.dpi.nsw.gov.au/fishing/habitat/publications/pubs/key-fish-habitat-maps*	Clarence Valley LGA	30/09/2021
	NSW Weedwise	*http://weeds.dpi.nsw.gov.au/*	Clarence Valley LGA	30/09/2021

Source	Database name	Accessed	Search areas	Date conducted
	Register of critical habitat	*http://www.dpi.nsw.gov.au/fisheries/species-protection/conservation/what/register*	NSW	30/09/2021
Australian Government Department of Agriculture, Water and the Environment	Protected Matters Search Tool (PMST) for Matters of National Environmental Significance (MNES)	*http://www.environment.gov.au/epbc/protected-matters-search-tool*	10 km radius of the site	23/09/2021
	Directory of important wetlands	*http://www.environment.gov.au/cgi-bin/wetlands/search.pl?smode=DOIW*	20 km x 20 km grid centred on the site	30/09/2021
Australian Government Bureau of Meteorology	Atlas of Groundwater Dependent Ecosystems (GDE)	*http://www.bom.gov.au/water/groundwater/gde/map.shtml*	20 km x 20 km grid centred on the site	30/09/2021
DPIE/OEH Seed datasets	Coastal Wetlands (SEPP Coastal Management 2018)	*https://mapprod1.environment.nsw.gov.au/arcgis/rest/services/Planning/SEPP/MapServer*	The site	30/09/2021
	Littoral Rainforests (SEPP Coastal Management 2018)	*https://mapprod1.environment.nsw.gov.au/arcgis/rest/services/Planning/SEPP/MapServer*	The site	30/09/2021

2.3 Habitat assessment

A preliminary evaluation of the likelihood of occurrence of threatened flora, fauna and populations within the study area based on background research was undertaken. This evaluation considers the broad habitat types within the study area, ecology of threatened species/populations and occurrence of local records. The initial habitat assessment forms the basis for targeted surveys and consideration of potential impacts of the proposal and was revised upon completion of the field surveys.

2.4 Field survey

The site was assessed on 27 September 2021, 6 April 2022 and 16 August 2022 by ecologist Samuel Smith. The assessment utilised the following methodology over three hours in the field:

- Mapping vegetation communities on the site and where possible assigning a NSW Plant Community Type (PCT) in accordance with the DPIE/BCD BioNet Vegetation Classification database.
- Random meander of the site and compilation of a flora inventory.
- Targeted survey for any threatened flora and/ or Threatened Ecological Communities (TEC) (undertaken following threatened species database searches).

- Record the occurrence and extent of any priority weeds listed in the NSW *Biosecurity Act 2015.*
- Survey by visual inspection using binoculars of hollow-bearing trees.
- Opportunistic survey of all fauna based on visual or aural observations.

Areas assessed included all vegetation within the proposal footprint with broader consideration of adjoining vegetation outside this area (refer to **Illustration 1.2**).

2.4.1 Vegetation surveys

Vegetation surveys were conducted across the site by undertaking walking transects along the west side of the road in proximity to the slip and works footprint. Vegetation at the site was mapped and classified as a native vegetation PCT where possible. Trees with a diameter at breast height (DBH) greater than 10 cm where also mapped. No plot-based surveys were undertaken given the disturbed nature of vegetation present and the linear nature of vegetation occurring within the road reserve. Additionally, large areas of weed incursions were also mapped.

2.4.2 Targeted flora surveys

Targeted searches were completed for threatened flora species identified by the potential occurrence assessment (refer to **Annexure B**) as having a moderate to high likelihood of occurrence within areas of suitable habitat. Any species that could not be reliably identified/or may have been overlooked in the survey was presumed to occur at the site and therefore subject to a test of significance (refer to **Annexure C**).

Where possible, surveys followed methods described in OEH's NSW Guideline for surveying threatened plants (OEH 2016), and the draft survey guidelines for Australia's threatened orchids *http://www.environment.gov.au/resource/draft-survey-guidelines-australias-threatened-orchids*.

2.4.3 Targeted fauna surveys

Subject species for targeted fauna surveys were identified as those threatened fauna species that have a moderate to high likelihood of occurrence at the site (refer to **Annexure B**).

Mature trees within the site provide general habitat/ foraging resources for locally occurring fauna species including birds and flying-foxes.

The primary Koala feed tree species Forest Red Gum (*Eucalyptus tereticornis*) and Tallowwood (*Eucalyptus microcorys*) occur throughout the proposal footprint. These Koala feed tree species are low-quality and highly fragmented in a disturbed landscape. Scattered trees within the proposal area provide low-quality potential foraging and refuge resource for any dispersing animals in the locality.

Any species that could not be adequately surveyed during the site assessment according to threatened species survey guidelines was assumed to occur.

Fauna survey efforts included visual canopy searches using binoculars. An assessment of habitat features was also undertaken, including presence of hollow-bearing trees.

2.4.4 Aquatic surveys

The habitat value of the South Arm River (i.e. habitat sensitivity and classification of waterways for fish passage) was characterised in accordance with NSW DPI (Fisheries) document *Policy and Guidelines for fish habitat conservation and management* (NSW DPI (Fisheries) 2013).

2.4.5 Summary of survey effort and limitations

The survey effort undertaken for the fieldwork is summarised below in **Table 2.3**.

Table 2.3: Survey effort

Field technique	Species	Location	Person hours	Date and time
Habitat assessment	Threatened species habitat	Study area	2.5	27/09/2021; 8:00 – 9:30 and 6/04/2022; 10:00 – 11:00
Random meander	Target threatened flora species (refer to Annexure B)	Areas of suitable habitat within study area		
Targeted diurnal bird survey	Potentially occurring threatened bird species (refer to Annexure B)	Study area		
Canopy inspection using binoculars	Koala	Preferred food trees	Random searches while conducting site inspection	

While aspects of the fauna survey effort were not in accordance with the (working) draft Threatened Biodiversity Survey and Assessment Guidelines (DEC 2004), the modified nature of the roadside environment justify the effort expended. While the survey only provides a 'snapshot' of fauna usage during the spring period, the techniques utilised provide suitable sampling for a range of fauna occurring within a modified roadside environment. Based on local fauna records and vegetation/habitat mapping, predictions of fauna usage can be made with a reasonable level of confidence.

Although every effort was made to undertake a full flora inventory, there is a possibility that occurrences of some of the smaller cryptic threatened flora species potentially occurring in the locality were inadvertently overlooked. Consequently, these species were assumed to be present.

The survey timing was considered appropriate for all potentially occurring threatened flora species derived from database searches.

3. Existing environment

The site occurs within the South Eastern Queensland bioregion as per the Interim Biogeographic Regionalisation for Australia (IBRA, version 7). The site lies within the Clarence Lowlands IBRA subregion.

The site lies within the *Clarence – Richmond Alluvial Plains* Mitchell Landscape (Mitchell Landscapes version 3.1), described as follows (DECC 2008):

Wide valleys, channels, floodplains, terraces and estuaries of the Clarence and Richmond Rivers and other coastal streams on Quaternary alluvium, general elevation 0 to 50m, local relief 15m. Deep brown earths and structured brown clay on floodplains. Terrace with yellow texture-contrast soil containing ironstone concretions. Extensively cleared the valley floor supported forest of cabbage gum (Eucalyptus amplifolia), forest red gum (Eucalyptus tereticornis), broad-leaved apple (Angophora subvelutina), river oak (Casuarina cunninghamiana), silky oak (Grevillea robusta), rough-barked apple (Angophora floribunda), native teak (Flindersia australis), coastal grey box (Eucalyptus bosistoana), pink bloodwood (Corymbia intermedia), spotted gum (Corymbia maculata), grey ironbark (Eucalyptus paniculata), broad-leaved paperbark (Melaleuca quinquenervia), blackwood (Acacia melanoxylon) and black she-oak (Casuarina littoralis). On the margins of the basalt based Lamington Volcanic Slopes Landscape; dry closed forest with native cascarilla (Croton verreauxii), yellow tulip (Drypetes deplanchei), silver basswood (Polyscias elegans), guioa (Guioa semiglauca), red cedar (Toona australis) with abundant vines and emergent hoop pine (Araucaria cunninghamii). Salt marsh, mangrove communities and paperbark (Melaleuca quinquenervia) freshwater swamps occur in the estuary.

The geology of the site is described in a nearby Soil Essentials Report as alluvial plain on alluvium lithology.

In general, the study area comprises mostly disturbed land lacking native vegetation because of historical agricultural pursuits and the Construction of Big River Way. Pockets of native vegetation subject to weed incursions are associated with the study area, mainly as riparian vegetation occurring alongside the South Arm River.

A summary of the findings of the desktop assessment are provided in **Table 3.1**.

Table 3.1: Summary of desktop assessment results

Source	Database name	Search area	Results
DPIE/OEH	BioNet	10 km x 10 km grid centred on the site	Records of five threatened flora species, 30 threatened fauna species and 11 TECs known from within the search area (refer to **Annexure A**)
	Areas of Outstanding Biodiversity Value	Clarence Valley LGA	No Areas of Outstanding Biodiversity Value have been declared in the Clarence Valley LGA
	Vegetation Information System (VIS)	Clarence Lowlands subregion	A range of vegetation communities occur in the locality – final communities occurring on-site determined with results of flora survey and comparison with VIS descriptions

Source	Database name	Search area	Results
NSW Department of Primary Industries (DPI)	Fisheries Spatial Data Portal	Clarence Valley LGA	The adjacent section of the South Arm River is not mapped as potential habitat for any threatened freshwater fish species and is ranked as fair habitat for freshwater fish.
	Key Fish habitat mapping	Clarence Valley LGA	Adjacent sections of the South Arm River the works area are mapped as key fish habitat.
	NSW Weedwise	Clarence Valley LGA	137 weed species are listed under the *Biosecurity Act 2015* for the Clarence Valley LGA.
	Register of critical habitat	NSW	No critical habitat occurs within 10 km of the site.
Australian Government Department of Environment and Energy	Protected Matters Search Tool (PMST) for Matters of National Environmental Significance (MNES)	10 km radius of the site	Habitat for two threatened ecological communities, 72 threatened species and 40 migratory species occurs within 10 km of the site.
	Directory of important wetlands	10 km radius of the site	The following three nationally important wetlands occur within the search area; Clarence River Estuary, Everlasting Swamp and Upper Coldstream. These areas occur within the buffer search area and would not be impacted by the proposal.
Australian Government Bureau of Meteorology	Atlas of Groundwater Dependent Ecosystems (GDE)	20 km x 20 km grid centred on the site	Mapping indicates that water resources associated with the site are a low probability of being GDEs
OEH Seed datasets	Coastal Wetlands	The site	Not present
	Littoral Rainforests	The site	Not present

3.1 Vegetation/plant community types

Vegetation at the site is represented alongside Big River Way and the opposite bank of the South Arm River, along South Arm Road (refer to **Illustration 3.1**). One plant community Type (PCT) was identified within the study area and additional miscellaneous areas which do not fall under a PCT category were also identified (refer to **Table 3.2** and **Illustration 3.1**).

Refer to **Annexure D** for a full list of flora recorded onsite.

Table 3.2 Plant community types within the study area

Plant community type (PCT)	Vegetation Formation	Condition	Threatened ecological community? BC Act	Threatened ecological community? EPBC Act	Area (ha) in study area
PCT 1235: - *Swamp Oak swamp forest of the coastal lowlands of the NSW North Coast Bioregion*	Forested Wetlands	Poor to Moderate (disturbed)	Yes: - *Swamp Oak Floodplain Forest of the NEW South Wales North Coast, Sydney and South East Corner Bioregions*	No: - does not meet the EPBC Act patch size of 0.5 ha (**refer to Section 3.2**)	0.27
PCT N/A: - Pasture Grassland	Grassland	Poor	No	No	0.48
PCT N/A: - Rock Armouring Area	N/A	Poor	No	No	0.09
Total					**0.84**

3.1.1 PCT 1235 Swamp Oak swamp forest of the coastal lowlands of the NSW North Coast Bioregion

This area occurs alongside Big River Way (refer to **Illustration 3.1**). For a summary of the characteristics of PCT 1235 refer to **Table 3.3** and is depicted in **Plate 3.1** below.

Table 3.3 Summary of PCT 1235 Swamp Oak swamp forest of the coastal lowlands of the NSW North Coast Bioregion

Description	
PCT justification	The canopy dominated by PCT indicator species: Swamp Oak (*Casuarina glauca*) and occasional Forest Red Gum (*Eucalyptus tereticornis)* Characteristic shrub and ground stratum as labelled in VIS are present in the study area.
Extent in study area (ha)	0.27
Condition	Poor – Moderate (past disturbance from Big River Way roadworks and maintenance).
Canopy species in study area	Swamp Oak (*C. glauca*), Tuckeroo (*Cupaniopsis anacardiodes*) and Forest Red Gum (*E. tereticornis*).

Description	
Mid story and shrub species in study area	Coffee Bush (*Breynia oblongifolia*), Cheese tree (*Glochidion ferinandi var. ferninadi*).
Ground cover species in study area	Blady Grass (*Imperata cylindrica*), Bracken (*Pteridium esculentum*), Common Reed (*Phragmites australis*) and Pennywort (*Centella asiatica*).
Exotic species in study area	Lantana (*Lantana camara**) and Annual Ragweed (*Ambrosia artemisiifolia**), Blue Billygoat Weed (*Ageratum houstonianum**) Coastal Morning Glory (*Ipomoea cairica**) and Broad-leaved Paspalum (*Paspalum mandiocanum**).
*Denotes exotic species	

Plate 3.1 Example of PCT 1235 alongside Big River Way and the South Arm River, facing north

3.1.2 PCT N/A – Pasture grassland

This area does not fit with align with PCT due to lack of native species and structure. This area occurs opposite the site, along South Arm Road (refer to **Illustration 3.1**). For a summary of pasture grassland refer to

Table 3.4 and is depicted in **Plate 3.2**.

Table 3.4 Summary of pasture grassland

Description	
PCT justification	While four isolated Forest Red Gums (*E. tereticornis*) occur within this area, the remainder is cleared and dominated with Kikuyu Grass (*Pennisetum clandestinum**). Likely used for cattle grazing, which is common within the area. Therefore, it does not align with a PCT.
Extent in study area (ha)	0.48

Description	
Condition	Poor (past disturbance agriculture and grazing).
Canopy species in study area	Forest Red Gum (*E. tereticornis*) and Camphor Laurel (*Cinnamomum camphora**).
Mid story and shrub species in study area	Coral Tree (*Erythrina crista-galli**).
Ground cover species in study area	Common Reed (*Phragmites australis*), Pennywort (*Centella asiatica*) and Dockweed (*Rumex brownii*).
Exotic species in study area	As above and additional species including Gomphrena Weed (*Gomphrena celosiodes**), Lamb's Tongue (*Plantago lanceolata**) and White Clover (*Trifolium repens**).
*Denotes exotic species	

Plate 3.2 Example of pasture grassland that occurs along South Arm Road, facing south

3.1.3 PCT N/A – Rock armouring area

This area does not fit with align with PCT due to lack of native species and structure. This area occurs along the southern portion of the site, adjacent Big River Way (refer to **Illustration 3.1**). For a summary of the rock armouring area, refer to

Table 3.5 and is depicted in **Plate 3.3**.

Table 3.5 Summary of rock armouring area

Description	
PCT justification	This area is dominated by regrowth exotic species. It lacks native species and community structure. Therefore, it does not align with a PCT.

Description	
Extent in study area (ha)	0.09
Condition	Poor (past disturbance from Big River Way roadworks, maintenance and weed incursion).
Canopy species in study area	None present
Mid story and shrub species in study area	Lantana (*L. camara**), Tobacco Bush (*Solanum mauritianum**) and Coastal Morning Glory (*Ipomoea cairica**).
Ground cover species in study area	Pidgeon Grass (*Setaria sphacelata**), Broad-leaved Paspalum (*Paspalum mandiocanum**) and Balloon Cotton Bush (*Gomphocarpus physocarpus**).
Exotic species in study area	As above.
*Denotes exotic species	

Plate 3.3 Example of rock armouring area, facing south

LEGEND

- Survey limit
- New Byron Lane stage V slip
- Cadastre
- Annual Ragweed
- Lantana
- PCT 1235 Swamp Oak swamp forest of the coastal lowlands of the NSW North Coast Bioregion
- Pasture / grassland
- Rock armouring area

0 30 Meters

Vegetation Map - Illustration 3.1

GeoLINK environmental management and design

Byron Lane Stage V Slip Biodiversity Report
4099-1018

Information shown is for illustrative purposes only
Drawn by: AB Checked by: RE Reviewed by: SDS
Source of base data: Department of Customer Services
Date: 11/04/2022
Revision: A

3.2 Threatened ecological communities

PCT 1235 within the study area, on the basis of floristics and geology, is representative of *Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions* which is listed as a TEC under the BC Act.

Swamp Oak forest is also listed in the EPBC Act (as the *TEC Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland*). It is subject to condition thresholds, where a minimum patch size of 0.5 ha applies. The small patches of Swamp Oak at the site equate to 0.27 ha and hence do not meet condition thresholds as per the EPBC Act listed community (DAWE, 2018).

3.3 Groundwater dependent ecosystems

The site is located within the Clarence River catchment. Terrestrial ecosystems within the proposal are most likely fed by surface rather than groundwater. This is supported by groundwater dependent ecosystem (GDE) mapping covering the locality that indicates that the vegetation communities present are a low probability of being GDEs (Bureau of Meteorology 2021).

3.4 Threatened species

3.4.1 Threatened flora

No threatened fauna species listed under the BC Act or EPBC Act were recorded in the study area during the site assessment.

Potentially occurring threatened flora species were readily identifiable at the time the site survey was conducted and therefore were assigned a low likelihood of occurrence on the basis that they were not recorded in the site survey (refer to **Annexure B**).

3.4.2 Threatened fauna

No threatened fauna was observed onsite. There was no evidence of Koala activity within the site (scratching on trees and scats in leaf litter).

The site occurs within an area known to be utilised by the Coastal Emu Population which is listed as an endangered population under the BC Act. The Yuraygir sub population occurring south of the Clarence River is known to occupy the coastal strip of Yuraygir National Park as well as surrounding contiguous areas in the Sandon and Brooms Head area in the north to Minnie Water and Red Rock in the south and Tucabia, Tyndale and Shark Creek to Pillar Valley and the lower Clarence River wetlands in the west. A detailed review of the movements and range of the Yuraygir sub-population of Coastal Emus was undertaken as part of the *Coastal Emu Management Plan* for the Woolgoolga to Ballina (W2B) Pacific Highway Upgrade project (RMS, 2017) by interpretation and discussion of the annual emu census results from NPWS land managers (Gina Hart and Matt Clarke) and interviews with long-standing property owners. Key findings of this review include:

- *The majority of the sub-population is centred on Yuraygir National Park including Station Creek to Red Rock, Wooli, Diggers Camp, Minnie Waters, Sandon, Sandon River, Brooms Head, Wooloweyah, James Creek and Taloumbi.*

- *The population is divided by a number of social groups that show fidelity to particular areas and habitat that support important pre and post-breeding life-cycle events. The degree of relatedness and interaction between the groups is not known.*
- *Groups range a considerable distance and include:*
  - *One ranging within the area south of Tucabia from the Coldstream River wetlands in the west to Pillar Valley and Yuraygir National Park in the east.*
  - *A second group that is largely found on the agricultural land and forests between Pine Brush and Candole State Forest in the south, Tyndale Swamp and north to Shark Creek and Green Hill and the cane farms around Shark Creek including Byrons Lane and McIntyres Lane at Tyndale.*
- *These two groups frequently access floodplain wetlands and creeks such as Chaffin Swamp and Pillar Valley Creek. They utilise modified agricultural habitats during pre- and post-breeding activities in spring and summer with the cane fields frequently occupied by adult males raising young.*
- *Anecdotal information on breeding activities suggests that breeding occurs in four broad areas: Station Creek to Red Rock River (south), Wooli - Diggers Camp - Minnie Water - Sandon River (central), Brooms Head - Sandon River - Candole State Forest - Wallaby Lane (north), Pillar Valley around Chaffin Hill and Whites Hill in the western edge of their range (west).*

Emus are known to forage within sugar cane land associated with the site.

Several other threatened fauna species were identified as having moderate potential to occur at the site (refer to **Table 3.6** and **Annexure B**). These species were not subjected to sufficient survey (i.e. not in accordance with the guidelines) and were therefore presumed to occur. Potential habitat for these threatened fauna species is associated with small areas of PCT 1235, and surrounding areas of agricultural land. No hollow-bearing trees occur at the site.

Table 3.6: Habitat assessment and surveys results - fauna

Scientific name	Common name	BC Act status	EPBC Act status	Potential occurrence within study area
Dromaius novaehollandiae	Emu population in the NSW North Coast Bioregion and Port Stephens LGA	E	-	Moderate – known to occur in the locality.
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	Moderate - potential foraging habitat associated with the site.
Grus rubicunda	Brolga	V	-	Moderate - potential foraging habitat associated with the site.
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Moderate - potential foraging habitat associated with the site.
V = Vulnerable E = Endangered				

3.4.3 Aquatic results

The subject site occurs alongside the South Arm River which connects to Clarence River. The South Arm River (and the Clarence River) is mapped as Key Fish Habitat for the Clarence Valley LGA.

Waterways at the site are unlikely to provide any habitat for FM Act listed threatened aquatic species. A review of the fisheries spatial data portal did not indicate any potential habitat for threatened fish species in any waterways in the study area. The fisheries spatial data portal lists the adject section of the South Arm River as having ‘fair’ freshwater fish community status.

3.5 Fauna habitat values

Vegetation to be affected by the proposal is small in area and generally lacking well-developed native vegetation. Fauna habitat features such as hollow-bearing trees, dense leaf litter and coarse woody debris are largely absent. As such the vegetation present represents a small area of opportunistic foraging habitat for a range of locally occurring fauna species.

The South Arm River and floodplains within the local area provides foraging habitat for wetland birds likely to utilise similar habitats associated with the Clarence River floodplain. The South Arm River also provides habitat to a range of native fish, including Dusky Flathead (*Platycephalus fuscus*), Yellowfin Bream (*Acanthopagrus australis*) and Channel Catfish (*Ictalurus punctatus*).

A range of common fauna species were recorded via incidental survey (refer to **Annexure D**).

Implementation of relevant safeguards is expected to minimise the risk of injury/mortality to native fauna during the proposed Activity.

3.6 Areas of outstanding biodiversity value

There are no declared areas of outstanding biodiversity value located in the Clarence Valley LGA.

3.7 Wildlife connectivity corridors

The site occurs approximately three kilometres north-west of the ‘Tyndale swamp’ mapped regional wildlife connectivity corridor (Scotts, 2003). Focus species for this corridor include the Yellow-bellied Glider and Rufous Bettong. However, being in a highly fragmented area, surrounded by cane fields and roads, the site provides poor connectivity.

3.8 State Environmental Planning Policies

3.8.1 State Environmental Planning Policy (Biodiversity & Conservation) 2021

State Environmental Planning Policy (Biodiversity & Conservation) 2021 aims to encourage the conservation and management of natural vegetation areas that provide habitat for Koalas, to ensure permanent free-living populations would be maintained over their present range. Clause 6 of the SEPP states that the SEPP applies only to land ‘in relation to which a development application has been made’. Clause 94 of ISEPP precludes the proposal from requiring consent therefore Part 2 of SEPP 44 does not apply to the proposal. It is TfNSW policy, however, to consider environmental issues relating to their work to the fullest extent possible, including impacts on Koalas.

The policy defines potential Koala habitat as areas of native vegetation where Schedule 2 trees constitute at least 15 percent of the total number of trees in the upper or lower strata of the tree component. Forest

Red Gum, Grey Gum and Tallowwood are both Schedule 2 trees. However, these tree species make up well below <15% of trees at the site. Furthermore, given that only a very small area of fragmented habitat occurs at the site and that Koala records in the study area are scarce the site is not considered to be core Koala habitat. No further consideration of the policy is required.

3.9 Matters of National Environmental Significance

The EPBC Act protects/regulates MNES, including:

- World heritage properties
- National heritage places
- Wetlands of international importance
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)
- A water resource, in relation to coal seam gas development and large coal mining development

Based on the search results and site assessment (refer to summary in **Table 3.7**) no significant impacts to any MNES are likely to result from the proposal, nor is the proposal subject to the EPBC Act Strategic Assessment.

Table 3.7: Assessment of MNES

Factor	Impact
Any impact on a World Heritage property? No World Heritage properties occur within 10 km of the site.	Nil
Any impact on a National Heritage place? No National Heritage places occur within 10 km of the site.	Nil
Any impact on a wetland of international importance (often called 'Ramsar' wetlands)? Clarence River Estuary, Everlasting Swamp and Upper Coldstream. These areas occur within the buffer search area and would not be impacted by the proposal.	Negligible
Any impact on nationally threatened species, ecological communities or migratory species? Habitat for two threatened ecological communities (TECs), 72 threatened species, and 40 migratory species is identified within 10 km of the site. No nationally listed threatened flora species or TECs were recorded in the site survey. No nationally listed threatened fauna species were recorded in the site survey. Several nationally listed threatened fauna species are considered to have a moderate likelihood of occurrence at the site, including Grey-headed Flying-fox, which is also listed as Vulnerable under the EPBC Act. No nationally listed migratory species were recorded in the site survey. It is likely that several listed species (e.g. Satin Flycatcher, Lathams Snipe) may utilise the site on an opportunistic or seasonal basis. However, the	Minor

Factor	Impact
site does not provide any important foraging or breeding habitat for any migratory species. With consideration of the above information, no nationally listed threatened biodiversity matters are likely to be significantly affected by the proposal.	
Any impact on a Commonwealth marine area? No Commonwealth marine areas occur within 10 km of the site.	Nil
Does the proposal involve a nuclear action (including uranium mining)? The proposal does not involve a nuclear action.	Nil
Additionally, any impact (direct or indirect) on the environment of Commonwealth land? The proposal would not have any impact on any Commonwealth Land within 10 km of the site.	Nil

4. Impact assessment

4.1 Avoidance and minimisation

Efforts have been made to ensure that the hierarchy of avoid and minimise was undertaken for the proposal.

- Avoid in the first instance – e.g. positioning of ancillary sites to utilise cleared and disturbed areas and avoid areas of native vegetation.
- Minimise impacts – minimising impacts by way of implementing proposed biodiversity mitigation measures.

The construction process for the proposal would continue to apply the principles of avoid and minimise. Any residual biodiversity impacts would be offset according to the TfNSW Guideline for Biodiversity Offsetting (TfNSW 2016), although the proposal does not trigger the need for offset requirements.

4.2 Construction impacts

4.2.1 Removal of vegetation

The proposal would require removal and/ or disturbance of up to 0.03 ha of vegetation in the form of PCT 1235 alongside the South Arm River and the Big River Way to facilitate sheet piling, riverbank stability and repair to the road shoulder.

Additionally, more clearing may be required adjacent this area as (up to 0.27 ha of PCT 1235 and within the rock armouring area). Disturbance of pasture species and grasses at the opposite side of the South Arm River (along South Arm Road) may be required to facilitate loading and unloading of a barge (up to 0.48 ha)

While up to 0.84 ha is the total area of vegetation that may be impacted (via clearing or disturbance) it likely to be much less due to the scope of the proposal. Impacted vegetation is shown in **Illustration 3.1** and summarised in **Table 4.1** below.

Table 4.1: Potential impacts on vegetation communities

Plant community type (PCT)	Status		Proposal area (ha)
	TEC BC Act	TEC EPBC Act	
PCT 1235 Swamp Oak swamp forest of the coastal lowlands of the NSW North Coast Bioregion	Yes	No	0.27 (removal of 0.03 ha).
Pasture grassland	No	No	0.48
Rock armouring area	No	No	0.09
Total			**0.84 ha**

While the proposed vegetation removal constitutes the Key Threatening Process (KTP) Clearing of Native Vegetation (as listed in the BC Act) the magnitude to which the proposal contributes to this KTP is negligible. Mitigation measures to reduce the risk of direct impacts to native vegetation adjacent to the site are provided in **Section 5**.

4.2.2 Removal of threatened fauna habitat

The results of the threatened fauna potential occurrence assessment in **Annexure C** indicated several threatened fauna species were considered potential occurrences within the study area and therefore have potential to be impacted by the proposal. These species are detailed in **Table 4.2**.

The proposal would require removal and/ or disturbance of up to 0.84 ha of vegetation, including approximately up to 0.27 ha of PCT 1235. This vegetation and the subject section of Big River Way, the South Arm River, South Arm Road and surrounds provides prospective habitat for potentially occurring threatened fauna species, including:

- Potential foraging habitat for a number of threatened bird species
- Potential foraging habitat for Grey-headed Flying-fox

The construction footprint generally comprises degraded habitats with only limited threatened fauna habitat value. There are a limited number of large mature trees present (>50 cm DBH) and hollow-bearing trees are absent. The fauna habitat directly affected by the proposal is negligible in a local context.

Table 4.2: Impacts on threatened fauna and fauna habitat

<table>
<tr><th>Species</th><th>Potential occurrence</th><th>Impacted by proposal?</th><th>Impact</th></tr>
<tr><td>Emu population in the NSW North Coast Bioregion and Port Stephens LGA</td><td>Moderate - known to occur in the locality.</td><td>Yes (minor extent)</td><td rowspan="4">Loss of potential foraging habitat comprising 0.84 ha (including 0.27 ha of PCT 1235).
Direct impacts are unlikely given mitigation measures proposed and that the subject species are all highly mobile</td></tr>
<tr><td>Black-necked Stork</td><td>Moderate - potential foraging habitat associated with the site.</td><td>Yes (minor extent)</td></tr>
<tr><td>Brolga</td><td>Moderate - potential foraging habitat associated with the site.</td><td>Yes (minor extent)</td></tr>
<tr><td>Grey-headed Flying-fox</td><td>Moderate - potential foraging habitat associated with the site.</td><td>Yes (minor extent)</td></tr>
</table>

4.2.3 Removal of threatened flora

No threatened flora species or habitat for such species would be removed as part of the proposal.

4.2.4 Aquatic impacts

Short-term minor and localised impacts during the proposal may occur via the risk of sedimentation of waterways, in particular during piling works. Mitigation measures requiring erosion and sediment controls would limit this impact. Use of the barge within The South Arm River, may result in very minor impacts to aquatic fauna and aquatic flora. In particular some minor impacts to aquatic flora such as Common Reed (*Phragmites australis*), that occurs along the banks of the South Arm River may occur. Mitigation measures to reduce the potential risk of direct and indirect impacts to waterways from the proposal are included in **Section 5**. Additional aquatic impacts from pests or disease can be found below.

4.2.5 Injury and mortality

The proposal may result in a minor risk of fauna injury/ mortality through:

- Vegetation removal if the impacted vegetation is occupied at the time of clearing. This is mainly a risk to nesting or non-flying species.
- Vehicle strike during construction for a range of fauna species including Coastal Emus.
- Minor impacts to aquatic species (such as turtles and aquatic birds), from potentially being struck by a barge and other watercraft.

Mitigation measures to reduce the potential for fauna mortality or injury are provided within **Section 5**.

4.3 Indirect/operational impacts

4.3.1 Wildlife connectivity and habitat fragmentation

Given the small amount of clearing required and already fragmented nature of the subject site, the proposal would not:

- Result in any significant increase in the fragmentation of fauna and flora habitats within the study area and the works proposed would not result in any barriers to fauna dispersal (terrestrial or aquatic).
- Impact fauna dispersal across the Big River Way, the South Arm River, South Arm Road and the surrounds (terrestrial or aquatic).
- Increase roadkill.

Consequently, the proposal is unlikely to significantly affect the dispersal of any fauna groups and no permanent barriers to movement would occur.

4.3.2 Edge effects on adjacent native vegetation and habitat

The proposal would result in a minor increase in edge effects by way of vegetation removal and the resulting new fringe of exposed vegetation. Edge effects that may occur include potential for increased exposure of sensitive vegetation to wind and heat and weed infiltration.

However, considering that vegetation within the study area is currently subject to a range of edge effects from the existing cleared and modified corridor of Big River Way (the old Pacific Highway), any increases relating to the proposal would not be significant.

4.3.3 Invasion and spread of terrestrial and aquatic weeds

Environmental and agricultural weeds are common along the disturbed roadside environment of the Big River Way throughout the study area. Weeds of national significance occurring within the study area/ site and relevant duty are included below in **Table 4.3**.

No Aquatic weeds of national significance were observed within the study area.

Table 4.3: Priority weeds within the site and relevant duty

Common Name	Species	Duty
Fireweed	*Senecio madagascariensis*	Prohibition on certain dealings Must not be imported into the state, sold, bartered, exchanged or offered for sale.
Lantana	*Lantana camara*	Prohibition on certain dealings Must not be imported into the state, sold, bartered, exchanged or offered for sale.

The works are unlikely to result in the spread of weeds provided that relevant mitigation measures relating to machinery hygiene protocols are effectively implemented (refer to **Section 5**).

4.3.4 Invasion and spread of terrestrial and aquatic pests

While a variety of terrestrial pest species may occur in the locality include Black Rat (*Rattus rattus**), Feral Dog (*Canis lupus familiaris**), Feral Cat (*Felis catus**), Red Fox (*Vulpes vulpes**), European Rabbit (*Oryctolagus cuniculus**). The proposal would not result in any potential to increase conditions such that pest species would become more prevalent.

Potential aquatic pests occurring within the South Arm River include Common Carp (*Cyprinus carpio**), Eastern Gambusia (*Gambusia holbrooki**) and Banded Grunter (*Amniataba percoides*). The proposal would not result in any potential to increase conditions such that pest species would become more prevalent.

*Denotes exotic species

4.3.5 Invasion and spread of pathogens and disease

With the adoption of standard hygiene measures (refer to **Section 5**) for plant and associated equipment during construction, it is unlikely that pathogens or diseases (terrestrial and aquatic) would be introduced to the site.

4.3.6 Changes to hydrology

The works do not involve any substantial excavation or redirecting of the surface water flow to an extent that changes to hydrology would occur.

4.3.7 Noise, light and vibration

During the works, a temporary increase in noise and vibration in proximity to the site is expected in association with machinery operations. The majority of noise and vibration will be a result of the following:

- Driving/ vibrating for piling works
- Saw cutting existing pavement
- Jack hammering concrete
- Excavation/ profiling existing pavement
- Tree mulching

However, it would be expected that terrestrial and aquatic fauna species in close proximity to the existing road alignment are habituated to noise (and vibration to an extent) and that the proposal would not increase these impacts to a level that fauna breeding or behaviour would be significantly impacted. Additionally, the impacts from noise and vibration would only be localised and short-term (length of the construction). Once operational, there will not be an increase in these impacts above what is already experienced at the site.

No significant increase in light impacts would be expected, either during the proposed works or during future operation of the subject section of the Big River Way.

Mitigations for these impacts can be found in **Section5**.

4.3.8 Groundwater dependent ecosystems

Groundwater dependent ecosystem (GDE) mapping covering the locality indicates that the vegetation communities present are a low probability of being GDEs (Bureau of Meteorology 2021). Furthermore, changes to groundwater flows are unlikely to occur as a result of the proposed works.

4.4 Cumulative impacts

Cumulative impacts of road upgrade and maintenance projects along Big River Way at the locality and in the broader region would mostly relate to habitat loss and modification. However, as most individual projects generally impact on previously disturbed road reserve/adjacent areas, and that similar and better-quality habitat are relatively widespread in adjacent areas (such as conservation reserves), this project would be considered unlikely to cumulatively result in any significant impacts to local biodiversity.

4.5 Assessments of significance

The BC Act requires a test of significance (five-part test) when assessing whether an action, development or activity is likely to significantly affect threatened species or ecological communities, or their habitats. Based on the potential for occurrence at the site (refer to **Annexure B**), assessments of significance have been completed for several NSW listed threatened species and threatened ecological communities (refer to **Annexure C**).

The assessments concluded that the proposal would be unlikely to significantly increase the risk of extinction for any of the subject threatened flora and fauna species (refer to **Table 4.4**).

Table 4.4: Summary of BC Act significance assessments

BC Act significance assessments						
Threatened species or communities	*Significance assessment question*					*Likely significant impact?*
	a	*b*	*c*	*d*	*e*	
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions	N	N	N	N	N	No
Emu population in the NSW North Coast Bioregion and Port Stephens LGA	N	X	N	N	N	No

BC Act significance assessments						
Black-necked Stork	N	X	N	N	N	No
Brolga	N	X	N	N	N	No
Grey-headed Flying-fox	N	X	N	N	N	No

Notes: Y= Yes (negative impact), N= No (no or positive impact), X= not applicable, ?= unknown impact.

Based on the potential for occurrence at the site (refer to **Annexure B**), several threatened species listed under the EPBC Act may occur.

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of national environmental significance (MNES) require approval from the Australian Government Minister for the Environment (the Minister).

On 24 March 2020, the Australian Government entered into a new agreement (‘Amending Agreement No. 1’) with the New South Wales Government to amend the bilateral agreement signed in 2015 relating to environmental assessment. The Amending Agreement declares that an action does not require assessment under part 8 of the EPBC Act if it is listed in the declared classes of actions in Schedule 1 of the Amending Agreement. In accordance with declared class of action (ii), the proposal is assessed under Part 5.1 of the EP&A Act and includes an environmental impact statement where the assessment has been undertaken in accordance with the requirements of Item 3 of Schedule 1 of the Amending Agreement.

The proposal is characteristic of declared class action (ii) and hence does not require assessment under part 8 of the EPBC Act.

5. Mitigation

A range of mitigation measures are presented in **Table 5.1** and would be implemented prior to construction, during construction and during post construction phases of the proposal. These measures have been developed to mitigate the potential impacts of the proposal on protected flora and fauna and threatened species and communities that occur in the study area.

Table 5.1: Mitigation measures

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
Removal of native vegetation	Native vegetation removal will be minimised throughout the project.	Prior to construction and during construction	Effective	Loss or disturbance of potential foraging habitat comprising up to 0.84 ha (including0.27 ha of PCT 1235).
	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Prior to construction	Effective	
	Vegetation removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bush rock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	
	Native vegetation will be re-established in accordance with *Guide 3: Re-establishment of native vegetation* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	Post construction	Effective	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened ecological communities, not assessed in the biodiversity assessment, are identified in the proposal site.	During construction	Proven	
Removal of threatened species habitat and habitat features	Habitat removal will be minimised throughout the project.	Prior to construction and during construction	Effective	Loss or disturbance of potential foraging habitat comprising up to 0.84 ha (including0.27 ha of PCT 1235).
	Habitat removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bush rock of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
	Habitat will be replaced or re-instated (where required) in accordance with *Guide 5: Re-use of woody debris and bush rock* and *Guide 8: Nest boxes* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Proven	
Removal of threatened plants	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Proven	Loss or disturbance of potential foraging habitat comprising up to 0.84 ha (including0.27 ha of PCT 1235).
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened flora species, not assessed in the biodiversity assessment, are identified in the proposal site.	During construction	Proven	
Aquatic impacts	Aquatic habitat will be protected in accordance with *Guide 10: Aquatic habitats and riparian zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) and Section 3.3.2 *Standard precautions and mitigation measures* of the *Policy and guidelines for fish habitat conservation and management Update 2013* (DPI (Fisheries NSW) 2013).	During construction	Effective	Potential sedimentation impacts from work. Potential short-term, minor disturbance to aquatic fauna. Minor disturbance, <0.01 ha to aquatic flora.
Groundwater dependent ecosystems	Interruptions to water flows associated with groundwater dependent ecosystems will be minimised.	Prior to construction and during construction	Effective	None
Changes to hydrology	Changes to existing surface water flows will be minimised.	Prior to construction and during construction	Effective	None

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
Edge effects on adjacent native vegetation and habitat	Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	None
Injury and mortality of fauna	Fauna will be managed in accordance with *Guide 9: Fauna handling* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	None
	Pre-clearing surveys will be undertaken in accordance with Guide 1: Pre-clearing process of the Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects (RTA 2011).	During construction	Effective	None
Invasion and spread of weeds	Weed species will be managed in accordance with *Guide 6: Weed management* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	None
Invasion and spread of pests	If vegetation is to be mulched, pest species will be managed within the proposal site in accordance with the TfNSW Technical Procedure: Mulch Management	During construction	Effective	None
Invasion and spread of pathogens and disease	Pathogens will be managed in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).	During construction	Effective	None
Noise, light and vibration	Shading and artificial light impacts will be minimised.	Prior to construction and during construction	Effective	Minor short-term localised impacts to fauna (terrestrial and aquatic).

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
Tree loss	Tree and hollows that require replacement will be identified in accordance with the Tree and Hollow replacement guideline, Transport Biodiversity Policy 2022. Where trees and hollows will be replaced within the project boundary, prepare a Tree and Hollow Replacement Plan to address the impacts described in Table 6-2 prior to the commencement of works. Alternatively, where tree and hollow replacement cannot be accommodated locally or can only be partially accommodated, payment must be made to the TfNSW Conservation Fund prior to the commencement of works in accordance with the Tree and Hollow Replacement Guideline. [additional safeguard].	Prior to construction	Effective	None

6. Offset strategy

6.1 Quantification of impacts

Transport for NSW is committed to offsetting impacts associated with the proposal in line with its biodiversity offsetting guidelines (TfNSW, 2016) and in general accordance with the BCD principles for the use of biodiversity offsets in NSW.

Transport for NSW will provide biodiversity offsets or, where offsets are not reasonable or feasible, supplementary measures for impacts that exceed the following thresholds (refer to **Table 6.1**).

Table 6.1: Summary of TfNSW Biodiversity Offset Guidelines

Description of activity or impact	Consider offsets or supplementary measures
Activities in accordance with TfNSW Environmental assessment procedure: Routine and Minor Works (RTA 2011)	No
Works on cleared land, plantations, exotic vegetation where there are no threatened species or habitat present	No
Works involving clearing of vegetation planted as part of a road corridor landscaping program (this includes where threatened species or species comprising listed ecological communities have been used for landscaping purposes)	No – vegetation has not been planted as part of a road corridor landscaping program. Consideration of offsets not required.
Works involving clearing of national or NSW listed critically endangered ecological communities (CEEC)	No
Works involving clearing of nationally listed threatened ecological community (TEC) or nationally listed threatened species habitat	Where clearing >one hectare of a TEC or habitat in moderate to good condition No, total area of TEC *Swamp Oak Floodplain Forest of the NEW South Wales North Coast, Sydney and South East Corner Bioregions* is 0.27 ha. Additionally, this total area would not require clearing.
Works involving clearing of NSW endanger ed or vulnerable ecological community	Where clearing >five hectares or where the ecological community is subject to an SIS No

Description of activity or impact	Consider offsets or supplementary measures
Works involving clearing of NSW listed threatened species habitat where the species is a species credit species as defined in the Threatened Biodiversity Data Collection (TBDC)	Where clearing >one hectare or where the species is the subject of an SIS No
Works involving clearing of NSW listed threatened species habitat and the species is an ecosystem credit species as defined in the Threatened Biodiversity Data Collection (TBDC)	Where clearing >five hectares or where the species is the subject of an SIS No
Type 1 or Type 2 key fish habitats (as defined by NSW Fisheries)	Where there is any net loss of habitat No

Based on the above the works do not trigger the TfNSW offset guidelines.

6.2 Biodiversity Offset Strategy/Tree and Hollow Replacement Plan

This Biodiversity Policy requires that TfNSW replace trees and hollows removed as a consequence of activities unless excluded.

Where tree removal cannot be avoided, the number of native and amenity trees and individual hollows to be removed must be counted and used to calculate the number of replacement trees and hollows (refer to **Table 6.2** below). The site features no amenity trees; therefore, they have been disregarded for the required tree replacement calculation.

The results of this calculation are to be included as a safeguard in the Review of Environment Factors (REF) or similar prepared for the project or a commitment made in the REF to calculate the requirement in accordance with this Plan.

This tree replacement is only calculated for the definite slip works as part of the proposal, where known tree removal within the footprint is required (refer to **Illustration 3.1**). If additional tree removal is required, additions to tree replacement calculations will need to be undertaken.

Table 6.2: Summary of tree and hollow replacement

Category	Number impacted	Replacement required	Number to be replaced
			Native Trees
Very Large Tree (DBH greater than 100 cm)	0	Plant minimum 16 trees	0
Large tree (DBH greater than 50cm, but less than100cm)	0	Plant minimum 8 trees	0
Medium tree (DBH greater than 20 cm, but less than 50cm)	12	Plant minimum 4 trees	48
Small tree (DBH greater than 5cm, but less than 20cm)	11	Plant minimum 2 trees	22
Hollows	No Hollow-bearing trees occur at the site	Provide 3 artificial hollows for every occupied hollow removed	N/A

7. Conclusion

Based on the site assessment and consideration of the work required, the following biodiversity matters apply to the proposal:

- The study area comprises mostly disturbed land lacking native vegetation because of historical agricultural pursuits and the construction of Big River Way. Pockets of native vegetation subject to weed incursions are associated with the study area, mainly as riparian vegetation occurring alongside the South Arm River.
- The proposal would result in disturbance of approximately 0.84 ha of vegetation (including 0.27 ha of PCT 1235). No hollow-bearing trees would be removed.
- The TEC '*Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions* occurs at the site. The proposal would result in the disturbance and/ or removal of approximately 0.27 ha of this TEC.
- No threatened flora species were detected at the site and habitat for such species is poor.
- No threatened fauna species were detected at the site.
- Short-term and localized minor impacts aquatic impacts due to sedimentation and erosion, minor disturbance to aquatic flora and fauna.
- There is potential for several threatened fauna species to occur based on available site habitats.
- A number of mitigation measures have been recommended to manage potential impacts relating to biodiversity.
- It was determined that the proposal is unlikely to significantly affect any species, communities or their habitat listed under the BC Act of the EPBC Act. Therefore, a Species Impact Statement is not required, nor is the proposal subject to the EPBC Act Strategic Assessment.
- The works do not trigger the TfNSW offset guidelines.

8. References

Australian Government. Department of the Environment (2013). *Matters of National Environmental Significance: Significant impact guidelines 1.1. Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth of Australia, Canberra.

Bureau of Meteorology (BOM) (2021). *Daily rainfall Point Lookout*, [Online]. Available: ***http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=057124***. BOM [30 September 2021].

Department of Agriculture, Water and the Environment (2018). *Conservation advice (incorporating listing advice) for the Coastal Swamp Oak* (Casuarina glauca) *Forest of New South Wales and South East Queensland ecological community*. Canberra: Department of the Environment and Energy.

Department of Environment and Climate Change (2007). *Threatened species assessment guidelines, The assessment of significance*. NSW Department of Environment and Climate Change.

Environment, Energy and Science (2021) Threatened Species Profiles [Accessed September 2021] ***https://www.environment.nsw.gov.au/threatenedspeciesapp/***

NSW Roads and Maritime Services (2017*). Woolgoolga to Ballina Pacific Highway Upgrade, Coastal Emu Management Plan*. NSW Government.

Annexure A
Database search results

Data from the BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°C; ^^ rounded to 0.01°C. Copyright the State of NSW through the Department of Planning, Industry and Environment. Search criteria : Public Report of all Valid Records of Threatened (listed on BC Act 2016) or Commonwealth listed Animals in selected area [North: -29.49 West: 153.13 East: 153.23 South: -29.59] returned a total of 648 records of 30 species.
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Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Animalia	Amphibia	Myobatrachidae	3137	*Crinia tinnula*		Wallum Froglet	V,P		2	
Animalia	Aves	Casuariidae	0001	*Dromaius novaehollandiae*		Emu population in the New South Wales North Coast Bioregion and Port Stephens local government area	E2,P		442	
Animalia	Aves	Apodidae	0334	*Hirundapus caudacutus*		White-throated Needletail	P	V,C,J,K	1	
Animalia	Aves	Ciconiidae	0183	*Ephippiorhynchus asiaticus*		Black-necked Stork	E1,P		43	
Animalia	Aves	Accipitridae	0226	*Haliaeetus leucogaster*		White-bellied Sea-Eagle	V,P		5	
Animalia	Aves	Accipitridae	0225	*Hieraaetus morphnoides*		Little Eagle	V,P		1	
Animalia	Aves	Accipitridae	0230	^^*Lophoictinia isura*		Square-tailed Kite	V,P,3		2	
Animalia	Aves	Accipitridae	8739	^^*Pandion cristatus*		Eastern Osprey	V,P,3		5	
Animalia	Aves	Gruidae	0177	*Grus rubicunda*		Brolga	V,P		20	
Animalia	Aves	Jacanidae	0171	*Irediparra gallinacea*		Comb-crested Jacana	V,P		1	
Animalia	Aves	Psittacidae	0260	*Glossopsitta pusilla*		Little Lorikeet	V,P		2	
Animalia	Aves	Strigidae	0248	^^*Ninox strenua*		Powerful Owl	V,P,3		4	
Animalia	Aves	Tytonidae	0252	^^*Tyto longimembris*		Eastern Grass Owl	V,P,3		1	
Animalia	Aves	Tytonidae	0250	^^*Tyto novaehollandiae*		Masked Owl	V,P,3		2	
Animalia	Aves	Pomatostomidae	8388	*Pomatostomus temporalis temporalis*		Grey-crowned Babbler (eastern subspecies)	V,P		11	
Animalia	Aves	Neosittidae	0549	*Daphoenositta chrysoptera*		Varied Sittella	V,P		2	
Animalia	Mammalia	Dasyuridae	1008	*Dasyurus maculatus*		Spotted-tailed Quoll	V,P	E	3	
Animalia	Mammalia	Dasyuridae	1017	*Phascogale tapoatafa*		Brush-tailed Phascogale	V,P		16	
Animalia	Mammalia	Phascolarctidae	1162	*Phascolarctos cinereus*		Koala	V,P	V	3	
Animalia	Mammalia	Petauridae	1136	*Petaurus australis*		Yellow-bellied Glider	V,P		1	
Animalia	Mammalia	Petauridae	1137	*Petaurus norfolcensis*		Squirrel Glider	V,P		6	
Animalia	Mammalia	Pseudocheiridae	1133	*Petauroides volans*		Greater Glider	P	V	5	
Animalia	Mammalia	Potoroidae	1187	*Aepyprymnus rufescens*		Rufous Bettong	V,P		17	
Animalia	Mammalia	Pteropodidae	1280	*Pteropus poliocephalus*		Grey-headed Flying-fox	V,P	V	23	
Animalia	Mammalia	Molossidae	1329	*Micronomus norfolkensis*		Eastern Coastal Free-tailed Bat	V,P		2	
Animalia	Mammalia	Vespertilionidae	1354	*Chalinolobus nigrogriseus*		Hoary Wattled Bat	V,P		2	

Animalia	Mammalia	Vespertilionidae	1357	*Myotis macropus*	Southern Myotis	V,P	6
Animalia	Mammalia	Vespertilionidae	1025	*Vespadelus troughtoni*	Eastern Cave Bat	V,P	2
Animalia	Mammalia	Miniopteridae	1346	*Miniopterus australis*	Little Bent-winged Bat	V,P	17
Animalia	Mammalia	Miniopteridae	3330	*Miniopterus orianae oceanensis*	Large Bent-winged Bat	V,P	1

Data from the BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°C; ^^ rounded to 0.01°C. Copyright the State of NSW through the Department of Planning, Industry and Environment. Search criteria : Public Report of all Valid Records of Threatened (listed on BC Act 2016) or Commonwealth listed Plants in selected area [North: -29.49 West: 153.13 East: 153.23 South: -29.59] returned a total of 295 records of 5 species.
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Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Plantae	Flora	Juncaginaceae	3363	*Maundia triglochinoides*			V		9	
Plantae	Flora	Myrtaceae	8724	*Angophora robur*		Sandstone Rough-barked Apple	V	V	281	
Plantae	Flora	Myrtaceae	4283	*Rhodamnia rubescens*		Scrub Turpentine	E4A		3	
Plantae	Flora	Myrtaceae	4284	*Rhodomyrtus psidioides*		Native Guava	E4A		1	
Plantae	Flora	Orchidaceae	4480	^*Phaius australis*		Southern Swamp Orchid	E1,P,2	E	1	

Data from the BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°C; ^^ rounded to 0.01°C. Copyright the State of NSW through the Department of Planning, Industry and Environment. Search criteria : Public Report of all Valid Records of Threatened (listed on BC Act 2016) or Commonwealth listed Communities in selected area [North: -29.49 West: 153.13 East: 153.23 South: -29.59] returned 0 records for 11 entities.
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Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Community				*Coastal Cypress Pine Forest in the New South Wales North Coast Bioregion*		Coastal Cypress Pine Forest in the New South Wales North Coast Bioregion	E3		K	
Community				*Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*		Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E3	V	K	
Community				*Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*		Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E3		K	
Community				*Grey Box—Grey Gum Wet Sclerophyll Forest in the NSW North Coast Bioregion*		Grey Box—Grey Gum Wet Sclerophyll Forest in the NSW North Coast Bioregion	E3		K	
Community				*Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*		Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E3	CE	K	
Community				*Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions*		Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions	E3	CE	K	
Community				*Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion*		Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion	E3	CE	K	
Community				*Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion*		Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion	E3		K	

Community	*Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E3	E	K
Community	*Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	Swamp Sclerophyll Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E3		K
Community	*Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions*	Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions	E3		K

Australian Government
Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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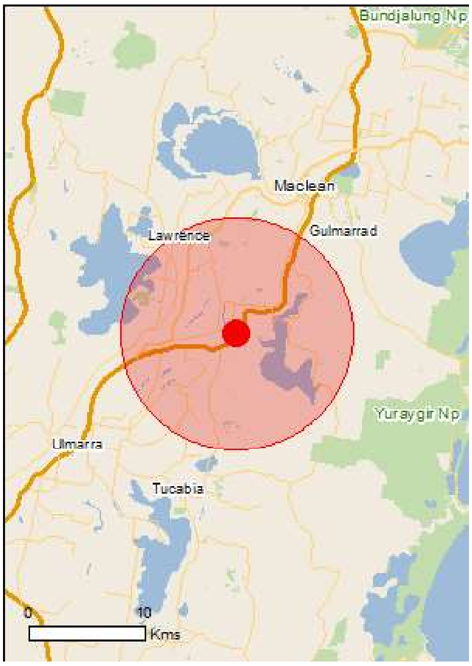

This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2015

Coordinates
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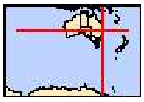

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	72
Listed Migratory Species:	40

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	45
Whales and Other Cetaceans:	1
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	1
Invasive Species:	40
Nationally Important Wetlands:	3
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities		[Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community likely to occur within area

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat likely to occur within area
Thinornis cucullatus cucullatus Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat may occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Nannoperca oxleyana Oxleyan Pygmy Perch [64468]	Endangered	Species or species habitat may occur within area
Frogs		
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat may occur within area
Litoria olongburensis Wallum Sedge Frog [1821]	Vulnerable	Species or species habitat may occur within area
Mixophyes iteratus Giant Barred Frog, Southern Barred Frog [1944]	Endangered	Species or species habitat may occur within area
Insects		
Argynnis hyperbius inconstans Australian Fritillary [88056]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Petrogale penicillata Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Plants		
Acronychia littoralis Scented Acronychia [8582]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Angophora robur Sandstone Rough-barked Apple [56088]	Vulnerable	Species or species habitat known to occur within area
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat likely to occur within area
Cryptocarya foetida Stinking Cryptocarya, Stinking Laurel [11976]	Vulnerable	Species or species habitat may occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat likely to occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat may occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat may occur within area
Eucalyptus glaucina Slaty Red Gum [5670]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus tetrapleura Square-fruited Ironbark [7490]	Vulnerable	Species or species habitat known to occur within area
Grevillea quadricauda [64651]	Vulnerable	Species or species habitat known to occur within area
Hibbertia marginata [21970]	Vulnerable	Species or species habitat likely to occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat may occur within area
Macadamia tetraphylla Rough-shelled Bush Nut, Macadamia Nut, Rough-shelled Macadamia, Rough-leaved Queensland Nut [6581]	Vulnerable	Species or species habitat likely to occur within area
Marsdenia longiloba Clear Milkvine [2794]	Vulnerable	Species or species habitat known to occur within area
Olax angulata Minnie Waters Olax [10666]	Vulnerable	Species or species habitat may occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat known to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat likely to occur within area
Rhodamnia rubescens Scrub Turpentine, Brown Malletwood [15763]	Critically Endangered	Species or species habitat likely to occur within area
Rhodomyrtus psidioides Native Guava [19162]	Critically Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Samadera sp. Moonee Creek (J.King s.n. Nov. 1949) [86885]	Endangered	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Tylophora woollsii [20503]	Endangered	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Coeranoscincus reticulatus Three-toed Snake-tooth Skink [59628]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat likely to occur within area
Migratory Marine Species		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Telecommunications Corporation
Commonwealth Land - Commonwealth Trading Bank of Australia

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Breeding likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross [64466]	Vulnerable*	Species or species habitat may occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat likely to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Everlasting Swamp	NSW
Everlasting Swamp	NSW
Munro Island	NSW
UNE Special Management Zone No1	NSW
Woodford Island	NSW

Regional Forest Agreements	[Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw		Species or species

Name	Status	Type of Presence
Creeper, Funnel Creeper [85119]		habitat likely to occur within area
Eichhornia crassipes		
Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Lantana camara		
Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp.		
Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis		
Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Clarence River Estuary	NSW
Everlasting Swamp	NSW
Upper Coldstream	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-29.55718 153.1502

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Annexure B
Habitat assessment table

Table B1 Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	The species was observed in the study area during the current survey
High	It is highly likely that a species inhabits the study area and is dependent on identified suitable habitat (i.e. for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality (10 km) and is known or likely to maintain resident populations in the study area. Also includes species known or likely to visit the study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the study area. Species unlikely to maintain sedentary populations; however, may seasonally use resources within the study area opportunistically or during migration. The species is unlikely to be dependent (i.e.. for breeding or important life cycle periods such as winter flowering resources) on habitat within the study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the study area and has not been recorded recently in the locality (10 km). It may be an occasional visitor, but habitat similar to the study area is widely distributed in the local area, meaning that the species is not dependent (i.e.. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the study area or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the study area. Based on a field assessment of the habitat constraints or microhabitats on the study area , the habitat is identified as being substantially degraded such that the species is unlikely to utilise the study area (or specific vegetation zones), or an expert report that is prepared that states the species is unlikely to be present on the study area or specific vegetation zones.

Table B2 Habitat assessment – threatened flora

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Acronychia littoralis	Scented Acronychia	E	E	Littoral rainforest on sand.	Nil (PMST)	Low; not recorded in site survey.
Angophora robur	Sandstone Rough-barked Apple	-	V	Dry open forest in sandy or skeletal soils on sandstone, or occasionally granite, with frequent outcrops of rock.	281 (BioNet)	Low; not recorded in site survey.
Arthraxon hispidus	Hairy Jointgrass	-	V	Moist shady places in or on the edges of rainforest and wet eucalypt forest, often near creeks or swamps.	Nil (PMST)	Low; not recorded in site survey.
Cryptocarya foetida	Stinking Cryptocary a	V	V	Littoral rainforest in sandy soils, mature trees known on basalt soils.	Nil (PMST)	Low; not recorded in site survey.
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	Does not have well defined habitat and is known from a range of communities, including swamp-heath and woodland.	Nil (PMST)	Low; not recorded in site survey.
Cynanchum elegans	White-flowered Wax Plant	-	E	Dry, littoral or subtropical rainforest, and occasionally in scrub or woodland.	Nil (PMST)	Low; not recorded in site survey.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Dichanthium setosum	Bluegrass	-	V	In NSW, occurs on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture.	Nil (PMST)	Low; not recorded in site survey.
Eucalyptus glaucina	Slaty Red Gum	-	V	Found only on the north coast of NSW and in separate districts: near Casino where it can be locally common, and farther south, from Taree to Broke, west of Maitland. Grows in grassy woodland and dry eucalypt forest. Grows on deep, moderately fertile and well-watered soils.	Nil (PMST)	Low; not recorded in site survey.
Eucalyptus tetrapleura	Square-fruited Ironbark	V	V	Dry or moist eucalypt forest on moderately fertile soil, often in low areas with poor drainage.	Nil (PMST)	Low; not recorded in site survey.
Grevillea quadricauda	Four-tailed Grevillea	V	V	Gravelly loam in understorey of dry eucalypt forest near creeks.	Nil (PMST)	Low; not recorded in site survey.
Hibbertia hexandra	Tree Guinea Flower	E	-	Heath, open forest or rainforest.	Nil (PMST)	Low; not recorded in site survey.
Macadamia tetraphylla	Rough-shelled Bush Nut	-	V	Subtropical rainforest usually near the coast.	Nil (PMST)	Low; not recorded in site survey.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Marsdenia longiloba	Slender Milkvine	-	V	Subtropical and warm temperate rainforest, lowland moist eucalypt forest adjoining rainforest and, sometimes, in areas with rock outcrops.	Nil (PMST)	Low; not recorded in site survey.
Maundia triglochinoides	-	V	-	Swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients.	9 (BioNet)	Low; not recorded in site survey.
Olax angulata	Square-stemmed Olax	V	V	Low-lying coastal heaths and heathy woodlands on sandy soils near swamps, often in association with Wallum Banksia (Banksia aemula).	Nil (PMST)	Low; not recorded in site survey.
Persicaria elatior	Tall Knot-weed	-	V	Damp or swampy situations and sometimes with Melaleuca linariifolia.	Nil (PMST)	Low; not recorded in site survey.
Phaius australis	Southern Swamp Orchid	-	E	Swampy grassland or swampy forest including rainforest, eucalypt or paperbark forest mostly in coastal areas.	1 (BioNet)	Low; not recorded in site survey.
Rhodamnia rubescens	Scrub Turpentine	CE	-	Subtropical rainforests, warm temperate rainforests, littoral rainforests, and wet sclerophyll forests. It may also occur as a pioneer in adjacent areas of dry sclerophyll and grassy woodland associations.	3 (BioNet)	Low; not recorded in site survey.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Rhodomyrtus psidioides	Native Guava	E	-	Rainforest and its margins with sclerophyll vegetation, often near creeks and drainage lines. Pioneer species in disturbed environments such as regrowth and rainforest margins.	1 (BioNet)	Low; not recorded in site survey.
Samadera sp. Moonee Creek (J.King s.n. 1949)(formerly Quassia sp. Mooney Creek)	Moonee Quassia	E	E	Shrubby layer below tall moist and dry eucalypt forest, including forest edges, generally at low altitudes.	Nil (PMST)	Low; not recorded in site survey.
Thesium australe	Austral Toadflax	-	V	Grassland or grassy eucalypt woodland where Themeda australis is predominant, on grassy headlands.	Nil (PMST)	Low; not recorded in site survey.
Tylophora woollsii		-	E	Moist eucalypt forest, moist sites in dry eucalypt forest and rainforest margins.	Nil (PMST)	Low; not recorded in site survey.

Table B3 Habitat assessment – threatened fauna

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Amphibians						
Crinia tinnula	Wallum Froglet	V	-	Acid paperbark and sedge swamps known as 'wallum', this is a banksia-dominated lowland heath ecosystem characterised by acidic waterbodies.	2 (BioNet)	None – Suitable habitat is absent from study area.
Litoria aurea	Green and Golden Bell Frog	E	V	Amongst vegetation in and around permanent swamps, lagoons, farm dams and on flood-prone river flats, particularly where there are bullrushes or spikerushes.	Nil (PMST)	None – Suitable habitat is absent from study area.
Litoria olongburensis	Olongburra Frog	V	V	Paperbark swamps and sedge swamps of the coastal 'wallum' country amongst sedges and rushes.	Nil (PMST)	None – Suitable habitat is absent from study area.
Mixophyes iteratus	Giant Barred Frog	E	E	Deep, damp leaf litter in rainforests, moist eucalypt forest and near dry eucalypt forest.	Nil (PMST)	None – Suitable habitat is absent from study area.
Avifauna						
Anthochaera phrygia	Regent Honeyeate r	CE	CE	Dry open forest and woodland with an abundance of nectar-producing eucalypts, particularly box-ironbark woodland, swamp mahogany forests, and riverine sheoak woodlands.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Botaurus poiciloptilus	Australasian Bittern	E	E	Permanent freshwater wetlands with tall dense vegetation, particularly bullrushes and spikerushes.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Calidris ferruginea	Curlew Sandpiper	E	CE	Tidal mudflats, sandy ocean shores and occasionally inland freshwater or salt-lakes.	Nil (PMST)	None – Suitable habitat is absent from the study area.
Daphoenositta chrysoptera	Varied Sittella	V	-	Inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland.	2 (BioNet)	Low – marginal foraging habitat occurs at the site.
Dromaius novaehollandiae	Emu population in the NSW North Coast Bioregion and Port Stephens LGA	E	-	Open forest, woodland, coastal heath, coastal dunes, wetland areas, tea tree plantations and open farmland, and occasionally in littoral rainforest.	442 (BioNet)	Moderate – Know to occur in locality.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	Swamps, mangroves, mudflats, dry floodplains.	43 (BioNet)	Moderate – Local records adjacent study area.
Erythrotriorchis radiatus	Red Goshawk	CE	V	Open woodland and forest, preferring a mosaic of vegetation types, a large population of birds as a source of food, and permanent water. Typically found in riparian habitats along or near watercourses or wetlands. In NSW, preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and riparian Eucalyptus forest of coastal rivers. Population in NSW is naturally small (probably only one pair), and lies at extreme of the natural range of the species in Australia.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Falco hypoleucos	Grey Falcon	E	V	The Grey Falcon is sparsely distributed in NSW, chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Glossopsitta pusilla	Little Lorikeet	V	-	Forages in open Eucalyptus forest and woodland; also feeds on Angophora, Melaleuca and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity.	2 (BioNet)	Low –Marginal foraging habitat occurs at the site.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Grantiella picta	Painted Honeyeater	V	V	Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. Specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus Amyema.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Grus rubicunda	Brolga	V	-	Shallow swamps, floodplains, grasslands and pastoral lands, usually in pairs or parties.	20 (BioNet)	Moderate – Local records adjacent study area.
Haliaeetus leucogaster	White-bellied Sea-eagle	V	-	Coastal habitats and around terrestrial wetlands characterised by the presence of large areas of open water (larger rivers, swamps, lakes, ocean). Habitats may include freshwater swamps, lakes, reservoirs, billabongs, saltmarsh and sewage ponds in addition to bays and inlets, beaches, reefs, lagoons, estuaries and mangroves.	5 (BioNet)	Low – could fly over site but unlikely to utilise the site.
Hieraaetus morphnoides	Little Eagle	V	-	Open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used.	1 (BioNet)	Low – could fly over site but unlikely to utilise the site.
Hirundapus caudacutus	White-throated Needletail	-	V	Most often recorded aerial foraging above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy. Breeding does not occur in Australia.	1 (BioNet)	Low – could fly over site but unlikely to utilise the site.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Irediparra gallinacea	Comb-crested Jacana	V	-	Among vegetation floating on slow-moving rivers and permanent lagoons, swamps, lakes and dams.	1 (BioNet)	None – Suitable habitat is absent from the study area.
Lathamus discolor	Swift Parrot	E	CE	On mainland Australia foraging occurs where eucalypts are flowering profusely or where abundant lerp infestations occur. Favoured feed trees include winter flowering species such as Swamp Mahogany Eucalyptus robusta, Spotted Gum Corymbia maculata, Red Bloodwood C. gummifera, Forest Red Gum E. tereticornis, Mugga Ironbark E. sideroxylon, and White Box E. albens. Commonly used lerp infested trees include Inland Grey Box E. microcarpa, Grey Box E. moluccana, Blackbutt E. pilularis and Yellow Box E. melliodora.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Lophoictinia isura	Square-tailed Kite	V	-	Dry woodland and open forest, particularly along major rivers and belts of trees in urban or semi-urban areas. Home ranges can extend over at least 100 km2.	2 (BioNet)	Low – could fly over site but unlikely to utilise the site.
Ninox strenua	Powerful Owl	V	-	Woodland and open forest to tall moist forest and rainforest. Requires large tracts of forest or woodland habitat but may also occur in fragmented landscapes.	4 (BioNet)	Low – marginal foraging habitat occurs at the site.
Numenius madagascariensis	Eastern Curlew	-	CE	Estuaries, bays, harbours, inlets and coastal lagoons, intertidal mudflats and sometimes saltmarsh of sheltered coasts.	Nil (PMST)	None – Suitable habitat is absent from the study area.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Pandion cristatus	Eastern Osprey	V	-	Littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. Typically occur in coastal areas but occasionally travel inland along major rivers. Wetland habitats include inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes.	5 (BioNet)	Low – could fly over site but unlikely to utilise the site.
Pomatostomus temporalis	Grey-crowned Babbler	V	-	Open woodlands dominated by mature eucalypts, with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs.	11 (BioNet)	Low – marginal foraging habitat occurs at the site.
Rostratula australis	Australian Painted Snipe	E	E	Well-vegetated shallows and margins of wetlands, dams, sewage ponds, wet pastures, marshy areas, irrigation systems, lignum, tea-tree scrub, and open timber.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Sternula nereis	Australian Fairy Tern	-	V	Nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. Feeds in Coastal waters.	Nil (PMST)	None – Suitable habitat is absent from the study area.
Thinornis cucullatus	Eastern Hooded Dotterel	CE	V	Open flat sandy beaches and sand dunes. Occasionally tidal bays and estuaries, rock platforms and rocky or sand-covered reefs	Nil (PMST)	None – Suitable habitat is absent from the study area.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Turnix melanogaster	Black-breasted Button-quail	CE	V	Drier rainforests and vine scrubs, often in association with Hoop Pine and a deep moist leaf litter layer. During drought it may move to adjacent wetter rainforests.	Nil (PMST)	None – Suitable habitat is absent from the study area.
Tyto longimembris	Eastern Grass Owl	V	-	Areas of tall grass, including tussocks in swampy areas, grassy plains, swampy heath, cane grass, sedges on flood plains.	1 (BioNet)	None – Suitable habitat is absent from the study area.
Tyto novaehollandiae	Masked Owl	V	-	Dry eucalypt forest and woodlands.	2 (BioNet)	Low – marginal foraging habitat occurs at the site.
Insecta						
Argynnis hyperbius	Australian Fritillary	E	CE	Open swampy coastal habitat where the caterpillar's food plant, Arrowhead Violet (Viola betonicifolia) occurs.	Nil (PMST)	None – Suitable habitat is absent from the study area.
Mammals						
Aepyprymnus rufescens	Rufous Bettong	V	-	Tall moist eucalypt forest to open woodland with tussock grass understorey.	17 (BioNet)	Low – marginal foraging habitat occurs at the site.
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Near cave entrances and crevices in cliffs.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Chalinolobus nigrogriseus	Hoary Wattled Bat	V	-	Dry open eucalypt forest dominated by spotted gum, boxes and ironbarks. Also healthy coastal forests where Red Bloodwood and Scribbly Gum are common. Naturally sparse understorey is favourable.	2 (BioNet)	Low – marginal foraging habitat occurs at the site.
Dasyurus maculatus	Spotted-tailed Quoll	V	E	Dry and moist eucalypt forests and rainforests, fallen hollow logs, large rocky outcrops.	3 (BioNet)	Low – marginal foraging habitat occurs at the site.
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V	-	Occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosts in tree hollows.	2 (BioNet)	Low – marginal foraging habitat occurs at the site.
Miniopterus australis	Little Bent-winged Bat	V	-	Moist eucalypt forest, rainforest and dense coastal scrub.	17 (BioNet)	Low – marginal foraging habitat occurs at the site.
Miniopterus orianae oceanensis	Large Bent-winged Bat	V	-	Forest or woodland, roost in caves, old mines and stormwater channels.	1 (BioNet)	Low – marginal foraging habitat occurs at the site.
Myotis macropus	Southern Myotis	V	-	Bodies of water, rainforest streams, large lakes, reservoirs.	6 (BioNet)	Low – marginal foraging habitat occurs at the site.
Petauroides volans	Greater Glider	-	V	Ranges and coastal plains of eastern Australia, where it inhabits a variety of eucalypt forests and woodlands.	5 (BioNet)	None – Suitable habitat is absent from the study area.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Petaurus australis	Yellow-bellied Glider	V	-	Tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Dens in tree hollows of large trees, often in family groups. Forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south.	1 (BioNet)	None – Suitable habitat is absent from the study area.
Petaurus norfolcensis	Squirrel Glider	V	-	Blackbutt, bloodwood and ironbark eucalypt forest with heath understorey in coastal areas, and box-ironbark woodlands and River Red Gum forest inland.	6 (BioNet)	Low – marginal foraging habitat occurs at the site.
Petrogale penicillata	Brush-tailed Rock Wallaby	E	V	North-facing cliffs and dry eucalypt forest and woodland, inhabiting rock crevices, caves, overhangs during the day, and foraging in grassy areas nearby at night.	Nil (PMST)	None – Suitable habitat is absent from the study area.
Phascogale tapoatafa	Brush-tailed Phascogale	V	-	Drier forests and woodlands with hollow-bearing trees and sparse ground cover.	16 (BioNet)	None – Suitable habitat is absent from the study area.
Phascolarctos cinereus	Koala	V	V	Appropriate food trees in forests and woodlands, and treed urban areas.	3 (BioNet)	Low – marginal foraging habitat occurs at the site.

Scientific name	Common name	BC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence
Potorous tridactylus	Long-nosed Potoroo	V	V	Cool temperate rainforest, moist and dry forests, and wet heathland, inhabiting dense layers of grass, ferns, vines and shrubs.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Pseudomys novaehollandiae	New Holland Mouse	-	V	Occurs in open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes.	Nil (PMST)	None – Suitable habitat is absent from the study area.
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops.	23 (BioNet)	Moderate – Potential foraging habitat associated with the site.
Vespadelus troughtoni	Eastern Cave Bat	V	-	Cave roosting species found in dry open forest and woodland near cliffs and rocky overhangs.	2 (BioNet)	Low – marginal foraging habitat occurs at the site.
Xeromys myoides	False Water-rat	-	V	Primarily in habitats mangrove forests but has been recorded in a variety of well-watered habitats including, freshwater lagoons, sedged lakes close to foredunes, and swamps.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.
Reptiles						
Coeranoscincus reticulatus	Three-toed Snake-tooth Skink	V	E	Rainforest and occasionally moist eucalypt forest, on loamy or sandy soils.	Nil (PMST)	Low – marginal foraging habitat occurs at the site.

Annexure C
Tests of Significance

BC Act five-part tests for TECs

TEC

Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions.

The study area habitat values and extent of local population per species/species group are detailed below. To minimise repetition, the responses to the five-part tests are structured as follows:

Part (a), (c), (d) and (e) are answered per species or as a collective group of species depending on the nature of impacts.

Part (b) deals specifically with threatened ecological communities.

in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

a) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Considering that equivalent or better quality areas of Swamp Oak floodplain forest TEC are present in the broader locality that will not be affected by the proposal, and that the proposal is unlikely to result in significant fragmentation or isolation of habitat of the TEC, it would be highly unlikely that an adverse effect of the TEC that it is likely to be placed at risk of extinction.

b) in relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

TEC: The potential for direct loss or disturbance of up to 0.27 ha of Swamp Oak floodplain forest TEC would not affect the life cycle of the species which makes up the ecological community or simplify floristic composition or vegetation structure, as areas of similar ecological value in the surrounding area would not be affected. As such, it is unlikely that the composition of the ecological community would be substantially or adversely modified such that its local occurrence is likely to be placed at risk of extinction.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

TEC: The Proposal would result in a minor increase in clearing alongside the South Arm River within an already fragmented landscape. In addition, the Proposal would not affect the potential for cross-pollination to occur between individuals which make up the ecological community or simplify floristic composition or vegetation structure, as areas of similar ecological value at the site would not be affected. Considering the above, no significant fragmentation or isolation of habitat for the subject TEC is likely.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality,

TEC: The habitat affected occurs within previously disturbed road reserve of Big River Way. The vegetation proposed for removal or disturbance consists of approximately 0.27 ha of Swamp Oak floodplain forest TEC. Given the minor area of disturbance, the area proposed for clearing would be of such a minor nature as to be negligible. Additionally, the area proposed for clearing makes up a small proportion of this vegetation community in the locality and equivalent or better habitat is present in the broader locality that can be utilised, and that this habitat will not be affected by the proposal.

c) ***whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),***

No areas of outstanding biodiversity value have been declared in Clarence Valley LGA.

d) ***whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.***

A key threatening process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species or ecological communities. The current list of KTP under the BC Act, and whether the proposal is recognised as a KTP is shown in **Table C.1**.

Table C.1 Key Threatening Processes

Key Threatening Process (as per Schedule 4 of the BC Act)	Is the development or activity proposed of a class of development or activity that is recognised as a threatening process?		
	Likely	Possible	Unlikely
Aggressive exclusion of birds by noisy miners (*Manorina melanocephala*)			✓
Alteration of habitat following subsidence due to longwall mining			✓
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands			✓
Anthropogenic climate change			✓
Bushrock removal			✓
Clearing of native vegetation	✓		
Competition and grazing by the feral European Rabbit (*Oryctolagus cuniculus*)			✓
Competition and habitat degradation by feral goats (*Capra hircus*)			✓
Competition from feral honeybees (*Apis mellifera*)			✓
Death or injury to marine species following capture in shark control programs on ocean beaches			✓
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments			✓
Forest eucalypt dieback associated with over-abundant psyllids and bell miners			✓
Habitat degradation by Feral Horses, *Equus caballus*			✓
Herbivory and environmental degradation caused by feral deer			✓
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition			✓
Importation of red imported fire ants (*Solenopsis invicta*)			✓

Key Threatening Process (as per Schedule 4 of the BC Act)	Is the development or activity proposed of a class of development or activity that is recognised as a threatening process?		
	Likely	Possible	Unlikely
Infection by *Psittacine circoviral* (beak and feather) disease affecting endangered psittacine species and populations			✓
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis			✓
Infection of native plants by *Phytophthora cinnamomi*			✓
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae			✓
Introduction of the large earth bumblebee (*Bombus terrestris*)			✓
Invasion and establishment of exotic vines and scramblers			✓
Invasion and establishment of Scotch Broom (*Cytisus scoparius*)			✓
Invasion and establishment of the Cane Toad (*Bufo marinus*)			✓
Invasion, establishment and spread of Lantana (*Lantana camara*)			✓
Invasion of native plant communities by African Olive (*Olea europaea L. subsp. cuspidata*)			✓
Invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed)			✓
Invasion of native plant communities by exotic perennial grasses			✓
Invasion of the Yellow Crazy Ant (*Anoplolepis gracilipes*) into NSW			✓
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants			✓
Loss of hollow-bearing trees			✓
Loss or degradation (or both) of sites used for hill-topping by butterflies			✓
Predation and hybridisation by feral dogs (*Canis lupus familiaris*)			✓
Predation by the European Red Fox (*Vulpes vulpes*)			✓
Predation by the feral cat (*Felis catus*)			✓
Predation by *Gambusia holbrooki* (Plague Minnow or Mosquito Fish)			✓
Predation by the Ship Rat (*Rattus rattus*) on Lord Howe Island			✓
Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*)			✓
Removal of dead wood and dead trees			✓

The KTP, 'clearing of native vegetation' is likely to be contributed to by the proposal.

Clearing of native vegetation: Clearing is defined as the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long-term modification, of the structure, composition and ecological function of stand or stands. The proposal would have a relatively minor contribution to this KTP due to the loss of a small section of roadside vegetation. Considering the relatively small area of native vegetation to be removed, it is unlikely that the proposal would contribute significantly to this KTP more broadly.

Conclusion

It is considered unlikely that the local population of Swamp Oak floodplain forest TEC would be placed at significant risk of extinction as a result of the proposal.

BC Act five-part tests for threatened fauna

Birds

Wetland

- Black-necked Stork
- Brolga

Populations

- Emu population in the NSW North Coast Bioregion and Port Stephens LGA

Flying foxes

- Grey-headed Flying-fox

The study area habitat values and extent of local population per species/species group are detailed below. To minimise repetition, the responses to the five-part tests are structured as follows:

Part (a), (c), (d) and (e) are answered per species or as a collective group of species depending on the nature of impacts.

Part (b) deals specifically with threatened ecological communities, and hence is not relevant to the subject threatened species assessment.

a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Birds

Brolga

Brolgas inhabit shallow swamps, floodplains, grasslands and pastoral lands, usually in pairs or parties. They are omnivorous and utilise a diverse range of food items on a seasonal basis. The main food items are vegetable materials, particularly the fleshy tubers of wetland plants, which are obtained by digging and foraging. The residues of grain and potato crops are also taken. Amphibians, sometimes small fish and a wide range of invertebrates are also taken including freshwater molluscs, crustaceans and insects.

During summer and autumn, many birds flock to deep freshwater marshes and permanent open water and adjacent dryland areas. These sites provide for the birds' drinking, feeding and roosting requirements. In late autumn and winter, the flocks disperse back to the breeding areas where bonded pairs re-establish substantial territories. Nests are generally constructed on a slight rise or island in shallow herb-dominated or sedge-dominated freshwater marshes and consist of a platform of coarse vegetation. Usually two eggs are laid, and the parents share in nest building, incubation of the eggs and rearing of the young. The chicks fledge 90-100 days after hatching and remain with the parents until the onset of the next breeding season or for another year if the parents do not re-nest.

Threatening processes for this species include:

- Drainage and modification of wetlands.
- Alteration of flood regimes during the breeding season which can cause nest abandonment.
- Modification of vegetation structure and species composition, water quality or soil structure at breeding and feeding sites.
- Widespread use of herbicides and pesticides especially in close proximity to breeding sites.
- Disturbance by hunting activities where young birds are still in the breeding wetland.
- Introduced predators taking eggs and killing chicks.

- Wildfire and burning programs, which remove nest material.
- Grazing by stock.
- Subdivision and fencing of large private landholdings.
- Erection of structures such as overhead powerlines.
- Use of wetlands for irrigation and/or re-use systems.

Black-necked Stork

Black-necked Storks (BNS) occur in floodplain wetlands (swamps, billabongs, watercourses and dams) of the major coastal rivers in NSW. Secondary habitat includes minor floodplains, coastal sandplain wetlands and estuaries. BNS usually forage in water 5-30 centimetres deep for vertebrate and invertebrate prey. Eels regularly contribute the greatest biomass to their diet, but they feed on a wide variety of animals, including other fish, frogs and invertebrates (such as beetles, grasshoppers, crickets and crayfish).

BNS build large nests high in tall trees close to water. Trees usually provide clear observation of the surroundings and are at low elevation (reflecting the floodplain habitat). In NSW, breeding activity occurs May - January; incubation May - October; nestlings July - January; fledging from September. Parents share nest duties and in one study about 1.3-1.7 birds were fledged per nest.

The NSW breeding population has been estimated at about 75 pairs. Territories are large and variable in size and estimated to average about 9000 ha, ranging from 3000-6000 ha in high quality habitat and 10,000-15,000 ha in areas where habitat is poor or dispersed.

Threatening processes for this species include:

- Powerlines, especially close to wetlands or over floodplains, are a significant cause of mortality of Storks and one of the most critical threats to the species in NSW.
- Modification or degradation of wetlands through changes in natural water flows. It is important to maintain or reintroduce flows to provide wetland habitats suitable for foraging by Storks as they require large amounts of vertebrate prey from such habitats.
- Loss of wetland habitat through clearing and draining for development.
- Loss of key habitat as a result of wetland drainage for flood mitigation and agricultural development.
- Degradation of wetland habitats through pollution.

Potential Impacts of the Proposal to Birds

The proposal occurs within a portion of Big River Way, the South Arm River and surrounding floodplain which provides a small area of potential foraging habitat for the subject species. In the long-term this habitat would not be adversely affected by the proposal. The subject habitat comprises a relatively minor amount of potential foraging and dispersal habitat for the subject avifauna in the context of the site and adjacent areas of floodplain habitat. On this basis, and with effective implementation of safeguards, particularly in relation to vegetation removal, it is considered unlikely that an adverse effect on the life cycle of the subject species would occur such that a viable local population of these species is likely to be placed at risk of extinction.

Populations

Emu (population in the New South Wales North Coast Bioregion and Port Stephens LGA)

The Emu formerly occurred throughout mainland Australia and Tasmania though only rarely in dense tropical forests or parts of the arid interior. It is now generally absent from densely settled regions and largely absent from south-eastern coastal and subcoastal regions. The species was formerly widespread in north-eastern NSW, but is now restricted to coastal and near-coastal areas between Evans Head and Red Rock and a small isolated population further west in the Bungawalbin area. The range of the species continues to contract in recent years. It now appears to be absent from Broadwater National Park, there are few recent sightings from its former stronghold in Bundjalung National Park and it is not known whether a natural population continues to persist in the Port Stephens area.

On the NSW north coast, Emus occur in a range of predominantly open lowland habitats, including grasslands, heathland, shrubland, open and shrubby woodlands, forest, and swamp and sedgeland communities, as well as the ecotones between these habitats. They also occur in plantations of tea-tree and open farmland, and occasionally in littoral rainforest.

Emus are omnivorous, taking a wide range of seeds and fruits, invertebrates (mainly insects) and foliage and other plant material. They take material directly from plants or bend down to take items from the ground, picking up the food and tossing them back in the throat before swallowing.

The population of Emus in the NSW North Coast Bioregion and Port Stephens LGA is of significant conservation value as the last known population in northern coastal NSW, and for the role that birds play in dispersing large seeds of native plant species, and over long distances.

Most breeding occurs in late autumn and winter, but better data are needed for the north-eastern NSW population. Eggs are laid on a platform of grass, twigs, leaves and bark on the ground, often at the base of some vegetation and with good views from the nest. Incubation and all parental care is by the male.

Threatening processes for this species include:

- The species is the risk of continued local extinctions owing to the small size of the extant population, fragmentation, isolation of individuals and groups within the total population, following past major declines.
- The habitat of the north coast population of Emus has been reduced and fragmented as a result of agricultural and rural and urban development, with consequent declines and isolation of subpopulations and local extinctions, a process that is continuing.
- Inappropriate fire regimes, rendering habitat unsuitable and loss of breeding habitat, and fires, including control burns, in areas where Emus are nesting. Back-burning operations can also trap and kill Emus fleeing fires.
- Predation of young and eggs by Red Foxes (*Vulpes vulpes*), feral Pigs (*Sus scrofa*), feral and domestic Dogs, native avian and reptilian predators.
- Vehicle collisions, with increasing human use and vehicular traffic leading to many deaths of adults and young.
- Deliberate killing through poisoning or shooting.
- Loss of habitat through weed and native shrub encroachment.
- Lack of knowledge about key threats, breeding locations and territories and diet and plant preferences.
- Impediments to movement and access to resources through artificial barriers, agricultural development, highway upgrades and urban development.

Potential impacts to this population

The proposal occurs within a portion of Big River Way, the South Arm River and surrounding cane fields which provides a small area of potential foraging habitat for the subject population. In the long-term this habitat would not be adversely affected by the proposal. The subject habitat comprises a relatively minor amount of potential foraging and dispersal habitat for the subject avifauna in the context of the site and adjacent areas of habitat. On this basis, and with effective implementation of safeguards, particularly in relation to vegetation removal, it is considered unlikely that an adverse effect on the life cycle of the subject population would occur such that a viable local population of these species is likely to be placed at risk of extinction.

Megachiropteran bats

Grey-headed Flying-fox (GHFF)

Grey-headed Flying-foxes (GHFF) have a distribution that typically extends approximately 200 km from the coast of Eastern Australia, from Rockhampton in Queensland to Adelaide in South Australia. Foraging areas include subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. GHFF feed on the nectar and pollen of native trees, in particular *Eucalyptus, Melaleuca* and *Banksia*, and fruits of rainforest trees and vines, as well as from cultivated gardens and orchards. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Individual camps may have tens of thousands of animals and are used for mating, and for giving birth and rearing young. Annual mating commences in January and conception occurs in April or May; a single young is born in October or November. Site fidelity to camps is high; some camps have been used for over a century. GHFF may travel up to 50 km from the camp to forage; commuting distances are more often <20 km.

Threatening processes for this species include:

- Clearing of woodlands for agriculture.
- Loss of roosting and foraging sites.
- Electrocution on powerlines, entanglement in netting and on barbed-wire.
- Heat stress.
- Conflict with humans.
- Incomplete knowledge of abundance and distribution across the species' range.

Potential Impacts from the Proposal

The works may require the disturbance and/ or removal of up to 0.27 ha of PCT 1235, with adjoining forest within the study area and adjacent lands remaining unaffected and occurring extensively in the locality (refer to CRAFTI vegetation mapping). No known roost habitat occurs within the study area (CVC Flying-fox Camp Monitor). In a local context, the works are unlikely to result in significant impacts to foraging resources for GHFF.

On this basis, it would be highly unlikely that an adverse effect on the life cycle of GHFF would occur such that a viable local population of the species is likely to be placed at risk of extinction.

b) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not relevant to assessment of threatened species.

c) in relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

- *Birds*: Temporary utilisation of a small area of potential foraging habitat. Retained areas of floodplain habitat will continue to provide foraging and nesting resources.
- *Emu Population*: very minor contraction to foraging habitat. Retained areas of local cane fields and open vegetated areas will continue to provide foraging, refuge and breeding resources.

- *Grey-headed Flying-fox*: very minor contraction of foraging habitat. Retained areas of adjacent forest will continue to provide foraging, refuge and breeding resources.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

No significant fragmentation of habitat would occur; the works (both in construction and operational phases) are unlikely to result in significant barriers to dispersal.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality,

- *Birds*: Habitat to be impacted by the proposal represents a small area of potential foraging habitat which is well represented on the Clarence floodplain in the locality.
- *Emu Population*: very minor contraction of foraging habitat. Retained areas of adjacent cane fields and open vegetated areas will continue to provide foraging, refuge and breeding resources.
- *Grey-headed Flying-fox*: very minor contraction of foraging habitat. Retained areas of adjacent forest will continue to provide foraging, refuge and breeding resources.

d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),

No areas of outstanding biodiversity value have been declared in Clarence Valley LGA.

e) whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

A key threatening process (KTP) is a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species or ecological communities. The current list of KTP under the BC Act, and whether the proposal is recognised as a KTP is shown in **Table C.2**.

Table C.2 Key Threatening Processes

Key Threatening Process (as per Schedule 4 of the BC Act)	Is the development or activity proposed of a class of development or activity that is recognised as a threatening process?		
	Likely	Possible	Unlikely
Aggressive exclusion of birds by noisy miners (*Manorina melanocephala*)			✓
Alteration of habitat following subsidence due to longwall mining			✓
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands			✓
Anthropogenic climate change			✓
Bushrock removal			✓
Clearing of native vegetation	✓		
Competition and grazing by the feral European Rabbit (*Oryctolagus cuniculus*)			✓
Competition and habitat degradation by feral goats (*Capra hircus*)			✓
Competition from feral honeybees (*Apis mellifera*)			✓
Death or injury to marine species following capture in shark control programs on ocean beaches			✓
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments			✓
Forest eucalypt dieback associated with over-abundant psyllids and bell miners			✓
Habitat degradation by Feral Horses, *Equus caballus*			✓
Herbivory and environmental degradation caused by feral deer			✓
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition			✓
Importation of red imported fire ants (*Solenopsis invicta*)			✓
Infection by *Psittacine circoviral* (beak and feather) disease affecting endangered psittacine species and populations			✓
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis			✓
Infection of native plants by *Phytophthora cinnamomi*			✓
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae			✓
Introduction of the large earth bumblebee (*Bombus terrestris*)			✓
Invasion and establishment of exotic vines and scramblers			✓
Invasion and establishment of Scotch Broom (*Cytisus scoparius*)			✓
Invasion and establishment of the Cane Toad (*Bufo marinus*)			✓
Invasion, establishment and spread of Lantana (*Lantana camara*)			✓
Invasion of native plant communities by African Olive (*Olea europaea L. subsp. cuspidata*)			✓

Key Threatening Process (as per Schedule 4 of the BC Act)	Is the development or activity proposed of a class of development or activity that is recognised as a threatening process?		
	Likely	Possible	Unlikely
Invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed)			✓
Invasion of native plant communities by exotic perennial grasses			✓
Invasion of the Yellow Crazy Ant (*Anoplolepis gracilipes*) into NSW			✓
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants			✓
Loss of hollow-bearing trees			✓
Loss or degradation (or both) of sites used for hill-topping by butterflies			✓
Predation and hybridisation by feral dogs (*Canis lupus familiaris*)			✓
Predation by the European Red Fox (*Vulpes vulpes*)			✓
Predation by the feral cat (*Felis catus*)			✓
Predation by *Gambusia holbrooki* (Plague Minnow or Mosquito Fish)			✓
Predation by the Ship Rat (*Rattus rattus*) on Lord Howe Island			✓
Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*)			✓
Removal of dead wood and dead trees			✓

Clearing of native vegetation: Clearing is defined as the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long-term modification, of the structure, composition and ecological function of stand or stands. The proposal would have a relatively minor contribution to this KTP due to the loss of a small area of native vegetation. Considering the relatively small area of native vegetation to be removed, it is unlikely that the proposal would contribute significantly to this KTP more broadly.

The proposal is such that no other KTPs are considered likely to be substantially contributed to, especially with effective implementation of the mitigation measures in this report. Overall, although the action proposed constitutes or is part of four key threatening process, the nature of the proposal is such that this contribution is very small and insignificant within the broader locality.

Conclusion

It is considered unlikely that the local population of any of the subject species would be placed at significant risk of extinction as a result of the proposal.

Annexure D
Fauna and flora records

Table D1 Recorded fauna

Taxa/Fauna group	Scientific Name	Common name	Status	
			BC Act	EPBC Act
Aves	*Anas superciliosa*	Pacific Black Duck	-	-
Aves	*Anthochaera chrysoptera*	Little Wattlebird	-	-
Aves	*Cracticus tibicen*	Australian Magpie	-	-
Aves	*Grallina cyanoleuca*	Magpie-lark	-	-
Aves	*Hirundo neoxena*	Welcome Swallow	-	-
Aves	*Myzomela sanguinolenta*	Scarlet Honeyeater	-	-
Aves	*Pelecanus conspicillatus*	Australian Pelican	-	-
Aves	*Rhipidura albiscapa*	Grey Fantail	-	-
Aves	*Rhipidura leucophrys*	Willie Wagtail	-	-
Aves	*Threskiornis molucca*	Australian White Ibis	-	-
Aves	*Vanellus miles*	Masked Lapwing	-	-

Table D2 Recorded flora

Family	Scientific name	Common name
Adiantaceae	*Adiantum hispidulum*	Rough Maidenhair
Apocynaceae	*Gomphocarpus physocarpus**	Balloon Cotton Bush
Apocynaceae	*Parsonsia straminea*	Monkey Rope
Asteraceae	*Ageratum houstonianum**	Blue Billygoat Weed
Asteraceae	*Ambrosia artemisiifolia**	Annual Ragweed
Asteraceae	*Bidens pilosa**	Cobbler's Pegs
Asteraceae	*Conyza sumatrensis**	Tall fleabane
Asteraceae	*Senecio madagascariensis**	Fireweed
Asteraceae	*Sonchus oleraceus**	Common Sowthistle
Caryophyllaceae	*Stellaria media**	Common Chickweed
Casuarinaceae	*Casuarina glauca*	Swamp Oak
Commelinaceae	*Commelina cyanea*	Scurvy Weed
Convolvulaceae	*Ipomoea cairica**	Coastal Morning Glory
Dennstaedtiaceae	*Pteridium esculentum*	Bracken
Dracaenaceae	*Sansevieria trifasciata**	Mother-in-law's Tongue
Euphorbiaceae	*Breynia oblongifolia*	Coffee Bush
Euphorbiaceae	*Glochidion ferdinandi var. ferdinandi*	Cheese Tree
Fabaceae	*Desmodium uncinatum**	Silverleaf Desmodium
Fabaceae (Faboideae)	*Macroptilium atropurpureum **	Siratro
Fabaceae (Mimosoideae)	*Acacia disparrima var. disparrima*	Brush Ironbark Wattle
Lamiaceae	*Clerodendrum floribundum*	Smooth Clerodendrum
Luzuriagaceae	*Eustrephus latifolius*	Wombat Berry
Malvaceae	*Hibiscus tiliaceus*	Cottonwood
Menispermaceae	*Stephania japonica var. discolor*	Snake Vine
Moraceae	*Trophis scandens subsp. scandens*	Burny Vine
Myrtaceae	*Eucalyptus microcorys*	Tallowwood
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum
Ochnaceae	*Ochna serrulata**	Mickey Mouse Plant

Family	Scientific name	Common name
Plantaginaceae	*Plantago lanceolata**	Lamb's Tongues
Poaceae	*Cenchrus clandestinus**	Kikuyu
Poaceae	*Chloris gayana**	Rhodes Grass
Poaceae	*Cynodon dactylon*	Common Couch
Poaceae	*Imperata cylindrica*	Blady Grass
Poaceae	*Panicum maximum**	Guinea Grass
Poaceae	*Paspalum dilatatum**	Paspalum
Poaceae	*Paspalum mandiocanum**	Broad-leafed Paspalum
Poaceae	*Phragmites australis*	Common Reed
Poaceae	*Setaria sphacelata**	South African Pigeon Grass
Polygonaceae	*Rumex brownii*	Swamp Dock
Rosaceae	*Rubus moluccanus*	Molucca Bramble
Rutaceae	*Citrus limon**	Lemon Tree
Sapindaceae	*Cupaniopsis anacardioides*	Tuckeroo
Sapindaceae	*Jagera pseudorhus var. pseudorhus*	Foambark Tree
Verbenaceae	*Lantana camara**	Lantana

*Introduced species

Appendix B

Geotechnical Detailed Design Reports

Member of the Surbana Jurong Group

SMEC INTERNAL REF. 30013154

100% Geotechnical Interpretive and Design Options Report

Byrons Lane Slip, Big River Way, Tyndale Geotechnical Design

Client Reference No. 21.0000129127.1219

Prepared for TfNSW

10 December 2021

Document Control

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Information may be gained from limited subsurface testing, surface observations, previous work, and is supplemented by knowledge of the local geology and experience of the range of properties that may exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely. Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities
- The actions of contractors responding to commercial pressures

If these occur, SMEC would be pleased to resolve the matter through further investigation, analysis or advice.

Logs of a borehole, recovered core, test pit, excavated face, or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling/observation spacing's and the ground conditions. It is not always possible or economic to obtain continuous high-quality data. It should also be recognised that the volume of material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

It should also be recognised that ground conditions can change over time (e.g. through drought, wet periods, snow/summer and disturbance after site investigation occurs). As such, ground information is only a representation of the site at a point in time and may change.

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

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1 Introduction

Transport for NSW (TfNSW) has engaged SMEC Australia Pty Ltd (SMEC) to design a slope remediation solution for an approximate 40 m long slip situated along Clarence River - South Arm, Big River Way, Tyndale, NSW.

This report presents the **100% Geotechnical Interpretive and Design Options Report**. It includes the following sections:

- Project background
- Site description
- Geological and geotechnical models
- Assessment of slip modes and mechanisms
- Design criteria and assumptions
- Presentation of concept remediation design options including engineering assessments and sketches of arrangements.
- Evaluation of relative merits of each option, including technical merit, constructability, traffic restrictions, environmental and community impacts, relative cost and maintenance considerations.
- Recommended preferred option for detailed design.

1.1 Changes from previous issue

This revised (Rev.02) includes the following changes and amendments:

- Amended terminology from landslide to slip.
- Section 5.4.1 and Appendix A – Interpreted geotechnical model cross sections and long section included.
- Section 6.1: Comments on the abandoned watermain.
- Sections 8.2 and 8.3: Discussion on potential drainage options and corrosion monitoring requirements.
- Section 8.4.1: Comment on alternate steel tubular pile option.
- Section 8.6.2.2 and Appendix I: Preliminary sliding and overturning calculations included for proposed gabion wall structure.
- Section 8.7: Revised weighted multi-criteria assessment with 1-5 scoring.
- Appendix K: Safety in Design register.
- Section 11 and Appendix M: TfNSW comments register with SMEC responses to the 80% concept design report.
- Section 12: Conclusions and Recommendations.

2 Available Information

Information obtained by SMEC as part of previous project work for TfNSW:

- SMEC Geotechnical Detailed Design Report Rev.06 – HW10 Pacific Highway Byrons Lane Slip – Stage 4, dated May 2014.
- Byrons Lane Slip – Stage 4 IFC Drawings (Ref. 30011433-DGT-0001 to 0300)

TfNSW has supplied SMEC with the following information to assist with the design:

- 04 Scope of Services – Byrons Lane Slip Stage V

- 20211031 Draft PS331 Big River Way Slip on the Clarence River, Geotechnical Investigation Factual Report
- TfNSW Draft Project QA Specification PS331
- Byrons Lane Slip SRA 20210309
- AECOM Byrons Slip Corrosion Protection Final Report Rev 0
- Topographical Site Survey, dated 20210507

3 Background

3.1 Timeline of Events

This area of the riverbank has a recent history of instability. A brief timeline of events is presented below:

- 14 June 2009: 60 m long slip occurred after flooding in June 2009. Situated adjacent to the subject slip site.
- June to September 2009: Stage 1 – Pacific Highway realigned away from slip and Stage 2 - Rock fill treatment constructed by TfNSW.
- 12 September 2009: Stage 2 rock fill treatment failed with most of the rock sliding in to the river.
- November to December 2009: Stage 3 – Cantilevered steel sheet pile wall constructed.
- December 2010 – Sheet pile corrosion assessment undertaken indicating relatively low design life for sheet pile and costly treatment measures.
- 2012: Alternative design involving steel tube stabilisation piles and rock fill developed. Design not constructed.
- January 2013: SMEC developed a 15% Concept Design for Contiguous Pile Wall. Design not developed further.
- September 2013: Stage 4 - Detailed design of timber slope stabilisation piles and rock fill buttress completed and IFC drawings issued.
- May 2014: Stage 4 timber slope stabilisation piles, rock fill buttress and rock armour works completed.
- 2 March 2021: Subject slip site identified by TfNSW immediately north of the previously remediated site.

4 Site Description

4.1 Slip Location

The slip site is situated along the outer, east bank of the Clarence River - South Arm, along Big River Way, Tyndale, NSW. Byrons Lane is located approximately 650 m southwest of the site and the Pacific Highway is approximately 500 m to the east. Refer to the site location map presented in Figure 4-1.

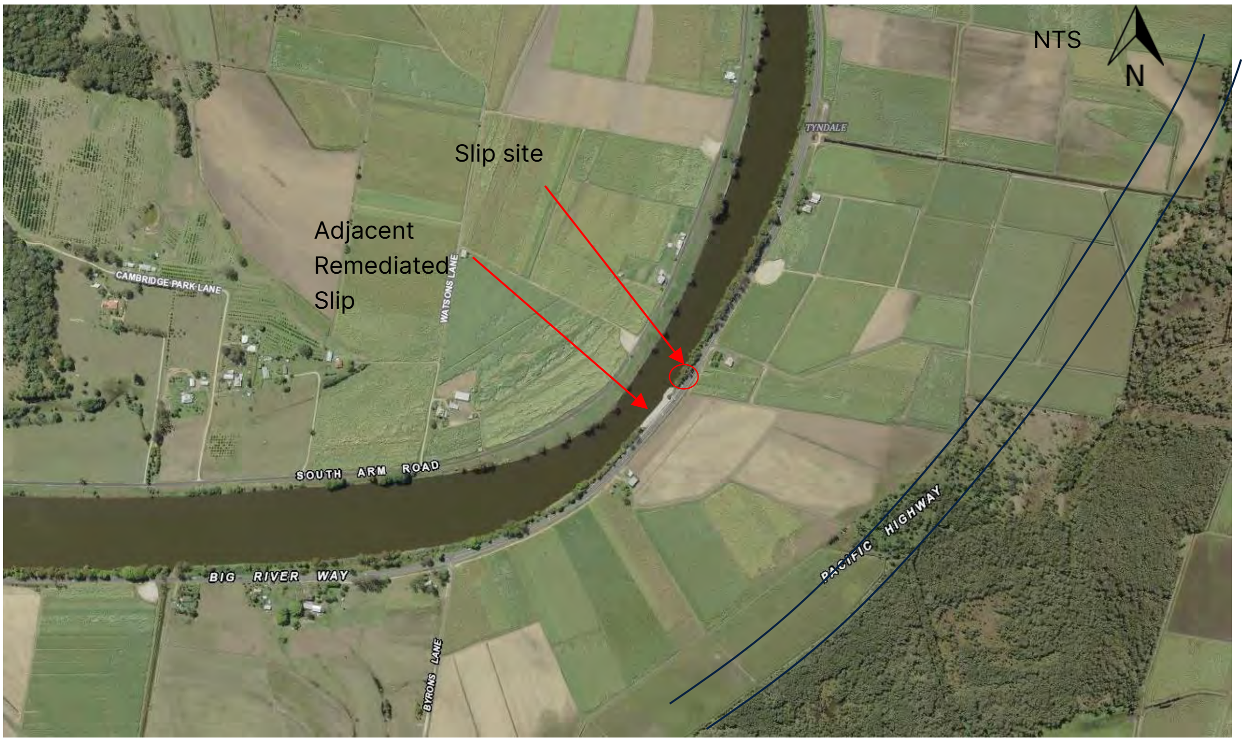


Figure 4-1 Site Locality Plan – Source: Six Maps, NSW (maps.six.nsw.gov.au)

4.2 Observations

A geotechnical engineer from the SMEC Grafton office visited the slip site on 29 June 2021 to observe the extent of the slip. The steep headscarp and the risk of instability constrained the site observations to viewing from the road shoulder.

The following photographs depict the site.

Dense vegetation obscured riverbank

Some patch repairs to Big River Way carriageway around Ch33480 m

No obvious tension cracks observed in sealed shoulder.

Photograph 1: Ch33490 m - view south; wide sealed shoulder at southern end of slip.

Landslip headscarp with some slumping observed regressing back beneath pavement

Photograph 2: Ch33490 m - view north showing slip headscarp profile.

No obvious tension cracks observed in pavement. Pavement cross fall is towards the riverbank.

Headscarp located approximately 5.5 m from edgeline.

Photograph 3: Ch33500 m – view north; slip headscarp and pavement profile viewed from southern end.

Photograph 4: ~Ch33515 – view of slumped road embankment and riverbank below headscarp.

Recent slumping of headscarp pavement and fill materials. Regression back beneath pavement.

Ponding water on subsided pavement

Photograph 5: Ch33530 – slip headscarp and subsidence viewed from southern end of headscarp.

Photograph 6: Ch33540 – Formation and vegetated riverbank north of slip (view south).

4.3 Previous Remediation Design for Adjacent Site

4.3.1 Concept Design of a Contiguous Pile Wall

SMEC previously developed a concept contiguous pile wall option (15% concept design) for the adjacent slip site before it was terminated due to TfNSW funding considerations and an alternative design pursued.

The preliminary concept contiguous pile wall design considered the following:

- Consideration of temporary stability of piling rig and an estimated maximum surcharge load = 30 kPa behind existing sheet piles.
- 900 mm diameter reinforced concrete piles at 925 mm centres. Sacrificial steel casing proposed for additional short term stability.

Consideration has been given to a contiguous pile wall option at the subject slip site.

4.3.2 Northern Transition Zone

The slope remediation design for the adjacent slip comprised a row of timber piles installed within the river, a rock fill buttress between the failed bank and the timber piles and placement of additional rock armour for scour protection. Refer Figure 4-2 below showing the previous detailed design layout in relation to the subject slip.

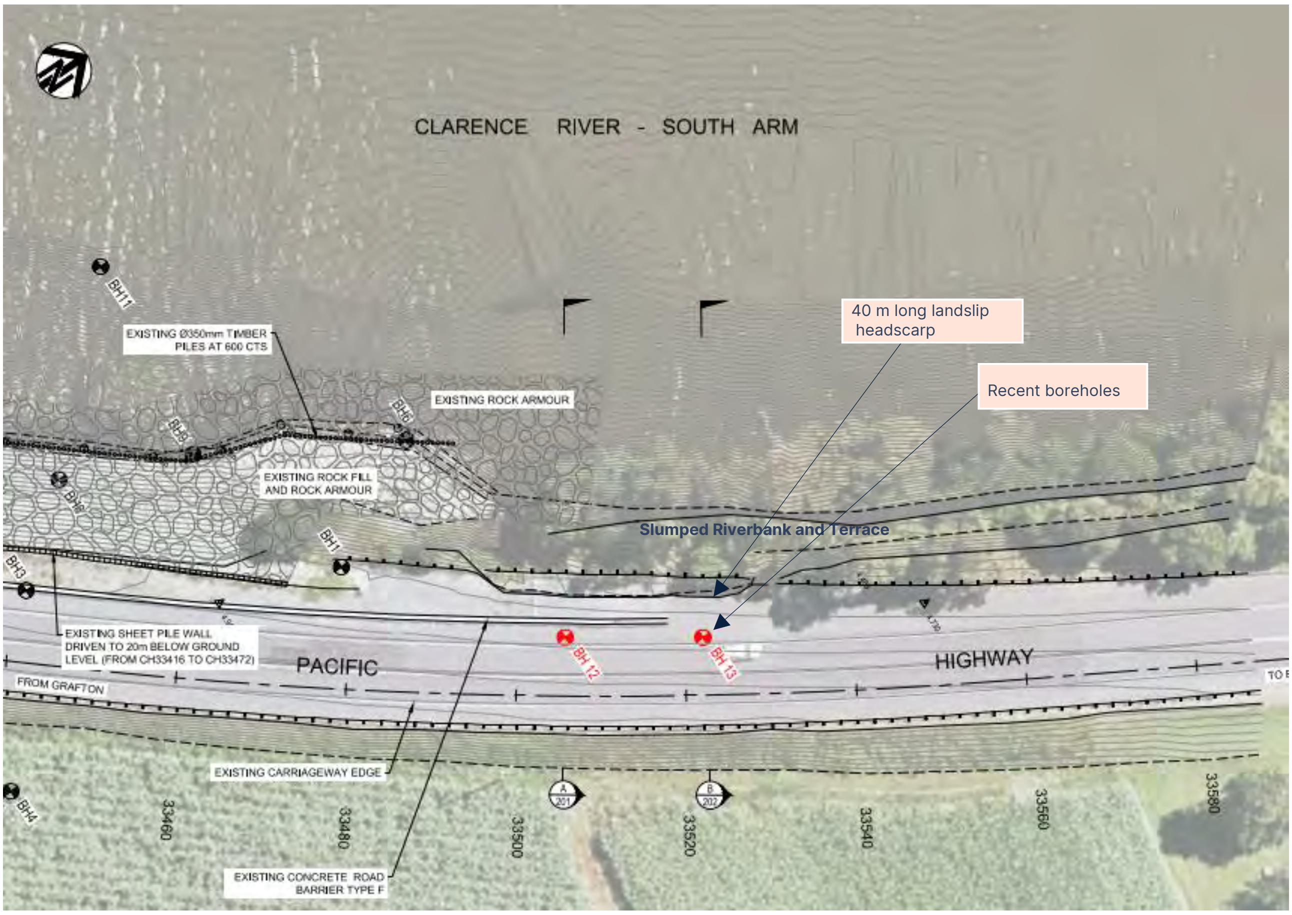


Figure 4-2 Layout Plan – Former Slip Remediation

The subject 40 m long slip is situated between approximately Ch33490 m and Ch33530 m. Rock armour was placed over the river bank in this area to form a 6H:1V longitudinal transition. However, as-built construction drawings have not been sighted.

5 Geotechnical Model

5.1 Geology Maps

Reference to the NSW Department of Primary Industries, Grafton Area Coastal Quaternary Geology Map, 1:100,000 scale, describes the geology of the site as Holocene levee; fluvial sand, silt and clay.

From experience on the nearby Woolgoolga to Ballina Pacific Highway Upgrade, the Holocene sediments situated within the Clarence River floodplain are understood to comprise alluvial, estuarine and deltaic clays, silts and sand. The cohesive materials range from very soft to stiff consistency, are grey to dark grey in colour and typically overly stiffer Pleistocene deposits.

5.2 Acid Sulfate Soil Maps

Reference to the published acid sulfate soil risk map geodatabase rates the site as a high probability of occurrence for acid sulfate soils below 4 m depth.

Acid Sulfate Soils (ASS) are soils containing significant concentrations of pyrite, which when exposed to oxygen in the presence of sufficient moisture, oxidises, resulting in the generation of sulfuric acid. Unoxidised pyritic soils are referred to as potential ASS (PASS). When the soils are exposed, the oxidation of pyrite occurs and sulfuric acids are generated, at which stage the soils are said to be actual ASS (AASS).

Disturbance or poorly managed development and use of ASS can generate significant amounts of sulfuric acid, which can lower soil and water pH to extreme levels (generally pH <4) and produce acid soils, resulting in high salinity.

The low pH, high salinity soils can reduce or altogether preclude vegetation growth and can produce aggressive conditions which may be detrimental to concrete and steel components of structures, foundations, pipelines and other engineering works.

5.3 Geotechnical Investigations

5.3.1 Previous Investigations

Eleven boreholes were drilled in 2009 to investigate the adjacent slip site. Two holes (BH1 and BH2) drilled at either end of the failed section, three holes (BH3, BH4 and BH10) on the existing embankment and the remaining six holes drilled in the river.

Table 5-1 below provides a summary of the boreholes.

Table 5-1: Geotechnical Investigation Summary Data

Hole Number	Hole Surface RL* (m AHD)	Hole Depth^ (m)	Termination Strata	Water Table RL (m AHD)
BH1	5.143	24.00	very stiff Clay	2.04
BH2	5.239	24.00	very stiff Clay	0.54
BH3	5.172	24.75	stiff Clay	0.37
BH4	3.161	23.65	very stiff Clay	0.06
BH5	-4.741	18.05	very stiff Clay	-0.04
BH6	-3.873	16.35	stiff Clay	-0.27
BH7	-3.852	16.05	stiff Clay	0.55
BH8	-3.0	18.25	stiff Clay	-0.2
BH9	-1.8	19.35	stiff Clay	-0.1
BH10	5.232	11.25	very stiff Clay	1.03
BH11	-7.934	15.45	medium dense to dense Sand	-0.33

Note: * Hole Surface RL starts from any earth material including slumped rock fill which may differ from those on logs; ^ Hole Depth starts from Hole Surface RL.

Borehole logs are provided in Appendix L.

5.3.2 Recent TfNSW Geotechnical Investigations

TfNSW conducted a geotechnical investigation comprising two boreholes (BH12 and BH13) at the subject slip site in April 2021. The results of the investigation are documented in the Geotechnical Factual Report Ref. N2021031, dated 07.06.2021, presented in Appendix L.

5.4 Interpreted Subsurface Conditions

5.4.1 Subsurface Conditions

The interpreted subsurface conditions are presented in Table 5-2 on the following page. The interpreted subsurface conditions are also presented on annotated cross sections and a long section; presented in Appendix A.

5.4.2 Concept Design Parameters

SMEC has developed geotechnical design parameters utilising the available geotechnical investigation data, the adjacent slip remediation design, experience from the Woolgoolga to Ballina Pacific Highway upgrade project and SMEC pile foundation design guidelines. Effective shear strength parameters were also adjusted based on slope stability back-analysis discussed in Section 6.1.

Table 5-3 presents the preliminary geotechnical design parameters for concept design.

5.4.3 Water Levels

5.4.3.1 Tidal Levels

Published tidal information for the Clarence River at Tyndale has been obtained the NSW Public Works Manly Hydraulics Laboratory.

This data indicates an annual average Mean High Water Spring = RL0.35 m and Mean Low Water Spring = RL-0.108 m.

5.4.3.2 Groundwater Levels

Groundwater levels were measured in the following boreholes during geotechnical investigations by others.

- BH3: RL0.37 m
- BH4: RL0.06 m
- BH10: RL1.03 m
- BH13: RL-0.08 m

No longer term groundwater monitoring has been undertaken at the site. Groundwater levels are expected to fluctuate with changing climate and river levels. Consideration has been given to elevated groundwater levels within the embankment as part of the design assessment.

Table 5-2: Summary of Subsurface Conditions

<table>
<tr><th rowspan="2">Unit No.</th><th rowspan="2">Unit</th><th rowspan="2">General Material Description</th><th colspan="2">Depth (m)</th><th colspan="2">RL (m AHD)</th></tr>
<tr><th>BH12</th><th>BH13</th><th>BH12</th><th>BH13</th></tr>
<tr><td>1</td><td>Pavement</td><td>200 mm thick Asphaltic Concrete over 300 mm to 400 mm Gravel layer.</td><td>0 to 0.5</td><td>0 to 0.6</td><td>4.93 to 4.43</td><td>4.92 to 4.32</td></tr>
<tr><td>2</td><td>Fill</td><td>Silty SAND, fine grained, medium dense relative density.</td><td>0.5 to 2.0</td><td>0.6 to 2.2</td><td>4.43 to 2.93</td><td>4.32 to 2.72</td></tr>
<tr><td>3a</td><td rowspan="2">Alluvium</td><td>Clayey SILT, low to medium plasticity; soft to firm consistency</td><td>2.0 to 3.4</td><td>2.2 to 3.5</td><td>2.93 to 1.53</td><td>2.72 to 1.42</td></tr>
<tr><td>3b</td><td>Silty CLAY, medium plasticity, with trace sand; firm consistency</td><td>3.4 to 5.0</td><td>3.5 to 5.0</td><td>1.53 to - 0.07</td><td>1.42 to -0.08</td></tr>
<tr><td>4a</td><td rowspan="3">Estuarine</td><td>Clayey SILT/CLAY, medium to high plasticity, some fine sand, trace shell fragments; soft consistency</td><td>5. 0 to 6.0</td><td>5. 0 to 8.0</td><td>-0.07 to -1.07</td><td>-0.08 to -3.08</td></tr>
<tr><td>4b</td><td>Silty CLAY, high plasticity, trace shell fragments; soft to firm consistency</td><td>6.0 - 9.5</td><td>8.0 – 11.0</td><td>-1.07 to -4.57</td><td>-3.08 to -6.08</td></tr>
<tr><td>4c</td><td>Silty CLAY, medium to high plasticity; stiff consistency</td><td>9.5 -16.2</td><td>11.0 – 17.0</td><td>-4.57 to -11.27</td><td>-6.08 to -12.08</td></tr>
<tr><td>5a</td><td rowspan="3">Alluvium</td><td>SAND, fine to medium grained, loose to medium dense relative density.</td><td>16.2 - 17.8</td><td>17.0 – 18.5</td><td>-11.27 to -12.87</td><td>-12.08 to -13.58</td></tr>
<tr><td rowspan="2">5b</td><td>CLAY, Sandy Clay, Silty Clay; medium to high plasticity, trace fine sand; stiff to very consistency</td><td>17.8 - 22.45 (EOH)</td><td>18.5 – 23.0</td><td>-12.87 to -17.52 (EOH)</td><td>-13.58 to -18.08</td></tr>
<tr><td>Sandy SILT, stiff consistency</td><td>N.E.</td><td>23.0 – 23.95 (EOH)</td><td>N.E.</td><td>-18.08 to -19.03 (EOH)</td></tr>
</table>

Notes: NE = Not encountered, EOH = End of borehole

Table 5-3: Summary of Design Parameters

Unit /Material	Unit Weight γ' (kN/m^3)	Cohesion **c'** (kPa)	Friction Angle ϕ' (°)	Undrained Shear Strength c_u (kPa)	Youngs Modulus **E'v** (MPa)	Horizontal Modulus **E'h** (MPa)
1. Pavement – Gravel; dense	20	0	40	-	40	30
2. Fill – Silty Sand; medium dense	18	0	34	-	7	5
3a. Clayey Silt, soft to firm consistency	17	4	26	30	6	4.5
3b. Silty Clay; firm consistency	18	5	27	50	10	7.5
4a. Clayey Silt/CLAY; soft consistency	17	2	26	25	5	3.75
4b. Silty Clay; soft to firm consistency	17	4	26	30	6	4.5
4c. Silty Clay; stiff consistency	19	8	27	75	15	11
5a. Sand; loose to medium dense	18	0	33	-	8	6
5b. Clay, Sandy Clay, Silty Clay; stiff/very stiff consistency	19	10	27	100	20	15
Unit 3a/4a/4b - Soft Clay residual strength parameters along inferred failure surfaces	17	0	22	12	2.5	1.8
New Rock Fill	18	0	40	-	40	30

6 Slip Failure Modes and Mechanisms

6.1 Review of Slope Risk Assessment Data

TfNSW conducted a preliminary slope risk assessment (SRA) of the slip site in March 2021. Reference to the preliminary SRA document and sketches (included in Appendix L) indicates the following:

- Evidence of undercutting of riverbank in tidal zone with localised slumping.
- Rock fill and crushed rock exposed on parts of slip slope and along water line.

The following apparent slip mechanisms were noted:

- Erosion of riverbank
- High water levels
- Low strength materials at depth
- Abandoned water main.

TfNSW have not provided SMEC with information on the abandoned watermain. Details such as the size and location of the abandoned watermain are not known and it is not clear how the abandoned watermain could have contributed to the slip.

The following slip modes/hazards were noted:

1. Collapse of headscarp. Erosion and slumping of sand fill, with potential to regress back beneath pavement towards carriageway. Assessed as ARL1 and C3 consequence class.
2. Shallow slip along inferred failure plane above tide level. Assessed as ARL2 to 3 and C3 consequence class.
3. Deeper slip along potential failure plane. Assessed as ARL4 and C3 consequence class.

Hazard 1 appeared active and is likely to regress back towards the carriageway. There is uncertainty about whether the slip is relatively shallow seated(Hazard 2) or deeper seated (Hazard 3). To investigate the potential critical slip surfaces, SMEC has undertaken slope stability analyses as discussed in the following section.

6.2 Stability Analyses

6.2.1 Back-analysis

SMEC has attempted to back-analyse the slip and investigate the critical slide surface using a representative geotechnical cross section through the slip (cross section B-B at ~Ch33520 m). The pre-failure slope profile has been estimated from the survey and the SRA data.

For back-analysis, ground water levels were assumed to be elevated within the embankment and tide levels adjusted as part of the analyses.

The slip was observed on 2 March 2021; before significant flooding of the Clarence River in late March. Rainfall records from the nearby Brushgrove Station indicate approximately 150 mm of rainfall between 15 and 25 February 2021 and with minimal rainfall between 26 February and 2 March 2021. It is likely that elevated water levels were present in the embankment at the time of failure.

Geostudio 2019 - SLOPE/W limit equilibrium software was used to conduct the analyses.

Figure 6-1 presents the results of the analyses.

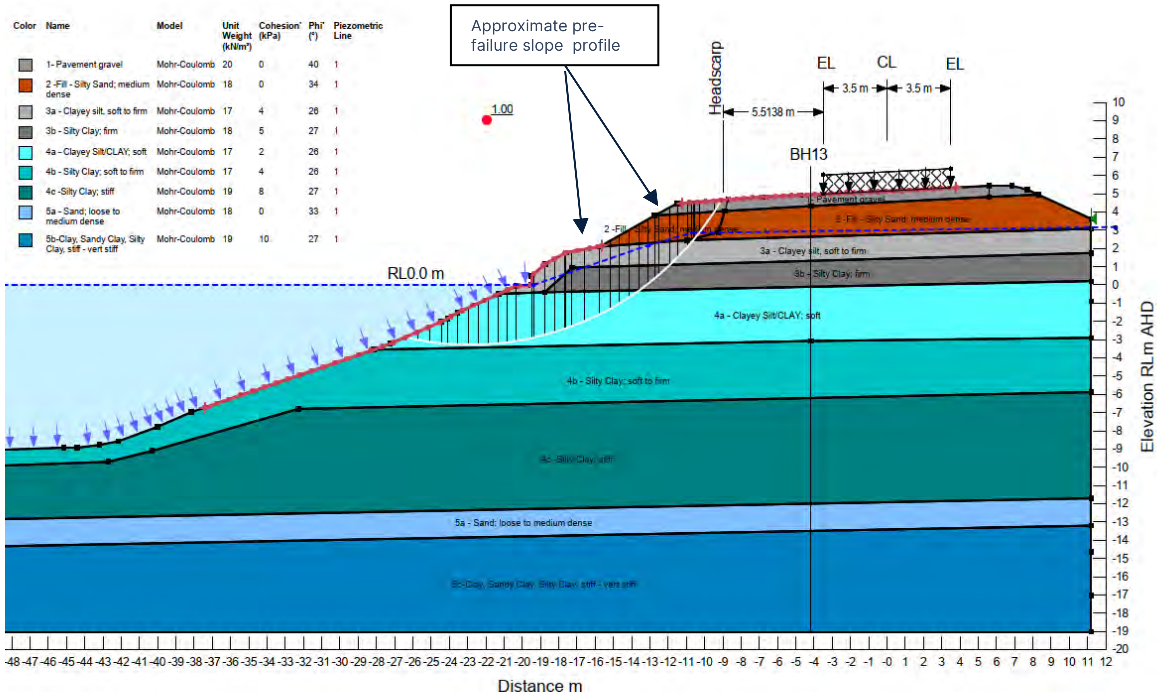


Figure 6-1 Slope/W Back Analysis Output

The analysis shows that the critical slip surface aligns close to the actual headscarp and exits the slope through the inferred soft clay layer at approximately RL-3 m. This failure mode is consistent with Hazard 3 – deeper seated slip.

Groundwater levels were modelled at RL0.0 m in the river and rising to approximately RL3.0 m within the embankment. The slope stability analyses is sensitive to water levels.

6.2.2 Stability of Road Embankment

Figure 6- 2 below shows presents the Slope/W analyses for the slumped riverbank profile at cross section B-B.

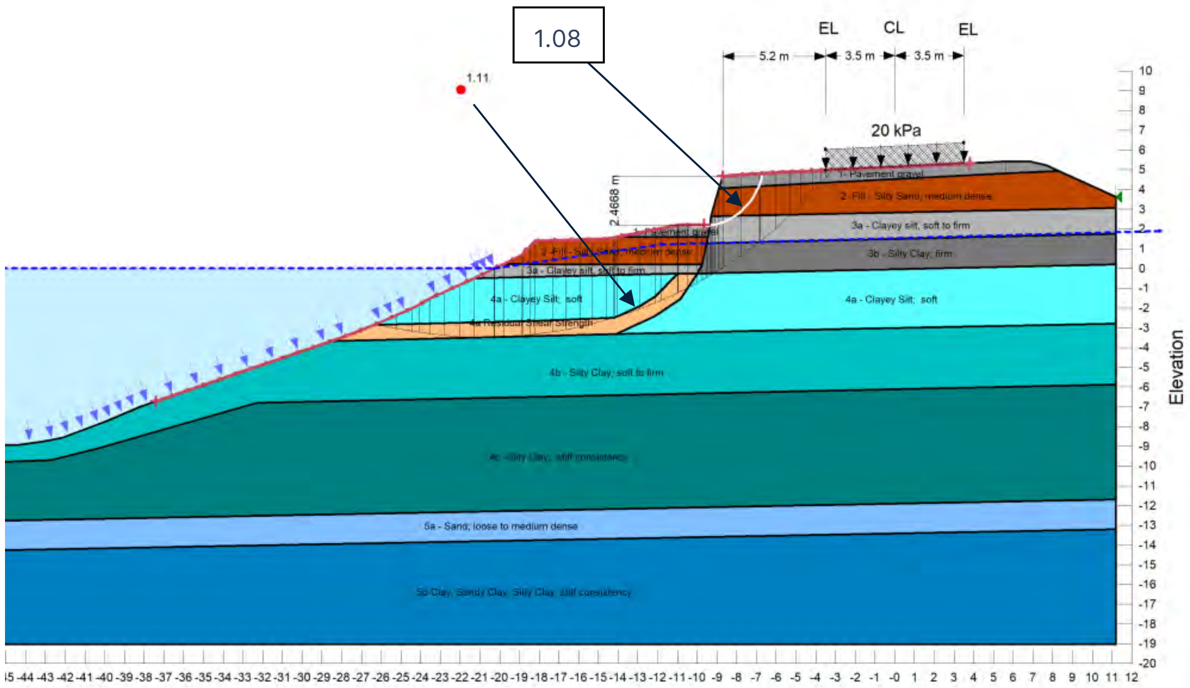


Figure 6-2 Slope/W Output for Slumped Riverbank Profile

The stability analyses for the slip profile indicates low factors of safety (1.08) for slip surfaces extending back behind the headscarp and low factors of safety (1.11) for deeper slide surfaces reaching the carriageway. These deeper slide surfaces are passing through an inferred shear zone modelled with residual shear strength parameters. The analyses is sensitive to assumed groundwater levels.

7 Preliminary Durability Assessment

7.1 Previous Durability Assessments

Reference has been made to the 2010 durability and corrosion assessment report prepared for the steel sheet piles installed at the adjacent slip site. The corrosion assessment assumed the water to be brackish and predicted the following corrosion rates for steel sheet piles.

Table 7-1: Corrosion Rates for Steel Sheet Piles

Exposure Zone	Exposure Classification	Corrosion Rate (mm/ year)	Comment
In soil, above groundwater	Mild	0.01 – 0.02	AS2159 Exposure classification assessed from limited lab testing to be non-aggressive. However, given the different soil horizons and the possibility of SRB, this has conservatively been raised to “Mild” above groundwater.
In soil, in groundwater	Moderate	0.02 – 0.04	AS2159 Exposure classification assessed from limited lab testing to be mild. However, given the different soil horizons and the possibility of SRB, this has conservatively been raised to “Moderate” in groundwater.
In rock fill, atmospheric exposure	Medium	0.025 – 0.05	“Medium” (C3) as per AS 4312 (2008)
In rock fill, tidal Exposure	Very Severe	0.1	AS2159 Exposure classification “Very Severe” in seawater tidal/splash zone.
In rock fill, submerged	Severe	0.04	AS2159 Exposure classification “Severe” for piles submerged in seawater

The following table summarises the estimated corrosion losses per exposed face for untreated steel for a 50 and 100 year design life.

Table 7-2: Estimated Corrosion Per Exposed Face

Exposure Zone	Exposure Classification	Assumed Corrosion Rates (mm/ year)	50 year Corrosion (mm)	100 year Corrosion (mm)
In soil, above groundwater	Mild	0.02	1	2
In soil, in groundwater	Moderate	0.04	2	4
Atmospheric exposure	Medium	0.04	2	4
Tidal Exposure	Very Severe	0.1	5	10
Submerged	Severe	0.04	2	4

7.2 Aggressivity Testing

One aggressivity test was carried out on a soil sample (BH12: 7.0m – 7.45m depth, Silty Clay). Compared AS2159-2009, the results of the aggressivity test indicate a **non-aggressive** exposure classification for steel and concrete piles embedded in the soil.

However, as indicated in section 6.2.1, other considerations are likely to govern the exposure classification for this site.

7.3 Acid Sulfate Soils

One acid sulfate soil test was carried out on a soil sample (BH12: 5.5m – 5.95m depth, Sandy Clayey Silt). The laboratory test results were Net Acidity = 462 mol H^+/t. This exceeds recommended guidelines, triggering the need for an acid sulfate management plan if soil disturbance is proposed.

Disturbance to acid sulfate soils may also influence corrosion rates.

7.4 Corrosion Rates for Concept Design

For concept design, SMEC has adopted the corrosion rates per exposed face presented in Table 7-2.

8 Concept Slope Remediation Options

8.1 Design Criteria

8.1.1 Purpose

The purpose of the concept remediation options are to investigate feasible alternative design solutions to primarily protect Big River Way from further regression of the slip. As per the project brief, consideration has been given to three piled solutions and an alternative structural solution.

8.1.2 Design Life

In accordance with the project brief, the remediation works are to achieve a minimum design life of 50 years. Consideration has also been given to solutions that can achieve a 100 year design life.

8.1.3 Global Stability Factor of Safety

Reference to TfNSW technical Direction GTD 2018/001 | TfNSW 18.748 – "Geotechnical design for Remediation of Existing Slopes and Embankments" 22 February 2018, the recommended factors of safety for different consequence classes are presented in Table 8-1.

Table 8-1 Factor of Safety (FOS) for different consequence class scenarios

Consequence Class	C1	C2	C3	C4	C5
Long Term FOS	1.5	1.4	**1.3**	1.25	1.25
Short Term FOS	1.25	1.25	**1.2**	1.2	1.2

In accordance with the contract, a long-term FOS of 1.3, a short-term FOS of 1.2 has been targeted in design remediation for a Consequence Class C3 slope.

8.1.4 Design Loading

The following design loads have been considered for concept design:

- Long term, 20 kPa vertical traffic live load applied to carriageway, breakdown lane and shoulder.
- Variable short term, 30 + kPa vertical live loads to represent construction plant such as a piling rig or crane.

8.2 Option 1A – Cantilever Sheet Piled Retaining Wall

8.2.1 Summary

Concept Option 1A seeks to retain the road embankment by installing a row of cantilevered steel sheetpiles along the alignment of the existing slip headscarp. The approximately length of the wall is 42 m and comprises AZ46-700N sheetpiles, at least 16 m length, embedded within the stiff clays.

The following Figure 8-1 presents a sketch layout of Option 1A.

Concept sketches showing Option 1A are presented in Appendix B.

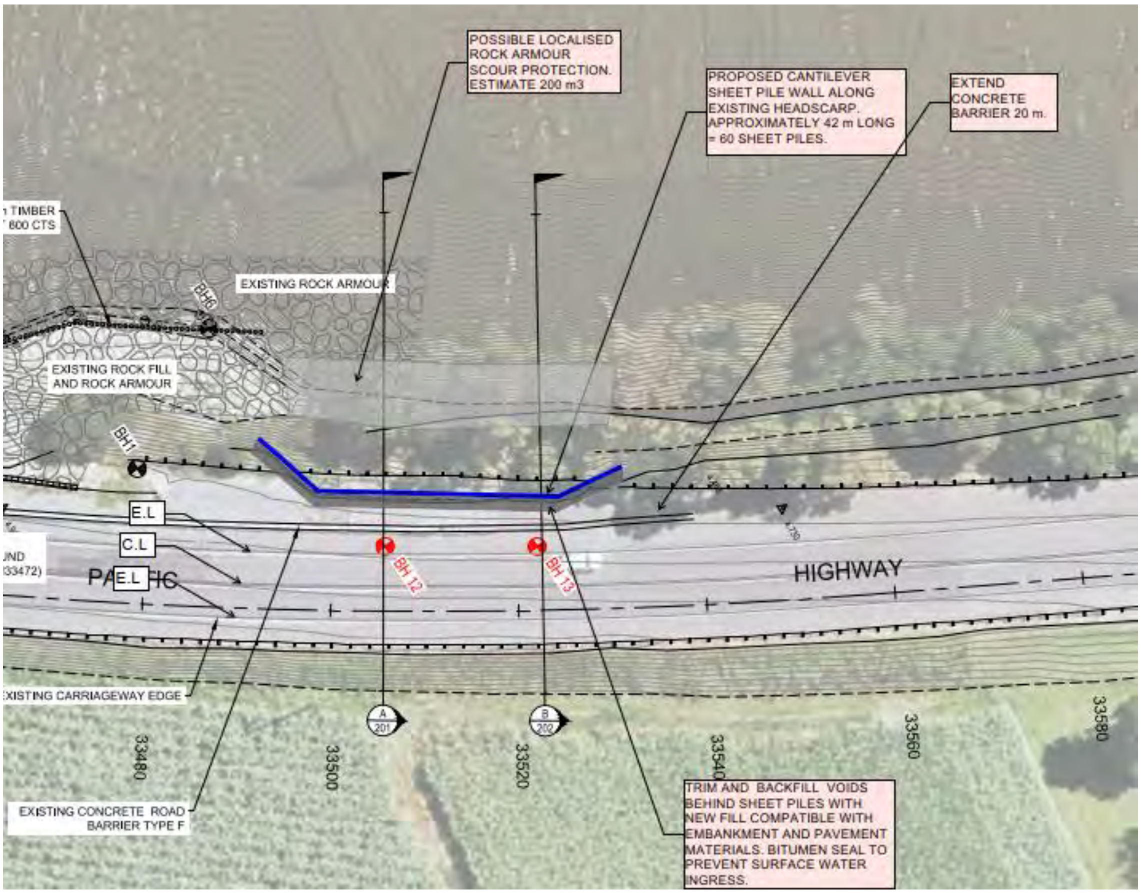


Figure 8-1 Sketch layout of Option 1A

8.2.2 Analysis and Results

8.2.2.1 Preliminary Design Life Assessment

Based on the predicted corrosion rates presented in Table 6-2, the steel sheetpiles will struggle to achieve a 100 year design life without robust corrosion treatment. However, a 50 year design life is considered achievable with allowance for sacrificial steel for corrosion.

The geotechnical assessment discussed in following sections has indicated a AZ24-700N sheet pile to be satisfactory. Allowing for corrosion in the critical tidal splash zone, a total of 7 mm of sacrificial steel thickness is assessed. A corresponding thicker AZ46-700N sheetpile is therefore proposed.

8.2.2.2 Scour Considerations

Consideration has been given to continued slumping, scour and erosion of the slip mass and riverbank located below the sheet piles. The inferred long term riverbank profile in front of the sheetpiles is presented on the sketch cross sections. This results in an estimated long term retained height of approximately 3.5 m.

Localised rock armour treatment within the undercut tidal zone has been proposed.

8.2.2.3 Geotechnical Assessment

Wallap Analysis

WALLAP retaining wall analysis software has been used to assess performance of the cantilever sheet piles.

- AZ24-700N sheet piles were modelled at 16 m long, pile toe elevation = RL-11 m.
- A uniform 20 kPa surcharge was applied, setback 2 m from the rear face of the wall.

The results of the analyses are summarised in the following table and the Wallap output is presented in Appendix C.

Table 8-2: Summary of Wallap Analyses

Scenario	Calculated Factor of Safety	Calculated Bending Moment (kNm)	Calculated Pile Head Deflection (mm)
Drained Analyses – water level RL0 m in river, RL 0 m in embankment.	1.53	66	29
Drained Analyses – water level RL0 m in river, RL 1m in embankment	1.47	84	54
Drained Analyses – water level RL0 m in river, RL2m in embankment	1.40	120	100
Drained Analyses – water level RL0 m in river, RL3m in embankment	1.31	204	195

Relatively large sheetpile displacements are calculated at high differential groundwater levels. Drainage could be incorporated behind the wall to reduce the likelihood of prolonged high differential groundwater levels and associated high sheetpile deflections.

Drainage behind the sheetpiles could comprise a drainage aggregate layer wrapped in geotextile with perforated subsoil drainage pipes discharging beyond the end of the wall or through the face of the wall. Alternately, a row of closely spaced weep holes with removable filter drains could be installed through the face of the sheet pile wall to dissipate water pressures behind the wall.

Drainage measures could

Slope Stability Analyses

SLOPE/W limit equilibrium software has been used to assess the stability of the embankment under short term construction loading at various setback distances.

The results of the analyses are summarised in the following table and example output is presented below.

Table 8-3: Summary of Slope Stability Analyses

Scenario	Surcharge Load (kPa)	Horizontal Setback from Headscarp (m)	Calculated Factor of Safety
Undrained Analyses - short term construction surcharge (ignoring sheet piles)	20	3.0	1.2
	35	3.0	1.2
	40	4.2	1.2

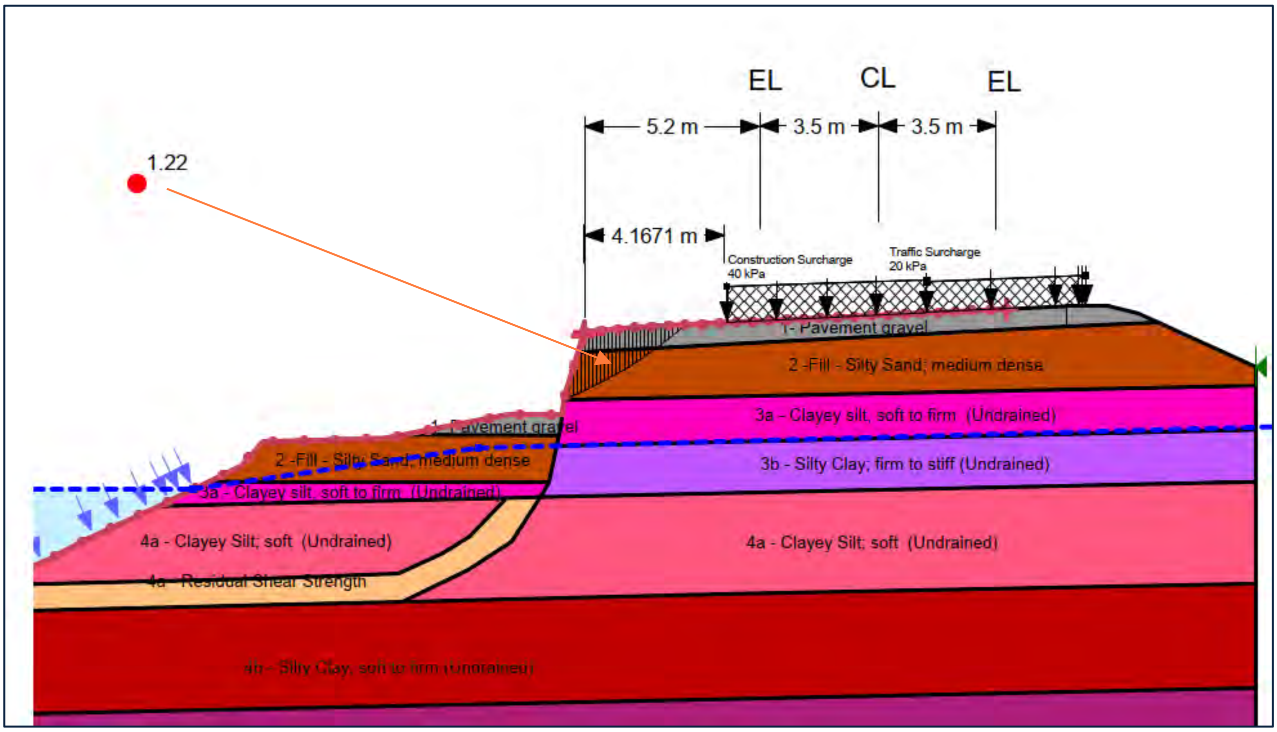


Figure 8-2 Slope/W output showing critical 4.2 m setback distance for 40 kPa surcharge load

8.2.2.4 Preliminary Structural Assessment

Allowing for sacrificial corrosion equivalent to AZ24-700N Grade 270GP sheetpile properties, the assessed design bending moment capacity = 0.9 x 656 = 590 kNm/m which exceeds the design bending moment action.

8.2.3 Anticipated Construction Sequence

The following construction sequence is anticipated for the sheetpiles:

1. Set up traffic control, close northbound lane.
2. Construct temporary working platform for excavator mounted or crane mounted sheet piling rig.
3. Install sheet piles using hydraulic impact hammer or vibratory hammers. The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration should be given to alternate installation methods such as jacking.
4. Install drainage behind wall, fill voids and reinstate pavement and bitumen wearing course to prevent surface water ingress.
5. Extend concrete safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

8.2.4 Maintenance and Monitoring Considerations

- Monitoring of sheet pile deflections is recommended to compare with design estimates.
- Monitor, repair and sealing of tension cracks that may form in the shoulder as a result of sheetpile wall deflections.
- Monitoring of corrosion and maintenance to any proposed corrosion treatments. Sheet pile thickness would need to be measured periodically, say every 3 to 5 years to compare corrosion rates against design assumptions. Localised excavation would likely be required in front of the sheet piles to enable measurements to be undertaken using ultrasonic gauges within the tidal zone where corrosion rate are expected to be greatest. A corrosion monitoring and maintenance plan would need to be developed. Corrosion treatment could also be applied to the upper 7 m section of sheet piles to protect against corrosion in the critical zones.

- Maintenance and monitoring of riverbank profile in front of sheetpile wall. If the retained height exceeds approximately 3.5 m, rock fill and rock armour may need to be placed to restore and maintain passive support to wall.

8.2.5 Considerations for Detailed Design

- Finite element analysis to model anticipated construction sequence, assess the soil-structure interaction, structural design actions and deflections.
- Detailing of measures to control sheet pile deflections to within acceptable limits such as incorporating drainage behind the wall.
- Consideration to corrosion treatments to achieve a 50+ year design life.
- Extent and staging of any proposed scour treatment to riverbank.

8.3 Option 1B – Anchored Sheet Piled Retaining Wall

8.3.1 Summary

Concept Option 1B seeks to retain and regain the failed embankment by installing a row of sheetpiles on the riverside of the headscarp, through the slip. In this location, the sheetpiles are supporting weak, slumped slip materials and are expected to require a row of anchors or tie bars to control displacements.

The concept design is a 40 m long sheet piled retaining wall comprising approximately 12 m long sheet piles. A second row of deadman sheetpiles (5 m long) are proposed to be located on the opposite side of the road, positioned to avoid buried services (Telstra and watermain). A row of steel tie bars anchor the retaining wall to the deadman via horizontal waler beams.

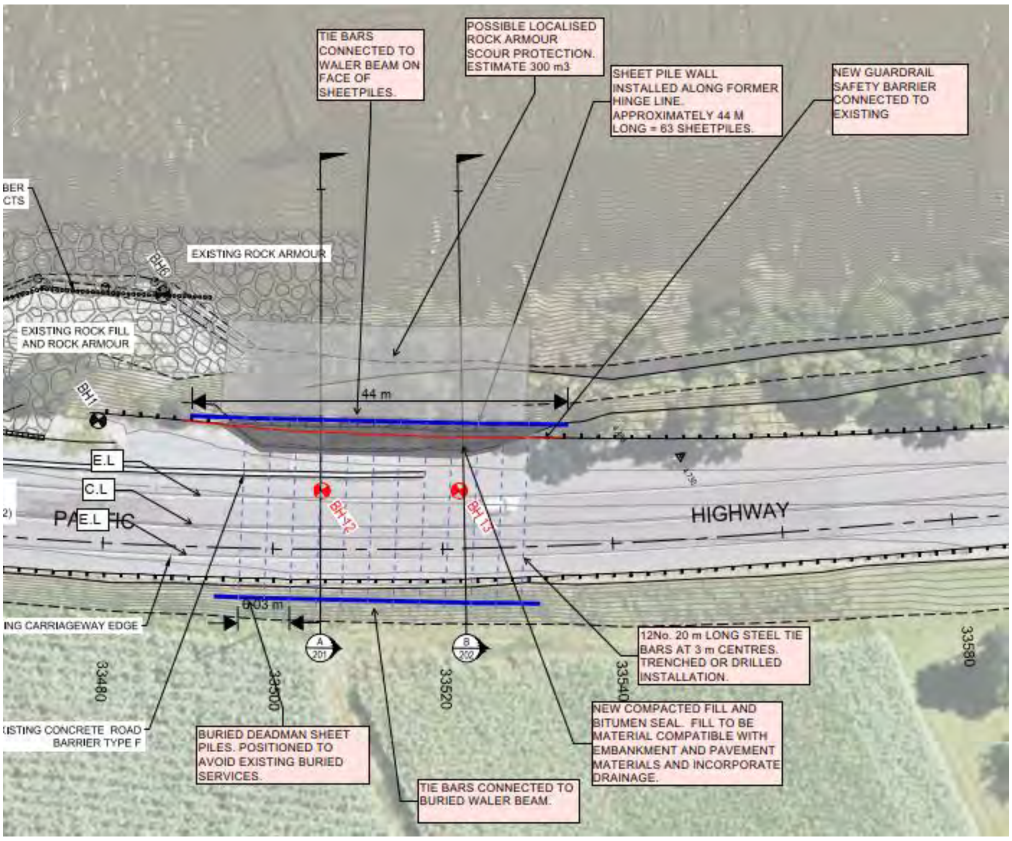


Figure 8-3 Sketch layout of Option 1B

Concept sketches showing Option 1B are presented in Appendix B.

8.3.2 Analysis and Results

8.3.2.1 Preliminary Design Life Assessment

A 50 year design life is considered achievable with a sacrificial steel allowance for corrosion. The geotechnical assessment discussed in following sections has indicated a AZ24-700N sheet pile to be satisfactory. Allowing for corrosion in the critical tidal splash zone, a total of 7 mm of sacrificial steel thickness is assessed. A thicker AZ46-700N sheetpile is proposed.

8.3.2.2 Scour Considerations

Similar to Option 1A with a 4 m high retained height considered.

8.3.2.3 Geotechnical Assessment

Wallap Analysis

WALLAP retaining wall analysis software has been used to assess performance of the cantilever sheet piles.

- AZ24-700N sheet piles were modelled at 12 m long, pile toe elevation = RL-7.0 m.
- A uniform 20 kPa surcharge was applied, setback 2 m from the rear face of the wall.

The results of the analyses are summarised in the following table and the Wallap output is presented in Appendix C.

Table 8-4: Summary of Wallap Analyses

Scenario	Calculated Factor of Safety	Calculated Bending Moment (kNm/m)	Calculated Pile Deflection (mm)	Anchor Force (kN/m run)
Drained Analyses – water level RL0 m in river, RL 0 m in embankment. Anchors installed.	1.83	64	17	53.3
Drained Analyses – water level RL0 m in river, RL 1m in embankment. Anchors installed.	1.76	94	13	63.0
Drained Analyses – water level RL0 m in river, RL2 m in embankment. Anchors installed.	1.69	139	20	79.0
Drained Analyses – water level RL0 m in river, RL3 m in embankment. Anchors installed.	1.61	190	32	102.6

Drainage could be installed behind the sheetpiles to control water levels and could comprise a drainage aggregate layer wrapped in geotextile with perforated subsoil drainage pipes discharging beyond the end of the wall or through the face of the wall. Alternatively, a row of closely spaced weep holes with removable filter drains could be installed through the face of the sheet pile wall.

Slope Stability Analyses

SLOPE/W limit equilibrium software has been used to assess the stability of the embankment under short term construction loading at various setback distances. Refer previous Table 8.3.

Option 1B requires the sheet piles to be installed below the existing headscarp, through unstable slip material. To maintain safe setback distances from the unstable slip headscarp, a large crane with hammer attachment is expected to be required to install the piles.

8.3.2.4 Preliminary Structural Assessment

Allowing for sacrificial corrosion equivalent to AZ24-700N Grade 270GP sheetpile properties, the assessed design bending moment capacity = 0.9 x 656 = 590 kNm/m which exceeds the design bending moment action.

Based on the assessed anchor forces, the concept design requires 38 mm diameter steel anchor bars at 3 m centres, connected to AZ36-700N deadman sheetpiles. The deadman sheet piles are required to be embedded 5 m deep to develop the requisite passive resistance. A factor of safety of 3 has been incorporated into the assessment of the passive pressure.

8.3.3 Anticipated Construction Sequence

The anticipated construction sequence for the sheetpiles is as follows:

1. Set up traffic control, close northbound lane.
2. Construct temporary working platform for specialist large excavator or crane mounted sheet piling rig.
3. Install sheet piles using hydraulic impact hammer or vibratory hammers. The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration should be given to alternate installation methods such as jacking.
4. Construct new fill behind sheet pile wall.
5. Switch traffic, close southbound lane.
6. Construct temporary working platform.
7. Install deadman sheet piles.
8. Install tie rods either by drilling or trenching.
9. Install waler beams and connect tie rods.
10. Repair/reinstate pavements.
11. Install new guardrail safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

8.3.4 Maintenance and Monitoring Considerations

- Monitoring of sheet pile deflections recommended to compare with design estimates.
- Monitor, repair and sealing of tension cracks that may form in the shoulder as a result of sheetpile wall deflections.
- Monitoring of corrosion and maintenance to any proposed corrosion treatments. Monitoring of corrosion and maintenance to any proposed corrosion treatments. Sheet pile and waler thicknesses would need to be measured periodically, say every 3 to 5 years to compare corrosion rates against design assumptions. Localised excavation would likely be required in front of the sheet piles to enable measurements to be undertaken using ultrasonic gauges within the tidal zone where corrosion rate are expected to be greatest. A corrosion monitoring and maintenance plan would need to be developed. Corrosion treatment could also be applied to the upper 7 m section of sheet piles to protect against corrosion in the critical zones.
- Monitoring riverbank profile in front of sheetpile wall. If retained height exceeds approximately 4 m, rock fill/rock armour may need to be placed to maintain passive support in front of the wall.

8.3.5 Considerations for Detailed Design

- Finite element analysis to model anticipated construction sequence, assess the soil-structure interaction, structural design actions and deflections.
- Detailed assessment of corrosion rates and any necessary corrosion treatments to achieve a minimum 50 year design life.
- Extent and staging of any proposed scour treatment to riverbank.
- Location of buried services (Watermain and Telstra) in relation to deadman sheetpiles and anchors.

8.4 Option 2 – Contiguous Pile Wall

8.4.1 Summary

Concept Option 2 seeks to retain the road embankment by installing a row of contiguous piles. The piles are proposed to be installed using a continuous flight auger (CFA) drilling rig. Alternately, driven steel tubular piles (possibly interlocked) may be installed and the upper 7 m to 10 m could be excavated and replaced with reinforced concrete for durability.

The approximately length of the wall is 42 m and comprises 750 mm diameter piles at close (1200 mm to 1400 mm) centres. The piles are proposed to be positioned approximately 1.5 m back from the existing headscarp, primarily to allow the piles to be installed without further temporary stability or casing requirements. The headscarp is proposed to be battered and rock armoured.

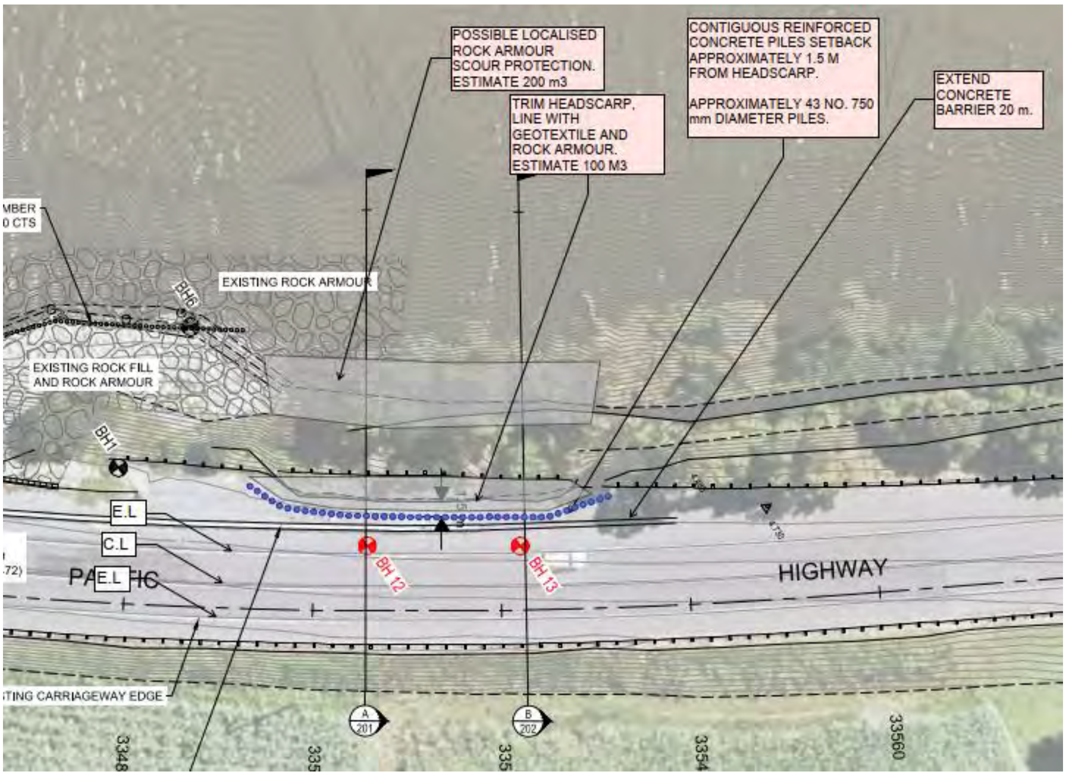


Figure 8-4 Sketch layout of Option 2

Concept sketches showing Option 2 are presented in Appendix D.

8.4.2 Analysis and Results

8.4.2.1 Preliminary Design Life Assessment

A 100 year design life is considered achievable with reinforced concrete piles.

8.4.2.2 Scour Considerations

Consideration has been given to continued slumping, scour and erosion of the slip mass located below the row of piles. The inferred long term embankment and riverbank profile in front of the piles is presented on the sketch cross sections and a retained height of approximately 3.5 m is estimated.

Allowance for some localised rock armour treatment near the tidal zone has been included in the concept. Trimming and rock armouring to the headscarp is also proposed.

8.4.2.3 Geotechnical Assessment

Wallap Analysis

WALLAP retaining wall analysis software has been used to assess performance of the cantilever sheet piles.

- 750 mm diameter, reinforced concrete piles were modelled, 17 m long with pile toe at RL-12 m.
- A uniform 20 kPa surcharge was applied, setback 1 m from the rear face of the wall.

The results of the analyses are summarised in the following table and the Wallap output is presented in Appendix E.

Table 8-5: Summary of Wallap Analyses

Scenario	Calculated Factor of Safety	Calculated Bending Moment (kNm)	Calculated Pile Head Deflection (mm)
Drained Analyses – water level RL0 m in river, RL 0 m in embankment.	1.56	168	26
Drained Analyses – water level RL0 m in river, RL 1m in embankment	1.50	193	40
Drained Analyses – water level RL0 m in river, RL2m in embankment	1.43	245	61
Drained Analyses – water level RL0 m in river, RL3m in embankment	1.35	337	95

Slope Stability Analyses

SLOPE/W limit equilibrium software has been used to assess the stability of the embankment under short term construction loading and associated setback distances.

The results of the analyses are summarised in the following table and the output is presented in Appendix E.

8.4.2.4 Structural Assessment

Pile reinforcement cage requirements have not been assessed as part of the concept design.

8.4.3 Anticipated Construction Sequence

The following construction sequence is anticipated for the sheetpiles:

1. Set up traffic control, close northbound lane.
2. Excavate and batter back headscarp.
3. Construct temporary working platform for CFA piling rig. CFA piling rigs typically have high track bearing pressures in the order of 250 kPa to 350 kPa. One or two rows of sacrificial micropiles may be required to be installed beneath working platform to provide the necessary temporary stability.
4. Drill and install reinforced concrete piles in a predetermined sequence (E.g. every 4th pile).
5. Collect and transport pile spoil offsite for treatment (such as ASS liming treatment) and subsequent disposal.
6. Trim headscarp and apply rock armour to slope face and riverbank.
7. Extend concrete safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

8.4.4 Maintenance and Monitoring Considerations

- Monitor, repair and sealing of tension cracks that may form in the shoulder as a result of pile wall deflections.
- Monitoring riverbank profile in front of pile wall. If piles become exposed, rock armouring or local shotcrete treatment to soils in between piles may be required to prevent erosion and scour. If retained height exceeds approximately 3.5m, rock fill/rock armour may need to be placed to maintain passive support to wall.

8.4.5 Considerations for Detailed Design

- Finite element analysis to model anticipated construction sequence, assess the soil-structure interaction, structural design actions and deflections.
- Detailed assessment of cover and reinforcing requirements to achieve a 100 year design life.
- Extent and staging of any proposed scour treatment to riverbank.

8.5 Option 3 – Shear Piles and Rock Fill

8.5.1 Description

Concept Option 3 is similar to the adjacent, previous slip remediation. It seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower river bank and backfilling behind the piles with rock fill and rock armour to reinstate the slumped riverbank profile and prevent further slip regression towards the carriageway.

Figure 8 -4 presents the concept arrangement layout. Concept sketches showing Option 3 are presented in Appendix F.

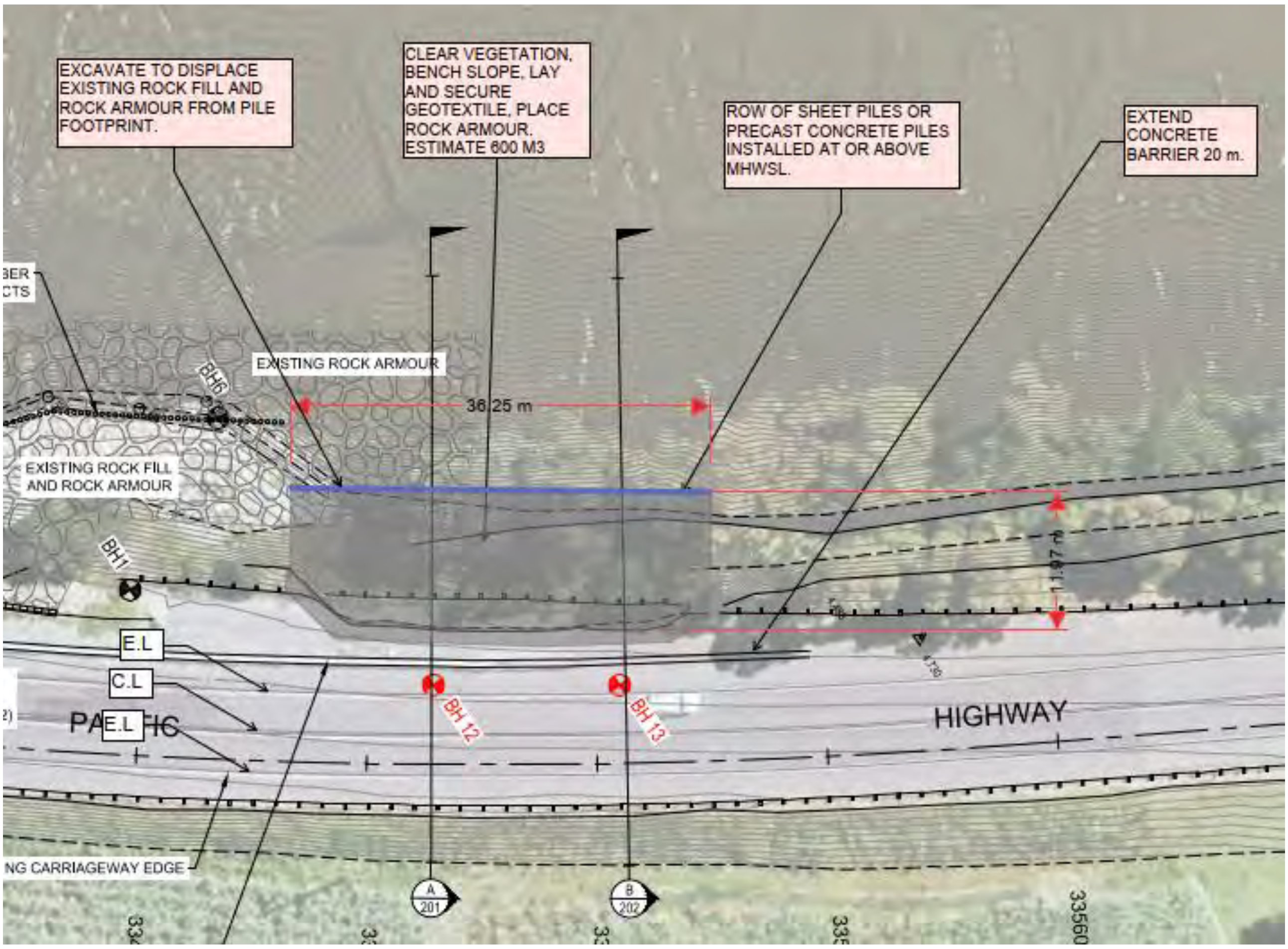


Figure 8-5 Sketch layout of Option 3

8.5.2 Analysis and Results

8.5.2.1 Preliminary Design Life Assessment

If sheet piles are used, a 50 year design life is expected to be achieved. Alternately, interlocking tubular steel piles could be used. If alternate precast reinforced concrete piles are adopted, a 100 year design life is expected for the piles.

8.5.2.2 Geotechnical Assessment

Slope Stability Analyses

SLOPE/W limit equilibrium software has been used to assess the stability of the embankment under short term and long term loading.

The results of the analyses are summarised in the following table and the output is presented in Appendix G.

Table 8-6: Summary of Slope Stability Analyses

Scenario	Calculated Factor of Safety	Shear Force (kN/m)
Undrained Analyses - short term - shear piles installed	1.38	90
Undrained Analyses - short term - shear piles and rock fill installed	1.39	
Drained Analyses – long term - shear piles and rock fill installed	1.33	

8.5.2.3 Structural Assessment

The Slope/W analyses indicates a 90kN pile shear force is required to achieve a long term factor of safety of at least 1.3.

At the adjacent slip site, SMEC previously designed similar timber shear piles supporting rock fill and rock armour. The 350 mm diameter timber shear piles were assessed to have a mobilised shear capacity of 96.7 kN per pile.

The proposed sheet piles or alternate reinforced concrete piles are expected to have similar or greater shear capacity and no further detailed assessment has been undertaken as part of this concept design stage.

8.5.3 Anticipated Construction Sequence

The following construction sequence is anticipated for this option:

1. Set out piles in river.
2. Mobilise a barge with a large excavator to excavate and displace existing rock fill and rock armour from the proposed pile footprint and obstructions to barge.
3. Mobilise a barge with pile driving rig to install the row of sheet piles or precast concrete piles. The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration should be given to hydraulic impact hammers rather than vibratory hammers.
4. Clear vegetation from riverbank and excavate terraces.
5. Lay and secure heavy duty geotextile.
6. Place rock fill and rock armour to slope commencing from behind the piles. Likely to require some rock fill to be placed from barge and/or a long reach excavator.
7. Extend concrete safety barrier.

8.5.4 Maintenance and Monitoring Considerations

- Monitoring of pile deflections recommended to compare with design estimates.
- Monitor, repair and sealing of cracks that may form in the shoulder as a result of settlement.
- Monitoring riverbank profile in front of shear piles. If retained height exceeds approximately 2.3m, rock fill/rock armour may need to be placed to maintain passive support to wall.

8.5.5 Considerations for Detailed Design

- Finite element analysis to model anticipated construction sequence, assess the soil-structure interaction, structural design actions and deflections.

- Detailed assessment of corrosion rates and corrosion treatments to achieve a minimum 50 year design life.
- Extent and staging of any proposed scour treatment to riverbank.

8.6 Option 4 - Micro Pile and Gabion Wall

8.6.1 Description

Concept Option 4 seeks to retain the road embankment with a gabion basket retaining wall founded on a piled raft footing. Two rows of precast, driven, reinforced concrete piles are proposed to be installed and connected to a reinforced concrete pad footing. The gabion baskets to be founded on the concrete raft footing constructed on top of the piles.

Temporary battered excavations are required to facilitate the construction of the reinforced concrete footing and gabion baskets. Figure 8-5 below shows the general layout of the gabion wall. Concept sketches showing Option 4 are presented in Appendix H.

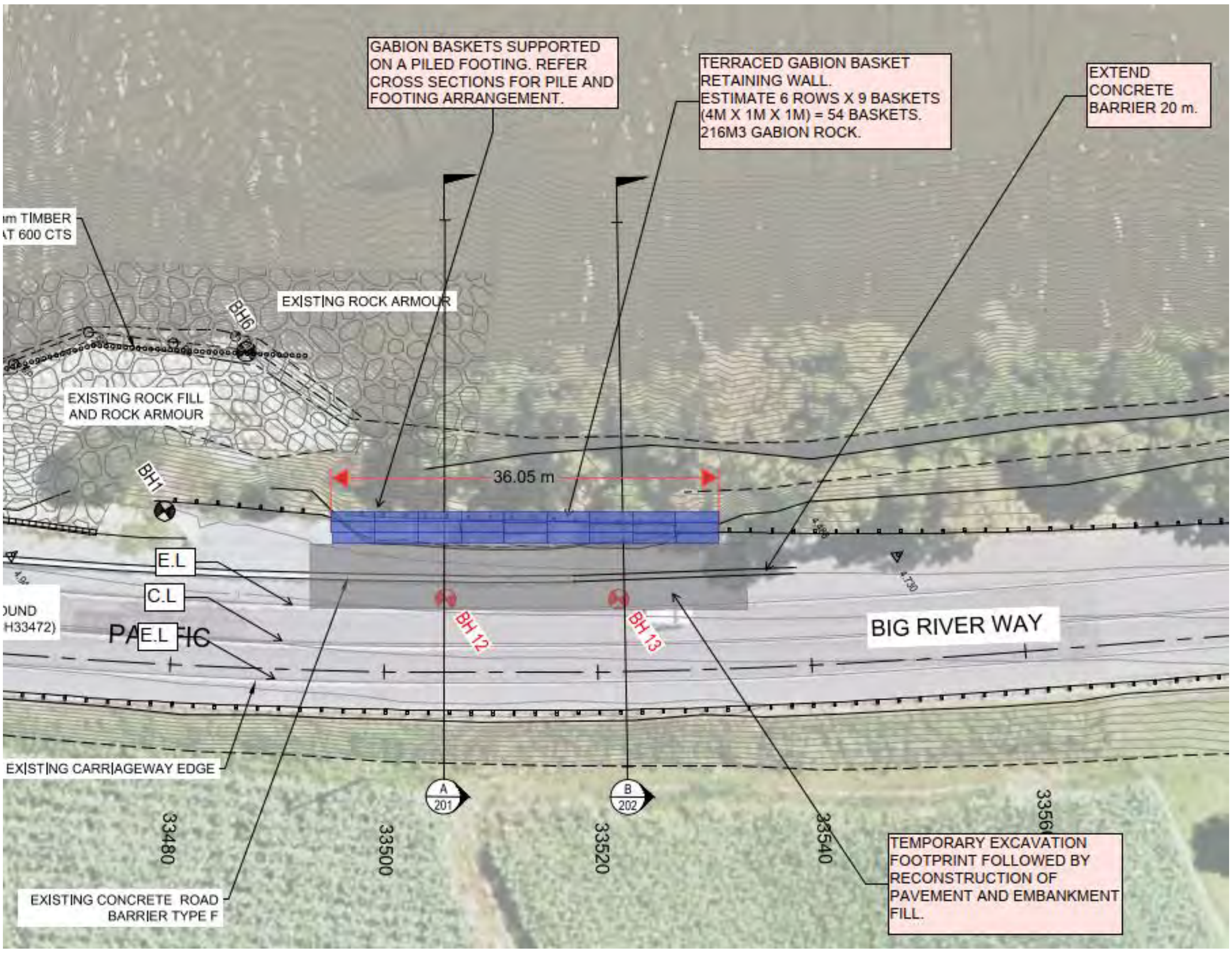


Figure 8-6 Sketch layout of Option 4

8.6.2 Analysis and Results

8.6.2.1 Preliminary Design Life Assessment

The piled foundation is expected to achieve a 100 year design life. The gabion baskets are expected to achieve a 50 year design life.

8.6.2.2 Geotechnical Assessment

Slope Stability Analyses

SLOPE/W limit equilibrium software has been used to assess the stability of the embankment under short term and long term loading.

The results of the analyses are summarised in the following table and the output is presented in Appendix I.

Table 8-7: Summary of Slope Stability Analyses

Scenario	Calculated Factor of Safety	Pile Shear Force (kN/m)
Undrained Analyses - short term - prior to installing piles.	1.22	N/A
Undrained Analyses - short term - piles installed.	1.36	70
Undrained Analyses - short term - temporary excavation batter	1.27	N/A
Drained Analyses – long term - shear piles gabion wall installed.	1.30	70

The proposed piles are designed support the weight of the gabion baskets and provide lateral shear restraint. The piles are required to found within the stiff clays to achieve the requisite axial capacity through a combination of skin friction and end bearing.

The Slope/W analyses indicates a 70 kN pile shear force is required to achieve a long term factor of safety of at least 1.3. Based on previous analyses undertaken at the adjacent slip site, at least 12 m long , 450 mm square reinforced concrete piles are expected to provide the necessary shear capacity and axial capacity, subject to further detailed analyses.

Sliding and Overturning Checks

Preliminary calculations have been carried out to check sliding and overturning stability of the proposed gabion wall structure founded upon a reinforced concrete foundation. The calculations were undertaken in accordance with AS5100.3:2017, adopting a geotechnical strength reduction factor of 0.55 and are presented in Appendix I. The calculations indicate the proposed geometry is adequate. However, to satisfy sliding stability, the concrete foundation must be roughened and potentially be inclined back towards the carriageway at 3 degrees. Further detailed calculations would be carried out as part of detailed design.

8.6.3 Anticipated Construction Sequence

The following construction sequence is anticipated for this option:

1. Set up traffic control, close northbound lane.
2. Excavate to facilitate piling.
3. Construct temporary working platform for excavator or crane mounted piling rig. Minimum 3 m setback required from slip headscarp.
4. Install driven piles.
5. Excavate temporary 2H:1V construction batter.

6. Construct reinforced concrete footing connected to piles.
7. Construct gabion basket retaining wall.
8. Fill in front and behind gabion wall. Rock armour on the river side to prevent undercutting of the piled raft and exposure of the mini piles
9. Reinstate pavement.
10. Extend concrete safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

8.6.4 Maintenance and Monitoring Considerations

- Monitoring riverbank profile in front of wall. If retained height exceeds approximately 3m, rock fill/rock armour may need to be placed to maintain passive support to wall.
- Monitor corrosion of gabion baskets and undertake repairs as necessary.

8.6.5 Considerations for Detailed Design

- Finite element analysis to model anticipated construction sequence, assess the soil-structure interaction, structural design actions and deflections.
- Detailed assessment of piled footing and reinforcement requirements.
- Detailed arrangement of gabion basket wall.
- Detailed assessment of corrosion rates and corrosion treatments to achieve a minimum 50 year design life.
- Extent and staging of any proposed scour treatment to riverbank.

8.7 Comparison of Options

SMEC has undertaken a weighted multicriteria assessment to compare the four concept slip remediation options. The assessment criteria and weightings were adopted from other TfNSW slope remediation projects and include design, construction, environmental, community and costing components.

The criteria weightings range from 10% to 30% and the criteria scores range from 1 (Very Poor) to 5 (Excellent).

The following Table 8-8 and Table 8-9 present the comparative assessment.

Table 8-8: Description of Options Against Criteria

Criteria	Descriptions				
	Option 1A - Cantilever Sheet Pile Wall	**Option 1B - Anchored Sheet Pile Wall**	**Option 2 - Contiguous Pile Wall**	**Option 3 – Shear Piles and Rock Fill**	**Option 4 – Gabion Wall and Piled Foundation**
Technical Merit					
Design life/durability	50 year design life expected with sacrificial corrosion allowance.	50 year design life expected with sacrificial corrosion allowance.	100 year design life expected with reinforced concrete.	50 to 100 year design life expected depending on type of shear piles.	100 year design life for foundation. 50 year design life for gabion walls.
Stability	GTD 2018/001 Factors of Safety met. Temporary stability requires minimum setbacks. Stability sensitive to groundwater levels and riverbank profile.	GTD 2018/001 Factors of Safety met. Temporary stability requires minimum setbacks. Stability less sensitive to fluctuating groundwater levels.	GTD 2018/001 Factors of Safety met. Temporary stability requires minimum setbacks and possibly micropiles.	GTD 2018/001 Factors of Safety met. Shear piles need to be accurately positioned.	GTD 2018/001 Factors of Safety met. Temporary stability requires minimum setbacks and battered excavations.
Construction					
Risks to Life	Temporary embankment stability. Heavy tracked plant and equipment. Vehicle movements.	Temporary embankment stability. Heavy tracked plant and equipment. Vehicle movements.	Temporary embankment stability. Heavy tracked plant and equipment. Vehicle movements. Deep excavations.	Temporary embankment stability. Working over water. Vehicle movements, plant roll over.	Temporary embankment and excavation stability. Tracked plant. Vehicle movements. Deep excavations.
Other Risks	Sheet pile driveability and adverse vibrations.	Sheet pile driveability and adverse vibrations. Proximity to buried services.	Quality assurance and control heavily reliant on contractor. Environmental contamination.	Existing rock fill in river obstructing pile driving. Excavation in riverbed. Manoeuvring barge to enable installation of piles above high tide level. Environmental contamination from earthworks. Rock fill transition zones.	Manual handling injuries, slip, trips and falls. Existing rock fill in river obstructing pile driving.
Constructability	Relatively simple construction sequence that has been done previously on adjacent site.	Relatively complex construction sequence with additional stages and traffic switches.	Relatively simple construction sequence. Specialist and experienced CFA piling contractor required.	Construction requires both overwater and land based construction activities.	Construction requires several elements; precast piles, cast in-situ slab, earthworks, gabion baskets, gabion rock.

Criteria	Descriptions				
	Option 1A - Cantilever Sheet Pile Wall	Option 1B - Anchored Sheet Pile Wall	Option 2 - Contiguous Pile Wall	Option 3 – Shear Piles and Rock Fill	Option 4 – Gabion Wall and Piled Foundation
Environment					
Impacts/ Footprint	Smallest disturbance footprint. Possible vegetation clearance and rock armouring (to be confirmed).	Relatively small disturbance footprint. Additional excavation for anchors and waler beams. Possible vegetation clearance and rock armouring (to be confirmed).	Relatively small disturbance footprint. However, a moderate volume of pile spoil (soils and water mixtures) will be displaced and requires collection, possible treatment and disposal.	Relatively large disturbance footprint associated with rock fill and rock armour treatment to embankment and transition zones.	Moderate disturbance footprint involving excavation to construct gabion wall structure.
Long term including visual	Sheet pile wall face exposed and deflection predicted to occur. Sheet piles expected to be obscured by regenerating riverbank vegetation.	Sheet pile wall face and anchors exposed. Expected to be obscured by regenerating riverbank vegetation.	Initially buried. Piles may become exposed with long term erosion and scour.	Shear piles and rock fill exposed. Similar visual appearance to adjacent slip remediation site.	Gabion wall structure visible.
Community Impacts During Construction					
Travel time	Minor delays due to lane closure.				
Road closure	Single northbound lane closure expected.	Single northbound and southbound lane closures expected.	Single northbound lane closure expected.	Single northbound lane closure expected.	Single northbound lane closure expected.
Property Access	Not expected to be required.				
Duration	Estimated at 2 weeks.	Estimated at 3 weeks.	Estimated at 3 weeks.	Estimated at 4 weeks.	Estimated at 4 weeks.
Noise	Not expected to be an issue here.				
Price					
Relative Construction Cost Estimate	$1.2 million	$1.3 million	$1.2 million	$1.0 million	$0.8 million

Table 8-9: Weighted Multicriteria Analysis

Criteria	Weighting (%)	Option 1a Cantilever Sheet Pile Wall		Option 1b Anchored Sheet Pile Wall		Option 2– Contiguous Pile Wall		Option 3 – Shear Piles And Rock Fill		Option 4 – Gabion Wall And Piled Footing		Comments
		Score (1 – 5)	Weighting % X Score	Score (1 – 5)	Weighting % X Score	Score (1 – 5)	Weighting % X Score	Score (1 – 5)	Weighting % X Score	Score (1 – 5)	Weighting % X Score	
Technical Merit (30%)												
Design life/ durability	**15%**	3	0.45	3	0.45	5	0.75	4	0.6	4	0.6	Option 3 expected to achieve highest design life. Option 2 scored lowest due to numerous steel components prone to corrosion.
Stability	**15%**	5	0.75	5	0.75	5	0.75	5	0.75	5	0.75	All options expected to achieve stability criteria.
Construction (20%)												
Risks to Life and Other Risks	**10%**	4	0.4	3	0.3	3	0.2	2	0.2	2	0.2	Option 2, 3 and 4 considered relatively high risk due to either working overwater, quality control, temporary/deep excavations.
Constructability	**10%**	5	0.5	4	0.4	4	0.4	3	0.3	2	0.2	Option 1a scored highest as has been done before on adjacent site. Option 3 and 4 scored lowest due to multiple construction activities.
Environment (20%)												
Impacts/ Footprint	**10%**	2	0.2	3	0.3	2	0.2	4	0.4	3	0.3	Options that seek to restore lost river bank (Option 1b, Option 3) now score higher.
Long term including visual	**10%**	2	0.2	2	0.2	3	0.3	4	0.4	3	0.3	Option 4 will blend in with adjacent slopes best.
Community Impacts During Construction (10%)												
Duration	**5%**	5	0.25	3	0.15	3	0.15	2	0.1	2	0.1	Option 1A expected to be quickest to construct. Material supply delays not accounted for.
Road Closures	**5%**	4	0.2	2	0.1	3	0.15	3	0.15	3	0.15	Option 1B scored lowest due to additional disruptions to install tie bars.
Price (20%)												
Relative Construction Cost (Estimate)	**20%**	3	0.6	2	0.4	3	0.6	4	0.8	5	1	Relative cost estimate has Option 4 as cheapest and Option 1b as costliest.
TOTALS	**100%**	-	3.55	-	3.05	-	3.5	-	**3.7**	-	3.6	

Based on the comparative options assessment, Option 3 is considered the preferred option followed closely by Option 4 and Option 1.

9 Schedule of Quantities and Relative Cost Estimate

The schedule of quantities and relative cost estimates prepared for this concept options report have been prepared by engineers, not quantity surveyors and are estimates. A qualified and appropriately experienced quantity surveyor should be engaged to evaluate quantities and costs more accurately for budgeting purposes and appropriate contingency allowed.

It is our experience that factors outside the unit rate approach often override the projects final costs. These include:

- Site access and the contractors' approach to work on the site;
- Delays due to weather and rain;
- Project quality issues and contractor reliability;
- Variation of the ground conditions from those expected.

The schedules of quantities estimates and relative cost estimates are presented in Appendix J.

10 Safety in Design

The Principal should hold a Health Safety in Design (HSID) workshop with the Contractor and Designer (i.e. SMEC) prior to construction commencing to use a systematic risk based approach that includes the identification of hazards.

The Contractor should be aware of:

- The site is a slip and stability is marginal.
- Providing a safe work area for construction personnel;
- Traffic management to provide safe passage past the site for road users;
- General safety issues with working on slopes, and how they are to manage these risks.

An initial safety in design is presented in Appendix K.

11 Comments Register

The TfNSW comments register with SMEC responses is presented in Appendix M.

12 Conclusions and Recommendations

A 40 m long landslip has occurred resulting in slumping of the road embankment and terraced riverbank and a 2.5 m high headscarp that is regressing back towards the Byrons Lane carriageway. The interpreted geotechnical model and slope stability analyses indicates the failure mode is a relatively deep, circular failure passing through soft alluvial and estuarine clays. The failure mechanisms are inferred to be a combination of riverbank erosion and high differential water levels between the river and the embankment.

Four concept slope remediation options have been designed to achieve a minimum design life of 50 years, a long term slope stability factor of safety of at least 1.3 and a short term slope stability factor of safety of at least 1.2.

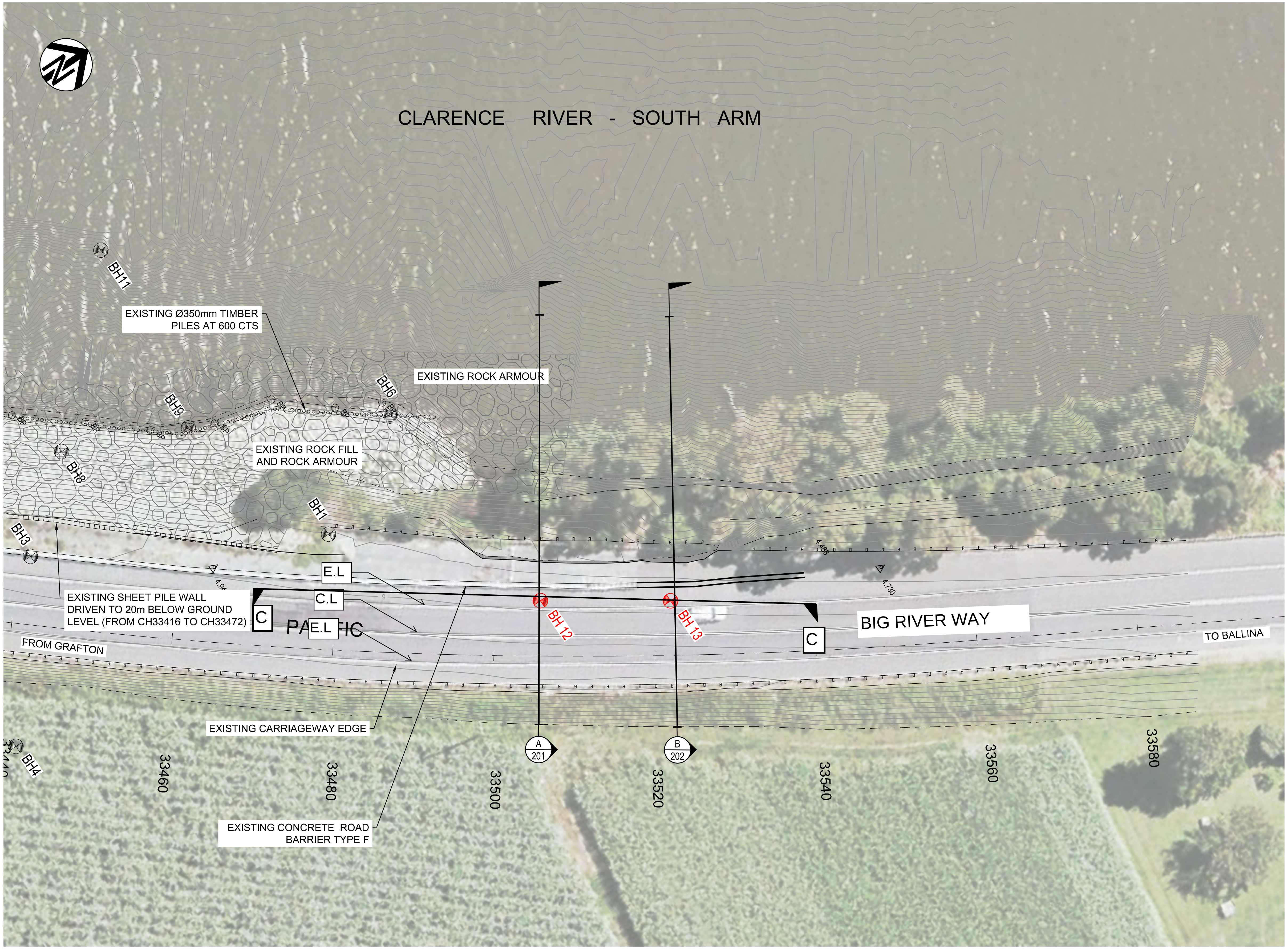
The options were evaluated using a weighted multicriteria analysis and Option 3 – Shear Piles and Rock Fill scored highest.

A key assumption in the concept design development was riverbank scour profiles. No scour assessment has been undertaken and estimated scour profiles were assumed in the concept designs. Reference to Figure 1 shows that the river is contracted at this location which might be influencing scour processes and riverbank instability.

The following is recommended to inform and support detailed design of the preferred concept:

- Undertake a scour assessment to inform design of remediation systems including predicted scour profiles and sizing of any proposed rock armour treatment.
- Finite element analysis to model anticipated construction sequence, assess the soil-structure interaction, structural design actions and deformations.
- Further assessment of corrosion rates and whether any necessary corrosion treatments or detailing is required to achieve a minimum 50 year design life or an alternate 100 year design life.
- Investigate the location of buried services including the abandoned watermain.
- Consideration to be given to additional site investigation comprising cone penetrometer testing (CPT) to provide further information on the strength, stiffness and variability of the sediments.
- Consideration to shifting the road away from the riverbank. This would involve clarification on actual pavement requirements through this section with a view to reducing the verge and carriageway widths and amending the scope of any proposed riverbank treatment with a view to reducing the design loads and project costs.

Appendix A Interpreted Geotechnical Model



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- BH 12 TfNSW BORE HOLE (2021)
- BH8 TfNSW BORE HOLE (2009)

SITE INVESTIGATION PLAN

NOT FOR CONSTRUCTION

THIS DRAWING MAY BE PREPARED IN COLOUR AND MAY BE INCOMPLETE IF COPIED

50mm ON A3 SIZE ORIGINAL

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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

PLOT DATE / TIME: 13 September 2021 03:15:40 PM

PLOT BY: TC13654

EXTERNAL REFERENCE FILES: X_RMS_NSW_CIVIL_A3, X_AERIAL, X_SURVEY, X_2014_BYRON_DES_CTRL, X_2014_DESIGN_30011433, X_LEGEND_GA

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
0	0	CONCEPT DESIGN	0	0

REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:500 (2.5 0 2.5 5.0 7.5 10 12.5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)

HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC — Member of the Surbana Jurong Group — ABN 47 065 475 149 — 52 VICTORIA STREET GRAFTON NSW 2460 — SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT (PRELIM / FINAL; INITIAL / DATE)

DISCIPLINE		
DISCIPLINE		
DISCIPLINE		
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CONFIRMED		

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 6

RMS REGISTRATION No. DS2021 / 00????

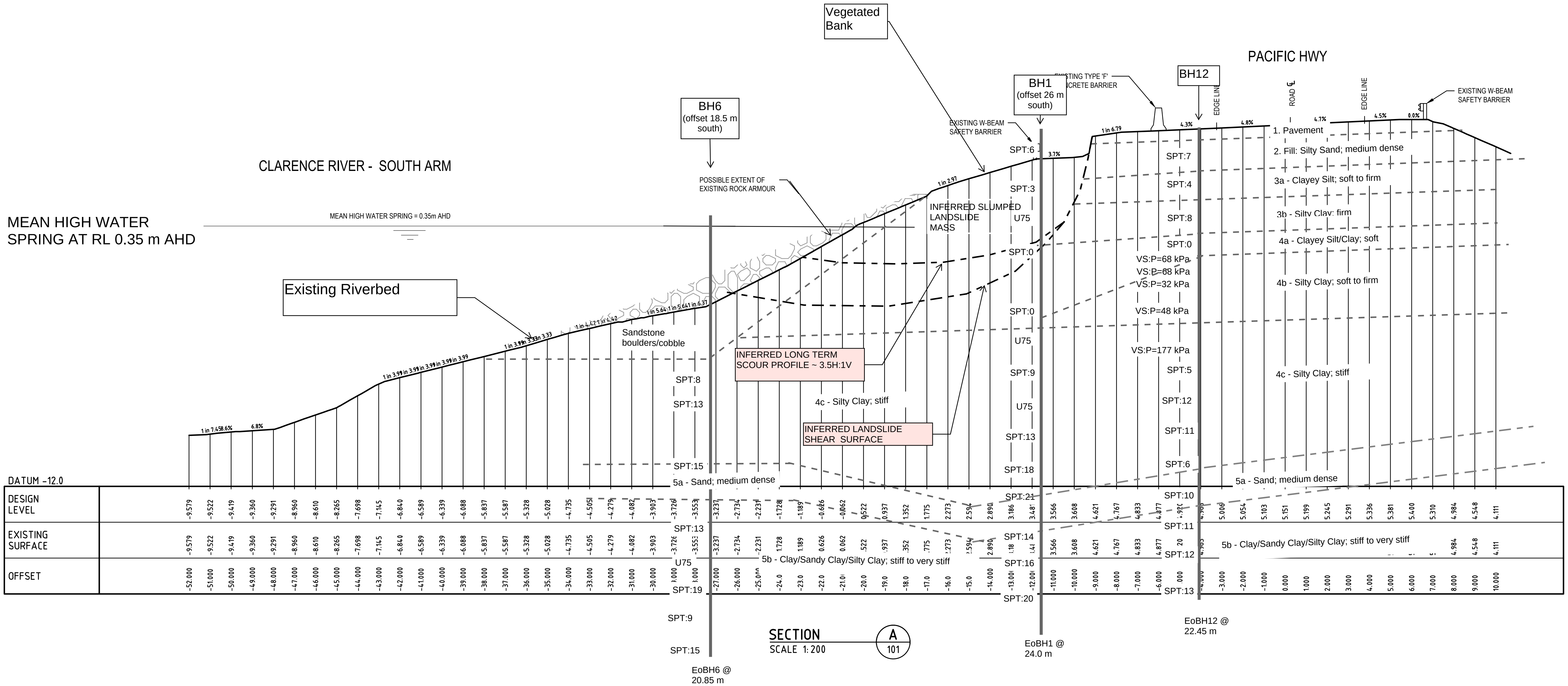
PART 1

ISSUE STATUS: CONCEPT DESIGN

EDMS No. DS2021 / 00????

SHEET No. GT-101

ISSUE #



DESIGN LEVEL	-9.579	-9.522	-9.419	-9.360	-9.291	-8.960	-8.610	-8.265	-7.698	-7.145	-6.840	-6.589	-6.339	-6.088	-5.837	-5.587
EXISTING SURFACE	-9.579	-9.522	-9.419	-9.360	-9.291	-8.960	-8.610	-8.265	-7.698	-7.145	-6.840	-6.589	-6.339	-6.088	-5.837	-5.587
OFFSET	-52.000	-51.000	-50.000	-49.000	-48.000	-47.000	-46.000	-45.000	-44.000	-43.000	-42.000	-41.000	-40.000	-39.000	-38.000	-37.000

DESIGN LEVEL	-5.328	-5.028	-4.735	-4.505	-4.279	-4.082	-3.903	-3.726	-3.553	-3.237	-2.734	-2.231	-1.728	-1.189	-0.626	-0.062
EXISTING SURFACE	-5.328	-5.028	-4.735	-4.505	-4.279	-4.082	-3.903	-3.726	-3.553	-3.237	-2.734	-2.231	1.728	1.189	0.626	0.062
OFFSET	-36.000	-35.000	-34.000	-33.000	-32.000	-31.000	-30.000	[illegible]	[illegible]	-27.000	-26.000	-25.000	-24.0	-23.0	-22.0	-21.0

DESIGN LEVEL	0.522	0.937	1.352	1.775	2.273	2.594	2.890	3.186	3.481	3.566	3.608	4.621	4.767	4.833	4.877	[illegible]
EXISTING SURFACE	.522	.937	.352	.775	2.273	2.594	2.890	[illegible]	[illegible]	3.566	3.608	4.621	4.767	4.833	4.877	[illegible]
OFFSET	-20.0	-19.0	-18.0	-17.0	-16.0	-15.0	-14.000	-13.000	-12.000	-11.000	-10.000	-9.000	-8.000	-7.000	-6.000	[illegible]

DESIGN LEVEL	[illegible]	5.006	5.054	5.103	5.151	5.199	5.245	5.291	5.336	5.381	5.400	5.310	4.984	4.548	4.111
EXISTING SURFACE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.984	4.548	4.111
OFFSET	-4.000	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.000

SECTION A / 101
SCALE 1:200

CROSS SECTION A-A - INFERRED GROUND MODEL

NOT FOR CONSTRUCTION

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DRAWING FILE LOCATION / NAME	DESIGN LOT CODE	DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING	PLOT DATE / TIME	PLOT BY
V:_Vault\Projects\3001\30013154\110_CADD\CAD\DWG\CI_Civil\30013154-CD-GT-201.dwg			13 September 2021 02:53:37 PM	TC13654

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 (1 0 1 2 3 4 5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC
Member of the Surbana Jurong Group
© ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT	PRELIM INITIAL	FINAL DATE
DISCIPLINE		
DISCIPLINE		
DISCIPLINE		
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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

A3

CROSS SECTION - SHEET 1

SHEET 5 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No. DS2021 / 00????
SHEET No. GT-201
ISSUE #

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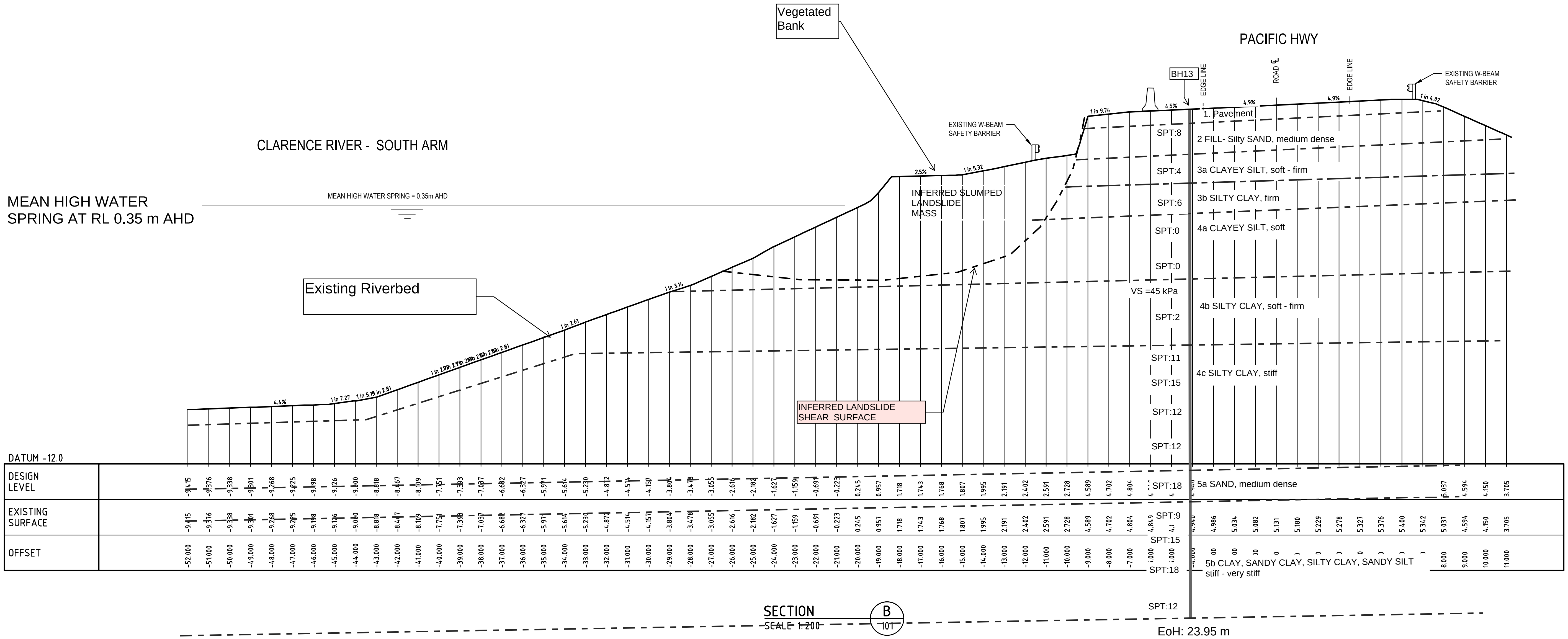
50mm ON A3 SIZE ORIGINAL



OFFSET	-52.000	-51.000	-50.000	-49.000	-48.000	-47.000	-46.000	-45.000	-44.000	-43.000	-42.000	-41.000	-40.000	-39.000	-38.000	-37.000
DESIGN LEVEL	-9.415	-9.376	-9.338	-9.301	-9.268	-9.225	-9.198	-9.126	-9.000	-8.818	-8.467	-8.109	-7.751	-7.393	-7.037	-6.682
EXISTING SURFACE	-9.415	-9.376	-9.338	-9.301	-9.268	-9.225	-9.198	-9.126	-9.000	-8.818	-8.467	-8.109	-7.751	-7.393	-7.037	-6.682

OFFSET	-36.000	-35.000	-34.000	-33.000	-32.000	-31.000	-30.000	-29.000	-28.000	-27.000	-26.000	-25.000	-24.000	-23.000	-22.000	-21.000
DESIGN LEVEL	-6.327	-5.971	-5.614	-5.230	-4.872	-4.514	-4.157	-3.804	-3.478	-3.055	-2.616	-2.182	-1.627	-1.159	-0.691	-0.223
EXISTING SURFACE	-6.327	-5.971	-5.614	-5.230	-4.872	-4.514	-4.157	-3.804	-3.478	-3.055	-2.616	-2.182	-1.627	-1.159	-0.691	-0.223

OFFSET	-20.000	-19.000	-18.000	-17.000	-16.000	-15.000	-14.000	-13.000	-12.000	-11.000	-10.000	-9.000	-8.000	-7.000	[illegible]	[illegible]
DESIGN LEVEL	0.245	0.957	1.718	1.743	1.768	1.807	1.995	2.191	2.402	2.591	2.728	4.589	4.702	4.804	[illegible]	[illegible]
EXISTING SURFACE	0.245	0.957	1.718	1.743	1.768	1.807	1.995	2.191	2.402	2.591	2.728	4.589	4.702	4.804	4.849	[illegible]

OFFSET	-4.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.000	9.000	10.000	11.000
DESIGN LEVEL	[illegible]												5.037	4.594	4.150	3.705
EXISTING SURFACE	4.940	4.986	5.034	5.082	5.131	5.180	5.229	5.278	5.327	5.376	5.400	5.342	5.037	4.594	4.150	3.705

CROSS SECTION B-B - INFERRED GROUND MODEL

NOT FOR CONSTRUCTION

DRAWING FILE LOCATION / NAME: V:_Vault\Projects\3001\30013154\110_CADD\CAD\DWG\CI_Civil\30013154-CD-GT-202.dwg	DESIGN LOT CODE	DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING	PLOT DATE / TIME: 13 September 2021 02:59:17 PM	PLOT BY: TC13654

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 (1 0 1 2 3 4 5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) — HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC
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© ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT	PRELIM / INITIAL	FINAL / DATE
DISCIPLINE		
DISCIPLINE		
DISCIPLINE		
BACKDRAFTED/CORRECTED		
CONFIRMED		

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

A3

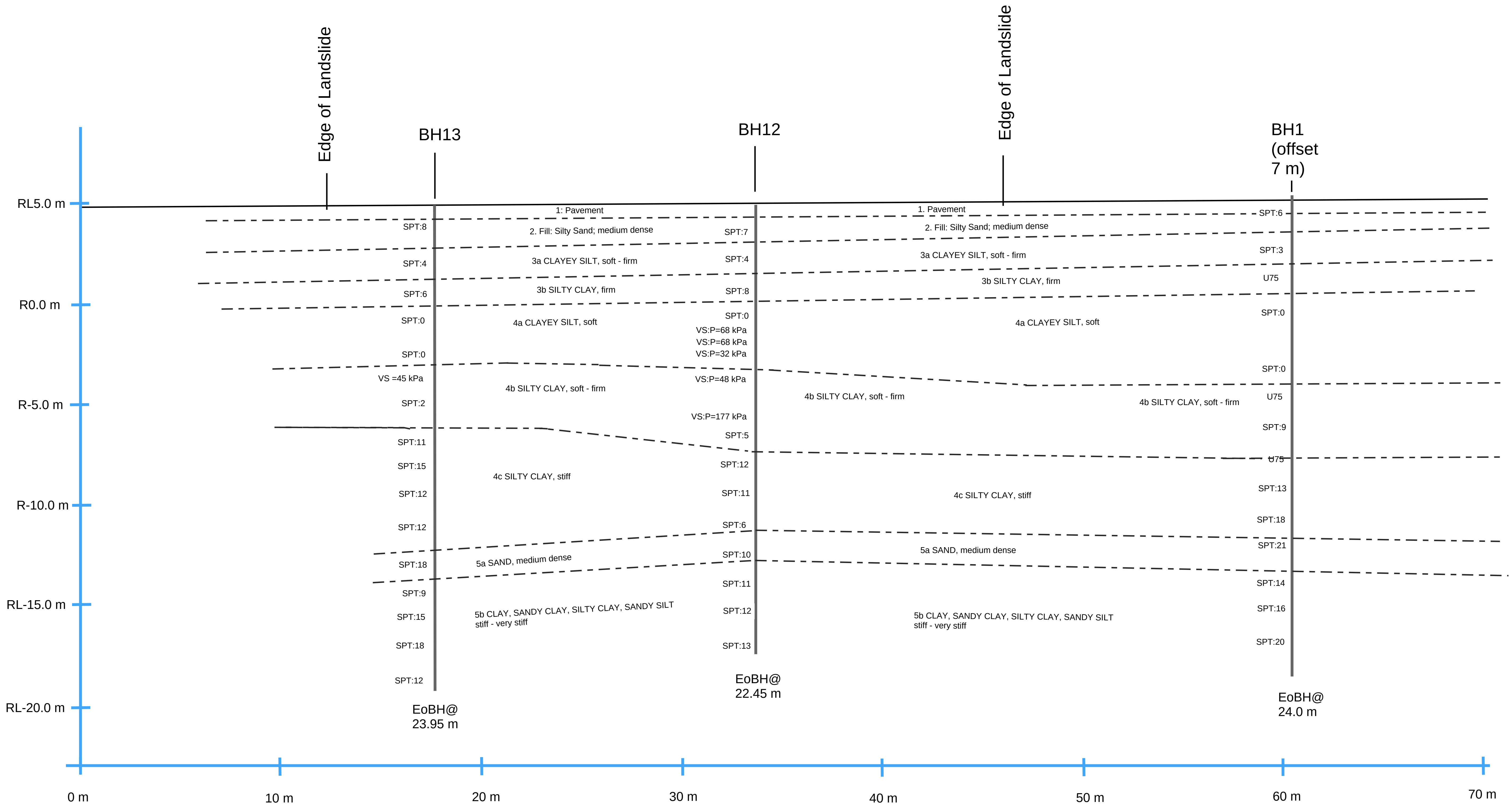
CROSS SECTION - SHEET 2

SHEET 6 OF 6

RMS REGISTRATION No. DS2021 / 00????

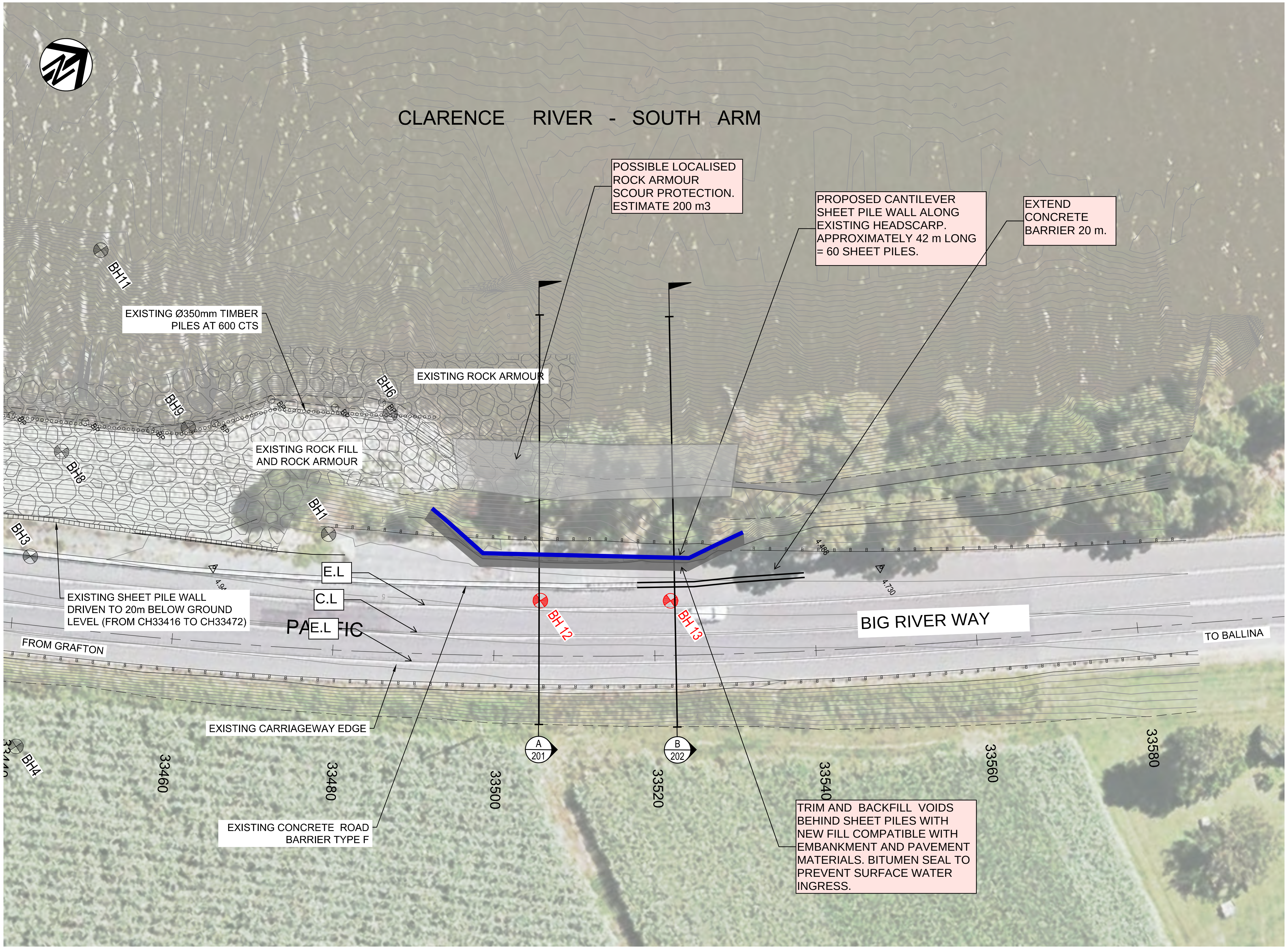
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No. DS2021 / 00????
SHEET No. GT-202
ISSUE #



LONG SECTION C-C - INFERRED GROUND MODEL **1:200**

Appendix B Concept Option 1 Sketches



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- BH 12 TfNSW BORE HOLE (2021)
- BH8 TfNSW BORE HOLE (2009)

ANTICIPATED CONSTRUCTION SEQUENCE:

1. Close northbound lane.
2. Construct temporary working platform for excavator mounted or crane mounted sheetpiling rig. Minimum 3.0 m setback from headscarp.
3. Install sheet piles.
4. Fill voids behind sheet piles and reinstate pavement and bitumen wearing course to prevent surface water ingress.
5. Extend concrete safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

CONCEPT SKETCHES OPTION 1A - CANTILEVER SHEET PILE RETAINING WALL

NOT FOR CONSTRUCTION

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50mm ON A3 SIZE ORIGINAL

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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING
SCALE 1:500 2.5 0 2.5 5.0 7.5 10 12.5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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SMEC PROJECT No 30013154

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PLOT BY: TC13654

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT	PRELIM. INITIAL	FINAL DATE
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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

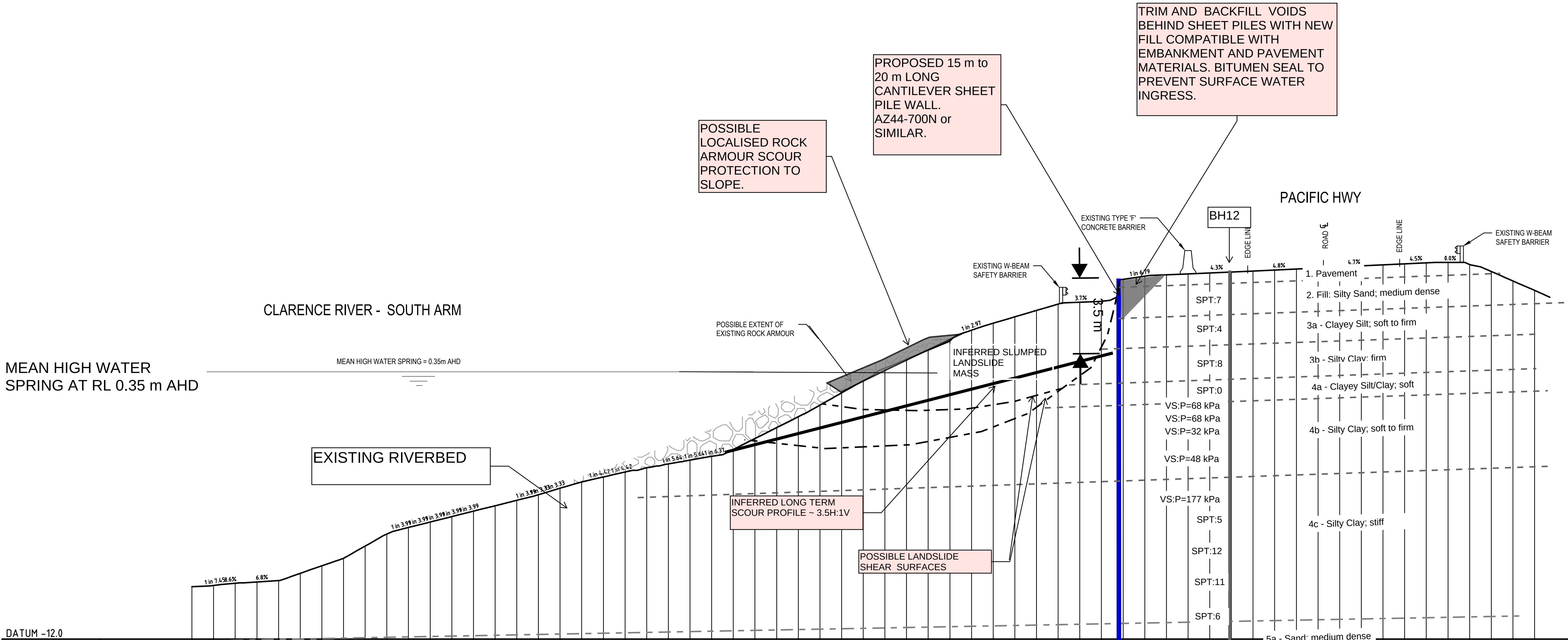
GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No.: DS2021 / 00????
SHEET No.: GT-101
ISSUE: #



OFFSET	DESIGN LEVEL	EXISTING SURFACE
-52.000	-9.579	-9.579
-51.000	-9.522	-9.522
-50.000	-9.419	-9.419
-49.000	-9.360	-9.360
-48.000	-9.291	-9.291
-47.000	-8.960	-8.960
-46.000	-8.610	-8.610
-45.000	-8.265	-8.265
-44.000	-7.698	-7.698
-43.000	-7.145	-7.145
-42.000	-6.840	-6.840
-41.000	-6.589	-6.589
-40.000	-6.339	-6.339
-39.000	-6.088	-6.088
-38.000	-5.837	-5.837
-37.000	-5.587	-5.587
-36.000	-5.328	-5.328
-35.000	-5.028	-5.028
-34.000	-4.735	-4.735
-33.000	-4.505	-4.505
-32.000	-4.279	-4.279
-31.000	-4.082	-4.082
-30.000	-3.903	-3.903
-29.000	-3.726	-3.726
-28.000	-3.553	-3.553
-27.000	-3.237	-3.237
-26.000	-2.734	-2.734
-25.000	-2.231	-2.231
-24.000	-1.728	-1.728
-23.000	-1.189	-1.189
-22.000	-0.626	-0.626
-21.000	-0.062	-0.062
-20.000	0.522	0.522
-19.000	0.937	0.937
-18.000	1.352	1.352
-17.000	1.775	1.775
-16.000	2.273	2.273
-15.000	2.594	2.594
-14.000	2.890	2.890
-13.000	3.186	3.186
-12.000	3.481	3.481
-11.000	3.566	3.566
-10.000	3.608	3.608
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-8.000	4.767	4.767
-7.000	4.833	4.833
-6.000	4.877	4.877
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4.000	5.336	[illegible]
5.000	5.381	[illegible]
6.000	5.400	[illegible]
7.000	5.310	[illegible]
8.000	4.984	4.984
9.000	4.548	4.548
10.000	4.111	4.111

SECTION A / 101
SCALE 1:200

CONCEPT SKETCHES OPTION 1A - CANTILEVER SHEET PILE RETAINING WALL

NOT FOR CONSTRUCTION

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PLOT BY: TC13654

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 1 0 1 2 3 4 5m

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GRAFTON NSW 2460
SMEC PROJECT No 30013154

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT — PRELIM. INITIAL — FINAL DATE
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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

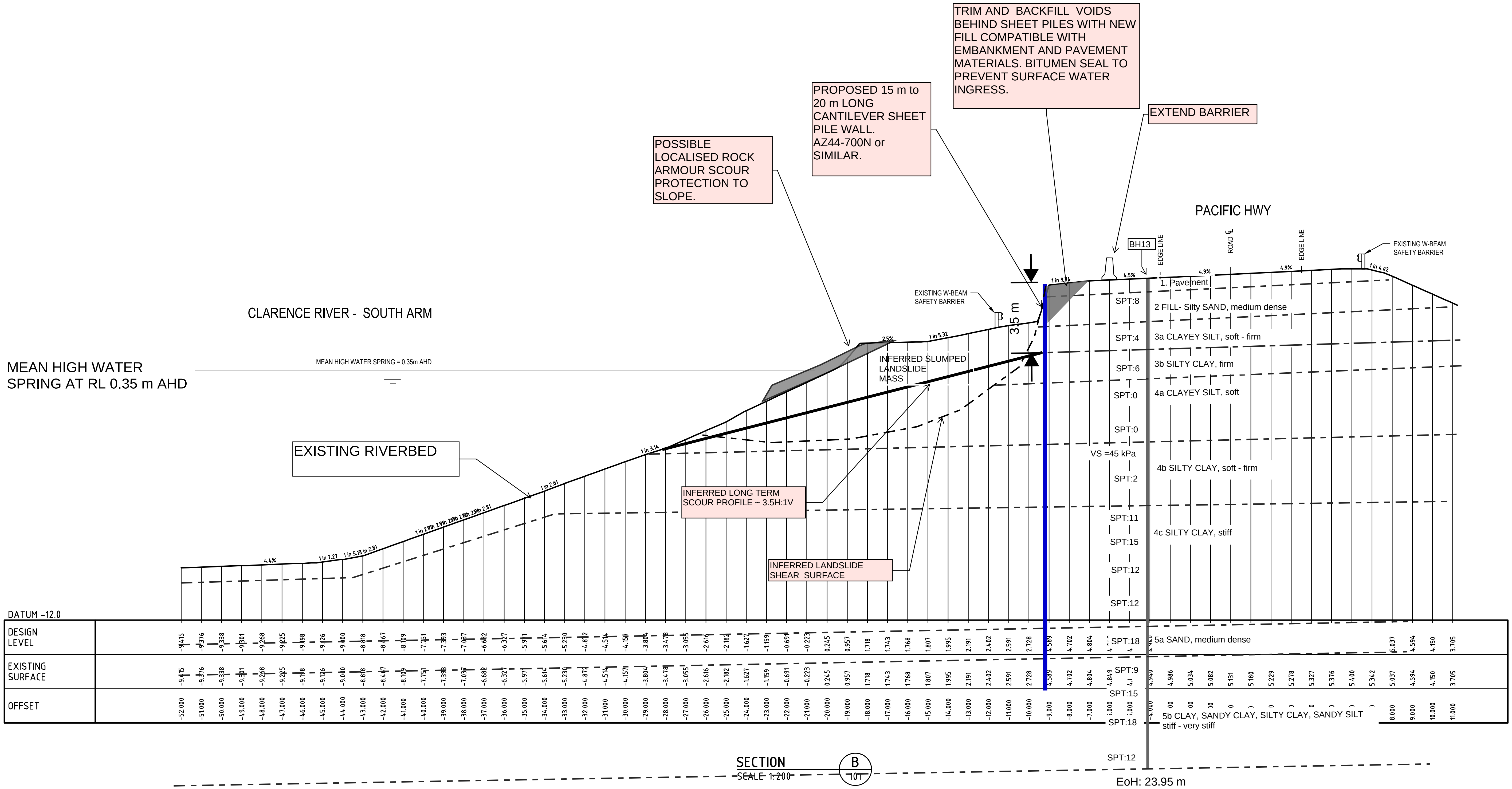
CROSS SECTION - SHEET 1

A3

SHEET 5 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No. DS2021 / 00????
SHEET No. GT-201
ISSUE #



OFFSET	DESIGN LEVEL	EXISTING SURFACE
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-51.000	-9.376	-9.376
-50.000	-9.338	-9.338
-49.000	-9.301	-9.301
-48.000	-9.268	-9.268
-47.000	-9.225	-9.225
-46.000	-9.198	-9.198
-45.000	-9.126	-9.126
-44.000	-9.040	-9.040
-43.000	-8.818	-8.818
-42.000	-8.467	-8.467
-41.000	-8.109	-8.109
-40.000	-7.751	-7.751
-39.000	-7.393	-7.393
-38.000	-7.037	-7.037
-37.000	-6.682	-6.682
-36.000	-6.327	-6.327
-35.000	-5.971	-5.971
-34.000	-5.614	-5.614
-33.000	-5.230	-5.230
-32.000	-4.812	-4.872
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-30.000	-4.157	-4.157
-29.000	-3.804	-3.804
-28.000	-3.478	-3.478
-27.000	-3.055	-3.055
-26.000	-2.616	-2.616
-25.000	-2.182	-2.182
-24.000	-1.627	-1.627
-23.000	-1.159	-1.159
-22.000	-0.691	-0.691
-21.000	-0.223	-0.223
-20.000	0.245	0.245
-19.000	0.957	0.957
-18.000	1.718	1.718
-17.000	1.743	1.743
-16.000	1.768	1.768
-15.000	1.807	1.807
-14.000	1.995	1.995
-13.000	2.191	2.191
-12.000	2.402	2.402
-11.000	2.591	2.591
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8.000	5.037	5.037
9.000	4.594	4.594
10.000	4.150	4.150
11.000	3.705	3.705

CONCEPT SKETCHES OPTION 1A - CANTILEVER SHEET PILE RETAINING WALL

NOT FOR CONSTRUCTION

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50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME
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DESIGN LOT CODE

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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING
SCALE 1:200 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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SMEC
Member of the Surbana Jurong Group
ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

PLOT DATE / TIME: 13 September 2021 02:59:17 PM
PLOT BY: TC13654

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT	PRELIM INITIAL	FINAL DATE
DISCIPLINE		
DISCIPLINE		
DISCIPLINE		
BACKDRAFTED/CORRECTED		
CONFIRMED		

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

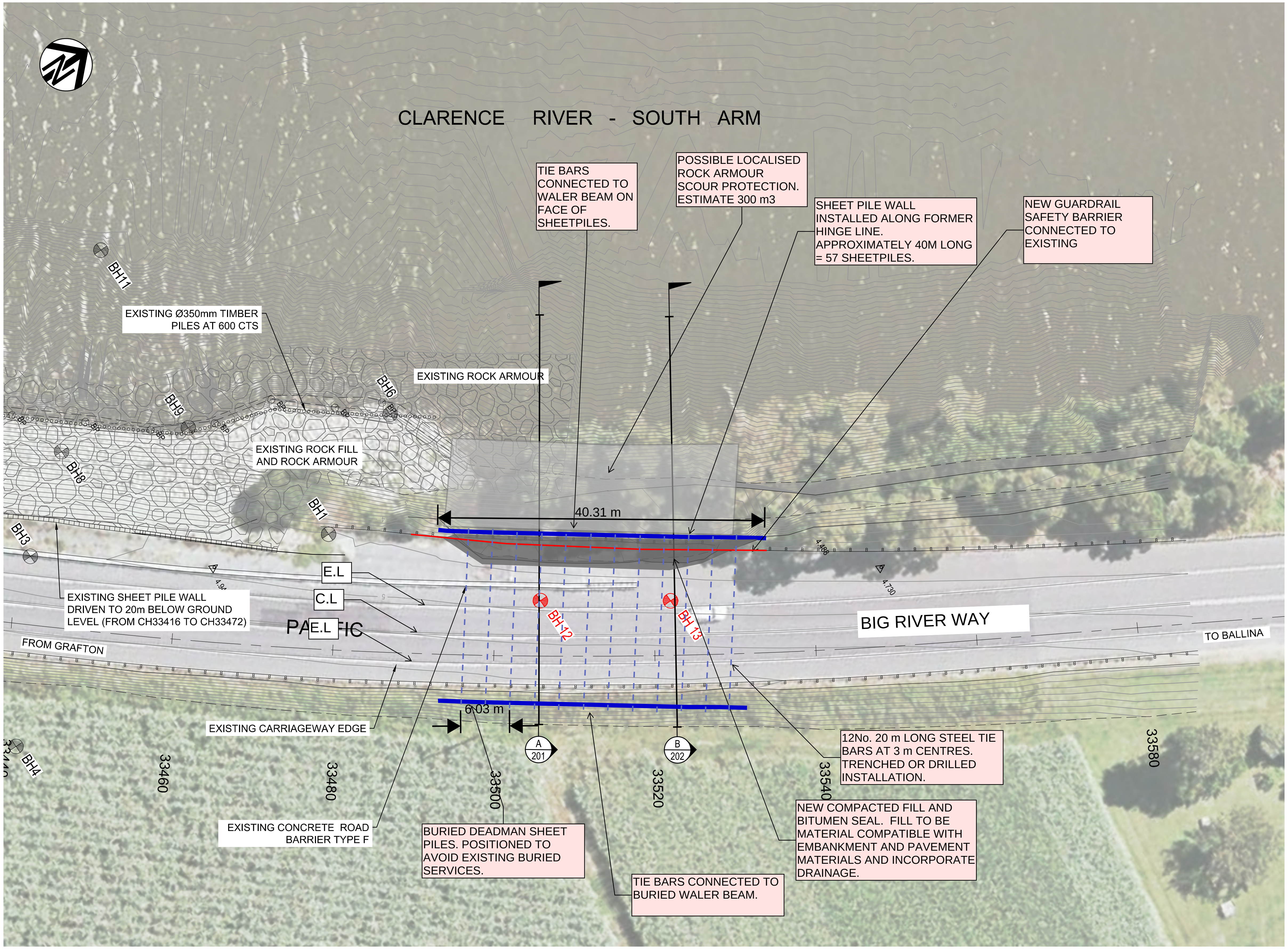
CROSS SECTION - SHEET 2

A3

SHEET 6 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No.: DS2021 / 00????
SHEET No.: GT-202
ISSUE: #



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- BH 12 TfNSW BORE HOLE (2021)
- BH8 TfNSW BORE HOLE (2009)

ANTICIPATED CONSTRUCTION SEQUENCE:

1. Close northbound lane.
2. Construct temporary working platform for excavator mounted or crane mounted sheetpiling rig. Minimum 3.0 m setback from headscarp.
3. Install sheet piles.
4. Excavate behind sheet piles and install new fill and drainage.
5. Switch traffic, close southbound lane.
6. Construct temporary working platform
7. Install deadman sheet piles.
8. Install tie rods either by drilling or trenching.
9. Install waler beams and connect tie rods.
10. Repair or reinstate pavements.
11. Install new guardrail safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

CONCEPT SKETCHES OPTION 1B - ANCHORED SHEET PILE RETAINING WALL

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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

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EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:500 (2.5 0 2.5 5.0 7.5 10 12.5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY
SMEC
Member of the Surbana Jurong Group
ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

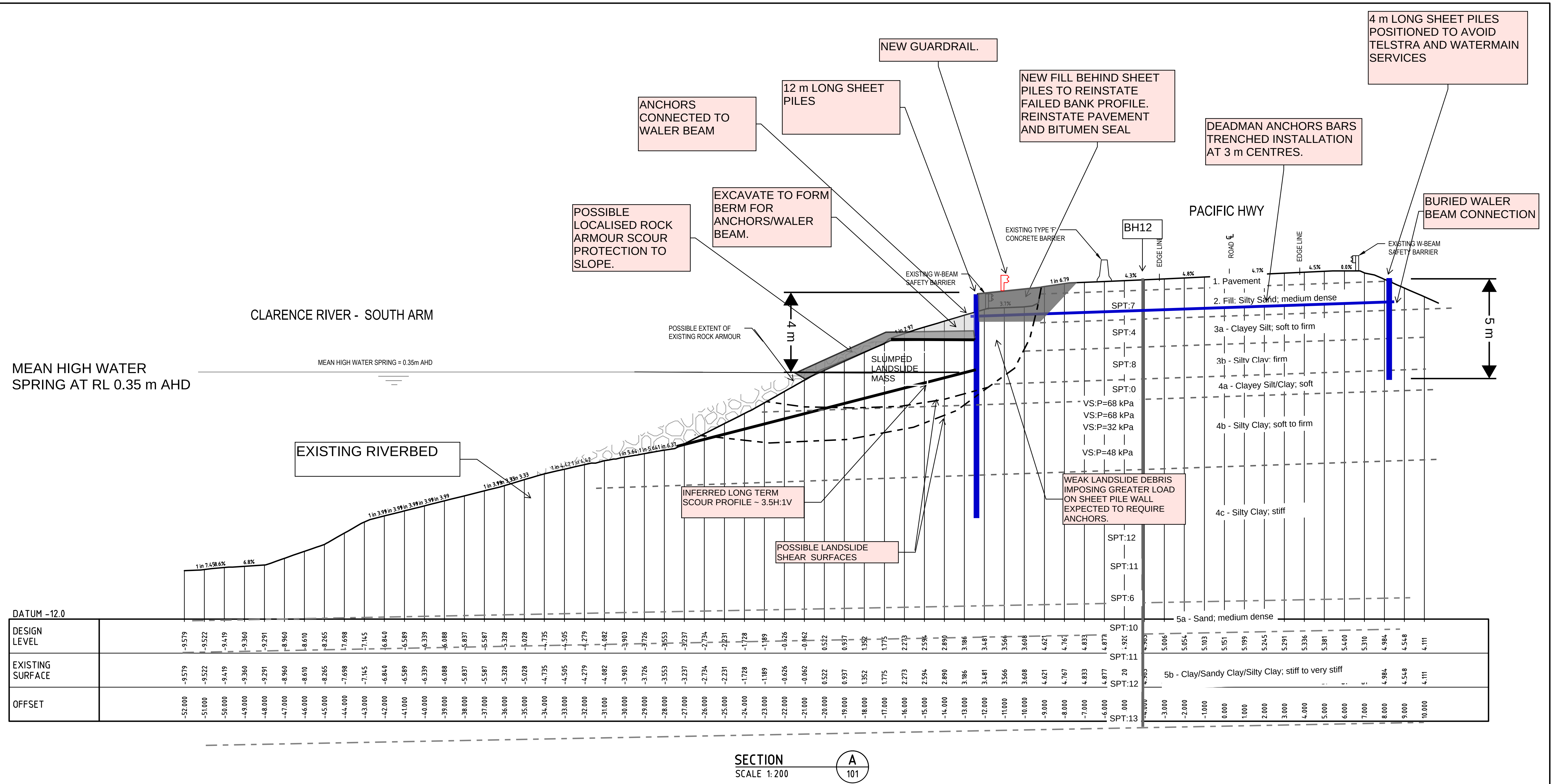
GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No. DS2021 / 00????
SHEET No. GT-101
ISSUE #



OFFSET	DESIGN LEVEL	EXISTING SURFACE
-52.000	-9.579	-9.579
-51.000	-9.522	-9.522
-50.000	-9.419	-9.419
-49.000	-9.360	-9.360
-48.000	-9.291	-9.291
-47.000	-8.960	-8.960
-46.000	-8.610	-8.610
-45.000	-8.265	-8.265
-44.000	-7.698	-7.698
-43.000	-7.145	-7.145
-42.000	-6.840	-6.840
-41.000	-6.589	-6.589
-40.000	-6.339	-6.339
-39.000	-6.088	-6.088
-38.000	-5.837	-5.837
-37.000	-5.587	-5.587
-36.000	-5.328	-5.328
-35.000	-5.028	-5.028
-34.000	-4.735	-4.735
-33.000	-4.505	-4.505
-32.000	-4.279	-4.279
-31.000	-4.082	-4.082
-30.000	-3.903	-3.903
-29.000	-3.726	-3.726
-28.000	-3.553	-3.553
-27.000	-3.237	-3.237
-26.000	-2.734	-2.734
-25.000	-2.231	-2.231
-24.000	-1.728	-1.728
-23.000	-1.189	-1.189
-22.000	-0.626	-0.626
-21.000	-0.062	-0.062
-20.000	0.522	0.522
-19.000	0.937	0.937
-18.000	1.352	1.352
-17.000	1.775	1.775
-16.000	2.273	2.273
-15.000	2.594	2.594
-14.000	2.890	2.890
-13.000	3.186	3.186
-12.000	3.481	3.481
-11.000	3.566	3.566
-10.000	3.608	3.608
-9.000	4.621	4.621
-8.000	4.767	4.767
-7.000	4.833	4.833
-6.000	4.877	4.877
[illegible]	4.920	[illegible]
-4.000	[illegible]	[illegible]
-3.000	5.006	[illegible]
-2.000	5.054	[illegible]
-1.000	5.103	[illegible]
0.000	5.151	[illegible]
1.000	5.199	[illegible]
2.000	5.245	[illegible]
3.000	5.291	[illegible]
4.000	5.336	[illegible]
5.000	5.381	[illegible]
6.000	5.400	[illegible]
7.000	5.310	[illegible]
8.000	4.984	4.984
9.000	4.548	4.548
10.000	4.111	4.111

SECTION A / 101
SCALE 1:200

CONCEPT SKETCHES OPTION 1B - ANCHORED SHEET PILE RETAINING WALL

NOT FOR CONSTRUCTION

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EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
X_RMS_NSW_CIVIL_A3 X_XSECTIONS	0	0	CONCEPT DESIGN	0	0

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DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

SCALES ON A3 SIZE DRAWING
SCALE 1:200 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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SMEC PROJECT No 30013154

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PLOT BY: TC13654

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DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
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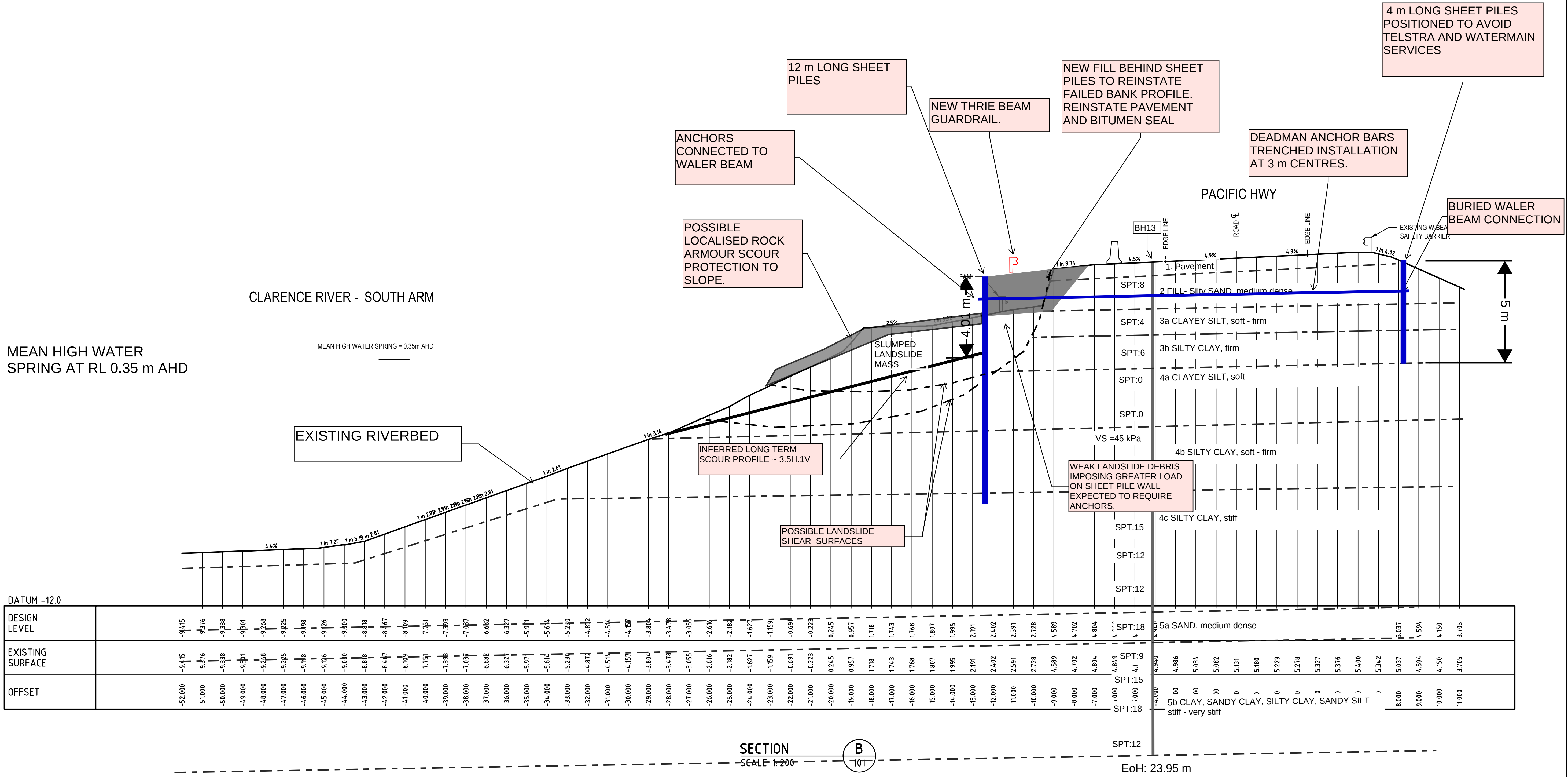
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION
CROSS SECTION - SHEET 1

A3

SHEET 5 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No.: DS2021 / 00????
SHEET No.: GT-201
ISSUE: #



CONCEPT SKETCHES OPTION 1B - ANCHORED SHEET PILE RETAINING WALL

NOT FOR CONSTRUCTION

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50mm ON A3 SIZE ORIGINAL

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PLOT DATE / TIME	13 September 2021 02:59:17 PM
PLOT BY	TC13654

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X_RMS_NSW_CIVIL_A3 X_XSECTIONS	0	0	CONCEPT DESIGN	0	0

REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) — HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC
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52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

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DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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BYRONS LANE SLIP REMEDIATION

CROSS SECTION - SHEET 2

A3

SHEET 6 OF 6

RMS REGISTRATION No. DS2021 / 00????

PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No.: DS2021 / 00????
SHEET No.: GT-202
ISSUE: #

Appendix C Concept Option 1 Analyses

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Left side		Soil types Right side	
1	4.92	1	1 Pavement	1	1 Pavement
2	4.32	2	2 FILL	2	2 FILL
3	2.72	3	3a s-f Clayey SILT	3	3a s-f Clayey SILT
4	1.42	4	3b firm Silty CLAY	4	3b firm Silty CLAY
5	-0.08	5	4a s Sandy CLAY	5	4a s Sandy CLAY
6	-3.08	6	4b s-f Silty CLAY	6	4b s-f Silty CLAY
7	-6.08	7	4c St Silty CLAY	7	4c St Silty CLAY
8	-12.08	8	5a l-md SAND	8	5a l-md SAND
9	-13.58	9	5b stiff mix CLAY	9	5b stiff mix CLAY

SOIL PROPERTIES

No.	-- Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	1 Pavement	20.00	30000	0.357	OC	0.196	8.175	
					(0.200)	(0.000)	(0.000)	
2	2 FILL	18.00	5000	0.441	OC	0.251	5.756	
					(0.300)	(0.000)	(0.000)	
3	3a s-f	17.00	4500	0.562	OC	0.341	3.799	4.000d
	Clayey SILT				(0.300)	(1.342)	(5.039)	
4	3b firm	18.00	7500	0.546	OC	0.329	3.992	5.000d
	Silty CLAY				(0.300)	(1.310)	(5.162)	
5	4a s Sandy	17.00	3750	0.577	OC	0.333	3.799	2.000d
	CLAY				(0.300)	(1.378)	(5.039)	
6	4b s-f	17.00	4500	0.562	OC	0.341	3.799	4.000d
	Silty CLAY				(0.300)	(1.342)	(5.039)	
7	4c St Silty	19.00	11000	0.546	OC	0.329	3.992	8.000d
	CLAY				(0.300)	(1.310)	(5.162)	
8	5a l-md	18.00	6000	0.455	OC	0.263	5.449	
	SAND				(0.300)	(0.000)	(0.000)	
9	5b stiff	19.00	15000	0.546	OC	0.333	4.238	10.00d
	mix CLAY				(0.300)	(1.310)	(5.162)	

Additional soil parameters associated with Ka and Kp

No.	------- Soil type ------- Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	1 Pavement	40.00	0.297	0.00	41.70	0.297	0.00
2	2 FILL	34.00	0.370	0.00	35.63	0.370	0.00
3	3a s-f Clayey SILT	26.00	0.511	0.00	29.05	0.352	0.00
4	3b firm Silty CLAY	27.00	0.489	0.00	30.10	0.336	0.00
5	4a s Sandy CLAY	25.84	0.819	0.00	29.05	0.352	0.00
6	4b s-f Silty CLAY	26.00	0.511	0.00	29.05	0.352	0.00
7	4c St Silty CLAY	27.00	0.489	0.00	30.10	0.336	0.00
8	5a l-md SAND	33.00	0.384	0.00	34.62	0.384	0.00
9	5b stiff mix CLAY	27.00	0.489	0.00	32.10	0.264	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	0.00	0.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Left side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Right side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	0.00	0.00	0.0	1	1.00	1.00	0.0
2	1	0.00	0.00	0.0	1	2.00	2.00	0.0
3	1	0.00	0.00	0.0	1	3.00	3.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -11.00
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 5.5890E-04 m4/m run
E.I = 117369 kN.m2/m run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	4.92	-2.00(R)	40.00	12.00	20.00	=	N/A	N/A

Note: L = Left side, R = Right side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Excavate to elevation 1.50 on LEFT side Toe of berm at elevation -9.30 Width of top of berm = 0.50 Width of toe of berm = 36.50
2	Change EI of wall to 117369 kN.m2/m run Reset wall displacements to zero at this stage
3	Apply surcharge no.1 at elevation 4.92
4	Apply water pressure profile no.1
5	Apply water pressure profile no.2
6	Apply water pressure profile no.3

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
 Method of analysis - Strength Factor method
 Factor on soil strength for calculating wall depth = 1.30

Parameters for undrained strata:
 Minimum equivalent fluid density = 5.00 kN/m3
 Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
 Method - 2-D finite element model
 Open Tension Crack analysis? - No
 Active limit arching modelled? - Yes
 Non-linear Modulus Parameter (L) = 20.00 m

Boundary conditions:
 Length of wall (normal to plane of analysis) = 40.00 m

 Width of excavation on Left side of wall = 50.00 m
 Width of excavation on Right side of wall = 20.00 m

 Distance to rigid boundary on Left side = 50.00 m
 Distance to rigid boundary on Right side = 30.00 m

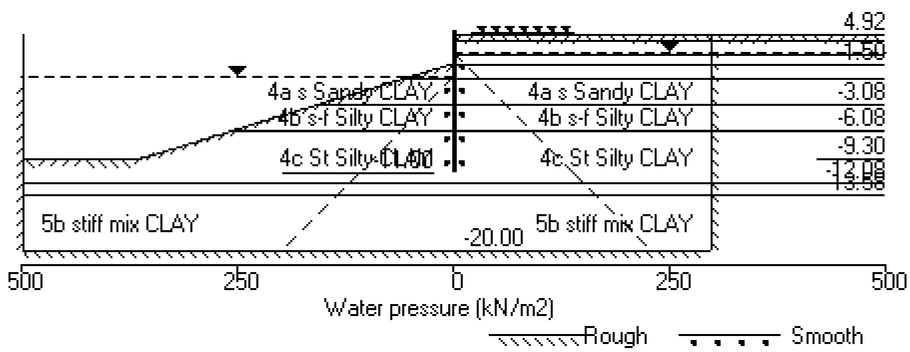
```
Elevation of rigid lower boundary = -20.00

Lower rigid boundary at elevation -20.00 - Rough
Rigid boundary on Left side           - Rough
Rigid boundary on Right side          - Rough
Wall / soil interface                   - Smooth
```

OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Excav. to elev. 1.50 on LEFT side	Yes	Yes	Yes
2	Change EI of wall to 117369kN.m2/m run	Yes	Yes	Yes
3	Apply surcharge no.1 at elev. 4.92	Yes	Yes	Yes
4	Apply water pressure profile no.1	Yes	Yes	Yes
5	Apply water pressure profile no.2	Yes	Yes	Yes
6	Apply water pressure profile no.3	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

```
SMEC AUSTRALIA PTY LTD                                      | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58         | Job No. 3001315
                             Licensed from GEOSOLVE         | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained                     |
Byron Lane Slip                                             | Date:24-09-2021
AZ 24-700N Sheet Pile                                       | Checked :
-----------------------------------------------------------------------------
                                                    Units: kN,m
```

Stage No.6   Apply water pressure profile no.3



Units: kN,m

Stage No. 1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -11.00		Toe elev. for FoS = 1.300		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	4.92	1.50	Cant.	1.628	-10.08	-6.04	7.54	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.087	-6.01E-03	0.0	0.0	
2	4.32	-2.35	-0.083	-6.01E-03	-0.7	-0.3	
		-3.01	-0.083	-6.01E-03	-0.7	-0.3	
3	3.66	-6.00	-0.079	-6.01E-03	-3.7	-1.8	
4	3.00	-8.98	-0.076	-5.98E-03	-8.6	-5.9	
5	2.72	-10.24	-0.074	-5.97E-03	-11.3	-8.7	
		-8.55	-0.074	-5.97E-03	-11.3	-8.7	
6	2.00	-12.73	-0.070	-5.88E-03	-19.0	-19.6	
7	1.50	-15.62	-0.067	-5.77E-03	-26.1	-30.9	
		4.53	-0.067	-5.77E-03	-26.1	-30.9	
8	1.42	9.24	-0.066	-5.75E-03	-25.5	-33.0	
		11.46	-0.066	-5.75E-03	-25.5	-33.0	
9	1.00	26.53	-0.064	-5.62E-03	-17.5	-42.7	
10	0.50	33.45	-0.061	-5.42E-03	-2.5	-48.1	
11	0.00	32.87	-0.058	-5.22E-03	14.0	-45.2	
12	-0.08	28.89	-0.058	-5.19E-03	16.5	-44.0	
		-18.64	-0.058	-5.19E-03	16.5	-44.0	
13	-0.84	-3.87	-0.054	-4.93E-03	8.0	-36.4	
14	-1.60	-2.07	-0.050	-4.71E-03	5.7	-31.4	
15	-2.34	-3.81	-0.047	-4.53E-03	3.5	-27.8	
16	-3.08	-5.03	-0.044	-4.36E-03	0.3	-26.2	
		-0.77	-0.044	-4.36E-03	0.3	-26.2	
17	-3.54	-2.04	-0.042	-4.25E-03	-0.4	-26.2	
18	-4.00	-3.81	-0.040	-4.15E-03	-1.7	-26.6	
19	-4.80	-5.65	-0.037	-3.96E-03	-5.5	-29.2	
20	-5.44	-7.65	-0.034	-3.79E-03	-9.8	-33.8	

(continued)

Stage No.1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
21	-6.08	-7.31	-0.032	-3.58E-03	-14.6	-41.7	
		20.16	-0.032	-3.58E-03	-14.6	-41.7	
22	-6.64	16.56	-0.030	-3.37E-03	-4.3	-46.6	
23	-7.20	10.93	-0.028	-3.15E-03	3.4	-46.4	
24	-8.00	6.65	-0.026	-2.86E-03	10.5	-40.2	
25	-8.65	3.28	-0.024	-2.66E-03	13.7	-32.0	
26	-9.30	0.93	-0.022	-2.50E-03	15.1	-22.4	
27	-9.73	-1.20	-0.021	-2.44E-03	15.0	-15.9	
28	-10.15	-3.58	-0.020	-2.39E-03	14.0	-9.7	
29	-10.58	-8.71	-0.019	-2.36E-03	11.4	-4.0	
30	-11.00	-30.45	-0.018	-2.36E-03	3.0	-0.0	
31	-11.20	-0.01	-0.018	0	-0.0	0.0	
32	-12.08	10.49	-0.018	0	4.6	0.0	
		-6.17	-0.018	0	4.6	0.0	
33	-13.58	-11.40	-0.014	0	-8.6	0.0	
		10.65	-0.014	0	-8.6	0.0	
34	-15.19	-0.00	-0.011	0	-0.0	0.0	
35	-16.79	-0.00	-0.008	0	-0.0	0.0	
36	-18.40	-0.00	-0.005	0	-0.0	0.0	
37	-20.00	0.04	-0.001	0	-0.0	0.0	

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4689
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4689
		0.00	1.36	0.00	25.59b	25.59	25.59p	7816
9	1.00	0.00	8.92	0.00	43.14b	43.14	43.14p	7816
10	0.50	0.00	17.92	0.00	57.00b	53.02	53.02	7816
11	0.00	0.00	26.92	2.30	72.95b	55.40	55.40	7816
12	-0.08	0.80	27.56	2.51	57.82b	53.12	53.92	7816
		0.80	27.56	6.41	20.56b	20.56	21.36p	3908
13	-0.84	8.40	32.88	8.18	38.95b	38.95	47.35p	3908
14	-1.60	16.00	38.21	9.95	62.59b	44.46	60.46	3908
15	-2.34	23.40	43.39	11.67	72.22b	46.35	69.75	3908
16	-3.08	30.80	48.58	13.40	81.16b	48.55	79.35	3908
		30.80	48.58	11.20	155.51b	49.17	79.97	4689
17	-3.54	35.40	51.81	12.30	129.81b	50.16	85.56	4689
18	-4.00	40.00	55.03	13.41	100.66b	50.99	90.99	4689
19	-4.80	48.00	60.65	15.32	110.72b	53.14	101.14	4689
20	-5.44	54.40	65.15	16.86	119.11b	54.59	108.99	4689
21	-6.08	60.80	69.65	18.39	127.09b	57.07	117.87	4689
		60.80	69.65	12.42	319.32	69.04	129.84	11463
22	-6.64	66.40	74.71	14.08	297.94	69.53	135.93	11463
23	-7.20	72.00	79.77	15.75	196.22b	69.35	141.35	11463

(continued)

Stage No.1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
24	-8.00	80.00	87.01	18.13	149.25b	71.06	151.06	11463
25	-8.65	86.50	92.90	20.06	249.94b	72.50	159.00	11463
26	-9.30	93.00	98.79	22.00	356.64b	74.48	167.48	11463
27	-9.73	97.25	102.64	23.26	351.40b	75.49	172.74	11463
28	-10.15	101.50	106.50	24.53	366.80b	76.35	177.85	11463
29	-10.58	105.75	110.36	25.80	382.20b	75.89	181.64	11463
30	-11.00	110.00	114.22	27.07	396.81b	66.00	176.00	11463
31	-11.20	112.00	116.04	27.67	407.25b	83.51	195.51	11463
32	-12.08	120.80	124.04	30.30	433.79b	93.24	214.04	11463
		120.80	124.04	32.67	519.74b	68.06	188.86	6253
33	-13.58	135.80	136.21	35.87	570.71b	70.90	206.70	6253
		135.80	136.21	32.22	600.85b	99.81	235.61	15632
34	-15.19	151.85	150.86	37.09	627.91b	102.22	254.07	15632
35	-16.79	167.90	165.55	41.98	653.42b	110.48	278.38	15632
36	-18.40	183.95	180.27	46.88	715.85b	118.28	302.23	15632
37	-20.00	200.00	195.03	51.79	774.87b	120.19	320.19	15632

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30580
2	4.32	0.00	12.00	2.35	98.10	2.35	2.35a	30580
		0.00	12.00	3.01	69.07	3.01	3.01a	5097
3	3.66	0.00	23.88	6.00	137.44	6.00	6.00a	5097
4	3.00	0.00	35.76	8.98	205.82	8.98	8.98a	5097
5	2.72	0.00	40.80	10.24	234.82	10.24	10.24a	5097
		0.00	40.80	8.55	175.17	8.55	8.55a	4587
6	2.00	0.00	53.04	12.73	221.68	12.73	12.73a	4587
7	1.50	0.00	61.54	15.62	253.97	15.62	15.62a	4587
8	1.42	0.00	62.90	16.09	259.14	16.09	16.09a	4587
		0.00	62.90	14.13	276.90	14.13	14.13a	7645
9	1.00	0.00	70.46	16.61	307.08	16.61	16.61a	7645
10	0.50	0.00	79.46	19.57	343.00	19.57	19.57a	7645
11	0.00	0.00	88.46	22.53	378.93	22.53	22.53a	7645
12	-0.08	0.80	89.10	22.74	381.49	24.23	25.03	7645
		0.80	89.10	26.88	348.56	39.20	40.00	3822
13	-0.84	8.40	94.42	28.65	368.76	42.82	51.22	3822
14	-1.60	16.00	99.74	30.41	388.97	46.52	62.52	3822
15	-2.34	23.40	104.92	32.14	408.65	50.17	73.57	3822
16	-3.08	30.80	110.10	33.86	428.33	53.58	84.38	3822
		30.80	110.10	32.19	438.47	49.94	80.74	4587
17	-3.54	35.40	113.32	33.29	450.71	52.20	87.60	4587
18	-4.00	40.00	116.54	34.39	462.94	54.80	94.80	4587
19	-4.80	48.00	122.14	36.30	484.22	58.78	106.78	4587
20	-5.44	54.40	126.62	37.82	501.24	62.25	116.65	4587
21	-6.08	60.80	131.10	39.35	518.26	64.39	125.19	4587
		60.80	131.10	32.62	564.63	48.87	109.67	11213
22	-6.64	66.40	136.14	34.28	584.75	52.97	119.37	11213
23	-7.20	72.00	141.18	35.93	604.87	58.42	130.42	11213

(continued)

Stage No.1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

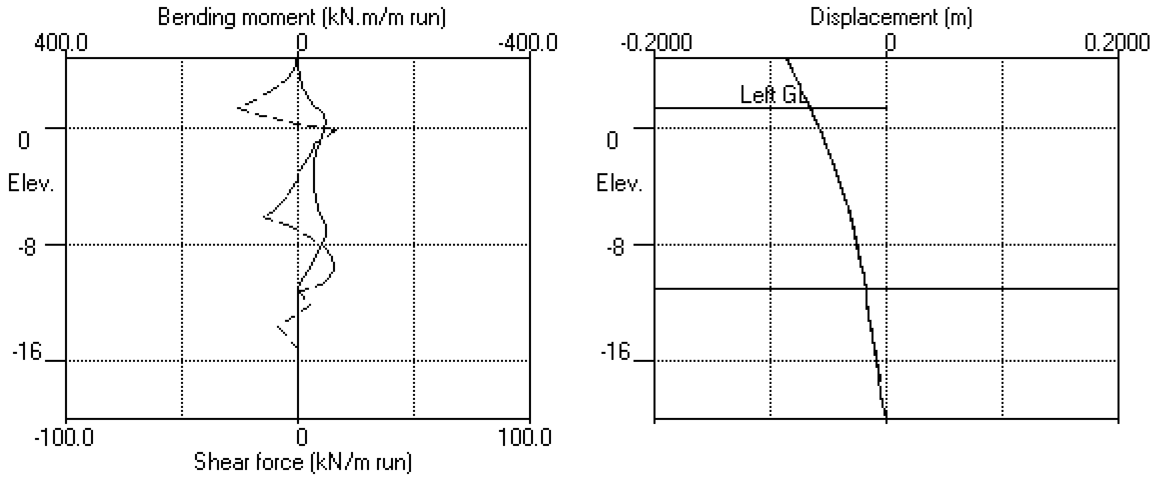
Node no.	Y coord	RIGHT side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
24	-8.00	80.00	148.38	38.30	633.61	64.40	144.40	11213
25	-8.65	86.50	154.23	40.22	656.96	69.22	155.72	11213
26	-9.30	93.00	160.08	42.15	680.32	73.56	166.56	11213
27	-9.73	97.25	163.91	43.40	695.58	76.69	173.94	11213
28	-10.15	101.50	167.73	44.66	710.85	79.93	181.43	11213
29	-10.58	105.75	171.56	45.92	726.12	84.61	190.36	11213
30	-11.00	110.00	175.38	47.17	741.39	96.45	206.45	11213
31	-11.20	112.00	177.18	47.77	748.58	83.52	195.52	11213
32	-12.08	120.80	185.10	50.37	780.19	82.75	203.55	11213
		120.80	185.10	48.75	1008.59	74.23	195.03	6116
33	-13.58	135.80	197.10	51.91	1073.97	82.30	218.10	6116
		135.80	197.10	52.48	886.99	89.16	224.96	15290
34	-15.19	151.85	211.55	57.28	948.21	102.22	254.07	15290
35	-16.79	167.90	225.99	62.09	1009.43	110.48	278.38	15290
36	-18.40	183.95	240.44	66.90	1070.65	118.28	302.23	15290
37	-20.00	200.00	254.88	71.70	1131.87	120.14	320.14	15290

Note: 22.53 a Soil pressure at active limit
47.35 p Soil pressure at passive limit
774.87 b Passive limit reduced because of berm

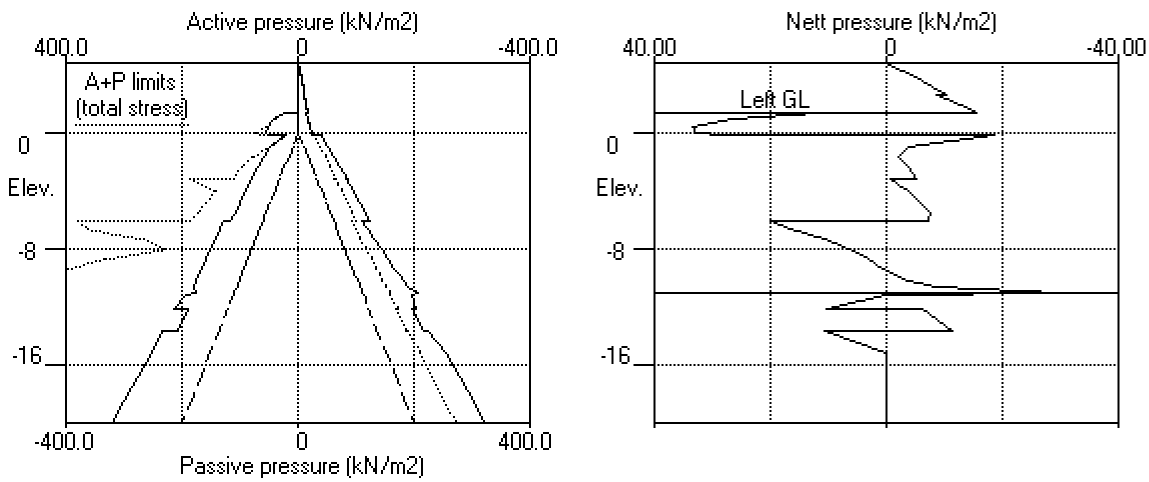
SMEC AUSTRALIA PTY LTD | Sheet No.
Program: WALLAP Version 6.07 Revision A55.B74.R58 | Job No. 3001315
Licensed from GEOSOLVE | Made by : MM
Data filename/Run ID: AZ24-700N_Drained |
Byron Lane Slip | Date:24-09-2021
AZ 24-700N Sheet Pile | Checked :

Units: kN,m

Stage No.1 Excav. to elev. 1.50 on LEFT side



Stage No.1 Excav. to elev. 1.50 on LEFT side



Units: kN,m

Stage No. 3 Apply surcharge no.1 at elevation 4.92

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = -11.00: Factor of Safety	FoS for toe elev. = -11.00: Moment equilib. at elev.	Toe elev. for FoS = 1.300: Toe elev.	Toe elev. for FoS = 1.300: Wall Penetr -ation	Direction of failure
3	4.92	1.50	Cant.	1.534	-10.12	-7.36	8.86	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.029	-2.14E-03	0.0	0.0	
2	4.32	-2.39	-0.027	-2.14E-03	-0.7	-0.3	
		-3.06	-0.027	-2.14E-03	-0.7	-0.3	
3	3.66	-6.35	-0.026	-2.14E-03	-3.8	-1.8	
4	3.00	-9.82	-0.025	-2.14E-03	-9.2	-6.2	
5	2.72	-11.31	-0.024	-2.14E-03	-12.1	-9.1	
		-9.99	-0.024	-2.14E-03	-12.1	-9.1	
6	2.00	-14.88	-0.022	-2.13E-03	-21.1	-21.1	
7	1.50	-18.21	-0.021	-2.12E-03	-29.3	-33.8	
		1.95	-0.021	-2.12E-03	-29.3	-33.8	
8	1.42	6.59	-0.021	-2.12E-03	-29.0	-36.1	
		8.91	-0.021	-2.12E-03	-29.0	-36.1	
9	1.00	23.69	-0.020	-2.11E-03	-22.2	-47.5	
10	0.50	34.30	-0.019	-2.08E-03	-7.7	-55.6	
11	0.00	41.05	-0.018	-2.04E-03	11.2	-55.2	
12	-0.08	31.68	-0.018	-2.04E-03	14.1	-54.2	
		-19.33	-0.018	-2.04E-03	14.1	-54.2	
13	-0.84	-5.19	-0.017	-1.96E-03	4.8	-48.7	
14	-1.60	0.11	-0.015	-1.87E-03	2.8	-46.6	
15	-2.34	-2.70	-0.014	-1.77E-03	1.9	-44.5	
16	-3.08	-4.64	-0.013	-1.67E-03	-0.8	-43.8	
		0.78	-0.013	-1.67E-03	-0.8	-43.8	
17	-3.54	-1.11	-0.012	-1.60E-03	-0.9	-44.1	
18	-4.00	-3.65	-0.011	-1.52E-03	-2.0	-44.7	
19	-4.80	-6.22	-0.010	-1.40E-03	-6.0	-47.4	
20	-5.44	-8.95	-0.009	-1.30E-03	-10.8	-52.5	
21	-6.08	-8.26	-0.008	-1.20E-03	-16.3	-61.3	
		25.69	-0.008	-1.20E-03	-16.3	-61.3	

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
22	-6.64	21.12	-0.008	-1.10E-03	-3.2	-66.4	
23	-7.20	13.69	-0.007	-1.01E-03	6.5	-64.9	
24	-8.00	8.14	-0.006	-9.01E-04	15.3	-55.3	
25	-8.65	3.80	-0.006	-8.27E-04	19.1	-43.6	
26	-9.30	0.80	-0.005	-7.73E-04	20.6	-30.4	
27	-9.73	-1.95	-0.005	-7.48E-04	20.4	-21.5	
28	-10.15	-5.07	-0.004	-7.32E-04	18.9	-13.0	
29	-10.58	-11.87	-0.004	-7.24E-04	15.3	-5.4	
30	-11.00	-40.92	-0.004	-7.21E-04	4.1	0.0	
31	-11.20	-0.05	-0.004	0	-0.0	0.0	
32	-12.08	12.31	-0.004	0	5.4	0.0	
		-7.29	-0.004	0	5.4	0.0	
33	-13.58	-13.33	-0.003	0	-10.1	0.0	
		12.44	-0.003	0	-10.1	0.0	
34	-15.19	-0.00	-0.002	0	-0.1	0.0	
35	-16.79	-0.00	-0.002	0	-0.1	0.0	
36	-18.40	-0.00	-0.001	0	-0.1	0.0	
37	-20.00	0.12	-0.000	0	-0.0	0.0	

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4689
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4689
		0.00	1.36	0.00	25.59b	25.59	25.59p	7816
9	1.00	0.00	8.92	0.00	43.14b	43.14	43.14p	7816
10	0.50	0.00	17.92	0.00	57.00b	57.00	57.00p	7816
11	0.00	0.00	26.92	2.30	72.95b	66.95	66.95	7816
12	-0.08	0.80	27.56	2.51	57.82b	57.82	58.62p	7816
		0.80	27.56	6.41	20.56b	20.56	21.36p	3908
13	-0.84	8.40	32.88	8.18	38.95b	38.95	47.35p	3908
14	-1.60	16.00	38.21	9.95	62.59b	48.58	64.58	3908
15	-2.34	23.40	43.39	11.67	72.22b	49.94	73.34	3908
16	-3.08	30.80	48.58	13.40	81.16b	51.76	82.56	3908
		30.80	48.58	11.20	155.51b	53.03	83.83	4689
17	-3.54	35.40	51.81	12.30	129.81b	53.65	89.05	4689
18	-4.00	40.00	55.03	13.41	100.66b	54.07	94.07	4689
19	-4.80	48.00	60.65	15.32	110.72b	55.83	103.83	4689
20	-5.44	54.40	65.15	16.86	119.11b	56.89	111.29	4689
21	-6.08	60.80	69.65	18.39	127.09b	59.44	120.24	4689
		60.80	69.65	12.42	319.32	74.81	135.61	11463
22	-6.64	66.40	74.71	14.08	297.94	74.62	141.02	11463
23	-7.20	72.00	79.77	15.75	196.22b	73.47	145.47	11463
24	-8.00	80.00	87.01	18.13	149.25b	74.46	154.46	11463
25	-8.65	86.50	92.90	20.06	249.94b	75.35	161.85	11463
26	-9.30	93.00	98.79	22.00	356.64b	76.94	169.94	11463
27	-9.73	97.25	102.64	23.26	351.40b	77.59	174.84	11463
28	-10.15	101.50	106.50	24.53	366.80b	78.04	179.54	11463

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
29	-10.58	105.75	110.36	25.80	382.20b	76.71	182.46	11463
30	-11.00	110.00	114.22	27.07	396.81b	62.74	172.74	11463
31	-11.20	112.00	116.04	27.67	407.25b	85.91	197.91	11463
32	-12.08	120.80	124.04	30.30	433.79b	96.52	217.32	11463
		120.80	124.04	32.67	519.74b	69.85	190.65	6253
33	-13.58	135.80	136.21	35.87	570.71b	72.14	207.94	6253
		135.80	136.21	32.22	600.85b	102.92	238.72	15632
34	-15.19	151.85	150.86	37.09	627.91b	104.23	256.08	15632
35	-16.79	167.90	165.55	41.98	653.42b	112.43	280.33	15632
36	-18.40	183.95	180.27	46.88	715.85b	120.10	304.05	15632
37	-20.00	200.00	195.03	51.79	774.87b	120.82	320.82	15632

RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30580
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30580
		0.00	12.21	3.06	70.25	3.06	3.06a	5097
3	3.66	0.00	25.29	6.35	145.55	6.35	6.35a	5097
4	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5097
5	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5097
		0.00	45.03	9.99	191.25	9.99	9.99a	4587
6	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4587
7	1.50	0.00	69.12	18.21	282.76	18.21	18.21a	4587
8	1.42	0.00	70.66	18.74	288.62	18.74	18.74a	4587
		0.00	70.66	16.68	307.87	16.68	16.68a	7645
9	1.00	0.00	79.10	19.45	341.56	19.45	19.45a	7645
10	0.50	0.00	88.98	22.70	381.03	22.70	22.70a	7645
11	0.00	0.00	98.72	25.90	419.89	25.90	25.90a	7645
12	-0.08	0.80	99.47	26.15	422.87	26.15	26.95a	7645
		0.80	99.47	30.32	387.94	39.89	40.69	3822
13	-0.84	8.40	105.64	32.38	411.37	44.15	52.55	3822
14	-1.60	16.00	111.57	34.35	433.92	48.47	64.47	3822
15	-2.34	23.40	117.17	36.21	455.20	52.65	76.05	3822
16	-3.08	30.80	122.63	38.03	475.94	56.40	87.20	3822
		30.80	122.63	36.46	486.09	52.25	83.05	4587
17	-3.54	35.40	125.97	37.60	498.76	54.76	90.16	4587
18	-4.00	40.00	129.26	38.72	511.27	57.72	97.72	4587
19	-4.80	48.00	134.91	40.65	532.74	62.04	110.04	4587
20	-5.44	54.40	139.37	42.17	549.67	65.84	120.24	4587
21	-6.08	60.80	143.78	43.68	566.43	67.70	128.50	4587
		60.80	143.78	36.79	615.25	49.13	109.93	11213
22	-6.64	66.40	148.73	38.41	635.00	53.50	119.90	11213
23	-7.20	72.00	153.65	40.03	654.65	59.78	131.78	11213
24	-8.00	80.00	160.65	42.33	682.59	66.32	146.32	11213
25	-8.65	86.50	166.31	44.19	705.18	71.54	158.04	11213
26	-9.30	93.00	171.95	46.05	727.71	76.14	169.14	11213
27	-9.73	97.25	175.63	47.26	742.40	79.54	176.79	11213
28	-10.15	101.50	179.31	48.47	757.08	83.11	184.61	11213
29	-10.58	105.75	182.98	49.67	771.74	88.59	194.34	11213
30	-11.00	110.00	186.65	50.88	786.38	103.65	213.65	11213
31	-11.20	112.00	188.38	51.45	793.27	85.95	197.95	11213

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

		RIGHT side						
			Effective stresses				Total	Adjusted
Node	Y	Water	Vertic	Active	Passive	Earth	earth	soil
no.	coord	press.	-al	limit	limit	pressure	pressure	modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
32	-12.08	120.80	195.96	53.94	823.55	84.21	205.01	11213
		120.80	195.96	51.61	1067.76	77.14	197.94	6116
33	-13.58	135.80	207.38	54.61	1129.98	85.47	221.27	6116
		135.80	207.38	55.90	930.55	90.48	226.28	15290
34	-15.19	151.85	221.20	60.50	989.13	104.23	256.08	15290
35	-16.79	167.90	235.04	65.10	1047.78	112.43	280.33	15290
36	-18.40	183.95	248.90	69.71	1106.54	120.10	304.05	15290
37	-20.00	200.00	262.80	74.34	1165.43	120.70	320.70	15290

Note: 26.95 a Soil pressure at active limit
47.35 p Soil pressure at passive limit
774.87 b Passive limit reduced because of berm

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SMEC AUSTRALIA PTY LTD                                         | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58            | Job No. 3001315
                             Licensed from GEOSOLVE            | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained                        |
Byron Lane Slip                                                | Date:24-09-2021
AZ 24-700N Sheet Pile                                          | Checked :
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                                                    Units: kN,m
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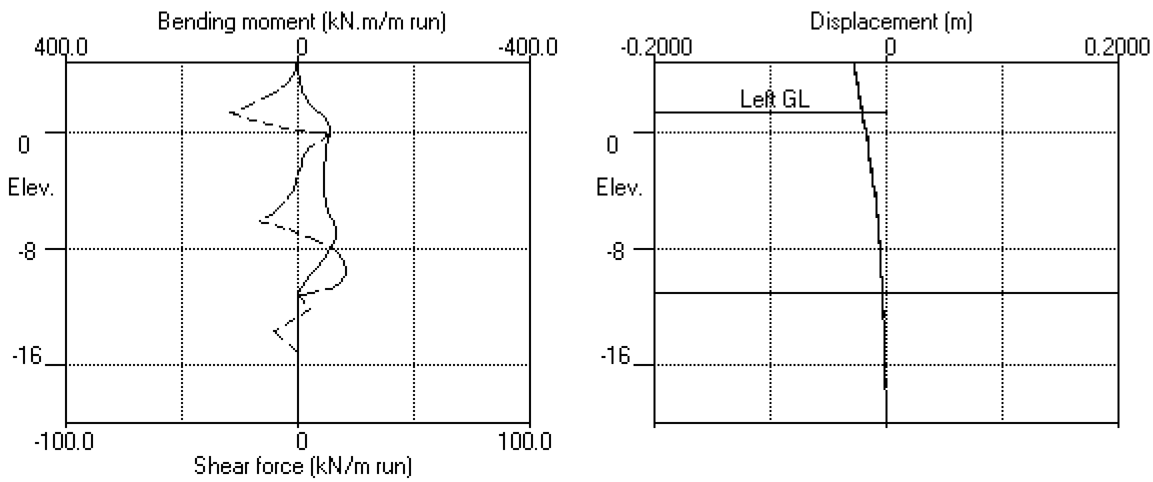
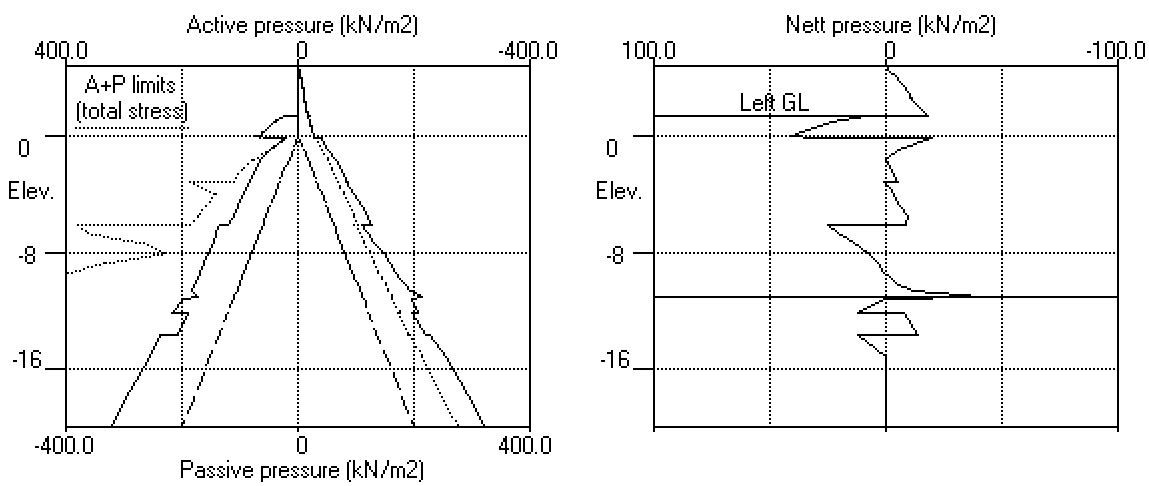
Stage No.3 Apply surcharge no.1 at elev. 4.92



Stage No.3 Apply surcharge no.1 at elev. 4.92



Units: kN,m

Stage No. 4 Apply water pressure profile no.1

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -11.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
4	4.92	1.50	Cant.	1.472	-10.11	-8.16	9.66	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.054	-3.78E-03	0.0	0.0	
2	4.32	-2.39	-0.052	-3.78E-03	-0.7	-0.3	
		-3.06	-0.052	-3.78E-03	-0.7	-0.3	
3	3.66	-6.35	-0.049	-3.78E-03	-3.8	-1.8	
4	3.00	-9.82	-0.047	-3.78E-03	-9.2	-6.2	
5	2.72	-11.31	-0.046	-3.78E-03	-12.1	-9.1	
		-9.99	-0.046	-3.78E-03	-12.1	-9.1	
6	2.00	-14.88	-0.043	-3.77E-03	-21.1	-21.1	
7	1.50	-18.21	-0.041	-3.76E-03	-29.3	-33.8	
		1.95	-0.041	-3.76E-03	-29.3	-33.8	
8	1.42	6.59	-0.041	-3.76E-03	-29.0	-36.1	
		8.91	-0.041	-3.76E-03	-29.0	-36.1	
9	1.00	23.69	-0.039	-3.75E-03	-22.2	-47.5	
10	0.50	30.94	-0.037	-3.72E-03	-8.5	-55.8	
11	0.00	40.33	-0.035	-3.68E-03	9.3	-56.3	
12	-0.08	24.96	-0.035	-3.67E-03	11.9	-55.4	
		-21.21	-0.035	-3.67E-03	11.9	-55.4	
13	-0.84	-7.29	-0.032	-3.59E-03	1.1	-52.1	
14	-1.60	1.73	-0.030	-3.46E-03	-1.0	-53.4	
15	-2.34	-1.85	-0.027	-3.31E-03	-1.1	-53.7	
16	-3.08	-4.34	-0.025	-3.14E-03	-3.4	-55.0	
		2.29	-0.025	-3.14E-03	-3.4	-55.0	
17	-3.54	-0.17	-0.023	-3.03E-03	-2.9	-56.3	
18	-4.00	-3.40	-0.022	-2.91E-03	-3.7	-57.6	
19	-4.80	-6.64	-0.020	-2.69E-03	-7.7	-61.6	
20	-5.44	-10.06	-0.018	-2.51E-03	-13.0	-67.9	
21	-6.08	-9.21	-0.016	-2.31E-03	-19.2	-78.3	
		31.64	-0.016	-2.31E-03	-19.2	-78.3	

(continued)

Stage No.4 Apply water pressure profile no.1

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
22	-6.64	25.93	-0.015	-2.14E-03	-3.1	-84.1	
23	-7.20	16.71	-0.014	-1.96E-03	8.8	-81.8	
24	-8.00	9.87	-0.013	-1.74E-03	19.5	-69.4	
25	-8.65	4.53	-0.012	-1.60E-03	24.2	-54.6	
26	-9.30	0.83	-0.011	-1.50E-03	25.9	-37.9	
27	-9.73	-2.56	-0.010	-1.45E-03	25.5	-26.9	
28	-10.15	-6.42	-0.009	-1.42E-03	23.6	-16.2	
29	-10.58	-14.87	-0.009	-1.40E-03	19.1	-6.8	
30	-11.00	-51.01	-0.008	-1.39E-03	5.1	-0.0	
31	-11.20	-0.05	-0.008	0	-0.0	0.0	
32	-12.08	14.61	-0.008	0	6.4	0.0	
		-8.64	-0.008	0	6.4	0.0	
33	-13.58	-15.82	-0.006	0	-11.9	0.0	
		14.77	-0.006	0	-11.9	0.0	
34	-15.19	-0.00	-0.005	0	-0.1	0.0	
35	-16.79	-0.00	-0.003	0	-0.1	0.0	
36	-18.40	-0.00	-0.002	0	-0.1	0.0	
37	-20.00	0.12	-0.000	0	-0.0	0.0	

LEFT side

			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	earth pressure kN/m2	soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4689
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4689
		0.00	1.36	0.00	25.59b	25.59	25.59p	7816
9	1.00	0.00	8.92	0.00	43.14b	43.14	43.14p	7816
10	0.50	0.00	17.92	0.00	57.00b	57.00	57.00p	7816
11	0.00	0.00	26.92	2.30	72.95b	72.95	72.95p	7816
12	-0.08	0.80	27.56	2.51	57.82b	57.82	58.62p	7816
		0.80	27.56	6.41	20.56b	20.56	21.36p	3908
13	-0.84	8.40	32.88	8.18	38.95b	38.95	47.35p	3908
14	-1.60	16.00	38.21	9.95	62.59b	52.61	68.61	3908
15	-2.34	23.40	43.39	11.67	72.22b	53.52	76.92	3908
16	-3.08	30.80	48.58	13.40	81.16b	55.01	85.81	3908
		30.80	48.58	11.20	155.51b	56.93	87.73	4689
17	-3.54	35.40	51.81	12.30	129.81b	57.20	92.60	4689
18	-4.00	40.00	55.03	13.41	100.66b	57.25	97.25	4689
19	-4.80	48.00	60.65	15.32	110.72b	58.64	106.64	4689
20	-5.44	54.40	65.15	16.86	119.11b	59.33	113.73	4689
21	-6.08	60.80	69.65	18.39	127.09b	61.90	122.70	4689
		60.80	69.65	12.42	319.32	80.84	141.64	11463
22	-6.64	66.40	74.71	14.08	297.94	79.93	146.33	11463
23	-7.20	72.00	79.77	15.75	196.22b	77.86	149.86	11463
24	-8.00	80.00	87.01	18.13	149.25b	78.17	158.17	11463
25	-8.65	86.50	92.90	20.06	249.94b	78.53	165.03	11463
26	-9.30	93.00	98.79	22.00	356.64b	79.76	172.76	11463
27	-9.73	97.25	102.64	23.26	351.40b	80.09	177.34	11463
28	-10.15	101.50	106.50	24.53	366.80b	80.15	181.65	11463

(continued)

Stage No.4 Apply water pressure profile no.1

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
29	-10.58	105.75	110.36	25.80	382.20b	78.01	183.76	11463
30	-11.00	110.00	114.22	27.07	396.81b	60.10	170.10	11463
31	-11.20	112.00	116.04	27.67	407.25b	88.77	200.77	11463
32	-12.08	120.80	124.04	30.30	433.79b	100.55	221.35	11463
		120.80	124.04	32.67	519.74b	72.04	192.84	6253
33	-13.58	135.80	136.21	35.87	570.71b	73.75	209.55	6253
		135.80	136.21	32.22	600.85b	106.93	242.73	15632
34	-15.19	151.85	150.86	37.09	627.91b	107.02	258.87	15632
35	-16.79	167.90	165.55	41.98	653.42b	115.30	283.20	15632
36	-18.40	183.95	180.27	46.88	715.85b	122.94	306.89	15632
37	-20.00	200.00	195.03	51.79	774.87b	122.23	322.23	15632

RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30580
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30580
		0.00	12.21	3.06	70.25	3.06	3.06a	5097
3	3.66	0.00	25.29	6.35	145.55	6.35	6.35a	5097
4	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5097
5	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5097
		0.00	45.03	9.99	191.25	9.99	9.99a	4587
6	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4587
7	1.50	0.00	69.12	18.21	282.76	18.21	18.21a	4587
8	1.42	0.00	70.66	18.74	288.62	18.74	18.74a	4587
		0.00	70.66	16.68	307.87	16.68	16.68a	7645
9	1.00	0.00	79.10	19.45	341.56	19.45	19.45a	7645
10	0.50	5.00	83.98	21.06	361.07	21.06	26.06a	7645
11	0.00	10.00	88.72	22.62	379.98	22.62	32.62a	7645
12	-0.08	10.80	89.47	22.86	382.95	22.86	33.66a	7645
		10.80	89.47	27.00	349.95	31.77	42.57	3822
13	-0.84	18.40	95.64	29.05	373.38	36.24	54.64	3822
14	-1.60	26.00	101.57	31.02	395.94	40.89	66.89	3822
15	-2.34	33.40	107.17	32.89	417.21	45.37	78.77	3822
16	-3.08	40.80	112.63	34.70	437.95	49.35	90.15	3822
		40.80	112.63	33.05	448.10	44.64	85.44	4587
17	-3.54	45.40	115.97	34.19	460.76	47.37	92.77	4587
18	-4.00	50.00	119.26	35.31	473.28	50.64	100.64	4587
19	-4.80	58.00	124.91	37.24	494.74	55.28	113.28	4587
20	-5.44	64.40	129.37	38.76	511.68	59.40	123.80	4587
21	-6.08	70.80	133.78	40.27	528.44	61.11	131.91	4587
		70.80	133.78	33.50	575.33	39.20	110.00	11213
22	-6.64	76.40	138.73	35.13	595.08	44.00	120.40	11213
23	-7.20	82.00	143.65	36.74	614.74	51.15	133.15	11213
24	-8.00	90.00	150.65	39.05	642.67	58.30	148.30	11213
25	-8.65	96.50	156.31	40.91	665.27	64.00	160.50	11213
26	-9.30	103.00	161.95	42.76	687.79	68.93	171.93	11213
27	-9.73	107.25	165.63	43.97	702.49	72.65	179.90	11213
28	-10.15	111.50	169.31	45.18	717.16	76.57	188.07	11213
29	-10.58	115.75	172.98	46.39	731.82	82.88	198.63	11213
30	-11.00	120.00	176.65	47.59	746.46	101.11	221.11	11213
31	-11.20	122.00	178.38	48.16	753.35	78.81	200.81	11213

(continued)

Stage No.4 Apply water pressure profile no.1

		RIGHT side						
			Effective stresses				Total	Adjusted
Node	Y	Water	Vertic	Active	Passive	Earth	earth	soil
no.	coord	press.	-al	limit	limit	pressure	pressure	modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
32	-12.08	130.80	185.96	50.65	783.63	75.94	206.74	11213
		130.80	185.96	48.97	1013.28	70.68	201.48	6116
33	-13.58	145.80	197.38	51.98	1075.49	79.57	225.37	6116
		145.80	197.38	52.57	888.16	82.16	227.96	15290
34	-15.19	161.85	211.20	57.17	946.75	97.02	258.87	15290
35	-16.79	177.90	225.04	61.77	1005.40	105.30	283.20	15290
36	-18.40	193.95	238.90	66.39	1064.16	112.94	306.89	15290
37	-20.00	210.00	252.80	71.01	1123.05	112.10	322.10	15290

Note: 33.66 a Soil pressure at active limit
47.35 p Soil pressure at passive limit
774.87 b Passive limit reduced because of berm

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SMEC AUSTRALIA PTY LTD                                          | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58             | Job No. 3001315
                             Licensed from GEOSOLVE             | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained                         |
Byron Lane Slip                                                 | Date:24-09-2021
AZ 24-700N Sheet Pile                                           | Checked :
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                                                       Units: kN,m
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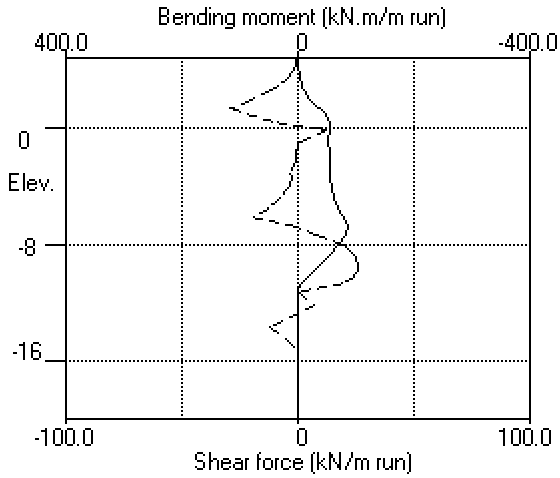
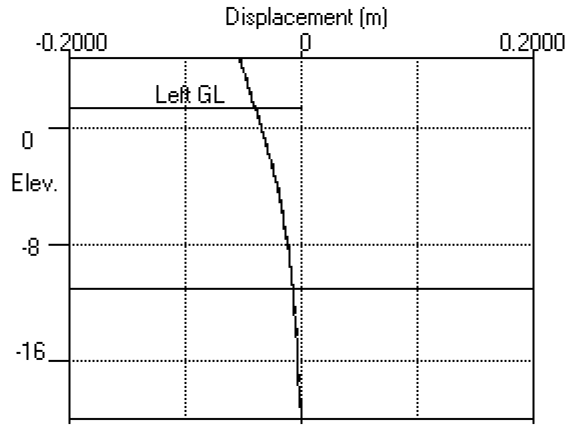
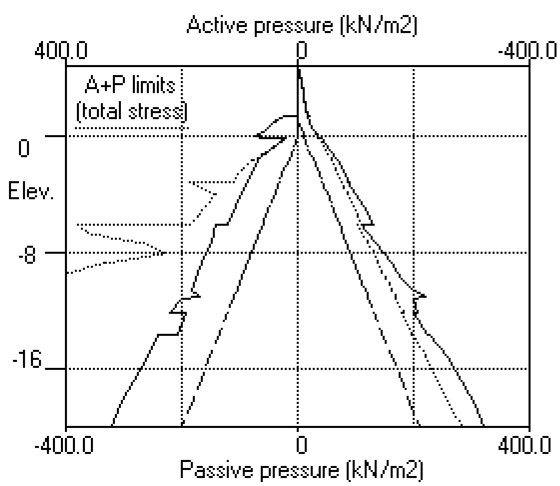
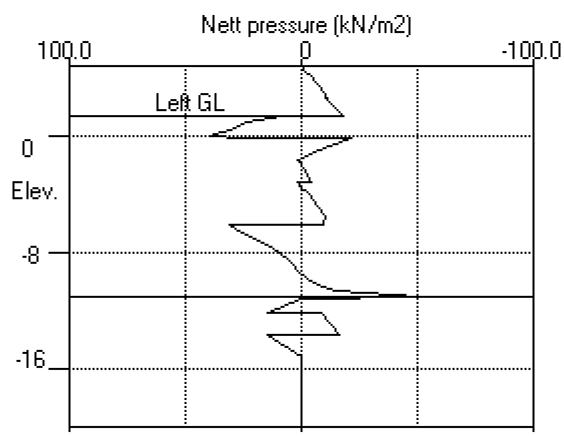
Stage No.4 Apply water pressure profile no.1





Stage No.4 Apply water pressure profile no.1





Units: kN,m

Stage No. 5 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = -11.00: Factor of Safety	FoS for toe elev. = -11.00: Moment equilib. at elev.	Toe elev. for FoS = 1.300: Toe elev.	Toe elev. for FoS = 1.300: Wall Penetr -ation	Direction of failure
5	4.92	1.50	Cant.	1.399	-10.09	-9.31	10.81	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.100	-7.29E-03	0.0	0.0	
2	4.32	-2.39	-0.095	-7.29E-03	-0.7	-0.3	
		-3.06	-0.095	-7.29E-03	-0.7	-0.3	
3	3.66	-6.35	-0.091	-7.29E-03	-3.8	-1.8	
4	3.00	-9.82	-0.086	-7.29E-03	-9.2	-6.2	
5	2.72	-11.31	-0.084	-7.29E-03	-12.1	-9.1	
		-9.99	-0.084	-7.29E-03	-12.1	-9.1	
6	2.00	-14.88	-0.078	-7.28E-03	-21.1	-21.1	
7	1.50	-21.50	-0.075	-7.27E-03	-30.2	-33.9	
		-1.35	-0.075	-7.27E-03	-30.2	-33.9	
8	1.42	2.77	-0.074	-7.27E-03	-30.1	-36.3	
		5.02	-0.074	-7.27E-03	-30.1	-36.3	
9	1.00	16.97	-0.071	-7.25E-03	-25.5	-48.6	
10	0.50	24.23	-0.068	-7.22E-03	-15.2	-59.3	
11	0.00	33.62	-0.064	-7.15E-03	-0.7	-64.0	
12	-0.08	18.25	-0.063	-7.14E-03	1.3	-64.0	
		-23.11	-0.063	-7.14E-03	1.3	-64.0	
13	-0.84	-7.64	-0.058	-6.97E-03	-10.3	-69.3	
14	-1.60	7.10	-0.053	-6.71E-03	-10.5	-79.3	
15	-2.34	1.83	-0.048	-6.37E-03	-7.2	-85.2	
16	-3.08	-1.78	-0.043	-5.99E-03	-7.2	-90.1	
		6.49	-0.043	-5.99E-03	-7.2	-90.1	
17	-3.54	2.96	-0.041	-5.74E-03	-5.0	-92.7	
18	-4.00	-1.60	-0.038	-5.47E-03	-4.7	-94.7	
19	-4.80	-6.08	-0.034	-5.00E-03	-7.8	-99.0	
20	-5.44	-10.74	-0.031	-4.62E-03	-13.2	-105.3	
21	-6.08	-9.22	-0.028	-4.22E-03	-19.6	-115.9	
		39.85	-0.028	-4.22E-03	-19.6	-115.9	

(continued)

Stage No.5 Apply water pressure profile no.2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
22	-6.64	32.69	-0.026	-3.87E-03	0.7	-120.6	
23	-7.20	20.60	-0.024	-3.53E-03	15.7	-115.1	
24	-8.00	11.77	-0.021	-3.10E-03	28.6	-96.0	
25	-8.65	4.98	-0.019	-2.83E-03	34.0	-74.9	
26	-9.30	0.27	-0.017	-2.63E-03	35.8	-51.7	
27	-9.73	-4.10	-0.016	-2.54E-03	34.9	-36.5	
28	-10.15	-9.15	-0.015	-2.48E-03	32.1	-22.0	
29	-10.58	-20.38	-0.014	-2.45E-03	25.8	-9.1	
30	-11.00	-68.85	-0.013	-2.44E-03	6.9	-0.0	
31	-11.20	-0.05	-0.013	0	-0.0	0.0	
32	-12.08	16.90	-0.013	0	7.4	0.0	
		-9.99	-0.013	0	7.4	0.0	
33	-13.58	-18.32	-0.010	0	-13.8	0.0	
		17.10	-0.010	0	-13.8	0.0	
34	-15.19	-0.00	-0.008	0	-0.1	0.0	
35	-16.79	-0.00	-0.006	0	-0.1	0.0	
36	-18.40	-0.00	-0.004	0	-0.1	0.0	
37	-20.00	0.12	-0.001	0	-0.0	0.0	

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4689
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4689
		0.00	1.36	0.00	25.59b	25.59	25.59p	7816
9	1.00	0.00	8.92	0.00	43.14b	43.14	43.14p	7816
10	0.50	0.00	17.92	0.00	57.00b	57.00	57.00p	7816
11	0.00	0.00	26.92	2.30	72.95b	72.95	72.95p	7816
12	-0.08	0.80	27.56	2.51	57.82b	57.82	58.62p	7816
		0.80	27.56	6.41	20.56b	20.56	21.36p	3908
13	-0.84	8.40	32.88	8.18	38.95b	38.95	47.35p	3908
14	-1.60	16.00	38.21	9.95	62.59b	59.04	75.04	3908
15	-2.34	23.40	43.39	11.67	72.22b	58.94	82.34	3908
16	-3.08	30.80	48.58	13.40	81.16b	59.73	90.53	3908
		30.80	48.58	11.20	155.51b	62.59	93.39	4689
17	-3.54	35.40	51.81	12.30	129.81b	62.18	97.58	4689
18	-4.00	40.00	55.03	13.41	100.66b	61.49	101.49	4689
19	-4.80	48.00	60.65	15.32	110.72b	62.20	110.20	4689
20	-5.44	54.40	65.15	16.86	119.11b	62.23	116.63	4689
21	-6.08	60.80	69.65	18.39	127.09b	64.97	125.77	4689
		60.80	69.65	12.42	319.32	88.35	149.15	11463
22	-6.64	66.40	74.71	14.08	297.94	86.40	152.80	11463
23	-7.20	72.00	79.77	15.75	196.22b	82.81	154.81	11463
24	-8.00	80.00	87.01	18.13	149.25b	82.06	162.06	11463
25	-8.65	86.50	92.90	20.06	249.94b	81.64	168.14	11463
26	-9.30	93.00	98.79	22.00	356.64b	82.34	175.34	11463
27	-9.73	97.25	102.64	23.26	351.40b	82.15	179.40	11463
28	-10.15	101.50	106.50	24.53	366.80b	81.59	183.09	11463

(continued)

Stage No.5 Apply water pressure profile no.2

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
29	-10.58	105.75	110.36	25.80	382.20b	78.06	183.81	11463
30	-11.00	110.00	114.22	27.07	396.81b	53.32	163.32	11463
31	-11.20	112.00	116.04	27.67	407.25b	91.70	203.70	11463
32	-12.08	120.80	124.04	30.30	433.79b	104.65	225.45	11463
		120.80	124.04	32.67	519.74b	74.28	195.08	6253
33	-13.58	135.80	136.21	35.87	570.71b	75.37	211.17	6253
		135.80	136.21	32.22	600.85b	111.00	246.80	15632
34	-15.19	151.85	150.86	37.09	627.91b	109.82	261.67	15632
35	-16.79	167.90	165.55	41.98	653.42b	118.20	286.10	15632
36	-18.40	183.95	180.27	46.88	715.85b	125.84	309.79	15632
37	-20.00	200.00	195.03	51.79	774.87b	123.46	323.46	15632

RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30580
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30580
		0.00	12.21	3.06	70.25	3.06	3.06a	5097
3	3.66	0.00	25.29	6.35	145.55	6.35	6.35a	5097
4	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5097
5	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5097
		0.00	45.03	9.99	191.25	9.99	9.99a	4587
6	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4587
7	1.50	5.00	64.12	16.50	263.77	16.50	21.50a	4587
8	1.42	5.80	64.86	16.76	266.58	16.76	22.56a	4587
		5.80	64.86	14.77	284.72	14.77	20.57a	7645
9	1.00	10.00	69.10	16.17	301.64	16.17	26.17a	7645
10	0.50	15.00	73.98	17.77	321.15	17.77	32.77a	7645
11	0.00	20.00	78.72	19.33	340.06	19.33	39.33a	7645
12	-0.08	20.80	79.47	19.57	343.03	19.57	40.37a	7645
		20.80	79.47	23.67	311.96	23.67	44.47a	3822
13	-0.84	28.40	85.64	25.72	335.40	26.59	54.99	3822
14	-1.60	36.00	91.57	27.70	357.95	31.94	67.94	3822
15	-2.34	43.40	97.17	29.56	379.23	37.11	80.51	3822
16	-3.08	50.80	102.63	31.38	399.96	41.51	92.31	3822
		50.80	102.63	29.64	410.10	36.09	86.89	4587
17	-3.54	55.40	105.97	30.78	422.77	39.22	94.62	4587
18	-4.00	60.00	109.26	31.90	435.29	43.09	103.09	4587
19	-4.80	68.00	114.91	33.83	456.75	48.28	116.28	4587
20	-5.44	74.40	119.37	35.35	473.68	52.97	127.37	4587
21	-6.08	80.80	123.78	36.86	490.45	54.20	135.00	4587
		80.80	123.78	30.21	535.41	28.50	109.30A	11213
22	-6.64	86.40	128.73	31.84	555.16	33.71	120.11	11213
23	-7.20	92.00	133.65	33.46	574.82	42.22	134.22	11213
24	-8.00	100.00	140.65	35.76	602.75	50.29	150.29	11213
25	-8.65	106.50	146.31	37.62	625.35	56.67	163.17	11213
26	-9.30	113.00	151.95	39.47	647.87	62.07	175.07	11213
27	-9.73	117.25	155.63	40.68	662.57	66.25	183.50	11213
28	-10.15	121.50	159.31	41.89	677.24	70.74	192.24	11213
29	-10.58	125.75	162.98	43.10	691.90	78.44	204.19	11213
30	-11.00	130.00	166.65	44.30	706.54	102.17	232.17	11213
31	-11.20	132.00	168.38	44.87	713.43	71.75	203.75	11213

(continued)

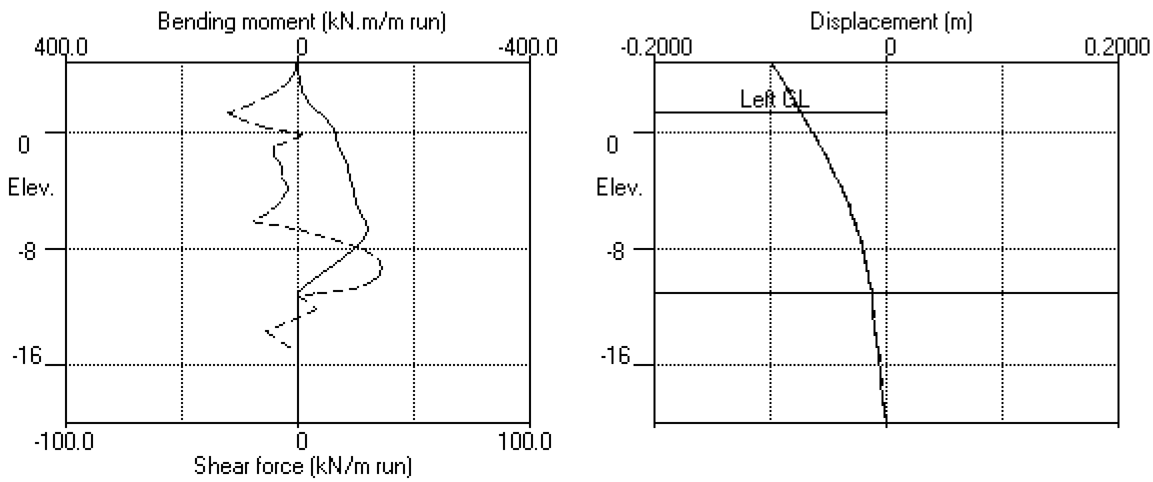
Stage No.5 Apply water pressure profile no.2

		RIGHT side						
			Effective stresses				Total	Adjusted
Node	Y	Water	Vertic	Active	Passive	Earth	earth	soil
no.	coord	press.	-al	limit	limit	pressure	pressure	modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
32	-12.08	140.80	175.96	47.37	743.71	67.74	208.54	11213
		140.80	175.96	46.34	958.79	64.27	205.07	6116
33	-13.58	155.80	187.38	49.35	1021.00	73.69	229.49	6116
		155.80	187.38	49.24	845.78	73.90	229.70	15290
34	-15.19	171.85	201.20	53.84	904.37	89.82	261.67	15290
35	-16.79	187.90	215.04	58.45	963.02	98.20	286.10	15290
36	-18.40	203.95	228.90	63.06	1021.78	105.84	309.79	15290
37	-20.00	220.00	242.80	67.68	1080.67	103.33	323.33	15290

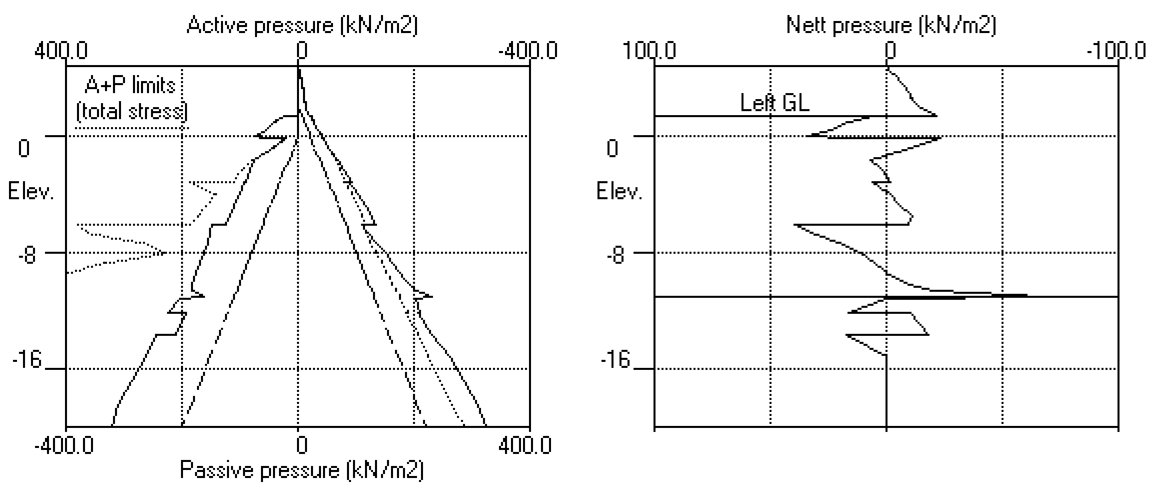
Note: 44.47 a Soil pressure at active limit
47.35 p Soil pressure at passive limit
774.87 b Passive limit reduced because of berm
109.30A Arching - soil pressure below active limit

```
SMEC AUSTRALIA PTY LTD                                    | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58       | Job No. 3001315
                             Licensed from GEOSOLVE       | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained                   |
Byron Lane Slip                                           | Date:24-09-2021
AZ 24-700N Sheet Pile                                     | Checked :
-----------------------------------------------------------------------------
                                                      Units: kN,m
```

Stage No.5 Apply water pressure profile no.2



Stage No.5 Apply water pressure profile no.2



Units: kN,m

Stage No. 6 Apply water pressure profile no.3

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = -11.00: Factor of Safety	FoS for toe elev. = -11.00: Moment equilib. at elev.	Toe elev. for FoS = 1.300: Toe elev.	Toe elev. for FoS = 1.300: Wall Penetr -ation	Direction of failure
6	4.92	1.50	Cant.	1.314	-10.05	-10.77	12.27	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.195	-1.50E-02	0.0	-0.0	
2	4.32	-2.39	-0.186	-1.50E-02	-0.7	-0.3	
		-3.06	-0.186	-1.50E-02	-0.7	-0.3	
3	3.66	-6.35	-0.176	-1.50E-02	-3.8	-1.8	
4	3.00	-9.82	-0.166	-1.50E-02	-9.2	-6.2	
5	2.72	-13.40	-0.161	-1.50E-02	-12.4	-9.2	
		-11.84	-0.161	-1.50E-02	-12.4	-9.2	
6	2.00	-21.47	-0.151	-1.50E-02	-24.4	-22.2	
7	1.50	-28.09	-0.143	-1.50E-02	-36.8	-37.4	
		-7.94	-0.143	-1.50E-02	-36.8	-37.4	
8	1.42	-3.82	-0.142	-1.50E-02	-37.3	-40.4	
		-1.69	-0.142	-1.50E-02	-37.3	-40.4	
9	1.00	10.26	-0.136	-1.49E-02	-35.5	-56.3	
10	0.50	17.51	-0.128	-1.49E-02	-28.5	-72.9	
11	0.00	26.90	-0.121	-1.47E-02	-17.4	-85.1	
12	-0.08	11.54	-0.120	-1.47E-02	-15.9	-86.4	
		-29.79	-0.120	-1.47E-02	-15.9	-86.4	
13	-0.84	-13.45	-0.108	-1.43E-02	-32.3	-106.6	
14	-1.60	8.22	-0.098	-1.38E-02	-34.3	-135.1	
15	-2.34	13.12	-0.088	-1.30E-02	-26.4	-158.3	
16	-3.08	7.38	-0.078	-1.21E-02	-18.8	-174.2	
		16.92	-0.078	-1.21E-02	-18.8	-174.2	
17	-3.54	12.61	-0.073	-1.16E-02	-12.0	-181.1	
18	-4.00	5.04	-0.068	-1.09E-02	-8.0	-185.3	
19	-4.80	-2.16	-0.059	-9.90E-03	-6.8	-190.0	
20	-5.44	-9.51	-0.053	-9.02E-03	-10.5	-194.8	
21	-6.08	-6.31	-0.048	-8.14E-03	-15.6	-203.5	
		55.23	-0.048	-8.14E-03	-15.6	-203.5	

(continued)

Stage No.6 Apply water pressure profile no.3

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
22	-6.64	45.37	-0.043	-7.38E-03	12.6	-203.6	
23	-7.20	27.39	-0.040	-6.66E-03	32.9	-189.4	
24	-8.00	14.67	-0.035	-5.79E-03	49.8	-154.3	
25	-8.65	5.08	-0.031	-5.23E-03	56.2	-118.8	
26	-9.30	-1.58	-0.028	-4.83E-03	57.3	-81.2	
27	-9.73	-7.85	-0.026	-4.65E-03	55.3	-57.0	
28	-10.15	-15.34	-0.024	-4.53E-03	50.4	-34.2	
29	-10.58	-32.34	-0.022	-4.47E-03	40.3	-14.2	
30	-11.00	-106.82	-0.020	-4.45E-03	10.7	-0.0	
31	-11.20	-0.05	-0.020	0	-0.0	0.0	
32	-12.08	19.19	-0.020	0	8.4	0.0	
		-11.33	-0.020	0	8.4	0.0	
33	-13.58	-20.81	-0.016	0	-15.7	0.0	
		19.43	-0.016	0	-15.7	0.0	
34	-15.19	-0.00	-0.012	0	-0.1	0.0	
35	-16.79	-0.00	-0.009	0	-0.1	0.0	
36	-18.40	-0.00	-0.005	0	-0.1	0.0	
37	-20.00	0.12	-0.001	0	-0.0	0.0	

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4689
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4689
		0.00	1.36	0.00	25.59b	25.59	25.59p	7816
9	1.00	0.00	8.92	0.00	43.14b	43.14	43.14p	7816
10	0.50	0.00	17.92	0.00	57.00b	57.00	57.00p	7816
11	0.00	0.00	26.92	2.30	72.95b	72.95	72.95p	7816
12	-0.08	0.80	27.56	2.51	57.82b	57.82	58.62p	7816
		0.80	27.56	6.41	20.56b	20.56	21.36p	3908
13	-0.84	8.40	32.88	8.18	38.95b	38.95	47.35p	3908
14	-1.60	16.00	38.21	9.95	62.59b	62.59	78.59p	3908
15	-2.34	23.40	43.39	11.67	72.22b	69.36	92.76	3908
16	-3.08	30.80	48.58	13.40	81.16b	68.53	99.33	3908
		30.80	48.58	11.20	155.51b	73.15	103.95	4689
17	-3.54	35.40	51.81	12.30	129.81b	71.18	106.58	4689
18	-4.00	40.00	55.03	13.41	100.66b	68.82	108.82	4689
19	-4.80	48.00	60.65	15.32	110.72b	68.03	116.03	4689
20	-5.44	54.40	65.15	16.86	119.11b	66.61	121.01	4689
21	-6.08	60.80	69.65	18.39	127.09b	69.83	130.63	4689
		60.80	69.65	12.42	319.32	100.22	161.02	11463
22	-6.64	66.40	74.71	14.08	297.94	96.23	162.63	11463
23	-7.20	72.00	79.77	15.75	196.22b	89.52	161.52	11463
24	-8.00	80.00	87.01	18.13	149.25b	86.68	166.68	11463
25	-8.65	86.50	92.90	20.06	249.94b	84.73	171.23	11463
26	-9.30	93.00	98.79	22.00	356.64b	84.38	177.38	11463
27	-9.73	97.25	102.64	23.26	351.40b	83.18	180.43	11463
28	-10.15	101.50	106.50	24.53	366.80b	81.34	182.84	11463

(continued)

Stage No.6 Apply water pressure profile no.3

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
29	-10.58	105.75	110.36	25.80	382.20b	74.93	180.68	11463
30	-11.00	110.00	114.22	27.07	396.81b	35.74	145.74	11463
31	-11.20	112.00	116.04	27.67	407.25b	94.82	206.82	11463
32	-12.08	120.80	124.04	30.30	433.79b	108.92	229.72	11463
		120.80	124.04	32.67	519.74b	76.61	197.41	6253
33	-13.58	135.80	136.21	35.87	570.71b	77.05	212.85	6253
		135.80	136.21	32.22	600.85b	115.20	251.00	15632
34	-15.19	151.85	150.86	37.09	627.91b	112.61	264.46	15632
35	-16.79	167.90	165.55	41.98	653.42b	121.17	289.07	15632
36	-18.40	183.95	180.27	46.88	715.85b	128.85	312.80	15632
37	-20.00	200.00	195.03	51.79	774.87b	124.21	324.21	15632

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30580
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30580
		0.00	12.21	3.06	70.25	3.06	3.06a	5097
3	3.66	0.00	25.29	6.35	145.55	6.35	6.35a	5097
4	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5097
5	2.72	2.80	42.23	10.60	243.06	10.60	13.40a	5097
		2.80	42.23	9.04	180.61	9.04	11.84a	4587
6	2.00	10.00	49.37	11.47	207.74	11.47	21.47a	4587
7	1.50	15.00	54.12	13.09	225.77	13.09	28.09a	4587
8	1.42	15.80	54.86	13.35	228.59	13.35	29.15a	4587
		15.80	54.86	11.49	244.80	11.49	27.29a	7645
9	1.00	20.00	59.10	12.88	261.72	12.88	32.88a	7645
10	0.50	25.00	63.98	14.49	281.23	14.49	39.49a	7645
11	0.00	30.00	68.72	16.04	300.14	16.04	46.04a	7645
12	-0.08	30.80	69.47	16.29	303.11	16.29	47.09a	7645
		30.80	69.47	20.35	273.97	20.35	51.15a	3822
13	-0.84	38.40	75.64	22.40	297.41	22.40	60.80a	3822
14	-1.60	46.00	81.57	24.37	319.96	24.37	70.37a	3822
15	-2.34	53.40	87.17	26.24	341.24	26.24	79.64a	3822
16	-3.08	60.80	92.63	28.05	361.98	31.15	91.95	3822
		60.80	92.63	26.23	372.11	26.23	87.03a	4587
17	-3.54	65.40	95.97	27.37	384.77	28.57	93.97	4587
18	-4.00	70.00	99.26	28.49	397.29	33.78	103.78	4587
19	-4.80	78.00	104.91	30.42	418.76	40.19	118.19	4587
20	-5.44	84.40	109.37	31.94	435.69	46.12	130.52	4587
21	-6.08	90.80	113.78	33.44	452.45	46.14	136.94	4587
		90.80	113.78	26.92	495.49	14.99	105.79A	11213
22	-6.64	96.40	118.73	28.55	515.24	20.86	117.26A	11213
23	-7.20	102.00	123.65	30.17	534.90	32.13	134.13	11213
24	-8.00	110.00	130.65	32.47	562.83	42.01	152.01	11213
25	-8.65	116.50	136.31	34.33	585.43	49.66	166.16	11213
26	-9.30	123.00	141.95	36.19	607.95	55.95	178.95	11213
27	-9.73	127.25	145.63	37.40	622.65	61.04	188.29	11213
28	-10.15	131.50	149.31	38.60	637.32	66.68	198.18	11213
29	-10.58	135.75	152.98	39.81	651.98	77.28	213.03	11213
30	-11.00	140.00	156.65	41.02	666.62	112.56	252.56	11213
31	-11.20	142.00	158.38	41.58	673.51	64.87	206.87	11213

(continued)

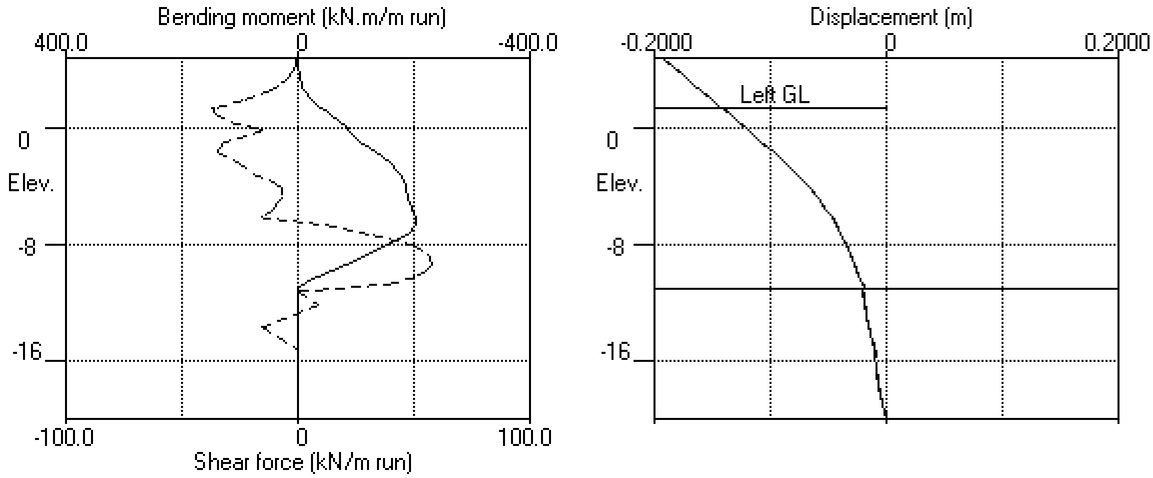
Stage No.6 Apply water pressure profile no.3

		RIGHT side						
			Effective stresses				Total	Adjusted
Node	Y	Water	Vertic	Active	Passive	Earth	earth	soil
no.	coord	press.	-al	limit	limit	pressure	pressure	modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
32	-12.08	150.80	165.96	44.08	703.79	59.72	210.52	11213
		150.80	165.96	43.71	904.30	57.94	208.74	6116
33	-13.58	165.80	177.38	46.71	966.51	67.87	233.67	6116
		165.80	177.38	45.92	803.40	65.77	231.57	15290
34	-15.19	181.85	191.20	50.52	861.98	82.61	264.46	15290
35	-16.79	197.90	205.04	55.12	920.63	91.17	289.07	15290
36	-18.40	213.95	218.90	59.73	979.39	98.85	312.80	15290
37	-20.00	230.00	232.80	64.35	1038.29	94.09	324.09	15290

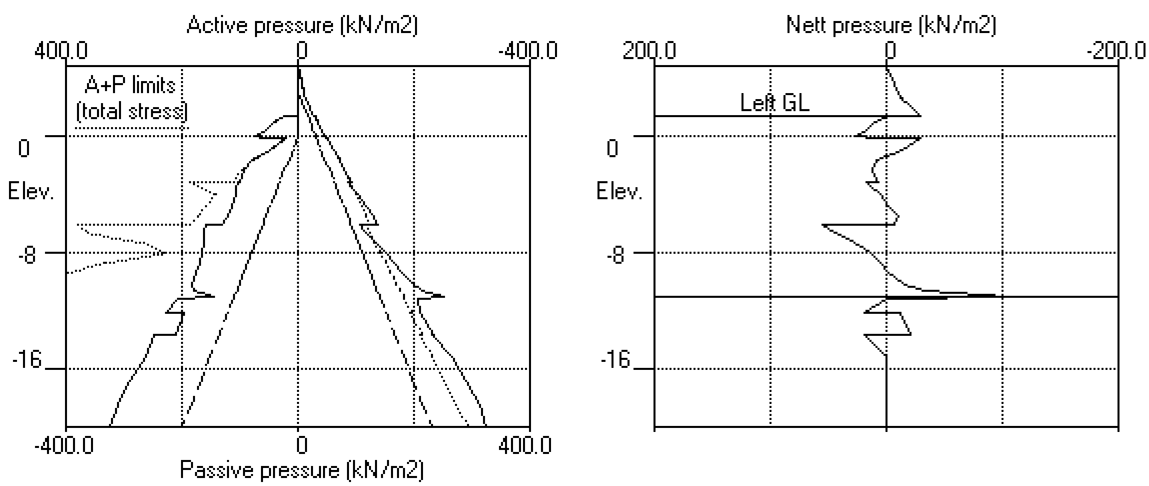
Note: 87.03 a Soil pressure at active limit
78.59 p Soil pressure at passive limit
774.87 b Passive limit reduced because of berm
117.26A Arching - soil pressure below active limit

Units: kN,m

Stage No.6 Apply water pressure profile no.3



Stage No.6 Apply water pressure profile no.3



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -11.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	4.92	1.50	Cant.	1.628	-10.08	-6.04	7.54	R to L
2	1.50	4.92		No analysis at this stage				
3	4.92	1.50	Cant.	1.534	-10.12	-7.36	8.86	R to L
4	4.92	1.50	Cant.	1.472	-10.11	-8.16	9.66	R to L
5	4.92	1.50	Cant.	1.399	-10.09	-9.31	10.81	R to L
6	4.92	1.50	Cant.	1.314	-10.05	-10.77	12.27	R to L

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum (m)	Displacement minimum (m)	Bending moment maximum (kN.m/m)	Bending moment minimum (kN.m/m)	Shear force maximum (kN/m)	Shear force minimum (kN/m)
1	4.92	0.000	-0.195	0.0	-0.0	0.0	0.0
2	4.32	0.000	-0.186	0.0	-0.3	0.0	-0.7
3	3.66	0.000	-0.176	0.0	-1.8	0.0	-3.8
4	3.00	0.000	-0.166	0.0	-6.2	0.0	-9.2
5	2.72	0.000	-0.161	0.0	-9.2	0.0	-12.4
6	2.00	0.000	-0.151	0.0	-22.2	0.0	-24.4
7	1.50	0.000	-0.143	0.0	-37.4	0.0	-36.8
8	1.42	0.000	-0.142	0.0	-40.4	0.0	-37.3
9	1.00	0.000	-0.136	0.0	-56.3	0.0	-35.5
10	0.50	0.000	-0.128	0.0	-72.9	0.0	-28.5
11	0.00	0.000	-0.121	0.0	-85.1	14.0	-17.4
12	-0.08	0.000	-0.120	0.0	-86.4	16.5	-15.9
13	-0.84	0.000	-0.108	0.0	-106.6	8.0	-32.3
14	-1.60	0.000	-0.098	0.0	-135.1	5.7	-34.3
15	-2.34	0.000	-0.088	0.0	-158.3	3.5	-26.4
16	-3.08	0.000	-0.078	0.0	-174.2	0.3	-18.8
17	-3.54	0.000	-0.073	0.0	-181.1	0.0	-12.0
18	-4.00	0.000	-0.068	0.0	-185.3	0.0	-8.0
19	-4.80	0.000	-0.059	0.0	-190.0	0.0	-7.8
20	-5.44	0.000	-0.053	0.0	-194.8	0.0	-13.2
21	-6.08	0.000	-0.048	0.0	-203.5	0.0	-19.6
22	-6.64	0.000	-0.043	0.0	-203.6	12.6	-4.3
23	-7.20	0.000	-0.040	0.0	-189.4	32.9	0.0
24	-8.00	0.000	-0.035	0.0	-154.3	49.8	0.0
25	-8.65	0.000	-0.031	0.0	-118.8	56.2	0.0
26	-9.30	0.000	-0.028	0.0	-81.2	57.3	0.0
27	-9.73	0.000	-0.026	0.0	-57.0	55.3	0.0
28	-10.15	0.000	-0.024	0.0	-34.2	50.4	0.0
29	-10.58	0.000	-0.022	0.0	-14.2	40.3	0.0
30	-11.00	0.000	-0.020	0.0	-0.0	10.7	0.0
31	-11.20	0.000	-0.020	0.0	0.0	0.0	-0.0
32	-12.08	0.000	-0.020	0.0	0.0	8.4	0.0
33	-13.58	0.000	-0.016	0.0	0.0	0.0	-15.7
34	-15.19	0.000	-0.012	0.0	0.0	0.0	-0.1
35	-16.79	0.000	-0.009	0.0	0.0	0.0	-0.1
36	-18.40	0.000	-0.005	0.0	0.0	0.0	-0.1
37	-20.00	0.000	-0.001	0.0	0.0	0.0	-0.0

Summary of results (continued)

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	elev.	Bending moment minimum kN.m/m	elev.	Shear force maximum kN/m	elev.	Shear force minimum kN/m	elev.
1	0.0	4.92	-48.1	0.50	16.5	-0.08	-26.1	1.50
2	No calculation at this stage							
3	0.0	4.92	-66.4	-6.64	20.6	-9.30	-29.3	1.50
4	0.0	4.92	-84.1	-6.64	25.9	-9.30	-29.3	1.50
5	0.0	4.92	-120.6	-6.64	35.8	-9.30	-30.2	1.50
6	0.0	4.92	-203.6	-6.64	57.3	-9.30	-37.3	1.42

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.000	4.92	-0.087	4.92	Excav. to elev. 1.50 on LEFT side
2	Wall displacements reset to zero				Change EI of wall to 117369kN.m2/m run
3	0.000	4.92	-0.029	4.92	Apply surcharge no.1 at elev. 4.92
4	0.000	4.92	-0.054	4.92	Apply water pressure profile no.1
5	0.000	4.92	-0.100	4.92	Apply water pressure profile no.2
6	0.000	4.92	-0.195	4.92	Apply water pressure profile no.3

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SMEC AUSTRALIA PTY LTD                                          | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58             | Job No. 3001315
                              Licensed from GEOSOLVE            | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained                         |
Byron Lane Slip                                                 | Date:24-09-2021
AZ 24-700N Sheet Pile                                           | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
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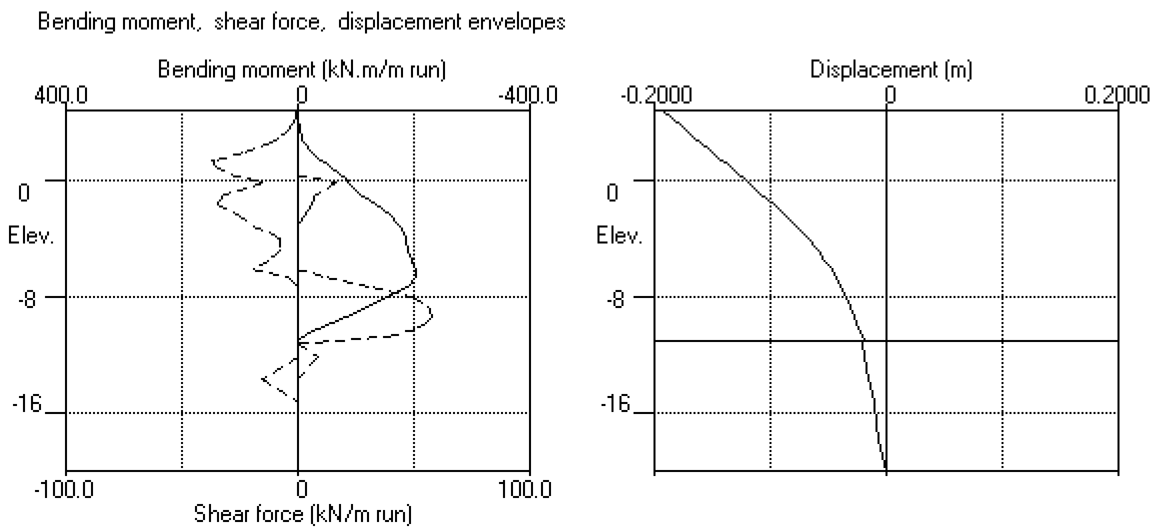

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Left side	Soil types: Right side
1	4.92	1 1 Pavement	1 1 Pavement
2	4.32	2 2 FILL	2 2 FILL
3	2.72	3 3a s-f Clayey SILT	3 3a s-f Clayey SILT
4	1.42	4 3b firm Silty CLAY	4 3b firm Silty CLAY
5	-0.08	5 4a s Sandy CLAY	5 4a s Sandy CLAY
6	-3.08	6 4b s-f Silty CLAY	6 4b s-f Silty CLAY
7	-6.08	7 4c St Silty CLAY	7 4c St Silty CLAY
8	-12.08	8 5a l-md SAND	8 5a l-md SAND
9	-13.58	9 5b stiff mix CLAY	9 5b stiff mix CLAY

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	1 Pavement	20.00	30000	0.357	OC	0.196	8.175	
					(0.200)	(0.000)	(0.000)	
2	2 FILL	18.00	5000	0.441	OC	0.251	5.756	
					(0.300)	(0.000)	(0.000)	
3	3a s-f	17.00	4500	0.562	OC	0.341	3.799	4.000d
	Clayey SILT				(0.300)	(1.342)	(5.039)	
4	3b firm	18.00	7500	0.546	OC	0.329	3.992	5.000d
	Silty CLAY				(0.300)	(1.310)	(5.162)	
5	4a s Sandy	17.00	2500	0.577	OC	0.392	2.619	0.0d
	CLAY				(0.300)	(1.505)	(4.007)	
6	4b s-f	17.00	4500	0.562	OC	0.341	3.799	4.000d
	Silty CLAY				(0.300)	(1.342)	(5.039)	
7	4c St Silty	19.00	11000	0.546	OC	0.329	3.992	8.000d
	CLAY				(0.300)	(1.310)	(5.162)	
8	5a l-md	18.00	6000	0.455	OC	0.263	5.449	
	SAND				(0.300)	(0.000)	(0.000)	
9	5b stiff	19.00	15000	0.546	OC	0.333	4.238	10.00d
	mix CLAY				(0.300)	(1.310)	(5.162)	

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	1 Pavement	40.00	0.297	0.00	41.70	0.297	0.00
2	2 FILL	34.00	0.370	0.00	35.63	0.370	0.00
3	3a s-f Clayey SILT	26.00	0.511	0.00	29.05	0.352	0.00
4	3b firm Silty CLAY	27.00	0.489	0.00	30.10	0.336	0.00
5	4a s Sandy CLAY	22.00	0.819	0.00	22.00	0.352	0.00
6	4b s-f Silty CLAY	26.00	0.511	0.00	29.05	0.352	0.00
7	4c St Silty CLAY	27.00	0.489	0.00	30.10	0.336	0.00
8	5a l-md SAND	33.00	0.384	0.00	34.62	0.384	0.00
9	5b stiff mix CLAY	27.00	0.489	0.00	32.10	0.264	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	0.00	0.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Left side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Right side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	0.00	0.00	0.0	1	1.00	1.00	0.0
2	1	0.00	0.00	0.0	1	2.00	2.00	0.0
3	1	0.00	0.00	0.0	1	3.00	3.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -7.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 5.5890E-04 m4/m run
E.I = 117369 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	3.00	3.00	0.000804	2.100E+08	20.00	0.00	20.00	Anchor	n/a	L

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	4.92	-2.00(R)	40.00	12.00	20.00	=	N/A	N/A

Note: L = Left side, R = Right side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Excavate to elevation 2.50 on LEFT side Toe of berm at elevation -9.30 Width of top of berm = 0.50 Width of toe of berm = 36.50
2	Change EI of wall to 117369 kN.m2/m run Reset wall displacements to zero at this stage
3	Apply surcharge no.1 at elevation 4.92
4	Install strut or anchor no.1 at elevation 3.00
5	Excavate to elevation 1.00 on LEFT side Toe of berm at elevation -9.30 Width of top of berm = 0.50 Width of toe of berm = 36.50
6	Apply water pressure profile no.1
7	Apply water pressure profile no.2
8	Apply water pressure profile no.3

FACTORS OF SAFETY and ANALYSIS OPTIONS

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 Stability analysis:
  Method of analysis  -  Strength Factor method
  Factor on soil strength for calculating wall depth = 1.30

 Parameters for undrained strata:
  Minimum equivalent fluid density             =   5.00 kN/m3
  Maximum depth of water filled tension crack  =   0.00 m

 Bending moment and displacement calculation:
  Method  -  2-D finite element model
  Open Tension Crack analysis? - No
  Active limit arching modelled?  -  Yes
  Non-linear Modulus Parameter (L) = 12.00 m

 Boundary conditions:
  Length of wall (normal to plane of analysis) = 40.00 m

  Width of excavation on Left  side of wall  = 50.00 m
  Width of excavation on Right side of wall  = 20.00 m

  Distance to rigid boundary on Left side  = 50.00 m
  Distance to rigid boundary on Right side = 30.00 m
  Elevation of rigid lower boundary = -20.00

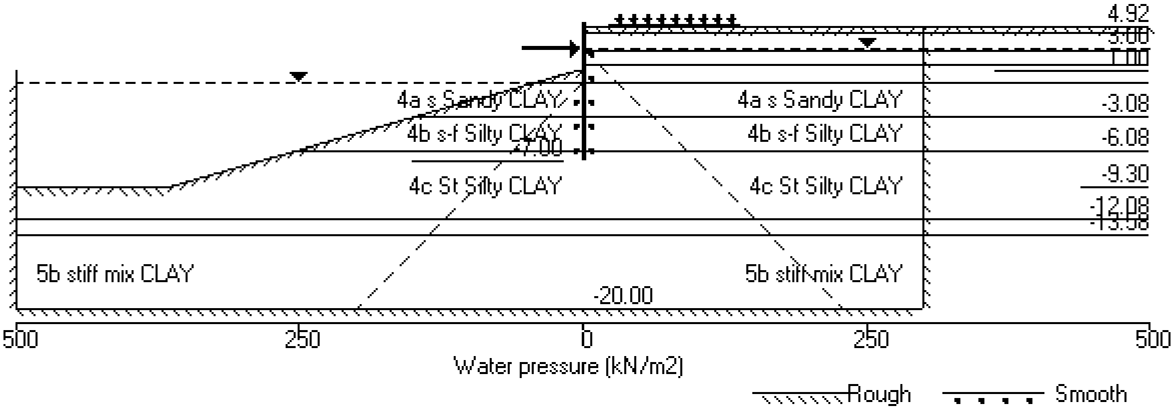
  Lower rigid boundary at elevation -20.00 - Rough
  Rigid boundary on Left side           - Rough
  Rigid boundary on Right side          - Rough
  Wall / soil interface                   - Smooth
```

OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Excav. to elev. 2.50 on LEFT side	Yes	Yes	Yes
2	Change EI of wall to 117369kN.m2/m run	Yes	Yes	Yes
3	Apply surcharge no.1 at elev. 4.92	No	No	No
4	Install prop no.1 at elev. 3.00	Yes	Yes	Yes
5	Excav. to elev. 1.00 on LEFT side	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Apply water pressure profile no.2	Yes	Yes	Yes
8	Apply water pressure profile no.3	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

```
SMEC AUSTRALIA PTY LTD                                              | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58                 | Job No. 3001315
                             Licensed from GEOSOLVE                 | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained_propped                     |
Byron Lane Slip                                                     | Date:27-09-2021
AZ 24-700N propped                                                  | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
```

Stage No.8   Apply water pressure profile no.3



Units: kN,m

Stage No. 1 Excavate to elevation 2.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -7.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	4.92	2.50	Cant.	1.422	-6.41	-5.57	8.07	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.065	-4.82E-03	0.0	0.0	
2	4.32	-2.35	-0.062	-4.82E-03	-0.7	-0.3	
		-3.01	-0.062	-4.82E-03	-0.7	-0.3	
3	3.96	-4.64	-0.060	-4.82E-03	-2.1	-0.8	
4	3.60	-6.27	-0.058	-4.81E-03	-4.0	-1.9	
5	3.00	-8.98	-0.055	-4.79E-03	-8.6	-5.7	
6	2.72	-10.24	-0.054	-4.78E-03	-11.3	-8.5	
		-8.55	-0.054	-4.78E-03	-11.3	-8.5	
7	2.50	-9.83	-0.053	-4.76E-03	-13.3	-11.2	
		-6.89	-0.053	-4.76E-03	-13.3	-11.2	
8	2.00	-2.59	-0.051	-4.69E-03	-15.7	-18.7	
9	1.42	3.31	-0.048	-4.58E-03	-15.5	-28.2	
		9.51	-0.048	-4.58E-03	-15.5	-28.2	
10	1.00	15.10	-0.046	-4.47E-03	-10.3	-33.8	
11	0.50	22.58	-0.044	-4.32E-03	-0.9	-37.1	
12	0.00	28.31	-0.042	-4.16E-03	11.8	-34.7	
13	-0.08	27.34	-0.041	-4.14E-03	14.0	-33.7	
		-3.19	-0.041	-4.14E-03	14.0	-33.7	
14	-0.64	-3.88	-0.039	-4.00E-03	12.1	-26.3	
15	-1.20	-4.46	-0.037	-3.89E-03	9.7	-20.2	
16	-1.80	-5.07	-0.035	-3.80E-03	6.9	-15.2	
17	-2.40	-5.60	-0.032	-3.73E-03	3.7	-12.0	
18	-2.74	-6.09	-0.031	-3.69E-03	1.7	-11.0	
19	-3.08	-5.86	-0.030	-3.66E-03	-0.4	-10.8	
		4.72	-0.030	-3.66E-03	-0.4	-10.8	
20	-3.64	3.36	-0.028	-3.61E-03	1.9	-10.3	
21	-4.20	1.11	-0.026	-3.57E-03	3.2	-8.7	
22	-4.80	-1.10	-0.024	-3.53E-03	3.2	-6.6	
23	-5.40	-3.00	-0.022	-3.50E-03	1.9	-4.9	
24	-5.74	-4.68	-0.020	-3.48E-03	0.6	-4.4	

(continued)

Stage No.1 Excavate to elevation 2.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
25	-6.08	-4.02	-0.019	-3.47E-03	-0.9	-4.4	
		17.69	-0.019	-3.47E-03	-0.9	-4.4	
26	-6.54	7.01	-0.018	-3.46E-03	4.8	-3.0	
27	-7.00	-21.12	-0.016	-3.45E-03	1.6	-0.0	
28	-7.15	-0.01	-0.016	0	-0.0	0.0	
29	-9.30	0.00	-0.013	0	-0.0	0.0	
30	-10.69	-0.00	-0.012	0	-0.0	0.0	
31	-12.08	5.83	-0.011	0	4.0	0.0	
		-5.41	-0.011	0	4.0	0.0	
32	-13.58	-8.24	-0.009	0	-6.2	0.0	
		7.67	-0.009	0	-6.2	0.0	
33	-15.19	-0.00	-0.007	0	-0.0	0.0	
34	-16.80	-0.00	-0.005	0	-0.0	0.0	
35	-18.40	-0.00	-0.003	0	-0.0	0.0	
36	-20.00	0.03	-0.001	0	-0.0	0.0	

		LEFT side						
			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	earth pressure kN/m2	soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	2.93b	2.93	2.93p	4580
8	2.00	0.00	8.50	0.00	10.13b	10.13	10.13p	4580
9	1.42	0.00	18.36	0.90	21.07b	21.07	21.07p	4580
		0.00	18.36	0.00	23.64b	23.64	23.64p	7633
10	1.00	0.00	25.92	1.97	31.71b	31.71	31.71p	7633
11	0.50	0.00	34.92	4.93	42.15b	42.15	42.15p	7633
12	0.00	0.00	43.92	7.89	52.32b	52.32	52.32p	7633
13	-0.08	0.80	44.56	8.10	53.97b	53.97	54.77p	7633
		0.80	44.56	17.46	57.84b	40.89	41.69	2544
14	-0.64	6.40	48.48	19.00	53.73b	42.79	49.19	2544
15	-1.20	12.00	52.41	20.54	48.76b	44.68	56.68	2544
16	-1.80	18.00	56.61	22.18	53.90b	46.73	64.73	2544
17	-2.40	24.00	60.82	23.83	58.85b	48.83	72.83	2544
18	-2.74	27.40	63.20	24.77	62.03b	49.93	77.33	2544
19	-3.08	30.80	65.59	25.70	64.68b	51.30	82.10	2544
		30.80	65.59	17.00	269.35	55.12	85.92	4580
20	-3.64	36.40	69.51	18.34	250.96	56.54	92.94	4580
21	-4.20	42.00	73.44	19.69	170.22b	57.57	99.57	4580
22	-4.80	48.00	77.66	21.12	121.92b	58.79	106.79	4580
23	-5.40	54.00	81.87	22.56	128.86b	60.18	114.18	4580
24	-5.74	57.40	84.26	23.38	133.09b	60.66	118.06	4580
25	-6.08	60.80	86.65	24.19	136.89b	62.18	122.98	4580
		60.80	86.65	18.01	387.20	70.98	131.78	11195
26	-6.54	65.40	90.81	19.37	290.71	67.80	133.20	11195
27	-7.00	70.00	94.96	20.74	172.83b	56.15	126.15	11195
28	-7.15	71.50	96.32	21.19	219.90b	67.16	138.66	11195

(continued)

Stage No.1 Excavate to elevation 2.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

LEFT side

Node no.	Y coord	Water press.	Vertic -al	Active limit (Effective stresses)	Passive limit (Effective stresses)	Earth pressure (Effective stresses)	Total earth pressure	Adjusted soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
29	-9.30	93.00	115.77	27.58	297.12b	77.73	170.73	11195
30	-10.69	106.90	128.37	31.72	385.99b	84.53	191.43	11195
31	-12.08	120.80	140.98	35.87	429.41b	94.37	215.17	11195
		120.80	140.98	37.13	545.21b	71.98	192.78	6106
32	-13.58	135.80	153.12	40.32	592.13b	76.08	211.88	6106
		135.80	153.12	37.85	591.21b	101.90	237.70	15266
33	-15.19	151.90	167.78	42.72	620.70b	105.99	257.89	15266
34	-16.80	168.00	182.46	47.61	653.00b	113.98	281.98	15266
35	-18.40	184.00	197.08	52.47	715.03b	122.02	306.02	15266
36	-20.00	200.00	211.72	57.34	771.49b	131.44	331.44	15266

RIGHT side

Node no.	Y coord	Water press.	Vertic -al	Active limit (Effective stresses)	Passive limit (Effective stresses)	Earth pressure (Effective stresses)	Total earth pressure	Adjusted soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.00	2.35	98.10	2.35	2.35a	30296
		0.00	12.00	3.01	69.07	3.01	3.01a	5049
3	3.96	0.00	18.48	4.64	106.36	4.64	4.64a	5049
4	3.60	0.00	24.96	6.27	143.66	6.27	6.27a	5049
5	3.00	0.00	35.76	8.98	205.82	8.98	8.98a	5049
6	2.72	0.00	40.80	10.24	234.82	10.24	10.24a	5049
		0.00	40.80	8.55	175.17	8.55	8.55a	4544
7	2.50	0.00	44.54	9.83	189.38	9.83	9.83a	4544
8	2.00	0.00	53.04	12.73	221.68	12.73	12.73a	4544
9	1.42	0.00	62.90	16.09	259.14	17.76	17.76	4544
		0.00	62.90	14.13	276.90	14.13	14.13a	7574
10	1.00	0.00	70.46	16.61	307.08	16.61	16.61a	7574
11	0.50	0.00	79.46	19.57	343.00	19.57	19.57a	7574
12	0.00	0.00	88.46	22.53	378.93	24.02	24.02	7574
13	-0.08	0.80	89.10	22.74	381.49	26.63	27.43	7574
		0.80	89.10	34.91	233.34	44.07	44.87	2525
14	-0.64	6.40	93.02	36.45	243.60	46.67	53.07	2525
15	-1.20	12.00	96.94	37.99	253.87	49.13	61.13	2525
16	-1.80	18.00	101.14	39.63	264.87	51.79	69.79	2525
17	-2.40	24.00	105.34	41.28	275.87	54.44	78.44	2525
18	-2.74	27.40	107.72	42.21	282.10	56.03	83.43	2525
19	-3.08	30.80	110.10	43.14	288.33	57.15	87.95	2525
		30.80	110.10	32.19	438.47	50.40	81.20	4544
20	-3.64	36.40	114.02	33.53	453.37	53.18	89.58	4544
21	-4.20	42.00	117.94	34.86	468.26	56.46	98.46	4544
22	-4.80	48.00	122.14	36.30	484.22	59.89	107.89	4544
23	-5.40	54.00	126.34	37.73	500.18	63.18	117.18	4544
24	-5.74	57.40	128.72	38.54	509.22	65.34	122.74	4544
25	-6.08	60.80	131.10	39.35	518.26	66.20	127.00	4544
		60.80	131.10	32.62	564.63	53.29	114.09	11109
26	-6.54	65.40	135.24	33.98	581.16	60.79	126.19	11109
27	-7.00	70.00	139.38	35.34	597.68	77.27	147.27	11109
28	-7.15	71.50	140.73	35.78	603.07	67.17	138.67	11109
29	-9.30	93.00	160.08	42.15	680.32	77.72	170.72	11109

(continued)

Stage No.1 Excavate to elevation 2.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

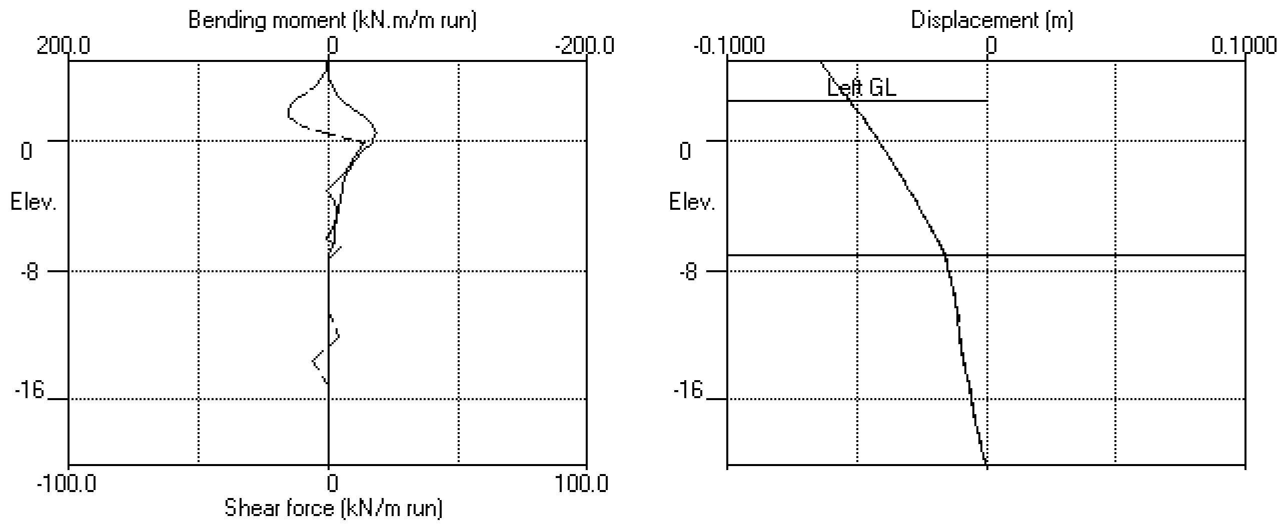
RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
30	-10.69	106.90	172.59	46.26	730.25	84.54	191.44	11109
31	-12.08	120.80	185.10	50.37	780.19	88.54	209.34	11109
		120.80	185.10	48.75	1008.59	77.39	198.19	6059
32	-13.58	135.80	197.10	51.91	1073.97	84.32	220.12	6059
		135.80	197.10	52.48	886.99	94.23	230.03	15148
33	-15.19	151.90	211.59	57.30	948.40	105.99	257.89	15148
34	-16.80	168.00	226.08	62.12	1009.81	113.98	281.98	15148
35	-18.40	184.00	240.48	66.91	1070.84	122.02	306.02	15148
36	-20.00	200.00	254.88	71.70	1131.87	131.41	331.41	15148

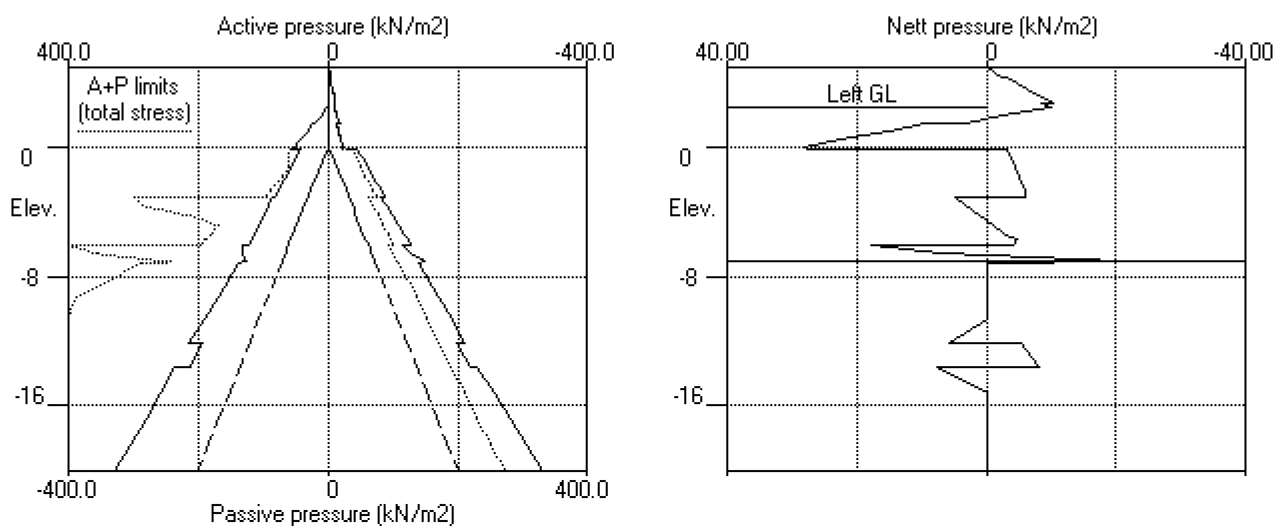
Note: 19.57 a Soil pressure at active limit
54.77 p Soil pressure at passive limit
771.49 b Passive limit reduced because of berm

```
SMEC AUSTRALIA PTY LTD                                         | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58            | Job No. 3001315
                                  Licensed from GEOSOLVE       | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained_propped                |
Byron Lane Slip                                                | Date:27-09-2021
AZ 24-700N propped                                             | Checked :
-----------------------------------------------------------------------------
                                                        Units: kN,m
```

Stage No.1 Excav. to elev. 2.50 on LEFT side



Stage No.1 Excav. to elev. 2.50 on LEFT side



Units: kN,m

Stage No. 3 Apply surcharge no.1 at elevation 4.92

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -7.00		Toe elev. for FoS = 1.300		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
3	4.92	2.50	Cant.	1.338	-6.45	-6.40	8.90	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.037	-2.96E-03	0.0	0.0	
2	4.32	-2.39	-0.035	-2.96E-03	-0.7	-0.3	
		-3.06	-0.035	-2.96E-03	-0.7	-0.3	
3	3.96	-4.82	-0.034	-2.96E-03	-2.1	-0.8	
4	3.60	-6.66	-0.033	-2.96E-03	-4.2	-1.9	
5	3.00	-9.82	-0.031	-2.96E-03	-9.1	-6.0	
6	2.72	-11.31	-0.030	-2.96E-03	-12.1	-9.0	
		-9.99	-0.030	-2.96E-03	-12.1	-9.0	
7	2.50	-11.50	-0.030	-2.96E-03	-14.5	-11.9	
		-8.57	-0.030	-2.96E-03	-14.5	-11.9	
8	2.00	-4.75	-0.028	-2.95E-03	-17.8	-20.1	
9	1.42	2.33	-0.027	-2.94E-03	-18.5	-31.2	
		6.96	-0.027	-2.94E-03	-18.5	-31.2	
10	1.00	12.26	-0.025	-2.93E-03	-14.5	-38.4	
11	0.50	19.45	-0.024	-2.90E-03	-6.5	-44.1	
12	0.00	26.42	-0.022	-2.87E-03	4.9	-45.0	
13	-0.08	27.82	-0.022	-2.86E-03	7.1	-44.5	
		0.80	-0.022	-2.86E-03	7.1	-44.5	
14	-0.64	-0.68	-0.021	-2.80E-03	7.1	-40.4	
15	-1.20	-2.04	-0.019	-2.73E-03	6.4	-36.5	
16	-1.80	-3.40	-0.017	-2.64E-03	4.7	-33.1	
17	-2.40	-4.56	-0.016	-2.55E-03	2.4	-30.9	
18	-2.74	-5.51	-0.015	-2.49E-03	0.6	-30.3	
19	-3.08	-5.09	-0.014	-2.43E-03	-1.2	-30.4	
		10.40	-0.014	-2.43E-03	-1.2	-30.4	
20	-3.64	7.93	-0.013	-2.34E-03	4.0	-29.5	
21	-4.20	4.04	-0.012	-2.25E-03	7.3	-26.0	
22	-4.80	0.34	-0.010	-2.17E-03	8.6	-20.9	
23	-5.40	-2.79	-0.009	-2.11E-03	7.9	-15.6	
24	-5.74	-5.56	-0.008	-2.08E-03	6.5	-13.1	
25	-6.08	-4.16	-0.008	-2.06E-03	4.8	-11.2	
		25.19	-0.008	-2.06E-03	4.8	-11.2	

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
26	-6.54	6.84	-0.007	-2.04E-03	12.2	-6.3	
27	-7.00	-45.15	-0.006	-2.03E-03	3.4	-0.0	
28	-7.15	-0.09	-0.006	0	-0.0	0.0	
29	-9.30	0.03	-0.005	0	-0.1	0.0	
30	-10.69	-0.00	-0.004	0	-0.1	0.0	
31	-12.08	7.26	-0.003	0	5.0	0.0	
		-6.75	-0.003	0	5.0	0.0	
32	-13.58	-10.17	-0.003	0	-7.7	0.0	
		9.46	-0.003	0	-7.7	0.0	
33	-15.19	-0.00	-0.002	0	-0.1	0.0	
34	-16.80	0.00	-0.001	0	-0.1	0.0	
35	-18.40	0.00	-0.001	0	-0.1	0.0	
36	-20.00	0.11	-0.000	0	-0.0	0.0	

LEFT side

			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	earth pressure kN/m2	soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	2.93b	2.93	2.93p	4580
8	2.00	0.00	8.50	0.00	10.13b	10.13	10.13p	4580
9	1.42	0.00	18.36	0.90	21.07b	21.07	21.07p	4580
		0.00	18.36	0.00	23.64b	23.64	23.64p	7633
10	1.00	0.00	25.92	1.97	31.71b	31.71	31.71p	7633
11	0.50	0.00	34.92	4.93	42.15b	42.15	42.15p	7633
12	0.00	0.00	43.92	7.89	52.32b	52.32	52.32p	7633
13	-0.08	0.80	44.56	8.10	53.97b	53.97	54.77p	7633
		0.80	44.56	17.46	57.84b	45.60	46.40	2544
14	-0.64	6.40	48.48	19.00	53.73b	47.22	53.62	2544
15	-1.20	12.00	52.41	20.54	48.76b	48.76	60.76p	2544
16	-1.80	18.00	56.61	22.18	53.90b	50.48	68.48	2544
17	-2.40	24.00	60.82	23.83	58.85b	52.31	76.31	2544
18	-2.74	27.40	63.20	24.77	62.03b	53.18	80.58	2544
19	-3.08	30.80	65.59	25.70	64.68b	54.57	85.37	2544
		30.80	65.59	17.00	269.35	61.01	91.81	4580
20	-3.64	36.40	69.51	18.34	250.96	61.83	98.23	4580
21	-4.20	42.00	73.44	19.69	170.22b	62.02	104.02	4580
22	-4.80	48.00	77.66	21.12	121.92b	62.46	110.46	4580
23	-5.40	54.00	81.87	22.56	128.86b	63.21	117.21	4580
24	-5.74	57.40	84.26	23.38	133.09b	63.12	120.52	4580
25	-6.08	60.80	86.65	24.19	136.89b	64.89	125.69	4580
		60.80	86.65	18.01	387.20	77.62	138.42	11195
26	-6.54	65.40	90.81	19.37	290.71	70.50	135.90	11195
27	-7.00	70.00	94.96	20.74	172.83b	47.06	117.06	11195
28	-7.15	71.50	96.32	21.19	219.90b	69.78	141.28	11195
29	-9.30	93.00	115.77	27.58	297.12b	80.26	173.26	11195
30	-10.69	106.90	128.37	31.72	385.99b	86.91	193.81	11195
31	-12.08	120.80	140.98	35.87	429.41b	97.39	218.19	11195
		120.80	140.98	37.13	545.21b	73.62	194.42	6106
32	-13.58	135.80	153.12	40.32	592.13b	77.32	213.12	6106
		135.80	153.12	37.85	591.21b	104.98	240.78	15266

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
33	-15.19	151.90	167.78	42.72	620.70b	108.01	259.91	15266
34	-16.80	168.00	182.46	47.61	653.00b	115.90	283.90	15266
35	-18.40	184.00	197.08	52.47	715.03b	123.88	307.88	15266
36	-20.00	200.00	211.72	57.34	771.49b	133.64	333.64	15266

RIGHT side

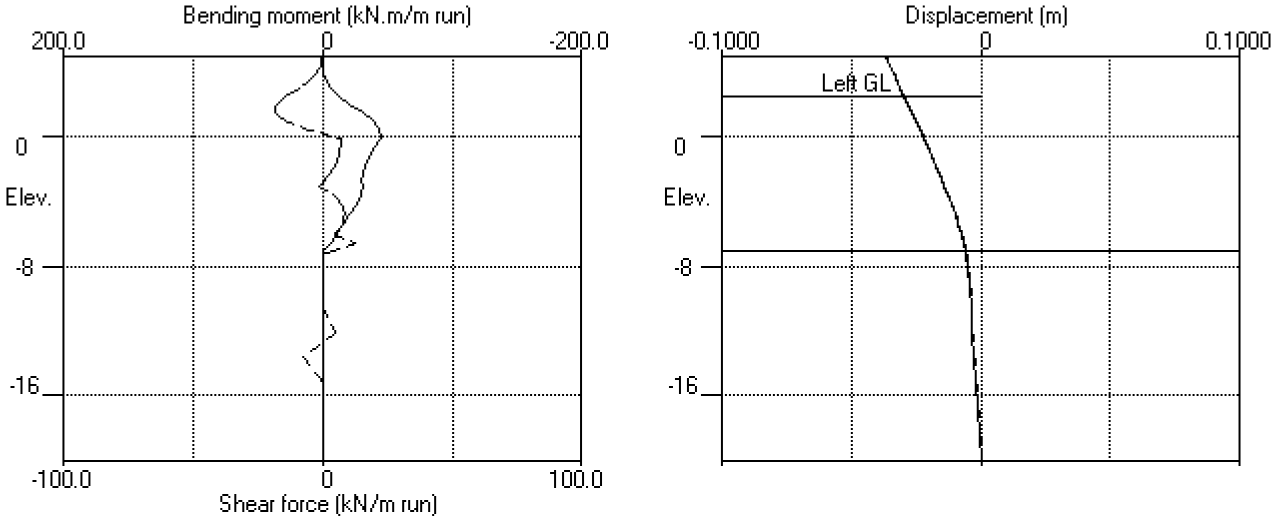
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30296
		0.00	12.21	3.06	70.25	3.06	3.06a	5049
3	3.96	0.00	19.21	4.82	110.55	4.82	4.82a	5049
4	3.60	0.00	26.53	6.66	152.67	6.66	6.66a	5049
5	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5049
6	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5049
		0.00	45.03	9.99	191.25	9.99	9.99a	4544
7	2.50	0.00	49.44	11.50	208.02	11.50	11.50a	4544
8	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4544
9	1.42	0.00	70.66	18.74	288.62	18.74	18.74a	4544
		0.00	70.66	16.68	307.87	16.68	16.68a	7574
10	1.00	0.00	79.10	19.45	341.56	19.45	19.45a	7574
11	0.50	0.00	88.98	22.70	381.03	22.70	22.70a	7574
12	0.00	0.00	98.72	25.90	419.89	25.90	25.90a	7574
13	-0.08	0.80	99.47	26.15	422.87	26.15	26.95a	7574
		0.80	99.47	38.98	260.49	44.80	45.60	2525
14	-0.64	6.40	104.04	40.77	272.46	47.90	54.30	2525
15	-1.20	12.00	108.47	42.51	284.07	50.81	62.81	2525
16	-1.80	18.00	113.10	44.32	296.19	53.88	71.88	2525
17	-2.40	24.00	117.62	46.09	308.03	56.87	80.87	2525
18	-2.74	27.40	120.14	47.08	314.63	58.69	86.09	2525
19	-3.08	30.80	122.63	48.05	321.15	59.66	90.46	2525
		30.80	122.63	36.46	486.09	50.61	81.41	4544
20	-3.64	36.40	126.69	37.85	501.49	53.90	90.30	4544
21	-4.20	42.00	130.68	39.21	516.67	57.98	99.98	4544
22	-4.80	48.00	134.91	40.65	532.74	62.13	110.13	4544
23	-5.40	54.00	139.09	42.08	548.62	66.00	120.00	4544
24	-5.74	57.40	141.44	42.88	557.55	68.69	126.09	4544
25	-6.08	60.80	143.78	43.68	566.43	69.05	129.85	4544
		60.80	143.78	36.79	615.25	52.42	113.22	11109
26	-6.54	65.40	147.85	38.12	631.48	63.67	129.07	11109
27	-7.00	70.00	151.90	39.45	647.65	92.21	162.21	11109
28	-7.15	71.50	153.21	39.89	652.90	69.88	141.38	11109
29	-9.30	93.00	171.95	46.05	727.71	80.23	173.23	11109
30	-10.69	106.90	183.97	50.00	775.70	86.91	193.81	11109
31	-12.08	120.80	195.96	53.94	823.55	90.13	210.93	11109
		120.80	195.96	51.61	1067.76	80.37	201.17	6059
32	-13.58	135.80	207.38	54.61	1129.98	87.49	223.29	6059
		135.80	207.38	55.90	930.55	95.53	231.33	15148
33	-15.19	151.90	221.24	60.51	989.31	108.01	259.91	15148
34	-16.80	168.00	235.13	65.13	1048.15	115.90	283.90	15148
35	-18.40	184.00	248.95	69.73	1106.73	123.88	307.88	15148
36	-20.00	200.00	262.80	74.34	1165.43	133.53	333.53	15148

```
Stage No.3   Apply surcharge no.1 at elevation 4.92
Note:     26.95 a  Soil pressure at active limit
          60.76 p  Soil pressure at passive limit
         771.49 b  Passive limit reduced because of berm
```

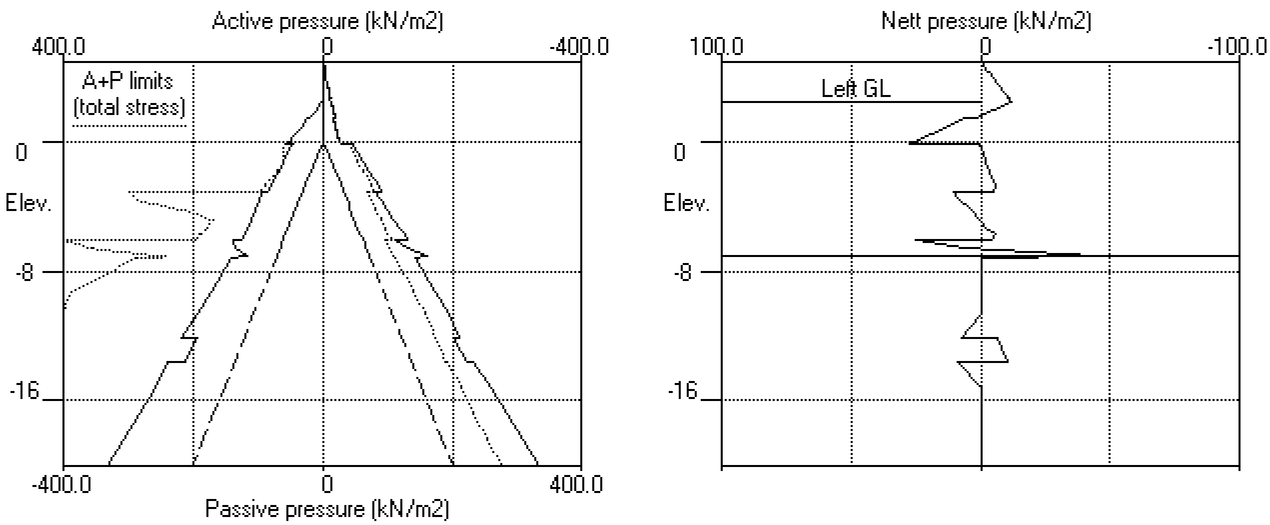
SMEC AUSTRALIA PTY LTD | Sheet No.
Program: WALLAP Version 6.07 Revision A55.B74.R58 | Job No. 3001315
Licensed from GEOSOLVE | Made by : MM
Data filename/Run ID: AZ24-700N_Drained_propped |
Byron Lane Slip | Date:27-09-2021
AZ 24-700N propped | Checked :

Units: kN,m

Stage No.3 Apply surcharge no.1 at elev. 4.92



Stage No.3 Apply surcharge no.1 at elev. 4.92



Units: kN,m

Stage No. 4 Install strut or anchor no.1 at elevation 3.00

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				FoS for toe elev. = -7.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
4	4.92	2.50	3.00	2.142	n/a	-3.35	5.85	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.035	-2.75E-03	0.0	0.0	
2	4.32	-7.88	-0.033	-2.75E-03	-2.4	-0.3	
		-3.98	-0.033	-2.75E-03	-2.4	-0.3	
3	3.96	-5.72	-0.032	-2.75E-03	-4.1	-1.4	
4	3.60	-7.51	-0.031	-2.74E-03	-6.5	-3.4	
5	3.00	-10.62	-0.030	-2.73E-03	-11.9	-8.9	6.7
		-10.62	-0.030	-2.73E-03	-5.3	-8.9	
6	2.72	-12.04	-0.029	-2.72E-03	-8.4	-10.9	
		-10.65	-0.029	-2.72E-03	-8.4	-10.9	
7	2.50	-12.10	-0.028	-2.72E-03	-10.9	-13.0	
		-10.14	-0.028	-2.72E-03	-10.9	-13.0	
8	2.00	-6.13	-0.027	-2.72E-03	-15.0	-19.7	
9	1.42	1.19	-0.025	-2.71E-03	-16.4	-29.4	
		5.05	-0.025	-2.71E-03	-16.4	-29.4	
10	1.00	10.70	-0.024	-2.70E-03	-13.1	-35.9	
11	0.50	18.22	-0.023	-2.69E-03	-5.9	-41.1	
12	0.00	25.40	-0.021	-2.67E-03	5.0	-41.8	
13	-0.08	27.12	-0.021	-2.66E-03	7.1	-41.3	
		0.56	-0.021	-2.66E-03	7.1	-41.3	
14	-0.64	-0.87	-0.020	-2.62E-03	7.0	-37.3	
15	-1.20	-2.20	-0.018	-2.56E-03	6.2	-33.5	
16	-1.80	-3.53	-0.017	-2.49E-03	4.4	-30.2	
17	-2.40	-4.66	-0.015	-2.41E-03	2.0	-28.2	
18	-2.74	-5.59	-0.015	-2.36E-03	0.2	-27.8	
19	-3.08	-5.21	-0.014	-2.31E-03	-1.6	-28.0	
		10.19	-0.014	-2.31E-03	-1.6	-28.0	
20	-3.64	7.76	-0.012	-2.23E-03	3.4	-27.3	
21	-4.20	3.93	-0.011	-2.15E-03	6.7	-24.2	
22	-4.80	0.29	-0.010	-2.08E-03	8.0	-19.4	
23	-5.40	-2.79	-0.009	-2.02E-03	7.2	-14.6	
24	-5.74	-5.51	-0.008	-2.00E-03	5.8	-12.3	

(continued)

Stage No.4 Install strut or anchor no.1 at elevation 3.00

Node no.	Y coord	Nett pressure	Wall disp.	Wall rotation	Shear force	Bending moment	Prop forces
		kN/m2	m	rad.	kN/m	kN.m/m	kN/m
25	-6.08	-4.18	-0.007	-1.98E-03	4.2	-10.7	
		25.15	-0.007	-1.98E-03	4.2	-10.7	
26	-6.54	7.16	-0.006	-1.96E-03	11.6	-6.1	
27	-7.00	-43.40	-0.006	-1.95E-03	3.3	-0.0	
28	-7.15	-0.09	-0.006	0	-0.0	0.0	
29	-9.30	0.03	-0.004	0	-0.1	0.0	
30	-10.69	-0.00	-0.004	0	-0.1	0.0	
31	-12.08	7.26	-0.003	0	5.0	0.0	
		-6.75	-0.003	0	5.0	0.0	
32	-13.58	-10.17	-0.003	0	-7.7	0.0	
		9.46	-0.003	0	-7.7	0.0	
33	-15.19	-0.00	-0.002	0	-0.1	0.0	
34	-16.80	0.00	-0.001	0	-0.1	0.0	
35	-18.40	0.00	-0.001	0	-0.1	0.0	
36	-20.00	0.11	-0.000	0	-0.0	0.0	

At elev. 3.00 Prop force = 6.7 kN/m run

LEFT side

Node no.	Y coord	Water press.	Vertic -al	Effective stresses Active limit	Passive limit	Earth pressure	Total earth pressure	Adjusted soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	2.93b	1.96	1.96	4580
8	2.00	0.00	8.50	0.00	10.13b	9.29	9.29	4580
9	1.42	0.00	18.36	0.90	21.07b	20.38	20.38	4580
		0.00	18.36	0.00	23.64b	22.49	22.49	7633
10	1.00	0.00	25.92	1.97	31.71b	30.77	30.77	7633
11	0.50	0.00	34.92	4.93	42.15b	41.41	41.41	7633
12	0.00	0.00	43.92	7.89	52.32b	51.70	51.70	7633
13	-0.08	0.80	44.56	8.10	53.97b	53.49	54.29	7633
		0.80	44.56	17.46	57.84b	45.44	46.24	2544
14	-0.64	6.40	48.48	19.00	53.73b	47.09	53.49	2544
15	-1.20	12.00	52.41	20.54	48.76b	48.65	60.65	2544
16	-1.80	18.00	56.61	22.18	53.90b	50.38	68.38	2544
17	-2.40	24.00	60.82	23.83	58.85b	52.23	76.23	2544
18	-2.74	27.40	63.20	24.77	62.03b	53.11	80.51	2544
19	-3.08	30.80	65.59	25.70	64.68b	54.49	85.29	2544
		30.80	65.59	17.00	269.35	60.87	91.67	4580
20	-3.64	36.40	69.51	18.34	250.96	61.72	98.12	4580
21	-4.20	42.00	73.44	19.69	170.22b	61.94	103.94	4580
22	-4.80	48.00	77.66	21.12	121.92b	62.42	110.42	4580
23	-5.40	54.00	81.87	22.56	128.86b	63.19	117.19	4580
24	-5.74	57.40	84.26	23.38	133.09b	63.13	120.53	4580
25	-6.08	60.80	86.65	24.19	136.89b	64.87	125.67	4580
		60.80	86.65	18.01	387.20	77.57	138.37	11195
26	-6.54	65.40	90.81	19.37	290.71	70.65	136.05	11195
27	-7.00	70.00	94.96	20.74	172.83b	47.91	117.91	11195
28	-7.15	71.50	96.32	21.19	219.90b	69.77	141.27	11195
29	-9.30	93.00	115.77	27.58	297.12b	80.25	173.25	11195
30	-10.69	106.90	128.37	31.72	385.99b	86.91	193.81	11195

(continued)

Stage No.4 Install strut or anchor no.1 at elevation 3.00

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
31	-12.08	120.80	140.98	35.87	429.41b	97.38	218.18	11195
		120.80	140.98	37.13	545.21b	73.62	194.42	6106
32	-13.58	135.80	153.12	40.32	592.13b	77.32	213.12	6106
		135.80	153.12	37.85	591.21b	104.98	240.78	15266
33	-15.19	151.90	167.78	42.72	620.70b	108.01	259.91	15266
34	-16.80	168.00	182.46	47.61	653.00b	115.89	283.89	15266
35	-18.40	184.00	197.08	52.47	715.03b	123.87	307.87	15266
36	-20.00	200.00	211.72	57.34	771.49b	133.63	333.63	15266

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.21	2.39	99.79	7.88	7.88	30296
		0.00	12.21	3.06	70.25	3.98	3.98	5049
3	3.96	0.00	19.21	4.82	110.55	5.72	5.72	5049
4	3.60	0.00	26.53	6.66	152.67	7.51	7.51	5049
5	3.00	0.00	39.11	9.82	225.12	10.62	10.62	5049
6	2.72	0.00	45.03	11.31	259.17	12.04	12.04	5049
		0.00	45.03	9.99	191.25	10.65	10.65	4544
7	2.50	0.00	49.44	11.50	208.02	12.10	12.10	4544
8	2.00	0.00	59.37	14.88	245.73	15.42	15.42	4544
9	1.42	0.00	70.66	18.74	288.62	19.19	19.19	4544
		0.00	70.66	16.68	307.87	17.44	17.44	7574
10	1.00	0.00	79.10	19.45	341.56	20.07	20.07	7574
11	0.50	0.00	88.98	22.70	381.03	23.19	23.19	7574
12	0.00	0.00	98.72	25.90	419.89	26.30	26.30	7574
13	-0.08	0.80	99.47	26.15	422.87	26.37	27.17	7574
		0.80	99.47	38.98	260.49	44.87	45.67	2525
14	-0.64	6.40	104.04	40.77	272.46	47.96	54.36	2525
15	-1.20	12.00	108.47	42.51	284.07	50.85	62.85	2525
16	-1.80	18.00	113.10	44.32	296.19	53.92	71.92	2525
17	-2.40	24.00	117.62	46.09	308.03	56.89	80.89	2525
18	-2.74	27.40	120.14	47.08	314.63	58.71	86.11	2525
19	-3.08	30.80	122.63	48.05	321.15	59.70	90.50	2525
		30.80	122.63	36.46	486.09	50.69	81.49	4544
20	-3.64	36.40	126.69	37.85	501.49	53.96	90.36	4544
21	-4.20	42.00	130.68	39.21	516.67	58.01	100.01	4544
22	-4.80	48.00	134.91	40.65	532.74	62.13	110.13	4544
23	-5.40	54.00	139.09	42.08	548.62	65.98	119.98	4544
24	-5.74	57.40	141.44	42.88	557.55	68.64	126.04	4544
25	-6.08	60.80	143.78	43.68	566.43	69.05	129.85	4544
		60.80	143.78	36.79	615.25	52.42	113.22	11109
26	-6.54	65.40	147.85	38.12	631.48	63.49	128.89	11109
27	-7.00	70.00	151.90	39.45	647.65	91.31	161.31	11109
28	-7.15	71.50	153.21	39.89	652.90	69.87	141.37	11109
29	-9.30	93.00	171.95	46.05	727.71	80.22	173.22	11109
30	-10.69	106.90	183.97	50.00	775.70	86.91	193.81	11109
31	-12.08	120.80	195.96	53.94	823.55	90.12	210.92	11109
		120.80	195.96	51.61	1067.76	80.37	201.17	6059
32	-13.58	135.80	207.38	54.61	1129.98	87.48	223.28	6059
		135.80	207.38	55.90	930.55	95.52	231.32	15148

(continued)

Stage No.4 Install strut or anchor no.1 at elevation 3.00

		RIGHT side						
			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
33	-15.19	151.90	221.24	60.51	989.31	108.01	259.91	15148
34	-16.80	168.00	235.13	65.13	1048.15	115.89	283.89	15148
35	-18.40	184.00	248.95	69.73	1106.73	123.87	307.87	15148
36	-20.00	200.00	262.80	74.34	1165.43	133.51	333.51	15148

Note: 771.49 b Passive limit reduced because of berm

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SMEC AUSTRALIA PTY LTD                                        | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58           | Job No. 3001315
                              Licensed from GEOSOLVE          | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained_propped               |
Byron Lane Slip                                               | Date:27-09-2021
AZ 24-700N propped                                            | Checked :
-----------------------------------------------------------------------------
                                                   Units: kN,m
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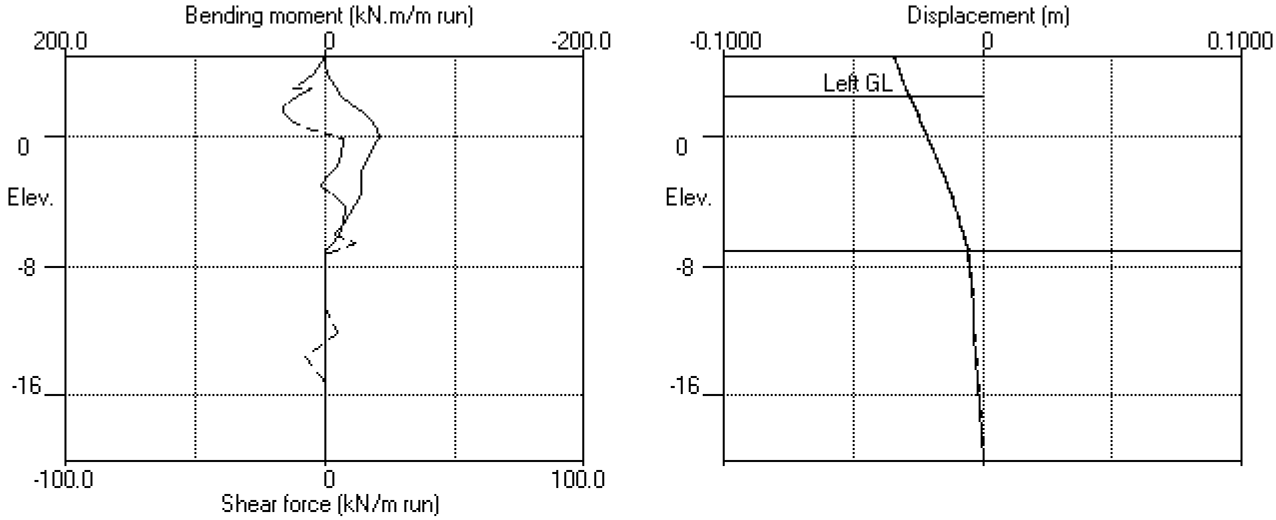
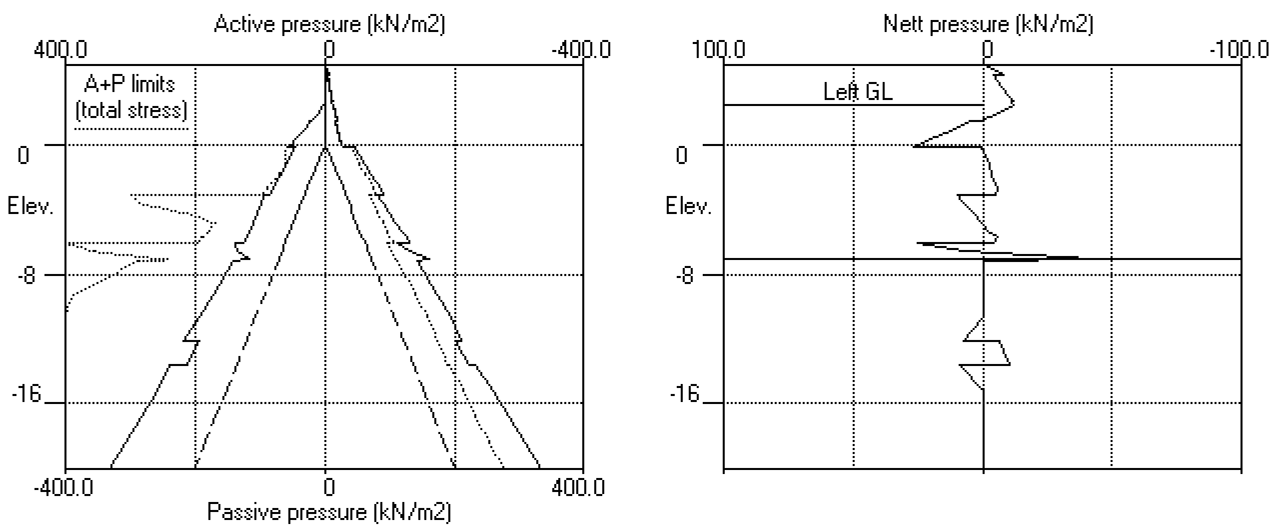
Stage No.4 Install prop no.1 at elev. 3.00



Stage No.4 Install prop no.1 at elev. 3.00



Units: kN,m

Stage No. 5 Excavate to elevation 1.00 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -7.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
5	4.92	1.00	3.00	1.834	n/a	-4.13	5.13	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.047	-5.64E-04	0.0	0.0	
2	4.32	-2.39	-0.047	-5.64E-04	-0.7	-0.3	
		-3.06	-0.047	-5.64E-04	-0.7	-0.3	
3	3.96	-4.82	-0.047	-5.63E-04	-2.1	-0.8	
4	3.60	-6.66	-0.046	-5.63E-04	-4.2	-1.9	
5	3.00	-9.82	-0.046	-5.63E-04	-9.1	-6.0	53.2
		-9.82	-0.046	-5.63E-04	44.1	-6.0	
6	2.72	-11.31	-0.046	-5.79E-04	41.1	5.9	
		-9.99	-0.046	-5.79E-04	41.1	5.9	
7	2.50	-11.50	-0.046	-6.17E-04	38.8	14.7	
8	2.00	-14.88	-0.046	-7.82E-04	32.2	32.5	
9	1.42	-18.74	-0.045	-1.09E-03	22.4	48.0	
		-16.68	-0.045	-1.09E-03	22.4	48.0	
10	1.00	-19.45	-0.044	-1.39E-03	14.8	55.7	
		-16.14	-0.044	-1.39E-03	14.8	55.7	
11	0.50	-12.20	-0.044	-1.79E-03	7.8	60.9	
12	0.00	-4.90	-0.043	-2.21E-03	3.5	63.3	
13	-0.08	-2.45	-0.042	-2.27E-03	3.2	63.5	
		-11.29	-0.042	-2.27E-03	3.2	63.5	
14	-0.64	-11.39	-0.041	-2.72E-03	-3.2	63.6	
15	-1.20	-13.50	-0.039	-3.12E-03	-10.1	59.9	
16	-1.80	-10.85	-0.037	-3.50E-03	-17.4	51.7	
17	-2.40	-8.23	-0.035	-3.80E-03	-23.2	39.5	
18	-2.74	-6.60	-0.034	-3.94E-03	-25.7	31.1	
19	-3.08	-5.08	-0.033	-4.05E-03	-27.7	22.0	
		19.89	-0.033	-4.05E-03	-27.7	22.0	
20	-3.64	15.84	-0.030	-4.17E-03	-17.7	9.6	
21	-4.20	10.29	-0.028	-4.24E-03	-10.3	2.2	

(continued)

Stage No.5 Excavate to elevation 1.00 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
22	-4.80	4.87	-0.025	-4.28E-03	-5.8	-2.1	
23	-5.40	0.36	-0.023	-4.30E-03	-4.2	-4.7	
24	-5.74	-3.47	-0.021	-4.29E-03	-4.8	-6.2	
25	-6.08	-2.99	-0.020	-4.29E-03	-5.9	-8.0	
		44.12	-0.020	-4.29E-03	-5.9	-8.0	
26	-6.54	18.99	-0.018	-4.27E-03	8.7	-6.0	
27	-7.00	-42.72	-0.016	-4.27E-03	3.2	-0.0	
28	-7.15	-0.10	-0.016	0	-0.0	0.0	
29	-9.30	0.03	-0.012	0	-0.1	0.0	
30	-10.69	-0.00	-0.011	0	-0.1	0.0	
31	-12.08	10.68	-0.010	0	7.4	0.0	
		-9.92	-0.010	0	7.4	0.0	
32	-13.58	-15.00	-0.008	0	-11.3	0.0	
		13.96	-0.008	0	-11.3	0.0	
33	-15.19	-0.00	-0.006	0	-0.1	0.0	
34	-16.80	-0.00	-0.004	0	-0.1	0.0	
35	-18.40	-0.00	-0.003	0	-0.1	0.0	
36	-20.00	0.13	-0.000	0	-0.0	0.0	

At elev. 3.00 Prop force = 53.2 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	3.32b	3.32	3.32p	7621
11	0.50	0.00	9.00	0.00	10.50b	10.50	10.50p	7621
12	0.00	0.00	18.00	0.00	21.01b	21.01	21.01p	7621
13	-0.08	0.80	18.64	0.00	23.70b	23.70	24.50p	7621
		0.80	18.64	7.30	27.68b	27.68	28.48p	2540
14	-0.64	6.40	22.56	8.84	29.38b	29.38	35.78p	2540
15	-1.20	12.00	26.48	10.38	30.22b	30.22	42.22p	2540
16	-1.80	18.00	30.69	12.02	36.12b	36.12	54.12p	2540
17	-2.40	24.00	34.89	13.67	41.88b	41.88	65.88p	2540
18	-2.74	27.40	37.27	14.61	45.44b	45.44	72.84p	2540
19	-3.08	30.80	39.66	15.54	48.58b	48.58	79.38p	2540
		30.80	39.66	8.16	170.83	59.72	90.52	4573
20	-3.64	36.40	43.58	9.50	181.72	59.89	96.29	4573
21	-4.20	42.00	47.51	10.84	142.61b	59.27	101.27	4573
22	-4.80	48.00	51.73	12.28	104.45b	58.87	106.87	4573
23	-5.40	54.00	55.94	13.71	112.52b	58.91	112.91	4573
24	-5.74	57.40	58.33	14.53	117.24b	58.27	115.67	4573
25	-6.08	60.80	60.72	15.35	121.75b	59.71	120.51	4573
		60.80	60.72	9.48	283.69	81.00	141.80	11178

(continued)

Stage No.5 Excavate to elevation 1.00 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

LEFT side

Node no.	Y coord	Water press.	Vertic -al	Effective stresses Active limit	Passive limit	Earth pressure	Total earth pressure	Adjusted soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
26	-6.54	65.40	64.88	10.85	300.29	70.69	136.09	11178
27	-7.00	70.00	69.04	12.22	296.50	42.44	112.44	11178
28	-7.15	71.50	70.40	12.66	189.79b	63.97	135.47	11178
29	-9.30	93.00	89.87	19.06	273.97b	74.49	167.49	11178
30	-10.69	106.90	102.49	23.21	386.22b	81.21	188.11	11178
31	-12.08	120.80	115.13	27.37	433.51b	93.37	214.17	11178
		120.80	115.13	30.32	506.64b	66.40	187.20	6097
32	-13.58	135.80	127.31	33.53	560.23b	69.28	205.08	6097
		135.80	127.31	29.26	591.20	101.47	237.27	15242
33	-15.19	151.90	142.03	34.16	630.97	102.35	254.25	15242
34	-16.80	168.00	156.79	39.07	661.72b	110.24	278.24	15242
35	-18.40	184.00	171.50	43.96	716.50b	118.27	302.27	15242
36	-20.00	200.00	186.24	48.87	776.71b	128.85	328.85	15242

RIGHT side

Node no.	Y coord	Water press.	Vertic -al	Effective stresses Active limit	Passive limit	Earth pressure	Total earth pressure	Adjusted soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30296
		0.00	12.21	3.06	70.25	3.06	3.06a	5049
3	3.96	0.00	19.21	4.82	110.55	4.82	4.82a	5049
4	3.60	0.00	26.53	6.66	152.67	6.66	6.66a	5049
5	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5049
6	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5049
		0.00	45.03	9.99	191.25	9.99	9.99a	4544
7	2.50	0.00	49.44	11.50	208.02	11.50	11.50a	4544
8	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4544
9	1.42	0.00	70.66	18.74	288.62	18.74	18.74a	4544
		0.00	70.66	16.68	307.87	16.68	16.68a	7574
10	1.00	0.00	79.10	19.45	341.56	19.45	19.45a	7574
11	0.50	0.00	88.98	22.70	381.03	22.70	22.70a	7574
12	0.00	0.00	98.72	25.90	419.89	25.90	25.90a	7574
13	-0.08	0.80	99.47	26.15	422.87	26.15	26.95a	7574
		0.80	99.47	38.98	260.49	38.98	39.78a	2525
14	-0.64	6.40	104.04	40.77	272.46	40.77	47.17a	2525
15	-1.20	12.00	108.47	42.51	284.07	43.71	55.71	2525
16	-1.80	18.00	113.10	44.32	296.19	46.97	64.97	2525
17	-2.40	24.00	117.62	46.09	308.03	50.11	74.11	2525
18	-2.74	27.40	120.14	47.08	314.63	52.03	79.43	2525
19	-3.08	30.80	122.63	48.05	321.15	53.66	84.46	2525
		30.80	122.63	36.46	486.09	39.82	70.62	4544
20	-3.64	36.40	126.69	37.85	501.49	44.05	80.45	4544
21	-4.20	42.00	130.68	39.21	516.67	48.99	90.99	4544
22	-4.80	48.00	134.91	40.65	532.74	54.00	102.00	4544
23	-5.40	54.00	139.09	42.08	548.62	58.55	112.55	4544
24	-5.74	57.40	141.44	42.88	557.55	61.74	119.14	4544
25	-6.08	60.80	143.78	43.68	566.43	62.70	123.50	4544
		60.80	143.78	36.79	615.25	36.88	97.68	11109
26	-6.54	65.40	147.85	38.12	631.48	51.70	117.10	11109

(continued)

Stage No.5 Excavate to elevation 1.00 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

RIGHT side

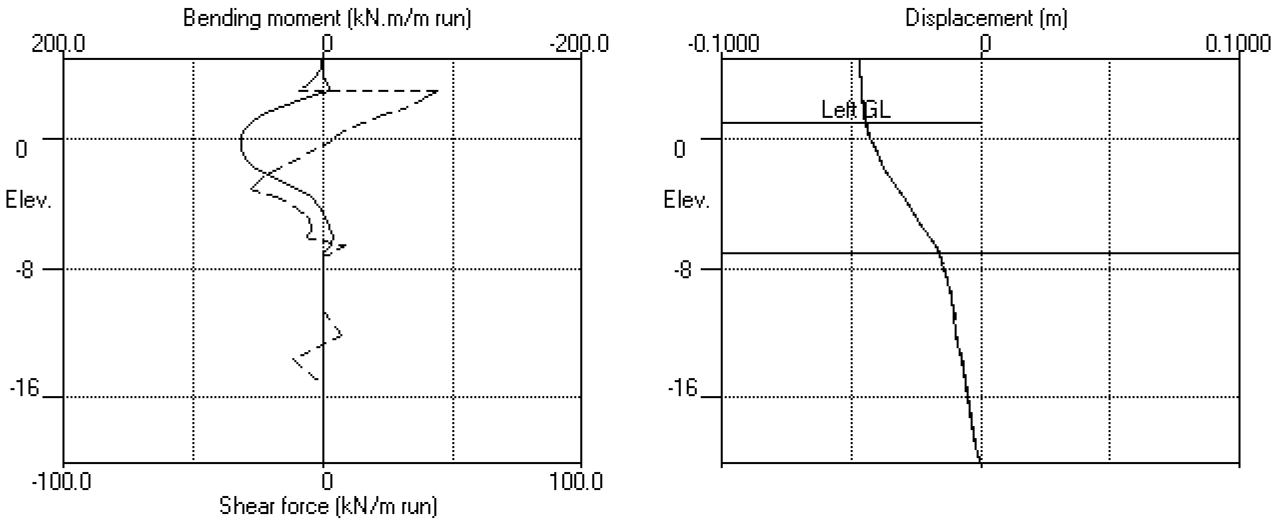
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
27	-7.00	70.00	151.90	39.45	647.65	85.16	155.16	11109
28	-7.15	71.50	153.21	39.89	652.90	64.07	135.57	11109
29	-9.30	93.00	171.95	46.05	727.71	74.46	167.46	11109
30	-10.69	106.90	183.97	50.00	775.70	81.22	188.12	11109
31	-12.08	120.80	195.96	53.94	823.55	82.69	203.49	11109
		120.80	195.96	51.61	1067.76	76.31	197.11	6059
32	-13.58	135.80	207.38	54.61	1129.98	84.28	220.08	6059
		135.80	207.38	55.90	930.55	87.51	223.31	15148
33	-15.19	151.90	221.24	60.51	989.31	102.35	254.25	15148
34	-16.80	168.00	235.13	65.13	1048.15	110.25	278.25	15148
35	-18.40	184.00	248.95	69.73	1106.73	118.27	302.27	15148
36	-20.00	200.00	262.80	74.34	1165.43	128.73	328.73	15148

Note: 47.17 a Soil pressure at active limit
79.38 p Soil pressure at passive limit
776.71 b Passive limit reduced because of berm

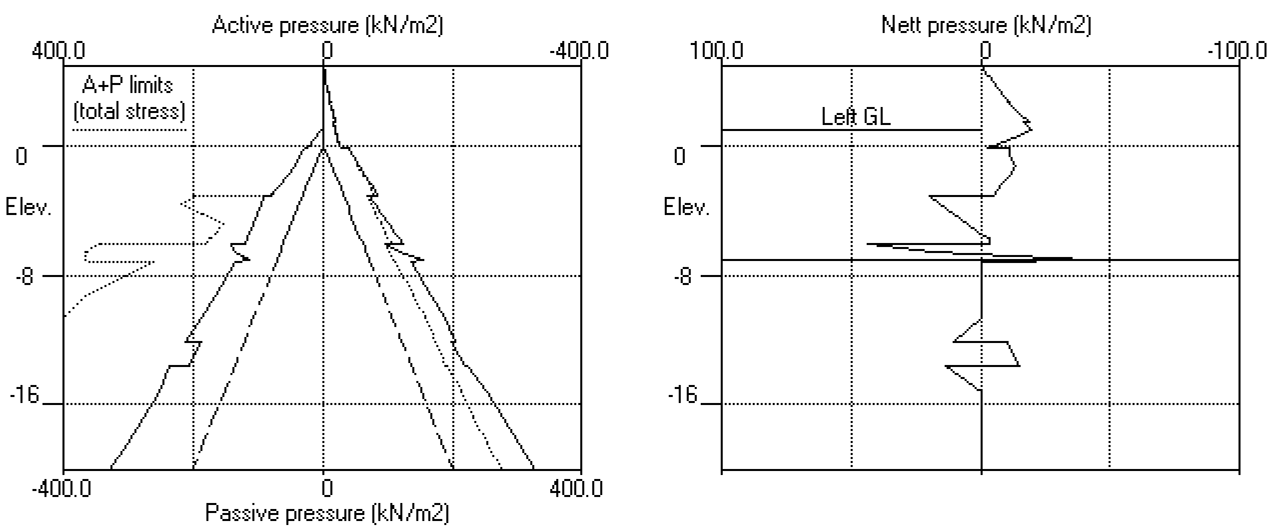
SMEC AUSTRALIA PTY LTD | Sheet No.
Program: WALLAP Version 6.07 Revision A55.B74.R58 | Job No. 3001315
Licensed from GEOSOLVE | Made by : MM
Data filename/Run ID: AZ24-700N_Drained_propped |
Byron Lane Slip | Date:27-09-2021
AZ 24-700N propped | Checked :

Units: kN,m

Stage No.5 Excav. to elev. 1.00 on LEFT side



Stage No.5 Excav. to elev. 1.00 on LEFT side



Units: kN,m

Stage No. 6 Apply water pressure profile no.1

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = -7.00: Factor of Safety	FoS for toe elev. = -7.00: Moment equilib. at elev.	Toe elev. for FoS = 1.300: Toe elev.	Toe elev. for FoS = 1.300: Wall Penetr -ation	Direction of failure
6	4.92	1.00	3.00	1.761	n/a	-4.25	5.25	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.049	3.26E-04	0.0	0.0	
2	4.32	-4.63	-0.049	3.26E-04	-1.4	-0.3	
		-3.44	-0.049	3.26E-04	-1.4	-0.3	
3	3.96	-4.63	-0.049	3.27E-04	-2.8	-1.0	
4	3.60	-6.08	-0.049	3.28E-04	-4.8	-2.4	
5	3.00	-8.87	-0.050	3.32E-04	-9.3	-6.7	63.1
		-8.87	-0.050	3.32E-04	53.8	-6.7	
6	2.72	-11.31	-0.050	3.14E-04	51.0	8.0	
		-9.99	-0.050	3.14E-04	51.0	8.0	
7	2.50	-11.50	-0.050	2.70E-04	48.6	18.9	
8	2.00	-14.88	-0.050	7.81E-05	42.0	41.6	
9	1.42	-18.74	-0.050	-2.95E-04	32.3	62.8	
		-16.68	-0.050	-2.95E-04	32.3	62.8	
10	1.00	-19.45	-0.050	-6.52E-04	24.7	74.6	
		-16.20	-0.050	-6.52E-04	24.7	74.6	
11	0.50	-15.56	-0.049	-1.14E-03	16.7	84.7	
12	0.00	-11.61	-0.048	-1.66E-03	10.0	91.0	
13	-0.08	-9.16	-0.048	-1.75E-03	9.1	91.7	
		-17.37	-0.048	-1.75E-03	9.1	91.7	
14	-0.64	-17.47	-0.047	-2.34E-03	-0.6	94.1	
15	-1.20	-18.37	-0.046	-2.89E-03	-10.7	91.0	
16	-1.80	-14.30	-0.044	-3.42E-03	-20.5	81.5	
17	-2.40	-11.69	-0.042	-3.87E-03	-28.3	66.8	
18	-2.74	-10.04	-0.040	-4.08E-03	-32.0	56.5	
19	-3.08	-8.76	-0.039	-4.26E-03	-35.2	45.1	
		20.99	-0.039	-4.26E-03	-35.2	45.1	
20	-3.64	16.66	-0.036	-4.49E-03	-24.6	28.7	
21	-4.20	10.85	-0.034	-4.64E-03	-16.9	17.5	
22	-4.80	5.11	-0.031	-4.75E-03	-12.1	9.3	
23	-5.40	0.31	-0.028	-4.81E-03	-10.5	2.9	
24	-5.74	-3.72	-0.027	-4.83E-03	-11.1	-0.6	

(continued)

Stage No.6 Apply water pressure profile no.1

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
25	-6.08	-3.68	-0.025	-4.83E-03	-12.3	-4.6	
		50.67	-0.025	-4.83E-03	-12.3	-4.6	
26	-6.54	24.67	-0.023	-4.83E-03	5.0	-4.9	
27	-7.00	-34.96	-0.020	-4.82E-03	2.6	-0.0	
28	-7.15	-0.10	-0.020	0	-0.0	0.0	
29	-9.30	0.03	-0.016	0	-0.1	0.0	
30	-10.69	-0.00	-0.014	0	-0.1	0.0	
31	-12.08	12.45	-0.013	0	8.6	0.0	
		-11.55	-0.013	0	8.6	0.0	
32	-13.58	-17.50	-0.010	0	-13.2	0.0	
		16.29	-0.010	0	-13.2	0.0	
33	-15.19	-0.00	-0.008	0	-0.1	0.0	
34	-16.80	-0.00	-0.006	0	-0.1	0.0	
35	-18.40	-0.00	-0.004	0	-0.1	0.0	
36	-20.00	0.13	-0.001	0	-0.0	0.0	

At elev. 3.00 Prop force = 63.1 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	3.32b	3.25	3.25	7621
11	0.50	0.00	9.00	0.00	10.50b	10.50	10.50p	7621
12	0.00	0.00	18.00	0.00	21.01b	21.01	21.01p	7621
13	-0.08	0.80	18.64	0.00	23.70b	23.70	24.50p	7621
		0.80	18.64	7.30	27.68b	27.68	28.48p	2540
14	-0.64	6.40	22.56	8.84	29.38b	29.38	35.78p	2540
15	-1.20	12.00	26.48	10.38	30.22b	30.22	42.22p	2540
16	-1.80	18.00	30.69	12.02	36.12b	36.12	54.12p	2540
17	-2.40	24.00	34.89	13.67	41.88b	41.88	65.88p	2540
18	-2.74	27.40	37.27	14.61	45.44b	45.44	72.84p	2540
19	-3.08	30.80	39.66	15.54	48.58b	48.58	79.38p	2540
		30.80	39.66	8.16	170.83	62.86	93.66	4573
20	-3.64	36.40	43.58	9.50	181.72	62.96	99.36	4573
21	-4.20	42.00	47.51	10.84	142.61b	62.24	104.24	4573
22	-4.80	48.00	51.73	12.28	104.45b	61.68	109.68	4573
23	-5.40	54.00	55.94	13.71	112.52b	61.57	115.57	4573
24	-5.74	57.40	58.33	14.53	117.24b	60.83	118.23	4573
25	-6.08	60.80	60.72	15.35	121.75b	62.11	122.91	4573
		60.80	60.72	9.48	283.69	86.88	147.68	11178
26	-6.54	65.40	64.88	10.85	300.29	76.21	141.61	11178
27	-7.00	70.00	69.04	12.22	296.50	48.97	118.97	11178
28	-7.15	71.50	70.40	12.66	189.79b	66.69	138.19	11178
29	-9.30	93.00	89.87	19.06	273.97b	77.23	170.23	11178
30	-10.69	106.90	102.49	23.21	386.22b	83.99	190.89	11178
31	-12.08	120.80	115.13	27.37	433.51b	97.01	217.81	11178
		120.80	115.13	30.32	506.64b	68.38	189.18	6097

(continued)

Stage No.6 Apply water pressure profile no.1

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
32	-13.58	135.80	127.31	33.53	560.23b	70.84	206.64	6097
		135.80	127.31	29.26	591.20	105.38	241.18	15242
33	-15.19	151.90	142.03	34.16	630.97	105.14	257.04	15242
34	-16.80	168.00	156.79	39.07	661.72b	113.03	281.03	15242
35	-18.40	184.00	171.50	43.96	716.50b	121.06	305.06	15242
36	-20.00	200.00	186.24	48.87	776.71b	132.03	332.03	15242

RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.21	2.39	99.79	4.63	4.63	30296
		0.00	12.21	3.06	70.25	3.44	3.44	5049
3	3.96	0.00	19.21	4.82	110.55	4.63	4.63A	5049
4	3.60	0.00	26.53	6.66	152.67	6.08	6.08A	5049
5	3.00	0.00	39.11	9.82	225.12	8.87	8.87A	5049
6	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5049
		0.00	45.03	9.99	191.25	9.99	9.99a	4544
7	2.50	0.00	49.44	11.50	208.02	11.50	11.50a	4544
8	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4544
9	1.42	0.00	70.66	18.74	288.62	18.74	18.74a	4544
		0.00	70.66	16.68	307.87	16.68	16.68a	7574
10	1.00	0.00	79.10	19.45	341.56	19.45	19.45a	7574
11	0.50	5.00	83.98	21.06	361.07	21.06	26.06a	7574
12	0.00	10.00	88.72	22.62	379.98	22.62	32.62a	7574
13	-0.08	10.80	89.47	22.86	382.95	22.86	33.66a	7574
		10.80	89.47	35.06	234.30	35.06	45.86a	2525
14	-0.64	16.40	94.04	36.85	246.27	36.85	53.25a	2525
15	-1.20	22.00	98.47	38.59	257.89	38.59	60.59a	2525
16	-1.80	28.00	103.10	40.40	270.01	40.42	68.42	2525
17	-2.40	34.00	107.62	42.17	281.84	43.56	77.56	2525
18	-2.74	37.40	110.14	43.16	288.44	45.48	82.88	2525
19	-3.08	40.80	112.63	44.14	294.97	47.34	88.14	2525
		40.80	112.63	33.05	448.10	31.87	72.67A	4544
20	-3.64	46.40	116.69	34.44	463.50	36.30	82.70	4544
21	-4.20	52.00	120.68	35.80	478.68	41.38	93.38	4544
22	-4.80	58.00	124.91	37.24	494.74	46.57	104.57	4544
23	-5.40	64.00	129.09	38.67	510.63	51.27	115.27	4544
24	-5.74	67.40	131.44	39.47	519.56	54.55	121.95	4544
25	-6.08	70.80	133.78	40.27	528.44	55.80	126.60	4544
		70.80	133.78	33.50	575.33	26.21	97.01A	11109
26	-6.54	75.40	137.85	34.84	591.56	41.54	116.94	11109
27	-7.00	80.00	141.90	36.17	607.73	73.93	153.93	11109
28	-7.15	81.50	143.21	36.60	612.98	56.79	138.29	11109
29	-9.30	103.00	161.95	42.76	687.79	67.20	170.20	11109
30	-10.69	116.90	173.97	46.71	735.78	73.99	190.89	11109
31	-12.08	130.80	185.96	50.65	783.63	74.57	205.37	11109
		130.80	185.96	48.97	1013.28	69.94	200.74	6059
32	-13.58	145.80	197.38	51.98	1075.49	78.34	224.14	6059
		145.80	197.38	52.57	888.16	79.09	224.89	15148
33	-15.19	161.90	211.24	57.18	946.93	95.14	257.04	15148
34	-16.80	178.00	225.13	61.80	1005.77	103.03	281.03	15148

(continued)

Stage No.6 Apply water pressure profile no.1

		RIGHT side						
			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
35	-18.40	194.00	238.95	66.40	1064.34	111.06	305.06	15148
36	-20.00	210.00	252.80	71.01	1123.05	121.90	331.90	15148

Note: 60.59 a Soil pressure at active limit
79.38 p Soil pressure at passive limit
776.71 b Passive limit reduced because of berm
97.01A Arching - soil pressure below active limit

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SMEC AUSTRALIA PTY LTD                                          | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58             | Job No. 3001315
                                  Licensed from GEOSOLVE        | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained_propped                 |
Byron Lane Slip                                                 | Date:27-09-2021
AZ 24-700N propped                                              | Checked :
-----------------------------------------------------------------------------
                                                          Units: kN,m
```
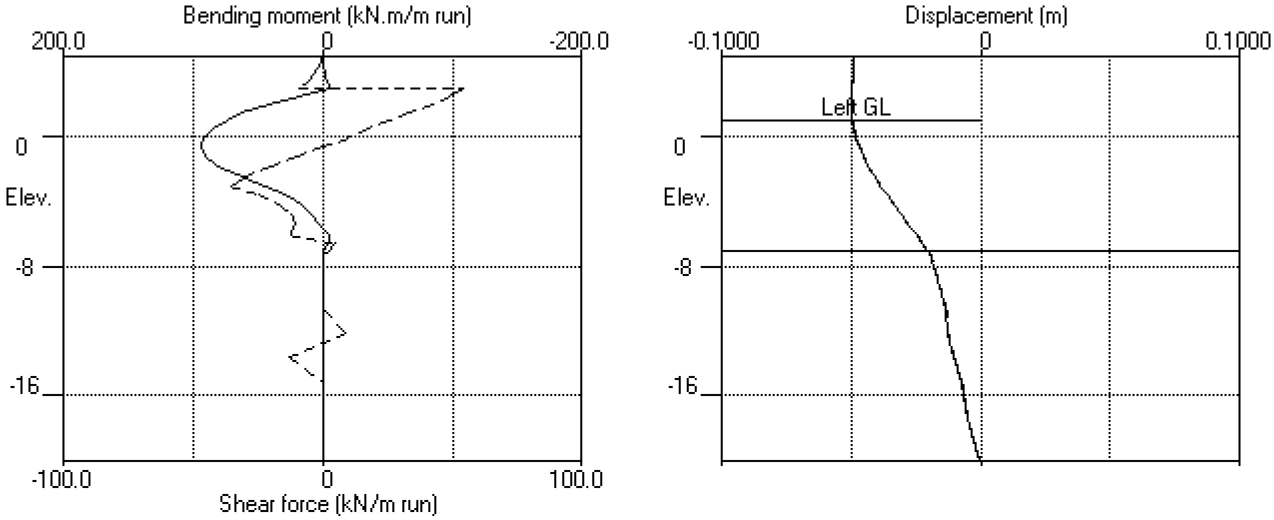
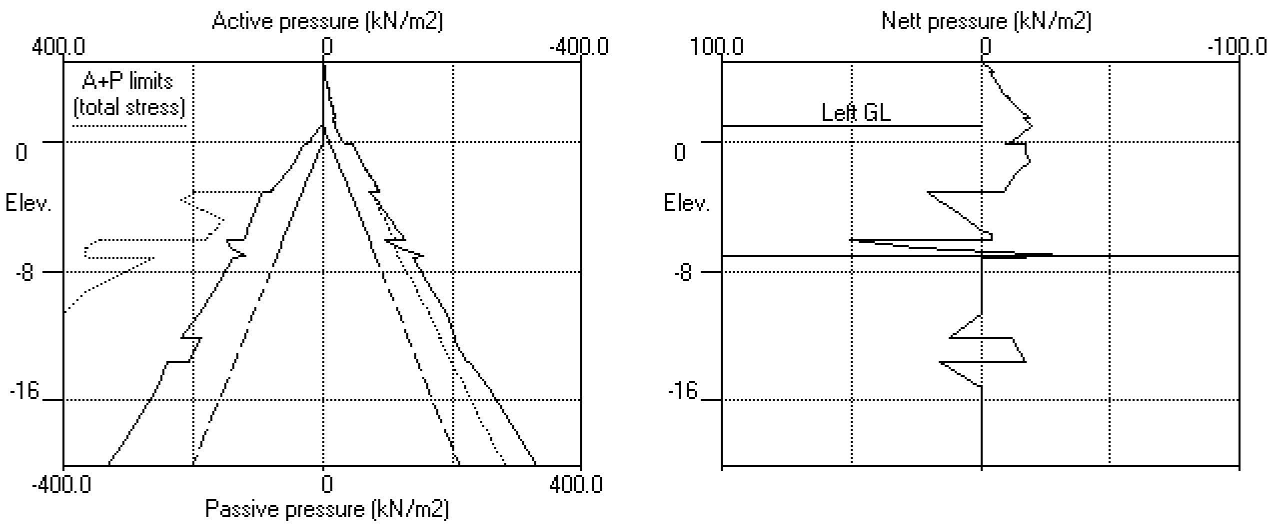

Stage No.6 Apply water pressure profile no.1



Stage No.6 Apply water pressure profile no.1



Units: kN,m

Stage No. 7 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	FoS for toe elev. = -7.00: Factor of Safety	FoS for toe elev. = -7.00: Moment equilib. at elev.	Toe elev. for FoS = 1.300: Toe elev.	Toe elev. for FoS = 1.300: Wall Penetr -ation	Direction of failure
7	4.92	1.00	3.00	1.686	n/a	-4.90	5.90	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.052	1.49E-03	0.0	0.0	
2	4.32	-4.94	-0.053	1.49E-03	-1.5	-0.3	
		-3.49	-0.053	1.49E-03	-1.5	-0.3	
3	3.96	-3.85	-0.054	1.49E-03	-2.8	-1.1	
4	3.60	-4.76	-0.054	1.49E-03	-4.4	-2.4	
5	3.00	-9.82	-0.055	1.50E-03	-8.7	-6.2	79.0
		-9.82	-0.055	1.50E-03	70.2	-6.2	
6	2.72	-11.31	-0.056	1.47E-03	67.3	13.0	
		-9.99	-0.056	1.47E-03	67.3	13.0	
7	2.50	-11.50	-0.056	1.41E-03	64.9	27.6	
8	2.00	-14.88	-0.057	1.17E-03	58.3	58.4	
9	1.42	-22.56	-0.057	6.92E-04	47.5	88.9	
		-20.57	-0.057	6.92E-04	47.5	88.9	
10	1.00	-26.17	-0.057	2.31E-04	37.6	106.7	
		-22.85	-0.057	2.31E-04	37.6	106.7	
11	0.50	-22.27	-0.057	-4.07E-04	26.4	122.4	
12	0.00	-18.32	-0.057	-1.10E-03	16.2	132.6	
13	-0.08	-15.88	-0.057	-1.21E-03	14.8	133.9	
		-23.46	-0.057	-1.21E-03	14.8	133.9	
14	-0.64	-23.55	-0.056	-2.01E-03	1.7	138.5	
15	-1.20	-24.45	-0.055	-2.77E-03	-11.8	135.7	
16	-1.80	-20.36	-0.053	-3.53E-03	-25.2	124.5	
17	-2.40	-16.38	-0.050	-4.18E-03	-36.2	105.9	
18	-2.74	-13.80	-0.049	-4.51E-03	-41.4	92.6	
19	-3.08	-11.63	-0.047	-4.78E-03	-45.7	77.8	
		17.78	-0.047	-4.78E-03	-45.7	77.8	
20	-3.64	16.29	-0.045	-5.15E-03	-36.1	55.0	
21	-4.20	13.68	-0.042	-5.42E-03	-27.7	37.3	
22	-4.80	7.24	-0.038	-5.61E-03	-21.5	23.1	
23	-5.40	1.86	-0.035	-5.73E-03	-18.7	11.5	
24	-5.74	-2.59	-0.033	-5.76E-03	-18.9	5.3	

(continued)

Stage No.7 Apply water pressure profile no.2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
25	-6.08	-3.10	-0.031	-5.78E-03	-19.8	-1.3	
		60.35	-0.031	-5.78E-03	-19.8	-1.3	
26	-6.54	31.97	-0.028	-5.79E-03	1.4	-4.0	
27	-7.00	-28.72	-0.026	-5.79E-03	2.2	-0.0	
28	-7.15	-0.10	-0.025	0	-0.0	0.0	
29	-9.30	0.03	-0.020	0	-0.1	0.0	
30	-10.69	-0.00	-0.017	0	-0.1	0.0	
31	-12.08	14.21	-0.016	0	9.8	0.0	
		-13.19	-0.016	0	9.8	0.0	
32	-13.58	-20.00	-0.013	0	-15.1	0.0	
		18.61	-0.013	0	-15.1	0.0	
33	-15.19	-0.00	-0.010	0	-0.1	0.0	
34	-16.80	-0.00	-0.007	0	-0.1	0.0	
35	-18.40	-0.00	-0.005	0	-0.1	0.0	
36	-20.00	0.13	-0.001	0	-0.0	0.0	

At elev. 3.00 Prop force = 79.0 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	3.32b	3.32	3.32p	7621
11	0.50	0.00	9.00	0.00	10.50b	10.50	10.50p	7621
12	0.00	0.00	18.00	0.00	21.01b	21.01	21.01p	7621
13	-0.08	0.80	18.64	0.00	23.70b	23.70	24.50p	7621
		0.80	18.64	7.30	27.68b	27.68	28.48p	2540
14	-0.64	6.40	22.56	8.84	29.38b	29.38	35.78p	2540
15	-1.20	12.00	26.48	10.38	30.22b	30.22	42.22p	2540
16	-1.80	18.00	30.69	12.02	36.12b	36.12	54.12p	2540
17	-2.40	24.00	34.89	13.67	41.88b	41.88	65.88p	2540
18	-2.74	27.40	37.27	14.61	45.44b	45.44	72.84p	2540
19	-3.08	30.80	39.66	15.54	48.58b	48.58	79.38p	2540
		30.80	39.66	8.16	170.83	67.42	98.22	4573
20	-3.64	36.40	43.58	9.50	181.72	67.32	103.72	4573
21	-4.20	42.00	47.51	10.84	142.61b	66.32	108.32	4573
22	-4.80	48.00	51.73	12.28	104.45b	65.42	113.42	4573
23	-5.40	54.00	55.94	13.71	112.52b	65.02	119.02	4573
24	-5.74	57.40	58.33	14.53	117.24b	64.06	121.46	4573
25	-6.08	60.80	60.72	15.35	121.75b	65.14	125.94	4573
		60.80	60.72	9.48	283.69	94.28	155.08	11178
26	-6.54	65.40	64.88	10.85	300.29	82.52	147.92	11178
27	-7.00	70.00	69.04	12.22	296.50	54.74	124.74	11178
28	-7.15	71.50	70.40	12.66	189.79b	69.40	140.90	11178
29	-9.30	93.00	89.87	19.06	273.97b	79.96	172.96	11178
30	-10.69	106.90	102.49	23.21	386.22b	86.75	193.65	11178
31	-12.08	120.80	115.13	27.37	433.51b	100.65	221.45	11178
		120.80	115.13	30.32	506.64b	70.36	191.16	6097

(continued)

Stage No.7 Apply water pressure profile no.2

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
32	-13.58	135.80	127.31	33.53	560.23b	72.40	208.20	6097
		135.80	127.31	29.26	591.20	109.27	245.07	15242
33	-15.19	151.90	142.03	34.16	630.97	107.92	259.82	15242
34	-16.80	168.00	156.79	39.07	661.72b	115.80	283.80	15242
35	-18.40	184.00	171.50	43.96	716.50b	123.85	307.85	15242
36	-20.00	200.00	186.24	48.87	776.71b	135.22	335.22	15242

RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Effective stresses: Passive limit kN/m2	Effective stresses: Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.21	2.39	99.79	4.94	4.94	30296
		0.00	12.21	3.06	70.25	3.49	3.49	5049
3	3.96	0.00	19.21	4.82	110.55	3.85	3.85A	5049
4	3.60	0.00	26.53	6.66	152.67	4.76	4.76A	5049
5	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5049
6	2.72	0.00	45.03	11.31	259.17	11.31	11.31a	5049
		0.00	45.03	9.99	191.25	9.99	9.99a	4544
7	2.50	0.00	49.44	11.50	208.02	11.50	11.50a	4544
8	2.00	0.00	59.37	14.88	245.73	14.88	14.88a	4544
9	1.42	5.80	64.86	16.76	266.58	16.76	22.56a	4544
		5.80	64.86	14.77	284.72	14.77	20.57a	7574
10	1.00	10.00	69.10	16.17	301.64	16.17	26.17a	7574
11	0.50	15.00	73.98	17.77	321.15	17.77	32.77a	7574
12	0.00	20.00	78.72	19.33	340.06	19.33	39.33a	7574
13	-0.08	20.80	79.47	19.57	343.03	19.57	40.37a	7574
		20.80	79.47	31.14	208.11	31.14	51.94a	2525
14	-0.64	26.40	84.04	32.93	220.08	32.93	59.33a	2525
15	-1.20	32.00	88.47	34.67	231.70	34.67	66.67a	2525
16	-1.80	38.00	93.10	36.48	243.82	36.48	74.48a	2525
17	-2.40	44.00	97.62	38.25	255.65	38.25	82.25a	2525
18	-2.74	47.40	100.14	39.24	262.25	39.24	86.64a	2525
19	-3.08	50.80	102.63	40.22	268.78	40.22	91.02a	2525
		50.80	102.63	29.64	410.10	29.64	80.44a	4544
20	-3.64	56.40	106.69	31.02	425.50	31.02	87.42a	4544
21	-4.20	62.00	110.68	32.39	440.69	32.63	94.63	4544
22	-4.80	68.00	114.91	33.83	456.75	38.18	106.18	4544
23	-5.40	74.00	119.09	35.26	472.63	43.16	117.16	4544
24	-5.74	77.40	121.44	36.06	481.56	46.65	124.05	4544
25	-6.08	80.80	123.78	36.86	490.45	48.24	129.04	4544
		80.80	123.78	30.21	535.41	13.93	94.73A	11109
26	-6.54	85.40	127.85	31.55	551.64	30.55	115.95A	11109
27	-7.00	90.00	131.90	32.88	567.81	63.46	153.46	11109
28	-7.15	91.50	133.21	33.31	573.06	49.50	141.00	11109
29	-9.30	113.00	151.95	39.47	647.87	59.93	172.93	11109
30	-10.69	126.90	163.97	43.43	695.86	66.76	193.66	11109
31	-12.08	140.80	175.96	47.37	743.71	66.44	207.24	11109
		140.80	175.96	46.34	958.79	63.55	204.35	6059
32	-13.58	155.80	187.38	49.35	1021.00	72.40	228.20	6059
		155.80	187.38	49.24	845.78	70.65	226.45	15148
33	-15.19	171.90	201.24	53.86	904.55	87.92	259.82	15148
34	-16.80	188.00	215.13	58.47	963.38	95.80	283.80	15148

(continued)

Stage No.7 Apply water pressure profile no.2

		RIGHT side						
			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
35	-18.40	204.00	228.95	63.07	1021.96	103.85	307.85	15148
36	-20.00	220.00	242.80	67.68	1080.67	115.09	335.09	15148

Note: 87.42 a Soil pressure at active limit
79.38 p Soil pressure at passive limit
776.71 b Passive limit reduced because of berm
115.95A Arching - soil pressure below active limit

```
SMEC AUSTRALIA PTY LTD                                            | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58               | Job No. 3001315
                             Licensed from GEOSOLVE               | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained_propped                   |
Byron Lane Slip                                                   | Date:27-09-2021
AZ 24-700N propped                                                | Checked :
--------------------------------------------------------------------------------
                                                          Units: kN,m
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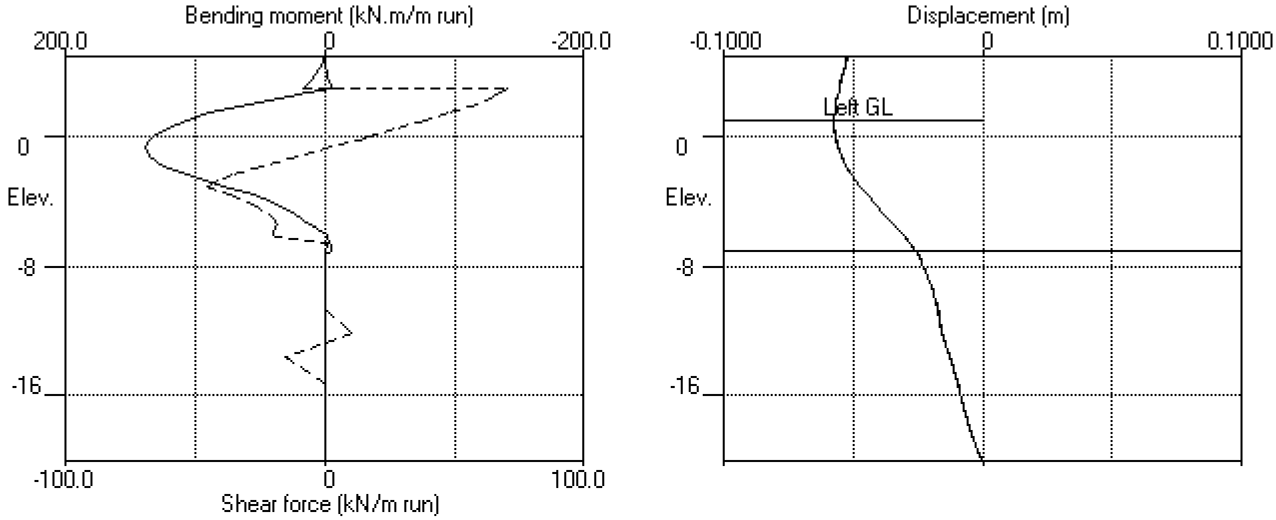
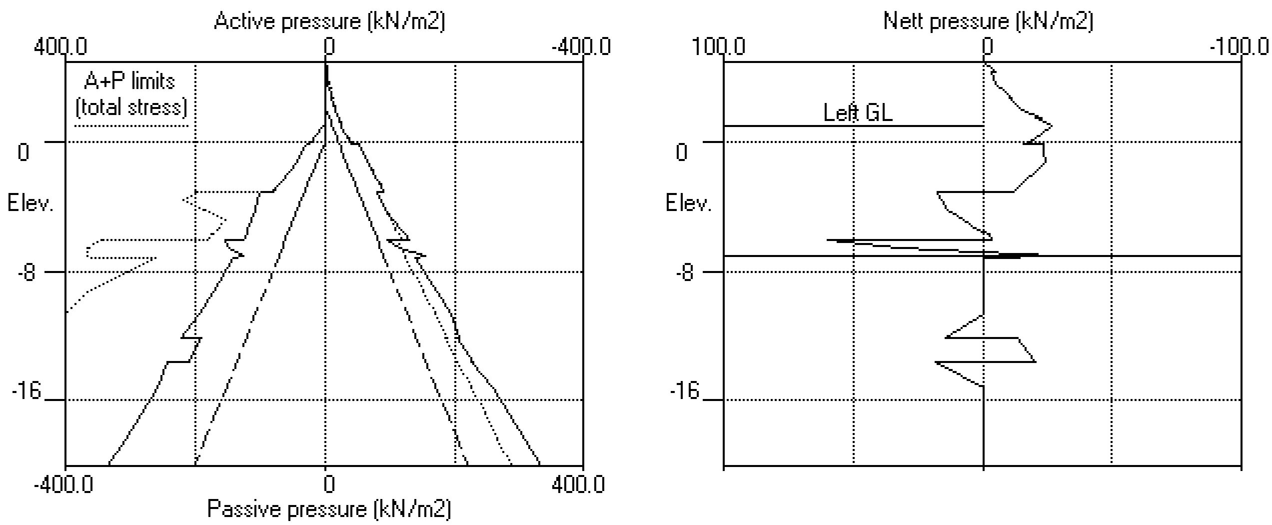
Stage No.7 Apply water pressure profile no.2



Stage No.7 Apply water pressure profile no.2



Units: kN,m

Stage No. 8 Apply water pressure profile no.3

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				FoS for toe elev. = -7.00		Toe elev. for FoS = 1.300		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
8	4.92	1.00	3.00	1.611	n/a	-5.96	6.96	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.058	2.79E-03	0.0	0.0	
2	4.32	-2.39	-0.060	2.79E-03	-0.7	-0.3	
		-3.06	-0.060	2.79E-03	-0.7	-0.3	
3	3.96	-4.82	-0.061	2.79E-03	-2.1	-0.8	
4	3.60	-6.66	-0.062	2.79E-03	-4.2	-1.9	
5	3.00	-9.82	-0.064	2.79E-03	-9.1	-6.0	102.6
		-9.82	-0.064	2.79E-03	93.5	-6.0	
6	2.72	-13.40	-0.064	2.76E-03	90.2	19.7	
		-11.84	-0.064	2.76E-03	90.2	19.7	
7	2.50	-14.79	-0.065	2.68E-03	87.3	39.3	
8	2.00	-21.47	-0.066	2.36E-03	78.2	80.7	
9	1.42	-29.15	-0.068	1.75E-03	63.6	121.7	
		-27.29	-0.068	1.75E-03	63.6	121.7	
10	1.00	-32.88	-0.068	1.16E-03	50.9	145.7	
		-29.56	-0.068	1.16E-03	50.9	145.7	
11	0.50	-28.98	-0.069	3.46E-04	36.3	167.1	
12	0.00	-25.03	-0.069	-5.49E-04	22.8	181.5	
13	-0.08	-22.59	-0.068	-6.96E-04	20.9	183.3	
		-29.54	-0.068	-6.96E-04	20.9	183.3	
14	-0.64	-29.63	-0.068	-1.73E-03	4.3	190.3	
15	-1.20	-30.53	-0.067	-2.74E-03	-12.5	188.0	
16	-1.80	-26.45	-0.065	-3.76E-03	-29.6	175.3	
17	-2.40	-22.46	-0.062	-4.67E-03	-44.3	152.9	
18	-2.74	-19.89	-0.060	-5.12E-03	-51.5	136.5	
19	-3.08	-17.71	-0.059	-5.52E-03	-57.9	117.9	
		17.18	-0.059	-5.52E-03	-57.9	117.9	
20	-3.64	15.45	-0.055	-6.06E-03	-48.8	88.2	
21	-4.20	12.74	-0.052	-6.47E-03	-40.9	63.3	
22	-4.80	9.96	-0.048	-6.77E-03	-34.1	41.0	
23	-5.40	5.73	-0.044	-6.97E-03	-29.4	22.4	
24	-5.74	0.75	-0.041	-7.03E-03	-28.3	12.8	

(continued)

Stage No.8 Apply water pressure profile no.3

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
25	-6.08	-0.40	-0.039	-7.07E-03	-28.2	3.2	
		74.25	-0.039	-7.07E-03	-28.2	3.2	
26	-6.54	33.18	-0.036	-7.08E-03	-3.5	-1.9	
27	-7.00	-13.61	-0.032	-7.08E-03	1.0	-0.0	
28	-7.15	-0.10	-0.032	0	-0.0	0.0	
29	-9.30	0.03	-0.024	0	-0.1	0.0	
30	-10.69	-0.00	-0.021	0	-0.1	0.0	
31	-12.08	15.97	-0.020	0	11.0	0.0	
		-14.82	-0.020	0	11.0	0.0	
32	-13.58	-22.50	-0.016	0	-17.0	0.0	
		20.94	-0.016	0	-17.0	0.0	
33	-15.19	-0.00	-0.012	0	-0.1	0.0	
34	-16.80	-0.00	-0.009	0	-0.1	0.0	
35	-18.40	-0.00	-0.006	0	-0.1	0.0	
36	-20.00	0.13	-0.001	0	-0.0	0.0	

At elev. 3.00 Prop force = 102.6 kN/m run

LEFT side

			Effective stresses					
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	2.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	3.32b	3.32	3.32p	7621
11	0.50	0.00	9.00	0.00	10.50b	10.50	10.50p	7621
12	0.00	0.00	18.00	0.00	21.01b	21.01	21.01p	7621
13	-0.08	0.80	18.64	0.00	23.70b	23.70	24.50p	7621
		0.80	18.64	7.30	27.68b	27.68	28.48p	2540
14	-0.64	6.40	22.56	8.84	29.38b	29.38	35.78p	2540
15	-1.20	12.00	26.48	10.38	30.22b	30.22	42.22p	2540
16	-1.80	18.00	30.69	12.02	36.12b	36.12	54.12p	2540
17	-2.40	24.00	34.89	13.67	41.88b	41.88	65.88p	2540
18	-2.74	27.40	37.27	14.61	45.44b	45.44	72.84p	2540
19	-3.08	30.80	39.66	15.54	48.58b	48.58	79.38p	2540
		30.80	39.66	8.16	170.83	73.41	104.21	4573
20	-3.64	36.40	43.58	9.50	181.72	73.06	109.46	4573
21	-4.20	42.00	47.51	10.84	142.61b	71.71	113.71	4573
22	-4.80	48.00	51.73	12.28	104.45b	70.38	118.38	4573
23	-5.40	54.00	55.94	13.71	112.52b	69.60	123.60	4573
24	-5.74	57.40	58.33	14.53	117.24b	68.37	125.77	4573
25	-6.08	60.80	60.72	15.35	121.75b	69.22	130.02	4573
		60.80	60.72	9.48	283.69	104.25	165.05	11178
26	-6.54	65.40	64.88	10.85	300.29	91.44	156.84	11178
27	-7.00	70.00	69.04	12.22	296.50	64.89	134.89	11178
28	-7.15	71.50	70.40	12.66	189.79b	72.11	143.61	11178
29	-9.30	93.00	89.87	19.06	273.97b	82.68	175.68	11178
30	-10.69	106.90	102.49	23.21	386.22b	89.51	196.41	11178
31	-12.08	120.80	115.13	27.37	433.51b	104.26	225.06	11178
		120.80	115.13	30.32	506.64b	72.34	193.14	6097

(continued)

Stage No.8 Apply water pressure profile no.3

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
32	-13.58	135.80	127.31	33.53	560.23b	73.94	209.74	6097
		135.80	127.31	29.26	591.20	113.14	248.94	15242
33	-15.19	151.90	142.03	34.16	630.97	110.68	262.58	15242
34	-16.80	168.00	156.79	39.07	661.72b	118.56	286.56	15242
35	-18.40	184.00	171.50	43.96	716.50b	126.62	310.62	15242
36	-20.00	200.00	186.24	48.87	776.71b	138.43	338.43	15242

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses: Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30296
2	4.32	0.00	12.21	2.39	99.79	2.39	2.39a	30296
		0.00	12.21	3.06	70.25	3.06	3.06a	5049
3	3.96	0.00	19.21	4.82	110.55	4.82	4.82a	5049
4	3.60	0.00	26.53	6.66	152.67	6.66	6.66a	5049
5	3.00	0.00	39.11	9.82	225.12	9.82	9.82a	5049
6	2.72	2.80	42.23	10.60	243.06	10.60	13.40a	5049
		2.80	42.23	9.04	180.61	9.04	11.84a	4544
7	2.50	5.00	44.44	9.79	189.02	9.79	14.79a	4544
8	2.00	10.00	49.37	11.47	207.74	11.47	21.47a	4544
9	1.42	15.80	54.86	13.35	228.59	13.35	29.15a	4544
		15.80	54.86	11.49	244.80	11.49	27.29a	7574
10	1.00	20.00	59.10	12.88	261.72	12.88	32.88a	7574
11	0.50	25.00	63.98	14.49	281.23	14.49	39.49a	7574
12	0.00	30.00	68.72	16.04	300.14	16.04	46.04a	7574
13	-0.08	30.80	69.47	16.29	303.11	16.29	47.09a	7574
		30.80	69.47	27.22	181.92	27.22	58.02a	2525
14	-0.64	36.40	74.04	29.01	193.89	29.01	65.41a	2525
15	-1.20	42.00	78.47	30.75	205.51	30.75	72.75a	2525
16	-1.80	48.00	83.10	32.56	217.63	32.56	80.56a	2525
17	-2.40	54.00	87.62	34.34	229.46	34.34	88.34a	2525
18	-2.74	57.40	90.14	35.32	236.06	35.32	92.72a	2525
19	-3.08	60.80	92.63	36.30	242.59	36.30	97.10a	2525
		60.80	92.63	26.23	372.11	26.23	87.03a	4544
20	-3.64	66.40	96.69	27.61	387.51	27.61	94.01a	4544
21	-4.20	72.00	100.68	28.98	402.69	28.98	100.98a	4544
22	-4.80	78.00	104.91	30.42	418.76	30.42	108.42a	4544
23	-5.40	84.00	109.09	31.84	434.64	33.88	117.88	4544
24	-5.74	87.40	111.44	32.65	443.57	37.62	125.02	4544
25	-6.08	90.80	113.78	33.44	452.45	39.61	130.41	4544
		90.80	113.78	26.92	495.49	0.00	90.80A	11109
26	-6.54	95.40	117.85	28.26	511.72	28.26	123.66a	11109
27	-7.00	100.00	121.90	29.59	527.89	48.49	148.49	11109
28	-7.15	101.50	123.21	30.03	533.15	42.21	143.71	11109
29	-9.30	123.00	141.95	36.19	607.95	52.65	175.65	11109
30	-10.69	136.90	153.97	40.14	655.94	59.51	196.41	11109
31	-12.08	150.80	165.96	44.08	703.79	58.29	209.09	11109
		150.80	165.96	43.71	904.30	57.16	207.96	6059
32	-13.58	165.80	177.38	46.71	966.51	66.44	232.24	6059
		165.80	177.38	45.92	803.40	62.20	228.00	15148
33	-15.19	181.90	191.24	50.53	862.17	80.68	262.58	15148
34	-16.80	198.00	205.13	55.15	921.00	88.56	286.56	15148

(continued)

Stage No.8 Apply water pressure profile no.3

		RIGHT side						
			Effective stresses				Total	Adjusted
Node no.	Y coord	Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
35	-18.40	214.00	218.95	59.75	979.58	96.62	310.62	15148
36	-20.00	230.00	232.80	64.35	1038.29	108.30	338.30	15148

Note: 123.66 a Soil pressure at active limit
79.38 p Soil pressure at passive limit
776.71 b Passive limit reduced because of berm
90.80A Arching - soil pressure below active limit

```
SMEC AUSTRALIA PTY LTD                                          | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58             | Job No. 3001315
                                     Licensed from GEOSOLVE     | Made by :    MM
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Byron Lane Slip                                                 | Date:27-09-2021
AZ 24-700N propped                                              | Checked :
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                                                        Units: kN,m
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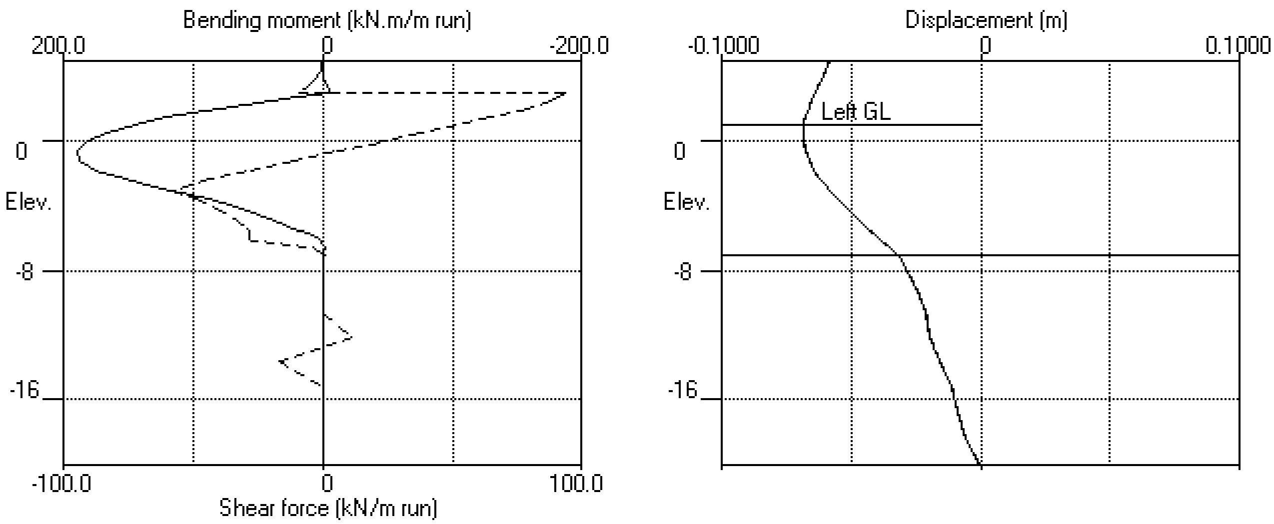
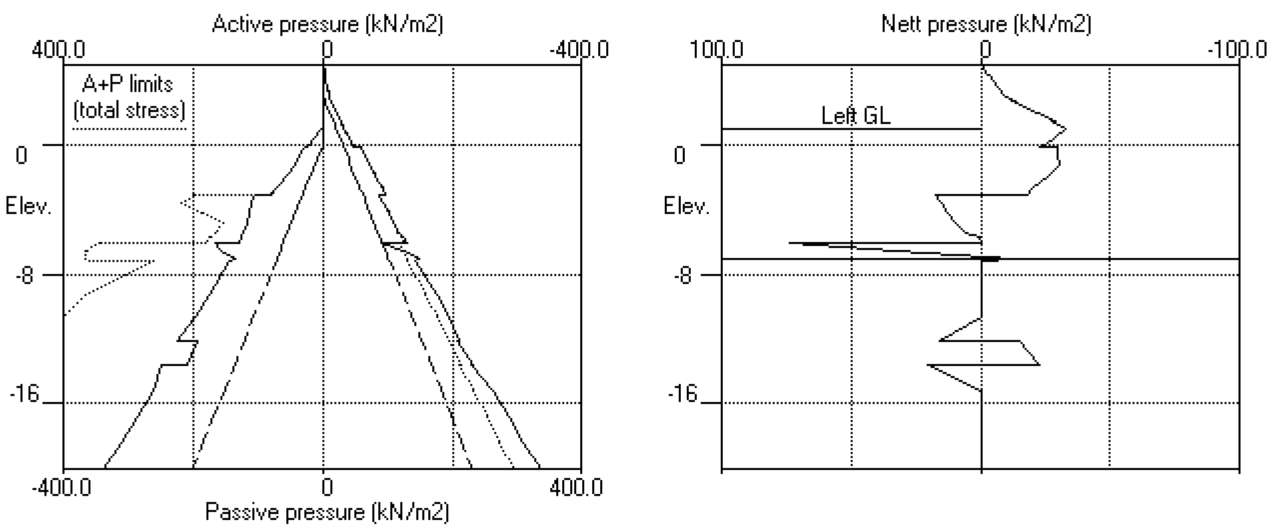
Stage No.8 Apply water pressure profile no.3



Stage No.8 Apply water pressure profile no.3



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -7.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Ground level Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	4.92	2.50	Cant.	1.422	-6.41	-5.57	8.07	R to L
2	2.50	4.92		No analysis at this stage				
3	4.92	2.50	Cant.	1.338	-6.45	-6.40	8.90	R to L
4	4.92	2.50	3.00	2.142	n/a	-3.35	5.85	R to L
5	4.92	1.00	3.00	1.834	n/a	-4.13	5.13	R to L
6	4.92	1.00	3.00	1.761	n/a	-4.25	5.25	R to L
7	4.92	1.00	3.00	1.686	n/a	-4.90	5.90	R to L
8	4.92	1.00	3.00	1.611	n/a	-5.96	6.96	R to L

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	4.92	0.000	-0.058	0.0	0.0	0.0	0.0
2	4.32	0.000	-0.060	0.0	-0.3	0.0	-2.4
3	3.96	0.000	-0.061	0.0	-1.4	0.0	-4.1
4	3.60	0.000	-0.062	0.0	-3.4	0.0	-6.5
5	3.00	0.000	-0.064	0.0	-8.9	93.5	-11.9
6	2.72	0.000	-0.064	19.7	-10.9	90.2	-12.1
7	2.50	0.000	-0.065	39.3	-13.0	87.3	-14.5
8	2.00	0.000	-0.066	80.7	-20.1	78.2	-17.8
9	1.42	0.000	-0.068	121.7	-31.2	63.6	-18.5
10	1.00	0.000	-0.068	145.7	-38.4	50.9	-14.5
11	0.50	0.000	-0.069	167.1	-44.1	36.3	-6.5
12	0.00	0.000	-0.069	181.5	-45.0	22.8	0.0
13	-0.08	0.000	-0.068	183.3	-44.5	20.9	0.0
14	-0.64	0.000	-0.068	190.3	-40.4	12.1	-3.2
15	-1.20	0.000	-0.067	188.0	-36.5	9.7	-12.5
16	-1.80	0.000	-0.065	175.3	-33.1	6.9	-29.6
17	-2.40	0.000	-0.062	152.9	-30.9	3.7	-44.3
18	-2.74	0.000	-0.060	136.5	-30.3	1.7	-51.5
19	-3.08	0.000	-0.059	117.9	-30.4	0.0	-57.9
20	-3.64	0.000	-0.055	88.2	-29.5	4.0	-48.8
21	-4.20	0.000	-0.052	63.3	-26.0	7.3	-40.9
22	-4.80	0.000	-0.048	41.0	-20.9	8.6	-34.1
23	-5.40	0.000	-0.044	22.4	-15.6	7.9	-29.4
24	-5.74	0.000	-0.041	12.8	-13.1	6.5	-28.3
25	-6.08	0.000	-0.039	3.2	-11.2	4.8	-28.2
26	-6.54	0.000	-0.036	0.0	-6.3	12.2	-3.5
27	-7.00	0.000	-0.032	0.0	-0.0	3.4	0.0
28	-7.15	0.000	-0.032	0.0	0.0	0.0	-0.0
29	-9.30	0.000	-0.024	0.0	0.0	0.0	-0.1
30	-10.69	0.000	-0.021	0.0	0.0	0.0	-0.1
31	-12.08	0.000	-0.020	0.0	0.0	11.0	0.0
32	-13.58	0.000	-0.016	0.0	0.0	0.0	-17.0
33	-15.19	0.000	-0.012	0.0	0.0	0.0	-0.1
34	-16.80	0.000	-0.009	0.0	0.0	0.0	-0.1
35	-18.40	0.000	-0.006	0.0	0.0	0.0	-0.1
36	-20.00	0.000	-0.001	0.0	0.0	0.0	-0.0

Summary of results (continued)

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	elev.	Bending moment minimum kN.m/m	elev.	Shear force maximum kN/m	elev.	Shear force minimum kN/m	elev.
1	0.0	4.92	-37.1	0.50	14.0	-0.08	-15.7	2.00
2	No calculation at this stage							
3	0.0	4.92	-45.0	0.00	12.2	-6.54	-18.5	1.42
4	0.0	4.92	-41.8	0.00	11.6	-6.54	-16.4	1.42
5	63.6	-0.64	-8.0	-6.08	44.1	3.00	-27.7	-3.08
6	94.1	-0.64	-6.7	3.00	53.8	3.00	-35.2	-3.08
7	138.5	-0.64	-6.2	3.00	70.2	3.00	-45.7	-3.08
8	190.3	-0.64	-6.0	3.00	93.5	3.00	-57.9	-3.08

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.000	4.92	-0.065	4.92	Excav. to elev. 2.50 on LEFT side
2	Wall displacements reset to zero				Change EI of wall to 117369kN.m2/m run
3	0.000	4.92	-0.037	4.92	Apply surcharge no.1 at elev. 4.92
4	0.000	4.92	-0.035	4.92	Install prop no.1 at elev. 3.00
5	0.000	4.92	-0.047	4.92	Excav. to elev. 1.00 on LEFT side
6	0.000	4.92	-0.050	2.00	Apply water pressure profile no.1
7	0.000	4.92	-0.057	1.00	Apply water pressure profile no.2
8	0.000	4.92	-0.069	0.50	Apply water pressure profile no.3

Prop forces at each stage (horizontal components)

Stage no.	Anchor no. 1 at elev. 3.00 kN/m run	kN/prop
4	-6.67	-20.00
5	-53.25	-159.74
6	-63.06	-189.17
7	-78.96	-236.89
8	-102.63	-307.89

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SMEC AUSTRALIA PTY LTD                                      | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58         | Job No. 3001315
                            Licensed from GEOSOLVE          | Made by :    MM
Data filename/Run ID: AZ24-700N_Drained_propped             |
Byron Lane Slip                                             | Date:27-09-2021
AZ 24-700N propped                                          | Checked :
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                                                   Units: kN,m
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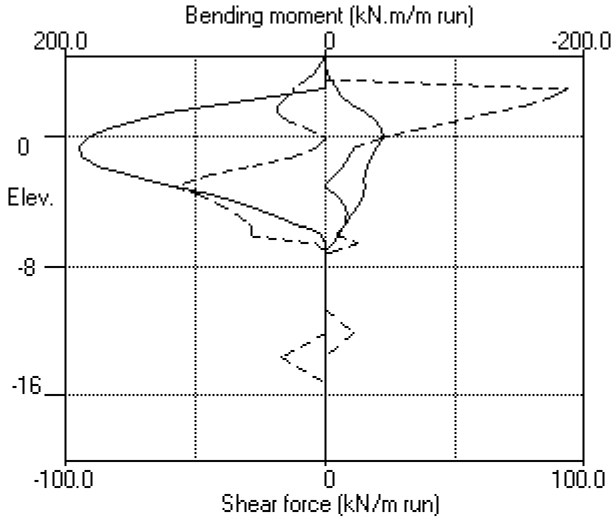
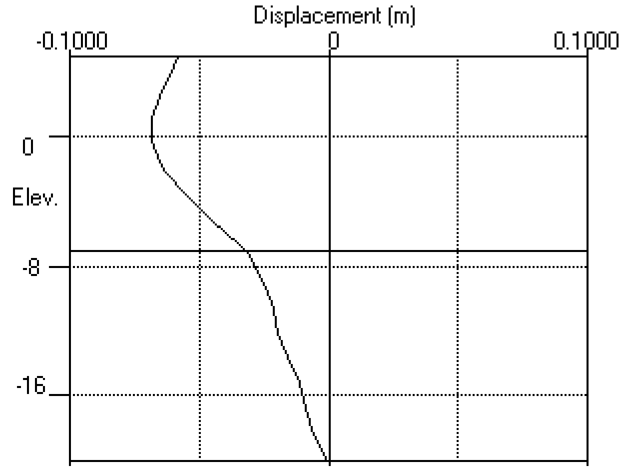
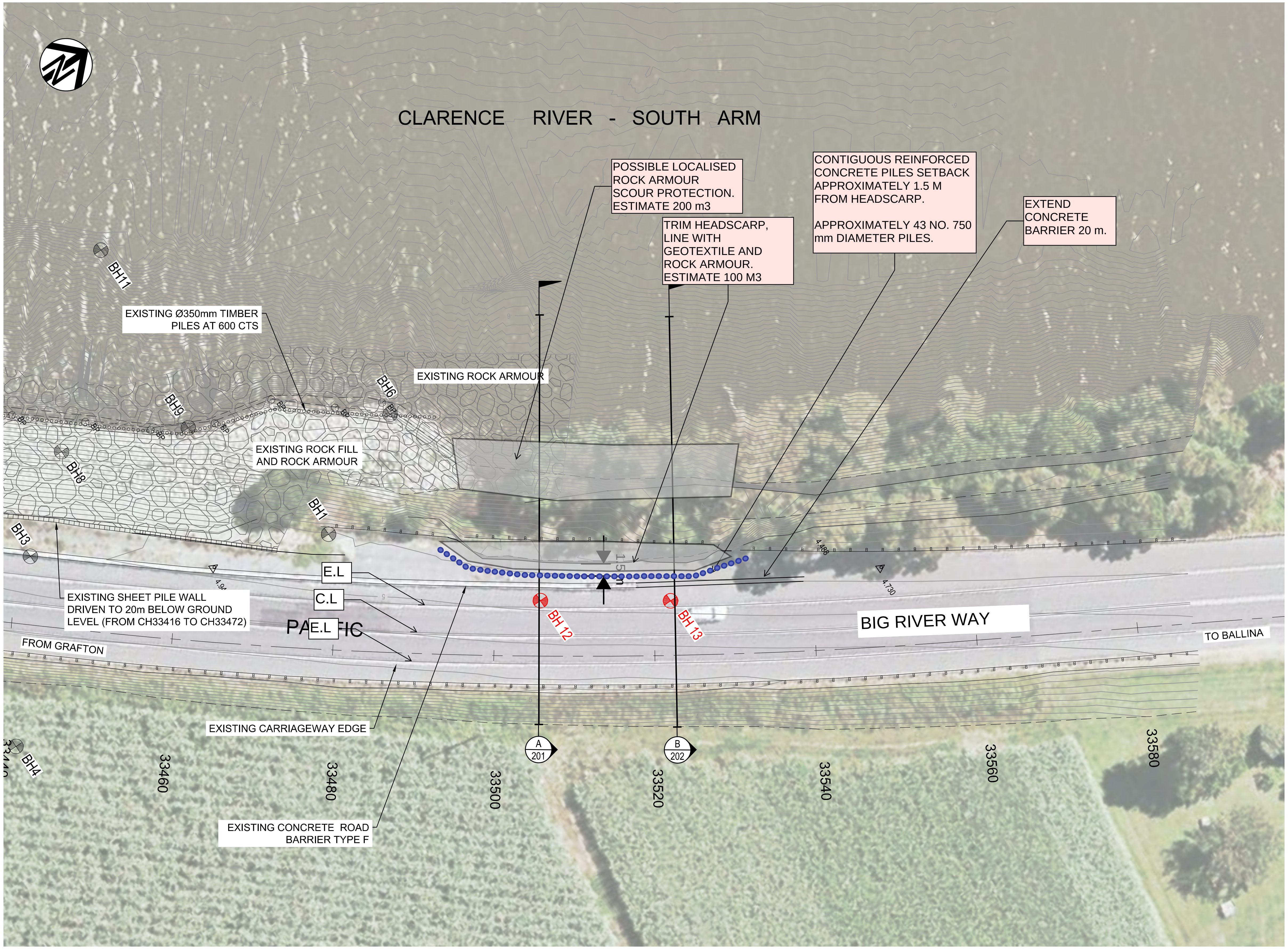
Bending moment, shear force, displacement envelopes





Appendix D Concept Option 2 – Sketches



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- TfNSW BORE HOLE (2021) (BH 12)
- TfNSW BORE HOLE (2009) (BH8)

ANTICIPATED CONSTRUCTION SEQUENCE:

1. Close northbound lane.
2. Excavate and batter back headscarp.
3. Construct temporary working platform for CFA piling rig. Minimum 3.0 m setback from headscarp. May require micropiles.
3. Drill and install reinforced concrete piles in a predetermined sequence.
4. Collect and transport pile spoil offsite for treatment and disposal.
5. Trim headscarp and apply rock armour to slope face and riverbank.
6. Extend concrete safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to vegetated riverbank are to be discussed and confirmed with TfNSW.

CONCEPT SKETCHES OPTION 2 - CONTIGUOUS PILE RETAINING WALL

NOT FOR CONSTRUCTION

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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

PLOT DATE / TIME: 13 September 2021 03:15:40 PM

PLOT BY: TC13654

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:500 (2.5 0 2.5 5.0 7.5 10 12.5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)

HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC

Member of the Surbana Jurong Group

ABN 47 065 475 149

52 VICTORIA STREET GRAFTON NSW 2460

SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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CLARENCE VALLEY COUNCIL

HW10 - PACIFIC HIGHWAY

BYRONS LANE SLIP REMEDIATION

GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 6

RMS REGISTRATION No. DS2021 / 00????

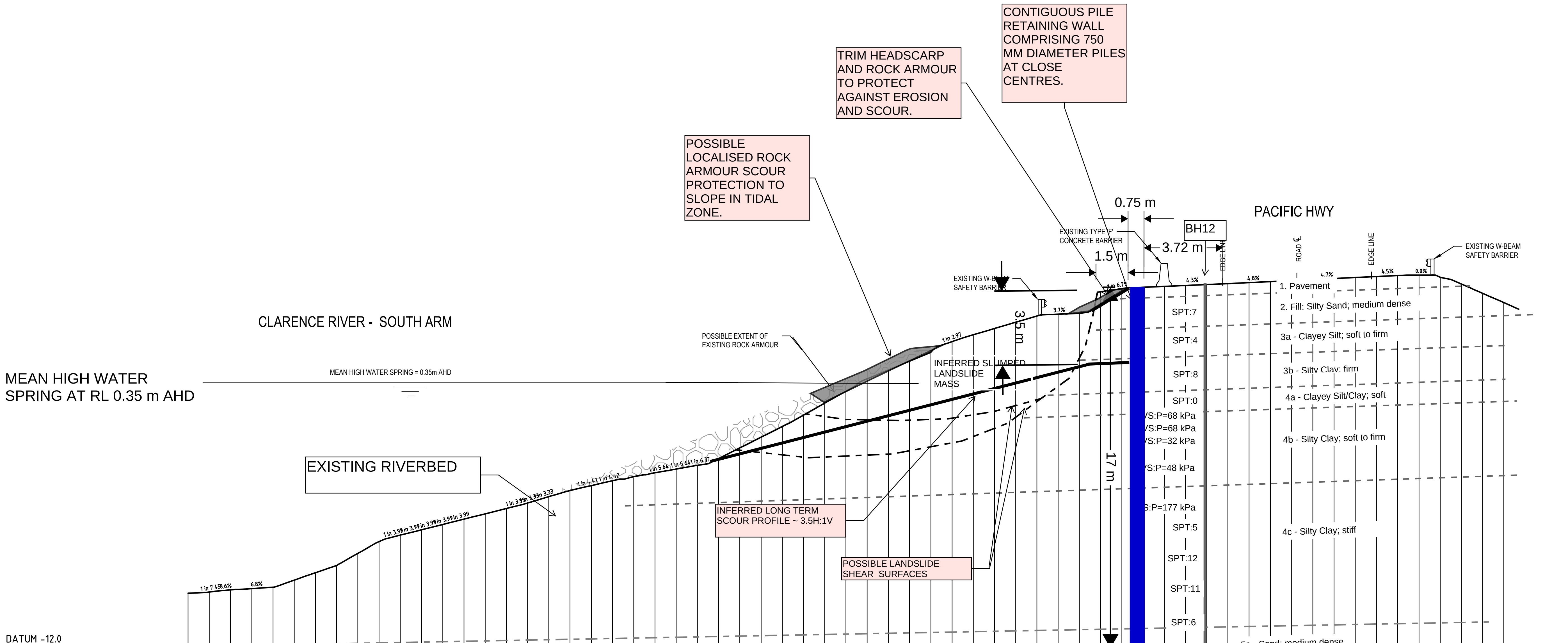
PART 1

ISSUE STATUS: CONCEPT DESIGN

EDMS No. DS2021 / 00????

SHEET No. GT-101

ISSUE #



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-46.000	-8.610	-8.610
-45.000	-8.265	-8.265
-44.000	-7.698	-7.698
-43.000	-7.145	-7.145
-42.000	-6.840	-6.840
-41.000	-6.589	-6.589
-40.000	-6.339	-6.339
-39.000	-6.088	-6.088
-38.000	-5.837	-5.837
-37.000	-5.587	-5.587
-36.000	-5.328	-5.328
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-33.000	-4.505	-4.505
-32.000	-4.279	-4.279
-31.000	-4.082	-4.082
-30.000	-3.903	-3.903
-29.000	-3.726	-3.726
-28.000	-3.553	-3.553
-27.000	-3.237	-3.237
-26.000	-2.734	-2.734
-25.000	-2.231	-2.231
-24.000	-1.728	-1.728
-23.000	-1.189	-1.189
-22.000	-0.626	-0.626
-21.000	-0.062	-0.062
-20.000	0.522	0.522
-19.000	0.937	0.937
-18.000	1.352	1.352
-17.000	1.775	1.775
-16.000	2.273	2.273
-15.000	2.594	2.594
-14.000	2.890	2.890
-13.000	3.186	3.186
-12.000	3.481	3.481
-11.000	3.566	3.566
-10.000	3.608	3.608
-9.000	4.621	4.621
-8.000	4.767	4.767
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2.000	5.245	[illegible]
3.000	5.291	[illegible]
4.000	5.336	[illegible]
5.000	5.381	[illegible]
6.000	5.400	[illegible]
7.000	5.310	[illegible]
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9.000	4.548	4.548
10.000	4.111	4.111

SECTION A 101
SCALE 1:200

CONCEPT SKETCHES OPTION 2 - CONTIGUOUS PILE RETAINING WALL

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50mm ON A3 SIZE ORIGINAL
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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

PLOT DATE / TIME: 13 September 2021 02:53:37 PM
PLOT BY: TC13654

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING
SCALE 1:200 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY
SMEC
Member of the Surbana Jurong Group
© ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT PRELIM. INITIAL FINAL DATE
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HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

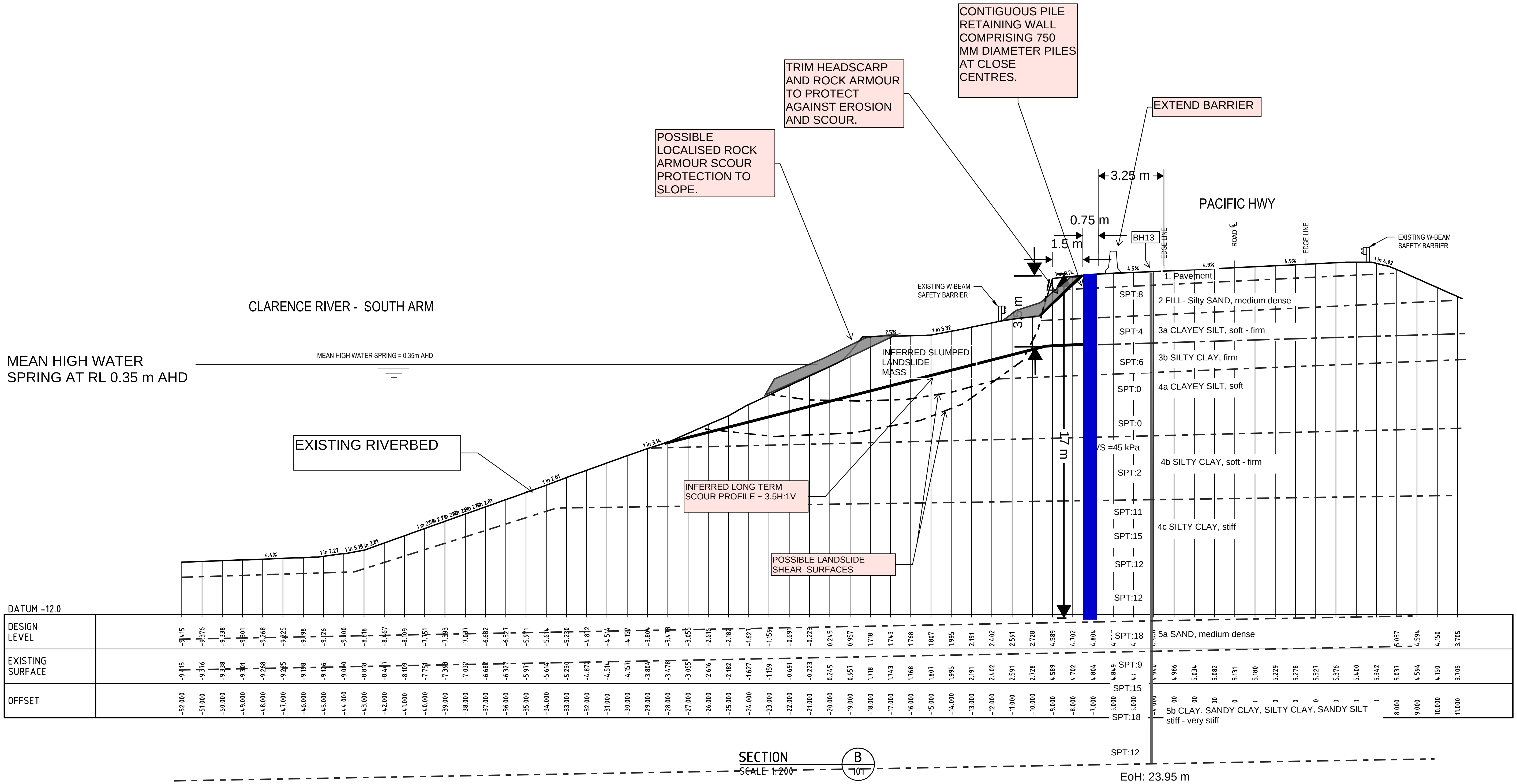
A3

CROSS SECTION - SHEET 1

SHEET 5 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No.: DS2021 / 00????
SHEET No.: GT-201
ISSUE: #



CONCEPT SKETCHES OPTION 2 - CONTIGUOUS PILE RETAINING WALL

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50mm ON A3 SIZE ORIGINAL

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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 — 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) — HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY

SMEC

Member of the Surbana Jurong Group

ABN 47 065 475 149

52 VICTORIA STREET

GRAFTON NSW 2460

SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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HW10 - PACIFIC HIGHWAY

BYRONS LANE SLIP REMEDIATION

CROSS SECTION - SHEET 2

A3

SHEET 6 OF 6

RMS REGISTRATION No. DS2021 / 00????

PART 1

ISSUE STATUS: CONCEPT DESIGN

EDMS No. DS2021 / 00????

SHEET No. GT-202

ISSUE #

Appendix E Concept Option 2 – Analyses

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Left side		Soil types Right side	
1	4.92	1	1 Pavement	1	1 Pavement
2	4.32	2	2 FILL	2	2 FILL
3	2.72	3	3a s-f Clayey SILT	3	3a s-f Clayey SILT
4	1.42	4	3b firm Silty CLAY	4	3b firm Silty CLAY
5	-0.08	5	4a s Sandy CLAY	5	4a s Sandy CLAY
6	-3.08	6	4b s-f Silty CLAY	6	4b s-f Silty CLAY
7	-6.08	7	4c St Silty CLAY	7	4c St Silty CLAY
8	-12.08	8	5a l-md SAND	8	5a l-md SAND
9	-13.58	9	5b stiff mix CLAY	9	5b stiff mix CLAY

SOIL PROPERTIES

No.	Soil type Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	1 Pavement	20.00	30000	0.357	OC (0.200)	0.196 (0.000)	8.175 (0.000)	
2	2 FILL	18.00	5000	0.441	OC (0.300)	0.251 (0.000)	5.756 (0.000)	
3	3a s-f Clayey SILT	17.00	4500	0.562	OC (0.300)	0.341 (1.342)	3.799 (5.039)	4.000d
4	3b firm Silty CLAY	18.00	7500	0.546	OC (0.300)	0.329 (1.310)	3.992 (5.162)	5.000d
5	4a s Sandy CLAY	17.00	3750	0.577	OC (0.300)	0.333 (1.378)	3.799 (5.039)	2.000d
6	4b s-f Silty CLAY	17.00	4500	0.562	OC (0.300)	0.341 (1.342)	3.799 (5.039)	4.000d
7	4c St Silty CLAY	19.00	11000	0.546	OC (0.300)	0.329 (1.310)	3.992 (5.162)	8.000d
8	5a l-md SAND	18.00	6000	0.455	OC (0.300)	0.263 (0.000)	5.449 (0.000)	
9	5b stiff mix CLAY	19.00	15000	0.546	OC (0.300)	0.333 (1.310)	4.238 (5.162)	10.00d

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	Ka: Soil friction angle	Ka: Wall adhesion coeff.	Ka: Back-fill angle	Kp: Soil friction angle	Kp: Wall adhesion coeff.	Kp: Back-fill angle
1	1 Pavement	40.00	0.297	0.00	41.70	0.297	0.00
2	2 FILL	34.00	0.370	0.00	35.63	0.370	0.00
3	3a s-f Clayey SILT	26.00	0.511	0.00	29.05	0.352	0.00
4	3b firm Silty CLAY	27.00	0.489	0.00	30.10	0.336	0.00
5	4a s Sandy CLAY	25.84	0.819	0.00	29.05	0.352	0.00
6	4b s-f Silty CLAY	26.00	0.511	0.00	29.05	0.352	0.00
7	4c St Silty CLAY	27.00	0.489	0.00	30.10	0.336	0.00
8	5a l-md SAND	33.00	0.384	0.00	34.62	0.384	0.00
9	5b stiff mix CLAY	27.00	0.489	0.00	32.10	0.264	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	0.00	0.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Left side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Right side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	0.00	0.00	0.0	1	1.00	1.00	0.0
2	1	0.00	0.00	0.0	1	2.00	2.00	0.0
3	1	0.00	0.00	0.0	1	3.00	3.00	0.0

WALL PROPERTIES

```
                 Type of structure = Fully Embedded Wall
          Elevation of toe of wall = -12.00
     Maximum finite element length =   1.00 m
         Youngs modulus of wall E = 3.5000E+07 kN/m2
     Moment of inertia of wall I = 0.015532 m4/m run
                              E.I = 543604 kN.m2/m run
              Yield Moment of wall = Not defined
```

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	4.92	-1.00(R)	40.00	12.00	20.00	=	N/A	N/A

Note: L = Left side, R = Right side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Excavate to elevation 1.50 on LEFT side Toe of berm at elevation -9.30 Width of top of berm = 0.50 Width of toe of berm = 36.50
2	Change EI of wall to 543604 kN.m2/m run Reset wall displacements to zero at this stage
3	Apply surcharge no.1 at elevation 4.92
4	Apply water pressure profile no.1
5	Apply water pressure profile no.2
6	Apply water pressure profile no.3

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
 Method of analysis - Strength Factor method
 Factor on soil strength for calculating wall depth = 1.30

Parameters for undrained strata:
 Minimum equivalent fluid density = 5.00 kN/m3
 Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
 Method - 2-D finite element model
 Open Tension Crack analysis? - No
 Active limit arching modelled? - Yes
 Non-linear Modulus Parameter (L) = 18.00 m

Boundary conditions:
 Length of wall (normal to plane of analysis) = 40.00 m

 Width of excavation on Left side of wall = 50.00 m
 Width of excavation on Right side of wall = 20.00 m

 Distance to rigid boundary on Left side = 50.00 m
 Distance to rigid boundary on Right side = 30.00 m

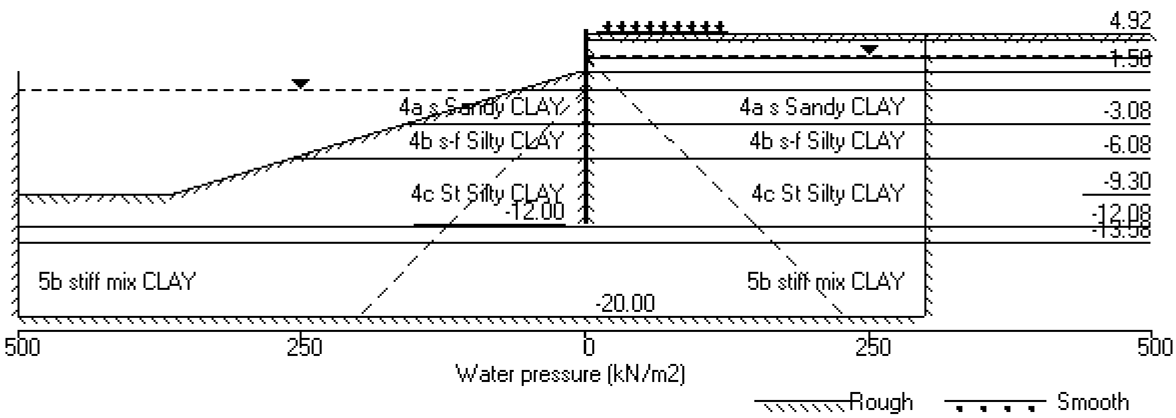
```
Elevation of rigid lower boundary = -20.00

Lower rigid boundary at elevation -20.00 - Rough
Rigid boundary on Left side           - Rough
Rigid boundary on Right side          - Rough
Wall / soil interface                   - Rough
```

OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Excav. to elev. 1.50 on LEFT side	Yes	Yes	Yes
2	Change EI of wall to 543604kN.m2/m run	Yes	Yes	Yes
3	Apply surcharge no.1 at elev. 4.92	Yes	Yes	Yes
4	Apply water pressure profile no.1	Yes	Yes	Yes
5	Apply water pressure profile no.2	Yes	Yes	Yes
6	Apply water pressure profile no.3	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

```
SMEC AUSTRALIA PTY LTD                                          | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58             | Job No. 3001315
                             Licensed from GEOSOLVE             | Made by :    MM
Data filename/Run ID: Dia750mm_SecantPileWall                   |
Byron Lane Slip                                                 | Date:28-09-2021
750diam secant pile wall                                        | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
```

Stage No.6 Apply water pressure profile no.3



Units: kN,m

Stage No. 1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -12.00		Toe elev. for FoS = 1.300		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	4.92	1.50	Cant.	1.695	-10.92	-6.11	7.61	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.061	-3.43E-03	0.0	0.0	
2	4.32	-2.35	-0.059	-3.43E-03	-0.7	-0.3	
		-3.01	-0.059	-3.43E-03	-0.7	-0.3	
3	3.66	-6.00	-0.056	-3.43E-03	-3.7	-1.8	
4	3.00	-8.98	-0.054	-3.43E-03	-8.6	-5.9	
5	2.72	-10.24	-0.053	-3.42E-03	-11.3	-8.7	
		-8.55	-0.053	-3.42E-03	-11.3	-8.7	
6	2.00	-12.73	-0.051	-3.40E-03	-19.0	-19.6	
7	1.50	-16.23	-0.049	-3.38E-03	-26.2	-30.9	
		3.92	-0.049	-3.38E-03	-26.2	-30.9	
8	1.42	9.81	-0.049	-3.38E-03	-25.7	-33.0	
		24.31	-0.049	-3.38E-03	-25.7	-33.0	
9	1.00	23.44	-0.047	-3.35E-03	-15.6	-41.6	
10	0.00	20.49	-0.044	-3.27E-03	6.3	-45.5	
11	-0.08	8.10	-0.044	-3.26E-03	7.5	-44.9	
		-18.30	-0.044	-3.26E-03	7.5	-44.9	
12	-1.04	-3.71	-0.041	-3.18E-03	-3.1	-46.2	
13	-2.00	-4.09	-0.038	-3.09E-03	-6.8	-50.9	
14	-2.54	-4.41	-0.036	-3.04E-03	-9.1	-55.1	
15	-3.08	-4.39	-0.034	-2.98E-03	-11.5	-60.7	
		0.00	-0.034	-2.98E-03	-11.5	-60.7	
16	-4.04	-2.84	-0.031	-2.87E-03	-12.9	-71.7	
17	-5.00	-3.39	-0.029	-2.73E-03	-15.9	-85.4	
18	-5.54	-2.20	-0.027	-2.64E-03	-17.4	-94.5	
19	-6.08	-0.35	-0.026	-2.54E-03	-18.1	-104.1	
		37.18	-0.026	-2.54E-03	-18.1	-104.1	

(continued)

Stage No.1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
20	-7.04	16.19	-0.024	-2.36E-03	7.6	-104.3	
21	-8.00	8.21	-0.021	-2.18E-03	19.3	-89.6	
22	-8.65	4.11	-0.020	-2.09E-03	23.3	-75.3	
23	-9.30	1.02	-0.019	-2.01E-03	24.9	-59.3	
24	-10.15	-1.98	-0.017	-1.93E-03	24.5	-37.8	
25	-11.00	-6.57	-0.015	-1.89E-03	20.9	-17.6	
26	-12.00	-32.63	-0.013	-1.87E-03	1.3	-0.0	
27	-12.08	19.83	-0.014	0	0.8	0.0	
		-1.08	-0.014	0	0.8	0.0	
28	-13.58	-13.21	-0.011	0	-9.9	0.0	
		6.12	-0.011	0	-9.9	0.0	
29	-16.79	-0.01	-0.006	0	-0.1	0.0	
30	-20.00	0.08	-0.001	0	-0.0	0.0	

LEFT side

			Effective stresses					
Node no.	Y coord	Water press. kN/m2	Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4677
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4677
		0.00	1.36	0.00	25.59b	25.59	25.59p	7795
9	1.00	0.00	8.92	0.00	40.06b	40.06	40.06p	7795
10	0.00	0.00	26.92	2.30	76.03b	50.45	50.45	7795
11	-0.08	0.80	27.56	2.51	57.82b	42.69	43.49	7795
		0.80	27.56	6.41	26.08b	26.08	26.88p	3897
12	-1.04	10.40	34.28	8.65	44.19b	41.49	51.89	3897
13	-2.00	20.00	41.01	10.88	67.36b	44.75	64.75	3897
14	-2.54	25.40	44.79	12.14	74.83b	46.55	71.95	3897
15	-3.08	30.80	48.58	13.40	81.36b	48.57	79.37	3897
		30.80	48.58	11.20	120.14b	49.21	80.01	4677
16	-4.04	40.40	55.32	13.50	118.35b	51.38	91.78	4677
17	-5.00	50.00	62.06	15.80	113.16b	54.76	104.76	4677
18	-5.54	55.40	65.85	17.10	120.41b	57.45	112.85	4677
19	-6.08	60.80	69.65	18.39	127.14b	60.43	121.23	4677
		60.80	69.65	12.42	297.73b	77.24	138.04	11432
20	-7.04	70.40	78.33	15.27	239.66b	71.31	141.71	11432
21	-8.00	80.00	87.01	18.13	155.16b	71.89	151.89	11432
22	-8.65	86.50	92.90	20.06	249.94b	72.95	159.45	11432
23	-9.30	93.00	98.79	22.00	352.24b	74.54	167.54	11432
24	-10.15	101.50	106.50	24.53	366.72b	77.17	178.67	11432
25	-11.00	110.00	114.22	27.07	398.07b	78.99	188.99	11432
26	-12.00	120.00	123.31	30.06	430.71b	71.39	191.39	11432
27	-12.08	120.80	124.04	30.30	436.57b	96.84	217.64	11432
		120.80	124.04	32.67	519.74b	70.02	190.82	6236
28	-13.58	135.80	136.21	35.87	570.71b	69.91	205.71	6236
		135.80	136.21	32.22	570.15b	97.33	233.13	15589

(continued)

Stage No.1 Excavate to elevation 1.50 on LEFT side
Toe of berm at elevation -9.30
Width of top of berm = 0.50
Width of toe of berm = 36.50

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
29	-16.79	167.90	165.55	41.98	672.06b	110.23	278.13	15589
30	-20.00	200.00	195.03	51.79	770.91b	127.54	327.54	15589

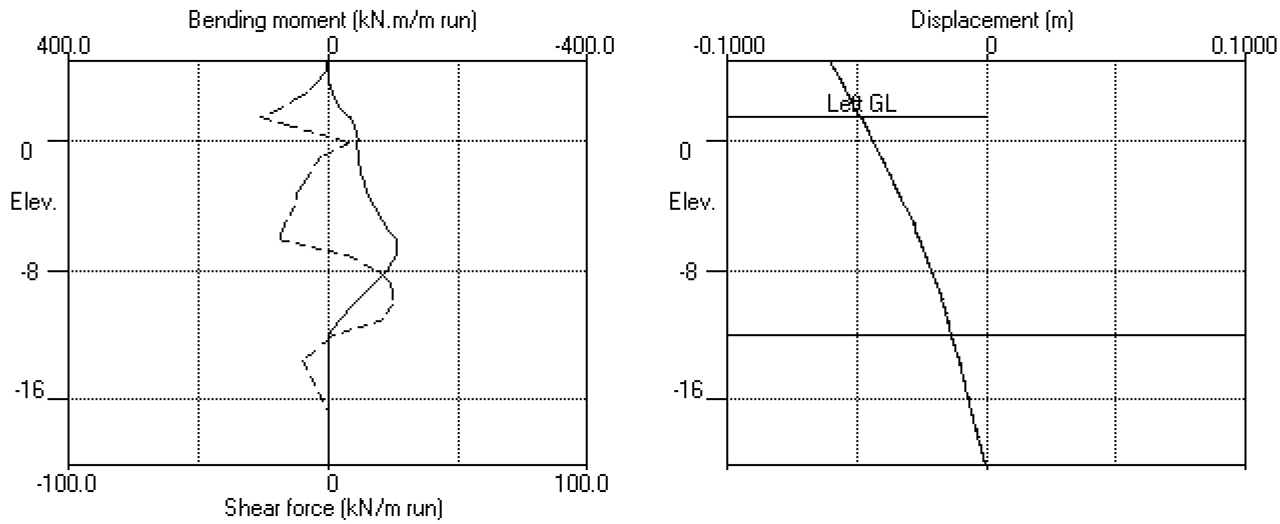
RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30555
2	4.32	0.00	12.00	2.35	98.10	2.35	2.35a	30555
		0.00	12.00	3.01	69.07	3.01	3.01a	5092
3	3.66	0.00	23.88	6.00	137.44	6.00	6.00a	5092
4	3.00	0.00	35.76	8.98	205.82	8.98	8.98a	5092
5	2.72	0.00	40.80	10.24	234.82	10.24	10.24a	5092
		0.00	40.80	8.55	175.17	8.55	8.55a	4583
6	2.00	0.00	53.04	12.73	221.68	12.73	12.73a	4583
7	1.50	0.00	61.54	15.62	253.97	16.23	16.23	4583
8	1.42	0.00	62.90	16.09	259.14	15.51	15.51A	4583
		0.00	62.90	14.13	276.90	1.29	1.29A	7639
9	1.00	0.00	70.46	16.61	307.08	16.61	16.61a	7639
10	0.00	0.00	88.46	22.53	378.93	29.96	29.96	7639
11	-0.08	0.80	89.10	22.74	381.49	34.59	35.39	7639
		0.80	89.10	26.88	348.56	44.38	45.18	3819
12	-1.04	10.40	95.82	29.11	374.08	45.19	55.59	3819
13	-2.00	20.00	102.54	31.35	399.61	48.84	68.84	3819
14	-2.54	25.40	106.32	32.60	413.97	50.96	76.36	3819
15	-3.08	30.80	110.10	33.86	428.33	52.97	83.77	3819
		30.80	110.10	32.19	438.47	49.20	80.00	4583
16	-4.04	40.40	116.82	34.48	464.00	54.22	94.62	4583
17	-5.00	50.00	123.54	36.77	489.54	58.15	108.15	4583
18	-5.54	55.40	127.32	38.06	503.90	59.65	115.05	4583
19	-6.08	60.80	131.10	39.35	518.26	60.78	121.58	4583
		60.80	131.10	32.62	564.63	40.06	100.86	11203
20	-7.04	70.40	139.74	35.46	599.12	55.12	125.52	11203
21	-8.00	80.00	148.38	38.30	633.61	63.68	143.68	11203
22	-8.65	86.50	154.23	40.22	656.96	68.84	155.34	11203
23	-9.30	93.00	160.08	42.15	680.32	73.52	166.52	11203
24	-10.15	101.50	167.73	44.66	710.85	79.15	180.65	11203
25	-11.00	110.00	175.38	47.17	741.39	85.56	195.56	11203
26	-12.00	120.00	184.38	50.13	777.32	104.01	224.01	11203
27	-12.08	120.80	185.10	50.37	780.19	77.02	197.82	11203
		120.80	185.10	48.75	1008.59	71.10	191.90	6111
28	-13.58	135.80	197.10	51.91	1073.97	83.12	218.92	6111
		135.80	197.10	52.48	886.99	91.21	227.01	15277
29	-16.79	167.90	225.99	62.09	1009.43	110.24	278.14	15277
30	-20.00	200.00	254.88	71.70	1131.87	127.45	327.45	15277

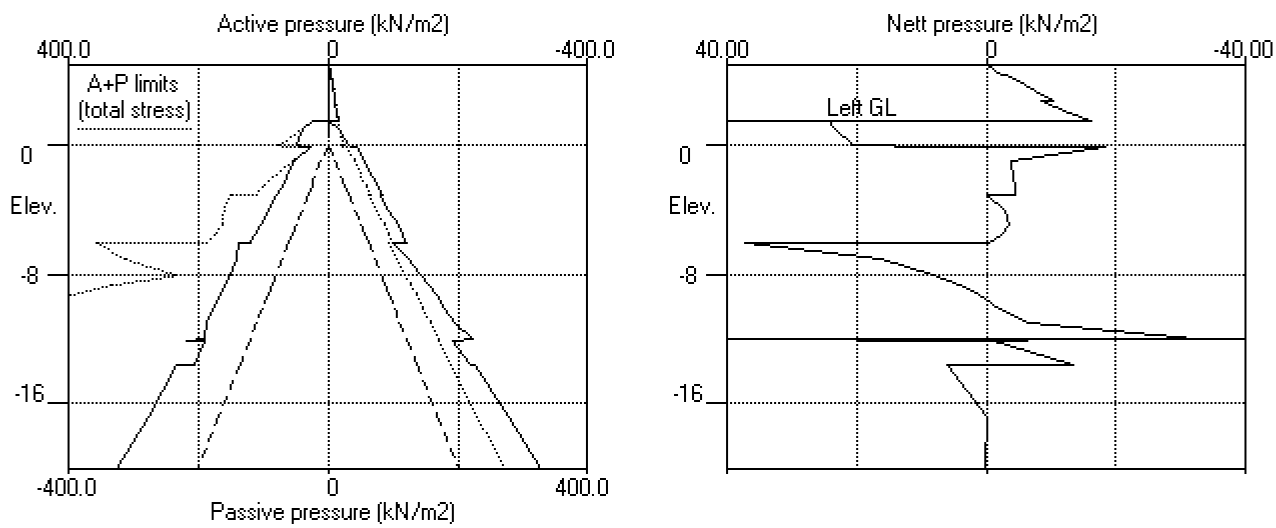
Note: 16.61 a Soil pressure at active limit
26.88 p Soil pressure at passive limit
770.91 b Passive limit reduced because of berm
1.29A Arching - soil pressure below active limit

```
SMEC AUSTRALIA PTY LTD                                           | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58              | Job No. 3001315
                             Licensed from GEOSOLVE              | Made by :    MM
Data filename/Run ID: Dia750mm_SecantPileWall                    |
Byron Lane Slip                                                  | Date:28-09-2021
750diam secant pile wall                                         | Checked :
-------------------------------------------------------------------------------
                                                      Units: kN,m
```

Stage No.1 Excav. to elev. 1.50 on LEFT side



Stage No.1 Excav. to elev. 1.50 on LEFT side



Units: kN,m

Stage No. 3 Apply surcharge no.1 at elevation 4.92

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -12.00		Toe elev. for FoS = 1.300		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
3	4.92	1.50	Cant.	1.561	-10.96	-7.89	9.39	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.026	-1.77E-03	0.0	-0.0	
2	4.32	-2.59	-0.025	-1.77E-03	-0.8	-0.3	
		-3.33	-0.025	-1.77E-03	-0.8	-0.3	
3	3.66	-7.31	-0.024	-1.77E-03	-4.3	-2.0	
4	3.00	-11.15	-0.022	-1.77E-03	-10.4	-6.9	
5	2.72	-12.69	-0.022	-1.77E-03	-13.7	-10.3	
		-11.87	-0.022	-1.77E-03	-13.7	-10.3	
6	2.00	-16.75	-0.021	-1.76E-03	-24.0	-23.9	
7	1.50	-19.99	-0.020	-1.76E-03	-33.2	-38.3	
		0.17	-0.020	-1.76E-03	-33.2	-38.3	
8	1.42	4.83	-0.020	-1.75E-03	-33.0	-40.9	
		7.22	-0.020	-1.75E-03	-33.0	-40.9	
9	1.00	19.00	-0.019	-1.75E-03	-27.5	-54.1	
10	0.00	33.36	-0.017	-1.71E-03	-1.3	-72.2	
11	-0.08	14.85	-0.017	-1.71E-03	0.6	-72.2	
		-22.18	-0.017	-1.71E-03	0.6	-72.2	
12	-1.04	-3.83	-0.015	-1.65E-03	-11.9	-81.9	
13	-2.00	-2.46	-0.014	-1.58E-03	-14.9	-95.0	
14	-2.54	-3.13	-0.013	-1.53E-03	-16.4	-103.4	
15	-3.08	-3.26	-0.012	-1.48E-03	-18.1	-112.7	
		2.67	-0.012	-1.48E-03	-18.1	-112.7	
16	-4.04	-1.50	-0.011	-1.39E-03	-17.6	-128.9	
17	-5.00	-2.38	-0.009	-1.28E-03	-19.4	-146.4	
18	-5.54	-0.81	-0.009	-1.22E-03	-20.3	-157.3	
19	-6.08	1.81	-0.008	-1.16E-03	-20.0	-168.3	
		51.45	-0.008	-1.16E-03	-20.0	-168.3	
20	-7.04	22.42	-0.007	-1.05E-03	15.4	-163.8	

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
21	-8.00	11.16	-0.006	-9.59E-04	31.6	-138.6	
22	-8.65	5.30	-0.005	-9.06E-04	36.9	-115.7	
23	-9.30	0.83	-0.005	-8.63E-04	38.9	-90.6	
24	-10.15	-3.58	-0.004	-8.23E-04	37.7	-57.2	
25	-11.00	-10.68	-0.004	-8.01E-04	31.7	-26.4	
26	-12.00	-48.78	-0.003	-7.93E-04	1.9	-0.0	
27	-12.08	23.47	-0.003	0	0.9	0.0	
		-1.38	-0.003	0	0.9	0.0	
28	-13.58	-15.65	-0.002	0	-11.8	0.0	
		7.10	-0.002	0	-11.8	0.0	
29	-16.79	0.00	-0.001	0	-0.4	0.0	
30	-20.00	0.27	-0.000	0	-0.0	0.0	

LEFT side

			Effective stresses					
Node no.	Y coord	Water press. kN/m2	Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4677
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4677
		0.00	1.36	0.00	25.59b	25.59	25.59p	7795
9	1.00	0.00	8.92	0.00	40.06b	40.06	40.06p	7795
10	0.00	0.00	26.92	2.30	76.03b	62.54	62.54	7795
11	-0.08	0.80	27.56	2.51	57.82b	50.95	51.75	7795
		0.80	27.56	6.41	26.08b	26.08	26.88p	3897
12	-1.04	10.40	34.28	8.65	44.19b	44.19	54.59p	3897
13	-2.00	20.00	41.01	10.88	67.36b	49.31	69.31	3897
14	-2.54	25.40	44.79	12.14	74.83b	50.82	76.22	3897
15	-3.08	30.80	48.58	13.40	81.36b	52.68	83.48	3897
		30.80	48.58	11.20	120.14b	54.13	84.93	4677
16	-4.04	40.40	55.32	13.50	118.35b	55.51	95.91	4677
17	-5.00	50.00	62.06	15.80	113.16b	58.61	108.61	4677
18	-5.54	55.40	65.85	17.10	120.41b	61.42	116.82	4677
19	-6.08	60.80	69.65	18.39	127.14b	64.69	125.49	4677
		60.80	69.65	12.42	297.73b	87.66	148.46	11432
20	-7.04	70.40	78.33	15.27	239.66b	77.56	147.96	11432
21	-8.00	80.00	87.01	18.13	155.16b	76.34	156.34	11432
22	-8.65	86.50	92.90	20.06	249.94b	76.41	162.91	11432
23	-9.30	93.00	98.79	22.00	352.24b	77.21	170.21	11432
24	-10.15	101.50	106.50	24.53	366.72b	79.02	180.52	11432
25	-11.00	110.00	114.22	27.07	398.07b	79.44	189.44	11432
26	-12.00	120.00	123.31	30.06	430.71b	65.90	185.90	11432
27	-12.08	120.80	124.04	30.30	436.57b	100.80	221.60	11432
		120.80	124.04	32.67	519.74b	72.18	192.98	6236
28	-13.58	135.80	136.21	35.87	570.71b	71.00	206.80	6236
		135.80	136.21	32.22	570.15b	100.07	235.87	15589
29	-16.79	167.90	165.55	41.98	672.06b	112.19	280.09	15589
30	-20.00	200.00	195.03	51.79	770.91b	129.55	329.55	15589

(continued)

Stage No.3 Apply surcharge no.1 at elevation 4.92

Node no.	Y coord	Water press. kN/m2	RIGHT side Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30555
2	4.32	0.00	13.26	2.59	108.43	2.59	2.59a	30555
		0.00	13.26	3.33	76.33	3.33	3.33a	5092
3	3.66	0.00	29.13	7.31	167.66	7.31	7.31a	5092
4	3.00	0.00	44.40	11.15	255.54	11.15	11.15a	5092
5	2.72	0.00	50.53	12.69	290.80	12.69	12.69a	5092
		0.00	50.53	11.87	212.13	11.87	11.87a	4583
6	2.00	0.00	64.83	16.75	266.48	16.75	16.75a	4583
7	1.50	0.00	74.32	19.99	302.54	19.99	19.99a	4583
8	1.42	0.00	75.82	20.49	308.22	20.49	20.49a	4583
		0.00	75.82	18.37	328.46	18.37	18.37a	7639
9	1.00	0.00	83.99	21.06	361.08	21.06	21.06a	7639
10	0.00	0.00	102.97	27.30	436.84	29.18	29.18	7639
11	-0.08	0.80	103.66	27.53	439.62	36.11	36.91	7639
		0.80	103.66	31.72	403.88	48.26	49.06	3819
12	-1.04	10.40	110.87	34.12	431.25	48.02	58.42	3819
13	-2.00	20.00	117.80	36.42	457.59	51.77	71.77	3819
14	-2.54	25.40	121.61	37.69	472.06	53.95	79.35	3819
15	-3.08	30.80	125.37	38.94	486.35	55.94	86.74	3819
		30.80	125.37	37.40	496.50	51.46	82.26	4583
16	-4.04	40.40	131.95	39.64	521.49	57.01	97.41	4583
17	-5.00	50.00	138.43	41.85	546.10	60.99	110.99	4583
18	-5.54	55.40	142.03	43.08	559.80	62.23	117.63	4583
19	-6.08	60.80	145.62	44.30	573.42	62.89	123.69	4583
		60.80	145.62	37.39	622.59	36.21	97.01A	11203
20	-7.04	70.40	153.87	40.10	655.54	55.15	125.55	11203
21	-8.00	80.00	162.09	42.81	688.34	65.19	145.19	11203
22	-8.65	86.50	167.64	44.63	710.48	71.11	157.61	11203
23	-9.30	93.00	173.18	46.45	732.59	76.38	169.38	11203
24	-10.15	101.50	180.41	48.83	761.48	82.59	184.09	11203
25	-11.00	110.00	187.64	51.21	790.35	90.12	200.12	11203
26	-12.00	120.00	196.15	54.00	824.31	114.69	234.69	11203
27	-12.08	120.80	196.83	54.23	827.03	77.33	198.13	11203
		120.80	196.83	51.84	1072.52	73.56	194.36	6111
28	-13.58	135.80	208.11	54.80	1133.96	86.65	222.45	6111
		135.80	208.11	56.14	933.64	92.97	228.77	15277
29	-16.79	167.90	235.55	65.27	1049.93	112.19	280.09	15277
30	-20.00	200.00	263.16	74.45	1166.95	129.29	329.29	15277

Note: 21.06 a Soil pressure at active limit
54.59 p Soil pressure at passive limit
770.91 b Passive limit reduced because of berm
97.01A Arching - soil pressure below active limit

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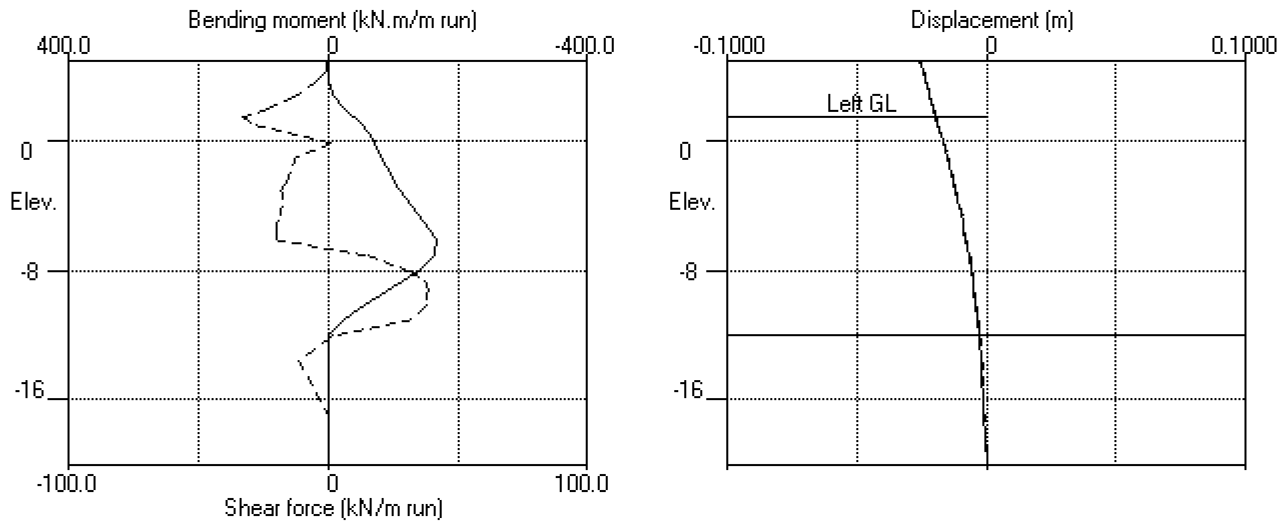
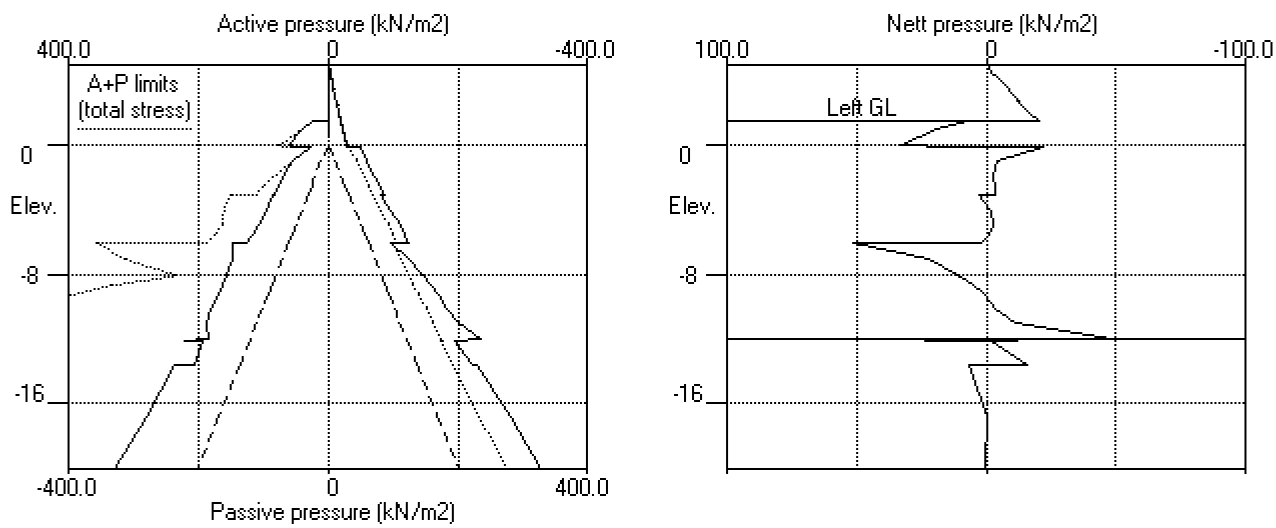
SMEC AUSTRALIA PTY LTD                                            | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58               | Job No. 3001315
                               Licensed from GEOSOLVE             | Made by :    MM
Data filename/Run ID: Dia750mm_SecantPileWall                     |
Byron Lane Slip                                                   | Date:28-09-2021
750diam secant pile wall                                          | Checked :
-------------------------------------------------------------------------------
                                                         Units: kN,m
```

Stage No.3 Apply surcharge no.1 at elev. 4.92



Stage No.3 Apply surcharge no.1 at elev. 4.92



Units: kN,m

Stage No. 4 Apply water pressure profile no.1

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -12.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
4	4.92	1.50	Cant.	1.501	-10.93	-8.74	10.24	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.040	-2.50E-03	0.0	-0.0	
2	4.32	-2.59	-0.038	-2.50E-03	-0.8	-0.3	
		-3.33	-0.038	-2.50E-03	-0.8	-0.3	
3	3.66	-7.31	-0.036	-2.50E-03	-4.3	-2.0	
4	3.00	-11.15	-0.035	-2.50E-03	-10.4	-6.9	
5	2.72	-12.69	-0.034	-2.50E-03	-13.7	-10.3	
		-11.87	-0.034	-2.50E-03	-13.7	-10.3	
6	2.00	-16.75	-0.032	-2.49E-03	-24.0	-23.9	
7	1.50	-19.99	-0.031	-2.49E-03	-33.2	-38.3	
		0.17	-0.031	-2.49E-03	-33.2	-38.3	
8	1.42	4.83	-0.031	-2.48E-03	-33.0	-40.9	
		7.22	-0.031	-2.48E-03	-33.0	-40.9	
9	1.00	19.00	-0.030	-2.48E-03	-27.5	-54.1	
10	0.00	35.18	-0.027	-2.44E-03	-0.4	-73.2	
11	-0.08	17.44	-0.027	-2.44E-03	1.7	-73.1	
		-26.16	-0.027	-2.44E-03	1.7	-73.1	
12	-1.04	-7.12	-0.025	-2.38E-03	-14.3	-83.5	
13	-2.00	-2.88	-0.022	-2.30E-03	-19.1	-100.5	
14	-2.54	-3.64	-0.021	-2.25E-03	-20.8	-111.3	
15	-3.08	-3.78	-0.020	-2.19E-03	-22.8	-123.0	
		3.19	-0.020	-2.19E-03	-22.8	-123.0	
16	-4.04	-1.68	-0.018	-2.07E-03	-22.1	-143.5	
17	-5.00	-2.72	-0.016	-1.94E-03	-24.2	-165.5	
18	-5.54	-0.89	-0.015	-1.86E-03	-25.2	-178.9	
19	-6.08	2.14	-0.014	-1.77E-03	-24.9	-192.7	
		60.51	-0.014	-1.77E-03	-24.9	-192.7	
20	-7.04	26.50	-0.012	-1.62E-03	16.9	-188.6	

(continued)

Stage No.4 Apply water pressure profile no.1

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
21	-8.00	13.30	-0.011	-1.48E-03	36.0	-160.2	
22	-8.65	6.43	-0.010	-1.40E-03	42.4	-134.0	
23	-9.30	1.18	-0.009	-1.34E-03	44.9	-105.0	
24	-10.15	-3.99	-0.008	-1.28E-03	43.7	-66.4	
25	-11.00	-12.28	-0.007	-1.25E-03	36.8	-30.7	
26	-12.00	-56.74	-0.006	-1.24E-03	2.3	-0.0	
27	-12.08	27.81	-0.006	0	1.1	0.0	
		-1.61	-0.006	0	1.1	0.0	
28	-13.58	-18.54	-0.005	0	-14.0	0.0	
		8.45	-0.005	0	-14.0	0.0	
29	-16.79	0.00	-0.003	0	-0.4	0.0	
30	-20.00	0.27	-0.000	0	-0.0	0.0	

LEFT side

			Effective stresses					
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4677
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4677
		0.00	1.36	0.00	25.59b	25.59	25.59p	7795
9	1.00	0.00	8.92	0.00	40.06b	40.06	40.06p	7795
10	0.00	0.00	26.92	2.30	76.03b	69.19	69.19	7795
11	-0.08	0.80	27.56	2.51	57.82b	55.80	56.60	7795
		0.80	27.56	6.41	26.08b	26.08	26.88p	3897
12	-1.04	10.40	34.28	8.65	44.19b	44.19	54.59p	3897
13	-2.00	20.00	41.01	10.88	67.36b	52.14	72.14	3897
14	-2.54	25.40	44.79	12.14	74.83b	53.55	78.95	3897
15	-3.08	30.80	48.58	13.40	81.36b	55.37	86.17	3897
		30.80	48.58	11.20	120.14b	57.36	88.16	4677
16	-4.04	40.40	55.32	13.50	118.35b	58.35	98.75	4677
17	-5.00	50.00	62.06	15.80	113.16b	61.34	111.34	4677
18	-5.54	55.40	65.85	17.10	120.41b	64.27	119.67	4677
19	-6.08	60.80	69.65	18.39	127.14b	67.74	128.54	4677
		60.80	69.65	12.42	297.73b	95.10	155.90	11432
20	-7.04	70.40	78.33	15.27	239.66b	82.48	152.88	11432
21	-8.00	80.00	87.01	18.13	155.16b	80.25	160.25	11432
22	-8.65	86.50	92.90	20.06	249.94b	79.80	166.30	11432
23	-9.30	93.00	98.79	22.00	352.24b	80.19	173.19	11432
24	-10.15	101.50	106.50	24.53	366.72b	81.60	183.10	11432
25	-11.00	110.00	114.22	27.07	398.07b	81.41	191.41	11432
26	-12.00	120.00	123.31	30.06	430.71b	64.81	184.81	11432
27	-12.08	120.80	124.04	30.30	436.57b	105.58	226.38	11432
		120.80	124.04	32.67	519.74b	74.79	195.59	6236
28	-13.58	135.80	136.21	35.87	570.71b	72.39	208.19	6236
		135.80	136.21	32.22	570.15b	103.53	239.33	15589
29	-16.79	167.90	165.55	41.98	672.06b	115.00	282.90	15589
30	-20.00	200.00	195.03	51.79	770.91b	132.67	332.67	15589

(continued)

Stage No.4 Apply water pressure profile no.1

			RIGHT side					
			Effective stresses				Total	Adjusted
Node	Y	Water	Vertic	Active	Passive	Earth	earth	soil
no.	coord	press.	-al	limit	limit	pressure	pressure	modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30555
2	4.32	0.00	13.26	2.59	108.43	2.59	2.59a	30555
		0.00	13.26	3.33	76.33	3.33	3.33a	5092
3	3.66	0.00	29.13	7.31	167.66	7.31	7.31a	5092
4	3.00	0.00	44.40	11.15	255.54	11.15	11.15a	5092
5	2.72	0.00	50.53	12.69	290.80	12.69	12.69a	5092
		0.00	50.53	11.87	212.13	11.87	11.87a	4583
6	2.00	0.00	64.83	16.75	266.48	16.75	16.75a	4583
7	1.50	0.00	74.32	19.99	302.54	19.99	19.99a	4583
8	1.42	0.00	75.82	20.49	308.22	20.49	20.49a	4583
		0.00	75.82	18.37	328.46	18.37	18.37a	7639
9	1.00	0.00	83.99	21.06	361.08	21.06	21.06a	7639
10	0.00	10.00	92.97	24.01	396.92	24.01	34.01a	7639
11	-0.08	10.80	93.66	24.24	399.70	28.36	39.16	7639
		10.80	93.66	28.39	365.89	42.24	53.04	3819
12	-1.04	20.40	100.87	30.79	393.26	41.31	61.71	3819
13	-2.00	30.00	107.80	33.10	419.60	45.02	75.02	3819
14	-2.54	35.40	111.61	34.36	434.08	47.19	82.59	3819
15	-3.08	40.80	115.37	35.61	448.36	49.15	89.95	3819
		40.80	115.37	33.99	458.50	44.17	84.97	4583
16	-4.04	50.40	121.95	36.23	483.50	50.04	100.44	4583
17	-5.00	60.00	128.43	38.44	508.10	54.06	114.06	4583
18	-5.54	65.40	132.03	39.67	521.81	55.17	120.57	4583
19	-6.08	70.80	135.62	40.89	535.43	55.60	126.40	4583
		70.80	135.62	34.10	582.67	24.59	95.39A	11203
20	-7.04	80.40	143.87	36.82	615.62	45.98	126.38	11203
21	-8.00	90.00	152.09	39.52	648.42	56.95	146.95	11203
22	-8.65	96.50	157.64	41.34	670.56	63.36	159.86	11203
23	-9.30	103.00	163.18	43.16	692.67	69.00	172.00	11203
24	-10.15	111.50	170.41	45.54	721.56	75.59	187.09	11203
25	-11.00	120.00	177.64	47.92	750.43	83.69	203.69	11203
26	-12.00	130.00	186.15	50.72	784.39	111.55	241.55	11203
27	-12.08	130.80	186.83	50.94	787.11	67.77	198.57	11203
		130.80	186.83	49.20	1018.03	66.40	197.20	6111
28	-13.58	145.80	198.11	52.17	1079.47	80.93	226.73	6111
		145.80	198.11	52.81	891.26	85.08	230.88	15277
29	-16.79	177.90	225.55	61.94	1007.55	105.00	282.90	15277
30	-20.00	210.00	253.16	71.13	1124.57	122.40	332.40	15277

Note: 34.01 a Soil pressure at active limit
54.59 p Soil pressure at passive limit
770.91 b Passive limit reduced because of berm
95.39A Arching - soil pressure below active limit

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SMEC AUSTRALIA PTY LTD                                            | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58               | Job No. 3001315
                             Licensed from GEOSOLVE               | Made by :    MM
Data filename/Run ID: Dia750mm_SecantPileWall                     |
Byron Lane Slip                                                   | Date:28-09-2021
750diam secant pile wall                                          | Checked :
---------------------------------------------------------------------------------
                                                        Units: kN,m
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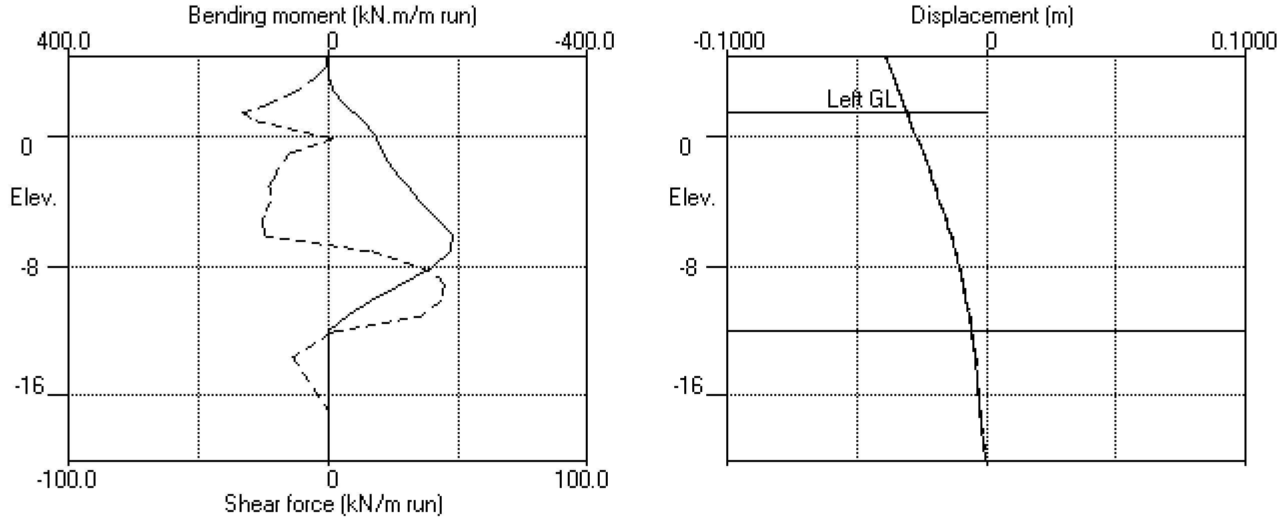
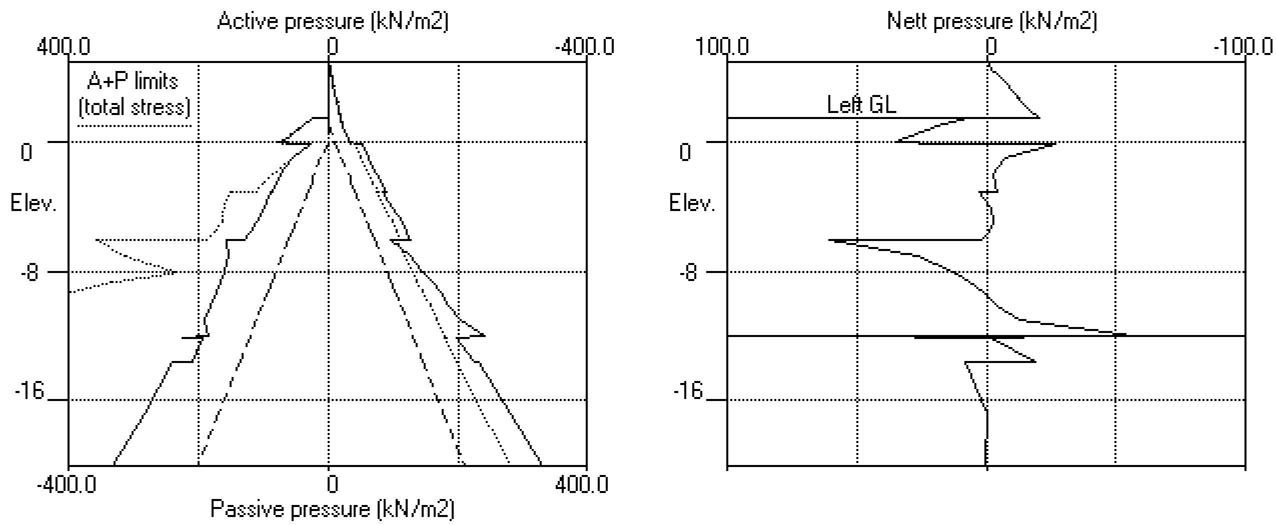
Stage No.4 Apply water pressure profile no.1



Stage No.4 Apply water pressure profile no.1



Units: kN,m

Stage No. 5 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -12.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
5	4.92	1.50	Cant.	1.430	-10.91	-9.91	11.41	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.061	-3.86E-03	0.0	-0.0	
2	4.32	-2.59	-0.059	-3.86E-03	-0.8	-0.3	
		-3.33	-0.059	-3.86E-03	-0.8	-0.3	
3	3.66	-7.31	-0.056	-3.86E-03	-4.3	-2.0	
4	3.00	-11.15	-0.054	-3.86E-03	-10.4	-6.9	
5	2.72	-12.69	-0.053	-3.86E-03	-13.7	-10.3	
		-11.87	-0.053	-3.86E-03	-13.7	-10.3	
6	2.00	-16.75	-0.050	-3.86E-03	-24.0	-23.9	
7	1.50	-23.28	-0.048	-3.85E-03	-34.0	-38.4	
		-3.12	-0.048	-3.85E-03	-34.0	-38.4	
8	1.42	1.01	-0.048	-3.85E-03	-34.1	-41.1	
		3.32	-0.048	-3.85E-03	-34.1	-41.1	
9	1.00	12.28	-0.046	-3.84E-03	-30.8	-55.2	
10	0.00	35.31	-0.042	-3.80E-03	-7.0	-80.9	
11	-0.08	16.87	-0.042	-3.79E-03	-5.0	-81.4	
		-29.61	-0.042	-3.79E-03	-5.0	-81.4	
12	-1.04	-9.50	-0.038	-3.71E-03	-23.7	-99.8	
13	-2.00	-1.21	-0.035	-3.60E-03	-28.9	-127.0	
14	-2.54	-2.24	-0.033	-3.52E-03	-29.8	-142.7	
15	-3.08	-2.51	-0.031	-3.43E-03	-31.1	-159.1	
		5.86	-0.031	-3.43E-03	-31.1	-159.1	
16	-4.04	-0.20	-0.028	-3.24E-03	-28.4	-186.2	
17	-5.00	-1.61	-0.025	-3.02E-03	-29.2	-213.5	
18	-5.54	0.51	-0.023	-2.89E-03	-29.5	-229.5	
19	-6.08	4.14	-0.022	-2.76E-03	-28.3	-245.4	
		73.66	-0.022	-2.76E-03	-28.3	-245.4	
20	-7.04	32.40	-0.019	-2.51E-03	22.6	-238.6	

(continued)

Stage No.5 Apply water pressure profile no.2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
21	-8.00	16.22	-0.017	-2.30E-03	46.0	-201.9	
22	-8.65	7.76	-0.015	-2.17E-03	53.8	-168.5	
23	-9.30	1.26	-0.014	-2.07E-03	56.7	-131.9	
24	-10.15	-5.21	-0.012	-1.98E-03	55.0	-83.3	
25	-11.00	-15.69	-0.011	-1.93E-03	46.1	-38.3	
26	-12.00	-70.92	-0.009	-1.91E-03	2.8	-0.0	
27	-12.08	32.15	-0.009	0	1.3	0.0	
		-1.84	-0.009	0	1.3	0.0	
28	-13.58	-21.43	-0.007	0	-16.2	0.0	
		9.80	-0.007	0	-16.2	0.0	
29	-16.79	0.00	-0.004	0	-0.4	0.0	
30	-20.00	0.27	-0.000	0	-0.0	0.0	

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4677
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4677
		0.00	1.36	0.00	25.59b	25.59	25.59p	7795
9	1.00	0.00	8.92	0.00	40.06b	40.06	40.06p	7795
10	0.00	0.00	26.92	2.30	76.03b	76.03	76.03p	7795
11	-0.08	0.80	27.56	2.51	57.82b	57.82	58.62p	7795
		0.80	27.56	6.41	26.08b	26.08	26.88p	3897
12	-1.04	10.40	34.28	8.65	44.19b	44.19	54.59p	3897
13	-2.00	20.00	41.01	10.88	67.36b	56.20	76.20	3897
14	-2.54	25.40	44.79	12.14	74.83b	57.38	82.78	3897
15	-3.08	30.80	48.58	13.40	81.36b	59.07	89.87	3897
		30.80	48.58	11.20	120.14b	61.79	92.59	4677
16	-4.04	40.40	55.32	13.50	118.35b	62.12	102.52	4677
17	-5.00	50.00	62.06	15.80	113.16b	64.87	114.87	4677
18	-5.54	55.40	65.85	17.10	120.41b	67.92	123.32	4677
19	-6.08	60.80	69.65	18.39	127.14b	71.65	132.45	4677
		60.80	69.65	12.42	297.73b	104.65	165.45	11432
20	-7.04	70.40	78.33	15.27	239.66b	88.36	158.76	11432
21	-8.00	80.00	87.01	18.13	155.16b	84.58	164.58	11432
22	-8.65	86.50	92.90	20.06	249.94b	83.29	169.79	11432
23	-9.30	93.00	98.79	22.00	352.24b	83.03	176.03	11432
24	-10.15	101.50	106.50	24.53	366.72b	83.77	185.27	11432
25	-11.00	110.00	114.22	27.07	398.07b	82.45	192.45	11432
26	-12.00	120.00	123.31	30.06	430.71b	60.64	180.64	11432
27	-12.08	120.80	124.04	30.30	436.57b	110.25	231.05	11432
		120.80	124.04	32.67	519.74b	77.34	198.14	6236
28	-13.58	135.80	136.21	35.87	570.71b	73.76	209.56	6236
		135.80	136.21	32.22	570.15b	106.97	242.77	15589
29	-16.79	167.90	165.55	41.98	672.06b	117.79	285.69	15589
30	-20.00	200.00	195.03	51.79	770.91b	135.77	335.77	15589

(continued)

Stage No.5 Apply water pressure profile no.2

		RIGHT side						
			Effective stresses					
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30555
2	4.32	0.00	13.26	2.59	108.43	2.59	2.59a	30555
		0.00	13.26	3.33	76.33	3.33	3.33a	5092
3	3.66	0.00	29.13	7.31	167.66	7.31	7.31a	5092
4	3.00	0.00	44.40	11.15	255.54	11.15	11.15a	5092
5	2.72	0.00	50.53	12.69	290.80	12.69	12.69a	5092
		0.00	50.53	11.87	212.13	11.87	11.87a	4583
6	2.00	0.00	64.83	16.75	266.48	16.75	16.75a	4583
7	1.50	5.00	69.32	18.28	283.55	18.28	23.28a	4583
8	1.42	5.80	70.02	18.52	286.18	18.52	24.32a	4583
		5.80	70.02	16.47	305.31	16.47	22.27a	7639
9	1.00	10.00	73.99	17.77	321.16	17.77	27.77a	7639
10	0.00	20.00	82.97	20.73	357.00	20.73	40.73a	7639
11	-0.08	20.80	83.66	20.95	359.78	20.95	41.75a	7639
		20.80	83.66	25.07	327.90	35.69	56.49	3819
12	-1.04	30.40	90.87	27.46	355.27	33.69	64.09	3819
13	-2.00	40.00	97.80	29.77	381.61	37.40	77.40	3819
14	-2.54	45.40	101.61	31.04	396.09	39.62	85.02	3819
15	-3.08	50.80	105.37	32.29	410.37	41.57	92.37	3819
		50.80	105.37	30.58	420.51	35.93	86.73	4583
16	-4.04	60.40	111.95	32.82	445.51	42.32	102.72	4583
17	-5.00	70.00	118.43	35.03	470.11	46.48	116.48	4583
18	-5.54	75.40	122.03	36.26	483.81	47.41	122.81	4583
19	-6.08	80.80	125.62	37.48	497.44	47.51	128.31	4583
		80.80	125.62	30.82	542.75	11.00	91.80A	11203
20	-7.04	90.40	133.87	33.53	575.70	35.96	126.36	11203
21	-8.00	100.00	142.09	36.23	608.50	48.36	148.36	11203
22	-8.65	106.50	147.64	38.05	630.64	55.53	162.03	11203
23	-9.30	113.00	153.18	39.88	652.76	61.77	174.77	11203
24	-10.15	121.50	160.41	42.25	681.64	68.98	190.48	11203
25	-11.00	130.00	167.64	44.63	710.51	78.14	208.14	11203
26	-12.00	140.00	176.15	47.43	744.47	111.56	251.56	11203
27	-12.08	140.80	176.83	47.65	747.19	58.10	198.90	11203
		140.80	176.83	46.57	963.54	59.18	199.98	6111
28	-13.58	155.80	188.11	49.54	1024.98	75.19	230.99	6111
		155.80	188.11	49.49	848.88	77.17	232.97	15277
29	-16.79	187.90	215.55	58.61	965.16	97.79	285.69	15277
30	-20.00	220.00	243.16	67.80	1082.18	115.50	335.50	15277

Note: 41.75 a Soil pressure at active limit
54.59 p Soil pressure at passive limit
770.91 b Passive limit reduced because of berm
91.80A Arching - soil pressure below active limit

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SMEC AUSTRALIA PTY LTD                                          | Sheet No.
Program: WALLAP  Version 6.07  Revision A55.B74.R58             | Job No. 3001315
                             Licensed from GEOSOLVE             | Made by :    MM
Data filename/Run ID: Dia750mm_SecantPileWall                   |
Byron Lane Slip                                                 | Date:28-09-2021
750diam secant pile wall                                        | Checked :
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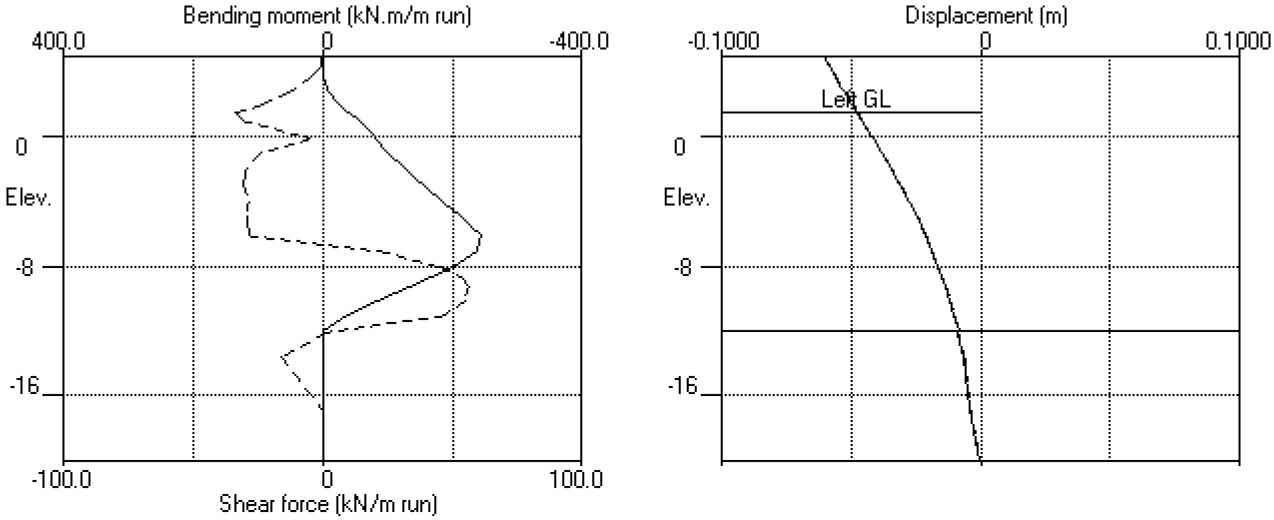
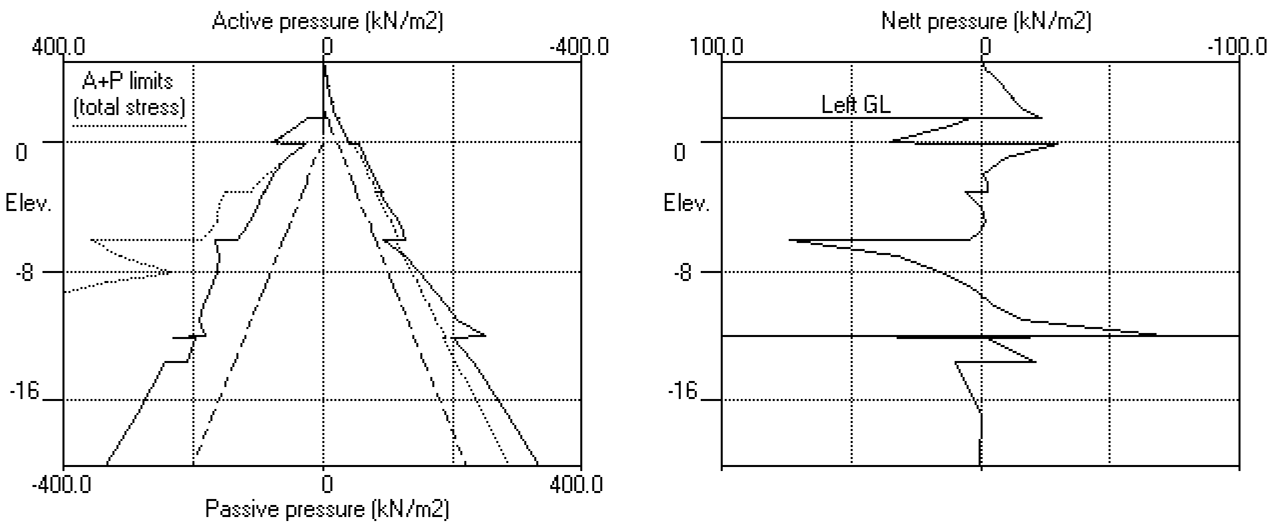
Units: kN,m

Stage No.5 Apply water pressure profile no.2



Stage No.5 Apply water pressure profile no.2



Units: kN,m

Stage No. 6 Apply water pressure profile no.3

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -12.00		Toe elev. for FoS = 1.300		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
6	4.92	1.50	Cant.	1.349	-10.87	-11.25	12.75	R to L

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	4.92	0.00	-0.095	-6.20E-03	0.0	-0.0	
2	4.32	-2.59	-0.091	-6.20E-03	-0.8	-0.3	
		-3.33	-0.091	-6.20E-03	-0.8	-0.3	
3	3.66	-7.31	-0.087	-6.20E-03	-4.3	-2.0	
4	3.00	-11.15	-0.083	-6.20E-03	-10.4	-6.9	
5	2.72	-14.78	-0.081	-6.20E-03	-14.0	-10.3	
		-13.71	-0.081	-6.20E-03	-14.0	-10.3	
6	2.00	-23.34	-0.077	-6.19E-03	-27.4	-25.0	
7	1.50	-29.87	-0.074	-6.19E-03	-40.7	-41.9	
		-9.71	-0.074	-6.19E-03	-40.7	-41.9	
8	1.42	-5.58	-0.073	-6.19E-03	-41.3	-45.2	
		-3.39	-0.073	-6.19E-03	-41.3	-45.2	
9	1.00	5.57	-0.070	-6.17E-03	-40.8	-62.9	
10	0.00	28.59	-0.064	-6.10E-03	-23.7	-102.0	
11	-0.08	10.16	-0.064	-6.09E-03	-22.2	-103.8	
		-32.26	-0.064	-6.09E-03	-22.2	-103.8	
12	-1.04	-10.52	-0.058	-5.96E-03	-42.7	-139.9	
13	-2.00	3.62	-0.052	-5.76E-03	-46.0	-185.8	
14	-2.54	2.05	-0.049	-5.61E-03	-44.5	-210.1	
15	-3.08	1.52	-0.046	-5.45E-03	-43.5	-233.8	
		11.83	-0.046	-5.45E-03	-43.5	-233.8	
16	-4.04	3.85	-0.041	-5.12E-03	-36.0	-270.1	
17	-5.00	1.79	-0.037	-4.75E-03	-33.3	-302.9	
18	-5.54	4.27	-0.034	-4.53E-03	-31.6	-320.6	
19	-6.08	8.78	-0.032	-4.31E-03	-28.1	-337.0	
		87.55	-0.032	-4.31E-03	-28.1	-337.0	
20	-7.04	41.32	-0.028	-3.91E-03	33.7	-323.6	

(continued)

Stage No.6 Apply water pressure profile no.3

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
21	-8.00	20.57	-0.024	-3.55E-03	63.4	-272.2	
22	-8.65	9.62	-0.022	-3.35E-03	73.3	-226.6	
23	-9.30	1.13	-0.020	-3.19E-03	76.7	-176.9	
24	-10.15	-7.45	-0.017	-3.04E-03	74.1	-111.2	
25	-11.00	-21.65	-0.015	-2.96E-03	61.7	-50.9	
26	-12.00	-94.23	-0.012	-2.93E-03	3.8	-0.0	
27	-12.08	36.48	-0.012	0	1.4	0.0	
		-2.07	-0.012	0	1.4	0.0	
28	-13.58	-24.32	-0.010	0	-18.3	0.0	
		11.15	-0.010	0	-18.3	0.0	
29	-16.79	0.00	-0.006	0	-0.4	0.0	
30	-20.00	0.27	-0.001	0	-0.0	0.0	

LEFT side

			Effective stresses					
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Adjusted soil modulus kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	20.16	20.16	20.16p	4677
8	1.42	0.00	1.36	0.00	25.32	25.32	25.32p	4677
		0.00	1.36	0.00	25.59b	25.59	25.59p	7795
9	1.00	0.00	8.92	0.00	40.06b	40.06	40.06p	7795
10	0.00	0.00	26.92	2.30	76.03b	76.03	76.03p	7795
11	-0.08	0.80	27.56	2.51	57.82b	57.82	58.62p	7795
		0.80	27.56	6.41	26.08b	26.08	26.88p	3897
12	-1.04	10.40	34.28	8.65	44.19b	44.19	54.59p	3897
13	-2.00	20.00	41.01	10.88	67.36b	62.10	82.10	3897
14	-2.54	25.40	44.79	12.14	74.83b	62.87	88.27	3897
15	-3.08	30.80	48.58	13.40	81.36b	64.29	95.09	3897
		30.80	48.58	11.20	120.14b	68.07	98.87	4677
16	-4.04	40.40	55.32	13.50	118.35b	67.31	107.71	4677
17	-5.00	50.00	62.06	15.80	113.16b	69.64	119.64	4677
18	-5.54	55.40	65.85	17.10	120.41b	72.83	128.23	4677
19	-6.08	60.80	69.65	18.39	127.14b	76.92	137.72	4677
		60.80	69.65	12.42	297.73b	117.55	178.35	11432
20	-7.04	70.40	78.33	15.27	239.66b	95.83	166.23	11432
21	-8.00	80.00	87.01	18.13	155.16b	89.68	169.68	11432
22	-8.65	86.50	92.90	20.06	249.94b	87.08	173.58	11432
23	-9.30	93.00	98.79	22.00	352.24b	85.77	178.77	11432
24	-10.15	101.50	106.50	24.53	366.72b	85.42	186.92	11432
25	-11.00	110.00	114.22	27.07	398.07b	82.17	192.17	11432
26	-12.00	120.00	123.31	30.06	430.71b	51.96	171.96	11432
27	-12.08	120.80	124.04	30.30	436.57b	114.76	235.56	11432
		120.80	124.04	32.67	519.74b	79.80	200.60	6236
28	-13.58	135.80	136.21	35.87	570.71b	75.12	210.92	6236
		135.80	136.21	32.22	570.15b	110.37	246.17	15589
29	-16.79	167.90	165.55	41.98	672.06b	120.54	288.44	15589
30	-20.00	200.00	195.03	51.79	770.91b	138.87	338.87	15589

(continued)

Stage No.6 Apply water pressure profile no.3

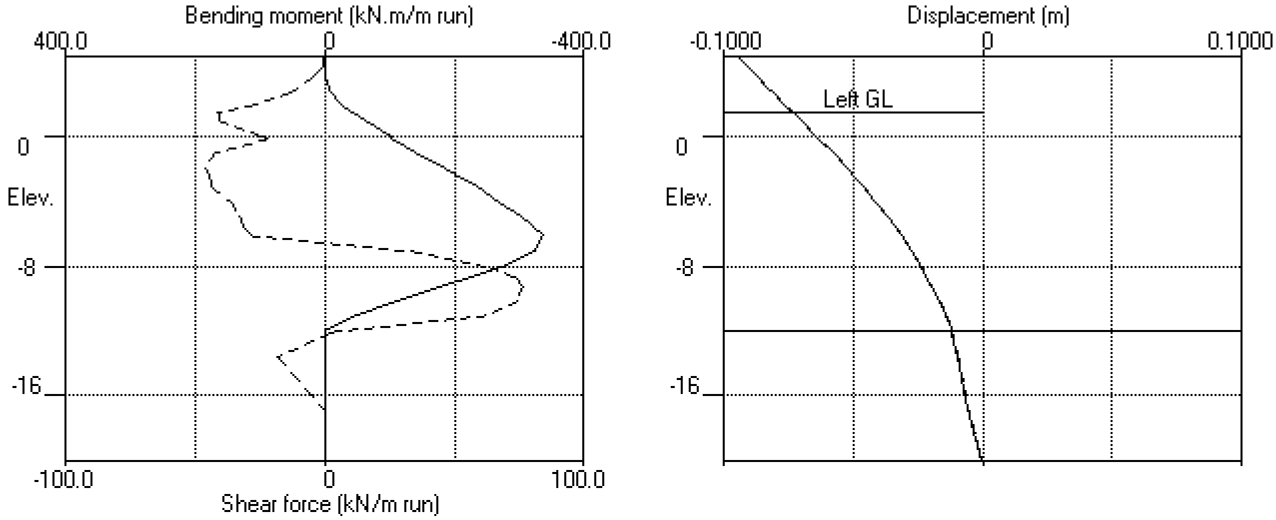
			RIGHT side					
			Effective stresses					
Node no.	Y coord	Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	Total earth pressure	Adjusted soil modulus
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2
1	4.92	0.00	0.00	0.00	0.00	0.00	0.00	30555
2	4.32	0.00	13.26	2.59	108.43	2.59	2.59a	30555
		0.00	13.26	3.33	76.33	3.33	3.33a	5092
3	3.66	0.00	29.13	7.31	167.66	7.31	7.31a	5092
4	3.00	0.00	44.40	11.15	255.54	11.15	11.15a	5092
5	2.72	2.80	47.73	11.98	274.69	11.98	14.78a	5092
		2.80	47.73	10.91	201.49	10.91	13.71a	4583
6	2.00	10.00	54.83	13.34	228.49	13.34	23.34a	4583
7	1.50	15.00	59.32	14.87	245.55	14.87	29.87a	4583
8	1.42	15.80	60.02	15.11	248.19	15.11	30.91a	4583
		15.80	60.02	13.18	265.39	13.18	28.98a	7639
9	1.00	20.00	63.99	14.49	281.24	14.49	34.49a	7639
10	0.00	30.00	72.97	17.44	317.08	17.44	47.44a	7639
11	-0.08	30.80	73.66	17.67	319.86	17.67	48.47a	7639
		30.80	73.66	21.74	289.91	28.34	59.14	3819
12	-1.04	40.40	80.87	24.14	317.28	24.71	65.11	3819
13	-2.00	50.00	87.80	26.44	343.62	28.48	78.48	3819
14	-2.54	55.40	91.61	27.71	358.10	30.81	86.21	3819
15	-3.08	60.80	95.37	28.96	372.38	32.78	93.58	3819
		60.80	95.37	27.16	382.51	26.24	87.04A	4583
16	-4.04	70.40	101.95	29.41	407.51	33.46	103.86	4583
17	-5.00	80.00	108.43	31.62	432.11	37.85	117.85	4583
18	-5.54	85.40	112.03	32.85	445.82	38.56	123.96	4583
19	-6.08	90.80	115.62	34.07	459.44	38.14	128.94	4583
		90.80	115.62	27.53	502.83	0.00	90.80A	11203
20	-7.04	100.40	123.87	30.24	535.78	24.51	124.91A	11203
21	-8.00	110.00	132.09	32.94	568.58	39.11	149.11	11203
22	-8.65	116.50	137.64	34.77	590.72	47.46	163.96	11203
23	-9.30	123.00	143.18	36.59	612.84	54.65	177.65	11203
24	-10.15	131.50	150.41	38.97	641.72	62.87	194.37	11203
25	-11.00	140.00	157.64	41.34	670.59	73.82	213.82	11203
26	-12.00	150.00	166.15	44.14	704.55	116.19	266.19	11203
27	-12.08	150.80	166.83	44.36	707.27	48.28	199.08	11203
		150.80	166.83	43.93	909.05	51.87	202.67	6111
28	-13.58	165.80	178.11	46.90	970.49	69.44	235.24	6111
		165.80	178.11	46.16	806.49	69.22	235.02	15277
29	-16.79	197.90	205.55	55.29	922.78	90.54	288.44	15277
30	-20.00	230.00	233.16	64.47	1039.80	108.60	338.60	15277

Note: 48.47 a Soil pressure at active limit
54.59 p Soil pressure at passive limit
770.91 b Passive limit reduced because of berm
124.91A Arching - soil pressure below active limit

SMEC AUSTRALIA PTY LTD | Sheet No.
Program: WALLAP Version 6.07 Revision A55.B74.R58 | Job No. 3001315
Licensed from GEOSOLVE | Made by : MM
Data filename/Run ID: Dia750mm_SecantPileWall |
Byron Lane Slip | Date:28-09-2021
750diam secant pile wall | Checked :

Units: kN,m

Stage No.6 Apply water pressure profile no.3



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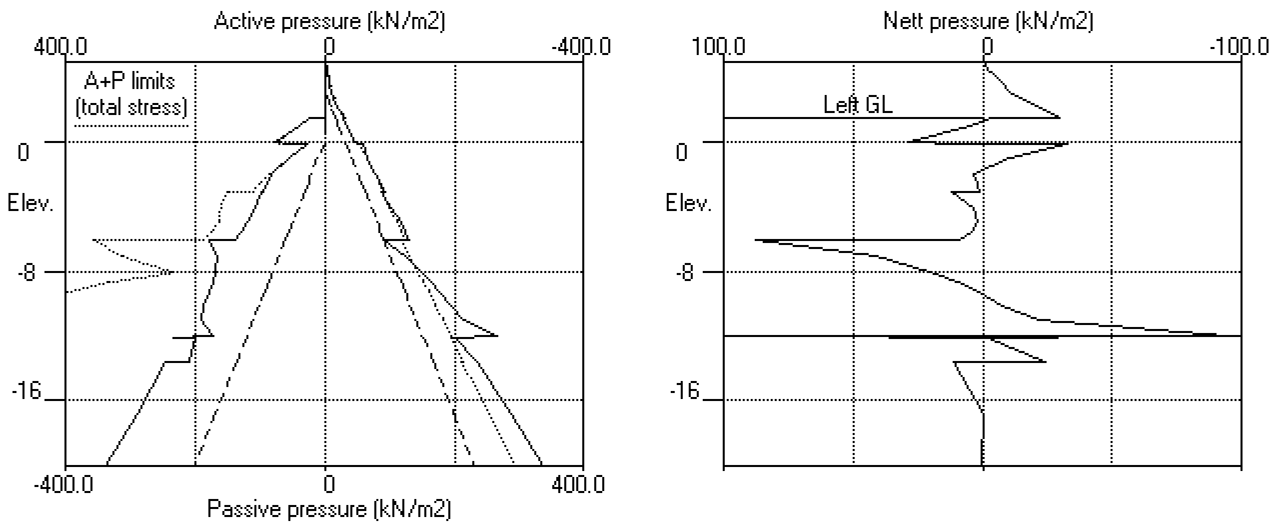

Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

				FoS for toe elev. = -12.00		**Toe elev. for FoS = 1.300**		
Stage No.	Ground level Act.	Pass.	Prop Elev.	Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
1	4.92	1.50	Cant.	1.695	-10.92	-6.11	7.61	R to L
2	1.50	4.92		No analysis at this stage				
3	4.92	1.50	Cant.	1.561	-10.96	-7.89	9.39	R to L
4	4.92	1.50	Cant.	1.501	-10.93	-8.74	10.24	R to L
5	4.92	1.50	Cant.	1.430	-10.91	-9.91	11.41	R to L
6	4.92	1.50	Cant.	1.349	-10.87	-11.25	12.75	R to L

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 40.00m
2-D finite element model. Active limit arching modelled.
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No
All soil moduli were factored to take account of
3-D effects due to the finite length of wall:
Modulus factors - Left side = 1.04
Right side = 1.02

Rigid boundaries: Left side 50.00 from wall Rough boundary
Right side 30.00 from wall Rough boundary
Lower rigid boundary at elevation -20.00 Rough boundary

Bending moment, shear force and displacement envelopes

Node	Y	Displacement		Bending moment		Shear force	
no.	coord	maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	4.92	0.000	-0.095	0.0	-0.0	0.0	0.0
2	4.32	0.000	-0.091	0.0	-0.3	0.0	-0.8
3	3.66	0.000	-0.087	0.0	-2.0	0.0	-4.3
4	3.00	0.000	-0.083	0.0	-6.9	0.0	-10.4
5	2.72	0.000	-0.081	0.0	-10.3	0.0	-14.0
6	2.00	0.000	-0.077	0.0	-25.0	0.0	-27.4
7	1.50	0.000	-0.074	0.0	-41.9	0.0	-40.7
8	1.42	0.000	-0.073	0.0	-45.2	0.0	-41.3
9	1.00	0.000	-0.070	0.0	-62.9	0.0	-40.8
10	0.00	0.000	-0.064	0.0	-102.0	6.3	-23.7
11	-0.08	0.000	-0.064	0.0	-103.8	7.5	-22.2
12	-1.04	0.000	-0.058	0.0	-139.9	0.0	-42.7
13	-2.00	0.000	-0.052	0.0	-185.8	0.0	-46.0
14	-2.54	0.000	-0.049	0.0	-210.1	0.0	-44.5
15	-3.08	0.000	-0.046	0.0	-233.8	0.0	-43.5
16	-4.04	0.000	-0.041	0.0	-270.1	0.0	-36.0
17	-5.00	0.000	-0.037	0.0	-302.9	0.0	-33.3
18	-5.54	0.000	-0.034	0.0	-320.6	0.0	-31.6
19	-6.08	0.000	-0.032	0.0	-337.0	0.0	-28.3
20	-7.04	0.000	-0.028	0.0	-323.6	33.7	0.0
21	-8.00	0.000	-0.024	0.0	-272.2	63.4	0.0
22	-8.65	0.000	-0.022	0.0	-226.6	73.3	0.0
23	-9.30	0.000	-0.020	0.0	-176.9	76.7	0.0
24	-10.15	0.000	-0.017	0.0	-111.2	74.1	0.0
25	-11.00	0.000	-0.015	0.0	-50.9	61.7	0.0
26	-12.00	0.000	-0.012	0.0	-0.0	3.8	0.0
27	-12.08	0.000	-0.012	0.0	0.0	1.4	0.0
28	-13.58	0.000	-0.010	0.0	0.0	0.0	-18.3
29	-16.79	0.000	-0.006	0.0	0.0	0.0	-0.4
30	-20.00	0.000	-0.001	0.0	0.0	0.0	-0.0

Summary of results (continued)

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	elev.	Bending moment minimum kN.m/m	elev.	Shear force maximum kN/m	elev.	Shear force minimum kN/m	elev.
1	0.0	4.92	-104.3	-7.04	24.9	-9.30	-26.2	1.50
2	No calculation at this stage							
3	0.0	4.92	-168.3	-6.08	38.9	-9.30	-33.2	1.50
4	0.0	4.92	-192.7	-6.08	44.9	-9.30	-33.2	1.50
5	0.0	4.92	-245.4	-6.08	56.7	-9.30	-34.1	1.42
6	0.0	4.92	-337.0	-6.08	76.7	-9.30	-46.0	-2.00

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.000	4.92	-0.061	4.92	Excav. to elev. 1.50 on LEFT side
2	Wall displacements reset to zero				Change EI of wall to 543604kN.m2/m run
3	0.000	4.92	-0.026	4.92	Apply surcharge no.1 at elev. 4.92
4	0.000	4.92	-0.040	4.92	Apply water pressure profile no.1
5	0.000	4.92	-0.061	4.92	Apply water pressure profile no.2
6	0.000	4.92	-0.095	4.92	Apply water pressure profile no.3

```
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                             Licensed from GEOSOLVE                | Made by :    MM
Data filename/Run ID: Dia750mm_SecantPileWall                      |
Byron Lane Slip                                                    | Date:28-09-2021
750diam secant pile wall                                           | Checked :
-----------------------------------------------------------------------------
                                                       Units: kN,m
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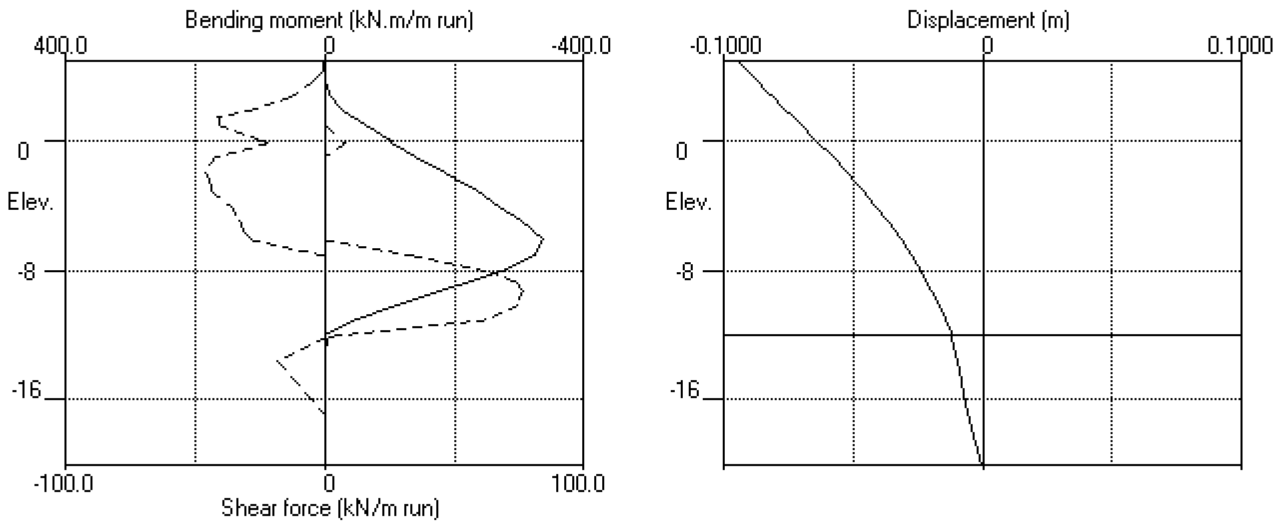
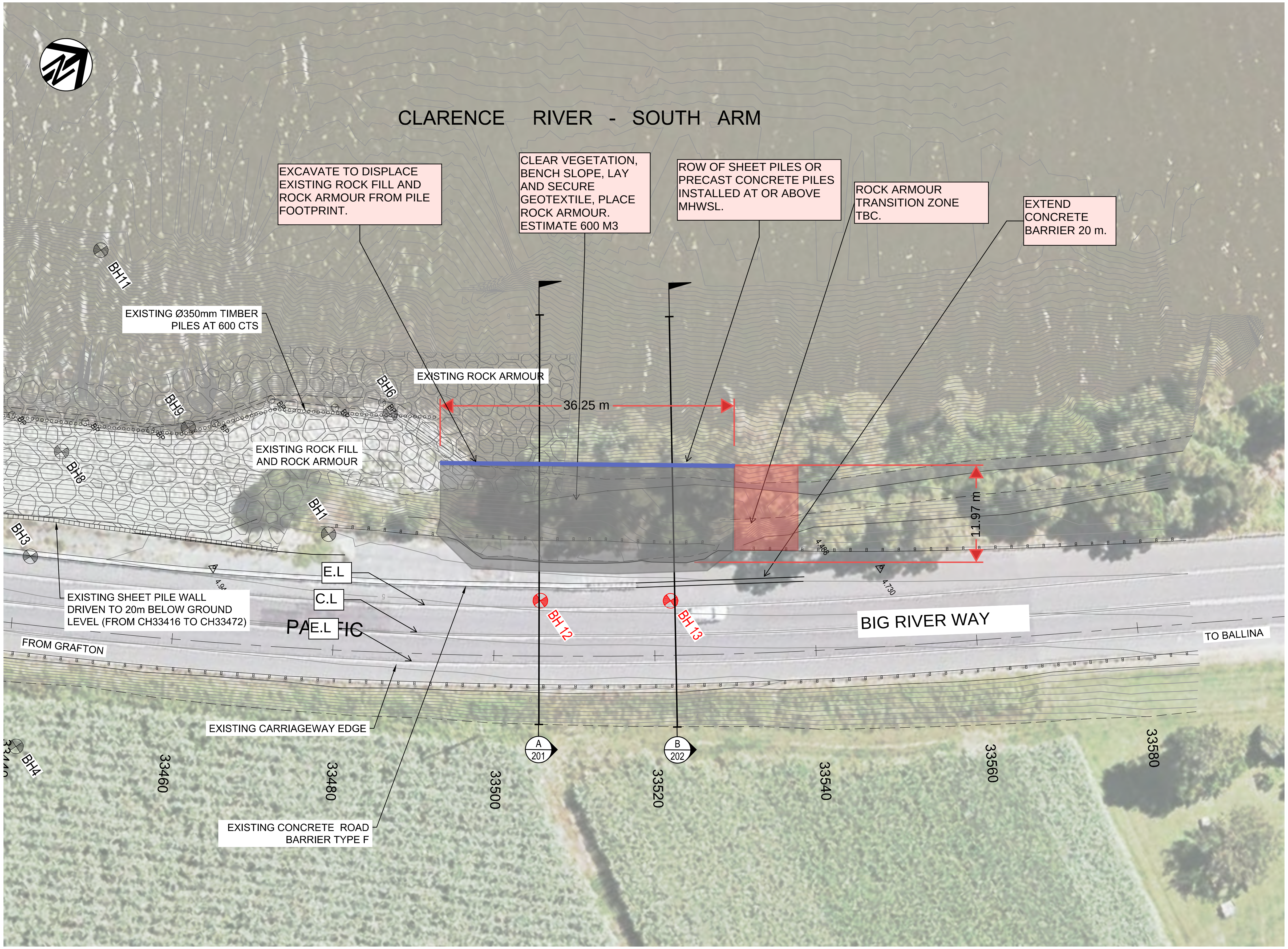
Bending moment, shear force, displacement envelopes



Appendix F Concept Design Option 3 – Sketches



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- BH 12 TfNSW BORE HOLE (2021)
- BH8 TfNSW BORE HOLE (2009)

ANTICIPATED CONSTRUCTION SEQUENCE:

1. Set out piles in river.
2. Mobilise a barge with a large excavator to excavate and displace existing rock fill and rock armour from the proposed pile footprint and obstructions to barge.
3. Mobilise a barge with pile driving rig to install the row of sheet piles or precast concrete piles.
4. Clear vegetation from riverbank.
5. Lay and secure heavy duty geotextile.
6. Place rock fill and rock armour to slope.
7. Extend concrete safety barrier.

CONCEPT SKETCHES OPTION 3 - SHEAR PILES AND ROCK FILL

NOT FOR CONSTRUCTION

THIS DRAWING MAY BE PREPARED IN COLOUR AND MAY BE INCOMPLETE IF COPIED

50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME
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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

PLOT DATE / TIME: 13 September 2021 03:15:40 PM
PLOT BY: TC13654

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
X_RMS_NSW_CIVIL_A3 X_AERIAL X_SURVEY X_2014_BYRON_DES_CTRL X_2014_DESIGN_30011433 X_LEGEND_GA	0	0	CONCEPT DESIGN	0	0

REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING
SCALE 1:500 2.5 0 2.5 5.0 7.5 10 12.5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY
SMEC
Member of the Surbana Jurong Group
© ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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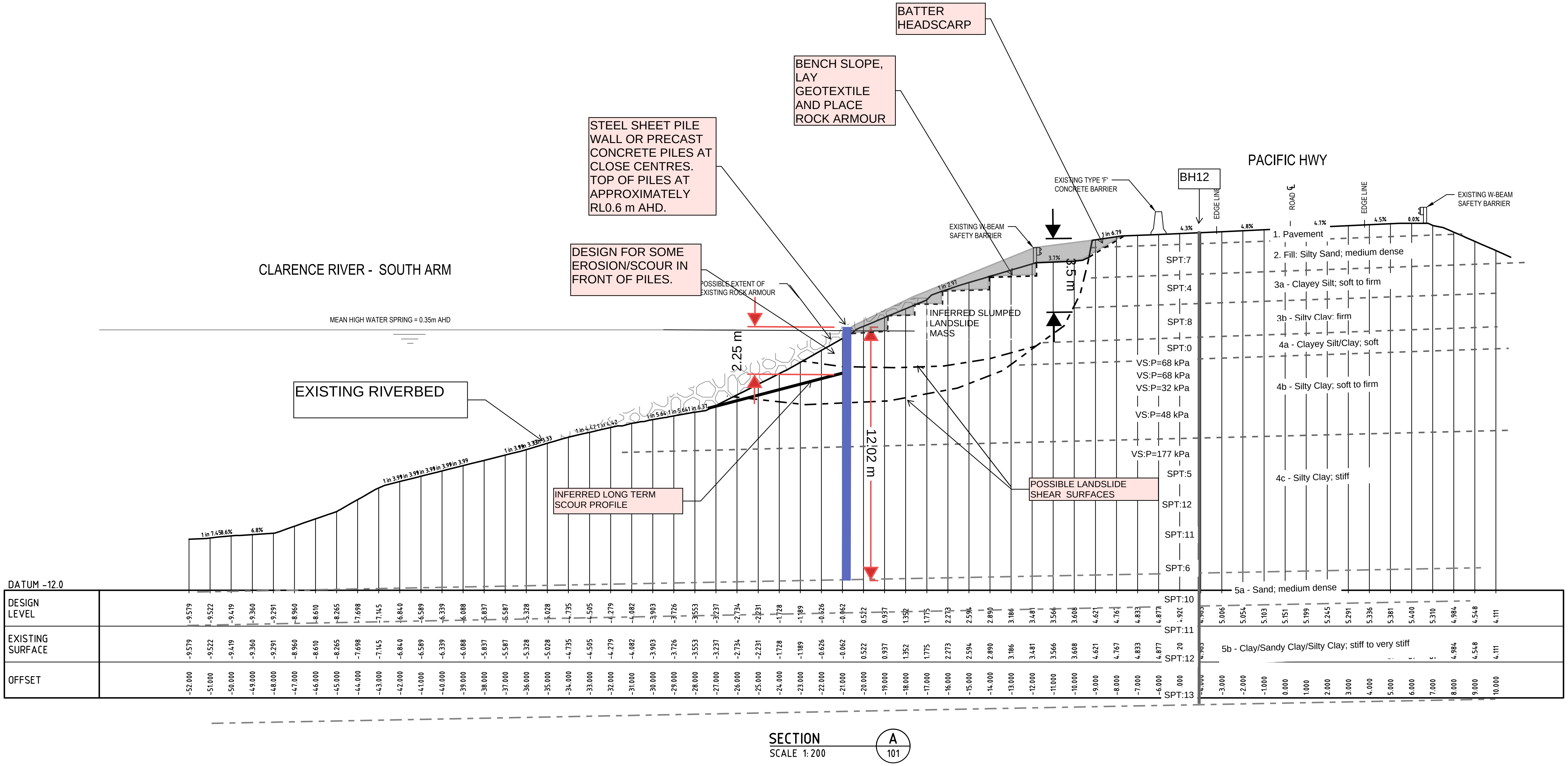
CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION
GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No. DS2021 / 00????
SHEET No. GT-101
ISSUE #



CONCEPT SKETCHES OPTION 3 - SHEAR PILES AND ROCK FILL

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REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 — 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY
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Member of the Surbana Jurong Group
ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

CROSS SECTION - SHEET 1

SHEET 5 OF 6

A3

RMS REGISTRATION No. DS2021 / 00????

PART 1

ISSUE STATUS: CONCEPT DESIGN
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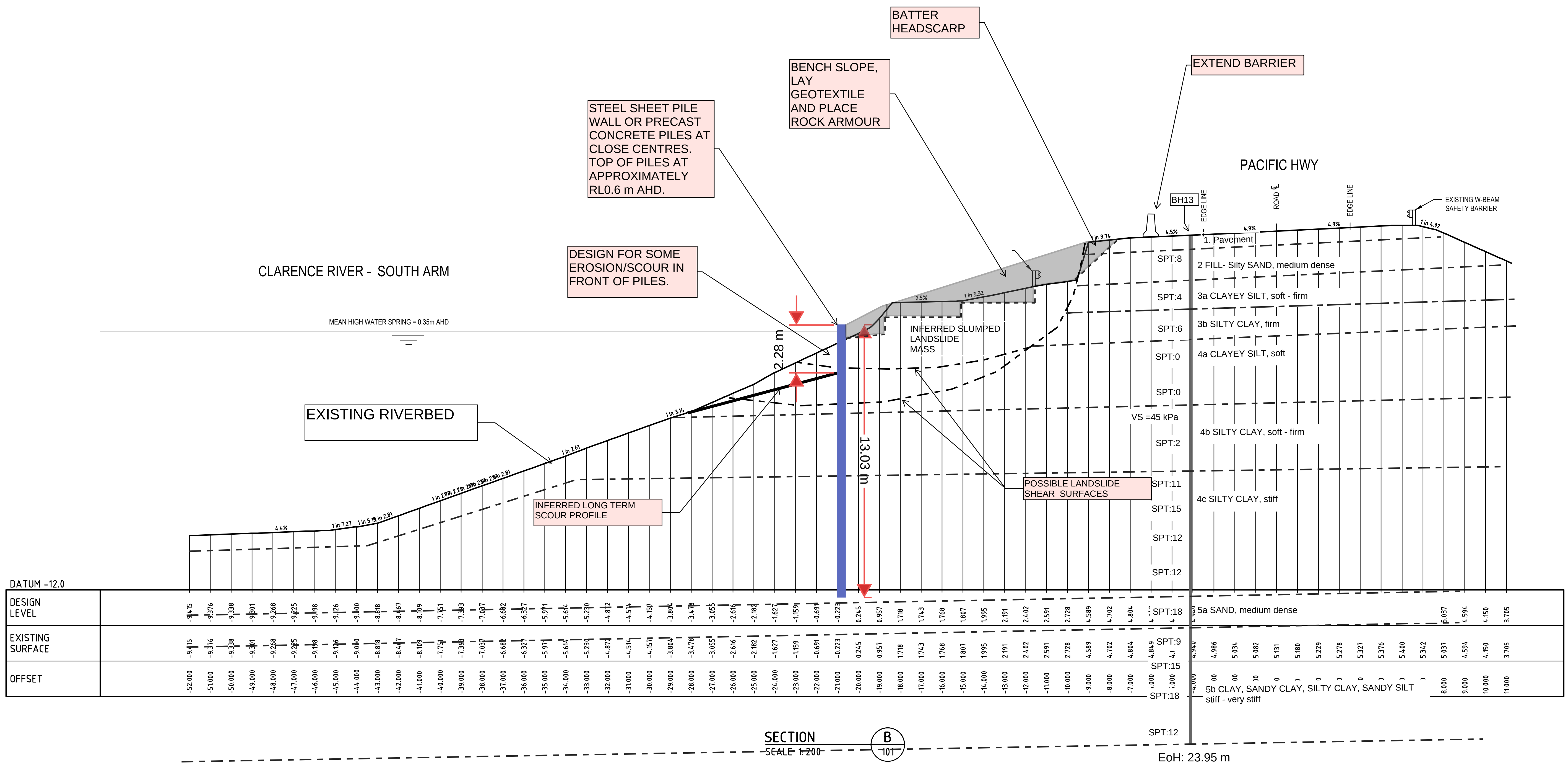

CONCEPT SKETCHES OPTION 3 - SHEAR PILES AND ROCK FILL

NOT FOR CONSTRUCTION

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50mm ON A3 SIZE ORIGINAL

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PLOT DATE / TIME	13 September 2021 02:59:17 PM
PLOT BY	TC13654
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DRG CHECK	
DESIGN	M.MAHARAJ
DESIGN CHECK	
DESIGN MNGR	
PROJECT MNGR	

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BYRONS LANE SLIP REMEDIATION

CROSS SECTION - SHEET 2

A3

SHEET 6 OF 6

RMS REGISTRATION No. DS2021 / 00????

PART 1

ISSUE STATUS: CONCEPT DESIGN

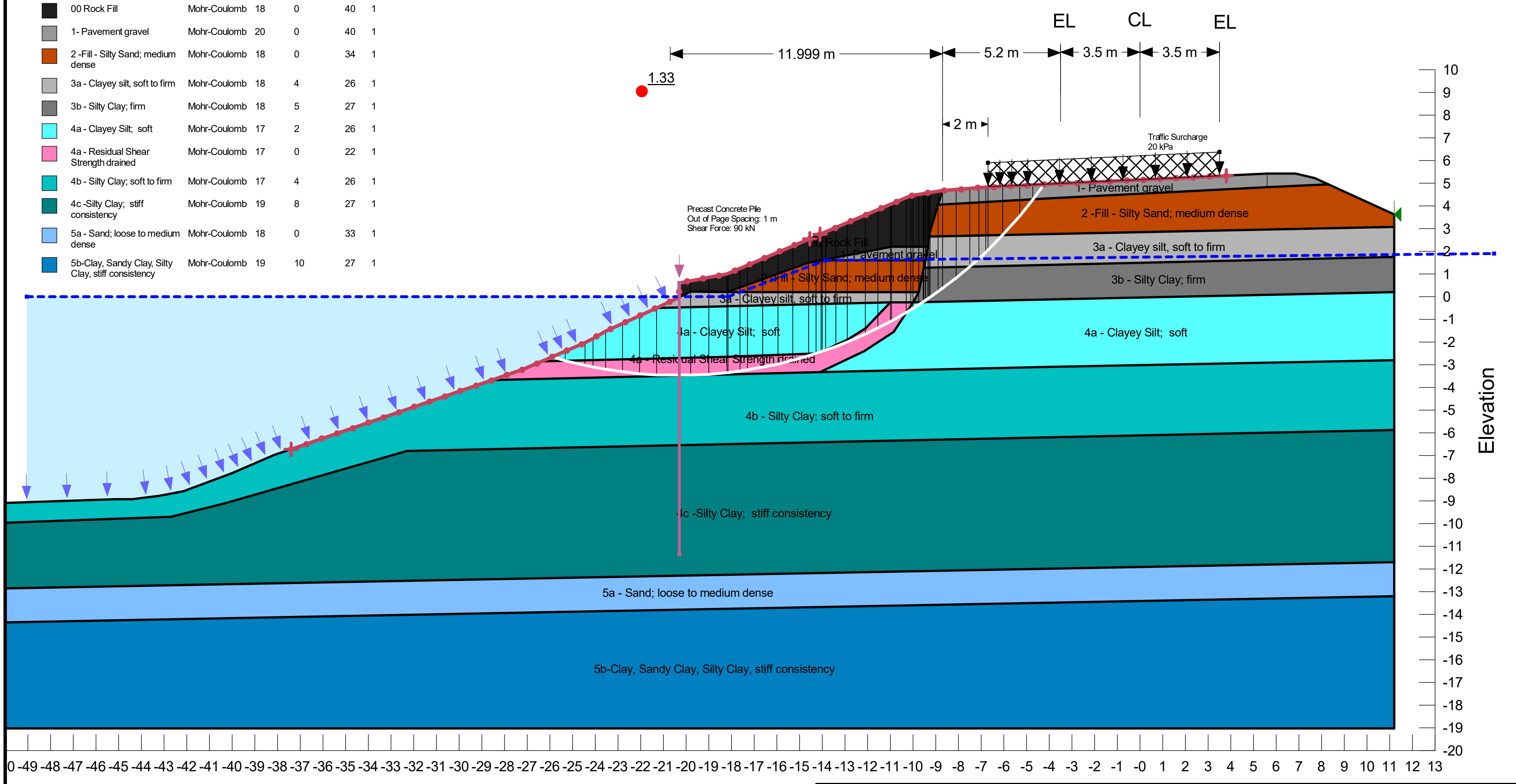
EDMS No. DS2021 / 00????

SHEET No. GT-202

ISSUE #

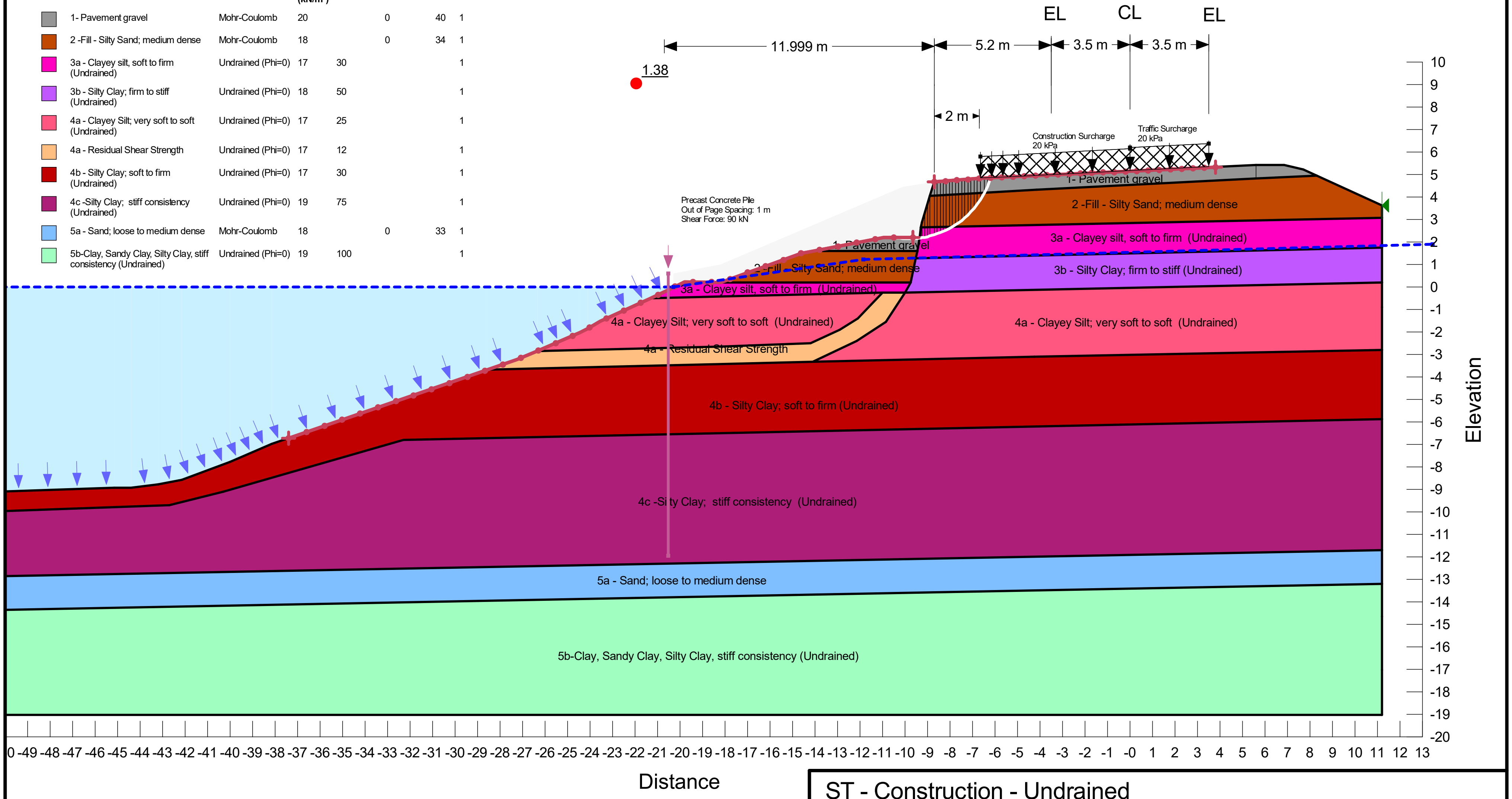
Appendix G Concept Design Option 3 – Analyses

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18	0	40	1
	1- Pavement gravel	Mohr-Coulomb	20	0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18	0	34	1
	3a - Clayey silt, soft to firm	Mohr-Coulomb	18	4	26	1
	3b - Silty Clay; firm	Mohr-Coulomb	18	5	27	1
	4a - Clayey Silt; soft	Mohr-Coulomb	17	2	26	1
	4a - Residual Shear Strength drained	Mohr-Coulomb	17	0	22	1
	4b - Silty Clay; soft to firm	Mohr-Coulomb	17	4	26	1
	4c -Silty Clay; stiff consistency	Mohr-Coulomb	19	8	27	1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18	0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency	Mohr-Coulomb	19	10	27	1



LT - Pile Installed LGWL - Drained	
Option 3 Shear Piles and Rock Fill.gsz	
30/09/2021	1:250

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Undrained (Phi=0)	17	12			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1

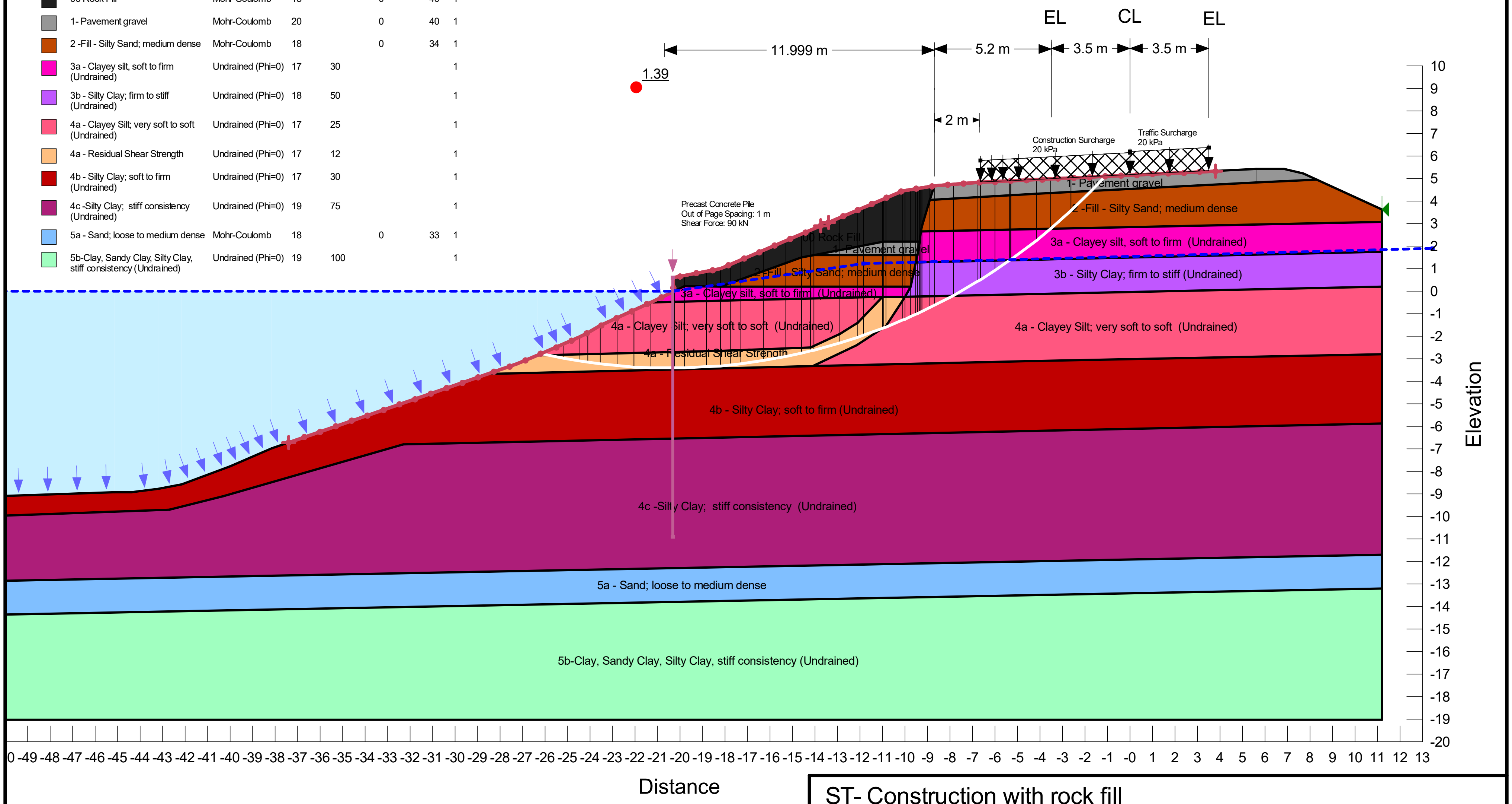


ST - Construction - Undrained

Option 3 Shear Piles and Rock Fill.gsz

30/09/2021 1:250

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Undrained (Phi=0)	17	12			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1

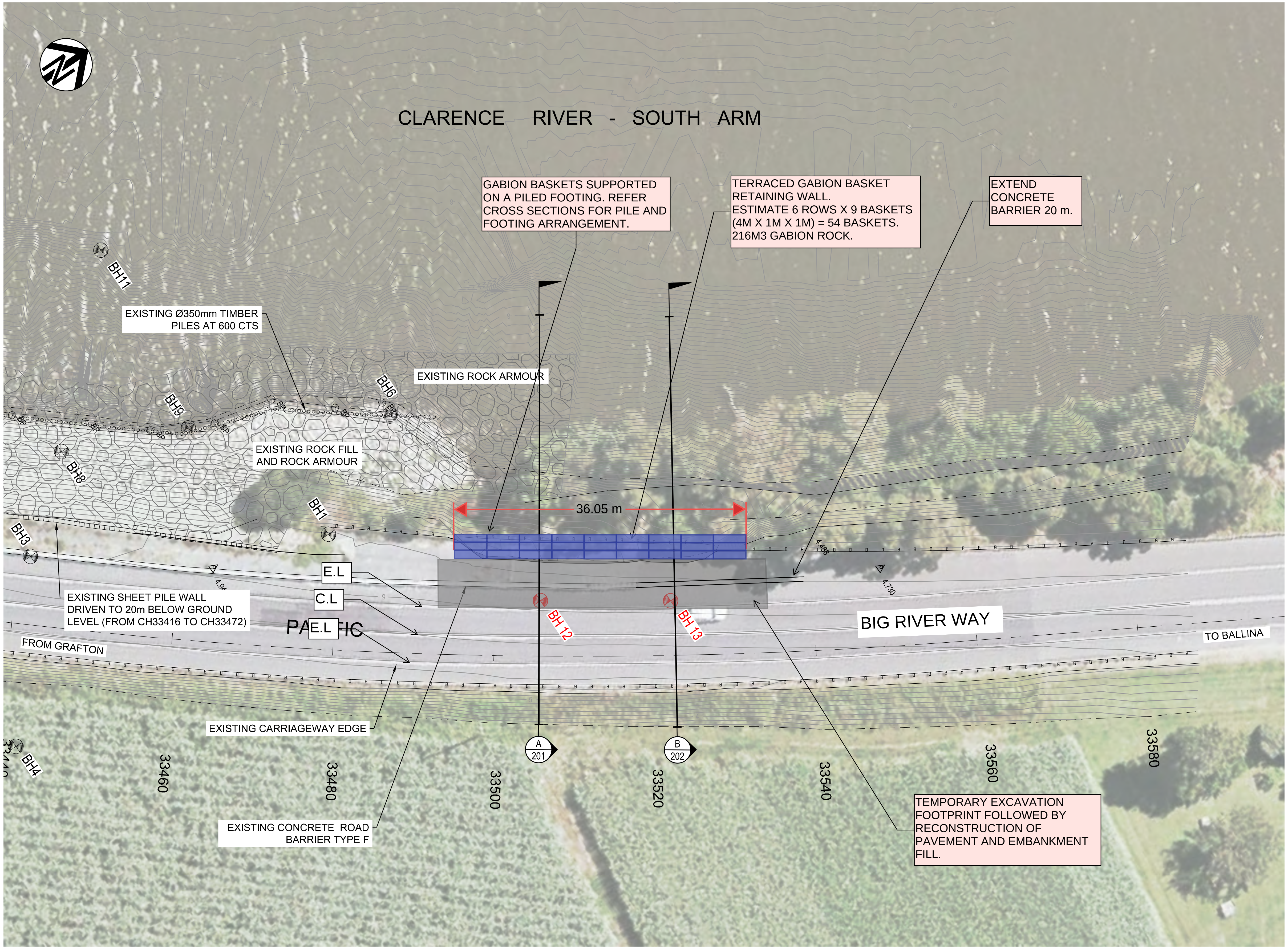


ST- Construction with rock fill

Option 3 Shear Piles and Rock Fill.gsz

30/09/2021 1:250

Appendix H Concept Design Option 4 – Sketches



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- BH 12 TfNSW BORE HOLE (2021)
- BH8 TfNSW BORE HOLE (2009)

CONCEPT SKETCHES OPTION 4 - GABION WALL ON PILED FOOTING

NOT FOR CONSTRUCTION

THIS DRAWING MAY BE PREPARED IN COLOUR AND MAY BE INCOMPLETE IF COPIED

50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME V:_Vault\Projects\3001\30013154\110_CADD\CAD\DWG\CI_Civil\30013154-CD-GT-101.dwg			DESIGN LOT CODE	DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
X_RMS_NSW_CIVIL_A3 X_AERIAL X_SURVEY X_2014_BYRON_DES_CTRL X_2014_DESIGN_30011433 X_LEGEND_GA	0	0	CONCEPT DESIGN	0	0

REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:500 (2.5 0 2.5 5.0 7.5 10 12.5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC
Member of the Surbana Jurong Group
© ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

PLOT DATE / TIME: 13 September 2021 03:15:40 PM PLOT BY: TC13654

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT	PRELIM. INITIAL	FINAL DATE
DISCIPLINE		
DISCIPLINE		
DISCIPLINE		
BACKDRAFTED/CORRECTED		
CONFIRMED		

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

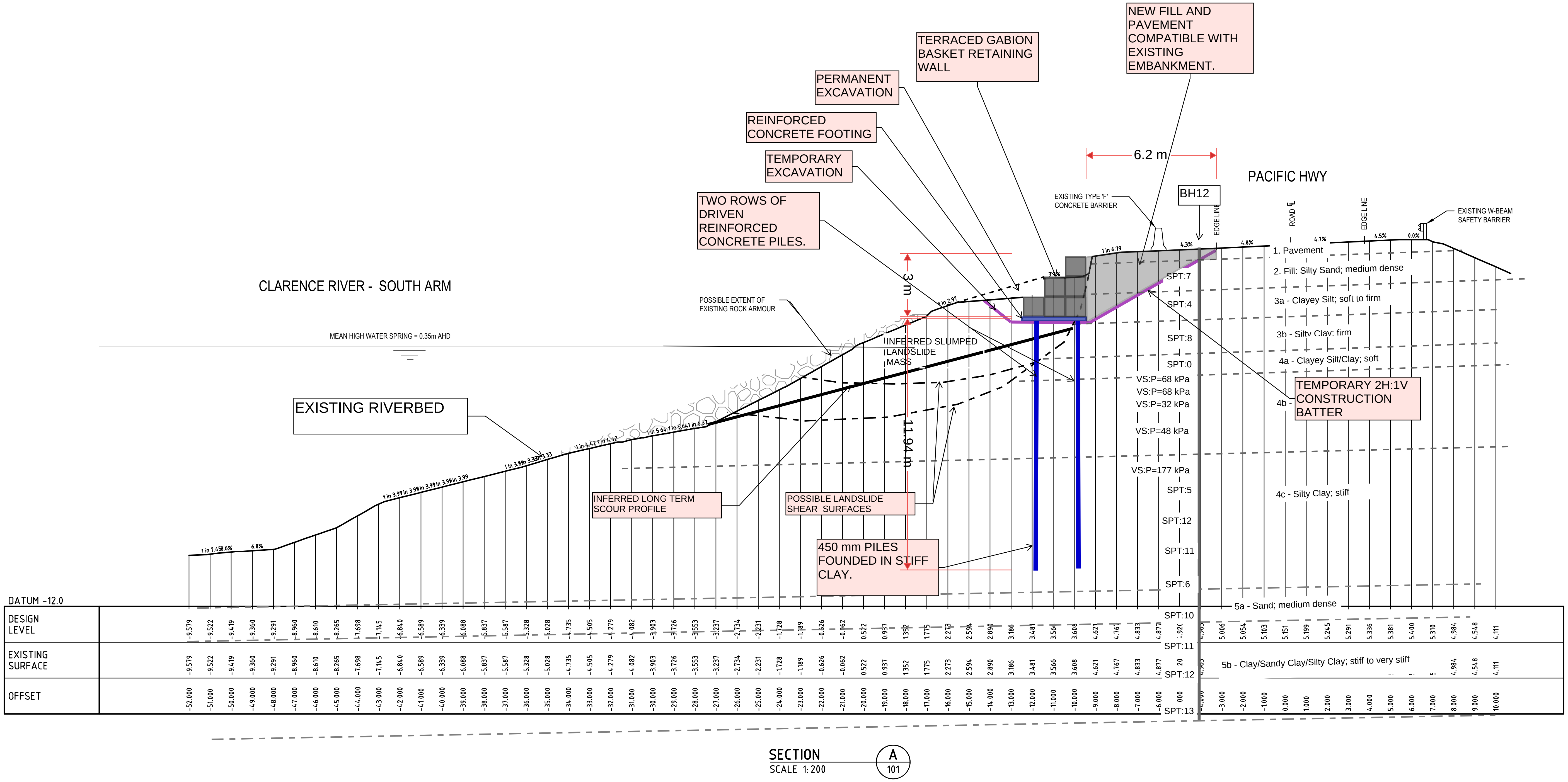
GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 6

RMS REGISTRATION No. DS2021 / 00???? PART 1

ISSUE STATUS: CONCEPT DESIGN | EDMS No. DS2021 / 00???? | SHEET No. GT-101 | ISSUE #



CONCEPT SKETCHES OPTION 4 - GABION WALL ON PILED FOOTING

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50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME
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DESIGN LOT CODE

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EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
X_RMS_NSW_CIVIL_A3 X_XSECTIONS	0	0	CONCEPT DESIGN	0	0

REVISION IN PROGRESS

SCALES ON A3 SIZE DRAWING: SCALE 1:200 (1 0 1 2 3 4 5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY
SMEC
Member of the Surbana Jurong Group
ABN 47 065 475 149
52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

DISCIPLINE
DISCIPLINE
DISCIPLINE
BACKDRAFTED/CORRECTED
CONFIRMED

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

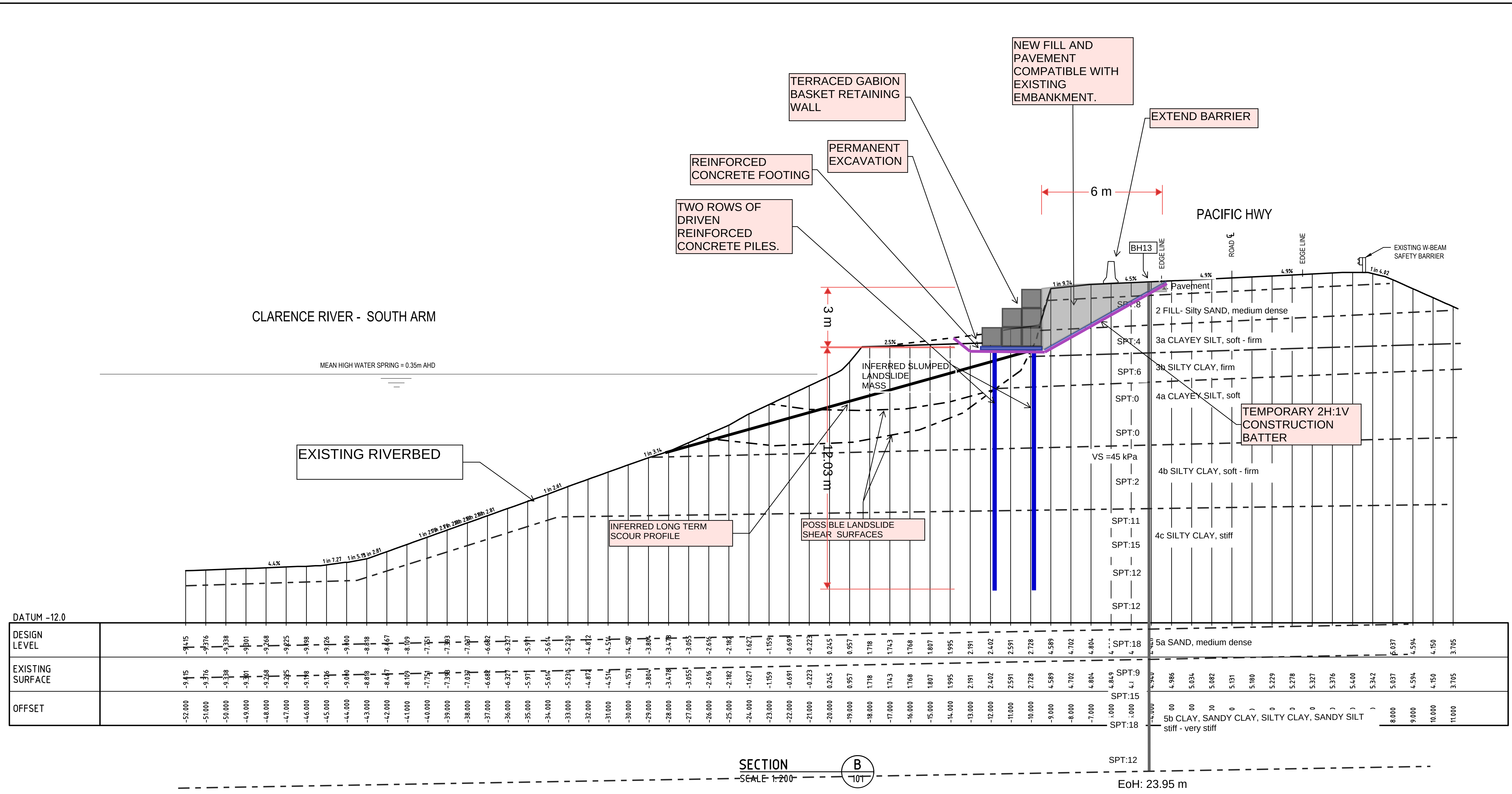
CROSS SECTION - SHEET 1

A3

SHEET 5 OF 6

RMS REGISTRATION No. DS2021 / 00????
PART 1

ISSUE STATUS: CONCEPT DESIGN
EDMS No. DS2021 / 00????
SHEET No. GT-201
ISSUE #



CONCEPT SKETCHES OPTION 4 - GABION WALL ON PILED FOOTING

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50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME: V:_Vault\Projects\3001\30013154\110_CADD\CAD\DWG\CI_Civil\30013154-CD-GT-202.dwg				DESIGN LOT CODE		DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING	
EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL	SCALES ON A3 SIZE DRAWING	DRAWINGS / DESIGN PREPARED BY
X_RMS_NSW_CIVIL_A3 X_XSECTIONS	0	0	CONCEPT DESIGN REVISION IN PROGRESS	0	0	SCALE 1:200	SMEC Member of the Surbana Jurong Group ABN 47 065 475 149 52 VICTORIA STREET GRAFTON NSW 2460 SMEC PROJECT No 30013154
						CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) HEIGHT DATUM: AHD	

PLOT DATE / TIME: 13 September 2021 02:59:17 PM	PLOT BY: TC13654	
TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT — PRELIM / FINAL — INITIAL / DATE

DISCIPLINE

DISCIPLINE

DISCIPLINE

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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

CROSS SECTION - SHEET 2

A3

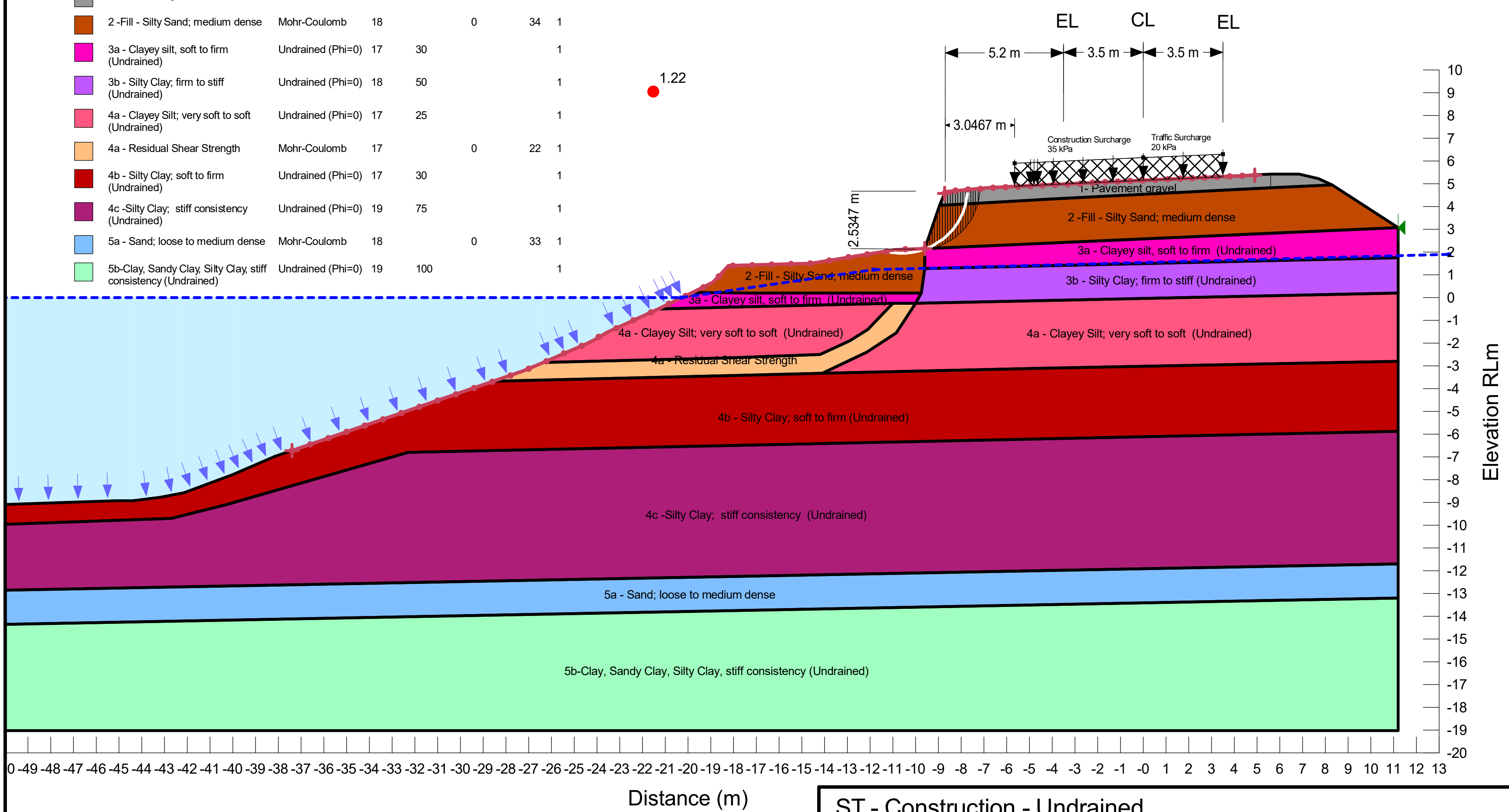
SHEET 6 OF 6

RMS REGISTRATION No. DS2021 / 00????

PART 1

ISSUE STATUS: CONCEPT DESIGN | EDMS No.: DS2021 / 00???? | SHEET No.: GT-202 | ISSUE: #

Appendix I Concept Design Option 4 – Analyses



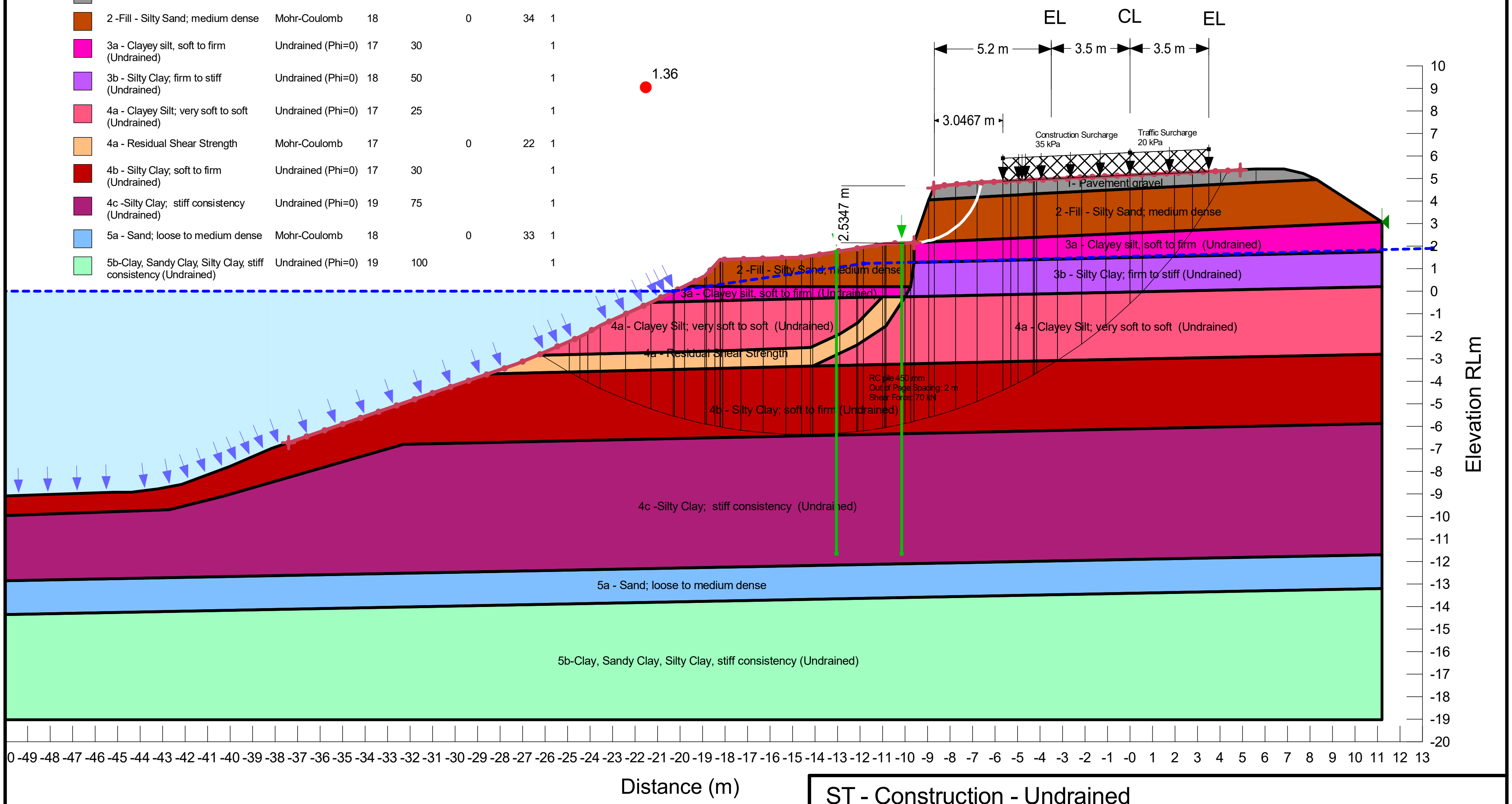
Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Mohr-Coulomb	17		0	22	1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1

ST - Construction - Undrained

Option 4 Gabion Wall undrained.gsz

11/10/2021 1:250

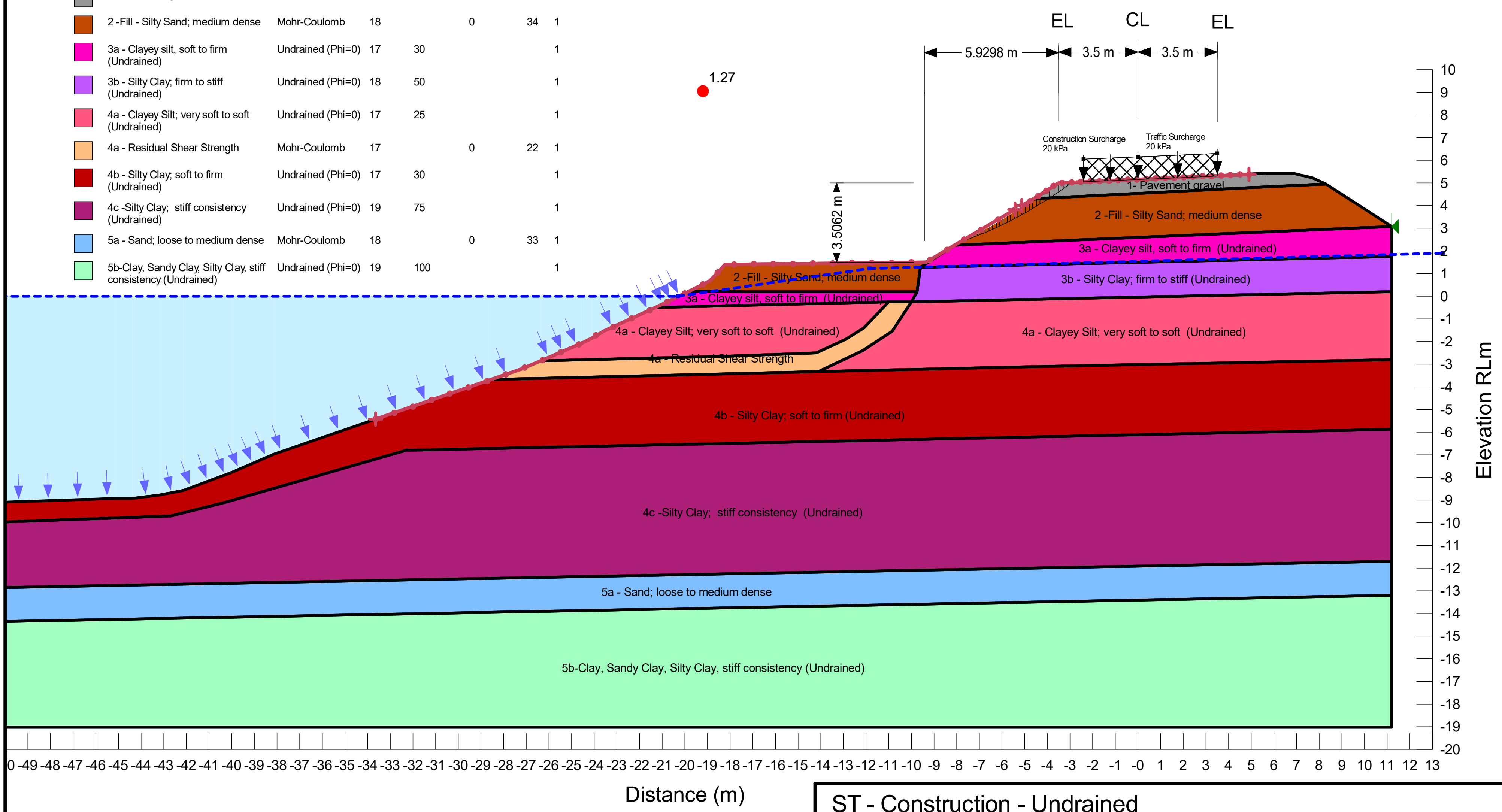
Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Mohr-Coulomb	17		0	22	1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



ST - Construction - Undrained

Option 4 Gabion Wall undrained piles installed.gsz

11/10/2021 1:250



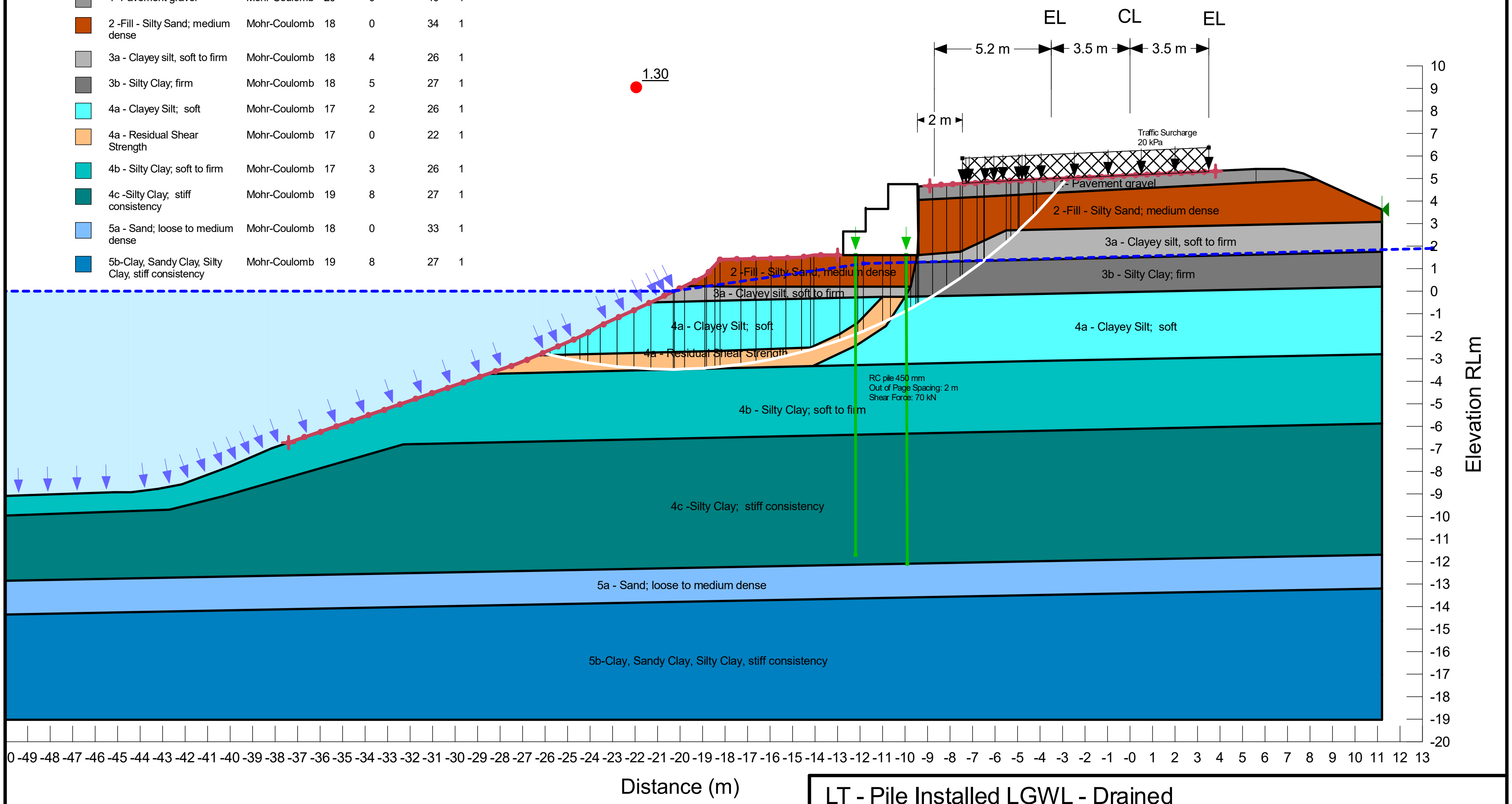
Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Mohr-Coulomb	17		0	22	1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1

ST - Construction - Undrained

Option 4 Gabion Wall undrained batter.gsz

11/10/2021 1:250

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20	0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18	0	34	1
	3a - Clayey silt, soft to firm	Mohr-Coulomb	18	4	26	1
	3b - Silty Clay; firm	Mohr-Coulomb	18	5	27	1
	4a - Clayey Silt; soft	Mohr-Coulomb	17	2	26	1
	4a - Residual Shear Strength	Mohr-Coulomb	17	0	22	1
	4b - Silty Clay; soft to firm	Mohr-Coulomb	17	3	26	1
	4c -Silty Clay; stiff consistency	Mohr-Coulomb	19	8	27	1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18	0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency	Mohr-Coulomb	19	8	27	1

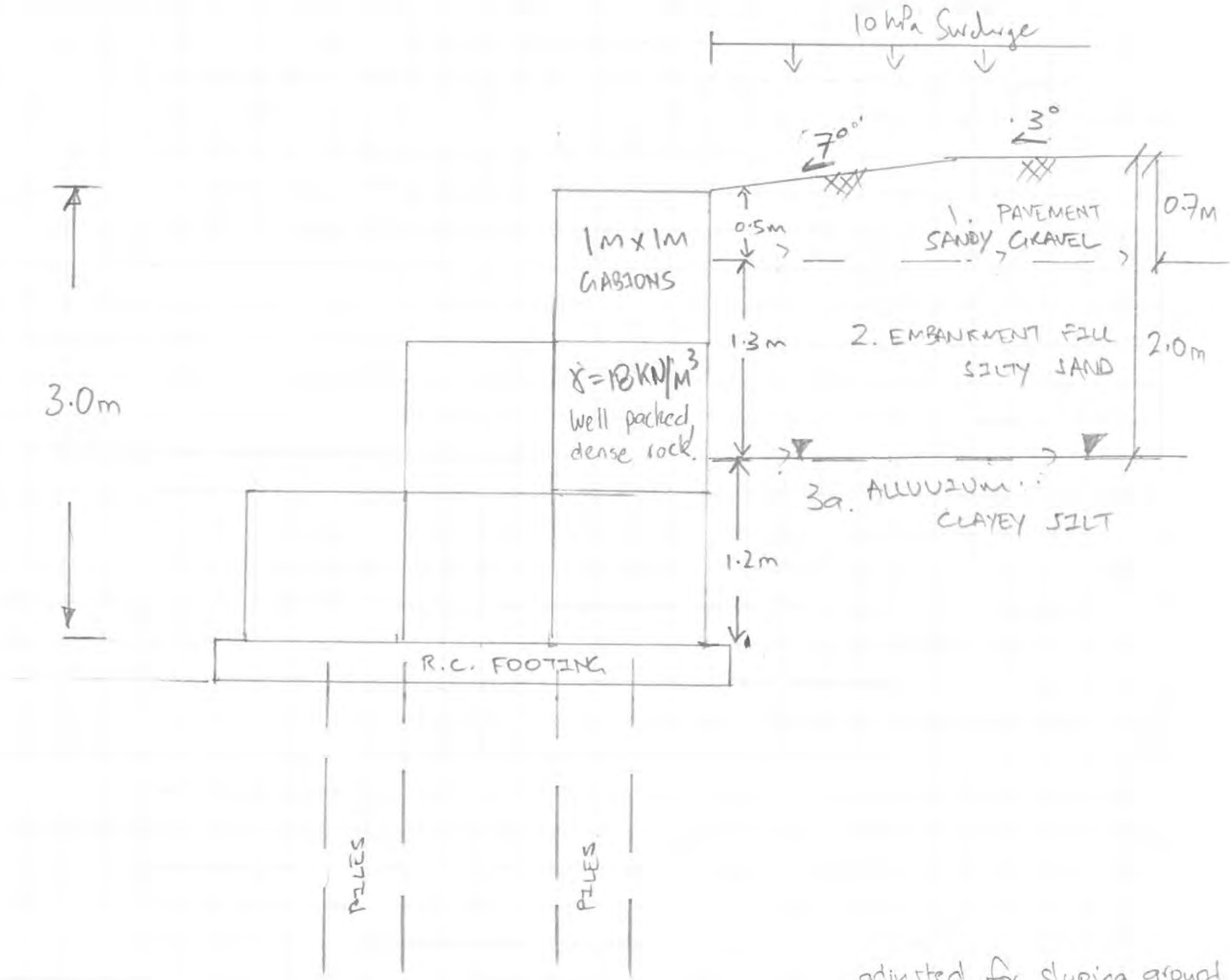


LT - Pile Installed LGWL - Drained
Option 4 Gabion Wall on pile footings.gsz
08/10/2021 1:250

SMEC
Member of the Surbana Jurong Group

COMPUTATION SHEET

Project	BYRON'S LANE SLIP	Page No.	01
Project No.	30013154	Date	06 / 11 / 21
Feature/Structure	OPTION 4 – GABION WALL CONCEPT	Calcs By	M. MAHARAJ
Details	SLIDING / OVERTURNING CHECK : PRELIMINARY	Checked By	



adjusted for sloping ground
ignores wall friction

PARAMETERS	γ (kN/m³)	c' (kPa)	ϕ' (Degrees)	K_a
SANDY GRAVEL	20	0	40	0.23
SILTY SAND	18	0	34	0.31
CLAYEY SILT	18	4	26	0.43

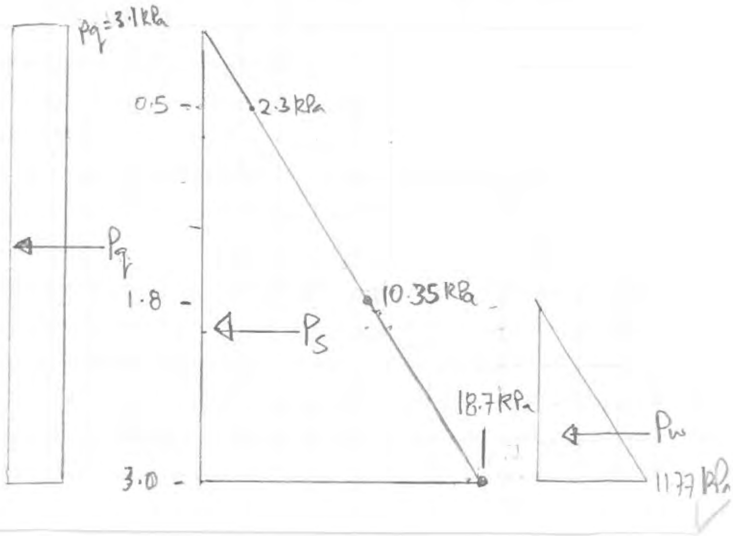
LATERAL EARTH PRESSURES

P_q = Surcharge Pressure
$= q K_a H$
$= 10\,kPa \times 0.31 \times 3$
$= 9.3\ kN/m$

P_s = Soil Pressure
$= \frac{18.7 \times 3.0}{2} = 28.1\ kN/m$

(Assumed approx triangular distribution)

$P_w = \frac{11.77 \times 1.2}{2} = 7.1\ kN/m$
(water pressure)

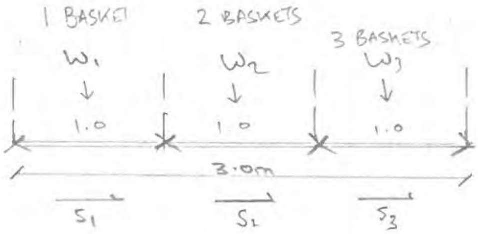


SLIDING CHECK

AS 5100.3:2017 $\quad R_{dg} = \phi_g R_{us} \geq E_d$

$\phi_g = 0.55$

$E_d = P_q + P_s + P_w = 44.5 \text{ kN/m}$



Friction angle between gabions and concrete footing assumed rough = 40°

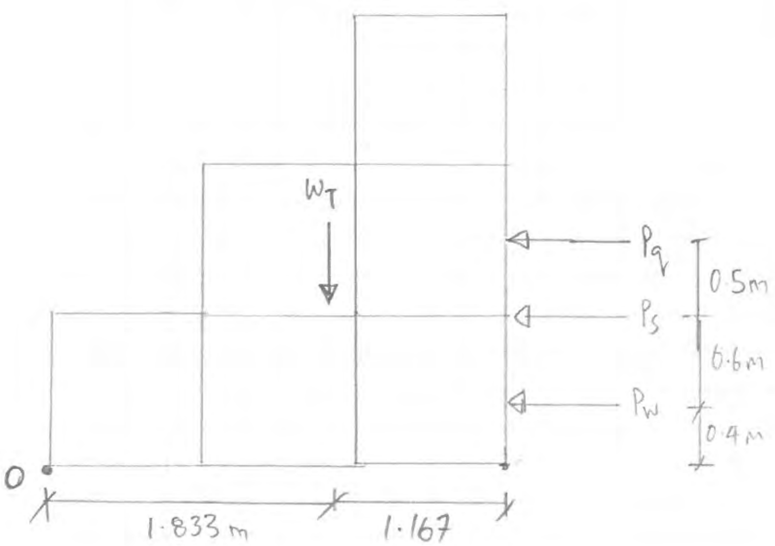
$S_1 = W_1 \tan 40° \times 1\text{m} = 15.1 \text{ kN/m}$
$S_2 = W_2 \tan 40° \times 1\text{m} = 30.2 \text{ kN/m}$
$S_3 = W_3 \tan 40° \times 1\text{m} = 45.3 \text{ kN/m}$

$R_{us} = S_1 + S_2 + S_3 = 90.6 \text{ kN/m}$

$\phi_g R_{us} = 49.83 \text{ kN} > 44.5 \text{ kN}$ (OK).

NB// RECOMMEND INCLINE FOOTING MINIMUM 3° BACK IN TO SLOPE TO PROVIDE ADDITIONAL RESISTANCE.

OVERTURNING CHECK



ΣM_o: $\phi_g \times 1.833 W_T > E_d$

$E_d = (P_q \times 1.5) + (P_s \times 1.0) + (P_w \times 0.4)$
$= 13.95 + 28.10 + 2.84$
$= 44.89 \text{ kNm/m}$

$\phi_g \times 1.833 \times W_T = 1 \times 108 = 108 \text{ kNm/m}$

$108 \text{ kNm/m} > 45 \text{ kNm/m}$

(OK).

Appendix J Schedule of Quantities

Summary of Preliminary Cost Estimates

Job No. 30013154
Date 30.09.2021

Byrons Lane Landslide Remediation

	Relative Cost Estimate Including GST ($)
Option 1A - Cantilevered Sheet Pile Wall	$1,156,100
Option 1B - Anchored Sheet Pile Wall	$1,315,402
Option 2 - Contiguous Pile Wall	$1,199,990
Option 3 - Shear Piles and Rock Fill	$986,480
Option 4 - Gabion Wall with Piled Foundation	$745,052

Schedule of Quantities and Relative Cost Estimates
Byrons Lane Landslide Remediation
Option 1A - Cantilevered Sheet Pile Wall

Job No 30013154
Date 30/09/2021

Comments and Calcs

Item	Description	Units	Quantity	Unit Rate	Totals	Comments and Calcs
1	**Preliminaries and General Items**					
	Establishment of plant to site	Item	1	$ 50,000	$ 50,000	Assumes sheet piling rig and medium excavator
	Site Compound, Barriers, Security, Amenities	Item	1	$ 15,000	$ 15,000	
	Traffic Control	week	2	$ 15,000	$ 30,000	Assumes 2 weeks construction timeframe - single lane closure
2	**Quality Control, Survey, As-Built Drawings, Geotechnical Advice**					
	3D coordinated survey and set-out, as-builts	Item	1	$ 6,000	$ 6,000	
	Engineer Construction Supervision	week	2	$ 7,500	$ 15,000	Experienced engineer supervision
	Project Management	Item	1	$ 10,000	$ 10,000	
3	**Clearing and Environmental Control**					
	Erosion and Sediment Control	Item	1	$ 5,000	$ 5,000	Sediment and erosion control measures
	Environmental REF and monitoring	Item	1	$ 7,500	$ 7,500	
4	**Construct Cantilevered Sheet Pile Wall**					
	Supply and install sheet piles	m2	672	$ 1,200	$ 806,400	AZ46-700N sheet piles: 158kg/m. 42 m @ 16 m long = 672 m2.
						Rawinson Rate = 74 kg/m = $620/m2. Estimate Rate for 158 kg/m = $1,200 m2.
	Fill voids behind sheet pile wall	m^3	24	$ 150.0	$ 3,600	Allow 0.3 m width and 2 m deep x 40 m = 24 m3.
						Allow for cement stabilised sand.
5	**Other Items**					
	Vegetation clearance	m^2	100	$ 10.0	$ 1,000	Localised clearing for rock armouring to riverbank.
	Geotextile Seperation Fabric Strength Class E	m^2	200	$ 10.0	$ 2,000	Beneath rock armour.
	Rock Armour to riverbank	m^3	200	$ 200	$ 40,000	500 mm to 700 mm size rock
	Repair pavement wearing course + line marking	m^2	300	$ 100	$ 30,000	50 m x 6 m width (including shoulder) = 300 m2
	Lengthen existing concrete barrier	m	20	$ 400	$ 8,000	Allow 20 m.
	Removal of Excavated Spoil - Off Site Disposal	m^3	10	$ 150	$ 1,500	Nominal excess material removed from site.
	Temporary Working Platform	allow	1	$ 20,000	$ 20,000	
	Total - Ex GST				**$ 1,051,000**	
	GST				$ 105,100	
	Total - Incl GST				**$ 1,156,100**	

Excludes:
Estimated maintenance cost over design life

<u>Schedule of Quantities and Relative Cost Estimates</u>
Byrons Lane Landslide Remediation
Option 1B - Anchored Sheet Pile Wall

Job No 30013154
Date 30/09/2021

Comments and Calcs

Item	Description	Units	Quantity	Unit Rate	Totals	Comments and Calcs
1	**Preliminaries and General Items**					
	Establishment of plant to site	Item	1	$ 50,000	$ 50,000	Assumes sheet piling rig and medium excavator
	Site Compound, Barriers, Security, Amenities	Item	1	$ 15,000	$ 15,000	
	Traffic Control	week	4	$ 15,000	$ 60,000	Assumes 2 weeks construction timeframe - single lane closure
2	**Quality Control, Survey, As-Built Drawings, Geotechnical Advice**					
	3D coordinated survey and set-out, as-builts	Item	1	$ 6,000	$ 6,000	
	Engineer Construction Supervision	week	4	$ 7,500	$ 30,000	Experienced engineer supervision
	Project Management	Item	1	$ 15,000	$ 15,000	
3	**Clearing and Environmental Control**					
	Erosion and Sediment Control	Item	1	$ 5,000	$ 5,000	Sediment and erosion control measures
	Environmental REF and monitoring	Item	1	$ 7,500	$ 7,500	
4	**Construct Anchored Sheet Pile Wall**					
	Supply and install riverbank sheet piles	m2	480	$ 1,200	$ 576,000	AZ46-700N sheet piles: 158kg/m. 40 m @ 12m long = 480 m2.
						Rawinson Rate = 74 kg/m = $620/m2. Estimate Rate for 158 kg/m = $1,200 m2. Estimate Rate for 119 kg/m = $1,000 m2.
	Supply and install deadman sheet piles	m2	200	$ 1,000	$ 200,000	AZ36-700N sheet piles: 119kg/m. 40 m @ 5m long = 200 m2.
	Supply and install anchor bars	m	240	$ 80	$ 19,200	12 No. @ 20 m length steel tie bars: 38 mm; Grade 500, Galvanised. Estimate supply rate for standard 6 m length from Dywidag = $60/m. Allow $80/m.
	Install anchor bars between sheet piles in trenches	m^3	162	$ 80	$ 12,960	Allow for excavation and backfill of anchor trenches for tie bars. Asumed trenched installation due to sand fill. 20 m long x 450 mm wide x 1.5 m deep.
	Supply and install waler beams	tonne	3.64	$ 4,000	$ 14,560	Allow for 2 x steel channel sections per waler beam comprising estimated 200 mm x 75 mm channels = 22.9kg/m. 22.9 x 4 x 40m = 3664 kg = 3.64 tonnes.
5	**Earthworks**					Allow $4000/tonne for supply and install.
	Construct new fill behind sheet pile wall	m^3	240	$ 30.0	$ 7,200	Reinstate landslide. Allow 3 m width and 2 m deep x 40 m = 240 m3. Allow for silty sand compatible with existing.
	Excavate for waler beam installation	m^3	80	$ 30.0	$ 2,400	Allow 1 m width and 2 m deep x 42 m = 84 m3. Allow for excavation and back fill excavated material.
6	**Other Items**					
	Vegetation clearance	m^2	200	$ 10.0	$ 2,000	Localised clearing for rock armouring to riverbank.
	Geotextile Seperation Fabric Strength Class E	m^2	300	$ 10.0	$ 3,000	Beneath rock armour.
	Rock Armour to riverbank	m^3	300	$ 200	$ 60,000	500 mm to 700 mm size rock
	Repair pavement wearing course + line marking	m^2	600	$ 100	$ 60,000	50 m x 12 m width (including shoulder) = 600 m2
	Lengthen existing concrete barrier	m	20	$ 400	$ 8,000	Allow 20 m.
	Removal of Excavated Spoil - Off Site Disposal	m^3	80	$ 150	$ 12,000	Excess material removed from site.
	Temporary Working Platform	allow	1	$ 30,000	$ 30,000	
	Total - Ex GST				**$ 1,195,820**	
	GST				$ 119,582	
	Total - Incl GST				**$ 1,315,402**	

Excludes:
Estimated maintenance cost over design life
Temporary working platforms

<u>Schedule of Quantities and Relative Cost Estimates</u>
Byrons Lane Landslide Remediation
Option 2 - Contiguous Pile Wall

Job No 30013154
Date 30/09/2021

Comments and Calcs

Item	Description	Units	Quantity	Unit Rate	Totals	Comments and Calcs
1	**Preliminaries and General Items**					
	Establishment of plant to site	Item	1	$ 75,000	$ 75,000	Assumes CFA piling rig and excavator.
	Site Compound, Barriers, Security, Amenities	Item	1	$ 15,000	$ 15,000	
	Traffic Control	week	3	$ 15,000	$ 45,000	Assumes 3 weeks construction timeframe - single lane closure
2	**Quality Control, Survey, As-Built Drawings, Geotechnical Advice**					
	3D coordinated survey and set-out, as-builts	Item	1	$ 6,000	$ 6,000	
	Engineer Construction Supervision	week	3	$ 7,500	$ 22,500	Experienced engineer supervision
	Project Management	Item	1	$ 12,000	$ 12,000	
3	**Clearing and Environmental Control**					
	Erosion and Sediment Control	Item	1	$ 5,000	$ 5,000	Sediment and erosion control measures
	Environmental REF and monitoring	Item	1	$ 7,500	$ 7,500	
4	**Construct Contiguous Pile Wall**					
	Construct Contiguous Piles	m	731	$ 1,000	$ 731,000	750 mm diameter piles. 43 No. Piles at 17 m long = 731 m. 50 MPa concrete, reinforced.
5	**Earthworks**					
	Excavate and form 2H:1V batter in front of piles	m^3	80	$ 30.0	$ 2,400	Allow 80 m3
	Rock armour batter face	m^3	100	$ 200.0	$ 20,000	Allow 100 m3. 500 mm to 700 mm size rock
6	**Other Items**					
	Vegetation clearance	m^2	200	$ 10.0	$ 2,000	Localised clearing for rock armouring to riverbank.
	Geotextile Seperation Fabric Strength Class E	m^2	350	$ 10.0	$ 3,500	Beneath rock armour.
	Rock Armour to riverbank	m^3	200	$ 200	$ 40,000	500 mm to 700 mm size rock
	Repair pavement wearing course + line marking	m^2	300	$ 100	$ 30,000	50 m x 6 m width (including shoulder) = 300 m2
	Lengthen existing concrete barrier	m	20	$ 400	$ 8,000	Allow 20 m.
	Removal of Excavated Spoil and water - Off Site Disposal	m^3	80	$ 200	$ 16,000	Allow for ASS treatment
	Temporary Working Platform	allow	1	$ 50,000	$ 50,000	May require micropiles.
	Total - Ex GST				**$ 1,090,900**	
	GST				$ 109,090	
	Total - Incl GST				**$ 1,199,990**	

Excludes:
Estimated maintenance cost over design life

<u>Schedule of Quantities and Relative Cost Estimates</u>
Byrons Lane Landslide Remediation
Option 3 - Shear Piles and Rock Fill

Job No 30013154
Date 30/09/2021

Comments and Calcs

Item	Description	Units	Quantity	Unit Rate	Totals	Comments and Calcs
1	**Preliminaries and General Items**					
	Establishment of plant to site	Item	1	$ 150,000	$ 150,000	Assumes barge, piling rig and excavator.
	Site Compound, Barriers, Security, Amenities	Item	1	$ 15,000	$ 15,000	
	Traffic Control	week	2	$ 15,000	$ 30,000	Assumes 2 out of 4 weeks single lane closure
	Barge Hire	Day	10	$ 5,000	$ 50,000	Estimated day rate.
2	**Quality Control, Survey, As-Built Drawings, Geotechnical Advice**					
	3D coordinated survey and set-out, as-builts	Item	1	$ 6,000	$ 6,000	
	Engineer Construction Supervision	week	3	$ 7,500	$ 22,500	Experienced engineer supervision
	Project Management	Item	1	$ 12,000	$ 12,000	
3	**Clearing and Environmental Control**					
	Erosion and Sediment Control	Item	1	$ 5,000	$ 5,000	Sediment and erosion control measures
	Environmental REF and monitoring	Item	1	$ 7,500	$ 7,500	
4	**Construct Shear Piles**					
	Excavate to remove rock armour from pile footprint	allow	1	$ 10,000	$ 10,000	Estimate allowance for excavator working off barge.
	Construct Driven Reinforced Concrete Piles	m	481	$ 800	$ 384,800	Allow for 450 mm square piles at 1 m centres = 37 piles. Piles @ 13m long = 481 m. Allow $800/m for piling off barge.
5	**Earthworks and Rock Armouring**					
	Vegetation clearance	m^2	500	$ 10.0	$ 5,000	Clear riverbank for rock armouring. Allow 500 m2.
	Excavate to form benches.	m^3	200	$ 30.0	$ 6,000	0.5 m max height benches. Allow 200 m3
	Geotextile Seperation Fabric Strength Class E	m^2	500	$ 10.0	$ 5,000	Beneath rock armour.
	Rock armour batter face	m^3	600	$ 200.0	$ 120,000	500 mm to 700 mm size rock
6	**Other Items**					
	Repair pavement wearing course + line marking	m^2	300	$ 100	$ 30,000	50 m x 6 m width (including shoulder) = 300 m2
	Lengthen existing concrete barrier	m	20	$ 400	$ 8,000	Allow 20 m.
	Removal of Excavated Spoil - Off Site Disposal	m^3	200	$ 150	$ 30,000	Excess material removed from site.
	Temporary Working Platform	allow	0		$ -	Not expected to be required
	Total - Ex GST				**$ 896,800**	
	GST				$ 89,680	
	Total - Incl GST				**$ 986,480**	

Excludes:
Estimated maintenance cost over design life

<u>Schedule of Quantities and Relative Cost Estimates</u>
Byrons Lane Landslide Remediation
Option 4 - Gabion Wall with Piled Foundation

Job No 30013154
Date 30/09/2021

Comments and Calcs

Item	Description	Units	Quantity	Unit Rate	Totals	Comments and Calcs
1	**Preliminaries and General Items**					
	Establishment of plant to site	Item	1	$ 50,000	$ 50,000	Assumes piling rig and excavator.
	Site Compound, Barriers, Security, Amenities	Item	1	$ 15,000	$ 15,000	
	Traffic Control	week	4	$ 15,000	$ 60,000	Assumes 4 weeks single lane closure
2	**Quality Control, Survey, As-Built Drawings, Geotechnical Advice**					
	3D coordinated survey and set-out, as-builts	Item	1	$ 6,000	$ 6,000	
	Engineer Construction Supervision	week	4	$ 7,500	$ 30,000	Experienced engineer supervision
	Project Management	Item	1	$ 12,000	$ 12,000	
3	**Clearing and Environmental Control**					
	Erosion and Sediment Control	Item	1	$ 5,000	$ 5,000	Sediment and erosion control measures
	Environmental REF and monitoring	Item	1	$ 7,500	$ 7,500	
4	**Construct Foundation**					
	Supply and Install Driven Reinforced Concrete Piles	m	456	$ 600	$ 273,600	Allow for 2 rows of 450 mm square piles at 2 m centres = 38 piles. Piles @ 12m long = 456 m.
	Construct reinforced concrete footing	m^3	37.00	$ 1,000	$ 37,000	37 m x 3.3 m x 0. 3 m 36.6 m3 = 37 m3.
5	**Construct Gabion Wall**					
	Supply gabion baskets with Polimac coating	each	54	$ 250	$ 13,500	4m x 1m x 1m baskets
	Install and fasten gabion baskets	Allow	1	$ 15,000	$ 15,000	
	Supply and install gabion rock 120 mm - 250 mm	tonnes	389	$ 40	$ 15,560	216 m3 x 1.8 tonnes/m3 = 389 tonnes. Supply rate = $30/tonne. Allow $40/tonne.
	Supply and place geotextile seperation fabric Strength Class E	m^2	108	$ 10.0	$ 1,080	Behind Gabions.
6	**Earthworks**					
	Excavate for reinforced concrete footing	m^3	114.00	$ 30.0	$ 3,420	Estimate 38 m x 1 m x 3 m = 114 m2
	Excavate temporary 2H:1V batter	m^3	372	$ 30.0	$ 11,160	Estimated 372 m3
	Fill to reinstate excavation	m^3	400	$ 50.0	$ 20,000	
7	**Other Items**					
	Repair pavement wearing course + line marking	m^2	300	$ 100	$ 30,000	50 m x 6 m width (including shoulder) = 300 m2
	Lengthen existing concrete barrier	m	20	$ 400	$ 8,000	Allow 20 m.
	Removal of Excavated Spoil - Off Site Disposal	m^3	90	$ 150	$ 13,500	Excess material removed from site.
	Temporary Working Platform	allow	1	$ 50,000	$ 50,000	May require micropiles.
	Total - Ex GST				**$ 677,320**	
	GST				$ 67,732	
	Total - Incl GST				**$ 745,052**	

Excludes:
Estimated maintenance cost over design life

Appendix K Safety in Design Register

T-PM10701 **SAFETY IN DESIGN RISK REGISTER**

SMEC
Member of the Surbana Jurong Group

Project Name: Byrons Lane Slip Remediation	**S.I.D. Register Rev: 00**
Design Package: Concept Options Design	**Date: 06/12/2021**

POTENTIAL RISK			Initial Risk Assessment				Residual Risk Assessment					
HAZARD	***DESCRIPTION***	**POTENTIAL CONSEQUENCES**	Initial Risk Likelihood (0-5)	Initial Risk Consequence (0-5)	Initial Risk Rating	**POTENTIAL ELIMINATION MEASURE, DESIGN INITIATIVE or CONTROL (Identify any Standard or Code of practice used)**	Residual Risk Likelihood (0-5)	Residual Risk Consequence (0-5)	Residual Risk Rating	**RESIDUAL RISK OWNER**	**Date SID Risk closed out**	**SID Risk Closed Out by:**
Geotechnical												
Unexpected ground conditions	Ground conditions differ from assumed. Variable alluvium profiles, unexpected rock armour.	Design Changes, delays during construction	3	4	12	Provide for some redundancy in design for variable ground conditions. Consider additional geotechnical investigation such as CPT to provide more understanding of subsurface conditions.	2	4	8	TfNSW/ Contractor		
Further slips	Existing slip scarp and marginally stable embankment slopes	Slips and engulfment during construction	4	5	20	Design for temporary stability and staging of works, identify exclusion zones for heavy plant. Review of contractors proposed methodologies. Avoid work during floods or prolonged wet periods.	2	5	10	Contractor		
Survey												
Insufficient or innacurate survey	Insufficient information to undertake design. Discrepancies between design and site.	Unable to complete design or design does not correlate with site conditions	3	4	12	Allow provision to undertake additional detailed site survey. Require contractor to setout and verify design dimensions at critical stages, prior to proceeding.	1	4	4	Contractor		
Environment												
Impact on Habitat	Vegetation clearance, sediment runoff	Habitat destruction, removal of native species, contamination of waterways	4	4	16	Undertake review of environmental factors. Develop and enforce environmental construction management plan.	2	4	8	TfNSW		
Design												
Constructability	Design cannot be practically or safely constructed	Re-design and associated costs	4	4	16	Meetings held to discuss constructability as part of the multicriteria analysis of concept options. Plan a constructability workshop to ensure design is safely constructible. Review contractors construction methodolgies and seek clarification from designer/ constructors	2	4	8	TfNSW		
Excessive Deformations	Embankment and Pavement deformations	Personal iunjury, vehicle damage, excessive maintenance	3	3	9	Design for serviceability	2	3	6	SMEC		
Durability	Remediation solutions not do not meet durability requirements	Remediation solution or components do not achieve intended design life	3	4	12	Design for durability. Highlight maintenance requirements.	2	4	8	TfNSW		
Loads	Loadings greater than expected	Failure due to over stressing	3	4	12	Model construction staging and traffic loads, adopt safety factors, specify load limits and set backs	2	4	8	SMEC/ Contractor		
Scour	Lack of hydraulic/ scour assessment information for clarence river. Incorrect long term scour profiles and scour treatments	Failure due to excessive scour	4	4	16	Investigate and assess hdyraulics and scour	2	4	8	TfNSW		
Construction												
Unexpected ground conditions	Ground conditions differ from the design assumptions	Construction difficulties, variations	3	4	12	Provide for some redundancy in design for variable ground conditions. Consider additional geotechnical investigation such as CPT to provide more understanding of subsurface conditions. Staged testing or trials at early stages of construction. Provision for a suitably qualified geotechnical engineer to supervise and document works during construction.	2	4	8	Contractor		
Instability	Unstable slopes during construction	LTI / injury / death,	4	5	20	Visual monitoring of slopes for deformation during construction. Undertake works during dry weather. Limit construction plant bearing pressures within designated setbacks or exclusion zones. Limit plant vibrations.	3	5	15	Contractor		
Excavations	Temporary and permanent excavations	Falling into excavations, wall collapse, striking services. LTI / injury / death,	4	5	20	Ensure that code of practice for excavations are complied with. Construct barriers where necessary. Provide shoring where necessary. Check for underground services.	2	5	10	Contractor		
Under / Above Ground Services	Striking Services during construction	Disruptions to live traffic, construction and increased risk to construction crews.	4	5	20	Investigate and identify buried services (**abandoned water main may be present through site**). Relocate/ protect services where practicable.	1	5	5	Contractor		
Inadequate Concrete Strength	Durability and strength	Structural collapse, durability issues.	2	4	8	Concrete quality control practices in place. Ensure that design team has been notified as a Non Conformance.	1	4	4	Contractor		
Fall from heights	Working on and adjacent to steep slopes	LTI / injury / death,	4	5	20	Follow WHS practices for working at heights.	2	4	8	Contractor		
Working adjacent to live traffic	Potential for accidents during construction in outer lane	Increased potential for accidents - LTI / injury / death,	4	5	20	Ensure adequate TCPs and safe working conditions are implemented, including reduction of speed limit. Review space constraints in relation to construction plant.	3	5	15	Contractor		
Pavement Damage	Damaged pavements creating unsafe pavement	Increased risk of accidents	3	4	12	Provision to repair and reinstate pavements	1	4	4	Contractor		
Noise	Excessive construction noise	Disruption to neighbourhood	2	3	6	Rural setting. Evaluate high noise activities and consider restrict working hours for noisy work.	1	3	3	Contractor		
Vibration	Excessive vibration	Generate slope instability	4	4	16	Adopt construction methodologies and plant/equipment that do not generate excessive vibrations.	2	4	8	Contractor		
Maintenance Issues												
Access to structures	Lack of safe access for maintenance	Increased risk to maintenance crews	2	4	8	Provide safe working conditions for maintenance	1	4	4	TfNSW		

SMEC

Member of the Surbana Jurong Group

RISK ACCEPTANCE CRITERIA

Residual Risk Scores	
1 to 6 - Low	Risks and controls are managed inside the project/business unit through normal day-to-day management
8 to 12 - Medium	Assign specific responsibility for control of risks (i.e. name responsible person)
15 to 16- High	Report risk to General Counsel/Head of Compliance together with risk treatment plan
20 to 25 - Extreme	Immediately report to General Counsel/Head of Compliance (GCHC) and devise risk treatment plan in conjuction with GCHC

	CONSEQUENCE				
Safety	• Ailments not requiring treatment	• Injury or illness but person is able to return to normal duties either immediately or by the beginning of their next shift	• Temporary impairment - person will fully recover but is unable to undertake normal duties at the beginning of their next shift • Breach of Act/Regulation leading to an improvement notice being issued by a regulatory authority • Practice deviates from a Code of Practice or Compliance Code	• Permanent impairment and/or disability as a result of injury or illness • Breach of Act/Regulation leading to penalty notice issued by a regulatory authority • Multiple cases of Moderate consequence	• Fatality as a result of injury or illness • Breach of Act/Regulation leading to SMEC or a SMEC employee being charged by a court or tribunal • Multiple cases of Major consequence
Reputation	Self-improvement review required	Internal reviews required to reverse decline in reputation	Scrutiny required in the form of external reviews and/or investigations	Intense public, political and media scrutiny evidenced by front page headlines and/or television coverage.	Complete Loss of Integrity as a Valued Business Supplier eg found guilty of major breaches of Trade Practices Act
Financial	< $500,000	$500k - $2M	$2M - $5M	$5M - $10M	>$10M
Legal Compliance	Breaches rectified without ongoing issues with authorities	Notifications by Authorities of Potential Breaches	Breach of Law or Statute with potential penalties under $5M	Breach of Law or Statute with potential penalties in excess of $5M	Breach of Laws with potential for a criminal prosecution
Organisational Objectives	Very little consequence to achievement of strategic plan	Would require some adjustment to achieve strategic plan	Would require significant adjustment to achieve strategic plan	Would threaten achievement of the strategic plan	Would stop achievement of the strategic plan
	1	2	3	4	5

LIKELIHOOD	Description	%			Insignificant	Minor	Moderate	Major	Catastrophic
	• The event can be expected to occur in most circumstances • The event has occurred in the past (at least annually) • Circumstances are in train that will cause the event to happen	40-99%	5	Almost Certain	5	10	15	20	25
	• The occurrence of the event would not be considered unusual • The event has occurred in the past few years • Circumstances are in train that may cause the event to happen	15-39%	4	Above Average	4	8	12	16	20
	• The occurrence of the event is unusual • The event has occuried at least once in SMEC history	5-14%	3	Moderate	3	6	9	12	15
	• The event has not occurred in SMEC history • The event has occurred, infrequently, to similar organisations	1-5%	2	Rare	2	4	6	8	10
	• The event only occurs in exceptional circumstances • The event has not occurred in SMEC history • The event is not known to have occurred within similar organisations	Less than 1%	1	Very Rare	1	2	3	4	5

Appendix L Relevant Information

Big River Way
Slip on Clarence River North of Byrons Lane

Geotechnical Investigation
Factual Report

Report No: N2021031
Report Issued Date: 7/6/2021
Prepared by: Northern Pavements and Geotechnical

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Report Registration

Report Title:	Geotechnical Investigation Report
Report Subtitle:	Big River Way – Slip on Clarence River North of Byrons lane
Report Number:	N2021031
Project Reference Number:	N2021031
Responsible Capability:	Northern Pavements and Geotechnical
Responsible Discipline:	Geotechnical Science
Report Authorisation:	Manager Pavements and Geotechnical Northern
Report Manager:	Geotechnical Scientist
Issue Number:	01
Version Date:	7/6/2021
Contact for this Report:	Rob Ticknor
Distribution List:	Shaun Gillespie

Report Prepared By:		**Report Reviewed By:**	
Name:	Rob Ticknor	Name:	David Groth
Title:	Geotechnical Scientist	Title:	Manager Pavements and Geotechnical
Team:	Engineering Services Northern	Team:	Engineering Services Northern
Unit:	Pavements and Geotechnical	Unit:	Pavements and Geotechnical
Date:	7/6/2021	Date:	7/6/2021

Note: The functions of the former State Government agency Roads and Maritime Services (RMS or Roads and Maritime) are now administered by Transport for NSW.

Contents

<u>Appendices</u>

1 Introduction

This report presents the results of a geotechnical investigation undertaken to support design and construction for treatment of a slip on the Big River Way north of Byrons Lane along the Clarence River.

The work was requested by the TfNSW Project/Contract Manager Shaun Gillespie. The scope consisted of drilling two boreholes through the pavement with Standard Penetration Testing, in situ shear vane testing and sampling soils for Acid Sulfate Soils and for aggressivity testing.

This report provides the following information for each site:

- Details of material types and observations of groundwater inflows;
- Standard penetration tests to determine consistency and density of soils;
- Laboratory test results of samples for aggressivity and acid sulphate.

This report should be read in conjunction with the following investigation and design reports prepared for the adjacent slip on the same road (formerly the Pacific Highway).

- HW10 – Pacific Highway - Byrons Lane Slip Stage 4 Geotechnical Design, SMEC, Project Number 30011433, 5 May 2014.
- HW10 – Pacific Highway – Road Embankment Slip at Byrons Lane Tyndale, Stage 3 Remedial Work using Sheet Piles and H-Piles, Pavement and Geotechnical Engineering Section, Roads And Traffic Authority, Report No. G4054, 5/11/2010.

2 Site description

The site is located on the bank of the Clarence River on the Big River Way between Tyndale and Maclean. (See Figure 1). The site is north of Byrons Lane, immediately downstream of a larger river bank slip that was previously repaired.

Location Number	Borehole Position MGA Zone 56	Site Description
BH12	517797.377E 6732393.964N RL 4.928m AHD	In pavement adjacent to slip scarp
BH13	517806.491E 6732407.305N RL 4.920m AHD	In pavement adjacent to slip scarp

Table 1: Location and site description.

Appendix A includes a site location plan (Figure 1) and geotechnical investigation plan (Figure 2).

3 Field Investigation

Fieldwork for the investigation comprised drilling of two boreholes using a geotechnical rotary drilling rig. The borehole was advanced using auger drilling using a TC followed by wash bore drilling using a roller bit. Rock requiring core drilling was not encountered.

Sampling was undertaken using standard penetration testing (SPT) at 1.5m intervals which also provided information on material consistency and density. Undisturbed samples were collected in U75 tubes in soft materials. In situ vane shear testing was conducted in soft conditions. Hand Penetrometer testing was conducted on SPT and U75 samples. Hand vane shear testing was conducted on U75 samples. A scientific officer from TfNSW supervised the field work including sampling and logging. A detailed bore log and explanatory notes are provided in Appendix B. The SPT and undisturbed soil samples have been retained by TfNSW if additional testing is required. A selection of samples was sent to a NATA certified laboratory for aggressivity and acid sulfate testing. Laboratory test reports are included in Appendix C.

Survey of borehole levels and positions was provided by TfNSW Surveyors and is provided on the log sheets.

4 Laboratory Testing

4.1 Acid sulfate soil testing

Acid sulfate soils (ASS) are those which contain iron sulphides such as pyrite (FeS_2). Exposure of iron sulphides to water and oxygen leads to generation of sulphuric acid and subsequent mobilization of heavy metals such as aluminum and iron into water bodies. This affects water quality and can lead to death of aquatic organisms and deterioration of engineered structures.

Advice regarding implementation of an acid sulfate soils management plan is based on the national acid sulfate soils guidance manual produced by the Department of Agriculture and Water Resources (2018). For disturbed soil volumes of less than 1000t, an acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture (eg sand/gravel) ≥0.03% S or 18 mol H^+/t; medium texture (eg sandy clay) ≥0.06% S or 36 mol H^+/t; fine texture (eg clay) ≥0.1% S or 62 mol H^+/t.

One samples was selected from BH12 for acid sulfate soil analysis at the Environmental Analysis Laboratory in Lismore. Results are summarized in Table 2 and presented in Appendix C.

Site + Depth (m)	Soil Texture	pH_{KCl}	Potential Sulfidic Acidity mole H^+/t	TAA mole H^+/t	Net Acidity mole H^+/t	Lime Calc. kg $CaCO_3$/t DW
BH12 5.5-5.95	Medium	5.57	455	7	462	35

Table 2: Summary of Acid Sulfate Soil Analysis

Based on results of the testing, it is recommended that an acid sulfate management plan is prepared.

4.2 Soil aggressivity testing

Soil aggressivity testing was undertaken on selected samples to inform design of the concrete/steel elements of the footings. Testing was carried out by the Environmental Analysis Laboratory in Lismore with results presented in Appendix C. A summary of the findings is shown in Table 3 below.

Site	BH12
Sample Depth (m)	7.0-7.45
Texture Class	Fine
pH (in water)	8.19
EC (dS/m)	0.294
Resistivity (ohm.mm)	33,972
Chloride (mgCl/kg)	119
Sulfate (mgSO4/kg)	251
Chloride/Sulfate Ratio	0.5

Table 3: Results of Soil Aggressivity Analysis.

5 Discussion

Two geotechnical boreholes were adjacent to a slip on the river bank of the Clarence River on the Big River Way north of Byrons Lane. Standard Penetration Testing and in situ vane shear testing was conducted in the boreholes. Samples were submitted for acid sulfate soil and aggressivity testing.

The results of these investigations should be read in conjunction with the results of investigations conducted for the previous adjacent slip.

6 References

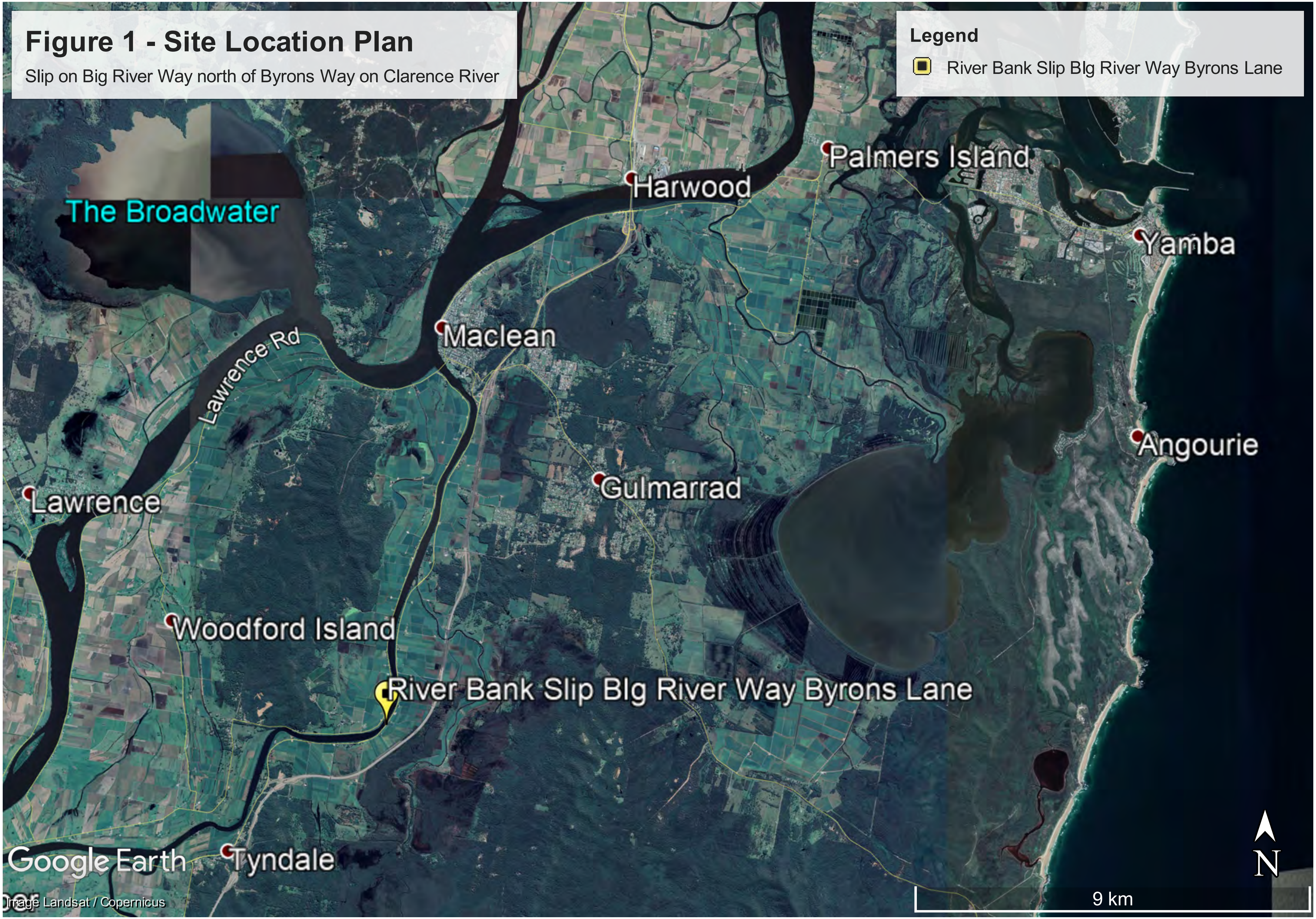
Australian Standard: AS 1726-1993, Geotechnical Site Investigations.

Sullivan L, Ward N, Toppler N and Lancaster G 2018, National Acid Sulphate Soils Guidance, Department of Agriculture and Water Resources, Canberra, ACT.

Appendix A. Site Location Plans

Figure 1 - Site Location Plan

Slip on Big River Way north of Byrons Way on Clarence River



0 5 10 20 30 40 50 Metres	REPORT No. 2021031	Date: 2/06/2021	SCALES 1:1,000 @ A3	Transport for NSW Infrastructure & Place - Northern Technical Services	Geotechnical Investigation plan FIGURE: 2
DESIGNED: RT REVIEWED: DG	CLIENT: Maintenance and Delivery north				

Path: C:\Users\ticknorr\Ticknor\03_Slopes\HW10 Byrons Lane\GIS\Byrons Lane Slip.mxd

Appendix B. Borehole Logs and Explanatory Notes

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

GENERAL

Information obtained from site investigations is recorded on log sheets. The "Cored Drill Hole Log" presents data from an operation where a core barrel has been used to recover material - commonly rock. The "Non-Core Drill Hole - Geological Log" presents data from an operation where coring has not been used and information is based on a combination of regular sampling and insitu testing. The material penetrated in non-core drilling is commonly soil but may include rock. The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The common depth scale is 8m per drill log sheet and about 3-5m for excavation logs sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

DRILLING

Drilling & Casing

AS	Auger Screwing
AD/V	Auger Drilling with V-Bit
AD/T	Auger Drilling with TC Bit
WB	Wash-bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.

▼ Standing water level measured in completed borehole

▽ Level taken during or immediately after drilling

Samples/Tests

D	Disturbed
U	Undisturbed
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (* sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Test
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer

Angle/Orientation: Angle from horizontal and orientation to magnetic north.

EXCAVATION LOGS

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

MATERIAL DESCRIPTION - SOIL

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.3

Moisture Condition

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Consistency - In accordance with AS 1726-1993, Appendix A2.5

	Description	Su	HP
VS	Very Soft	≤ 12kPa	< 25kPa
S	Soft	12 - 25 kPa	25 - 50 kPa
F	Firm	25 - 50 kPa	50 - 100 kPa
St	Stiff	50 - 100 kPa	100 - 200 kPa
VSt	Very Stiff	100 - 200 kPa	200 - 400 kPa
H	Hard	≥ 200 kPa	≥ 400 kPa

Strength figures quoted are the approximate range of Unconfined Compressive Strength for each class.

Density Index (%) is estimated or is based on SPT results. Approximate N Value correlation is shown in right column.

	Description	Density Index	SPT Value
VL	Very Loose	< 15%	0 – 4
L	Loose	15 – 35%	4 – 10
MD	Medium Dense	35 – 65%	10 – 30
D	Dense	65 – 85%	30 – 50
VD	Very Dense	> 85%	> 50

MATERIAL DESCRIPTION - ROCK

Material Description

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-1993, Appendix A3.1-A3.3 and Tables A6a, A6b and A7.

Core Loss

Is shown at the bottom of the run unless otherwise indicated.

Bedding

Description	**Spacing** (mm)
Thinly Laminated	< 6
Laminated	6 - 20
Very Thinly Bedded	20 - 60
Thinly Bedded	60 -200
Medium Bedded	200 - 600
Thickly Bedded	600 - 2000
Very Thickly Bedded	> 2000

Weathering - No distinction is made between weathering and alteration. Weathering classification assists in identification but does not imply engineering properties.

F	**Fresh**	Rock substance unaffected by weathering
SW	**Slightly Weathered**	Rock substance partly stained or discoloured. Colour and texture of fresh rock recognisable.
MW	**Moderately Weathered**	Staining or discolouration extends throughout rock substance. Fresh rock colour not recognisable.
HW	**Highly Weathered**	Stained or discoloured throughout. Signs of chemical or physical alteration. Rock texture retained.
EW	**Extremely Weathered**	Rock texture evident but material has soil properties and can be remoulded.

Strength - The following terms are used to described rock strength:

	Rock Strength Class	**Point Load Strength Index, Is(50)** (MPa)
EL	**Extremely Low**	< 0.03
VL	**Very Low**	0.03 - 0.1
L	**Low**	0.1 - 0.3
M	**Medium**	0.3 - 1.0
H	**High**	1.0 - 3.0
VH	**Very High**	3.0 - 10.0
EH	**Extremely High**	≥ 10.0

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical estimated strength by using:

○ Diametral Point Load Test

● Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown.

MATERIALS STRUCTURE/FRACTURES

ROCK

Natural Fracture Spacing - A plot of average fracture spacing excluding defects known or suspected to be due to drilling, core boxing or testing. Closed or cemented joints, drilling breaks and handling breaks are not included in the Natural Fracture Spacing.

Visual Log - A diagrammatic plot of defects showing type, spacing and orientation in relation to core axis.

Defects	————	Defects open in-situ or clay sealed
	- - - - - - - -	Defects closed in-situ
	————	Breaks through rock substance

Additional Data - Description of individual defects by type, orientation, in-filling, shape and roughness in accordance with AS 1726-1993, Appendix A Table A10, notes and Figure A2.

Type	BP	Bedding Parting
	JT	Joint
	SM	Seam
	FZ	Fracture Zone
	SZ	Shear Zone
	VN	Vein
	FL	Foliation
	CL	Cleavage
	DL	Drill Lift
	HB	Handling Break
	DB	Drilling Break

Orientation - angle relative to the plane normal to the core axis.

Infilling	CN	Clean
	X	Carbonaceous
	Clay	Clay
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
	MS	Secondary Mineral
	MU	Unidentified Mineral
Shape	PR	Planar
	CU	Curved
	UN	Undulose
	ST	Stepped
	IR	Irregular
	DIS	Discontinuous
Roughness	POL	Polished
	SL	Slickensided
	S	Smooth
	RF	Rough
	VR	Very Rough

SOIL

Structures - Fissuring and other defects are described in accordance with AS 1726-1993, Appendix A2.6, using the terminology for rock defects.

Origin - Where practicable an assessment is provided of the probable origin of the soil, eg fill, topsoil, alluvium, colluvium, residual soil.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : N2021031
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517797.377, N: 6732393.964 ( ) | SURFACE ELEVATION : 4.928 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 30/4/21 | DATE COMPLETED : 30/4/21 | DATE LOGGED : 30/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD CASING (0.0–2.3m)	0% Water LOSS	H	Not Observed		0.0–0.20m		ASPHALTIC CONCRETE	M	VD	ROAD SURFACE
		F			0.20–0.50m	GW	GRAVEL: dark grey to orange, fine to medium gravel, angular, with some fine to coarse grained sand		D	FILL
		VE		1.00m SPT 6, 4, 3 N*=7 1.45m	0.50–2.00m	SM	SILTY SAND: brown, fine grained sand, with medium plasticity fines and some clay		MD	
RR (2.3m–)				2.50m SPT 2, 2, 2 N*=4 2.95m	2.00–3.40m	ML	CLAYEY SILT: brown, low to medium plasticity	VM	S	ALLUVIUM
				4.00m SPT 2, 3, 5 N*=8 4.45m	3.40–5.00m	CI	SILTY CLAY: brown mottled grey, medium plasticity, trace fine grained sand		F to St	4.00: HP Samp = 150 kPa
				5.50m SPT 1, 0, 0 N*=0 5.95m	5.00–6.00m	ML	SANDY CLAYEY SILT: grey, low to medium plasticity, fine grained sand, trace shell fragments			ESTUARINE DEPOSITS 5.50: HP Samp = 30 - 40 kPa
				6.10m in-situ VS P=68kPa R=41kPA 6.70m in-situ VS P=68kPa R=27kPA 7.00m U75 7.40m Samp VS P=32kPa R=13.5kPA 7.50m	6.00–8.0m	CH	SILTY CLAY: dark grey, high plasticity, with some fine grained sand, trace shell fragments	> WL	S	7.40: HP Samp = 20 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : N2021031
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517797.377, N: 6732393.964 ( ) | SURFACE ELEVATION : 4.928 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 30/4/21 | DATE COMPLETED : 30/4/21 | DATE LOGGED : 30/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	VE	Not Observed		8.0		CH	SILTY CLAY: dark grey, high plasticity, with some fine grained sand, trace shell fragments *(continued)*	> WL	S	
				8.50m U7575 8.95m							8.50: HP Samp = 30 kPa
											8.90: Samp VS P=48kPa R=15kPA
					9.0			From 9.0m, with some organics.			
					9.50m		CI	SILTY CLAY: grey, medium to high plasticity, trace fine grained sand, trace shell fragments	> Wp	St	
				10.00m U75	10.0						
				10.40m Samp VS P=177kPa R=45kPA 10.50m							10.40: HP Samp = 150 kPa
					11.0			From 11.0m, colour change to pale grey mottled brown.		F to St	11.00: ALLUVIUM
				11.50m SPT 2, 2, 3 N*=5 11.95m							11.95: HP Samp = 150 kPa
					12.0						
		E		13.00m SPT 4, 5, 7 N*=12 13.45m	13.0			13.0-13.5m, iron oxide zones up to 2mm.			13.00: HP Samp = 180 - 200 kPa
					14.0						
				14.50m SPT 3, 4, 7 N*=11 14.95m							14.50: HP Samp = 150 kPa
					15.0						
				16.00m	16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : N2021031
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517797.377, N: 6732393.964 ( ) | SURFACE ELEVATION : 4.928 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 30/4/21 | DATE COMPLETED : 30/4/21 | DATE LOGGED : 30/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	E	Not Observed	SPT 4, 2, 4 N*=6 (16.00m–16.45m)	16.0–16.20	CI	SILTY CLAY: grey, medium to high plasticity, trace fine grained sand, trace shell fragments *(continued)*	> Wp	F to St	
				17.50m SPT 3, 5, 5 N*=10 17.95m	16.20–17.80	SP	SAND: pale grey, fine to medium grained sand, with some silt, clay and trace shell fragments, grading to SC - Sandy CLAY, grey, medium plasticity			ALLUVIUM; 17.50: HP Samp = 160 kPa
				19.00m SPT 4, 5, 6 N*=11 19.45m; 20.50m SPT 4, 5, 7 N*=12 20.95m; 22.00m SPT 5, 6, 7 N*=13 22.45m	17.80–22.45	CI	CLAY: pale grey to orange, grey, medium to high plasticity, trace fine grained sand			19.00: HP Samp = 150 - 180 kPa; 20.50: HP Samp = 170 - 190 kPa
					22.45		BOREHOLE BH12 TERMINATED AT 22.45 m Limit of Investigation			

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : N2021031
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517806.491, N: 6732407.305 ( ) | SURFACE ELEVATION : 4.920 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 29/4/21 | DATE COMPLETED : 29/4/21 | DATE LOGGED : 29/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING: Drilling & Casing: AD to 5.50m, RR from 5.50m; casing to 2.30m. Water: 0% Water Loss. Ground water level: 29/04/21 at approx. 5.0m.

Depth (m)	Drilling Penetration	Samples & Field Tests	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
0.00–0.20m	VH			ASPHALTIC CONCRETE		VD	ROAD SURFACE
0.20–0.60m	H		GW	GRAVEL: dark grey, fine to coarse gravel, angular, with some fine to coarse grained sand, gravel is fresh sandstone	M	D	FILL
0.60–2.20m	VE	1.00m SPT 6, 5, 3 N*=8 1.45m	SM	SILTY SAND: brown, fine grained sand, low plasticity From 1.8m, colour change to pale brown.	SM	MD	
2.20–3.50m	VE	2.50m SPT 1, 2, 2 N*=4 2.95m	ML	CLAYEY SILT: brown, low plasticity		S	ALLUVIUM 2.50: HP Samp = 80 - 100 kPa
3.50–5.00m	VE	4.00m SPT 2, 2, 4 N*=6 4.45m	CI	SILTY CLAY: brown mottled grey, medium plasticity	VM	F	4.00: HP Samp = 120 - 180 kPa
5.00–6.20m	VE	5.50m SPT 1, 0, 0 N*=0 5.95m	ML	CLAYEY SILT: dark grey, medium plasticity, with some fine grained sand, trace shell fragments			ESTUARINE DEPOSITS 5.50: HP Samp = 20 kPa
6.20–8.00m	VE	7.00m SPT 0, 0, 0 N*=0 7.45m	CH	CLAY: dark grey, high plasticity, trace fine grained sand sand, trace shell fragments	W	VS to S	7.00: HP Samp = 20 kPa 7.45: SPT dropped under hammer weight

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : N2021031
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517806.491, N: 6732407.305 ( ) | SURFACE ELEVATION : 4.920 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 29/4/21 | DATE COMPLETED : 29/4/21 | DATE LOGGED : 29/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	VE			8.0	CH	CLAY: dark grey, high plasticity, trace fine grained sand sand, trace shell fragments *(continued)*	W		
				8.50m U75						8.50: HP Samp = 40 kPa
				8.90m Samp VS P=45kPa R=18kPA 9.00m	9.0					
					9.50m	CI-CH	SILTY CLAY: pale grey, medium to high plasticity	>Wp	S	ALLUVIUM
				10.00m SPT 0, 0, 2 N*=2 10.45m	10.0					10.00: HP Samp = 50 kPa
		E			11.0					
				11.50m U75						11.50: HP Samp = 110 kPa
				11.90m					St	11.90: HP Samp = 110 kPa HV Samp P: 113 kPa R: 45 kPa
				12.00m SPT 2, 5, 6 N*=11 12.45m	12.0		From 12.0m, colour change to pale grey and orange, with some zones of extremely weathered, angular siltstone (?) gravels (soil strength).			12.45: HP Samp = 110 - 180 kPa
				13.00m SPT 5, 7, 8 N*=15 13.45m	13.0				VSt to St	13.00: HP Samp = 230 - 250 kPa
					14.0					
				14.50m SPT 4, 4, 8 N*=12 14.95m			14.5m, some zones of iron oxide coated 'joint' or 'fissure' structures in clay. From 14.7m, some silty sand zones up to 50mm thick.			14.50: HP Samp = 250 kPa
					15.0				St	
				16.00m	16.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : N2021031
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517806.491, N: 6732407.305 ( ) SURFACE ELEVATION : 4.920 () ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer MOUNTING : Truck CONTRACTOR : NCD DRILLER : DB

DATE STARTED : 29/4/21 DATE COMPLETED : 29/4/21 DATE LOGGED : 29/4/21 LOGGED BY : AB CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	E		SPT 5, 5, 7 N*=12 16.45m	16.0	CI-CH	SILTY CLAY: pale grey, medium to high plasticity *(continued)*	>Wp	St	ALLUVIUM 16.45: HP Samp = 220 - 270 kPa
				17.50m SPT 6, 8, 10 N*=18 17.95m	17.0	SP	17.00m SAND: pale grey, medium grained sand, with trace silt, clay and shell fragments	W	MD	
				19.00m SPT 3, 4, 5 N*=9 19.45m	18.50m	SC	SANDY CLAY: pale grey, medium plasticity, with fine grained sand, and some sandy lenses to 20mm thickness		St	19.00: HP Samp = 120 kPa
				20.50m SPT 5, 7, 8 N*=15 20.95m 22.00m SPT 6, 8, 10 N*=18 22.45m	20.00m	CI	SILTY CLAY: pale grey and orange, medium plasticity, with trace fine grained sand	>Wp	VSt	20.50: HP Samp = 180 - 240 kPa 22.00: HP Samp = 220 - 250 kPa
				23.50m SPT 4, 4, 8 N*=12 23.95m	23.00m	SM	SANDY SILT: pale grey and orange, low plasticity, fine grained sand		St	23.50: HP Samp = 120 kPa
					23.95m / 24.0		BOREHOLE BH13 TERMINATED AT 23.95 m Limit of Investigation			

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NSW GOVERNMENT Transport for NSW

Appendix C. Laboratory Reports

RESULTS OF ACID SULFATE SOIL ANALYSIS

1 sample supplied by Transport For NSW on 5/05/2021 . Lab Job No. K6526.
Analysis requested by Adam Brown. Your Job: N2021031.

3/76 Victoria Street GRAFTON NSW 2460

Sample Identification	EAL Lab Code	Texture	Moisture Content		Potential Sulfidic Acidity (Chromium Reducible Sulfur - CRS)			Actual Acidity (Titratable Actual Acidity - TAA)	Retained Acidity		Non-treated soil: Acid Neutralising Capacity (ANC_{BT})		Non-treated soil: Net Acidity	Lime Calculation
			(% moisture of total wet weight)	(g moisture / g of oven dry soil)	(% S_{cr})	(mol H^+/t)	pH_{KCl}	(mol H^+/t)	(%S_{NAS})	(mol H^+/t)	(% $CaCO_3$)	(mol H^+/t)	(mol H^+/t)	(kg $CaCO_3$/t DW)
Method Info.		**	**		*(In-house method S20)*		*(In-house method 16b)*		**		*(In-house method S14)*		**	**
BH12 5.5-5.95m	*K6526/1*	Medium	32.2	0.47	0.730	455	5.57	7	..	..	..	..	462	35

NOTES:

1. All analysis is reported on a dry weight (DW) basis, unless wet weight (WW) is specified.
2. Samples are dried and ground immediately upon arrival (unless supplied dried and ground).
3. Analytical procedures are sourced from Sullivan L, Ward N, Toppler N and Lancaster G. 2018. National acid sulfate soils guidance: national acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0.
4. The Acid Base Accounting Equation, where Acid Neutralising Capacity has not been corroborated by other data, is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity** (Eq. 3.2; Sullivan et al. 2018 - full reference above).
5. The Acid Base Accounting Equation for post-limed soil materials is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - (post treatment Acid Neutralising Capacity - initial Acid Neutralising Capacity)** (Eq. 3.3; Sullivan et al. 2018 - full reference above).
   While the Acid Neutralising Capacity of a soil material may not be included in the Net Acidity calculation (Note 4), it must be measured to give an Initial Acid Neutralising Capacity if verification testing is planned post-liming.
   The Inital Acid Neutralising Capacity must be provided by the client to enable EAL to produce Verification Net Acidity and Liming calculations for post-limed soil materials.
6. The Acid Base Accounting Equation, where Acid Neutralising Capacity has been corroborated by other data, is Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - Acid Neutralising Capacity (Eq. 3.1; Sullivan et al. 2018 - full reference above).
7. The lime calculation includes a Safety Factor of 1.5 as a safety margin for acid neutralisation (Sullivan et al. 2018). This is only applied to positive values. An increased Safety Factor may be required in some cases.
8. Retained Acidity is required when the pH_{KCl} < 4.5 or where jarosite has been visually observed.
9. A negative Net Acidity result indicates an excess acid neutralising capacity.
10. If insufficient mixing occurs during intial sampling, or during post-liming, or both: the Potential Sulfidic Acidity may be greater in the post-limed sample than in the intial sample; the post-liming Acid Neutralising Capacity may be lower in the post-limed sample than in the intial sample.
11. **An acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture ≥ 0.03% S or 18 mol H^+/t; medium texture ≥ 0.06% S or 36 mol H^+/t; fine texture ≥ 0.1% S or 62 mol H^+/t)** (Table 1.1; Sullivan et al. 2018 - full reference above)
12. For projects that disturb > 1000 t of soil material, the coarse trigger of ≥ 0.03% S or ≥ 18 mol H^+/t must be applied in accordance with Sullivan et al. (2018) (full reference above).
13. Acid sulfate soil texture triggers can be related to NCST (2009) textures: coarse and peats = sands to loamy sands; medium = clayey sand to light clays; fine = light medium to heavy clays (Sullivan et al. 2018 - full reference above).
14. Bulk density is required to convert liming rates to soil volume based results. Field bulk density rings can be submitted to EAL for bulk density determination.
15. A negative Net Acidity result indicates an excess acid neutralising capacity.
16. '..' is reported where a test is either not requested or not required. Where pH_{KCl} is < 4.5 or > 6.5, zero is reported for S_{NAS} and ANC in Net Acidity calculations, respectively.
17. Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
18. ** NATA accreditation does not cover the performance of this service.
19. Analysis conducted between sample arrival date and reporting date.
20. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).
21. Results relate to the samples tested.
22. This report was issued on 11/05/2021.

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WORLD RECOGNISED ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025 - Testing

checked: ....
Graham Lancaster
Laboratory Manager

RESULTS OF SOIL ANALYSIS

1 samples supplied by Transport For NSW on 5/05/2021 . Lab Job No. K6527.
Analysis requested by Adam Brown. Your Job: N2021031
3/76 Victoria St GRAFTON NSW 2460

	Method	Sample 3 BH12 7.0-7.45m
	EAL job No.	***K6527/1***
Moisture (%)	*inhouse*	35
Texture	*See note 2 below.*	Fine
pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.19
Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.294
Resistivity (ohm.mm)	** Calculation	33,972
Resistivity (ohm.cm)	** Calculation (ohm.mm / 10)	3,397
Chloride (mg/kg)	** Water Extract - ISE (1:5 Water)	119
Chloride **(as %)**	** Calculation	0.012
Sulfate (mg/kg)	** Water Extract-APHA 3120 ICPOES	251
Sulfate **(as % SO_4)**	** Calculation	0.025
Chloride / Sulfate Ratio	** Calculation	0.5

Notes:

1. ppm = mg/kg dried soil
2. For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
3. All results as dry weight DW - soils were dried at 60°C for 48hrs prior to crushing and analysis.
4. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
5. Methods from Rayment and Lyons, 2011. Soil Chemical Methods - Australasia.CSIRO Publishing: Collingwood.
6. Based on Australian Standard AS: 2159-2009
7. Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines*. QLD DNRME.
8. Analysis conducted between sample arrival date and reporting date.
9. ** NATA accreditation does not cover the performance of this service.
10. .. Denotes not requested.
11. This report is not to be reproduced except in full.
12. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).
13. Results relate only to the samples tested.
14. This report was issued on 18/05/2020.

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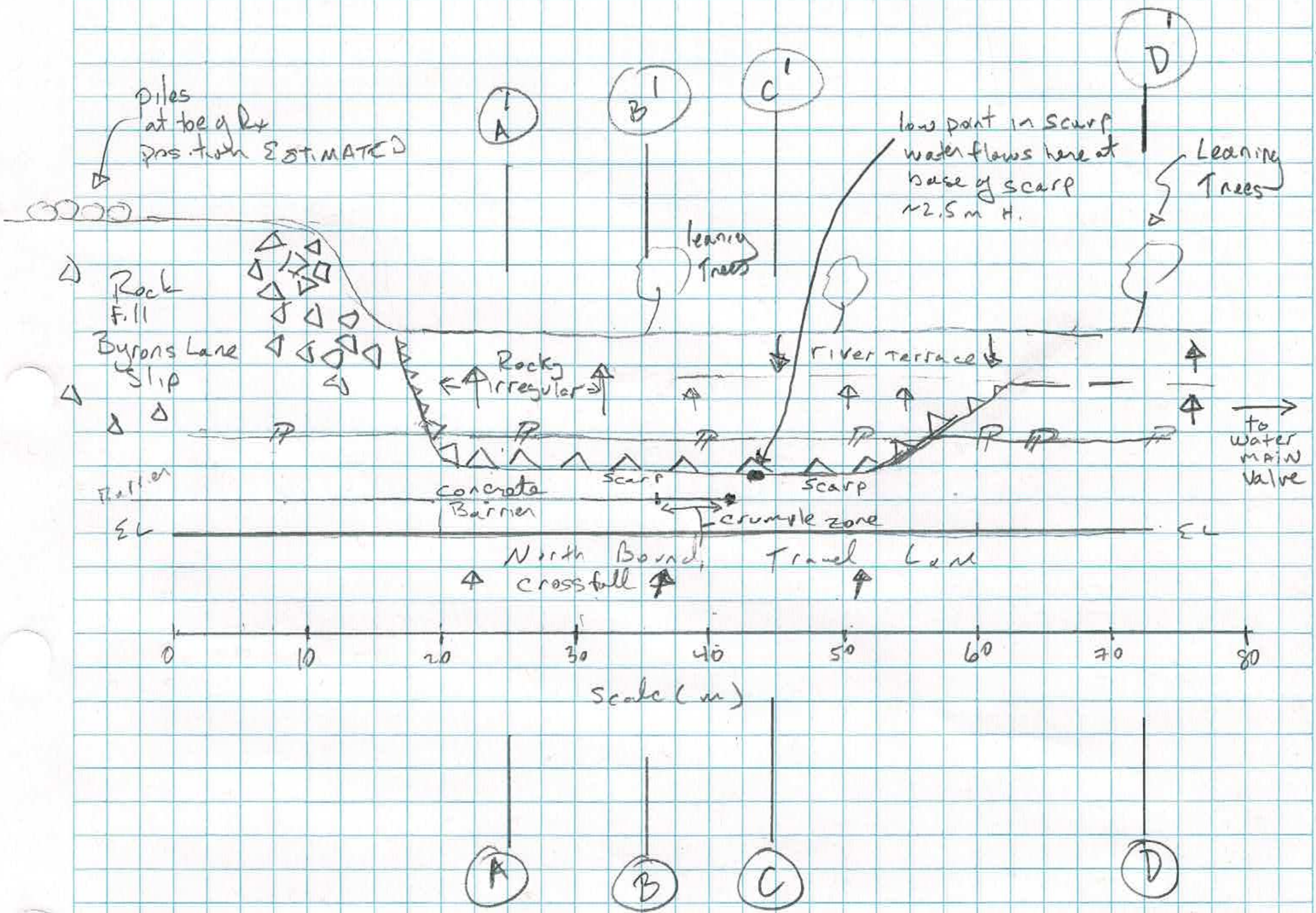
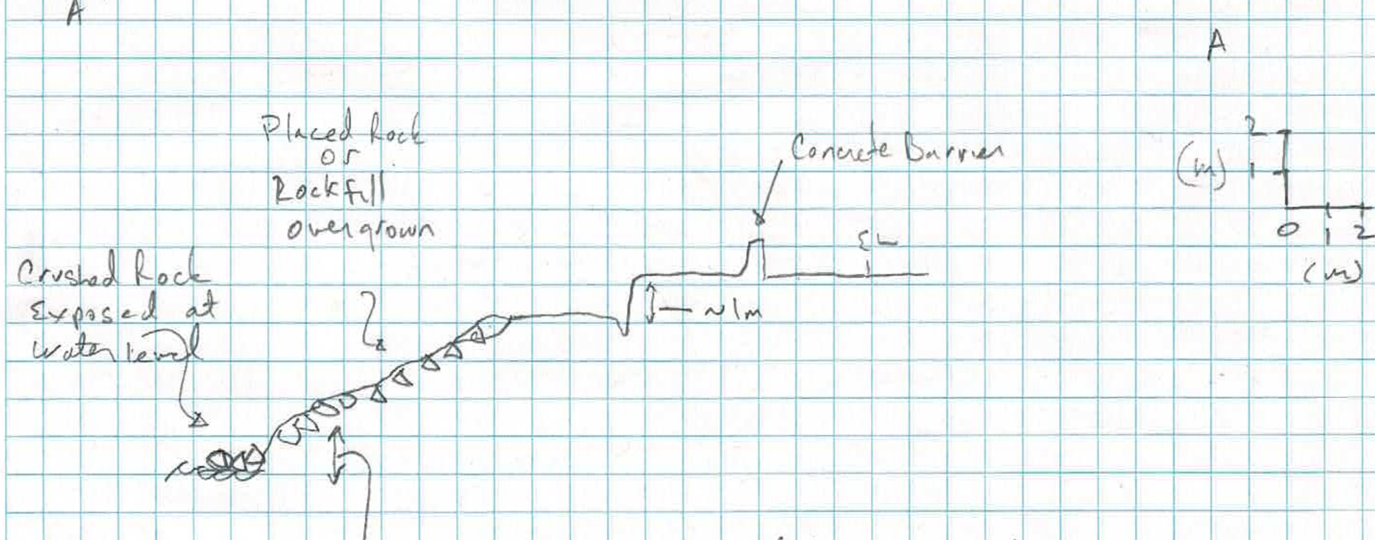
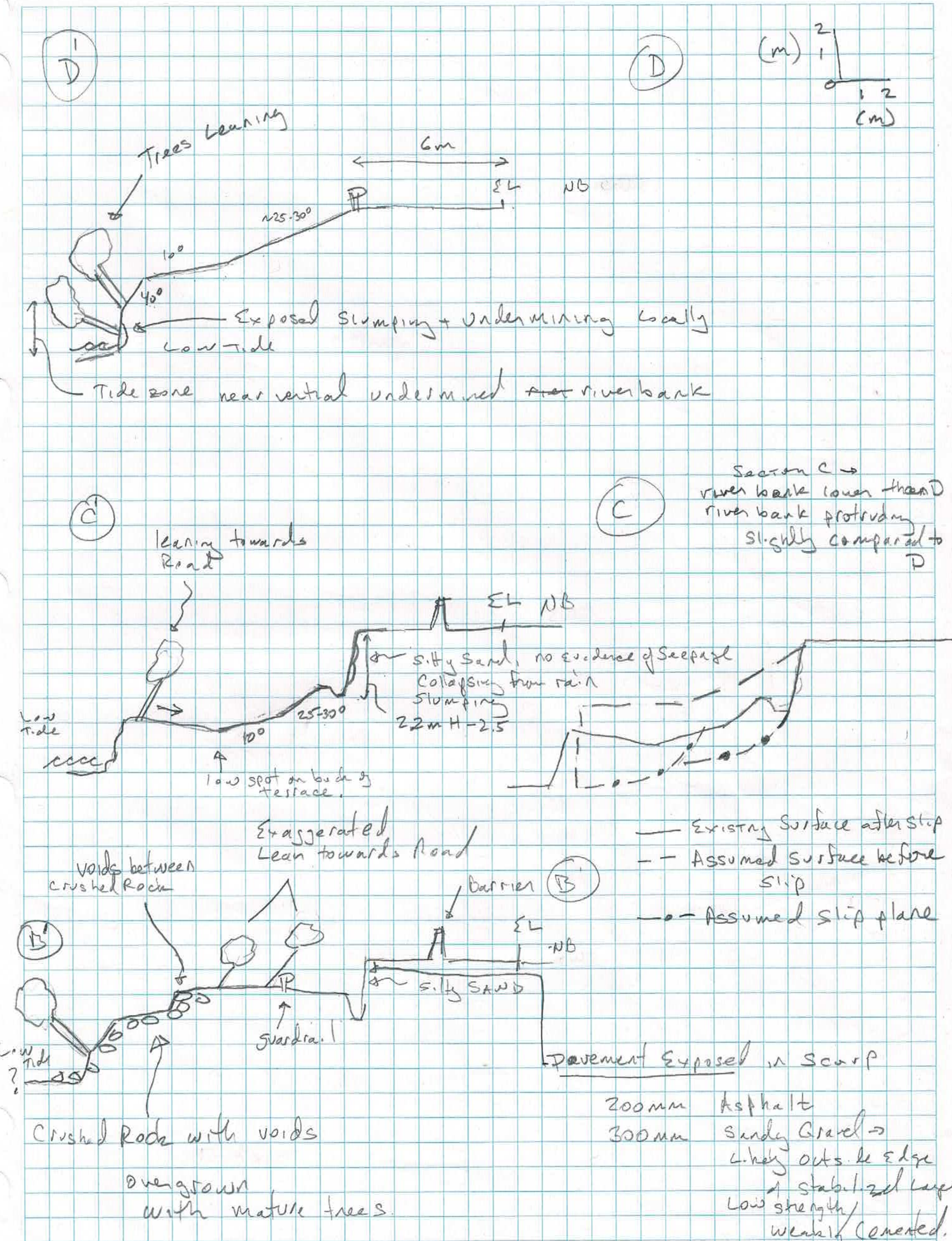
checked: ....
Graham Lancaster
Laboratory Manager

Slip ~40-43m Long





Appears Rock at Toe has moved, pushed towards river.
Some Large voids between Rock


D'
D
(m) 2 1 0 1 2 (m)
Trees Leaning
6m
P
EL NB
~25-30°
10°
40°
Exposed slumping + undermining locally
Low Tide
Tide zone near vertical undermined ~~at~~ riverbank
C'
C
Section C → river bank lower than D river bank protruding slightly compared to D
leaning towards Road
EL NB
silty sand, no evidence of seepage
Collapsing from rain
slumping
2.2m H - 2.5
Low Tide
10°
25-30°
low spot on back of terrace.
Existing surface after slip
Assumed surface before slip
Assumed slip plane
Exaggerated Lean towards Road
voids between crushed Rock
Barrier
B'
B'
EL
NB
silty SAND
P
Guardrail
Low Tide ?
Pavement Exposed in Scarp
200mm Asphalt
300mm Sandy Gravel → Likely outside Edge of stabilized layer
Low strength weakly cemented.
Crushed Rock with voids
overgrown with mature trees.

Slip Appears to be in the River Bank above water level.
It Appears that river bank has pushed out due to lack of support.

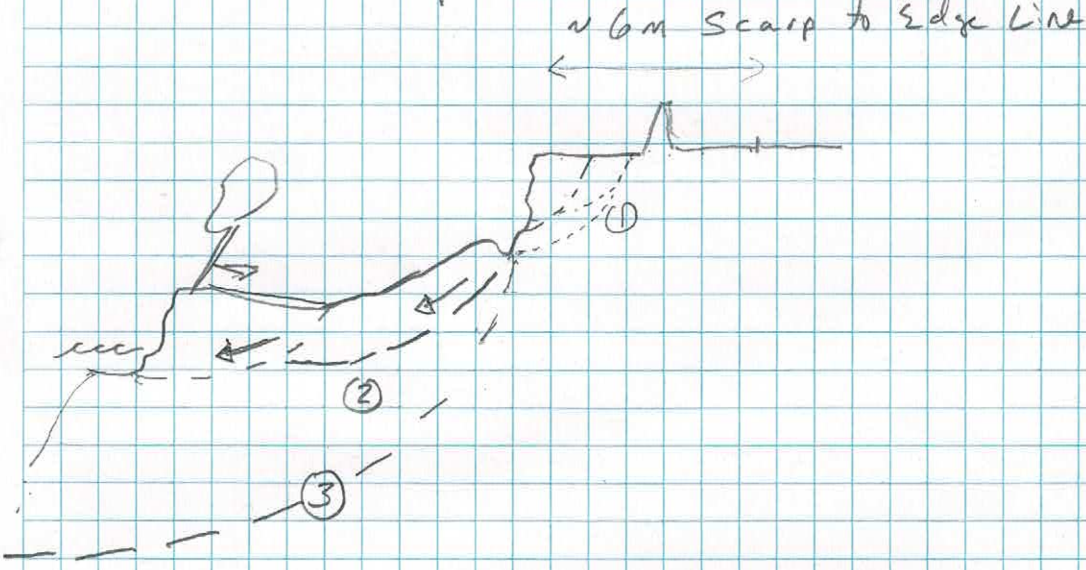
Apparent Mechanisms

(1) Erosion on River Bank – Tidal Action
River flow
Turbulence from upstream Rock fill

(2) High water – potential increased river heights from recent RAIN

(3) Abandoned water MAIN – unlikely but worth checking

(4) Low strength Materials below river bench.



HAZARDS

(1) Collapse of Scarp – SANDY MATERIAL, erodes + slumps when wet, creating void under pavement which eventually collapses.

rain – protect scarp from rain + surface runoff
does not appear to have seepage within scarp

(2) CONTINUED Slip → increases height of headwall scarp + potential for collapse

Slip headwall progresses towards Road

rain → protect from RAIN + surface flow from pavement

wet low strength layer → cannot act in short term

(3) Deep Slip into River channel –
we do NOT know River Channel shape or
if a deep weak layer is continuity

Slope Risk Analysis Summary Report Version 4

?? 13900??

Page 1

Transport Roads & Maritime Services NSW GOVERNMENT

Slope Identification No.	Big River WAY - Byrons Lane Slip					Date	9/3/21	
Inspection Date	9/3/21		Completed By:	RT		Checked By:		
Slope Data	Slope Class	Slope below	Max Slope Height (m)	6	Av. Slope Angle (o)	30°	Material	Soil
	Description:		River Bank Slip North of Byrons Lane					
Location								
Roadloc Coordinates	Road No		Start Link No		Finish Link No		L or R?	
	C'way Code		Start Distance		Finish Distance		Length	
GPS Coordinates (WGS84/GDA94)	Start		Latitude		Longitude		Elevation	
	Finish		Latitude		Longitude		Elevation	
MGA Coordinates	Start		Zone		Easting		Northing	
	Finish		Zone		Easting		Northing	
Plan Reference No.					Plan Start Chainage		L or R?	
Locality Name	Byrons Lane							
Road Data	AADT		400 v/d	Year of Count	2021	Speed Limit (km/hr)		100
	No of Lanes	Prescribed Direction	1	Counter Direction	1	Sight Distance Adequate? (Y/N)		Y
Risk Analysis								
Hazard/Failure Mechanism	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Hazard Type	Slump	Slip	Deep Slip					
Failure Dynamics Ratings								
Scale of Failure Rating - for Volume (S1 - S5)	S4	S3	S2					
Scale of Failure Rating - for Block Size (S1 - S5)								
Velocity of Failure Rating (R1 - R5)	R1	R3	R4					
Likelihood Rating (L1 - L6)	L1	L2/L3	L4					
Consequence Class Ratings								
Temporal Probability (T1 - T5)	T4	T4	T4		TRAFFic Volumes		for Big River Way	
Vulnerability (V1 - V5)	V3	V2	V2		between Tyndale + Maclean			
Consequence Class for Loss of Life (C1 - C5)	C4	C3	C3		derived from		2021 Counts for	
Consequence Class for property damage etc (C1 - C5)	C3	C3	C3		W2B Noise Modelling		on	
Risk Analysis Ratings								
Slope Attribute Score					Big River Way		S of Tyndale	
Event Magnitude (M1 - M5)					and on Pacific Highway RAMPS			
Hazard Classification (H1 - H5)					at Tyndale.			
Assessed Risk Level (ARL1 - ARL5)	ARL1	ARL2+3	ARL4		NB + SB is		~ 200 v/c/d	

between Tyndale + Maclean.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH1
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517775.752, N: 6732376.884 (56 MGA94) | SURFACE ELEVATION : 5.143 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER :

DATE STARTED : 26/9/09 | DATE COMPLETED : 26/9/09 | DATE LOGGED : 26/9/09 | LOGGED BY : RT | CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V (0.0–1.5)	N/A				0.0			AC			ROAD SURFACE
							GP	SANDSTONE GRAVEL: pale brown Silty Gravel: red brown, dry, low plasticity.			
				1.00m SPT 5, 3, 3 N=6 1.45m	1.0		SM	1.00m SILTY SAND: brown, fine grained sand, low plasticity, slightly moist. Silty sand: pale brown, slightly moist, low plasticity. Fine sand with silt and trace of clay.	M		1.80: Started firming up
				2.50m SPT 1, 1, 2 N*=3 2.95m	2.0		ML	2.50m CLAYEY SILT: pale brown, mottled dark brown, medium plasticity, wet, firm, no clay.			2.50: SPT Recovery: 0.45 m; Dropped 70mm under hammer weight. 2.70: HP Samp = 1 kPa
		E	▽ 26/09/09	4.00m U75 4.40m	3.0		CH	3.10m SILTY CLAY: grey brown, high plasticity		F	3.10: Per driller's: clayey silt 4.40: Bottom of U75 gravel wet
				5.50m SPT 0, 0, 0 N*=0 5.95m	5.0		ML	5.50m CLAYEY SILT: dark grey, medium plasticity, with silty clay layers up to 20mm thick.	W	S	5.50: SPT Recovery: 0.45 m; Hammer weight.
					6.0						
					7.0						
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH1
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517775.752, N: 6732376.884 (56 MGA94) SURFACE ELEVATION : 5.143 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER :

DATE STARTED : 26/9/09 DATE COMPLETED : 26/9/09 DATE LOGGED : 26/9/09 LOGGED BY : RT CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
	N/A				8.0	ML	CLAYEY SILT: dark grey, medium plasticity, with silty clay layers up to 20mm thick. *(continued)*			
				8.50m SPT 0, 0, 0 N*=0 8.95m	8.50m	ML	CLAYEY SILT: dark grey, high plasticity, trace gravel, roots and shells.		S	8.50: SPT Recovery: 0.45 m; Hammer weight 450mm. 8.70: HP Samp = 1 kPa
					9.0					
									St	9.40: Changed to pale grey 9.50: Driller's note: 9-10m: needs to keep cleaning it out
				10.00m U75	10.0 (10.00m)	CH	SILTY CLAY: grey, high plasticity		F - St	10.00: Where stiff clay started above that clay strip
					11.0			W		11.20: Change to sandy clay
		E		11.50m SPT 3, 4, 5 N*=9 11.95m	11.50m	CH	SILTY CLAY: pale grey, high plasticity, with highly weathered gravel, trace fine grained sand, in lenses. Some ironstones. Trace of dark brown rootlets.		F	11.50: SPT Recovery: 0.45 m 11.70: HP Samp = 1 kPa
					12.0					
				13.00m U75	13.0		Clay with silt: pale grey, wet, high plasticity, with trace of oxidised gravel (orange, weathered).			13.10: HP Samp = 1 kPa
					14.0					
				14.50m SPT 3, 5, 8 N*=13 14.95m			Clay: pale grey, moist, high plasticity, trace of root (5mm thick) and trace of orange oxidised silt/sand.	M	F - St	14.50: SPT Recovery: 0.45 m 14.60: HP Samp = 2 kPa
					15.0					
				16.00m	16.0 (16.00m)					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH1
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517775.752, N: 6732376.884 (56 MGA94) SURFACE ELEVATION : 5.143 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER :
DATE STARTED : 26/9/09 DATE COMPLETED : 26/9/09 DATE LOGGED : 26/9/09 LOGGED BY : RT CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
	N/A			SPT 6, 8, 10 N*=18 (16.00–16.45m)	16.0–17.50	CI	SILTY SANDY CLAY: pale grey, orange brown, medium plasticity, fine to medium grained sand, trace oxidised gravel, and some clay layers up to 20mm. Colour in layers.		D	16.00: SPT Recovery: 0.45 m
				SPT 5, 9, 12 N*=21 (17.50–17.95m)	17.50–19.00	CI	SILTY CLAYEY SAND: pale grey to dark grey, fine and medium grained sand, medium plasticity clay		D	17.50: SPT Recovery: 0.45 m
		E		SPT 5, 7, 7 N*=14 (19.00–19.45m)	19.00–20.50	CH	CLAY: high plasticity, with silt, with EW, up to 5mm, oxidised red gravel	W	F - St	19.00: SPT Recovery: 0.45 m
				SPT 5, 6, 10 N*=16 (20.50–20.95m)	20.50–22.00	CH	CLAY: pale grey, orange brown, mottled, high plasticity		St	20.50: SPT Recovery: 0.2 m 20.60: HP Samp = 3 kPa
				SPT 7, 10, 10 N*=20 (22.00–22.45m)	22.00–24.00	CH	CLAY: brown grey, mottled orange brown, high plasticity, with silt, some stain.		F - St	22.00: SPT Recovery: 0.45 m 22.10: HP Samp = 3 kPa

BOREHOLEBH1 TERMINATED AT 24.00 m

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH2
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517732.245, N: 6732324.802 (56 MGA94) | SURFACE ELEVATION : 5.239 (AHD) | ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER :
DATE STARTED : 27/9/09 | DATE COMPLETED : 27/9/09 | DATE LOGGED : 27/9/09 | LOGGED BY : RT | CHECKED BY : RT

DRILLING: Progress – Drilling & Casing: HW Casing (0.0–8.0 m); Drilling Penetration: E; Ground Water Levels: 27/09/09, 8.45am

Depth (m)	Samples & Field Tests	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
0.0			AC			ROAD SURFACE
– 0.70m		GP	GRAVEL			
0.70m – 1.00m		SM	SILTY SAND: brown			
1.00m – 2.50m	1.00m SPT 6, 6, 5 N=11 1.45m	SM	SILTY SAND: brown, fine grained sand, low plasticity	D	D	2.20: Increasing clay in auger
2.50m – 4.00m	2.50m SPT 1, 1, 1 N=2 2.95m	ML	SANDY SILT AND CLAYEY SILT: pale orange brown, low plasticity, with rootlets up to 1mm. Silty sandy clay in auger.	M	F	
4.00m – 5.50m	4.00m SPT 4, 6, 7 N=13 4.45m		4.00 - 4.20m: Clay/silty clay: brown with mottled orange brown, high plasticity 4.20 - 4.40m: Sand, pale brown, medium grained with trace of silt.	M	St - VSt; MD	4.00: Plumbed tape - no free water at 4.00m 4.20: HP Samp = 2 - 3 kPa
5.50m – 7.00m	5.50m SPT 2, 0, 0 N=0 5.95m	SP	SAND: grey brown, fine grained sand, with silt Top: Sand with clay/clayey sand, grey brown, fine grained.	W	VL	5.50: Sand in Auger - very wet, bottom of Auger
7.00m – 7.50m	7.00m U75 7.40m	CH	CLAY: grey, high plasticity	M - W	F	7.10: HP Samp = 1 kPa 7.40: Hammer weight
7.50m – 8.0	7.40m SPT 0, 0, 0 N=0 7.85m	CH	CLAY /SILTY CLAY: grey, high plasticity, with silt, with snail/shell and rootlets	W	S	7.50: Shells to 5mm wide

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH2
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517732.245, N: 6732324.802 (56 MGA94) SURFACE ELEVATION : 5.239 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER :
DATE STARTED : 27/9/09 DATE COMPLETED : 27/9/09 DATE LOGGED : 27/9/09 LOGGED BY : RT CHECKED BY : RT

DRILLING: Progress (Drilling & Casing)	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Classification Symbol	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	STRUCTURE & Other Observations
HW Casing (to 10.20)				8.05m U75	8.0	CH	CLAY /SILTY CLAY: grey, high plasticity, with silt, with snail/shell and rootlets *(continued)*	W	S	8.60: HP Samp = 1 kPa
				8.90m	8.90m		Clay with silt - S to A			
				9.00m SPT 0, 0, 0 N=0 9.45m	9.0	CH	CLAY /SILTY CLAY: grey, high plasticity, with silt, with fine gravel, and sand. Trace of shell fragments. With roots to 2mm.	W	S	9.00: Hammer 9.70: Increasing stiffness
				10.00m SPT 0, 3, 4 N*=7 10.45m	10.00m	CH	CLAY: pale grey, high plasticity	W		10.00: SPT Recovery: 0.15 m 10.10: HP Samp = 1 kPa 10.20: Casing driven to 10.20m to stop silty clay collasping
				11.50m U75	11.50m	CH	CLAY: grey with orange brown, high plasticity, trace fine gravel, trace sand	M - W	F - St	
		E		11.90m SPT 5, 5, 8 N*=13 12.35m	12.0		Silty clay: pale grey, high plasticity with lenses of fine gravel stained orange brown. Fine grained sand and lenses of stiff clay.	M - W	F - St	11.90: SPT Recovery: 0.45 m 12.00: HP Samp = 1 kPa
				13.00m SPT 5, 10, 13 N=23 13.45m	13.0	CH	Clay: pale grey with orange brown staining, with some rootlets and some EW orange brown gravels to 4mm.	M	F - St	13.10: HP Samp = 3 kPa
				14.50m SPT 6, 8, 13 N=21 14.95m	14.0–16.0		Clay: pale grey with some orange brown staining, high plasticity, with trace of EW gravel.	M - W	F - St	14.60: HP Samp = 1 kPa
					16.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH2
FILE / JOB NO : 4054/1
SHEET 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517732.245, N: 6732324.802 (56 MGA94) | SURFACE ELEVATION : 5.239 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER

DATE STARTED : 27/9/09 | DATE COMPLETED : 27/9/09 | DATE LOGGED : 27/9/09 | LOGGED BY : RT | CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
				16.10m SPT 4, 5, 9 N*=14 16.55m	16.0			16.00 - 16.30m Clay: pale grey, high plasticity, trace of silt and fine sand. Some lenses of fine sand. Trace of rootlet.	M	VSt	16.10: SPT Recovery: 0.34 m
								16.30 - 16.35m Sandy clay, pale grey, high plasticity 16.30 - 16.45m Sandy clay to sand. 16.33 - 16.40m Sand with clay/clayey sand, pale grey, medium plasticity. 16.40 - 16.45m Sand with silt, brown, non-plastic.		St	16.35: HP Samp = 2 kPa
					17.0						
				17.50m SPT 11, 13, 16 N*=29 17.95m	17.50m			SAND: pale and dark grey bands, fine to medium grained sand, low plasticity, with silt, trace clay, increasing clay content towards 17.950m. Tip: 30mm clayey sand.	W	MD	17.50: SPT Recovery: 0.45 m
					18.0						
				19.00m SPT 4, 3, 7 N*=10 19.45m	19.0			Clay and clayey silt interbedded: pale grey, high plasticity. Clayey silt lenses - 50 -100mm thick.	M - W	F - St	19.00: SPT Recovery: 0.45 m; HP in clay 19.10: HP Samp = 2 kPa 19.20: HP Samp = 1 kPa
		E			20.0		SP				
				20.50m SPT 5, 9, 9 N*=18 20.95m				Clay with silt: pale grey, orange brown stains, high plasticity. With lenses of EW fine gravel heavily stained of orange red. With silty clay lenses.			20.50: SPT Recovery: 0.45 m 20.60: HP Samp = 3 kPa
					21.0					VSt	
				22.00m SPT 6, 9, 10 N*=19 22.45m	22.0			22.00m CLAY: pale grey, orange brown, high plasticity, with silt, with silty clay lenses and lamination.	M		22.00: SPT Recovery: 0.45 m 22.10: HP Samp = 2 kPa
					23.0		CH			St - VSt	
					24.0			24.00m BOREHOLEBH2 TERMINATED AT 24.00 m			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 1 OF 4

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94) SURFACE ELEVATION : 5.172 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN
DATE STARTED : 23/9/09 DATE COMPLETED : 24/9/09 DATE LOGGED : 23/9/09 LOGGED BY : JT CHECKED BY : RT

DRILLING

PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS
AD/T (0.0–2.50 m)	N/A (0.0–2.50 m)	H (0.0–0.30 m)	
		E-F (0.30–0.80 m)	
		H (0.80–0.90 m)	
RR (2.50–8.0 m)	0% LOSS (2.50–8.0 m)	E (0.90–8.0 m)	25/09/09 (approx. 4.8 m)

SAMPLES & FIELD TESTS
1.00m SPT 5, 3, 3 N*=6 1.45m
2.50m SPT 1, 1, 1 N*=2 2.95m
3.20m SPT 3, 3, 3 N*=6 3.65m
4.20m SPT 2, 6, 7 N*=13 4.65m
5.20m SPT 1, 1, 2 N*=3 5.65m
6.20m SPT 0, 0, 0 N*=0 6.65m
7.20m SPT 0, 0, 0 N*=0 7.65m

MATERIAL

DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
0.0–0.30m		ROAD PAVEMENT			ROAD SURFACE
0.30m–0.70m	GW	SANDY GRAVEL / GRAVELLY SAND: brown, fine to coarse gravel, fine to coarse grained sand	D		FILL
0.70m–0.80m					
0.80m–1.20m	SW	GRAVELLY SAND: red brown, fine to coarse grained sand			0.80: NW= 3.2m NW= 11.5m 1.00: SPT Recovery: 0.45 m
1.20m–1.80m	ML	SANDY SILT / SILTY SAND: dark brown, non plastic, fine grained sand			possibly TOPSOIL 1.20: Natural Topsoil Layer? possibly TOPSOIL
1.80m–2.80m	ML	SANDY SILT: pale brown, low plasticity, fine grained sand			ALLUVIUM 2.50: SPT Recovery: 0.45 m
2.80m–3.20m	CI	SILTY CLAY: brown, medium plasticity			
3.20m–4.00m	SM	SILTY SAND: Brown, fine grained sand, clay % present also		L	3.20: SPT Recovery: 0.45 m
4.00m–4.35m	SM	SILTY CLAY: orange brown, pale blue grey, medium plasticity		St	4.20: SPT Recovery: 0.45 m 4.30: HP Samp =196 kPa
4.35m–5.10m	SM	SILTY SAND: brown, fine grained sand Becoming coarse grained with depth	M	MD	
5.10m–8.0	ML	CLAYEY SILT: grey, low plasticity, some organic material present			5.20: SPT Recovery: 0.45 m 5.50: HP Samp =50 kPa
		SILTY CLAY: dark grey, high plasticity		S / F	6.20: SPT Recovery: 0.45 m; * SPT penetrated 0.45m on weight of SPT hammer 6.50: HP Samp =50 kPa
		CLAY: as above except decrease in silt %. Also some shells present			7.20: SPT Recovery: 0.45 m 7.30: HP Samp =50 kPa 7.54: * SPT penetrated 0.45m on weight of drill rods only

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 2 OF 4

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94)	SURFACE ELEVATION : 5.172 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD	DRILLER : T. MARTIN
DATE STARTED : 23/9/09	DATE COMPLETED : 24/9/09	DATE LOGGED : 23/9/09	LOGGED BY : JT / CHECKED BY : RT

DRILLING: PROGRESS — DRILLING & CASING: RR; WATER: 0% LOSS; DRILLING PENETRATION: E

DEPTH (m)	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
8.0	8.20m SPT 0, 0, 0 N*=0 8.65m		CLAYEY SILT: grey, low plasticity, some organic material present *(continued)*		S / F	8.20: SPT Recovery: 0.45 m 8.30: HP Samp =50 kPa 8.52: * SPT penetrated 0.45m on rod weight only
9.0	9.20m SPT 0, 0, 0 N*=0 9.65m	ML	SANDY SILTY CLAY: dark grey, medium to high plasticity, fine and medium grained sand		F	9.20: SPT Recovery: 0.45 m 9.30: HP Samp =78 kPa 9.50: * SPT penetrated 0.45m on hammer weight.
10.0	10.20m SPT 0, 5, 6 N*=11 10.65m		CLAY: dark grey, high plasticity (note: material increasing in strength from 10.30m)			10.20: SPT Recovery: 0.45 m 10.50: HP Samp =196 - 290 kPa
11.00m	11.20m SPT 4, 4, 8 N*=12 11.65m		SANDY SILTY CLAY: yellow brown, pale grey mottled, low to medium plasticity, fine grained sand		St / VSt	11.20: SPT Recovery: 0.45 m 11.50: HP Samp =190 - 200 kPa
12.0			Note: boundary uncertain	M		
	12.20m U50 12.60m SPT 4, 5, 9 N*=14 13.05m	CL-CI	CLAY: pale grey, high plasticity			12.50: HP Samp =245 - 294 kPa 12.60: SPT Recovery: 0.45 m 13.00: HP Samp =290 kPa
14.0	14.00m SPT 3, 6, 8 N*=14 14.45m		CLAY: pale grey, red brown and yellow brown mottled, some silty sandy layers present, high plasticity, fine and medium grained sand		VSt	14.00: SPT Recovery: 0.45 m 14.25: HP Samp =245 kPa
15.0	15.25m SPT 4, 6, 9 N*=15 15.70m		CLAY: pale grey high plasticity			15.25: SPT Recovery: 0.45 m 15.50: HP Samp =294 - 343 kPa
16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 3 OF 4

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94)	SURFACE ELEVATION : 5.172 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD / DRILLER : T. MARTIN
DATE STARTED : 23/9/09	DATE COMPLETED : 24/9/09	DATE LOGGED : 23/9/09 / LOGGED BY : JT / CHECKED BY : RT

DRILLING: PROGRESS — DRILLING & CASING: RR; WATER: 0% LOSS; DRILLING PENETRATION: E; GROUND WATER LEVELS: —

Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
	16.0	CL-CI	SANDY SILTY CLAY: yellow brown, pale grey mottled, low to medium plasticity, fine grained sand *(continued)*	M	VSt / H	
16.75m SPT 5, 10, 13 N*=23 17.20m	17.0					16.75: SPT Recovery: 0.45 m 17.00: HP Samp =343 - >400 kPa
	17.75m	SC	CLAYEY SAND: pale grey, yellow brown, fine and medium grained sand			
18.25m U50	18.0 / 18.20m	ML	CLAYEY SILT: pale grey with some yellow brown, low plasticity, trace fine grained sand		VSt	18.50: HP Samp =245 kPa
18.65m SPT 3, 5, 9 N*=14 19.10m	19.0					18.65: SPT Recovery: 0.45 m
19.75m SPT 3, 5, 8 N*=13 20.20m	20.0		SILTY CLAY: pale grey and brown, medium plasticity, trace fine grained sand		St	19.75: SPT Recovery: 0.45 m 20.00: HP Samp =147 kPa
21.25m SPT 4, 6, 9 N*=15 21.70m	21.0 / 22.0		as above except High Plasticity		VSt	21.25: SPT Recovery: 0.45 m 21.50: HP Samp =343 kPa
22.75m SPT 2, 5, 7 N*=12 23.20m	23.0		SILTY SANDY CLAY: pale grey and orange brown mottled, medium plasticity, some fine grained sand		St	22.75: SPT Recovery: 0.45 m 23.00: HP Samp =118 kPa
	24.0 / 24.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 4 OF 4

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94) | SURFACE ELEVATION : 5.172 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : T. MARTIN

DATE STARTED : 23/9/09 | DATE COMPLETED : 24/9/09 | DATE LOGGED : 23/9/09 | LOGGED BY : JT | CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% LOSS	E		24.25m SPT 3, 6, 7 N=13 24.70m	24.0		CI	SILTY CLAY: dark grey with some orange brown mottled, medium plasticity (24.75m)	M	VSt	24.25: SPT Recovery: 0.45 m 24.50: HP Samp =245 - 294 kPa
					25.0			BOREHOLEBH3 TERMINATED AT 24.75 m Note: A second hole was drilled to do Vane Shear Testing: See Log Sheet BH: 3A			
					26.0						
					27.0						
					28.0						
					29.0						
					30.0						
					31.0						
					32.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH3A
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : 1.3m Sth of BH:3

POSITION : E: 517748.036, N: 6732333.908 (56 MGA94) SURFACE ELEVATION : 5.235 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN

DATE STARTED : 25/10/09 DATE COMPLETED : 25/10/09 DATE LOGGED : 25/10/09 LOGGED BY : JT CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0						
					1.0			Note: For material description see BH:3			
					2.0						
					3.0			Vane Shear Test (VST) Vane = 65/130mm			
					4.0						
					5.0						
				5.65m In-situ VS P>63kPa							
					6.0						6.00: H.P. = 68 KPa
				6.55m In-situ VS P=43kPa R=6kPa							
					7.0					S	
				7.35m In-situ VS P=34kPa R=6kPa						S	
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : 1.3m Sth of BH:3

HOLE NO : BH3A
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

POSITION : E: 517748.036, N: 6732333.908 (56 MGA94)	SURFACE ELEVATION : 5.235 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD	DRILLER : T. MARTIN
DATE STARTED : 25/10/09	DATE COMPLETED : 25/10/09	DATE LOGGED : 25/10/09	LOGGED BY : JT
CHECKED BY : RT			

DRILLING | MATERIAL

PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0						
				8.10m In-situ VS P=33kPa R=7kPa						S	
				8.40m U75 8.80m						S	8.70: H.P. = 69 KPa
					9.0						
				9.10m In-situ VS P=54kPa R=9kPa							
				10.00m In-situ VS P=54kPa R=21kPa	10.0						
				11.00m In-situ VS P>63kPa	11.0						
					12.0			Note: material onwards too stiff for Vane Shear Testing		F	
					13.0						
					14.0						
					15.0						
					16.0			BOREHOLEBH3A TERMINATED AT 16.00 m			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Cane Paddock

HOLE NO : BH4
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

POSITION : E: 517775.668, N: 6732330.415 (56 MGA94) | SURFACE ELEVATION : 3.161 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : T. MARTIN

DATE STARTED : 30/9/09 | DATE COMPLETED : 30/9/09 | DATE LOGGED : 30/9/09 | LOGGED BY : JT | CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
ADT (0.0–3.0)	N/A				0.0	ML	CLAYEY SANDY SILT: dark brown, fine, low to medium plasticity, fine grained sand			TOPSOIL
						ML	As above except brown & medium plasticity			
					1.00m	CI	SILTY CLAY: pale grey, orange brown mottled, medium plasticity	M	H	1.00: HW= 2.7m
				1.50m SPT 3, 6, 6 N=12 1.95m		CI				1.50: SPT Recovery: 0.45 m
					2.30m	SP	SAND: pale grey, fine and medium grained sand		L	
RR (3.0–8.0)	0% Polymer LOSS	E	30/09/09, drilled to 3.1 m	3.00m SPT 2, 1, 1 N*=2 3.45m		SP	As above except orange brown	W		3.00: SPT Recovery: 0.45 m
					3.20m	SC	CLAYEY SAND: grey, fine and medium grained sand		VL	
				3.70m SPT 0, 0, 0 N*=0 4.15m	3.50m	ML	CLAYEY SILT: dark grey, low plasticity, trace fine grained sand			3.70: SPT Recovery: 0.45 m; 3.91: SPT penetrated on weight of SPT hammer; 4.10: HP Samp =50 kPa
				4.35m In-situ VS P=[illegible] R=[illegible] 36						
				5.35m In-situ VS P=[illegible] R=[illegible] 5.[illegible] 31.5 U75 6.00m	5.00m	CI	SILTY CLAY: dark grey, medium plasticity		S	
							Some shells present			6.00: HP Samp =50 kPa
				6.35m In-situ VS P=[illegible] R=8kPa 24.5						
				7.35m In-situ VS P=[illegible] R=12kPa 34 7.70m U75	7.20m	CI	CLAY: pale blue grey, some yellow brown mottled, high plasticity			
							Only 80mm of U75 sample recovered			7.90: HP Samp =98 kPa
					8.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Cane Paddock

HOLE NO : BH4
FILE / JOB NO : 4054/1
SHEET 2 OF 2

POSITION : E: 517775.668, N: 6732330.415 (56 MGA94) SURFACE ELEVATION : 3.161 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN
DATE STARTED : 30/9/09 DATE COMPLETED : 30/9/09 DATE LOGGED : 30/9/09 LOGGED BY : JT CHECKED BY : RT

DRILLING

PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)
RR	0% Polymer LOSS	m		8.35m [illegible] >63	8.0 – 15.65
				8.70m SPT 5, 9, 12 N*=21 9.15m	
				10.70m SPT 4, 7, 9 N*=16 11.15m	
				12.20m SPT 4, 5, 9 N*=14 12.65m	
				13.70m SPT 4, 5, 6 N*=11 14.15m	
				15.20m SPT 8, 12, 26 N*=38 15.65m	

Depth scale: 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0

MATERIAL

Depth	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
8.00	CH	SILTY CLAY: pale grey and orange brown mottled, high plasticity	W	VSt / H	ALLUVIUM 8.70: SPT Recovery: 0.45 m 9.00: HP Samp =350 - >=400 kPa
10.70		As above - Predominently pale blue grey		VSt	10.70: SPT Recovery: 0.45 m 11.00: HP Samp >294 kPa 12.20: SPT Recovery: 0.45 m 12.50: HP Samp =245 - 294 kPa
		As above			
13.70		As above		St / VSt	13.70: SPT Recovery: 0.45 m 14.00: HP Samp =196 - 245 kPa
14.20m	SM	SILTY SAND: pale grey, fine and medium grained sand, some coarse grain present			
14.80m	CH	SILTY CLAY: orange brown and pale grey, high plasticity		St	15.20: SPT Recovery: 0.45 m 15.40: HP Samp =196 kPa
15.50m	CI	SANDY CLAY: pale grey, medium plasticity, fine and medium sand		VSt	15.60: HP Samp =245 - 294 kPa
15.65m		BOREHOLEBH4 TERMINATED AT 15.65 m			

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH5
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517709.412, N: 6732323.863 (56 MGA94) SURFACE ELEVATION : -4.741 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 7/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : MP CHECKED BY : RT

Samples & Field Tests	Depth (m)	Graphic Log	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
	0.0			BARGE			
	1.0			WATER			
				ROCK BOULDERS			
	5.90m		CI	SILTY CLAY: pale brown, medium plasticity, slightly sandy	M		
6.40m SPT 3, 4, 5 N*=9	6.40m		CI	SILTY CLAY: yellow brown, medium plasticity, with sand	M		6.40: SPT Recovery: 0.45 m
6.85m 6.90m U75 7.30m	6.70m		CI-CH	CLAY: pale blue grey, medium to high plasticity 7.2m: with ironestone bands, mottled grey brown	M	St	7.30: HP Samp =180 kPa
	8.00m						

Drilling columns: Progress (Drilling & Casing, Water), Drilling Penetration, Ground Water Levels. Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH5
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517709.412, N: 6732323.863 (56 MGA94)	SURFACE ELEVATION : -4.741 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD / DRILLER : Joel Wright
DATE STARTED : 7/10/09 / DATE COMPLETED :	DATE LOGGED :	LOGGED BY : MP / CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
				8.90m U75 9.30m	8.0 – 9.30m		CI	CLAY: mottled red brown grey, medium plasticity, with ironstone gravel		St VSt	8.90: HP Samp =300 kPa
				10.00m SPT 5, 9, 11 N*=20 10.45m; 11.50m U75 11.90m	9.30m – 12.50m		CI	CLAY: grey mottled red brown, medium plasticity, with ironstone gravel	M	MD	10.00: SPT Recovery: 0.45 m 10.10: HP Samp =340 kPa 11.90: HP Samp =350 kPa
				13.00m SPT 5, 7, 9 N*=16 5, 9, 13 N=19 13.45m; 13.70m	12.50m – 14.20m		SC	SAND: pale brown grey, fine grained sand, medium plasticity, with clay		MD	13.00: SPT Recovery: 0.45 m
				14.50m SPT 6, 6, 9 N*=15 14.95m; 16.00m	14.20m – 16.00m		CI	SILTY CLAY: pale grey mottled brown, medium plasticity, with fine sand		St VSt	14.50: SPT Recovery: 0.45 m

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:01 8.30.003 Datgel CPT Tool gINT Add-In

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH5
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517709.412, N: 6732323.863 (56 MGA94) SURFACE ELEVATION : -4.741 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 7/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : MP CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
				SPT 5, 9, 10 N*=19 16.45m	16.0		CI	SILTY CLAY: pale grey mottled brown, medium plasticity, with fine sand, and ironstone gravel	M	VSt	16.00: SPT Recovery: 0.45 m
				17.50m SPT 6, 9, 12 N*=21 17.95m	17.0–18.0						17.50: SPT Recovery: 0.45 m
				18.90m SPT 2, 7, 9 N*=16 19.35m	19.0						18.90: SPT Recovery: 0.45 m
					20.0			20.20m			
							CH	CLAY (MARINE CLAY): dark grey and brown grey, high plasticity, with silt	M	VSt	
				20.40m SPT 6, 8, 11 N*=19 20.85m				20.50m			20.40: SPT Recovery: 0.45 m
					21.0		CH	CLAY (MARINE CLAY): grey, high plasticity			
				21.90m SPT 4, 5, 9 N*=14 22.35m	22.0					St	21.90: SPT Recovery: 0.45 m
					23.0			23.20m			
				23.20m SPT 6, 10, 12 N*=22 23.65m			CH	CLAY: grey, high plasticity, with silt		VSt	23.20: SPT Recovery: 0.45 m
								23.65m BOREHOLEBH5 TERMINATED AT 23.65 m			
					24.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH6
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517767.757, N: 6732391.579 (56 MGA94) | SURFACE ELEVATION : -3.873 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 8/10/09 | DATE COMPLETED : 8/10/09 | DATE LOGGED : 8/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			DECK			
					1.0			WATER			
					2.0						
					3.0						
					4.0						
RR	20% Polymer LOSS	F		4.60m			CI	SANDY CLAY: dark grey, very soft	M	VS	FILL 4.60: SPT sunk under hammer weight
							4.80m				
		H		5.40m	5.0			SANDSTONE BOULDERS/COBBLES		H	5.40: SPT bouncing
					6.0						
					7.0		7.00m				
				7.50m SPT 2, 4, 4 N*=8 7.95m			CL	CLAY: pale blue grey and brown, low plasticity, with some fine gravel	M	F / St	
					8.0		8.00m				

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH6
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517767.757, N: 6732391.579 (56 MGA94) | SURFACE ELEVATION : -3.873 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 8/10/09 | DATE COMPLETED : 8/10/09 | DATE LOGGED : 8/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING: Drilling & Casing: RR; Drilling Penetration: F; Water: 0% Polymer LOSS (8.0–11.60m), 2% Polymer LOSS (11.60–13.30m), 0% Polymer LOSS (13.30–16.0m)

MATERIAL: Moisture Condition: M

Depth (m)	Samples & Field Tests	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Consistency / Relative Density	Structure & Other Observations
8.0–8.50m	VST	CL	CLAY: pale blue grey and brown, low plasticity		8.00: HV Samp P: 110 kPa
8.50–9.30m	8.50m SPT 2, 6, 7 N=13 8.95m	CL-CI	SANDY CLAY / CLAY: pale grey mottled, red brown, low to medium plasticity, with some fine gravel	St	
9.30–11.00m	10.10m U75 10.50m	CL-CI	SANDY CLAY: mottled red brown grey, low to medium plasticity, with ironstone gravel	VSt	10.50: HP Samp =350 kPa
11.00–11.80m	11.60m SPT 4, 7, 8 N=15 12.05m	CI-CH	CLAY: pale grey to brown grey, medium to high plasticity	St - VSt	
11.80–13.30m	13.10m SPT 7, 11, 15 N*=26 13.55m	SP	SAND: pale brown, fine to medium grained sand	MD	
13.30–14.50m		CH	CLAY: pale grey mottled yellow brown, high plasticity	VSt	13.50: HP Samp = 320 kPa
14.50–16.00m	14.60m SPT 5, 5, 8 N*=13 15.05m	CL-CI	SILTY CLAY: pale grey mottled yellow brown, low to medium plasticity, with some fine sand	St	

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH6
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517767.757, N: 6732391.579 (56 MGA94) SURFACE ELEVATION : -3.873 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 8/10/09 DATE COMPLETED : 8/10/09 DATE LOGGED : 8/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
RR	5% Polymer LOSS	F		16.10m U75 16.50m	16.0	CL-CI	SILTY CLAY: yellow brown and grey, low to medium plasticity	M	St	16.50: HP Samp =150 kPa
				17.50m SPT 5, 8, 11 N*=19 17.95m	17.0–18.0		with some fine sand			
				18.90m SPT 2, 4, 5 N*=9 19.35m	18.60m	CL-ML	CLAYEY SILT / SILTY CLAY: pale brown mottled grey, low plasticity			
				20.40m SPT 4, 8, 7 N*=15 20.85m	20.00m	CL-CI	CLAY / SILTY CLAY: clay is pale and dark grey mottled brown, low to medium plasticity; clay is		St - VSt	
					20.85m		BOREHOLEBH6 TERMINATED AT 20.85 m			

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See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH7
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Byrons Lane Slip

POSITION : E: 517732.596, N: 6732347.651 (56 MGA94)	SURFACE ELEVATION : -3.852 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 3/10/09	DATE COMPLETED :	DATE LOGGED :	LOGGED BY : RT/MP	CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
HW Casing (0.0–5.3)					0.0			DECK			
					0.9			WATER			
ROTARY (5.3–8.0)	20-30% Polymer LOSS	H			5.3			BOULDERS/ SANDSTONE BLOCKS			
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH7
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Byrons Lane Slip

POSITION : E: 517732.596, N: 6732347.651 (56 MGA94) SURFACE ELEVATION : -3.852 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 3/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : RT/MP CHECKED BY : RT

DRILLING: Progress (Drilling & Casing: ROTARY; Water: 0% Polymer LOSS to 12.0 m, 10% Polymer LOSS 12.0–15.7 m)

Drilling Penetration	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
H		8.0–8.50		BOULDERS/ SANDSTONE BLOCKS *(continued)*			
	8.90m U75 9.30m	8.50–9.50	CI	CLAY: pale grey, medium plasticity; with ferrigious sandstone fragments with geotextile pieces	M	St	FILL; 9.30: HP Samp = 300 kPa
	10.30m SPT 3, 7, 9 N=16 10.75m; 11.60m U75; 12.00m SPT 5, 6, 9 N=15 12.45m	9.50–12.10	CH	CLAY: pale grey, high plasticity		VSt	10.30: HP Samp = 200 kPa; 12.00: HP Samp =265 kPa
F		12.10–13.00	CL	SANDY CLAY: pale grey mottled, yellow brown, low plasticity		St / VSt	
	13.50m SPT 9, 11, 14 N=25 13.95m	13.00–14.60	SC	CLAYEY SAND: pale grey mottled yellow, fine grained	M	MD	
	15.00m SPT 5, 7, 8 N=15 15.45m	14.60–15.70	CL-CI	SANDY CLAY: pale grey brown mottled yellow, low to medium plasticity, with some silt		St / VSt	
		15.70–16.0	CH	CLAY: pale grey mottled yellow brown, high plasticity		VSt	

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH7
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Byrons Lane Slip

POSITION : E: 517732.596, N: 6732347.651 (56 MGA94) SURFACE ELEVATION : -3.852 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 3/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : RT/MP CHECKED BY : RT

DRILLING: PROGRESS Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Graphic Log	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
ROTARY		F		16.50m U75 16.90m	16.0–18.00		CH	CLAY: pale grey mottled yellow brown, high plasticity *(continued)*	M	VSt	
				18.00m SPT 4, 5, 6 N=11 18.45m	18.00–19.00		CI	SILTY CLAY: pale grey mottled yellow brown, medium plasticity		St	
				19.40m SPT 6, 8, 10 N=18 19.85m	19.00–20.90		CL	SANDY CLAY /CLAYEY SAND: pale grey to blue grey mottled yellow brown, low plasticity		VSt	
				20.90m SPT 4, 7, 8 N=15 21.35m	20.90–21.35		CI	CLAY (MARINE CLAY): dark grey, medium plasticity		St / VSt	
					21.35			BOREHOLEBH7 TERMINATED AT 21.35 m			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH8
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517748.614, N: 6732355.274 (56 MGA94) SURFACE ELEVATION : -5.496 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 11/10/09 DATE COMPLETED : DATE LOGGED : 11/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			BARGE			
					0.9			WATER			
				3.70m SPT 2, 3, 5 N=8 4.15m	3.70		GC	CLAYEY GRAVEL: brown	M	L	3.70: (slumped material)
				6.50m SPT 3, 4, 5 N=9 6.95m 8.00m	6.20m		CL	SANDY CLAY: pale grey to blue grey mottled brown, low plasticity, with fine gravel, with silt	M	St	
					8.00m						

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH8
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517748.614, N: 6732355.274 (56 MGA94) SURFACE ELEVATION : -5.496 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 11/10/09 DATE COMPLETED : DATE LOGGED : 11/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
				U75 8.40m	8.0		CI	SILTY CLAY: pale grey blue mottled red brown, medium plasticity, with ironstone gravel	M	St	8.40: HP Samp =180 kPa
				9.50m SPT 3, 4, 9 N=13 9.95m	9.0, 10.0						
				11.00m SPT 3, 6, 8 N=14 11.45m	10.50m, 11.0, 12.0		CI	CLAY: grey mottled red brown, medium plasticity, with ironstone gravel	M	St	12.40: HP Samp =240 kPa
				12.50m U75 12.90m	12.50m, 13.0		CL	SANDY CLAY / CLAYEY SAND: pale grey mottled pale brown, low plasticity, fine grained sand	M	VSt / MD	
				14.00m SPT 4, 6, 5 N=11 14.45m	14.00m, 14.0, 15.0		ML	CLAYEY SILT / SANDY SILT: pale grey and brown, low plasticity	M	St	
				15.50m SPT 3, 7, 6 N=13 15.95m	16.00m, 16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH8
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517748.614, N: 6732355.274 (56 MGA94) | SURFACE ELEVATION : -5.496 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 11/10/09 | DATE COMPLETED : | DATE LOGGED : 11/10/09 | LOGGED BY : MP | CHECKED BY : RT

SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
	16.0	ML	CLAYEY SILT / SANDY SILT: pale grey and brown, low plasticity	M	St	
17.00m U75 17.40m	17.00m	CL-CI	SILTY CLAY pale grey brown, low to medium plasticity	M	VSt	17.40: HP Samp =260 kPa
18.50m SPT 3, 5, 10 N=15 18.95m; 20.00m SPT 2, 5, 7 N=12 20.45m	18.50m	ML	CLAYEY SILT: pale grey and brown, low plasticity, with some fine sand; with some clay layers	M	St / VSt; St	
21.50m	21.00m	CI-CH	CLAY (MARINE CLAY): dark grey, medium to high plasticity, with some silt	M	St	
21.95m SPT 4, 7, 7 N=14 22.40m	21.95m		BOREHOLEBH8 TERMINATED AT 21.95 m			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH9
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517755.045 N: 6732369.932 (56 MGA94) | SURFACE ELEVATION : -4.079 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 9/10/09 | DATE COMPLETED : | DATE LOGGED : 9/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0		BARGE			
					0.9		WATER			
RR	20-30% Water LOSS	H			2.6		SANDSTONE BOULDERS/COBBLES			
				4.90m SPT 0, 1, 6 N=7 5.35m	4.90m		CLAY AND SANDSTONE COBBLES: clay is dark grey; grey white		F	4.90: Slumped material
	5-10% Water LOSS	E		5.90m SPT 0, 2, 1 N=3 6.35m	5.50m	CI	SILTY CLAY / COBBLES SANDSTONE: clay is dark grey, medium plasticity, with some sand; cobbles is	W	S	
				6.70m U75 7.10m; 7.10m [illegible] 34; 7.80m [illegible] 35	6.60m	CL-ML	CLAYEY SILT / CLAYEY SAND: silt is dark grey, low plasticity, trace gravel; sand is fine grained sand		S / VL	7.10: HP Samp =60 kPa
					8.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH9
FILE / JOB NO 4054/1
SHEET : 2 OF 3

POSITION : E: 517755.045, N: 6732369.932 (56 MGA94) | SURFACE ELEVATION : -4.079 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR NCD | DRILLER . Joel Wright

DATE STARTED : 9/10/09 | DATE COMPLETED : | DATE LOGGED : 9/10/09 | LOGGED BY : MP | CHECKED BY : RT

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DRILLING: Progress – Drilling & Casing	Progress – Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Classification Symbol	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	STRUCTURE & Other Observations
RR	0% Water LOSS	E		9.00m SPT 4, 5, 7 N=12	8.0 – 9.20m	CH	CLAY: pale grey, high plasticity	M	St	
		F		9.45m; 9.50m U75; 9.95m	9.20m – 11.00m	CH	CLAY: grey mottled red brown, high plasticity, with ironstone gravel to 9.5m		VSt	9.20: HP Samp =160 kPa 9.90 HP Samp =240 kPa
				11.00m SPT 3, 5, 7 N=12; 11.45m	11.00m – 12.80m	CH	CLAY: pale grey, high plasticity		St	
	5-10% Water LOSS			12.50m SPT 8, 12, 21 N=33; 12.95m	12.80m – 14.00m	CI	SANDY CLAY pale grey, medium plasticity		H	
				14.00m SPT 5, 5, 7 N=12; 14.45m	14.00m – 15.20m	SC	CLAYEY SAND: grey, fine grained sand		MD	
				15.50m U75; 15.90m	15.20m – 16.0	ML	CLAYEY SILT: pale grey mottled yellow brown, low plasticity		VSt	15.90. HP Samp =260 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH9
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517755.045, N: 6732369.932 (56 MGA94) SURFACE ELEVATION : -4.079 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 9/10/09 DATE COMPLETED : DATE LOGGED : 9/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	5-10% Water LOSS	F			16.0 – 16.50m	ML	CLAYEY SILT: pale grey mottled yellow brown, low plasticity *(continued)*	M		
				17.00m SPT 5, 8, 11 N=19 17.45m	16.50m – 18.00m	CL-CI	SILTY CLAY: pale grey mottled yellow brown, low to medium plasticity		VSt	
				18.50m SPT 2, 3, 6 N=9 18.95m; 20.00m SPT 3, 2, 6 N=8 20.45m	18.00m – 21.00m	ML	CLAYEY SILT: pale grey mottled yellow brown, low plasticity, with some fine sand		St (18.0–20.0); F / St (20.0–21.0)	
				21.50m SPT 1, 3, 8 N=11 21.95m	21.00m – 21.95m	CI	CLAY: dark grey, medium plasticity, slightly silty		St	
					21.95m		BOREHOLEBH9 TERMINATED AT 21.95 m			

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH10
FILE / JOB NO 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517748.039, N: 6732333.899 (56 MGA94)		SURFACE ELEVATION : 5.232 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 29/9/09	DATE COMPLETED : 29/9/09	DATE LOGGED : 29/9/09	LOGGED BY : MP	CHECKED BY : RT

DRILLING: PROGRESS (DRILLING & CASING; WATER); DRILLING PENETRATION; GROUND WATER LEVELS; SAMPLES & FIELD TESTS; DEPTH (m)

MATERIAL: GRAPHIC LOG; CLASSIFICATION SYMBOL; MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components); MOISTURE CONDITION; CONSISTENCY RELATIVE DENSITY; STRUCTURE & Other Observations

Depth	Classification Symbol	Material Description	Structure & Other Observations
0.0		ASPHALT	ROAD SURFACE
0.30m		SANDY GRAVEL / GRAVELLY SAND: brown, (road base material)	FILL
1.00m	SM	SILTY SAND: brown	
1.30m	ML	SANDY SILT: dark brown, fine, low to non plasticity	1.30: Old Topsoil
1.70m	ML	SANDY SILT as above except brown	ALLUVIUM
2.50m	CI	SILTY CLAY: brown, fine, medium plasticity (Note: Material description not accurate due to no SPTs) (boundary uncertain due to augering) SAND: brown, fine and medium grained sand	2.50: HW=4.60m =5.60m
5.50m	SM	SILTY SAND: grey, fine to medium grained sand	
5.70m		SILTY CLAY: grey, some organic material present (Note: No material description due to continuous Vane Shear Tests. See BH3 log	

Drilling & casing: ADT (0.0–5.0 m); RR (5.0–8.0 m)

Water: N/A (0.0–5.0 m); 5% Water LOSS (5.0–8.0 m)

Drilling penetration: E-F (0.30–1.0 m); E

Ground water levels: 30/09/09 (approx. 4.2 m)

Samples & field tests:
6.40m In-situ VS P=[illegible]kPa R=[illegible]kPa 44 8.5
7.30m In-situ VS P=[illegible]kPa R=10kPa 32.5

Depth (m): 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH10
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

POSITION : E: 517748.039, N: 6732333.899 (56 MGA94)	SURFACE ELEVATION : 5.232 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD
DRILLER : Joel Wright		
DATE STARTED : 29/9/09	DATE COMPLETED : 29/9/09	DATE LOGGED : 29/9/09
LOGGED BY : MP	CHECKED BY : RT	

DRILLING: PROGRESS (DRILLING & CASING: RR; WATER: 5% Water LOSS); DRILLING PENETRATION: E; GROUND WATER LEVELS; SAMPLES & FIELD TESTS; DEPTH (m)

MATERIAL: GRAPHIC LOG; CLASSIFICATION SYMBOL; MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components); MOISTURE CONDITION; CONSISTENCY RELATIVE DENSITY; STRUCTURE & Other Observations

Depth (m)	Samples & Field Tests	Classification Symbol	Material Description	Consistency	Structure & Other Observations
8.0			SILTY CLAY: grey, some organic material present *(continued)*		
	8.25m In-situ VS P=[illegible] R=8kPa 33		(Note: No material description due to continuous Vane Shear Tests. See BH3 log		
9.0	9.30m In-situ VS P=[illegible] R=14kPa 49				
10.0	10.25m In-situ VS P=[illegible] R=23kPa 55		(Note: Vane Shear body started to slowly penetrate from 10.70m - stiffer material)		
	10.80m SPT 4, 8, 10 N=18		SILTY SANDY CLAY: greenish grey, fine grained sand, medium to high plasticity	VSt	10.90: HP Samp =294 kPa
11.05m		SC	CLAYEY SAND: pale grey, fine to medium grained sand	MD	
11.15m		CI-CH	SANDY CLAY: pale grey yellow brown mottled, fine, medium to high plasticity	VSt	11.20: HP Samp =[illegible] kPa
11.25m	11.25m		BOREHOLEBH10 TERMINATED AT 11.25 m		

12.0 13.0 14.0 15.0 16.0

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See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services NSW GOVERNMENT

File: 4054/1 BH10 2 OF 2

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH11
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517730.705, N: 6732373.388 (56 MGA94)	SURFACE ELEVATION : -7.934 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 12/10/09	DATE COMPLETED : 12/10/09	DATE LOGGED : 12/10/09	LOGGED BY : MP / CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
HW Casing	N/A				0.0			BARGE			
					0.9			WATER			
					1.0 – 8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH11
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517730.705, N: 6732373.388 (56 MGA94) | SURFACE ELEVATION : -7.934 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 12/10/09 | DATE COMPLETED : 12/10/09 | DATE LOGGED : 12/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING: PROGRESS – Drilling & Casing	DRILLING: PROGRESS – Water	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
HW Casing	N/A				8.0		WATER *(continued)*			
RR	0% Water LOSS	E		8.50m SPT 0, 0, 0 N=0 8.95m; 9.50m In-situ VS P=14kPa 31.5 R=7kPa; 10.00m In-situ UB P=kPa 80; 10.60m U75	8.50–10.70	CI	CLAY (MARINE CLAY): dark grey, medium plasticity, seashells, with fine sand & silt	M	S	
		F		11.00m	10.70–12.20	CL-CI	SANDY CLAY: pale grey mottled red brown, low to medium plasticity with fine ironstone gravel		VSt	11.00: HP Samp =380 kPa
	5-10% Water LOSS			12.00m SPT 5, 8, 9 N=17 12.45m	12.20–13.50		SAND: grey, fine to medium grained sand	W	MD	
				13.50m SPT 4, 6, 9 N=15 13.95m	13.50–15.00	ML	SANDY SILT: pale grey, low plasticity, with some clayey layers	M	St / VSt	
	0% Water LOSS			15.00m SPT 5, 8, 11 N=19 15.45m	15.00–16.0	CI	CLAY: pale grey mottled yellow, medium plasticity, with some silt and fine sand		VSt	

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Transport Roads & Maritime Services

File: 4054/1 BH11 2 OF 3

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH11
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517730.705, N: 6732373.388 (56 MGA94) SURFACE ELEVATION : -7.934 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 12/10/09 DATE COMPLETED : 12/10/09 DATE LOGGED : 12/10/09 LOGGED BY : MP CHECKED BY : RT

Drilling & Casing	Water	Drilling Penetration	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
RR	0% Water LOSS	F	16.50m SPT 5, 9, 12 N=21 16.95m	16.0–17.50	CI	CLAY: pale grey mottled yellow, medium plasticity, with some silt and fine sand *(continued)*	M	VSt	
			18.00m SPT 3, 4, 8 N=12 18.45m	17.50–19.20	CL-ML	SILTY CLAY / CLAYEY SILT: pale grey and brown, low plasticity, with fine sand	M	St	
			19.50m SPT 5, 6, 9 N=15 19.95m	19.20–21.10	CL-CI	CLAY: pale grey and brown, low to medium plasticity, trace silt, and fine ironstone gravel	M	St / VSt	
	10% Water LOSS		21.00m SPT 6, 6, 8 N=14 21.45m; 22.50m SPT 9, 13, 15 N=28 22.95m	21.10–23.95		SAND: pale brown and grey, fine to medium grained sand, with some clay	W	MD	
			23.50m SPT 8, 12, 21 N=33 23.95m			some river gravel	W	D	
				23.95m		BOREHOLEBH11 TERMINATED AT 23.95 m BOTTOM OF MARKER PIPE			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH12
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

POSITION : E: 517751.550, N: 6732366.995 (56 MGA94) SURFACE ELEVATION : -3.836 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 15/10/09 DATE COMPLETED : 15/10/09 DATE LOGGED : 15/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			TOP OF DECK			
					1.0			WATER LEVEL			
					1.25m			1.25m: BOTTOM OF DECK			1.50: - 13.0m: Steel Pipe
					3.70			SANDSTONE COBBLES / CLAYEY GRAVEL		L	3.70: - 13.0m: No sampling hole logged from cutting to the bottom of marker pole
					6.20m			SANDY CLAY		St	
					8.00m						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH12
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

POSITION : E: 517751.550, N: 6732366.995 (56 MGA94)	SURFACE ELEVATION : -3.836 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD
DRILLER : Joel Wright		
DATE STARTED : 15/10/09	DATE COMPLETED : 15/10/09	DATE LOGGED : 15/10/09
LOGGED BY : MP	CHECKED BY : RT	

DRILLING: PROGRESS - DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0			SILTY CLAY		St	
					8.50m			SILTY CLAY			
					10.50m			CLAY		St	
					12.50m			SANDY CLAY / CLAYEY SAND			
					13.00m			BOREHOLEBH12 TERMINATED AT 13.00 m BOTTOM OF MARKER POLE			

Depth scale: 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517745.042, N: 6732357.755 (56 MGA94) SURFACE ELEVATION : -2.137 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 14/10/09 DATE COMPLETED : 14/10/09 DATE LOGGED : 14/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			TOP OF DECK			
					1.0			WATER			
					1.25m			1.25m: BOTTOM OF DECK			1.80: - 9.0m: Steel Pipe
					2.0			SANDSTONE BOULDERS / COBBLES			2.00: - 9.0m: No sampling hole logged from cuttings to install marker pole
					5.50m			SILTY CLAY			
					6.50m			CLAYEY SILT		S	
					8.00m						

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517745.042, N: 6732357.755 (56 MGA94) SURFACE ELEVATION : -2.137 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 14/10/09 DATE COMPLETED : 14/10/09 DATE LOGGED : 14/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0			CLAY		St	
					9.0			9.00m BOREHOLEBH13 TERMINATED AT 9.00 m BOTTOM OF MARKER POLE			
					10.0						
					11.0						
					12.0						
					13.0						
					14.0						
					15.0						
					16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH14
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

POSITION : E: 517735.446, N: 6732346.598 (56 MGA94) | SURFACE ELEVATION : -5.545 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 13/10/09 | DATE COMPLETED : 13/10/09 | DATE LOGGED : 13/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			TOP OF DECK			
					1.0			WATER			
					1.25m			bottom of deck TOP OF MARKER POLE			1.30: - 9.2m: Steel Pipe
					5.40			CLAY: (slumped?)			5.40: - 9.2m: No sampling hole logged from cuttings to install marker pole
					6.60m			BOULDERS / COBBLES			
					7.50m			CLAY		St	
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH14
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

POSITION : E: 517735.446, N: 6732346.598 (56 MGA94)	SURFACE ELEVATION : -5.545 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 13/10/09	DATE COMPLETED : 13/10/09	DATE LOGGED : 13/10/09	LOGGED BY : MP / CHECKED BY : RT

DRILLING: PROGRESS - DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0			CLAY *(continued)*			
								8.30m			
								CLAY		St	
					9.0						
								9.20m			
								BOREHOLEBH14 TERMINATED AT 9.20 m			
					10.0						
					11.0						
					12.0						
					13.0						
					14.0						
					15.0						
					16.0						

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:04 8.30.003 Datgel CPT Tool gINT Add-In

See Explanatory Notes for details of abbreviations & basis of descriptions.

Appendix M Comments Register

		REVIEW REPORT
	Slope No:	**File No:**	**Objective ID:**
	Project Name: Byrons Lane Slip No. 2 Big River Way	**Preparer:** SMEC

Project Number	**Document Title**	**Issue Status**	**Issue No**	**Issue Date**
	80% Geotechnical Interpretive and Design Options Report	80%	01	13/10/2021

Item	**Date** [DD-MMM-YY]	**Reviewer**	**Page No / Section**	**Reviewer Comment** *(DD/MM/YY: Subsequent comments)*	**Consultant Response** *(DD/MM/YY: Response to Reviewer comments)*	**Closeout** [DD-MMM-YY]
1.	27/10/2021	S Yau	General	Technically it's a road embankment slip or riverbank slip, not a landslide	Agreed, SMEC to revert to slip terminology.	

2.	27/10/2021	S Yau	Section 5.4.1	1) Refer to Table 5-3. For clarity please discuss how the design parameters compared with the design parameters adopted in Slip 1. 2) Residual strength of soft clay (unit 3a/4a/4b) appears high. Pl.ease clarify and justify	1) The geotechnical design parameters adopted for concept design compared to the parameters adopted for Slip 1: • Pavement – same parameters adopted. • Embankment Fill – increased friction angle (from 30 to 34 degrees) and lower young's modulus (from 15 to 7) adopted. • Soft Alluvium – similar parameters adopted; friction angle increased by 1 degree, effective cohesion reduced by 1 to 2 kPa. Youngs modulus increased by 1MPa. • Firm/stiff Alluvium - similar parameters adopted; friction angle increased by 1 degree, effective cohesion reduced by 2 kPa. Youngs modulus increased by 2 MPa. • Stiff/very stiff Alluvium - same parameters adopted. The shear strength parameters were adjusted as part of slope stability back-analysis. 2) The residual effective shear strength parameters (friction angle = 17 degrees and cohesion =0 degrees) are the same. Peak and Residual undrained shear strength values measured from Vane Shear tests in BH12 and BH13: (see table below) The residual shear strength values are typically higher than	

	Depth m	Peak kPa	Residual kPa	NOTE
BH12	6.1	68	41	in-situ VS
	6.7	68	27	in-situ VS
	7.4	32	13.5	sample VS
	8.9	48	15	sample VS
	10.4	177	45	sample VS
BH13	8.9	45	18	sample VS
	11.9	113	45	sample VS

Resolved by:	Action 'I' = Design Engineer's Information contained in Response Action 'R' = Comments addressed in Design Report or Document (e.g. Plan, Specification, Tech Memo, Audit) Action 'D' = Comment addressed by Design drawing revision and re-issue	Closeout:	Record date of closeout by Reviewer/Approver. Responsible designer to seek closeout of all comments prior to submission of revised design.

Item	Date [DD-MMM-YY]	Reviewer	Page No / Section	Reviewer Comment *(DD/MM/YY: Subsequent comments)*	Consultant Response *(DD/MM/YY: Response to Reviewer comments)*	Closeout [DD-MMM-YY]
					values obtained from investigations for the previous Slip 1.Therefore a lower 12 kPa value has been adopted for design.	
3.	27/10/2021	S Yau	Section 6.1	Please elaborate how an abandoned water main could contribute to current embankment slip	The abandoned watermain was noted in the SRA report and included in the concept design report for completeness. SMEC consider that the abandoned water main is unlikely to have contributed to the slip. However, additional comments have been included in the report seeking additional information on the location and size of the abandoned watermain which could be important to know for piling.	

Resolved by:	Action '**I**' = Design Engineer's Information contained in Response Action '**R**' = Comments addressed in Design Report or Document (e.g. Plan, Specification, Tech Memo, Audit) Action '**D**' = Comment addressed by Design drawing revision and re-issue	Closeout:	Record date of closeout by Reviewer/Approver. Responsible designer to seek closeout of all comments prior to submission of revised design.

4.	27/10/2021	S Yau	Sections 8.2 and 8.3 Appendix A Option 1A and Option 1B	1) Refer to Table 8-2. Pending detailed design analysis, pile deflections currently presented are much higher than allowable 1/200 of retaining height. Please clarify 2) It is unclear how and what drainage measures can be placed behind sheet pile wall. Besides sheet pile wall may not be able to retain water due to gaps between steel sheets. 3) Option 1A has a design retaining height of 3.5 m as compared to 4 m for Option 1B. Please clarify 4) Why sheet piles of Option 1B are proposed further away from Option 1A sheet piles by about 3 m? 5) Need to elaborate and devise on how to monitor steel corrosion 6) Refer to Table 8-4, please clarify why relatively high pile deflections (> 1/200 H) were resulted even with use of a deadman anchor/tieback system 7) Refer to SLOPE/W outputs. For clarify please remove fill colour of slip circles 8) Please confirm if FEM will be used to aid pile wall detail design for added confidence	1) Based on the WALLAP analyses it appears that the cantilever sheetpile deflections will exceed H/200 criteria. (17.5mm). 2) A drainage aggregate layer wrapped in geotextile and incorporating a perforated subsoil drainage pipe could be installed behind the wall. Alternately, weep holes with removable filter drains could be installed through the face of the sheet pile wall to dissipate water pressures behind the wall. Reliance on the gaps between the sheetpiles is not recommended as they could become blocked by debris and corrosion. 3) The retained height was calculated from the assumed long-term scour profile grade 3.5H:1V. Option 1B has the sheetpiles positioned closer to the river which results in the higher retained height. 4) Option 1B seeks to restore the slumped embankment and provide a smoother transition between the retaining wall and adjacent riverbanks. 5) Sheet pile thickness would need to be monitored periodically, say every 3 to 5 years to compare corrosion rates against design assumptions. Sheet pile thickness can be measured using ultrasonic gauges. Localised excavation would likely be required in front of the sheet piles to enable measurements to be undertaken within the tidal zone where corrosion rate are expected to be greatest. A corrosion monitoring and maintenance plan would need to be developed. Corrosion treatment could also be applied to the upper 7 m section of sheet piles to protect against corrosion in the critical zones. 6) The Table 8-4 deflections have been updated ignoring any deflections prior to installing the tie back anchors which may occur during construction. The pile deflections satisfy the H/200 criteria (20mm) for all but the highest elevated groundwater scenario (32mm). 7) Slope/W outputs have been removed from the appendices and an example Slope/W output has been	

Item	Date [DD-MMM-YY]	Reviewer	Page No / Section	Reviewer Comment (DD/MM/YY: Subsequent comments)	Consultant Response (DD/MM/YY: Response to Reviewer comments)	Closeout [DD-MMM-YY]
					amended and included in the report under Table 8-3. 8) FEM will be used during detailed design of the preferred solution.	
5.	27/10/2021	S Yau	Section 8.4 Option 2	1) Please clarify if a capping beam is required to tie all cast in place piles 2) Pending detailed design analysis, 17 m long pile appears excessive for a design retaining height of 3.5 m. 3) Please clarify if FEM will be used to aid pile wall detail design for added confidence	1) Whilst not necessary, a capping beam would be beneficial to restrain individual piles from displacement. 2) The piles need to be embedded within the stiff clay which commences at approximately 11 m depth below top of pile. The piles are also protecting against deeper seated slip surfaces. The detailed design would seek to refine pile lengths. 3) FEM analyses would be used to design piles during detailed design.	
6.	27/10/2021	S Yau	Section 8.5 Option 3	1) Refer to Table 8-6. Driven precast piles will also be subject to bending. Please include 2) Predicted pile head deflections not presented 3) Stability (sliding and overturning) of gabion wall needs to be checked	1) and 2) Detailed FEM modelling is required to assess bending moments and displacements for the shear piles. SMEC propose to undertake these analyses as part of detailed design. 3) The preliminary stability (sliding and overturning) has been assessed and comments and calculations included in the revised concept design report.	
~~7.~~	~~27/10/2021~~	~~S Yau~~	~~Section 8.6~~ ~~Option 4~~	~~1)~~		
8.	27/10/2021	S Yau	Section 8.7	1) Refer to Table 8-9. The criteria score range of 1 to 10 is too broad. Consider to use 1 poor to 5 excellent 2) Refer to Table 8-8, driveability of sheet piles/precast concrete piles (Options 3 & 4) needs to be considered carefully due to existing rockfill in river	1) Table 8-9 has been revised based on a 1 to 5 score range and comments added. 2) Noted and comments included in Table 8-8.	

Resolved by:	Action '**I**' = Design Engineer's Information contained in Response Action '**R**' = Comments addressed in Design Report or Document (e.g. Plan, Specification, Tech Memo, Audit) Action '**D**' = Comment addressed by Design drawing revision and re-issue	Closeout:	Record date of closeout by Reviewer/Approver. Responsible designer to seek closeout of all comments prior to submission of revised design.

Project Number	Document Title	Issue Status	Issue No	Issue Date
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Item	Date [DD-MMM-YY]	Reviewer	Page No / Section	Reviewer Comment *(DD/MM/YY: Subsequent comments)*	Consultant Response *(DD/MM/YY: Response to Reviewer comments)*	Closeout [DD-MMM-YY]
9.						
10.						
11.						
12.						
13.						
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15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.				**End of Comments**		

All comments closed out or transferred to a new form

Reviewer signature ....

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Date

Resolved by:	Action '**I**' Action '**R**' Action '**D**'	= Design Engineer's Information contained in Response = Comments addressed in Design Report or Document (e.g. Plan, Specification, Tech Memo, Audit) = Comment addressed by Design drawing revision and re-issue	Closeout:	Record date of closeout by Reviewer/Approver. Responsible designer to seek closeout of all comments prior to submission of revised design.

Member of the Surbana Jurong Group

SMEC INTERNAL REF. 30013154

Geotechnical Detailed Design Report Rev.02

Byrons Lane Slip, Big River Way, Tyndale Geotechnical Design

Client Reference No. 21.0000129127.1219

Prepared for TfNSW

27 July 2022

Document Control

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Project Number	30013154
Revision Number	02

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Revision No.	Date	Prepared By	Reviewed By	Approved for Issue By
01	06/06/2022	Mark Maharaj/ Omid Ghaffaripour	David Malorey	Mark Maharaj
02	26/07/2022	Mark Maharaj/ Omid Ghaffaripour	David Malorey	Mark Maharaj

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Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work, and is supplemented by knowledge of the local geology and experience of the range of properties that may exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely. Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities
- The actions of contractors responding to commercial pressures

If these occur, SMEC would be pleased to resolve the matter through further investigation, analysis or advice.

Logs of a borehole, recovered core, test pit, excavated face, or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling/observation spacing's and the ground conditions. It is not always possible or economic to obtain continuous high-quality data. It should also be recognised that the volume of material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

It should also be recognised that ground conditions can change over time (e.g. through drought, wet periods, snow/summer and disturbance after site investigation occurs). As such, ground information is only a representation of the site at a point in time and may change.

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

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Appendices

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1 Introduction

Transport for NSW (TfNSW) has engaged SMEC Australia Pty Ltd (SMEC) to design a slope remediation solution for an approximate 40 m long slip situated along Clarence River - South Arm, Big River Way, Tyndale, NSW.

The slip was identified by TfNSW representatives on 2 March 2021. The slip headscarp measured 2.5 m high and was setback approximately 5.5 m from the road edge line. Slope remediation treatment is required to be designed and constructed to prevent further regression of the slip.

In December 2021, SMEC submitted the 100% Concept Design Report (Rev.02, dated 07.12.2021), presenting four concept remediation options. Following review of the report and option, TfNSW advised SMEC to proceed with detailed design for Option 3 – Steel Shear Piles and Rock Fill.

This report presents the **Geotechnical Detailed Design Report** for the preferred slope remediation solution comprising steel shear piles and rock fill. It includes the following:

- Available Information
- Description of the Site
- Geotechnical Investigations
- Geological and geotechnical models
- Design criteria, load cases, design parameters, design assumptions and limitations
- Design methodologies
- Results of analyses
- Durability assessment
- Constructability, operation and maintenance considerations
- Safety in design register
- Schedule of quantities
- Detailed Design Drawings

This rev.02 design report includes the following additions:

- IFC drawing package incorporating TfNSW 100% detailed design review comments
- Additional Plaxis output presenting global factor of safety slip surface output included in Appendix E.
- Inclusion of a wedge of rock armour in front of the shear piles at the southern end of the site.

2 Available Information

- SMEC Geotechnical Detailed Design Report (Rev.06 – HW10 Pacific Highway Byrons Lane Slip – Stage 4, dated May 2014) .
- SMEC Stage 4 IFC Drawings (Ref. 30011433-DGT-0001 to 0300)
- SMEC 100% Geotechnical Interpretive and Design Options Report, dated December 2021.

- TfNSW 04 Scope of Services document
- TfNSW Geotechnical Investigation Factual Report (N20211031 Big River Way Slip on the Clarence River)
- TfNSW Draft PS331 Big River Way at Byrons Lane_Rev.1
- TfNSW SRA 20210309
- TfNSW Survey, dated 20210507

- AECOM Byrons Slip Corrosion Protection Final Report Rev 0

3 Site Information

3.1 Site Description and Locality

The slip site is situated along the outer, east bank of the Clarence River - South Arm, along Big River Way, Tyndale, NSW. Big River Way (formerly the Pacific Highway) is now a low volume, dual lane carriageway between Tyndale and Maclean. The 2 m to 2.5 m high road embankment is situated over a broad, flat, alluvial flood plain that is farmed for crops and has historically been modified by excavation of drainage channels and formation of access tracks.

Byrons Lane is located approximately 650 m southwest of the site and the Pacific Highway is approximately 500 m to the east. Refer to the site location map presented in Figure 3-1.

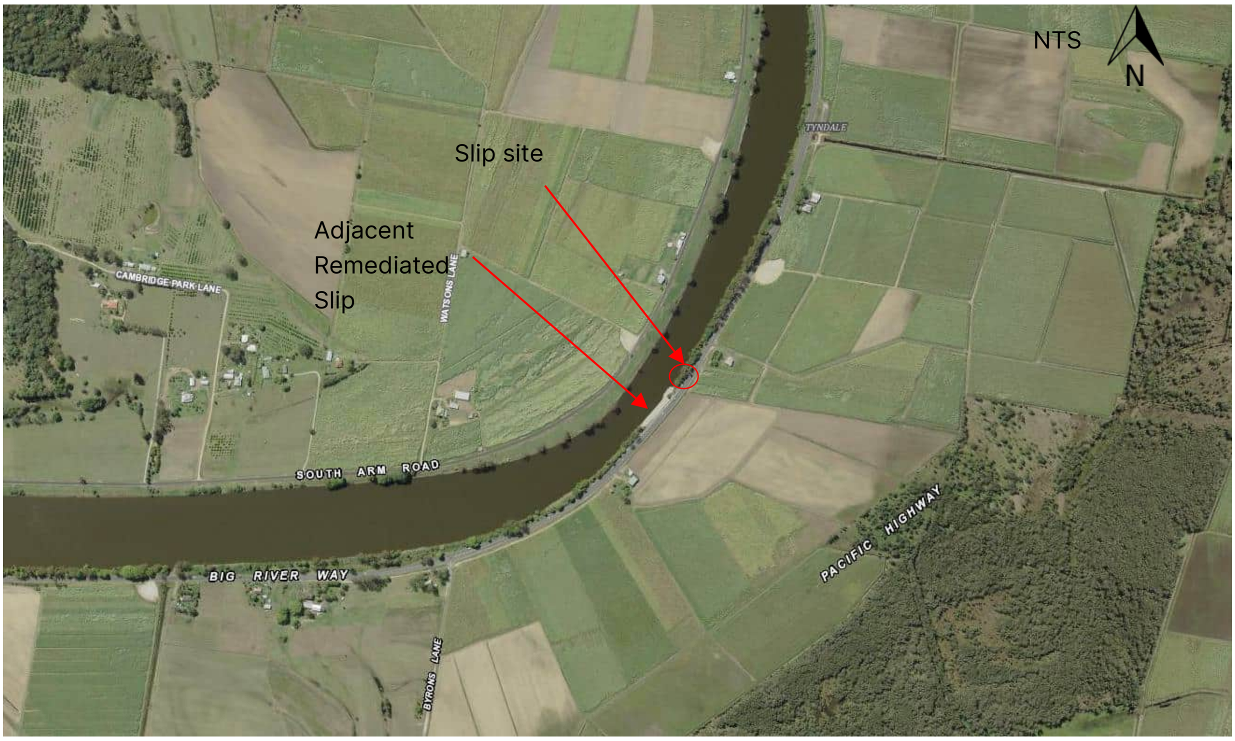


Figure 3-1 Site Locality Plan – Source: Six Maps, NSW (maps.six.nsw.gov.au)

The slip measures approximately 40 m in length and the headscarp is located within the shoulder, setback approximately 5.5 m from the edge line. Erosion and slumping of the headscarp comprising pavement and embankment fill materials has occurred. In some locations, the embankment fill materials have eroded back beneath the paving, creating cavities (refer Section 3.2 below).

The subject slip site adjoins a previously remediated slip that comprises rock fill, rock armouring, timber stabilisation piles and a buried sheet pile wall. Details of the previous slip are described in the Geotechnical Interpretive and Design Options report. Interfacing with the previously remediated slip site is discussed in later sections of this design report.

3.2 Site Observations

A geotechnical engineer from the SMEC Grafton office visited the slip site on 29 June 2021 and on 11 March 2022 to observe the extent of the slip.

Site observations in the form of annotated photographs are presented in Appendix B.

3.3 Geology

Reference to the NSW Department of Primary Industries, Grafton Area Coastal Quaternary Geology Map, 1:100,000 scale, describes the geology of the site as Holocene levee; fluvial sand, silt and clay.

From experience on the nearby Woolgoolga to Ballina Pacific Highway Upgrade, the Holocene sediments situated within the Clarence River floodplain are understood to comprise alluvial, estuarine and deltaic clays, silts and sand. The cohesive materials range from very soft to stiff consistency, are grey to dark grey in colour and typically overly stiffer Pleistocene deposits.

3.4 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are soils containing significant concentrations of pyrite, which when exposed to oxygen in the presence of sufficient moisture, oxidises, resulting in the generation of sulfuric acid. Unoxidised pyritic soils are referred to as potential ASS (PASS). When the soils are exposed, the oxidation of pyrite occurs and sulfuric acids are generated, at which stage the soils are said to be actual ASS (AASS).

Disturbance or poorly managed development and use of ASS can generate significant amounts of sulfuric acid, which can lower soil and water pH to extreme levels (generally pH <4) and produce acid soils, resulting in high salinity.

Reference to the published acid sulfate soil risk map geodatabase rates the site as a H4 - high probability of occurrence for acid sulfate soils below 3 m depth.

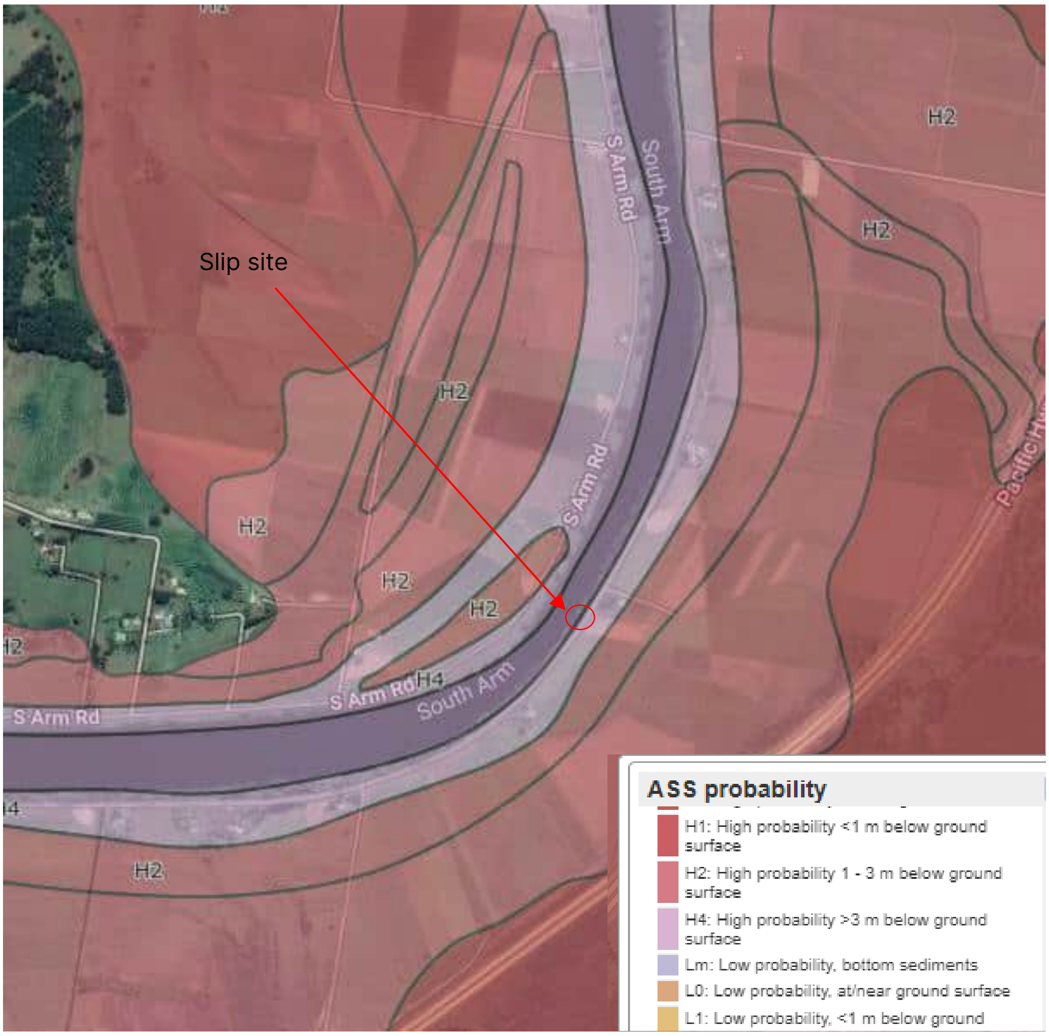


Figure 3-2 ASS Probability Map – Source: NSW Government SEED Map (https://geo.seed.nsw.gov.au/)

4 Geotechnical Investigations

4.1.1 2009 Investigations

Eleven boreholes were drilled in 2009 to investigate the adjacent slip site. Two holes (BH1 and BH2) drilled at either end of the failed section, three holes (BH3, BH4 and BH10) on the existing embankment and the remaining six holes drilled in the river.

Table 4-1 below provides a summary of the boreholes.

Table 4-1: Geotechnical Investigation Summary Data

Hole Number	Hole Surface RL* (m AHD)	Hole Depth^ (m)	Termination Strata	Water Table RL (m AHD)
BH1	5.143	24.00	very stiff Clay	2.04
BH2	5.239	24.00	very stiff Clay	0.54
BH3	5.172	24.75	stiff Clay	0.37

BH4	3.161	23.65	very stiff Clay	0.06
BH5	-4.741	18.05	very stiff Clay	-0.04
BH6	-3.873	16.35	stiff Clay	-0.27
BH7	-3.852	16.05	stiff Clay	0.55
BH8	-3.0	18.25	stiff Clay	-0.2
BH9	-1.8	19.35	stiff Clay	-0.1
BH10	5.232	11.25	very stiff Clay	1.03
BH11	-7.934	15.45	medium dense to dense Sand	-0.33

Note: * Hole Surface RL starts from any earth material including slumped rock fill which may differ from those on logs; ^ Hole Depth starts from Hole Surface RL.

Borehole logs are provided in Appendix J.

4.1.2 2021 Investigations

TfNSW conducted a geotechnical investigation comprising two boreholes (BH12 and BH13) at the subject slip site in April 2021. The results of the investigation are documented in the Geotechnical Factual Report Ref. N2021031, dated 07.06.2021, presented in Appendix J.

4.2 Laboratory Testing

4.2.1 Aggressivity Testing

One aggressivity test was carried out as part of the 2021 investigations on a soil sample (BH12: 7.0m – 7.45m depth, Silty Clay). Compared AS2159-2009, the results of the aggressivity test indicate a **non-aggressive** exposure classification for steel piles embedded in the soil.

4.2.2 Acid Sulfate Soils

One acid sulfate soil test was carried out on a soil sample (BH12: 5.5m – 5.95m depth, Sandy Clayey Silt). The laboratory test results were Net Acidity = 462 mol H^{+}/t. This exceeds recommended guidelines, triggering the need for an acid sulfate management plan if soil disturbance is proposed.

Laboratory test results are presented in the TfNSW the Geotechnical Factual Report Ref. N2021031, dated 07.06.2021, presented in Appendix J.

4.3 Interpreted Subsurface Conditions

4.3.1 Subsurface Conditions

The interpreted subsurface conditions are presented in Table 4-2 on the following page. The interpreted subsurface conditions are also presented on annotated cross sections and a long section; presented in Appendix C.

4.3.2 Detailed Design Parameters

SMEC has developed geotechnical design parameters utilising the available geotechnical investigation data, the adjacent slip remediation design, experience from the Woolgoolga to Ballina Pacific Highway upgrade project and SMEC pile foundation design guidelines. Effective shear strength parameters were also adjusted based on slope stability back-analysis and parameters are presented in Table 4-3.

4.3.3 Water Levels

4.3.3.1 Tidal Levels

Published tidal information for the Clarence River at Tyndale has been obtained from the NSW Public Works Manly Hydraulics Laboratory.

This data indicates an annual average Mean High Water Spring = RL0.35 m and Mean Low Water Spring = RL-0.108 m.

4.3.3.2 Groundwater Levels

Groundwater levels were measured in the following boreholes during geotechnical investigations by others.

- BH3: RL0.37 m
- BH4: RL0.06 m
- BH10: RL1.03 m
- BH13: RL-0.08 m

No longer term groundwater monitoring has been undertaken at the site. Groundwater levels are expected to fluctuate with changing climate and river levels. Consideration has been given to elevated groundwater levels within the embankment as part of the design.

Table 4-2: Summary of Subsurface Conditions

Unit No.	Unit	General Material Description	Depth (m)		RL (m AHD)	
			BH12	BH13	BH12	BH13
1	Pavement	200 mm thick Asphaltic Concrete over 300 mm to 400 mm Gravel layer.	0 to 0.5	0 to 0.6	4.93 to 4.43	4.92 to 4.32
2	Fill	Silty SAND, fine grained, medium dense relative density.	0.5 to 2.0	0.6 to 2.2	4.43 to 2.93	4.32 to 2.72
3a	Alluvium	Clayey SILT, low to medium plasticity; soft to firm consistency	2.0 to 3.4	2.2 to 3.5	2.93 to 1.53	2.72 to 1.42
3b		Silty CLAY, medium plasticity, with trace sand; firm consistency	3.4 to 5.0	3.5 to 5.0	1.53 to - 0.07	1.42 to -0.08
4a	Estuarine	Clayey SILT/CLAY, medium to high plasticity, some fine sand, trace shell fragments; soft consistency	5. 0 to 6.0	5. 0 to 8.0	-0.07 to -1.07	-0.08 to -3.08
4b		Silty CLAY, high plasticity, trace shell fragments; soft to firm consistency	6.0 - 9.5	8.0 – 11.0	-1.07 to -4.57	-3.08 to -6.08
4c		Silty CLAY, medium to high plasticity; stiff consistency	9.5 -16.2	11.0 – 17.0	-4.57 to -11.27	-6.08 to -12.08
5a	Alluvium	SAND, fine to medium grained, loose to medium dense relative density.	16.2 - 17.8	17.0 – 18.5	-11.27 to -12.87	-12.08 to -13.58
5b		CLAY, Sandy Clay, Silty Clay; medium to high plasticity, trace fine sand; stiff to very consistency	17.8 - 22.45 (EOH)	18.5 – 23.0	-12.87 to -17.52 (EOH)	-13.58 to -18.08
		Sandy SILT, stiff consistency	N.E.	23.0 – 23.95 (EOH)	N.E.	-18.08 to -19.03 (EOH)

Notes: NE = Not encountered, EOH = End of borehole

Table 4-3: Summary of Design Parameters

Unit /Material	Unit Weight γ' (kN/m^3)	Cohesion c' (kPa)	Friction Angle ϕ' (°)	Undrained Shear Strength c_u (kPa)	Youngs Modulus E'v (MPa)	Horizontal Modulus E'h (MPa)
1. Pavement – Gravel; dense	20	0	40	-	40	30
2. Fill – Silty Sand; medium dense	18	0	34	-	7	5
3a. Clayey Silt, soft to firm consistency	17	4	26	30	6	4.5
3b. Silty Clay; firm consistency	18	5	27	50	10	7.5
4a. Clayey Silt/CLAY; soft consistency	17	2	26	25	5	3.75
4b. Silty Clay; soft to firm consistency	17	4	26	30	6	4.5
4c. Silty Clay; stiff consistency	19	8	27	75	15	11
5a. Sand; loose to medium dense	18	0	33	-	8	6
5b. Clay, Sandy Clay, Silty Clay; stiff/very stiff consistency	19	10	27	100	20	15
Unit 3a/4a/4b - Soft Clay residual strength parameters along inferred failure surfaces	17	0	22	12	2.5	1.8
New Rock Fill/Rock Armour	18	0	40	-	40	30

5 Detailed Design

5.1 Design Criteria

5.1.1 Design Life

In accordance with the project brief, the remediation works are to achieve a minimum design life of 50 years.

5.1.2 Global Stability Factor of Safety

Reference to TfNSW technical Direction GTD 2018/001 | TfNSW 18.748 – "Geotechnical design for Remediation of Existing Slopes and Embankments" 22 February 2018, the recommended factors of safety (FOS) for different consequence classes are presented in Table 5-1.

Table 5-1 Factor of Safety (FOS) for different consequence class scenarios

Consequence Class	C1	C2	C3	C4	C5
Long Term FOS	1.5	1.4	**1.3**	1.25	1.25
Short Term FOS	1.25	1.25	**1.2**	1.2	1.2

In accordance with the contract, a long-term FOS of 1.3 and a short-term FOS of 1.2 has been targeted in design remediation for a Consequence Class C3 slope.

5.1.3 Design Loading

The following design loads have been considered for concept design:

1. 20 kPa vertical traffic live load applied to carriageway, breakdown lane and shoulder.
2. 10 kPa short term construction surcharge above slip
3. Variable short term, 30 + kPa vertical live loads to represent construction plant such as a piling rig or crane.
4. Groundwater is modelled at RL2m AHD inside the embankment and drops to RL0.3m (Mean High Water Spring) at river.

   Under rapid drawdown conditions associated with a flood, water levels are modelled at RL4.0m AHD inside the embankment and RL-0.1m AHD (Mean Low Water Spring) on the river side;
5. Sensitivity analyses has been carried out using the healed material shear strength properties ($c'=4$ kPa, $\phi'=26^{\circ}$) and residual shear strength parameters ($c'=0$ kPa, $\phi'=22^{\circ}$) for the inferred shear zone.
6. Seismic coefficient of 0.025 (horizontal) has been adopted for embankment stability analyses based on AS1170.4 as the Hazard Factor Z is 0.05 for the project site;

5.2 Design Methodology

The design of the steel shear pile and rock fill solution has adopted the following design methodology:

1. Review the interpreted ground model developed as part of the concept design.
2. Estimate the required pile size. Assess the lateral shear capacity that can be developed from the piles using the method by Viggiani (1981).
3. Model the stability of the slope remediation using SLOPE/W 2D limit equilibrium analysis software. Incorporating the shear resistance from the piles and the final remediation profile including rock fill and rock armouring. Analyse several combinations covering short term and long scenarios, traffic and construction surcharges. Compare the calculated FOS to the design criteria.
4. Model the proposed slope remediation in PLAXIS 2D finite element analyses software to assess deformations and structural actions (i.e. bending moments and shear forces) induced in the piles. Include short term and long term scenarios and anticipated construction staging.
5. Undertake structural capacity assessment of the proposed piles. Where piles are undersized, select larger size and repeat steps 3 to 6.
6. Assess durability of the proposed piles and detail recommended corrosion treatments.
7. Consider constructability of slope remediation including pile installation options.
8. Detail the transition zone treatments.

5.2.1 Stability Analysis

Stability analyses were performed using Slope/W software. Slope/W is proprietary software that adopts limit equilibrium theory to compute the factor of safety (FOS) of slopes. The stability was assessed using the Morgenstern-Price method.

Total stress analysis with undrained shear strength for clay materials has been used for design cases of short duration for which excess pore water pressure generated has no time to fully dissipate. Effective stress analysis with effective strength parameters for soil materials has been used for the design case with drained conditions.

The design bending moment was used as an input to the design spreadsheet based on the method by Viggiani (1981) with corrections by Chmoulian (2004). Based on Viggiani (1981), the shear plane is chosen at the interface of unstable soil layer and stable soil layer. In the design, the soft clay layer is considered as unstable soil layer and the firm to stiff clay layer is considered as stable soil layer.

5.2.2 Deformations and Soil-Structure Interaction

The proposed remediation has been modelled using Finite Element Method (Plaxis 2D software) to evaluate the following items:

- The induced deformations at critical locations (i.e. top of piles, the ground surface behind the piles, the Big River Way pavement).
- Structural actions mobilised along the piles.
- Controlling the integrity of the proposed remediation additional to conventional Slope/W models.
- Additional check on slope stability factors of safety.

5.2.3 Durability

SMEC has relied upon the 2010 durability and corrosion assessment report prepared for the steel sheet piles installed at the adjacent slip site. The corrosion assessment assumed the water to be brackish and predicted corrosion rates for steel sheet piles as discussed in Section 7.

For steel piles, the corrosion rates for various exposure zones were assessed and durability requirements comprising sacrificial steel, coating treatments and cathodic protection systems considered.

Further discussion on durability for the proposed shear piles alternatives is presented in Section 7.

5.2.4 Constructability

SMEC has obtained preliminary constructability advice from a piling contractor to assist with evaluating the relative merits of the alternate shear pile options.

The constructability advice is discussed in Section 9.

A preliminary driveability assessment has also been undertaken using the interpreted ground model and GRLWEAP analysis software. The results of this assessment are presented in Section 5.4.

5.3 Analyses and Results

5.3.1 Shear Pile Option Considered

SMEC has considered the following shear pile option to stabilise the slip:

- 310UC158 steel piles

5.3.2 Slope Stability Analyses

Two sections were selected for stability analysis:

- Section through the slip site
- Section through transition zone immediately north of the slip site

The calculated slope stability factors of safety for the various stability cases are summarised in Table 5-2 and the results of the analyses are presented in Appendix D.

The stabilising piles were modelled as pile reinforcements in Slope/W. The ultimate shear force used in Slope/W for the piles was calculated using an in-house spreadsheet based on Viggiani (1981) method with the piles embedded a minimum of 5 metres in to stiff clay; below the inferred shear plane.

The Viggiani method is restricted to 2-layer cohesive soils, i.e. above and below the slip surface. Six possible failure modes are considered, three in which the pile remains rigid and three in which the pile yields. The equilibrium equations for these six modes have been programmed into the spreadsheet. The most critical failure mode for any problem depends on the relative strengths of pile and soils and the lengths of pile embedded in the unstable and stable soil masses. Limiting soil stresses are calculated using bearing capacity factors. Bearing capacity factors of k=4.0 and k=8.0 were used for the unstable soil layer and the stable layer, respectively as suggested by Viggiani (1981). The critical failure mode is determined from a flowchart built into the spreadsheet.

Based on the analysis, ultimate shear force mobilised due to the soil pressure was calculated to be 100 kN per steel pile. These values were used in the slope stability analyses. Results of mobilised shear force assessment based on Viggiani method are presented in Appendix F.

Table 5-2: Summary of Slope Stability Analysis

Pile Type	Stability Case	Calculated FOS		Target FOS	Design Criteria Satisfied
		Slip zone (Section B-B)	Transition zone (Section C-C)		
12m long Steel H Pile @ 900mm centres	Long-term	1.37	1.50	1.3	Yes
	Short-term stage 1 piles installed	1.51	1.52	1.2	Yes
	Short-term stage 2 rockfill placement	1.29	1.48	1.2	Yes
	Seismic loading	1.28	1.37	1.2	Yes
	Flood with rapid draw-down	1.22	1.45	1.2	Yes

Note: The calculated factors of safety at the northern transition zone is where additional shear piles P1 to P6 are proposed. Immediately north of this zone, no slope treatment is proposed to the existing vegetated slope and the slope stability factors of safety are accordingly expected to be lower.

Short term – stage 2 rock armour and rock fill placement works will require excavation of benches to key the fill in to the existing slopes. To manage local embankment stability, this work should be undertaken in a staged excavation and backfill approach with the excavated width of the slope exposed at any stage limited to not more than 10 m, subject to on site geotechnical assessment and monitoring during construction.

5.3.3 Finite Element Analyses

A section through the slip zone was considered for FEM analysis in Plaxis 2D. The following construction sequence was modelled in Plaxis:

1. Initial stage – existing slope profile
2. Pile installation – no construction surcharges applied to slope assuming piles installed from barge. The design has assumed that no slope surcharge is applied without stabilisation piles first being installed. Any machinery required to remove rock obstructions from beneath the proposed pile footprint is also assumed to be operating from a temporary platform located behind previously installed piles.
3. Rock placement - rock fill/rock armour modelled behind piles to finished surface profile and a 10 kPa construction surcharge applied.
4. Short term case – undrained shear strength parameters and no scour to river bed in front of piles
5. Long term case – effective shear strength parameters and allowance for some nominal scour in front of piles. 20 kPa traffic surcharge applied.
6. Long term case – as per Stage 5, with corroded steel section properties. 20 kPa traffic surcharge applied.

A sensitivity assessment was carried out with fully healed shear strength parameters and residual shear strength parameters modelled. The main results from the PLAXIS 2D analysis are summarised in Table 5-3 and Plaxis 2D output is presented in Appendix E.

Table 5-3: Summary of FEM analyses

Pile Type	Sensitivity Case	Top of Pile Movement - Horizontal (mm)	Top of Pile Movement- Vertical (mm)	Pile Bending Moment (kN.m/pile)	Pile Shear Force (kN/pile)	Road Surface Movement - Horizontal (mm)	Road Surface Movement - Vertical (mm)
12m long Steel H Pile @ 900mm centres	Fully healed parameters	113	<10	188	94	47	60
	Residual strength parameters	125	<10	209	94	50	62

Factor of safety analysis was conducted in Plaxis 2D on the section at slip site using phi-c reduction approach to calculate FOS for short-term and long-term cases and to cross check with FOS obtained from the SLOPE/W limit equilibrium analyses. Summary of Plaxis FOS results and a comparison with Slope/W results is presented in Table 5-4.

It is noted that Plaxis and Slope/W follow completely different approaches to obtain FOS which accounts for the difference in FOS values reported in Table 5-4. FOS results from both approaches satisfy the design criteria.

Table 5-4 Summary of Plaxis 2D FOS analyses

Pile Type	Stability Case	Calculated FOS	
		Plaxis 2D	Slope/W
12m long Steel H Pile @ 900mm centres	Long-term	1.33	1.37
	Short-term stage 2 rockfill placement	1.46	1.29

5.4 Preliminary Driveability Assessment

SMEC has undertaken a preliminary driveability assessment. The results of the analysis using GRLWEAP software are summarised in the following table.

Table 5-5 Summary of GRLWEAP Drivability Assessment

Pile Width (mm)	Maximum Compression Stress (MPa)	Maximum Tension Stress (MPa)	Maximum Driving Energy Input (KJ)	Final Set (mm/blow)	Stroke (m)
310	170	88	27	10	1.2

The following assumptions were adopted for the driveability assessment:

- Unfactored soil strength parameters based on the available SPT numbers have been used drivability analyses. Any existing rock armour/rock fill has been ignored in the driveability assessment.
- Resistance during pile driving is derived primarily from shaft adhesion along the external perimeter of the pile plus a small end bearing on net area of the toe of the pile. Pile end bearing is considerably lower than the shaft adhesion.
- A Junttan 3T hydraulic hammer with 1.2m stroke has been adopted in the assessment.

- Manufacturer's default specifications contained in the GRLWEAP database have been used for both the hammer and the cushion.
- Hammer efficiency of 80% has been adopted.

The preliminary driveability assessment indicates the proposed steel piles can be installed to the target depths with a relatively small hydraulic hammer. The calculated maximum compression and tension stresses are less than 80% of the steel yield stress.

However, installation methodology, available hammers and the risk of encountering rock armour will need to be considered by prospective contractors and confirm that their methodology can install all the piles to the required depths and tolerances to achieve the requisite design criteria. Vibratory hammers have not been considered due to the risk of piles sinking under self-weight with vibratory installation techniques.

6 Scour and Transition Zone Treatments

6.1 Scour Treatment

From discussions with TfNSW representatives, SMEC understand that no specific scour assessment has been undertaken for this particular section of river. Therefore, rock fill and rock armour specifications generally consistent with the adjacent remediated site have been adopted.

Generally, no rock armour is proposed to be installed on the river side of the shear piles. This is consistent with TfNSW advice during concept design review whereby additional rock armour placement over existing steep river banks was not recommended without additional support. Instead, SMEC has made an allowance for up to approximately 2.2 m of scour in front of the piles (measured from top of piles) in the design. Notwithstanding this, scour depths in front of the piles will need to be monitored over the design life and there may be a need to install geotextile and rock armour treatment in front of the piles as part of longer term maintenance and monitoring.

Following detailed design review, TfNSW recommended a wedge of rock armour be placed at the southern end of the slip; in front of piles P37 to P47 to transition from the existing rock armour to no rock armour in front of the shear piles. The extent of the existing rock armour and the final location and extent of proposed new rock armour placement will need to be confirmed on site by survey.

To reinstate the slumped embankment, the larger size rock armour is proposed to be installed below RL2.0 m (within the tidal splash zone) and buttressing up against the shear piles. Smaller size rock fill is proposed to be installed above RL2.0 m where scour potential is expected to be relatively low.

6.2 Northern Transition Zone

The riverbank at the northern end of the slip is characterised by a narrowing terrace and a steeply inclined bank along the tidal splash zone. Within this location, additional shear piles (P1 to P6) are proposed to increase the slope stability factor of safety and to support additional rock armour and rock fill which are to be keyed in to the slope. The additional shear piles have been positioned to create a gentle taper to transition back towards the existing slopes. Beyond the shear piles, the stability of the existing riverbank slopes are expected to be marginal and there remains a risk that further slips could occur within these slopes. Geotechnical investigation and treatment to these adjacent existing vegetated slopes does not form part of the scope of this design report.

7 Durability

7.1 Exposure Classification and Corrosion Rates

Reference has been made to the 2010 durability and corrosion assessment report prepared for the steel sheet piles installed at the adjacent slip site. The corrosion assessment assumed the water to be brackish and predicted the following corrosion rates for steel sheet piles.

Table 7-1: Corrosion Rates for Steel Sheet Piles

Exposure Zone	Exposure Classification	Corrosion Rate (mm/ year)	Comment
In soil, above groundwater	Mild	0.01 – 0.02	AS2159 Exposure classification assessed from limited lab testing to be non-aggressive. However, given the different soil horizons and the possibility of sulfate reducing bacteria (SRB), this has conservatively been raised to “Mild” above groundwater.
In soil, in groundwater	Moderate	0.02 – 0.04	AS2159 Exposure classification assessed from limited lab testing to be mild. However, given the different soil horizons and the possibility of SRB, this has conservatively been raised to “Moderate” in groundwater.
In rock fill, atmospheric exposure	Medium	0.025 – 0.05	“Medium” (C3) as per AS 4312 (2008)
In rock fill, tidal Exposure	Very Severe	0.1	AS2159 Exposure classification “Very Severe” in seawater tidal/splash zone.
In rock fill, submerged	Severe	0.04	AS2159 Exposure classification “Severe” for piles submerged in seawater

The following table summarises the estimated corrosion losses per exposed face for untreated steel for a 50 year design life.

Table 7-2: Estimated Corrosion Rates Per Exposed Face

Exposure Zone	Exposure Classification	Assumed Corrosion Rates (mm / year)	Estimated 50 year Corrosion (mm)
In soil, above groundwater	Mild	0.02	1
In soil, in groundwater	Moderate	0.04	2
Atmospheric exposure	Medium	0.04	2
Tidal Exposure	Very Severe	0.1	5
Rock fill, submerged	Severe	0.04	2

The 50 year corrosion rates are for uniform corrosion only and don’t cover pitting corrosion or corrosion induced by sulfate reducing bacteria.

7.2 Corrosion Treatment

To achieve a 50 year design life, a combination of sacrificial steel and corrosion protection treatment is recommended for the steel piles.

The highest corrosion rates are expected to occur within the tidal splash zone where a total of 10 mm of uniform steel section loss is calculated. To delay the onset of corrosion in this critical zone, SMEC recommend the upper 4 m of each steel pile are be coated in Dulux GFX PC 256 High Performance Surface Tolerant Glass Flake Epoxy or an approved equivalent:

- 1st coat Zincanode 402 - 75 micron dry film thickness
- 2nd coat Duremax GFX - 250 micron dry film thickness
- 3rd coat Duremax GFX - 250 micron dry film thickness

This high-performance coating has good abrasion resistance and provides excellent protection. Where damage to the coating occurs on the exposed surfaces of the piles above water levels, patch repairs of the coating can be undertaken. The risk of damage to the coating system from driving through the weak alluvial sediments is difficult to assess but generally considered to be low; given that the uncoated, lower portions of the pile will penetrate the ground first.

The lower 8 m of pile will be embedded in stiff clay where corrosion rates are lower and will rely on sacrificial steel thickness to achieve the design life. Adopting a 2 mm corrosion per face (4 mm total corrosion loss) the 310UC158 section properties reduce to a smaller 310UC96.8 section. The 310UC96.8 section properties were modelled in the long term analyses presented in Section 5.3.

To provide resistance against corrosion and/or achieve a greater design life, consideration should be given to provision for installation of cathodic protection systems – by making the piles electrically continuous by welding adjacent the piles together. This can be done by tack welding an additional member along the top of adjacent piles after driving and then applying corrosion treatment to the exposed members and welds.

8 Traffic Barrier and Maintenance Access

The design includes a 20 m long extension to the existing Type F concrete road barrier and a 6.7 m long TL3 rated Quadguard-M10 crash cushion to be connected to the Type F barrier. A stainless steel dowel connection detail has been developed to connect the existing barrier to the proposed new slip formed barrier. The detail is presented in the design drawings.

The barrier and crash cushion extension have been positioned to allow for a 3.5 m wide vehicle maintenance access to the remediated slip site and a minimum 1.5 m offset between the road edge line and the crash cushion. Refer to the General Arrangement Plan presented in Appendix A for details.

The 3.5 m access bay width was adopted with reference to AS2890.2: 2018 - Table 4.1 – Service Bay Dimensions.

Austroads Guide to Road Design: Part 3 and Part 6 were referenced to confirm that the minimum 1.5 m offset between the barrier and the road edge line is acceptable for Big River Way for a 100 km/hr speed limit and a low AADT of less than 1000 vehicles per day.

9 Constructability

9.1 Anticipated Construction Sequence

The following construction sequence is assumed for the slope remediation.

1. Install sediment and environmental controls.
2. Set out and install stabilisation piles, commencing at the northern end of the site where the risk of encountering existing rock fill/rock armour obstructions is low. As per direction from TfNSW, piles are assumed to be installed from a barge.
3. Clear vegetation from slope face.
4. Excavate benches within the slumped landslide debris and batter the headscarp. To manage temporary stability, limit the width of slope to be benched to not more than 10 m at a time, subject to on site geotechnical assessment and slope stability monitoring.
5. Lay geotextile and place rock armour and rock fill to benched slope.
6. Repeat steps 4 and 5 until full extent of slope has been treated.
7. Construct extension to existing Type F barrier and install crash cushion.
8. Construct maintenance gate.

9.2 Pile Installation Considerations

SMEC consulted with a piling contractor to obtain information on constructability of driven piles along the riverbank. The preliminary advice relevant to steel piles obtained from the contractor is presented below:

- Barges & marine side installation: Large barges for even relatively smaller 30-50 Tonne piling plant are rare at present and difficult to obtain for 60-80 Tonne Kellybar Piling Rigs. Due to the alignment along the embankment, large barges could 'run dry' attempting to get as close to the piles as desired.

- As the alignment of the piles is along the embankment at the high tide line - cost of piling will be more economic from land. Even if some micropiles for working platform are required, or small segmented sheet pile temp sheets and 150mm rock working platform.

- The use of steel piles Is easily attained in a single 12 m spliced length (i.e. no expensive splicing/welding required) with conventional land based piling equipment. Will provide contractors with far more options of how to execute from land (e.g. excavator mount equipment, suspended hammers off cranes, etc).

Temporary working platforms will likely need to be designed with consideration given to bearing capacity and embankment stability to facilitate any land based piling operations at this site.

9.3 Utilities

A Dial Before You Dig enquiry was made for the site. The approximate location of the following services were identified:

- Power poles and overhead power located offset and parallel to the southbound lane.
- Buried telstra cable located offset and parallel to the southbound lane.
- Buried watermain located offset and parallel to the southbound lane.
- TfNSW has indicated the presence of an abandoned water main blanked off (disrupted by the previous failure) beneath the northbound carriageway.

The approximate indicative location of services are shown on the General Arrangement drawing.

The DBYD plans may not identify all underground services. On-site visual location of services by hand digging or pot holing is to be undertaken prior to beginning ground penetration works. Caution should be exercised when working in the vicinity of all utility services.

9.4 Construction Monitoring

9.4.1 Geotechnical Observation

The project presents geotechnical risks during construction that will require careful management by the contractor during the works. Geotechnical observation by a Site Geotechnical Representative (SGR) is recommended throughout the works to advise the contractor and to manage this geotechnical risk on behalf of the Principal.

Full time site geotechnical professional overview, preferably by the designer of the geotechnical aspects of the project, will reduce the risk of unexpected outcomes considerably. This is therefore recommended. Should the Principal not require this, then as a minimum we recommend specific geotechnical input be sought as follows:

- Review the contractor's construction methodology and quality control methodology prior to mobilising to site;
- Workshop the site risks with the contractor and Principal at the start of the project.
- Undertake review and release of hold points as per the construction staging in the specification.
- Conduct site visits to observe the site for signs of adverse movement such as cracking, subsidence, slumping; to assist in managing risk of further landslips.
- Observe, record and review earthworks and piling operations.
- On-call field advice as required to manage the potential cost of variations.

9.4.2 Temporary Stability

The site comprises a landslip with high risk of further instability encroaching back towards the Big River Way carriageway.

Slope stability analyses has been undertaken to assist with establishing vehicle exclusion zones during remediation works. The exclusion zones are depicted on the general arrangement drawing and described below.

- Zone 1 - Construction vehicle limitation zone: This area is road shoulder located close to the landslip and assessed to be high risk of instability. Avoid trafficking this area during the initial stages of site remediation; prior to pile installation. Following pile installation, excavators and light vehicles up to 20 kPa surcharge are permitted in this zone. Heavier plant up to 30 kPa are to maintain a 4 m setback from the slip headscarp.

- Zone 2 – Construct vehicle limitation zone: This area is road shoulder located further away from the landslip and above either previously remediated slopes or unfailed sections of slope. Light vehicles and excavators up to 20 kPa surcharge are permitted to access these areas.

Access in to exclusion zones may require temporary stability works to be designed and implemented, subject to prior consultation and review by the Designer and Principal.

9.4.3 Environmental Risks

The following environmental risks have been identified:

- Sediment runoff or loss of excavated material during construction into the Clarence River.
    - ➢ A silt curtain is expected to be required to contain mobilised soil particles from propagating any significant distance into the waterway.

- Generation of acid sulfate soils from disturbed soils may require an acid sulfate management plan to be implemented and followed.
    - Disturbed soils for this project are limited to excavation of benches in slopes to facilitate rock armour and rock fill placement and are typically limited to less than 1 m depth below existing ground level. The risk of encountering acid sulfate soils within these shallow depths are considered to be low. Some additional acid sulfate soil testing is recommended either prior to or during construction to verify.
- Flooding and surface water infiltration into the site during adverse weather events.
- Remediation works triggering landslips or slumps within embankment situated immediately to the north of the subject site.

10 Future Maintenance and Monitoring Considerations

SMEC recommend annual visual and survey monitoring of the remediated site for the first five years including following rainfall or high river level (flood) events. The survey monitoring should be carried out by suitably qualified personnel which may include engineers and/or surveyors. The inspections should include a documented assessment of the following:

- Detailed baseline survey of the site and new works immediately after construction.
- Ongoing survey of pavement, traffic barrier and shear piles to calculate displacements and compare with design estimates.
- Monitor, repair and sealing of cracks that may form in the shoulder as a result of settlement.
- Monitoring riverbank profile in front of shear piles. If scour causes retained heights to exceed 1.5 m in front of shear piles or loss of material from in between the shear piles, geotextile and rock armour should be placed in front of the piles to retain soil and maintain passive support to the shear piles.

11 Safety in Design

The Principal held a Health Safety in Design (HSID) workshop with the Contractor and Designer (i.e. SMEC) on 12 May 2022 to use a systematic risk based approach that includes the identification of hazards.

The updated safety in design register is presented in Appendix G.

The Contractor should be aware of:

- The site is a slip and stability is marginal.
- Providing a safe work area for construction personnel;
- Traffic management to provide safe passage past the site for road users;
- General safety issues with working on slopes, and how they are to manage these risks.
- Working on or adjacent to water

12 Schedule of Quantities

A schedule of quantities has been prepared by engineers, not quantity surveyors and are estimates. A qualified and appropriately experienced quantity surveyor should be engaged to evaluate quantities and costs more accurately for budgeting purposes and appropriate contingency allowed.

The schedules of quantities estimates are presented in Appendix H.

13 References

Alexander Y. C. 2004. “Briefing: Analysis of Piled Stabilisation of Landslides”. Geotechnical Engineering Volume 157, Issue GE2, pp. 55-56.

Viggiani, C. 1981. “Ultimate Lateral Load on Piles Used to Stabilize Landslides”. Proceeding. 10th I.C.S.M.F.E. 3, 555-560, Stockholm.

Appendix A Detailed Design Drawings

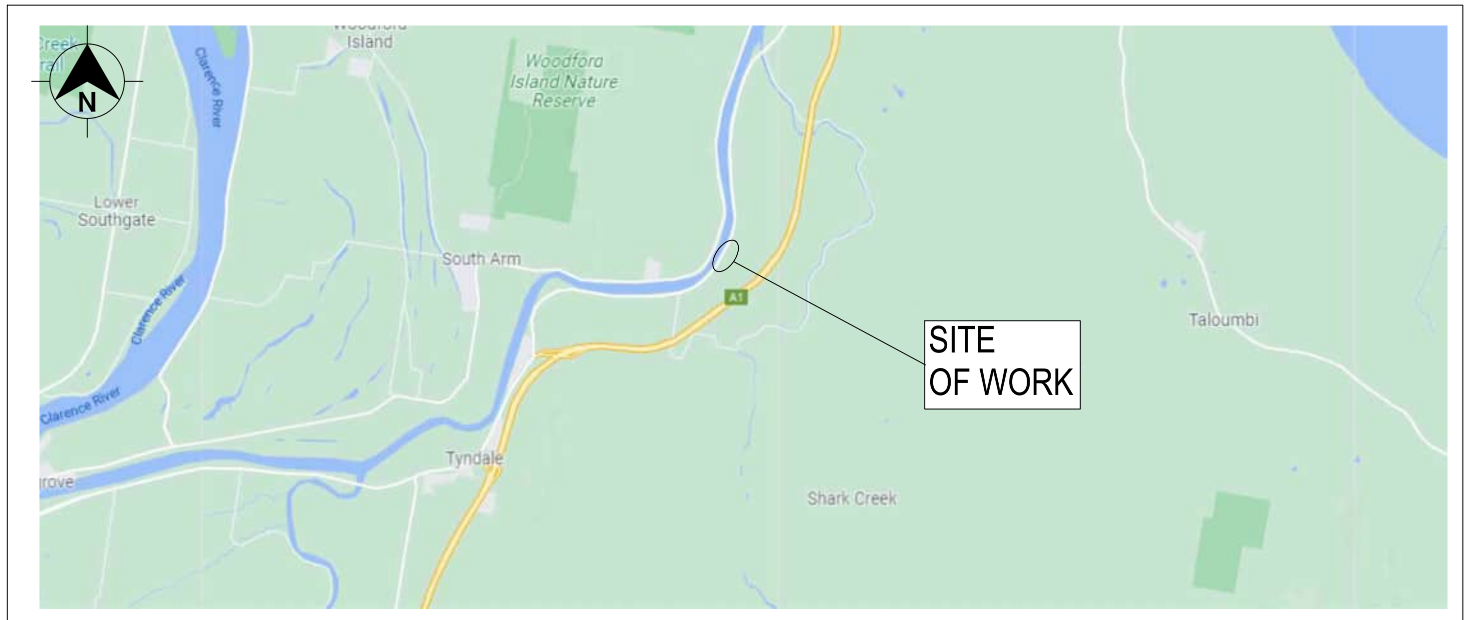
CLARENCE VALLEY COUNCIL

HW10 PACIFIC HIGHWAY

BYRONS LANE SLIP REMEDIATION

AT 33.49km TO 33.55km NORTH OF GRAFTON
PROPOSED RIVER BANK PERMANENT STABILISATION

ISSUED FOR CONSTRUCTION



LOCALITY PLAN

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SCHEDULE OF DRAWINGS

30013154-CD-GT-001	COVER SHEET
30013154-CD-GT-011	GENERAL NOTES - SHEET 1
30013154-CD-GT-012	GENERAL NOTES - SHEET 2
30013154-CD-GT-101	GENERAL ARRANGEMENT PLAN
30013154-CD-GT-201	CROSS SECTION - SHEET 1
30013154-CD-GT-202	CROSS SECTION - SHEET 2
30013154-CD-GT-203	CROSS SECTION - SHEET 3
30013154-CD-GT-301	DETAILS

THIS DRAWING MAY BE PREPARED IN COLOUR AND MAY BE INCOMPLETE IF COPIED

50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME
V:_Vault\Projects\3001\30013154\110_CADD\CAD\DWG\CI_Civil\30013154-CD-GT-001.dwg

LINEAR REFERENCING
START: 0000, 0000, XX, 00.000 FINISH: 0000, 0000, XX, 00.000

PLOT DATE / TIME: 26 July 2022 09:25:54 AM
PLOT BY: DK12753

CLIENT

PREPARED BY
SMEC
Member of the Surbana Jurong Group
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DESIGNED	REVIEWED	VERIFIED
NAME OMID GHAFFARIPOUR	NAME MARK MAHARAJ	NAME DAVID MALOREY
TITLE EXPERIENCED ENGINEER	TITLE ASSOCIATE GEOTECHNICAL ENG.	TITLE TECHNICAL PRINCIPAL
DATE 20.07.22	DATE 20.07.22	DATE 20.07.22

TFNSW PROJECT MANAGER
NAME IAN DRINKWATER
TITLE PROJECT MANAGER

VALIDATION AND ACCEPTANCE OF THESE DRAWINGS AND THE DESIGN SHOWN THEREON IS TO BE CARRIED OUT UNDER SEPARATE PROCESS

PREPARED FOR
NETWORK AND ASSETS MAINTENANCE AND DELIVERY PROJECT SERVICES NORTH

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

A3

TfNSW PROJECT No.	DESIGN PROJECT No.		
-	30013154		
TfNSW REGISTRATION No. DS2022 / 000311			PART 1
ISSUE STATUS: ISSUED FOR CONSTRUCTION	EDMS No.: -	SHEET No.: GT-001	ISSUE: A

GENERAL NOTES:

G1. THESE DRAWINGS SHALL BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DRAWINGS AND WITH SUCH OTHER WRITTEN INSTRUCTIONS AS MAY BE ISSUED.
G2. ANY DISCREPANCIES OR OMISSIONS SHALL BE REFERRED TO THE PRINCIPAL FOR A DECISION BEFORE PROCEEDING WITH THE WORK.
G3. ALL WORKMANSHIP AND MATERIALS SHALL COMPLY WITH THE APPROPRIATE CURRENT AUSTRALIAN STANDARDS, EXCEPT WHERE OTHERWISE SHOWN ON THE DRAWINGS.
G4. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
G5. DIMENSIONS SHALL NOT BE OBTAINED BY SCALING THE DRAWINGS.
G6. ALL SERVICES SHALL BE LOCATED AND DESIGN AMENDED, IF NECESSARY, PRIOR TO CONSTRUCTION.
G7. SETTING OUT DIMENSIONS SHALL BE VERIFIED ON SITE BY THE CONTRACTOR PRIOR TO CONSTRUCTION/FABRICATION, WHO SHALL BE RESPONSIBLE FOR THEIR CORRECTNESS.
G8. WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH ALL WORKCOVER REQUIREMENTS AND THE WORK HEALTH AND SAFETY ACT AND THE WORK HEALTH AND SAFETY REGULATION.
G9. ALL PROPRIETARY PRODUCTS ARE TO BE INSTALLED STRICTLY IN ACCORDANCE WITH MANUFACTURER'S WRITTEN RECOMMENDATIONS UNLESS NOTED OTHERWISE.
G10. ALL DISTURBED AREAS NOT SUBJECTED TO NEW WORKS SHALL BE REINSTATED TO THEIR EXISTING CONDITION BY THE CONTRACTOR AT THE COMPLETION OF WORKS TO THE SATISFACTION OF THE RESPONSIBLE AUTHORITY.
G11. THESE DRAWINGS DO NOT DETAIL TEMPORARY WORKS. CONSTRUCTION METHODS AND TEMPORARY WORKS ARE THE RESPONSIBILITY OF THE CONTRACTOR.
G12. THE DESIGN CERTIFICATION AND PERFORMANCE OF FORMWORK AND FALSEWORK SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR, AND SHALL BE CARRIED OUT IN ACCORDANCE WITH THE RELEVANT CODES.
G13. REDUCED LEVELS ARE TO AUSTRALIAN HEIGHT DATUM.
G14. THE FOLLOWING DESIGN LOADS HAVE BEEN CONSIDERED FOR DESIGN:
-20kPa VERTICAL TRAFFIC LIVE LOAD APPLIED TO CARRIAGEWAY, BREAKDOWN LANE AND SHOULDER,
-10kPa SHORT TERM CONSTRUCTION SURCHARGE ABOVE SLIP
-30kPa SHORT TERM CONSTRUCTION SURCHARGE SET BACK MINIMUM HORIZONTAL DISTANCE OF 4 M FROM SLIP HEADSCARP.

CONSTRUCTION SEQUENCE FOR SLOPE REMEDIATION:

THE FOLLOWING CONSTRUCTION SEQUENCE HAS BEEN ASSUMED FOR THE SLOPE REMEDIATION DESIGN. DEVIATION FROM THIS SEQUENCE MAY POTENTIALLY AFFECT THE LOADING ASSUMPTIONS AND SHALL BE SUBMITTED TO THE PRINCIPAL FOR REVIEW PRIOR TO COMMENCEMENT OF CONSTRUCTION. THIS CONSTITUTES A **HOLD POINT**.

CS1. INSTALL SEDIMENT AND ENVIRONMENTAL CONTROLS. THIS CONSTITUTE A **HOLD POINT**.
CS2. SETOUT AND INSTALL STABILISATION PILES, COMMENCING AT NORTHERN END OF SITE. THIS CONSTITUTES A **HOLD POINT**. ASSUMPTION IS THAT PILES ARE INSTALLED FROM BARGE TO AVOID SURCHARGING UNSTABLE SLOPE WITH HEAVY PLANT.
CS3. CLEAR VEGETATION FROM SLOPE.
CS4. EXCAVATE BENCHES WITHIN THE SLUMPED LANDSLIDE DEBRIS AND BATTER HEADSCARP. THIS CONSTITUTE A **HOLD POINT**.
CS5. LAY GEOTEXTILE AND PLACE ROCK FILL AND ROCK ARMOUR TO SLOPE. THIS CONSTITUTES A **HOLD POINT.** ASSUMPTION IS THAT CS4. AND CS5. OCCUR SEQUENTIALLY WITH NOT MORE THAN 10 M WIDTH OF SLOPE EXCAVATED AT ANY STAGE AND SUBJECT TO ON-SITE GEOTECHNICAL ASSESSMENT BY THE SGR.
CS6. CONSTRUCT EXTENSION TO EXISTING TYPE F BARRIER AND INSTALL CRASH CUSHION.
CS7. CONSTRUCT MAINTENANCE GATE

ROCK FILL AND ROCK ARMOUR

R1. ROCK FILL AND ROCK ARMOUR SHALL COMPRISE CLEAN, FRESH, ANGULAR ROCK WITH A MINIMUM POINT LOAD STRENGTH INDEX Is(50) = 1MPa, WET\DRY STRENGTH VARIATION NOT EXCEEDING 35%. ALL OTHER REQUIREMENT FOR ROCK FILL CONFORMING TO R44 SPECIFICATION WITH GRADING AS PER BELOW.
R2. ROCK FILL MINIMUM PARTICLE SIZE 0-5% PASSING 100mm SIEVE, D_{50} = 250mm, MAXIMUM PARTICLE SIZE 500mm.
R3. ROCK ARMOUR MINIMUM PARTICLE SIZE 700mm, MAXIMUM PARTICLE SIZE 1000mm, MINIMUM THICKNESS 700mm.
R4. SEPARATION GEOTEXTILE TO BE PLACED BETWEEN EXISTING SLOPE AND PROPOSED ROCK FILL AND ROCK ARMOUR. LAID LOOSE AND WITH MINIMUM 500mm LAP BETWEEN SHEETS REQUIRED TO ACCOMMODATE DEFORMATION. SEPARATION GEOTEXTILE TO BE CLASS E AND TO COMPLY WITH TfNSW R63 SPECIFICATION. MAXIMUM ROCK DROP HEIGHT MUST NOT EXCEED 1.0m TO AVOID DAMAGING GEOTEXTILE.

GEOTECHNICAL NOTES:

GE1. SGR = SITE GEOTECHNICAL REPRESENTATIVE.
GE2. GEOTECHNICAL DESIGN IS BASED ON AN INTERPRETED GROUND MODEL DEVELOPED FROM THE AVAILABLE GEOTECHNICAL INFORMATION AND SUMMARISED ON THE DRAWINGS. WHERE POSSIBLE, THESE ASSUMPTIONS SHALL BE VALIDATED ON SITE BY SGR.
GE3. IF WEAKER GROUND CONDITIONS THAN THOSE SHOWN IN THE GEOTECHNICAL MODELS ARE ENCOUNTERED, DESIGNER AND PRINCIPAL ARE TO BE NOTIFIED.
GE4. THE PROPOSED SLOPE REMEDIATION IS DESIGNED TO SUIT THE INTERPRETED GROUND CONDITIONS. THE REMEDIATION SYSTEM TO BE RE-ASSESSED WHERE THE ENCOUNTERED CONDITIONS VARY FROM THE ASSUMED DESIGN MODEL.
GE5. PILING CONTRACTOR TO BE AWARE OF VARIABLE GROUND CONDITIONS LIKELY TO BE ENCOUNTERED DURING PILING.
GE6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN AND CONSTRUCTION OF ANY TEMPORARY WORKS DEEMED NECESSARY TO ACHIEVE THE FINAL CONFIGURATION.TEMPORARY WORK DESIGNS TO BE REVIEWED AND ACCEPTED BY THE PRINCIPAL PRIOR TO CONSTRUCTION. THIS CONSTITUTES A HOLD POINT.
GE7. IF THE FOUNDING MATERIAL PROPERTIES ARE FOUND TO BE INFERIOR TO THE DESIGN ASSUMPTIONS, CONSTRUCTION MUST CEASE AND THE PRINCIPAL SHALL BE NOTIFIED IMMEDIATELY.

SURVEY NOTES

S1. ALL SURVEY SETOUT SHALL BE UNDERTAKEN BY A REGISTERED SURVEYOR AS ENGAGED BY THE CONTRACTOR.
S2. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND INFORMATION CONTAINED WITHIN THE SITE PRIOR TO COMMENCING WORKS.
S3. THE CONTRACTOR SHALL PREPARE WORK AS EXECUTED DRAWINGS FOR THE WORKS. AS A MINIMUM, THE ISSUED FOR CONSTRUCTION DRAWINGS SHALL BE UPDATED AND A NEW REVISION ISSUED. A SURVEYOR SHALL CERTIFY THE UPDATED LEVELS ARE CORRECT.

PILING NOTES

P1. PILES SHALL BE DRIVEN TO THE REQUIRED DEPTHS AND TOLERANCES PRESENTED ON THE DESIGN DRAWINGS AND TfNSW B53 SPECIFICATION.
P2. REFER TO TABLE 2 - DWG.GT-012 FOR PRELIMINARY PILE DRIVEABILITY ASSESSEMENT.
P3. PILE DURABILITY COATING SYSTEM FOR TIDAL SPLASH ZONE. THE UPPER 4m OF EACH PILE TO BE COATED IN DULUX GFX PC 256 HIGH PERFORMANCE SURFACE TOLERANT GLASS FLAKE EPOXY OR AN APPROVED EQUIVALENT:
- 1^{st} COAT ZINCANODE 402 - 75 MICRON DRY FILM THICKNESS
- 2^{nd} COAT DUREMAX GFX - 250 MICRON DRY FILM THICKNESS
- 3^{rd} COAT DUREMAX GFX - 250 MICRON DRY FILM THICKNESS

P4. ANY DAMAGE TO DURABILITY COATING SYSTEM DURING CONSTRUCTION TO BE REPAIRED. ROCK ARMOUR PLACEMENT MAY CAUSE DAMAGE TO DURABILITY COATING SYSTEM.

CONCRETE BARRIERS

CR1. DRILL AND EPOXI DOWEL INTO EXISTING BARRIER WITH HILTI HIT-RE 500 OR APPROVED EQUIVALENT WITH 300mm EMBEDMENT.
CR2. DEBONDED END OF DOWEL INSERTED IN TO NEW BARRIER.
CR3. PLACING AND CURING OF CONCRETE SHALL BE IN ACCORDANCE WITH TfNSW QA SPECIFICATION B80.
CR4. MINIMUM 28 DAYS COMPRESSIVE STRENGTH OF CAST IN PLACE CONCRETE SHALL BE 40MPa.

TABLE 1 - PILING SCHEDULE

PILE ID	DESIGN SETOUT COORDINATES		STEEL PILES SECTION PORPERTIES	PILE LENGTH (m)	DESIGN TOP OF PILE LEVEL (mAHD)	DESIGN TOE OF PILE LEVEL (mAHD)
	EASTING	NORTHING				
P1	517801.726	6732426.087	310UC158	12	0.6	-11.4
P2	517801.215	6732425.347	310UC158	12	0.6	-11.4
P3	517800.621	6732424.672	310UC158	12	0.6	-11.4
P4	517799.950	6732424.072	310UC158	12	0.6	-11.4
P5	517799.213	6732423.556	310UC158	12	0.6	-11.4
P6	517798.466	6732423.055	310UC158	12	0.6	-11.4
P7	517797.736	6732422.528	310UC158	12	0.6	-11.4
P8	517797.051	6732421.945	310UC158	12	0.6	-11.4
P9	517796.415	6732421.309	310UC158	12	0.6	-11.4
P10	517795.769	6732420.651	310UC158	12	0.6	-11.4
P11	517795.262	6732419.907	310UC158	12	0.6	-11.4
P12	517794.755	6732419.164	310UC158	12	0.6	-11.4
P13	517794.248	6732418.420	310UC158	12	0.6	-11.4
P14	517793.741	6732417.676	310UC158	12	0.6	-11.4
P15	517793.234	6732416.932	310UC158	12	0.6	-11.4
P16	517792.727	6732416.189	310UC158	12	0.6	-11.4
P17	517792.220	6732415.445	310UC158	12	0.6	-11.4
P18	517791.714	6732414.701	310UC158	12	0.6	-11.4
P19	517791.207	6732413.958	310UC158	12	0.6	-11.4
P20	517790.700	6732413.214	310UC158	12	0.6	-11.4
P21	517790.193	6732412.470	310UC158	12	0.6	-11.4
P22	517789.686	6732411.727	310UC158	12	0.6	-11.4
P23	517789.179	6732410.983	310UC158	12	0.6	-11.4
P24	517788.672	6732410.239	310UC158	12	0.6	-11.4
P25	517788.165	6732409.496	310UC158	12	0.6	-11.4
P26	517787.659	6732408.752	310UC158	12	0.6	-11.4
P27	517787.152	6732408.008	310UC158	12	0.6	-11.4
P28	517786.645	6732407.264	310UC158	12	0.6	-11.4
P29	517786.138	6732406.521	310UC158	12	0.6	-11.4
P30	517785.631	6732405.777	310UC158	12	0.6	-11.4
P31	517785.124	6732405.033	310UC158	12	0.6	-11.4
P32	517784.617	6732404.290	310UC158	12	0.6	-11.4
P33	517784.111	6732403.546	310UC158	12	0.6	-11.4
P34	517783.604	6732402.802	310UC158	12	0.6	-11.4
P35	517783.097	6732402.059	310UC158	12	0.6	-11.4
P36	517782.590	6732401.315	310UC158	12	0.6	-11.4
P37	517782.083	6732400.571	310UC158	12	0.6	-11.4
P38	517781.576	6732399.828	310UC158	12	0.6	-11.4
P39	517781.069	6732399.084	310UC158	12	0.6	-11.4
P40	517780.562	6732398.340	310UC158	12	0.6	-11.4
P41	517780.056	6732397.596	310UC158	12	0.6	-11.4
P42	517779.549	6732396.853	310UC158	12	0.6	-11.4
P43	517779.042	6732396.109	310UC158	12	0.6	-11.4
P44	517778.535	6732395.365	310UC158	12	0.6	-11.4
P45	517778.028	6732394.622	310UC158	12	0.6	-11.4
P46	517777.521	6732393.878	310UC158	12	0.6	-11.4
P47	517777.014	6732393.134	310UC158	12	0.6	-11.4

TABLE 2 - DRIVING OF STEEL PILES

MIN. PILE TOE LEVEL	-11.4 mAHD
FINAL PERMANENT SET AND DRIVING ENERGY	10mm / BLOW WITH JUNTTAN 3T HYDRAULIC HAMMER WITH 1.2m STROKE AT A NET DRIVING ENERGY OF 27 kJ
MAX COMPRESSION STRESS EXPECTED DURING DRIVING	170 MPa
MAX. TENSION STRESS EXPECTED DURING DRIVING	88 MPa

TABLE 2 NOTES:

1. TABLE 2 PRESENTS THE RESULT OF A PRELIMINARY, THEORETICAL PILE DRIVEABILITY ANALYSIS OF THE BEHAVIOUR OF THE PILING EQUIPMENT, PILE AND INFERRED GROUND CONDITIONS. ACCORDINGLY, THE VALUES ARE TO BE USED AS GUIDE ONLY FOR DRIVING OF PILES. THE CONTRACTOR IS TO UNDERTAKE INDEPENDENT DERIVABILITY ASSESSMENT.

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X_RMS_NSW_CIVIL_A3 X_NOTES	A	20.07.22	ISSUED FOR CONSTRUCTION	005	M.M.

SCALES ON A3 SIZE DRAWING

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	A.SCHAUREN	20.07.22
DRG CHECK	D. KELLY	20.07.22
DESIGN	O. GRAFFARIPOUR	20.07.22
DESIGN CHECK	M.MAHARAJ	20.07.22
DESIGN MNGR	M.MAHARAJ	20.07.22
PROJECT MNGR	M.MAHARAJ	20.07.22

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GENERAL NOTES - SHEET 2

A3

SHEET 3 OF 8

RMS REGISTRATION No. DS2022 / 000311
PART 1

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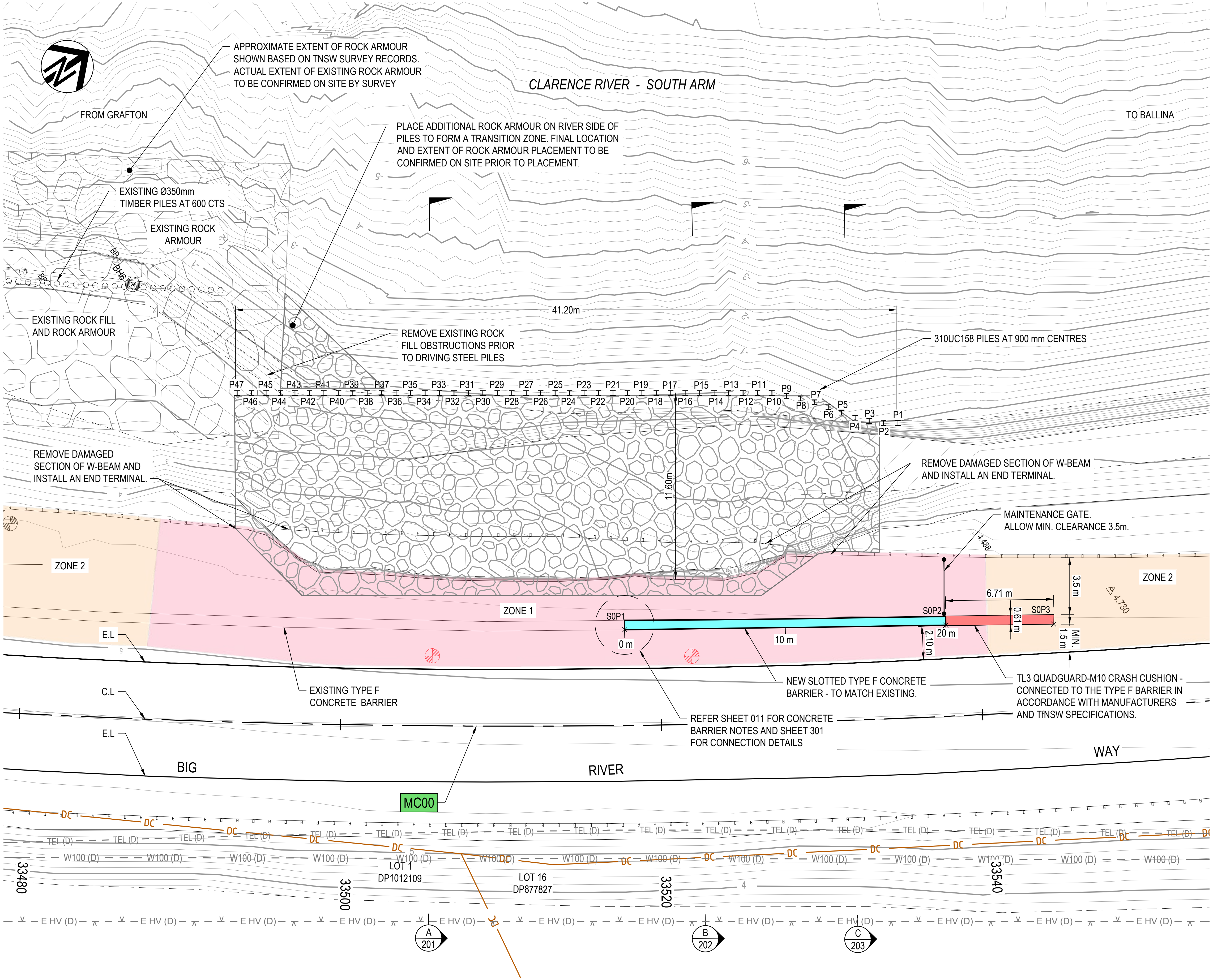

LEGEND - EXISTING

-2	MAJOR CONTOURS
DC	APPROXIMATE PROPERTY BOUNDARY
	MINOR CONTOURS
	SAFETY BARRIER GUARD FENCE
	EXISTING ROCK FILL AND ARMOUR

LEGEND - EXISTING UTILITIES

TEL (D)	BURIED TELSTRA
W100 (D)	BURIED WATER MAIN
E HV (D)	OVERHEAD POWER

LEGEND

	CONTROL LINE
C.L	CENTRE LINE
E.L	EDGE LINE
S0P1 ×	SETOUT POINT
BH 12	TfNSW BORE HOLE (2021)
BH 8	TfNSW BORE HOLE (2009)
	EXTENT OF NEW ROCK FILL AND ARMOUR
	ZONE 1 - CONSTRUCTION VEHICLE LIMITATION ZONE - GT-011 CS1 AND CS2: NO VEHICLES PERMITTED IN ZONE 1. - GT-011 CS3, CS4 AND CS5: EXCAVATORS AND LIGHT VEHICLES UP TO 20kPa PERMITTED IN ZONE 1. HEAVIER PLANT UP TO 30kPa TO MAINTAIN 4m SETBACK FROM HEADSCARP.
	ZONE 2 - CONSTRUCTION VEHICLE LIMITATION ZONE - EXCAVATORS AND LIGHT VEHICLES PERMITTED DURING ALL CONSTRUCTION STAGES.

BARRIER AND CRASH CUSHION SETOUT

POINT	EASTING	NORTHING
SOP1	517802.780	6732404.771
SOP2	517813.806	6732421.460
SOP3	517817.539	6732427.046

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SCALES ON A3 SIZE DRAWING: SCALE 1:250 (1.25, 0, 2.5, 5)

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CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) — HEIGHT DATUM: AHD

TITLE	NAME	DATE
DRAWN	A.SCHAUREN	20.07.22
DRG CHECK	D. KELLY	20.07.22
DESIGN	O. GRAFFARIPOUR	20.07.22
DESIGN CHECK	M.MAHARAJ	20.07.22
DESIGN MNGR	M.MAHARAJ	20.07.22
PROJECT MNGR	M.MAHARAJ	20.07.22

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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

GENERAL ARRANGEMENT PLAN

A3

SHEET 4 OF 8

RMS REGISTRATION No. DS2022 / 000311 — PART 1

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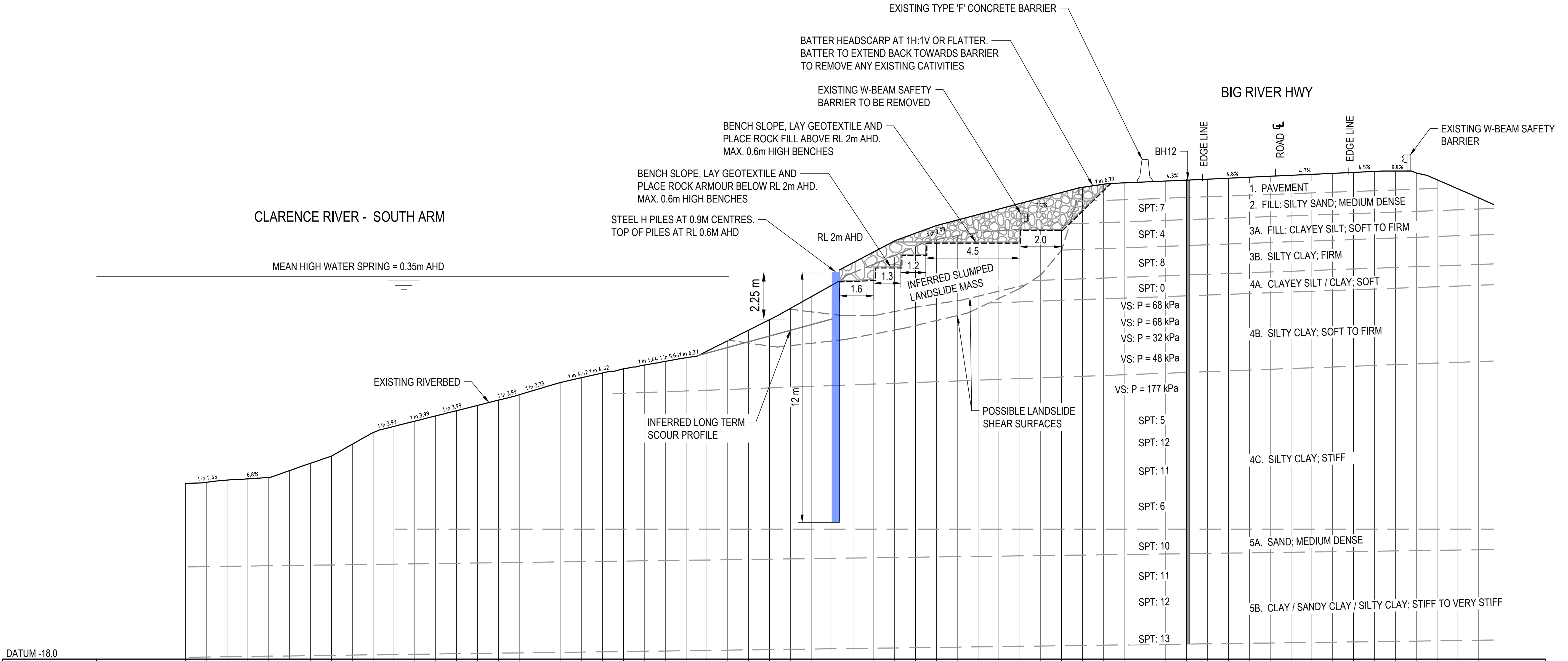

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-51.000	-9.522	-9.522
-50.000	-9.419	-9.419
-49.000	-9.360	-9.360
-48.000	-9.291	-9.291
-47.000	-8.960	-8.960
-46.000	-8.610	-8.610
-45.000	-8.265	-8.265
-44.000	-7.698	-7.698
-43.000	-7.145	-7.145
-42.000	-6.840	-6.840
-41.000	-6.589	-6.589
-40.000	-6.339	-6.339
-39.000	-6.088	-6.088
-38.000	-5.837	-5.837
-37.000	-5.587	-5.587
-36.000	-5.328	-5.328
-35.000	-5.028	-5.028
-34.000	-4.735	-4.735
-33.000	-4.505	-4.505
-32.000	-4.279	-4.279
-31.000	-4.082	-4.082
-30.000	-3.903	-3.903
-29.000	-3.726	-3.726
-28.000	-3.553	-3.553
-27.000	-3.237	-3.237
-26.000	-2.734	-2.734
-25.000	-2.231	-2.231
-24.000	-1.728	-1.728
-23.000	-1.189	-1.189
-22.000	-0.626	-0.626
-21.000	0.600	-0.062
-20.000	1.000	0.522
-19.000	1.525	0.937
-18.000	2.050	1.352
-17.000	2.418	1.783
-16.000	2.782	2.113
-15.000	3.047	2.301
-14.000	3.313	2.445
-13.000	3.578	2.544
-12.000	3.843	2.600
-11.000	4.109	2.600
-10.000	4.374	2.600
-9.000	4.621	4.621
-8.000	4.767	4.767
-7.000	4.833	4.833
-6.000	4.877	4.877
-5.000	4.920	4.920
-4.000	4.963	4.963
-3.000	5.006	5.006
-2.000	5.054	5.054
-1.000	5.103	5.103
0.000	5.151	5.151
1.000	5.199	5.199
2.000	5.245	5.245
3.000	5.291	5.291
4.000	5.336	5.336
5.000	5.381	5.381
6.000	5.400	5.400
7.000	5.310	5.310
8.000	4.984	4.984
9.000	4.548	4.548
10.000	4.111	4.111

SECTION A / 101
SCALE 1:200

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EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
X_RMS_NSW_CIVIL_A3 X_XSECTIONS	A	20.07.22	ISSUED FOR CONSTRUCTION	005	M.M.

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SCALE 1:200

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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SMEC PROJECT No 30013154

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PLOT BY: DK12753

TITLE	NAME	DATE
DRAWN	A.SCHAUREN	20.07.22
DRG CHECK	D. KELLY	20.07.22
DESIGN	O. GRAFFARIPOUR	20.07.22
DESIGN CHECK	M.MAHARAJ	20.07.22
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CROSS SECTION - SHEET 1

A3

SHEET 5 OF 8

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PART 1

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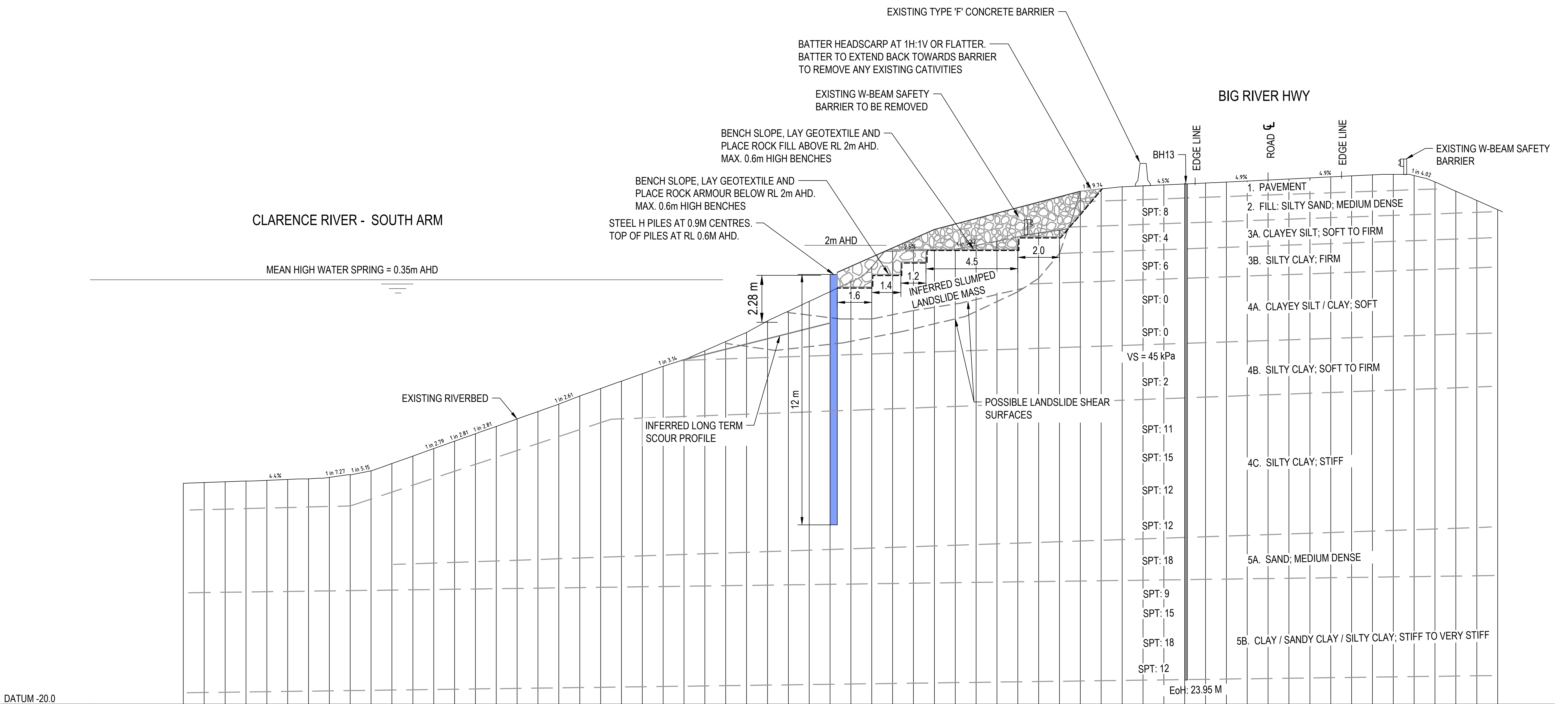

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DESIGN LEVEL	-9.415	-9.376	-9.338	-9.301	-9.268	-9.225	-9.198	-9.126	-9.000	-8.818	-8.467	-8.109	-7.751	-7.393	-7.037	-6.682
EXISTING SURFACE	-9.415	-9.376	-9.338	-9.301	-9.268	-9.225	-9.198	-9.126	-9.000	-8.818	-8.467	-8.109	-7.751	-7.393	-7.037	-6.682

OFFSET	-36.000	-35.000	-34.000	-33.000	-32.000	-31.000	-30.000	-29.000	-28.000	-27.000	-26.000	-25.000	-24.000	-23.000	-22.000	-21.000
DESIGN LEVEL	-6.327	-5.971	-5.614	-5.230	-4.872	-4.514	-4.157	-3.804	-3.478	-3.055	-2.616	-2.182	-1.627	-1.159	-0.691	0.600
EXISTING SURFACE	-6.327	-5.971	-5.614	-5.230	-4.872	-4.514	-4.157	-3.804	-3.478	-3.055	-2.616	-2.182	-1.627	-1.159	-0.691	-0.223

OFFSET	-20.000	-19.000	-18.000	-17.000	-16.000	-15.000	-14.000	-13.000	-12.000	-11.000	-10.000	-9.000	-8.000	-7.000	-6.000	-5.000
DESIGN LEVEL	0.779	1.110	1.440	1.771	2.097	2.423	2.748	3.074	3.400	3.725	4.051	4.377	4.702	4.804	4.849	4.895
EXISTING SURFACE	0.245	0.957	1.718	1.743	1.768	1.807	1.995	2.191	2.402	2.591	2.728	4.589	4.702	4.804	4.849	4.895

OFFSET	-4.000	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.000	11.000
DESIGN LEVEL	4.940	4.986	5.034	5.082	5.131	5.180	5.229	5.278	5.327	5.376	5.400	5.342	5.037	4.594	4.150	3.705
EXISTING SURFACE	4.940	4.986	5.034	5.082	5.131	5.180	5.229	5.278	5.327	5.376	5.400	5.342	5.037	4.594	4.150	3.705

SECTION B / 101
SCALE 1: 200

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EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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GRAFTON NSW 2460
SMEC PROJECT No 30013154

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

PLOT DATE / TIME: 26 July 2022 09:28:04 AM
PLOT BY: DK12753

TITLE	NAME	DATE
DRAWN	A.SCHAUREN	20.07.22
DRG CHECK	D. KELLY	20.07.22
DESIGN	O. GRAFFARIPOUR	20.07.22
DESIGN CHECK	M.MAHARAJ	20.07.22
DESIGN MNGR	M.MAHARAJ	20.07.22
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CROSS SECTION - SHEET 2

A3

SHEET 6 OF 8

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PART 1

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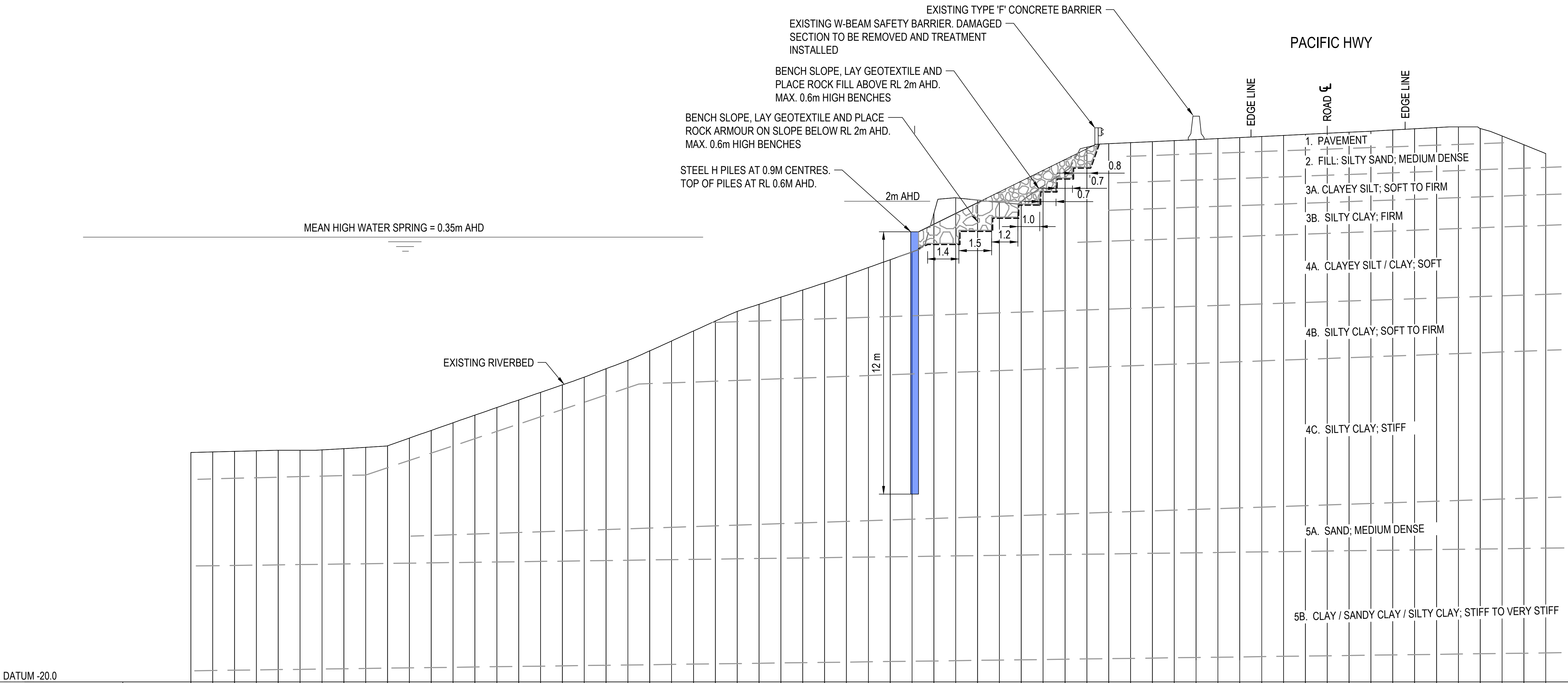

DATUM -20.0

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EXISTING SURFACE	-9.499	-9.474	-9.448	-9.423	-9.400	-9.400	-9.383	-9.323	-9.261	-9.193	-8.841	-8.489	-8.137	-7.789	-7.442	-7.095
OFFSET	-52.000	-51.000	-50.000	-49.000	-48.000	-47.000	-46.000	-45.000	-44.000	-43.000	-42.000	-41.000	-40.000	-39.000	-38.000	-37.000

DESIGN LEVEL	-6.749	-6.402	-6.050	-5.667	-5.284	-4.847	-4.394	-3.940	-3.485	-3.045	-2.718	-2.391	-2.065	-1.738	-1.392	-1.036
EXISTING SURFACE	-6.749	-6.402	-6.050	-5.667	-5.284	-4.847	-4.394	-3.940	-3.485	-3.045	-2.718	-2.391	-2.065	-1.738	-1.392	-1.036
OFFSET	-36.000	-35.000	-34.000	-33.000	-32.000	-31.000	-30.000	-29.000	-28.000	-27.000	-26.000	-25.000	-24.000	-23.000	-22.000	-21.000

DESIGN LEVEL	0.600	0.885	1.326	1.767	2.209	2.650	3.091	3.532	3.974	4.415	4.627	4.676	4.723	4.770	4.818	4.865
EXISTING SURFACE	-0.680	-0.324	1.442	2.152	2.052	1.951	1.982	2.690	3.359	4.472	4.628	4.676	4.723	4.770	4.818	4.865
OFFSET	-20.000	-19.000	-18.000	-17.000	-16.000	-15.000	-14.000	-13.000	-12.000	-11.000	-10.000	-9.000	-8.000	-7.000	-6.000	-5.000

DESIGN LEVEL	4.912	4.959	5.006	5.055	5.105	5.154	5.204	5.260	5.314	5.369	5.400	5.325	4.982	4.581	4.180
EXISTING SURFACE	4.912	4.959	5.006	5.055	5.105	5.154	5.204	5.260	5.314	5.369	5.400	5.325	4.982	4.581	4.180
OFFSET	-4.000	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.000

SECTION B / 101
SCALE 1: 200

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SCALES ON A3 SIZE DRAWING
SCALE 1:200

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
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SMEC PROJECT No 30013154

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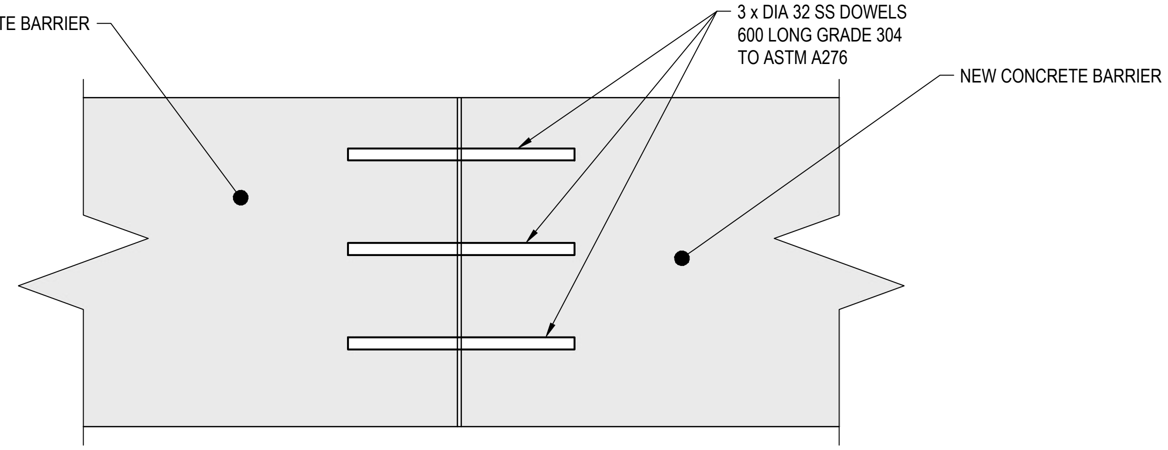
CROSS SECTION - SHEET 3

A3

SHEET 7 OF 8

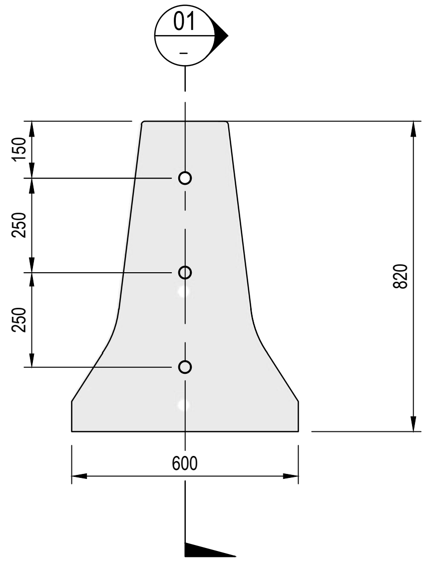
RMS REGISTRATION No. DS2022 / 000311
PART 1

ISSUE STATUS: ISSUED FOR CONSTRUCTION
EDMS No.: -
SHEET No.: GT-203
ISSUE: A

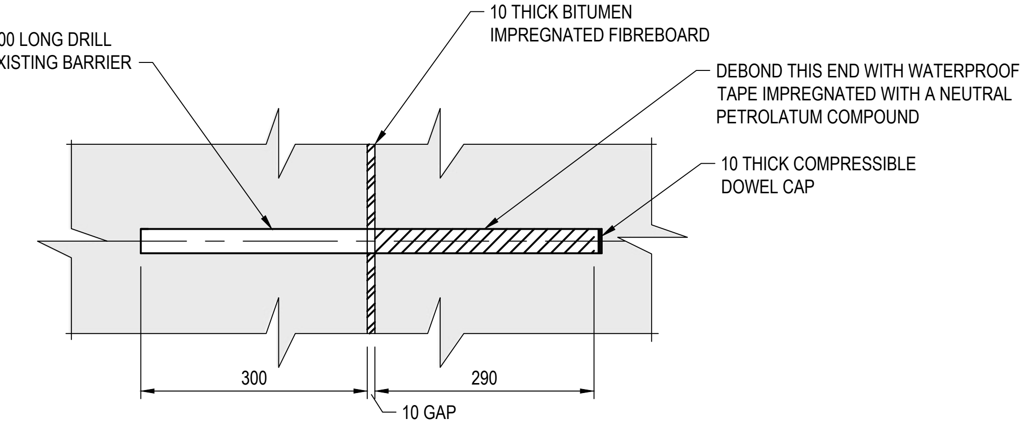


SECTION 1 / 101
SCALE 1:20

DOWELLED CONNECTION DETAIL BETWEEN EXISTING
AND NEW CONCRETE ROAD BARRIER TYPE F
SCALE 1:20



MEDIAN - TL3
SCALE 1:20



DOWEL DETAIL
SCALE 1:10

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X_RMS_NSW_CIVIL_A3	A	20.07.22	ISSUED FOR CONSTRUCTION	005	M.M.

SCALES ON A3 SIZE DRAWING
SCALE 1:20 0.1 0 0.1 0.2 0.3 0.4

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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GRAFTON NSW 2460
SMEC PROJECT No 30013154

PLOT DATE / TIME: 26 July 2022 09:29:05 AM
PLOT BY: DK12753

TITLE	NAME	DATE
DRAWN	A.SCHAUREN	20.07.22
DRG CHECK	D. KELLY	20.07.22
DESIGN	O. GRAFFARIPOUR	20.07.22
DESIGN CHECK	M.MAHARAJ	20.07.22
DESIGN MNGR	M.MAHARAJ	20.07.22
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HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

DETAILS

A3

SHEET 8 OF 8

RMS REGISTRATION No. DS2022 / 000311
PART 1

ISSUE STATUS: ISSUED FOR CONSTRUCTION
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ISSUE A

Appendix B Site Observations

Slip headscarp with some slumping observed regressing back beneath pavement

Photograph 1: 29 June 2021 - Ch33490 m - view north showing slip headscarp profile.

Additional slumping to headscarp observed.

Photograph 2: 11 March 2021 - Ch33490 m - view north showing slip headscarp profile.

Photograph 3: 11 March 2021 - Headscarp exposing pavement layers and undercutting.

Dense vegetation obscured riverbank

Some patch repairs to Big River Way carriageway around Ch33480 m

No obvious tension cracks observed in sealed shoulder.

Photograph 4: 29 June 2021 - Ch33490 m - view south; wide sealed shoulder at southern end of slip.

Slumping of headscarp pavement and fill materials. Regression back beneath pavement.

Ponding water on subsided pavement

Photograph 5: 29 June 2021 - Ch33530 – slip headscarp and subsidence viewed from southern end of headscarp.

Additional slumping of pavement and fill materials. Regression back beneath pavement.

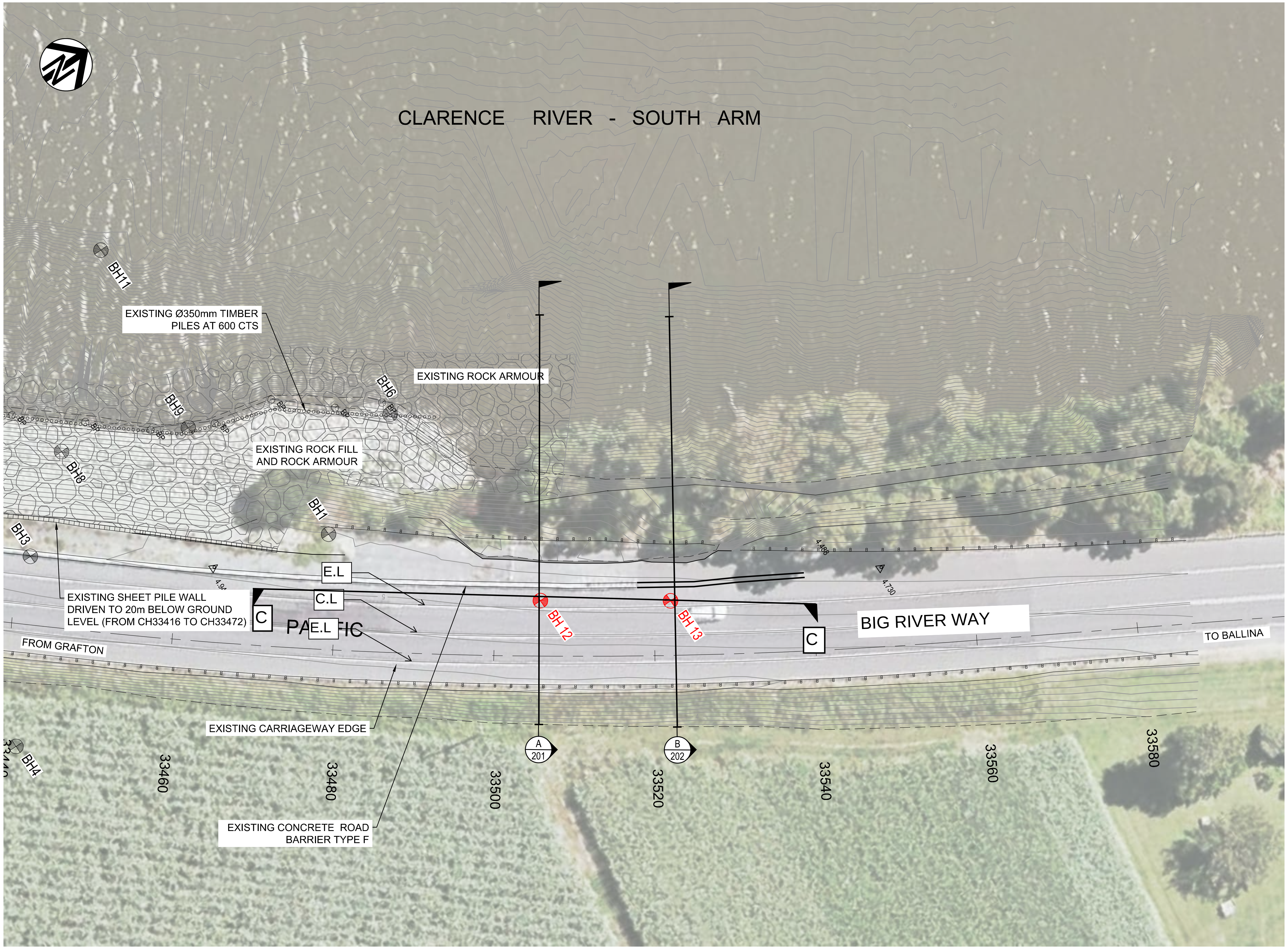
Photograph 6: 11 March 2021 – Additional slumping

Photograph 7: 29 June 2021 - Ch33500 m – view north; slip headscarp and pavement profile viewed from southern end.

Photograph 8: 29 June 2021 - ~Ch33515 – view of slumped road embankment and riverbank below headscarp.

Photograph 9: 29 June 2021 - Ch33540 – Road formation and vegetated riverbank north of slip (view south).

Appendix C Interpreted Geotechnical Model Cross Sections and Long Section



LEGEND - EXISTING

- MAJOR CONTOURS
- MINOR CONTOURS
- 450Ø PIPE
- STORMWATER PIT
- HEADWALL
- TREE
- VEGETATION
- SAFETY BARRIER GUARD FENCE

LEGEND

- CONTROL LINE
- NEW SAFETY BARRIER GUARD FENCE
- S0P1 × SETOUT POINT
- AREA OF SLIP TO BE REMEDIATED
- BH 12 TfNSW BORE HOLE (2021)
- BH8 TfNSW BORE HOLE (2009)

SITE INVESTIGATION PLAN

NOT FOR CONSTRUCTION

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50mm ON A3 SIZE ORIGINAL

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SCALES ON A3 SIZE DRAWING: SCALE 1:500 (2.5 0 2.5 5.0 7.5 10 12.5m)

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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52 VICTORIA STREET
GRAFTON NSW 2460
SMEC PROJECT No 30013154

PLOT DATE / TIME: 13 September 2021 03:15:40 PM
PLOT BY: TC13654

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DRAWN	T.CORFIAS	
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DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

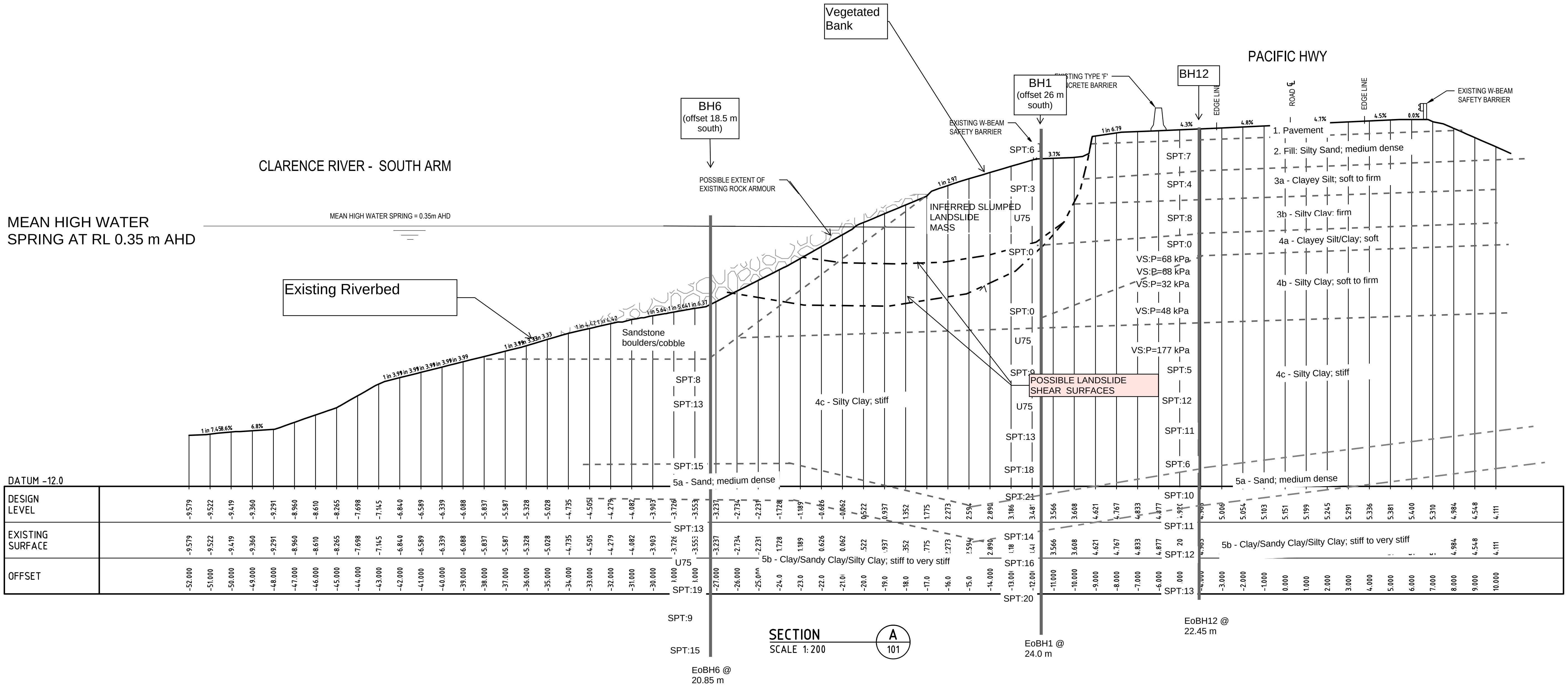
GENERAL ARRANGEMENT PLAN

A3

SHEET 1 OF 4

RMS REGISTRATION No.
PART

ISSUE STATUS	EDMS No.	SHEET No.	ISSUE
		1	



INFERRED ENGINEERING GEOLOGICAL BOUNDARY BETWEEN UNITS

CROSS SECTION A-A - INFERRED GROUND MODEL

NOT FOR CONSTRUCTION

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50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME	V:_Vault\Projects\3001\30013154\110_CADD\CAD\DWG\CI_Civil\30013154-CD-GT-201.dwg
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PLOT BY	TC13654
EXTERNAL REFERENCE FILES	X_RMS_NSW_CIVIL_A3 X_XSECTIONS

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
0	0	CONCEPT DESIGN	0	0

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CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) | HEIGHT DATUM: AHD

DRAWINGS / DESIGN PREPARED BY: SMEC — Member of the Surbana Jurong Group — ABN 47 065 475 149 — 52 VICTORIA STREET GRAFTON NSW 2460 — SMEC PROJECT No 30013154

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT (PRELIM / FINAL; INITIAL / DATE)

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DISCIPLINE		
DISCIPLINE		
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CONFIRMED		

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

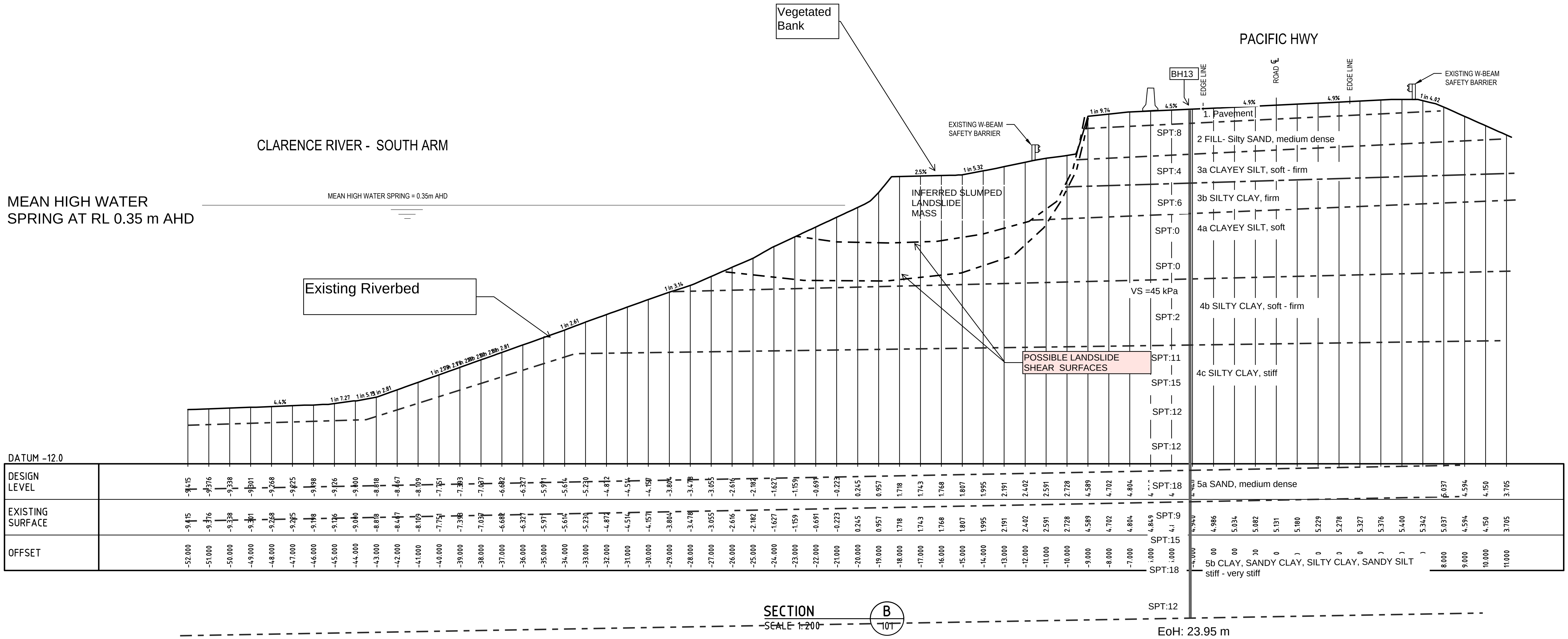
A3

CROSS SECTION - SHEET 1

SHEET 2 OF 4

RMS REGISTRATION No. | PART

ISSUE STATUS | EDMS No. | SHEET No. 2 | ISSUE



CROSS SECTION B-B - INFERRED GROUND MODEL

NOT FOR CONSTRUCTION

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SCALES ON A3 SIZE DRAWING: SCALE 1:200 — 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020) — HEIGHT DATUM: AHD

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DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

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HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

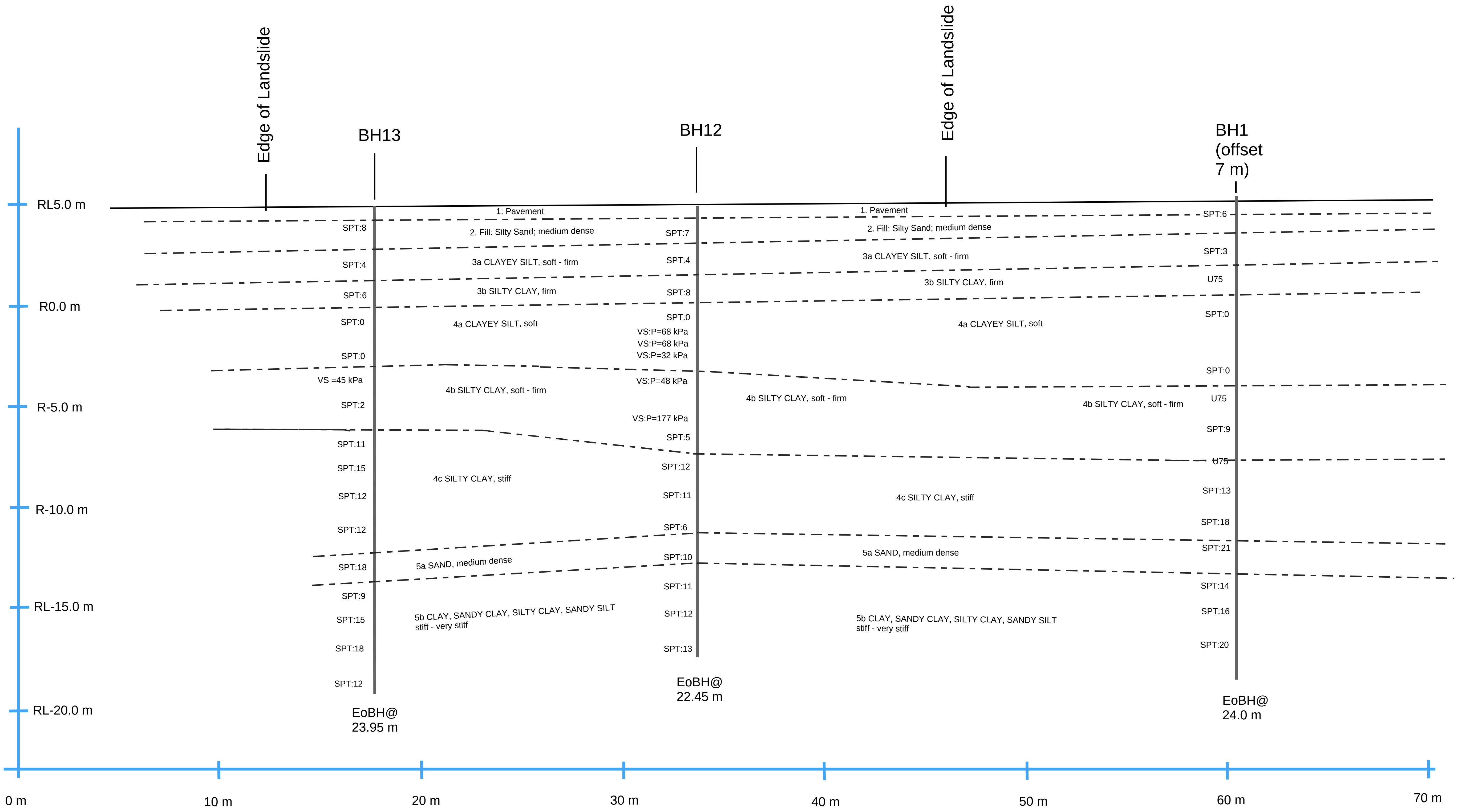
CROSS SECTION - SHEET 2

A3

SHEET 3 OF 4

RMS REGISTRATION No. — PART

ISSUE STATUS — EDMS No. — SHEET No. 3 — ISSUE



LONG SECTION C-C - INFERRED GROUND MODEL

50mm ON A3 SIZE ORIGINAL

DRAWING FILE LOCATION / NAME
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DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

EXTERNAL REFERENCE FILES	REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
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SCALES ON A3 SIZE DRAWING
SCALE 1:200 1 0 1 2 3 4 5m

CO-ORDINATE SYSTEM: MGA ZONE 56 (GDA2020)
HEIGHT DATUM: AHD

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GRAFTON NSW 2460
SMEC PROJECT No 30013154

PLOT DATE / TIME: 13 September 2021 02:59:17 PM
PLOT BY: TC13654

TITLE	NAME	DATE
DRAWN	T.CORFIAS	
DRG CHECK		
DESIGN	M.MAHARAJ	
DESIGN CHECK		
DESIGN MNGR		
PROJECT MNGR		

CHECK PRINT PRELIM. FINAL	INITIAL	DATE
DISCIPLINE		
DISCIPLINE		
DISCIPLINE		
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CONFIRMED		

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
BYRONS LANE SLIP REMEDIATION

LONG SECTION

A3

SHEET 4 OF 4

RMS REGISTRATION No.

PART

ISSUE STATUS

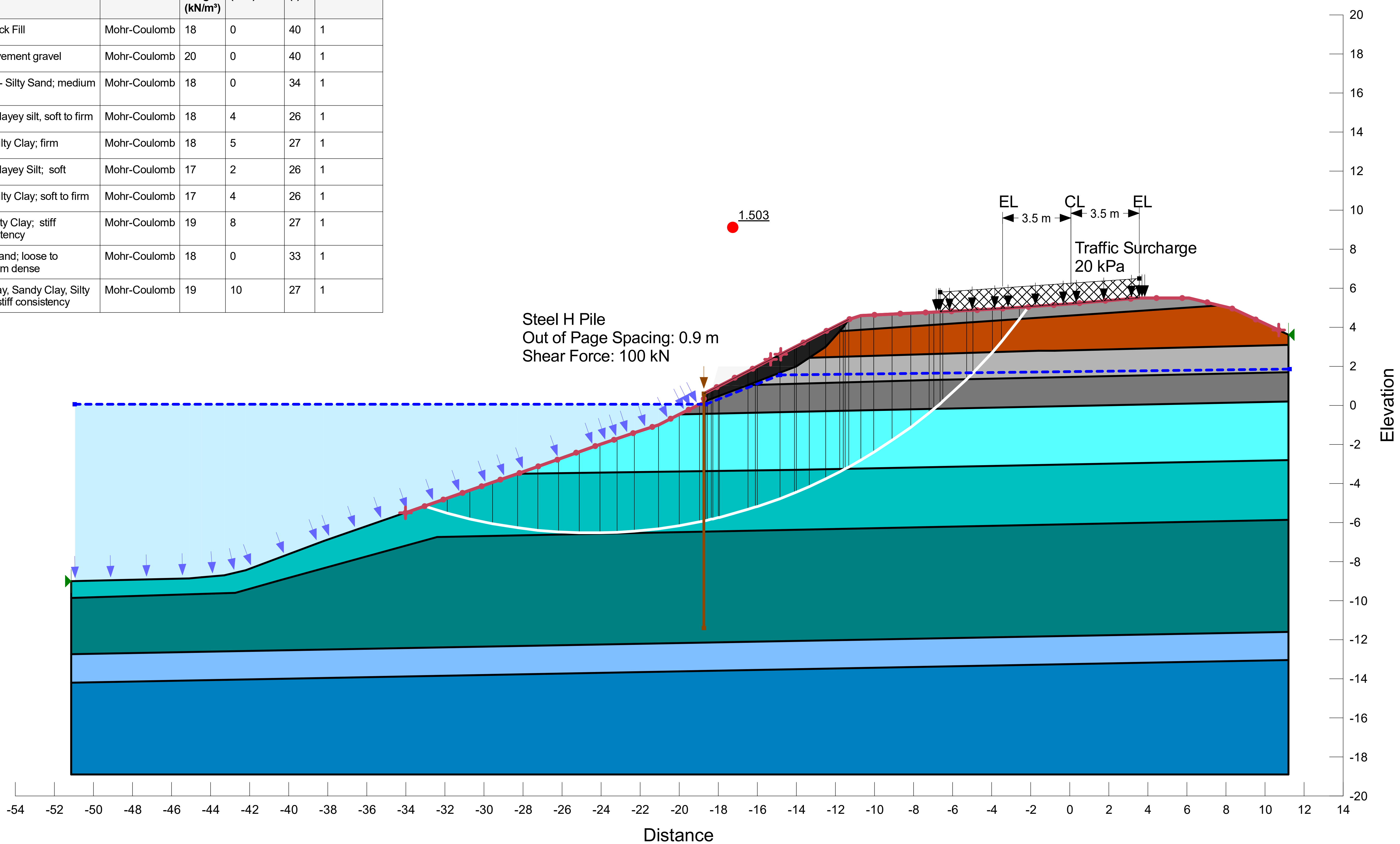
EDMS No.

SHEET No. 4

ISSUE

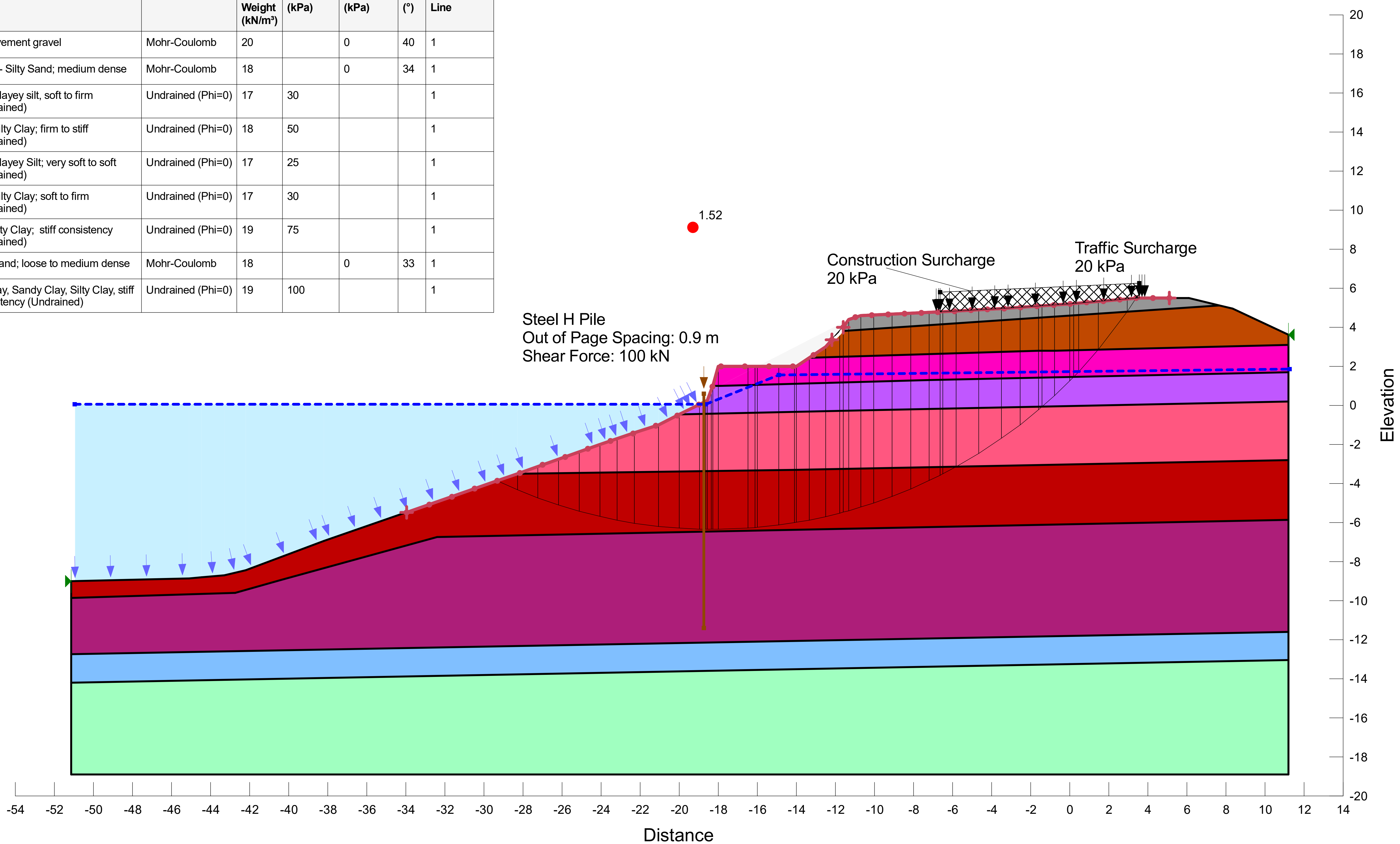
Appendix D Slope/W Output

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18	0	40	1
	1- Pavement gravel	Mohr-Coulomb	20	0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18	0	34	1
	3a - Clayey silt, soft to firm	Mohr-Coulomb	18	4	26	1
	3b - Silty Clay; firm	Mohr-Coulomb	18	5	27	1
	4a - Clayey Silt; soft	Mohr-Coulomb	17	2	26	1
	4b - Silty Clay; soft to firm	Mohr-Coulomb	17	4	26	1
	4c -Silty Clay; stiff consistency	Mohr-Coulomb	19	8	27	1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18	0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency	Mohr-Coulomb	19	10	27	1



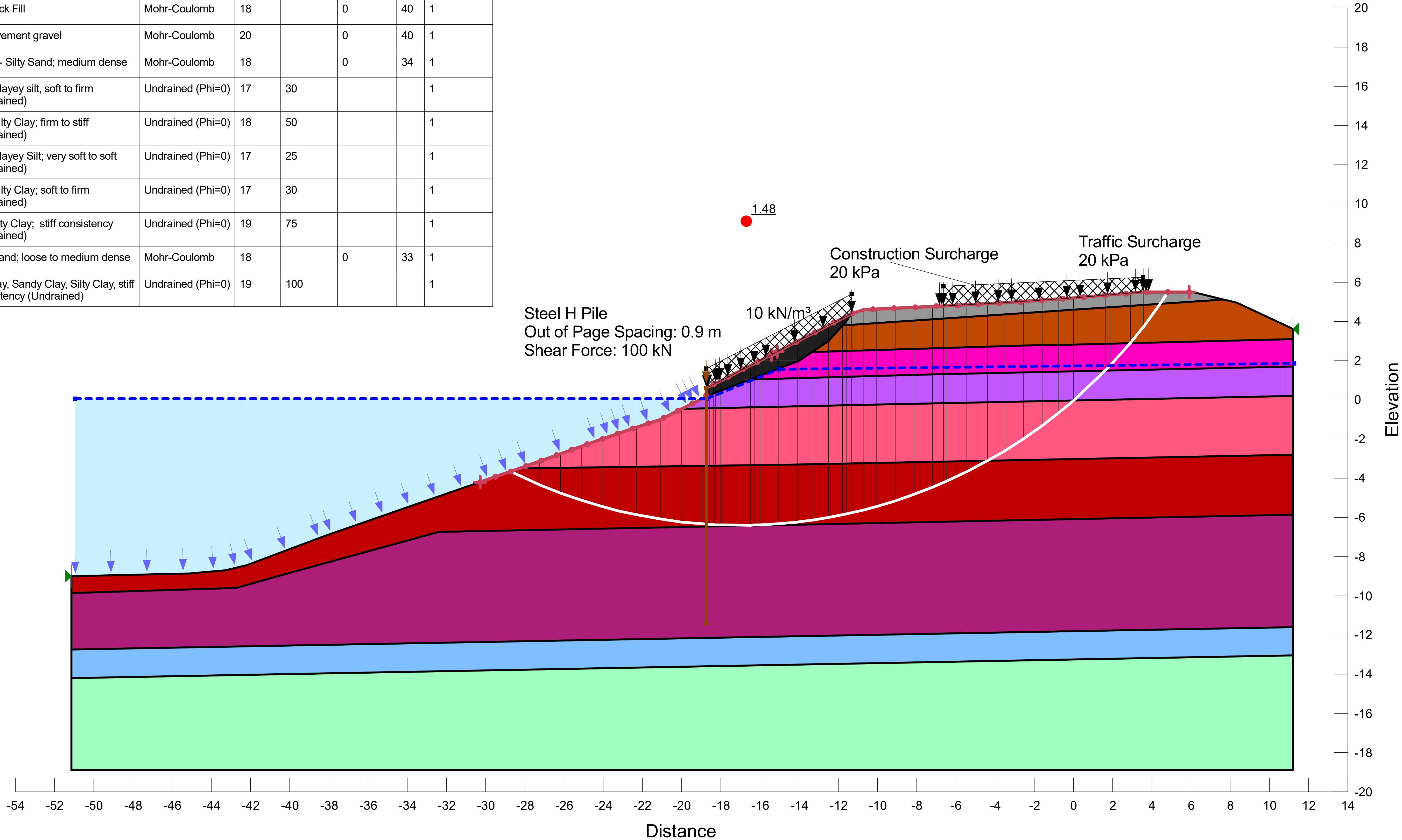
Slope Stability Analysis Ouput	Modeller : OG	LT - Pile Installed LGWL
Byrons Lane Slip, Big River Way	Reviewer : MM	Byrons Lane - Steel H Pile - Non Slip Section.gsz
30013154	100% Detailed Design	08/06/2022 — 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



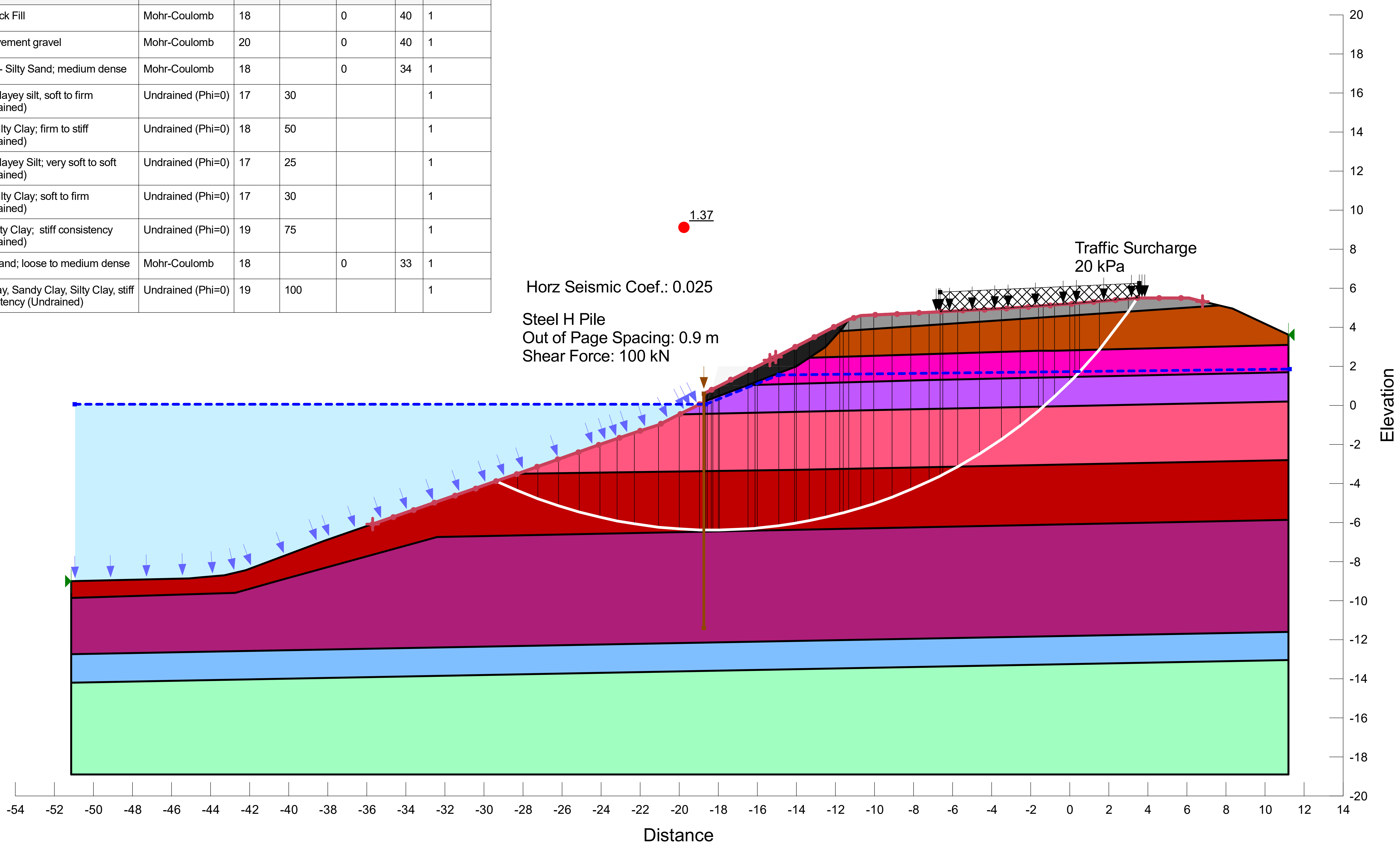
Slope Stability Analysis Ouput	Modeller : OG	SMEC / NSW Transport for NSW	ST - Construction
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Non Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 — 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



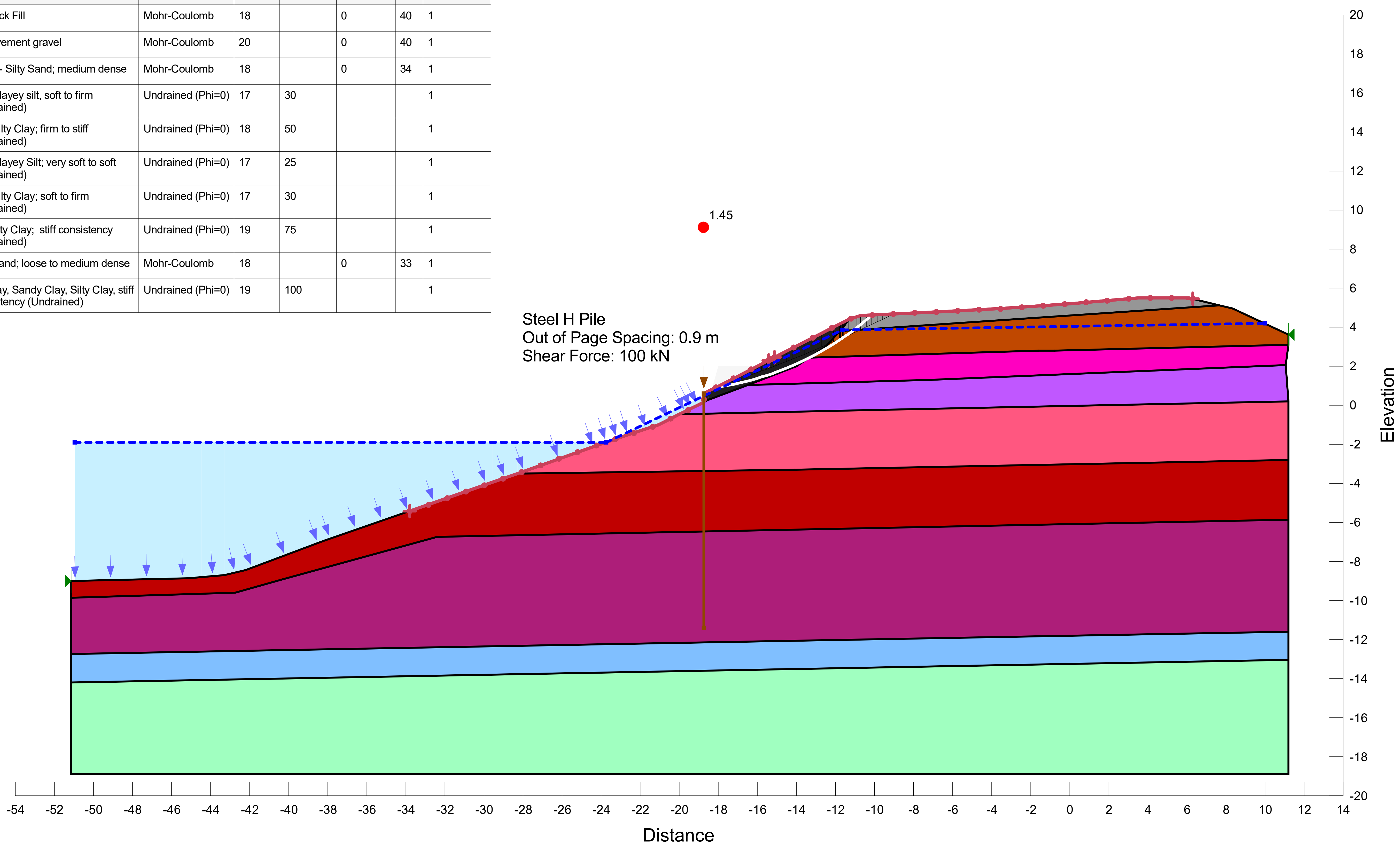
Slope Stability Analysis Ouput	Modeller : OG		ST - Construction with Rockfill
Byrons Lane Slip, Big River Way	Reviewer : MM	SMEC / Transport for NSW	Byrons Lane - Steel H Pile - Non Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 — 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



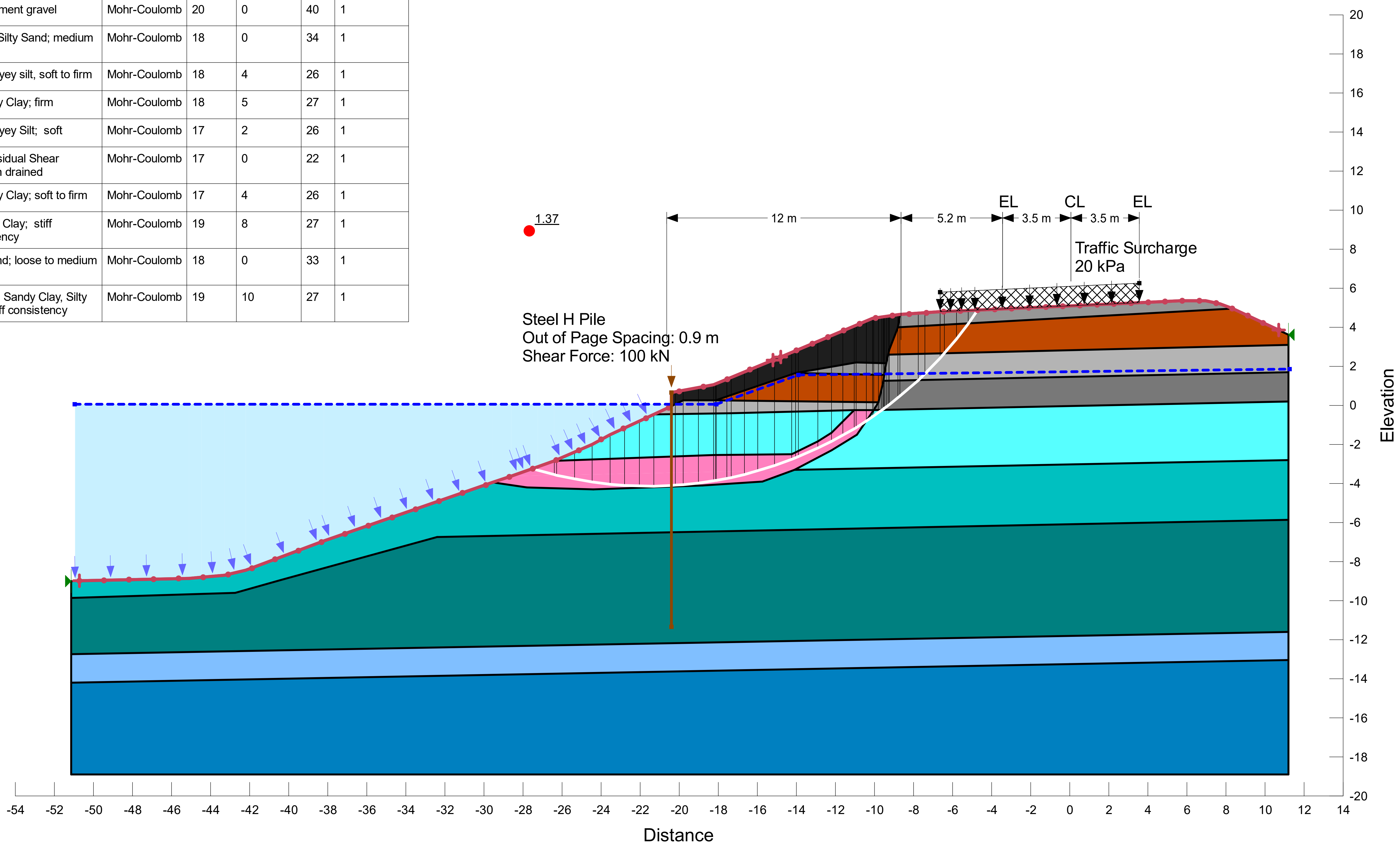
Slope Stability Analysis Ouput	Modeller : OG	SMEC Member of the Surbana Jurong Group / NSW Government Transport for NSW	ST - Seismic
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Non Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 — 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



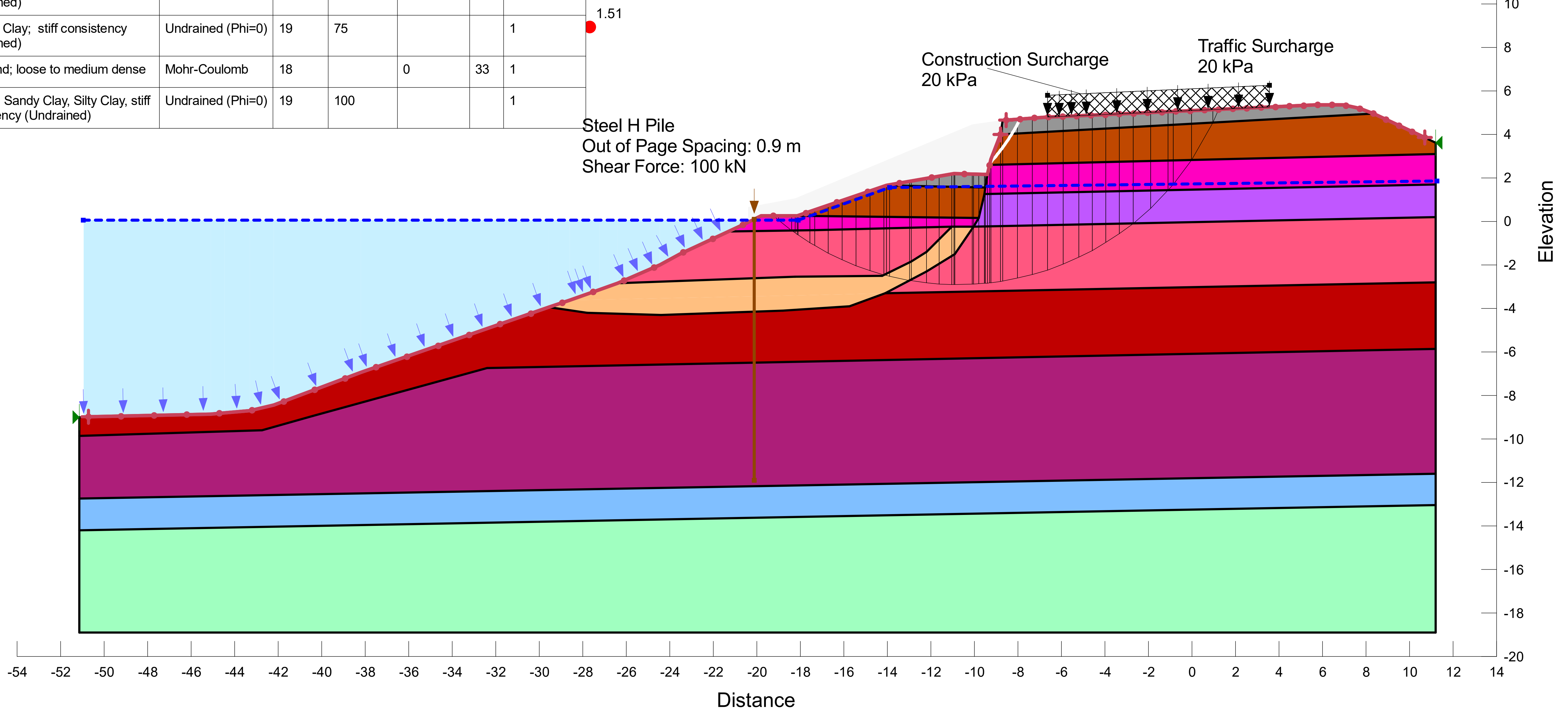
Slope Stability Analysis Ouput	Modeller : OG	ST - Rapid Drawdown
Byrons Lane Slip, Big River Way	Reviewer : MM	Byrons Lane - Steel H Pile - Non Slip Section.gsz
30013154	100% Detailed Design	08/06/2022 — 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18	0	40	1
	1- Pavement gravel	Mohr-Coulomb	20	0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18	0	34	1
	3a - Clayey silt, soft to firm	Mohr-Coulomb	18	4	26	1
	3b - Silty Clay; firm	Mohr-Coulomb	18	5	27	1
	4a - Clayey Silt; soft	Mohr-Coulomb	17	2	26	1
	4a - Residual Shear Strength drained	Mohr-Coulomb	17	0	22	1
	4b - Silty Clay; soft to firm	Mohr-Coulomb	17	4	26	1
	4c -Silty Clay; stiff consistency	Mohr-Coulomb	19	8	27	1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18	0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency	Mohr-Coulomb	19	10	27	1



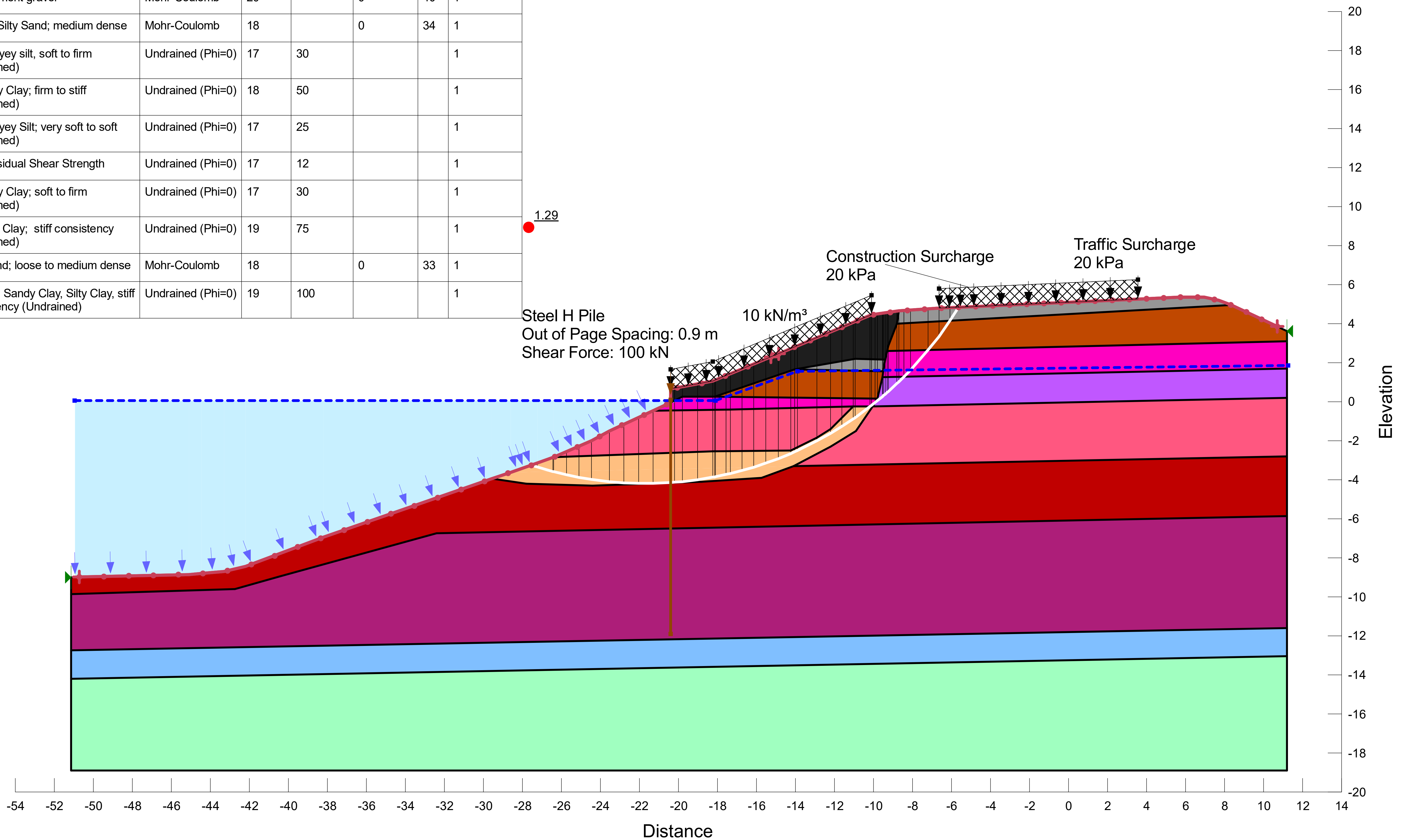
Slope Stability Analysis Ouput	Modeller : OG		LT - Pile Installed LGWL - Drained
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Undrained (Phi=0)	17	12			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



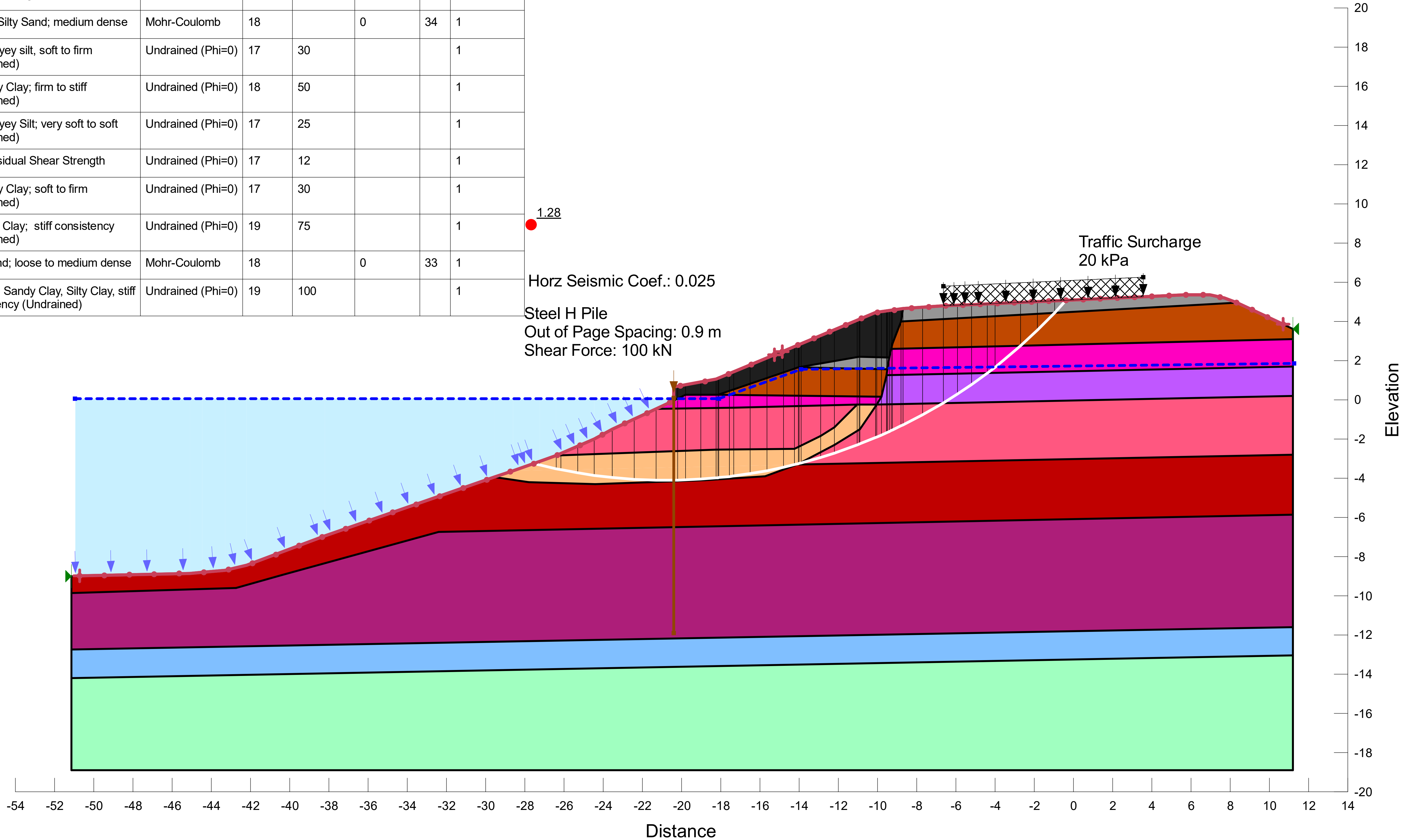
Slope Stability Analysis Ouput	Modeller : OG		ST - Construction - Undrained
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 | 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Undrained (Phi=0)	17	12			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



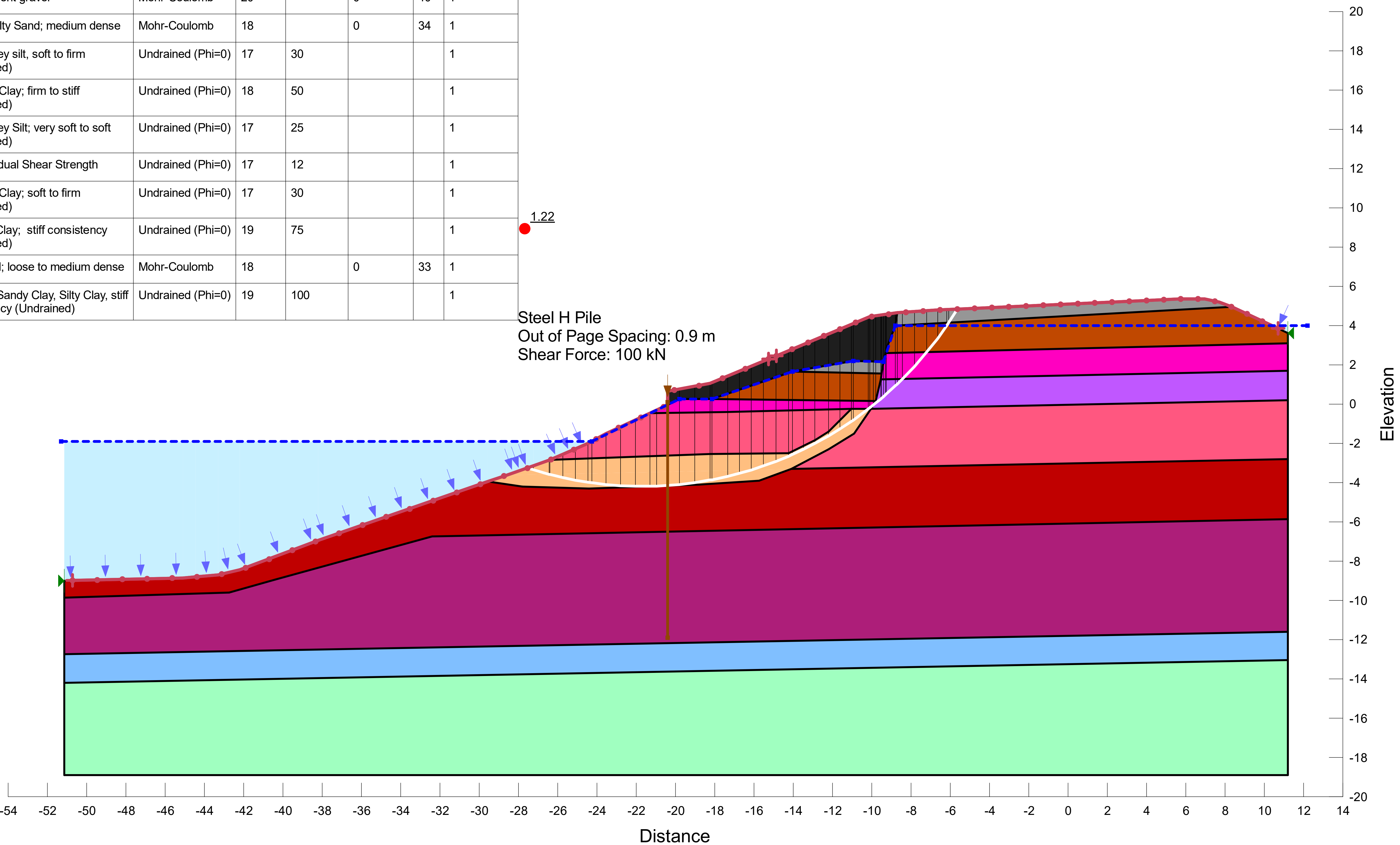
Slope Stability Analysis Ouput	Modeller : OG		ST - Construction - Undrained - with Rockfill
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 — 1:200

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Undrained (Phi=0)	17	12			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



Slope Stability Analysis Ouput	Modeller : OG	SMEC / NSW Transport for NSW	ST - Seismic
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 — 1:200

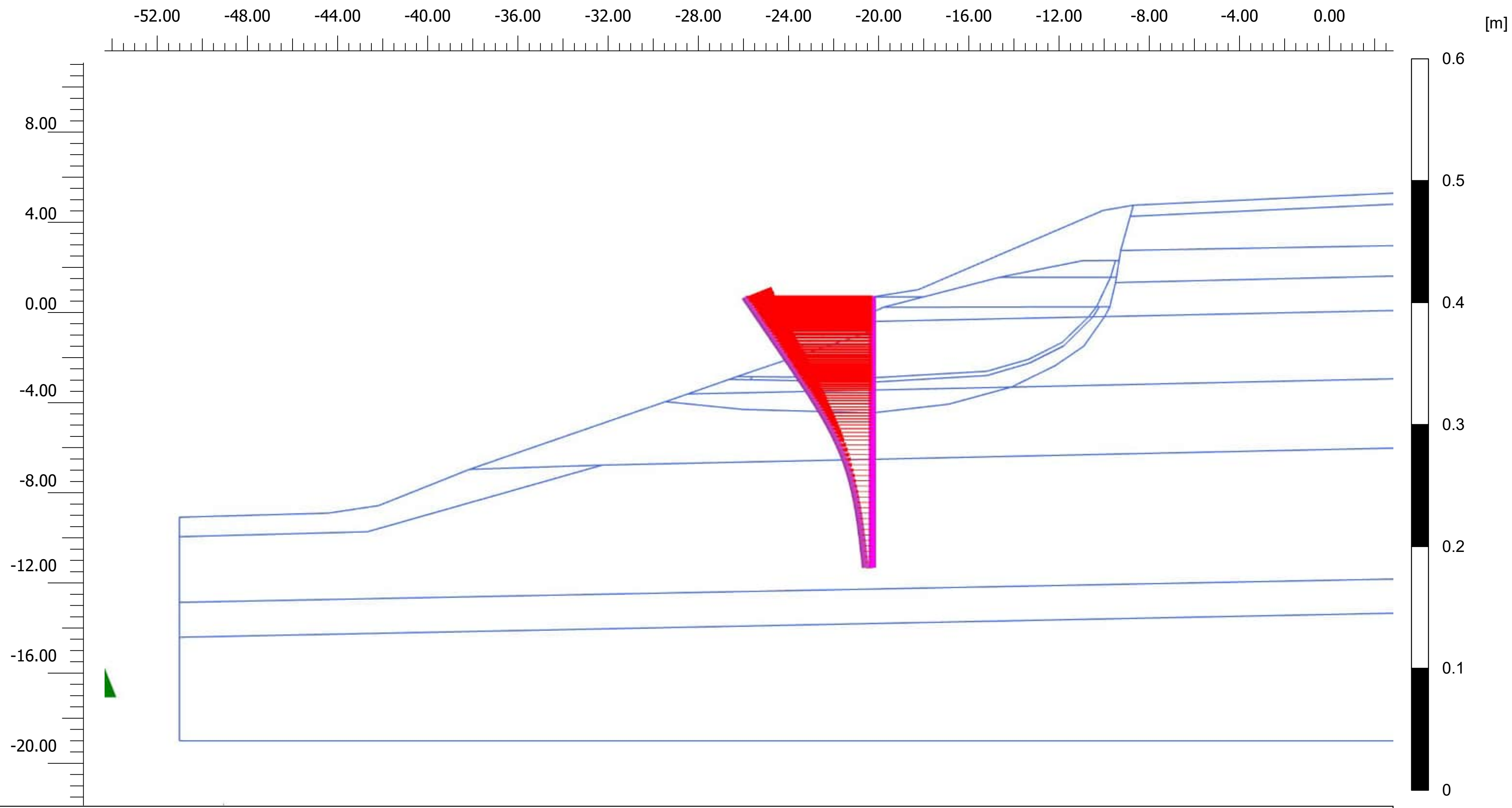
Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
	00 Rock Fill	Mohr-Coulomb	18		0	40	1
	1- Pavement gravel	Mohr-Coulomb	20		0	40	1
	2 -Fill - Silty Sand; medium dense	Mohr-Coulomb	18		0	34	1
	3a - Clayey silt, soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	3b - Silty Clay; firm to stiff (Undrained)	Undrained (Phi=0)	18	50			1
	4a - Clayey Silt; very soft to soft (Undrained)	Undrained (Phi=0)	17	25			1
	4a - Residual Shear Strength	Undrained (Phi=0)	17	12			1
	4b - Silty Clay; soft to firm (Undrained)	Undrained (Phi=0)	17	30			1
	4c -Silty Clay; stiff consistency (Undrained)	Undrained (Phi=0)	19	75			1
	5a - Sand; loose to medium dense	Mohr-Coulomb	18		0	33	1
	5b-Clay, Sandy Clay, Silty Clay, stiff consistency (Undrained)	Undrained (Phi=0)	19	100			1



Slope Stability Analysis Ouput	Modeller : OG	SMEC Member of the Surbana Jurong Group / NSW GOVERNMENT Transport for NSW	Rapid Drawdown
Byrons Lane Slip, Big River Way	Reviewer : MM		Byrons Lane - Steel H Pile - Slip Section.gsz
30013154	100% Detailed Design		08/06/2022 1:200

Appendix E Plaxis 2D Output

Output Version 21.1.0.479



Total displacements u_x (scaled up 50.0 times)

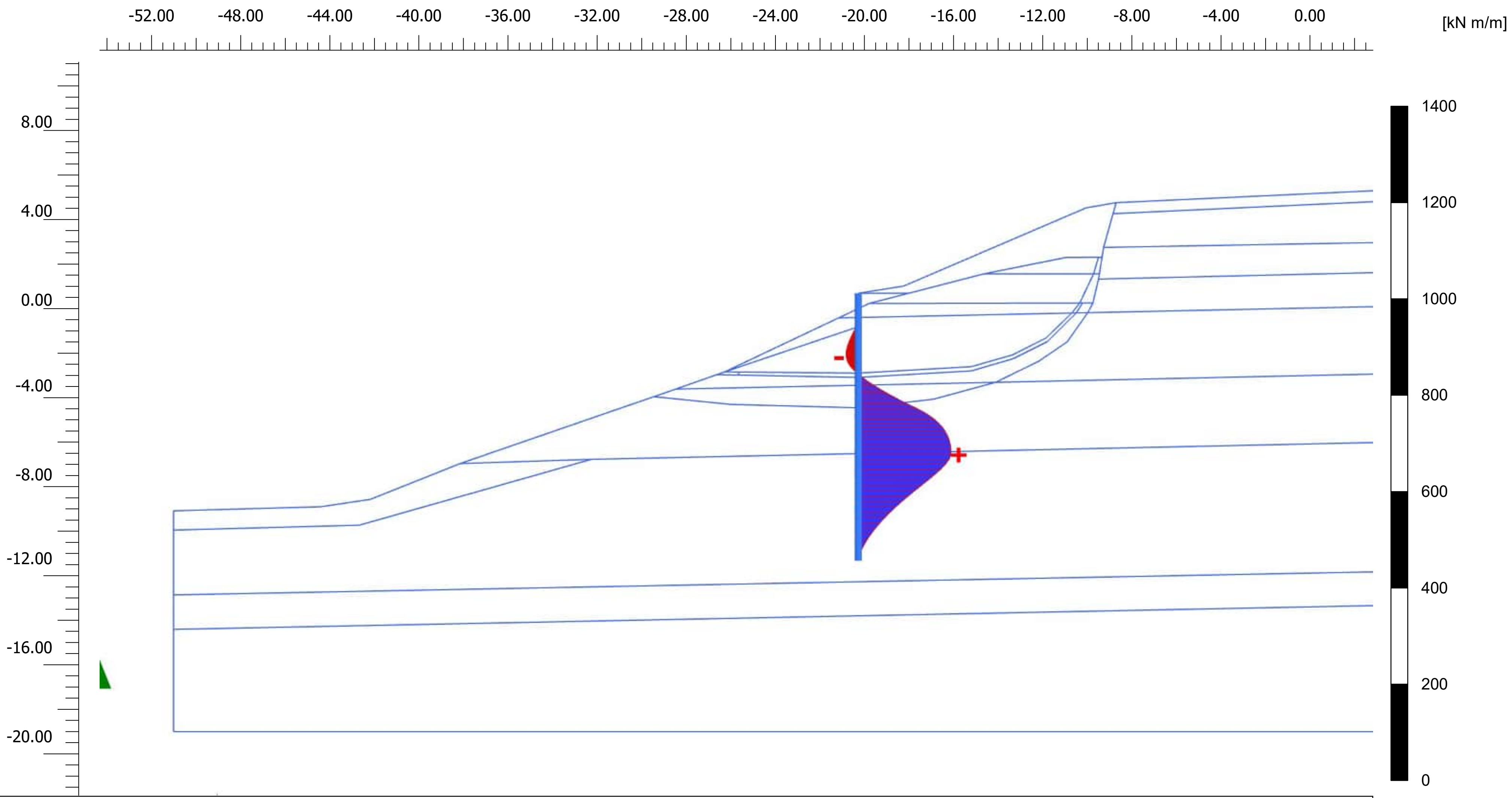
Maximum value = -6.190×10^{-3} m (Element 21 at Node 16216)

Minimum value = -0.1133 m (Element 1 at Node 2638)

PLAXIS® 2D CONNECT Edition

Project description		*Date*
Byrons Lane Slip		20/04/2022
Project filename	*Step*	*Company*
Byrons Lane Slip-REV24-12 ...	280	SMEC Australia Pty Ltd

Output Version 21.1.0.479



Bending moments M (scaled up 0.0200 times)

Maximum value = 208.4 kN m/m (Element 16 at Node 14647)

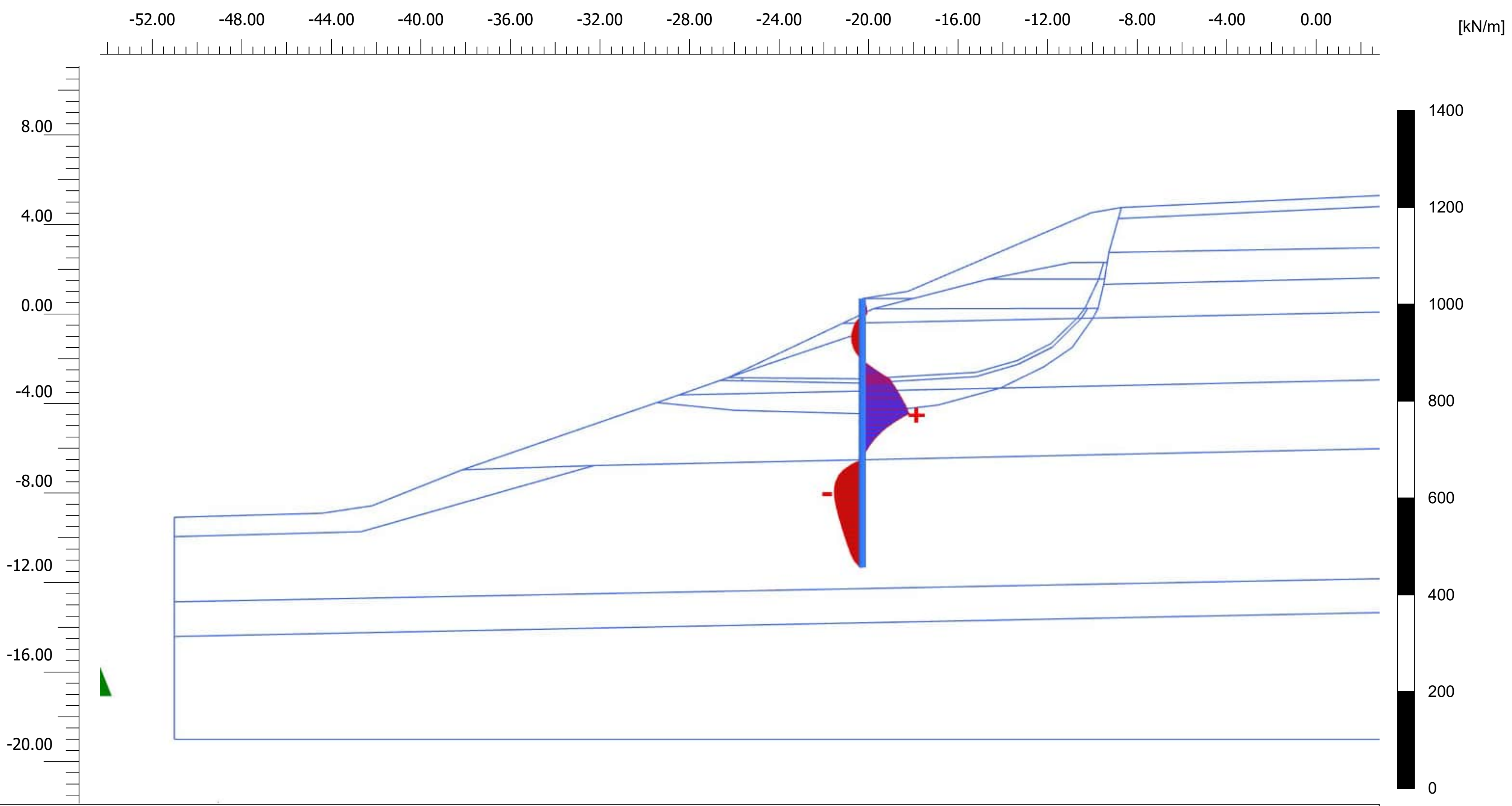
Minimum value = -27.33 kN m/m (Element 7 at Node 8123)

PLAXIS® 2D CONNECT Edition

Project description		Date
Byrons Lane Slip		20/04/2022

Project filename	Step	Company
Byrons Lane Slip-REV24-12 ...	165	SMEC Australia Pty Ltd

Output Version 21.1.0.479



Shear forces Q (scaled up 0.0200 times)

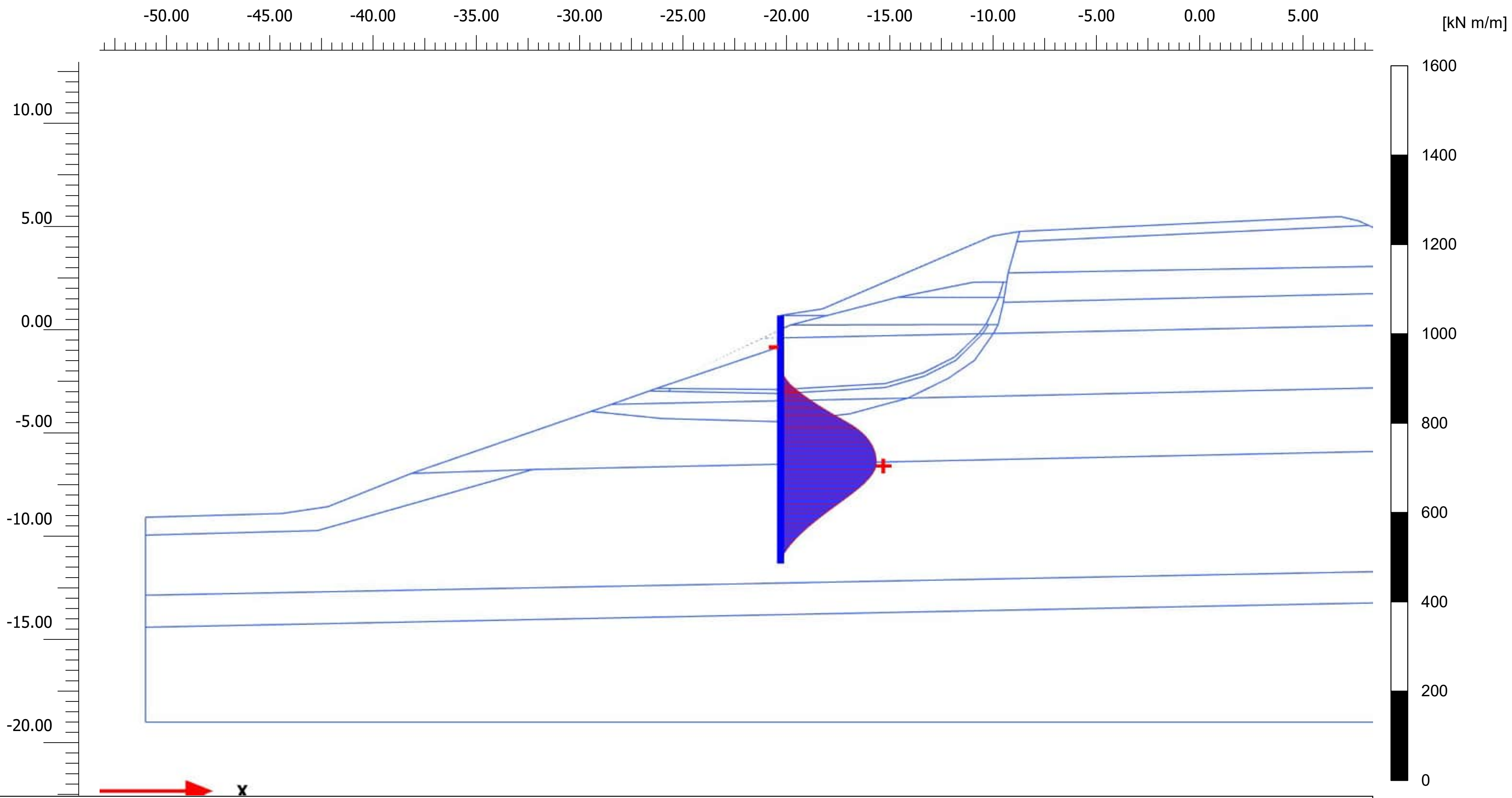
Maximum value = 104.5 kN/m (Element 13 at Node 13853)

Minimum value = -62.60 kN/m (Element 18 at Node 15185)

PLAXIS® 2D CONNECT Edition

Project description		Date
Byrons Lane Slip		20/04/2022
Project filename	Step	Company
Byrons Lane Slip-REV24-12 ...	165	SMEC Australia Pty Ltd

Output Version 21.1.0.479



Bending moments M (scaled up 0.0200 times)

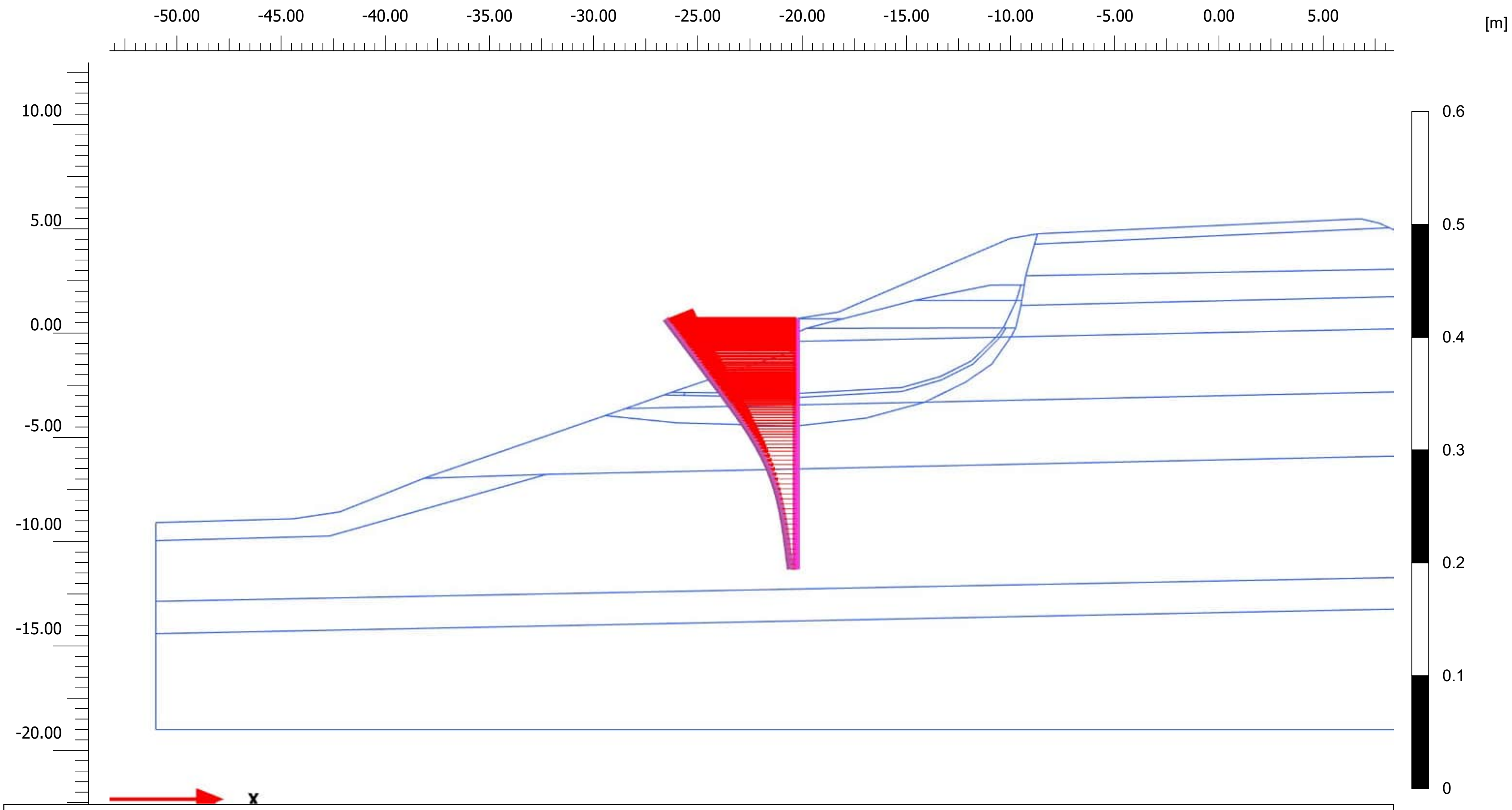
Maximum value = 231.8 kN m/m (Element 16 at Node 14647)

Minimum value = -0.6190 kN m/m (Element 4 at Node 4292)

RESIDUAL SHEAR STRENGTH PARAMETERS

PLAXIS® 2D CONNECT Edition	*Project description* Byrons Lane Slip		*Date* 20/04/2022
	Project filename Byrons Lane Slip-REV25-12 ...	*Step* 283	*Company* SMEC Australia Pty Ltd

Output Version 21.1.0.479



Total displacements u_x (scaled up 50.0 times)

Maximum value = $-5.728*10^{-3}$ m (Element 21 at Node 16216)

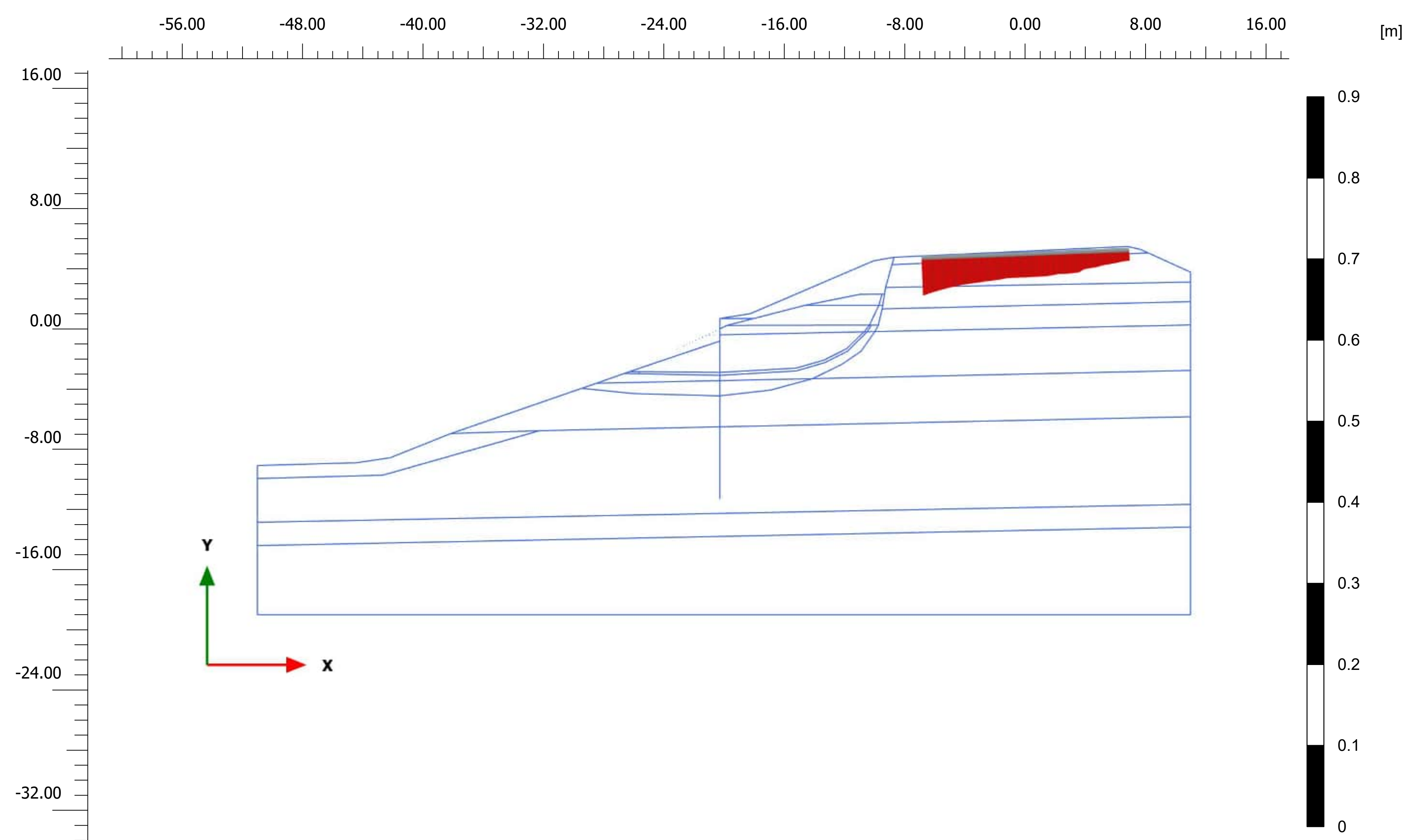
Minimum value = -0.1253 m (Element 1 at Node 2638)

RESIDUAL SHEAR STRENGTH PARAMETERS

PLAXIS® 2D CONNECT Edition

Project description Byrons Lane Slip			*Date* 20/04/2022
Project filename Byrons Lane Slip-REV25-12 ...	*Step* 650	*Company* SMEC Australia Pty Ltd	

Output Version 21.1.0.479



Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.01375 m

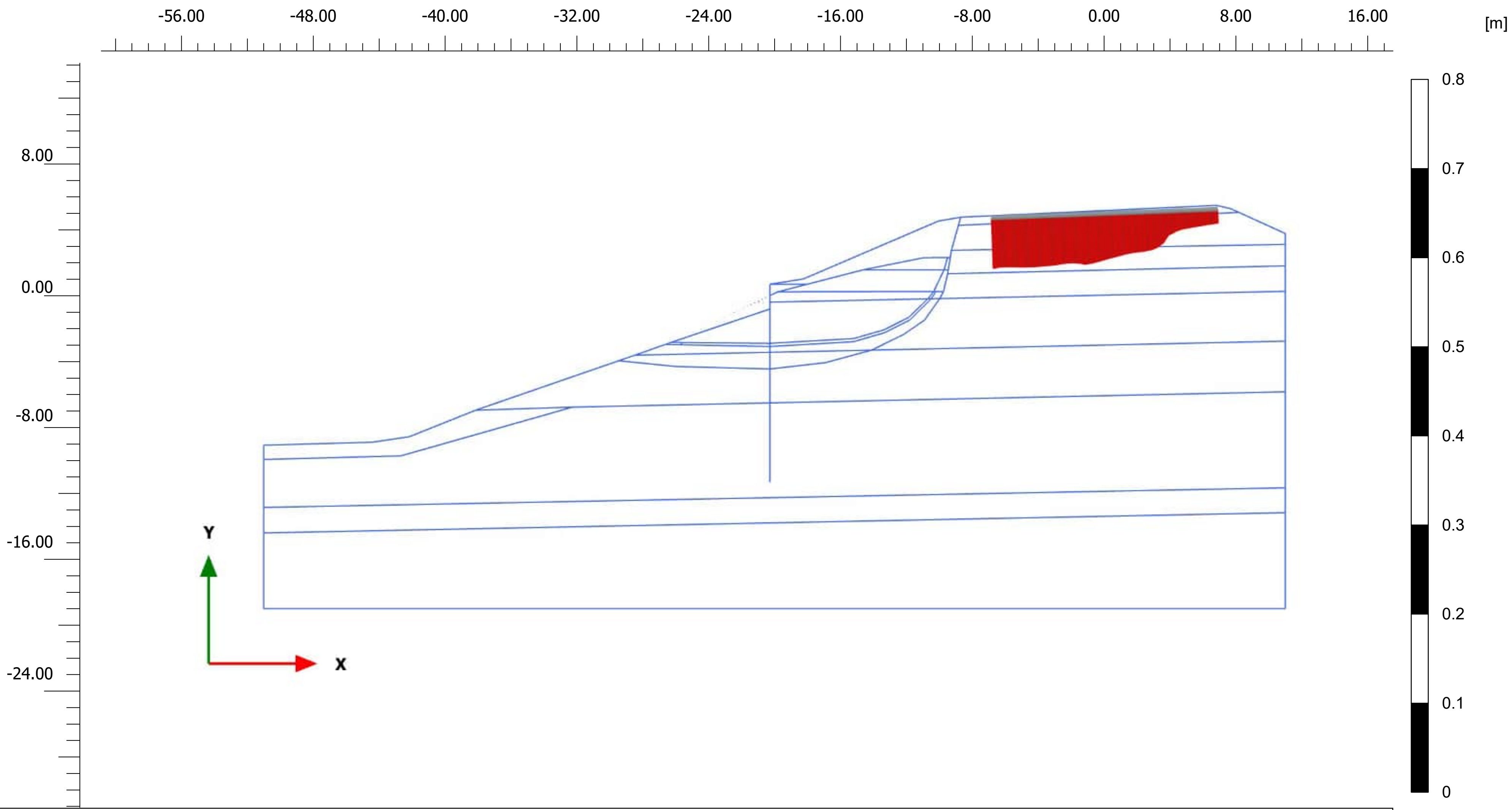
Minimum value = -0.04969 m

RESIDUAL SHEAR STRENGTH PARAMETERS

PLAXIS® 2D CONNECT Edition

Project description			Date
Byrons Lane Slip			20/04/2022
Project filename	Step	Company	
Byrons Lane Slip-REV25 ...	650	SMEC Australia Pty Ltd	

Output Version 21.1.0.479



Total displacements u_y (scaled up 50.0 times)

Maximum value = -0.01708 m

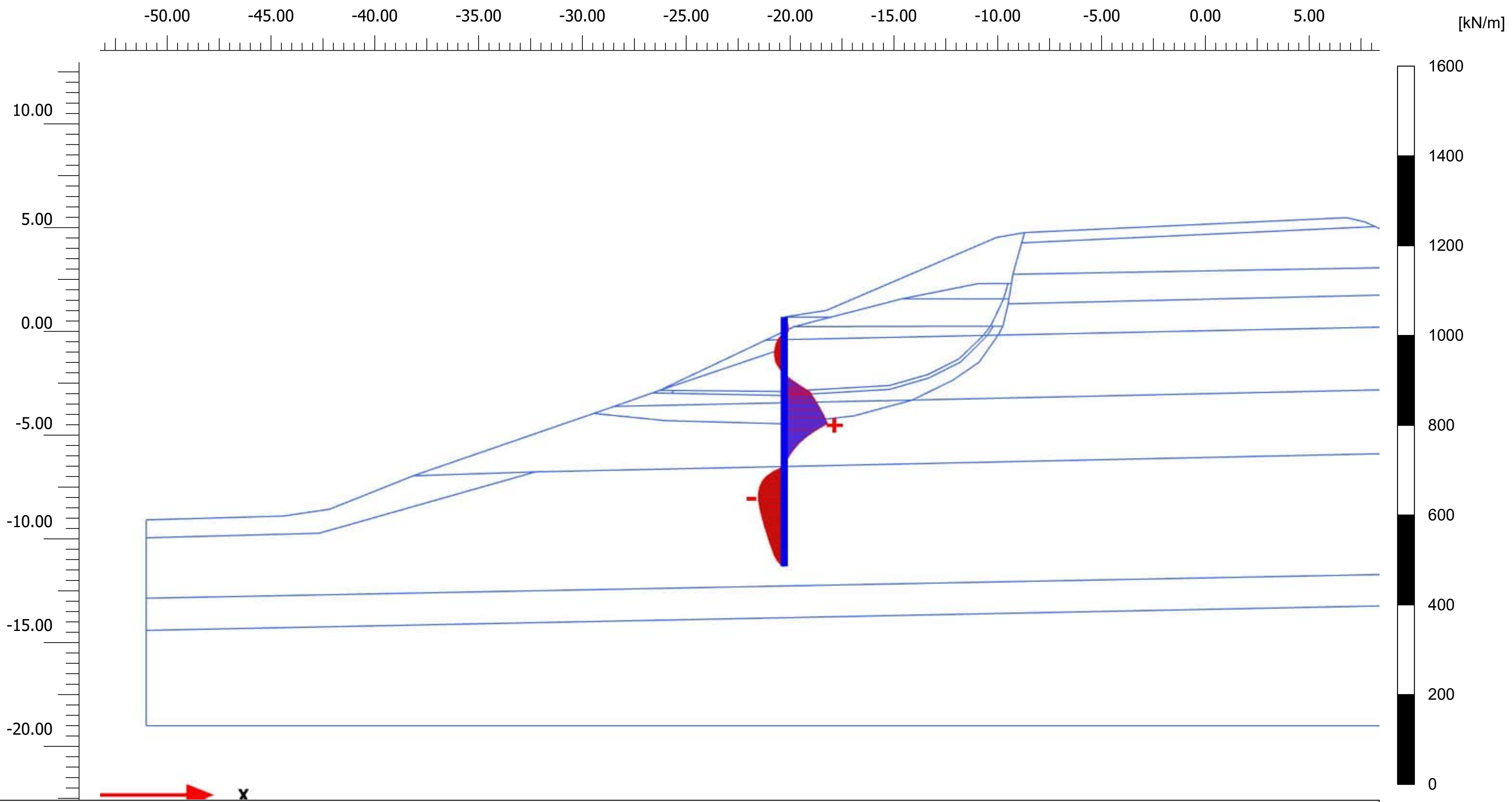
Minimum value = -0.06155 m

RESIDUAL SHEAR STRENGTH PARAMETERS

PLAXIS® 2D CONNECT Edition

Project description			*Date*
Byrons Lane Slip			20/04/2022
Project filename	*Step*	*Company*	
Byrons Lane Slip-REV25-12 ...	650	SMEC Australia Pty Ltd	

Output Version 21.1.0.479



Shear forces Q (scaled up 0.0200 times)

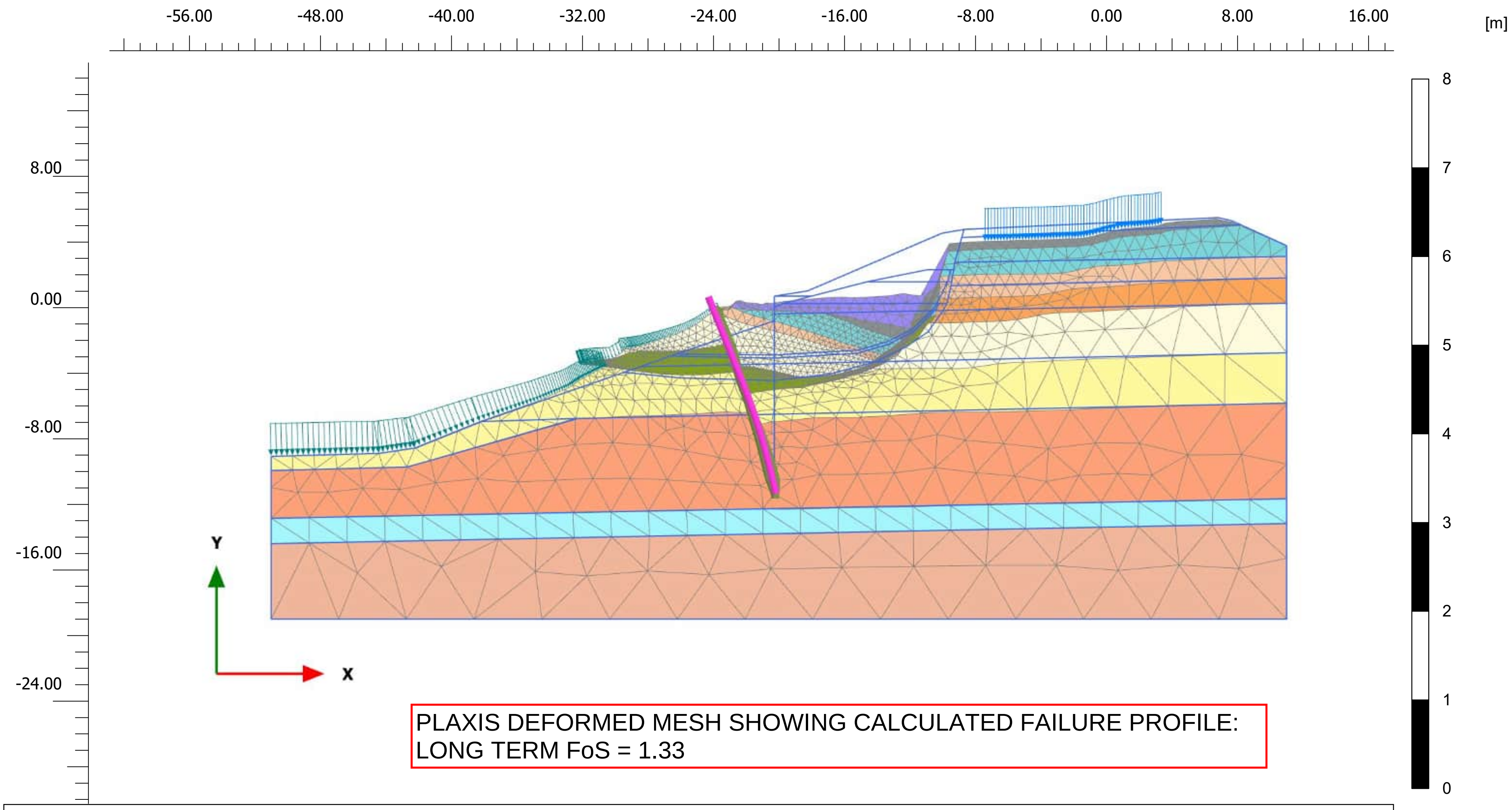
Maximum value = 104.5 kN/m (Element 13 at Node 13853)

Minimum value = -62.60 kN/m (Element 18 at Node 15185)

RESIDUAL SHEAR STRENGTH PARAMETERS

PLAXIS® 2D CONNECT Edition	*Project description* Byrons Lane Slip		*Date* 20/04/2022
	Project filename Byrons Lane Slip-REV25-12 ...	*Step* 165	*Company* SMEC Australia Pty Ltd

Output Version 21.1.0.479



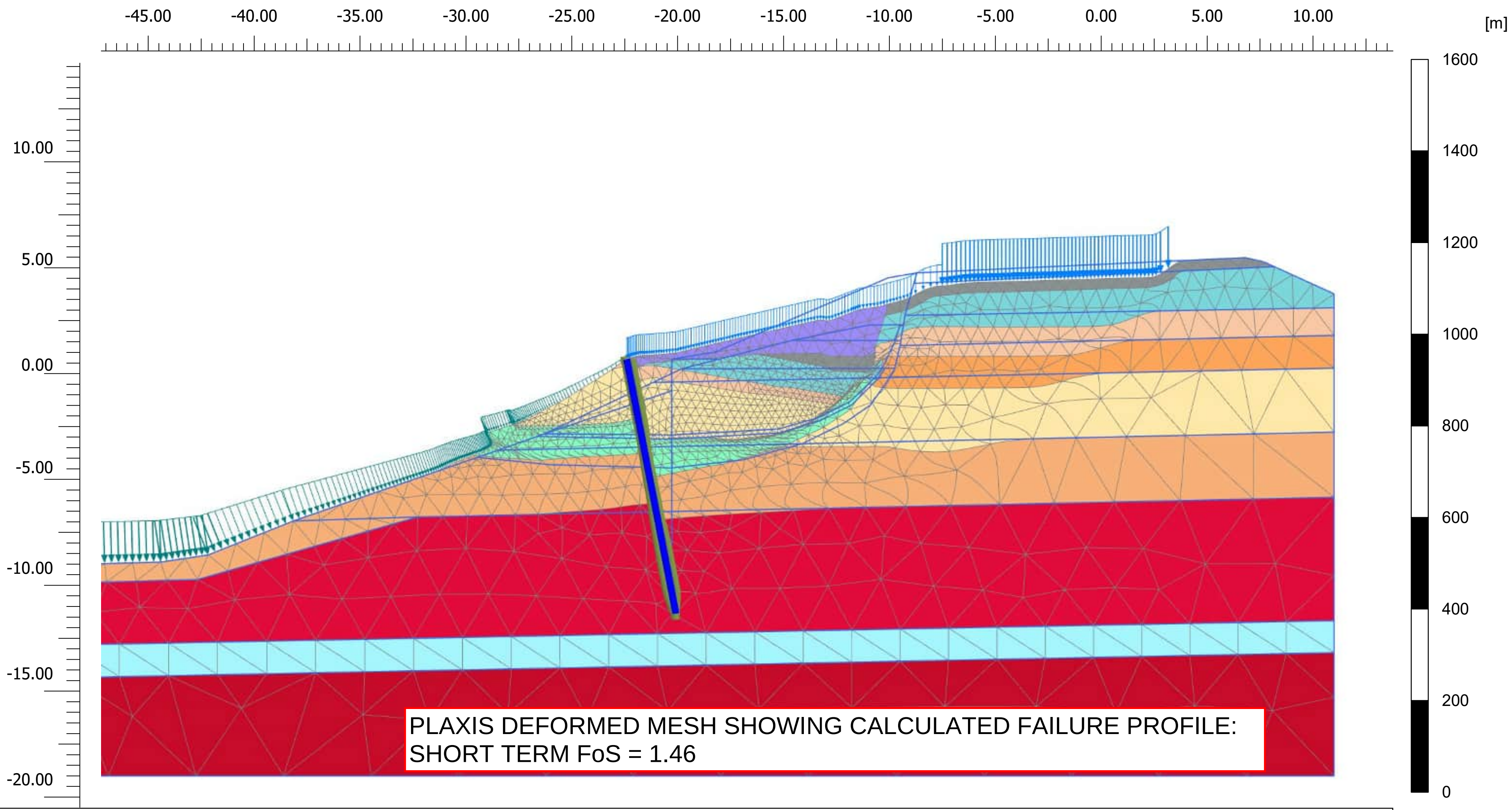
Deformed mesh |u| (scaled up 5.00 times)

Maximum value = 0.9238 m (Element 158 at Node 2553)

PLAXIS® 2D
CONNECT Edition

Project description Byrons Lane Slip			*Date* 26/07/2022
Project filename Byrons Lane Slip-REV25-12 ...	*Step* 442	*Company* SMEC Australia Pty Ltd	

Output Version 21.1.0.479



Deformed mesh |u| (scaled up 0.0200 times)

Maximum value = 115.3 m (Element 1024 at Node 8225)

PLAXIS® 2D CONNECT Edition	*Project description* Byrons Lane Slip		*Date* 26/07/2022
	Project filename Byrons Lane Slip-REV25-12 ...	*Step* 263	*Company* SMEC Australia Pty Ltd

Appendix F Results of Viggiani Assessment

Calculations

Sheet	1	of	1

Job Title	Byrons Lane Concrete Pile	Date 20/5/2022	Job no. 30013154 Project no.

Originator	Checked	Revision	Suffix	Orig
OG	MM		Date	Check

Stabilising Piles in 2-layer Cohesive Soils (Viggiani 1981)

Note: cell colour coding User input | Intermediate data | Results output

Pile properties		Unstable soil layer				Stable soil layer				Layer coefficients	
pile yield moment	pile diameter	pile length	cohesion	bearing capacity factor	limiting stress	pile length	cohesion	bearing capacity factor	limiting stress	length ratio	limiting stress ratio
M_y (kNm)	d (m)	L_1 (m)	c_1 (kPa)	k_1	p_{y1} (kPa)	L_2 (m)	c_2 (kPa)	k_2	p_{y2} (kPa)	$\lambda = L_2/L_1$	$\chi = p_{y1}/p_{y2}$
150	0.50	7.00	12.0	4.0	48.0	5.00	50.0	8.0	400.0	0.71	0.12

Failure mode	Ultimate shear force	Upper bending moment	Lower bending moment
lower hinge	**T (kN)**	M_U (kNm)	M_L (kNm)
B2	**94.1**	56.8	150.0

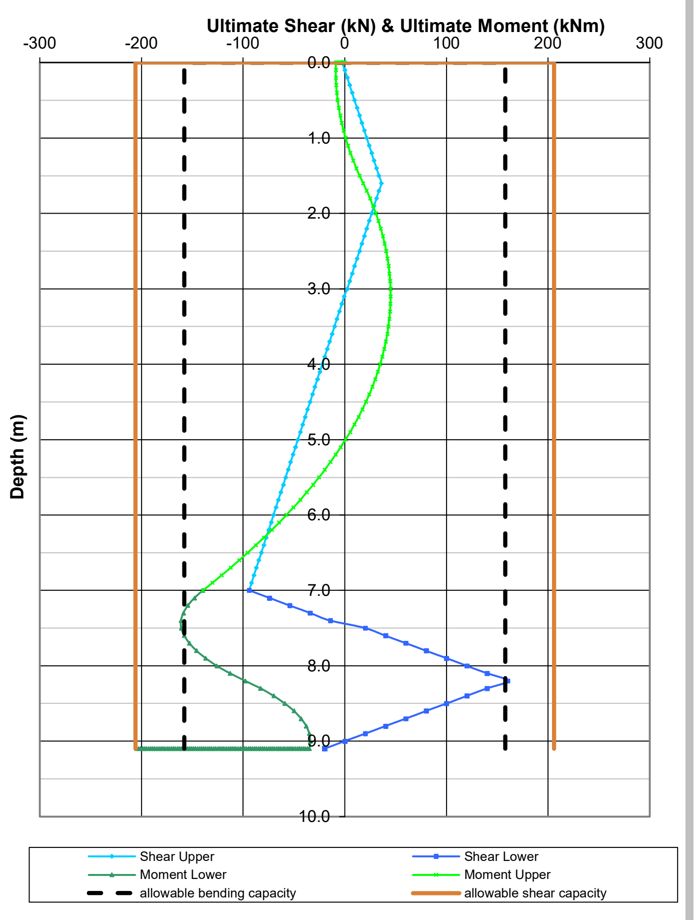
Pile spacing, m 1 Mobilised shear per m run 94.1 kN/m

Yes

No

Use Nc from Tomlinson No

Thickness, H'	Shear Strength, t	H*t	H	gamma, g	H*g
3.5	18	62	3.5	22	77
3	30	90	3.5	17	59.5
0.5	8	4			
Average Shear Strength		22	7		20



$k_1c_1d.L_1$	$k_1c_1d.L_1^2$	χ_{bar}	λ'	λ''	λ_{bar}	$\lambda < \lambda'$	$\lambda > \lambda''$	$\lambda' <= \lambda <= \lambda''$	$\lambda <= \lambda_{bar}$	$\lambda > \lambda_{bar}$	$\chi <= \chi_{bar}$	$\chi > \chi_{bar}$
168.0	1176.0	-0.745	0.048	0.638	0.057	no	yes	no	no	yes	no	yes
						Determine Mode from specified checks						

Mode A Eqn 2

T_A (kN)	M (kNm)	Applies
1000.0	< My	NO

Mode C Eqn 6, 7, 8

T_C (kN)	M (kNm)	Applies
168.0	< My	NO

Mode B Eqn 3, 4, 5#

T_B (kN)	M_1 (kNm)	$M_1 < M_y$	M_2 (kNm)	$M_2 < M_y$	Applies
188.4	4.3	yes	823.5	no	NO

Mode B1 Eqn 9#, 10, 11

$M_1 >= M_y$	T_{B1} (kN)	M_2' (kNm)	$M_2' < M_y$	$M_2' >= M_y$	Applies
no	201.5	797.1	no	yes	NO

Mode B2 Eqn 12

$M_1 < M_y$	M_2 (kNm)	$M_2 >= M_y$	T_{B2} (kN)	M_1'' (kNm)	$M_1'' <$ My	Applies
yes	823.5	yes	94.1	56.8	yes	YES

Mode BY

$M_1 < M_y$	M_2 (kNm)	$M_2 >= M_y$	T_{BY} (kN)	M_1'' (kNm)	$M_1'' >=$ My	Applies
yes	823.5	yes	113.4	56.8	no	NO

Mode	**Pile**	**Type**	**Applies**
A	rigid	short	NO
B	rigid	inter	NO
C	rigid	flow	NO
B1	yielding	hinge U	NO
B2	yielding	hinge L	YES
BY	yielding	2 hinges	NO

Moment	**kNm**
M_y	150.0
M_1	4.3
M_1''	56.8
M_2	823.5
M_2'	797.1

Calculations

SMEC

Sheet	1	of	1	
Job Title	*Byrons Lane* *Steel Pile*	Date: *20/5/2022*	**Job no.**	*30013154*
			Project no.	

Originator	Checked	Revision	Suffix	Orig
OG	*MM*		Date	Check

Stabilising Piles in 2-layer Cohesive Soils (Viggiani 1981)

Note: cell colour coding User input | Intermediate data | Results output

Pile properties		Unstable soil layer				Stable soil layer				Layer coefficients	
pile yield moment	pile diameter	pile length	cohesion	bearing capacity factor	limiting stress	pile length	cohesion	bearing capacity factor	limiting stress	length ratio	limiting stress ratio
M_y (kNm)	d (m)	L_1 (m)	c_1 (kPa)	k_1	p_{y1} (kPa)	L_2 (m)	c_2 (kPa)	k_2	p_{y2} (kPa)	$\lambda = L_2/L_1$	$\chi = p_{y1}/p_{y2}$
422	0.30	7.00	12.0	4.0	48.0	5.00	50.0	8.0	400.0	0.71	0.12

Failure mode	Ultimate shear force	Upper bending moment	Lower bending moment
Flow mode	**T (kN)**	M_U (kNm)	M_L (kNm)
C	**100.8**	< My	< My

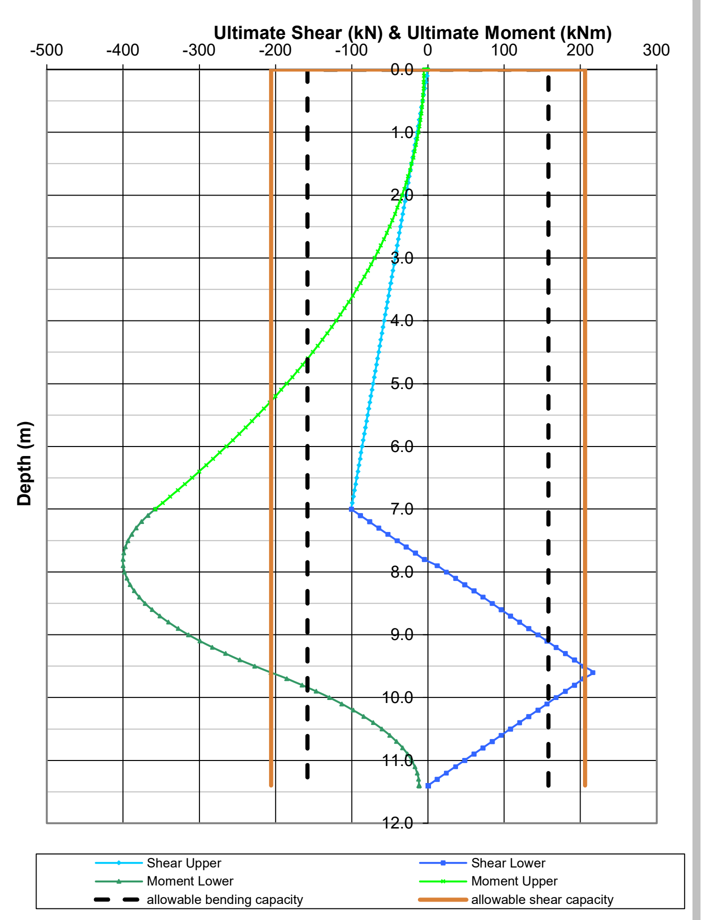
Pile spacing, m 0.9 Mobilised shear per m run 112 kN/m

Yes

No

Use Nc from Tomlinson No

Thickness, H'	Shear Strength, t	H*t	H	gamma, g	H*g
3.5	18	62	3.5	22	77
3	30	90	3.5	17	59.5
0.5	8	4			
Average Shear Strength		22		7	20



$k_1c_1d.L_1$	$k_1c_1d.L_1^2$	χ_{bar}	λ'	λ''	λ_{bar}	$\lambda < \lambda'$	$\lambda > \lambda''$	$\lambda' <= \lambda <= \lambda''$	$\lambda <= \lambda_{bar}$	$\lambda > \lambda_{bar}$	$\chi <= \chi_{bar}$	$\chi > \chi_{bar}$
100.8	705.6	0.196	0.048	0.638	0.124	no	yes	no	no	yes	yes	no
						Determine Mode from specified checks						

Mode A Eqn 2

T_A (kN)	M (kNm)	Applies
600.0	< My	**NO**

Mode C Eqn 6, 7, 8

T_C (kN)	M (kNm)	Applies
100.8	< My	**YES**

Mode B Eqn 3, 4, 5#

T_B (kN)	M_1 (kNm)	$M_1 < M_y$	M_2 (kNm)	$M_2 < M_y$	Applies
113.0	2.6	yes	494.1	no	**NO**

Mode B1 Eqn 9#, 10, 11

$M_1 >= M_y$	T_{B1} (kN)	M_2' (kNm)	$M_2' < M_y$	$M_2' >= M_y$	Applies
no	147.7	426.2	no	yes	**NO**

Mode B2 Eqn 12

$M_1 < M_y$	M_2 (kNm)	$M_2 >= M_y$	T_{B2} (kN)	M_1'' (kNm)	$M_1'' <$ My	Applies
yes	494.1	yes	104.2	0.2	yes	**NO**

Mode BY

$M_1 < M_y$	M_2 (kNm)	$M_2 >= M_y$	T_{BY} (kN)	M_1'' (kNm)	$M_1'' >=$ My	Applies
yes	494.1	yes	147.3	0.2	no	**NO**

Mode	**Pile**	**Type**	**Applies**
A	rigid	short	NO
B	rigid	inter	NO
C	rigid	flow	YES
B1	yielding	hinge U	NO
B2	yielding	hinge L	NO
BY	yielding	2 hinges	NO

Moment	**kNm**
M_y	422.0
M_1	2.6
M_1''	0.2
M_2	494.1
M_2'	426.2

Appendix G Safety in Design Register

T-PM10701	SAFETY IN DESIGN RISK REGISTER	
Project Name: Byrons Lane Slip Remediation	S.I.D. Register Rev: 00	
Design Package: 80% Detailed Design	Date: 12/05/2022	Risk Workshop

POTENTIAL RISK			Initial Risk Assessment				Residual Risk Assessment					
HAZARD	*DESCRIPTION*	POTENTIAL CONSEQUENCES	Initial Risk Likelihood (0-5)	Initial Risk Consequence (0-5)	Initial Risk Rating	POTENTIAL ELIMINATION MEASURE, DESIGN INITIATIVE or CONTROL (Identify any Standard or Code of practice used)	Residual Risk Likelihood (0-5)	Residual Risk Consequence (0-5)	Residual Risk Rating	RESIDUAL RISK OWNER	Date SID Risk closed out	SID Risk Closed Out by:
Geotechnical												
Unexpected ground conditions	Ground conditions differ from assumed. Variable alluvium profiles, unexpected rock armour.	Design Changes - longer piles, delays during construction	3	4	12	Provide for some redundancy in design for variable ground conditions. Consider test piles or additional geotechnical investigation such as CPT to verify subsurface conditions along pile footprint.	2	4	8	TfNSW/ Contractor		
Further slips	Existing slip scarp and marginally stable embankment slopes. RT - Collapse and regression of headscarp towards the road	Slips and engulfment during construction. Loss of NB Carriageway, formation of voids beneath pavement with potential for sudden collapse.	4	5	20	Design for temporary stability and staging of works, identify exclusion zones for heavy plant. Review of contractors proposed methodologies. Avoid work during floods or prolonged wet periods. Construction monitoring and temporary works to support headscarp.	2	5	10	SMEC/ Contractor		
Further slips	RT - Extent of Piles	Further slumping of northern end of river bank	3	4	12	Survey sset out of slip headscarp and potential for inclusion of additional shear piles at northern end of slope. Contingency for additional piles as part of design and construction	2	4	8	SMEC/ Contractor		
Further slips	RT - Extent of rock fill not as far as antiicpiated	Construction delays, access issues	4	5	20	. Construction setout and investigation. Allowance for design and construction.	3	5	15	SMEC/ Contractor		
Survey												
Insufficient or innacurate survey	Insufficient information to undertake design. Discrepancies between design and site.	Discrepancies between design and site conditions	3	3	9	Recent flooding may have caused further site degradation and slumping of headscarp. Undertake additional detailed site survey to verify profiles and feedback in to design. During construction, contractor to setout and verify design dimensions at critical stages, prior to proceeding.	1	3	3	Contractor		
Environment												
Impact on Habitat	Vegetation clearance, sediment runoff, piling and earthworks operations impacting on aquatic habitats	Habitat destruction, removal of native species, contamination of waterways, adverse impacts on aquatic habitats	4	4	16	Undertake review of environmental factors. Develop and enforce environmental construction management plan.	2	4	8	TfNSW		
Acid Sulfate Soils (ASS)	Distubance of acid sulfate soils (ASS)	Disturbance of ASS can generate significant amounts of sulfuric acid, which can lower soil and water pH to extreme levels and produce acid soils.	4	4	16	Prepare an acid sulfate management plan and undertake additional ASS testing and treatment during construction.	2	4	8	TfNSW/ Contractor		
KD - Contamination of river water	Excavation of material and seiment runoff	Adverse impacts on water quality.	4	4	16	Construction methodology and limiting ground disturbance, selection of materials and implementing appropriate erosion and sediment controls	2	4	8	TfNSW/ Contractor		
Gi - Impact on aboroignal cultural heritage items	Excavation, piling oeprations impacting or disturbig aboriginal/cultural heritage items	damaging aborigianl cultural items of significance to community				REF, CEMP,						
Design												
Constructability	Design cannot be practically or safely constructed	Re-design and associated costs and delays	4	4	16	Preliminary consultation with piling contractor held to evaluate some constructability issues between concrete and steel piles. Plan a constructability workshop to ensure design is safely constructible. Review contractors construction methodolgies and seek clarification from designer/ constructors	2	4	8	TfNSW		
Excessive Deformations	Embankment and Pavement deformations	Personal injury, vehicle damage, excessive maintenance	3	3	9	Design for serviceability	2	3	6	TfNSW/ SMEC		
Durability	Remediation solutions not do not meet durability requirements	Remediation solution or components do not achieve intended design life	3	4	12	Design for durability. Highlight maintenance requirements which may include postconstruction monitoring and communicating requirements.	2	4	8	TfNSW		
Loads	Loadings greater than expected	Failure due to over stressing	3	4	12	Model construction staging and traffic loads, adopt safety factors, specify load limits and set backs	2	4	8	SMEC		
Scour	Lack of hydraulic/ scour assessment information for clarence river. Incorrect long term scour profiles and scour treatments	Failure due to excessive scour	4	4	16	Investigate and assess hdyraulics and scour within limits of site and donstream of site. Include provision for additional scour treatment as part of long term maintenance.	2	4	8	TfNSW		
Construction												
Unexpected ground conditions	Ground conditions differ from the design assumptions	Construction difficulties, variations, delays	3	4	12	Provide for some redundancy in design for variable ground conditions. Consider additional geotechnical investigation such as CPT to provide more understanding of subsurface conditions. Staged testing or trials at early stages of construction. Provision for a suitably qualified geotechnical engineer to supervise and document works during construction	2	4	8	Contractor		
Water levels	River and or groundwater levels will vary with climate, tide and seasons.	Flooding, impact on earthworks, piling, slope stability.	3	4	12	Monitor weather forecasts and water/tidal levels. Avoid working during flood or heavy/prolonged rainfall conditions.	1	4	4	Contractor		
Instability	Unstable slopes during construction	LTI / injury / death,	4	5	20	Visual monitoring of slopes for deformation during construction. Undertake works during dry weather. Limit construction plant bearing pressures within designated setbacks or exclusion zones. Limit plant vibrations. Design termporary works to support heavy plant for land based operations.	2	5	10	Contractor		
Instability	Plant roll over working on batter slopes undertaking earthworks and rock fill/rock armour placement	LTI / injury / death,	4	5	20	Utilise apprpropriate plant and equipment for earthworks and placement of rock fill behind shear piles. Design and construct appropriate temporary working platforms to support plant.	2	5	10	Contractor		
Excavations	Temporary and permanent excavations	Falling into excavations, wall collapse, striking services. LTI / injury / death,	4	5	20	Ensure that code of practice for excavations are complied with. Construct barriers where necessary. Provide shoring where necessary. Check for underground services.	2	5	10	Contractor		
Under / Above Ground Services	Striking Services during construction	Disruptions to live traffic, construction and increased risk to construction crews.	3	3	9	Investigate and identify buried services. Relocate/ protect services where necessary	2	3	6	Contractor		
Inadequate Concrete Strength	Durability and strength	Structural collapse, durability issues.	2	4	8	Concrete quality control practices in place. Ensure that design team has been notified as a Non Conformance.	1	4	4	Contractor		
Fall from heights	Working on and adjacent to steep slopes	LTI / injury / death,	4	5	20	Follow WHS practices for working at heights.	2	5	10	Contractor		
River	Fall in to river from slope or barge. Strong current, obstructions, entaglement.	LTI / injury / death - drowning	4	5	20	Follow WHS practices for working near and over water	2	5	10	Contractor		
Working adjacent to live traffic	Potential for traffic accidents during construction	Increased potential for accidents - LTI / injury / death,	4	5	20	Ensure adequate TCPs and safe working conditions are implemented, including reduction of speed limit and single lane closures.	2	5	10	Contractor		
Working adjacent to live traffic on river	Potential for traffic accidents during construction - river traffic	Increased potential for accidents - LTI / injury / death,	4	5	20	Ensure adequate TCPs and safe working conditions are implemented for barge work. Barge laoding unlaoding zones, transporiting barge to worksite, material storage site, at the slip work zone	2	5	10	Contractor		
Barge work and interactions between barge and other river users, barge and crane operations, barge loading/unloading operations	Potential for accidents associated with ooperating barges on river and undertaking piling operations.	Increased potential for accidents - LTI / injury / death,	4	4	16	Ensure adequate management plans and SWMS are developed.	2	5	10	Contractor		
Pavement Damage	Damaged pavements creating unsafe pavement	Increased risk of accidents	3	4	12	Provision to repair and reinstate pavements	2	4	8	TfNSW/Contractor		
Noise	Excessive construction noise	Disruption to neighbourhood	2	3	6	Rural setting. Evaluate high noise activities and consider restrict working hours for noisy work.	1	3	3	Contractor		
Vibration	Excessive vibration	Generate slope instability	4	4	16	Adopt construction methodologies and plant/equipment that do not generate excessive vibrations.	2	4	8	Contractor		
Maintenance Issues												
Access to structures	Lack of safe access for maintenance	Increased risk to maintenance crews	2	4	8	Provide safe working conditions for inspection and maintenance.	1	4	4	TfNSW		

Notes for working with the Health and Safety in Design (HSiD) Risk Register

Step 1- (Pre-design). Confirm scope of the project and identify project constraints and assumptions.

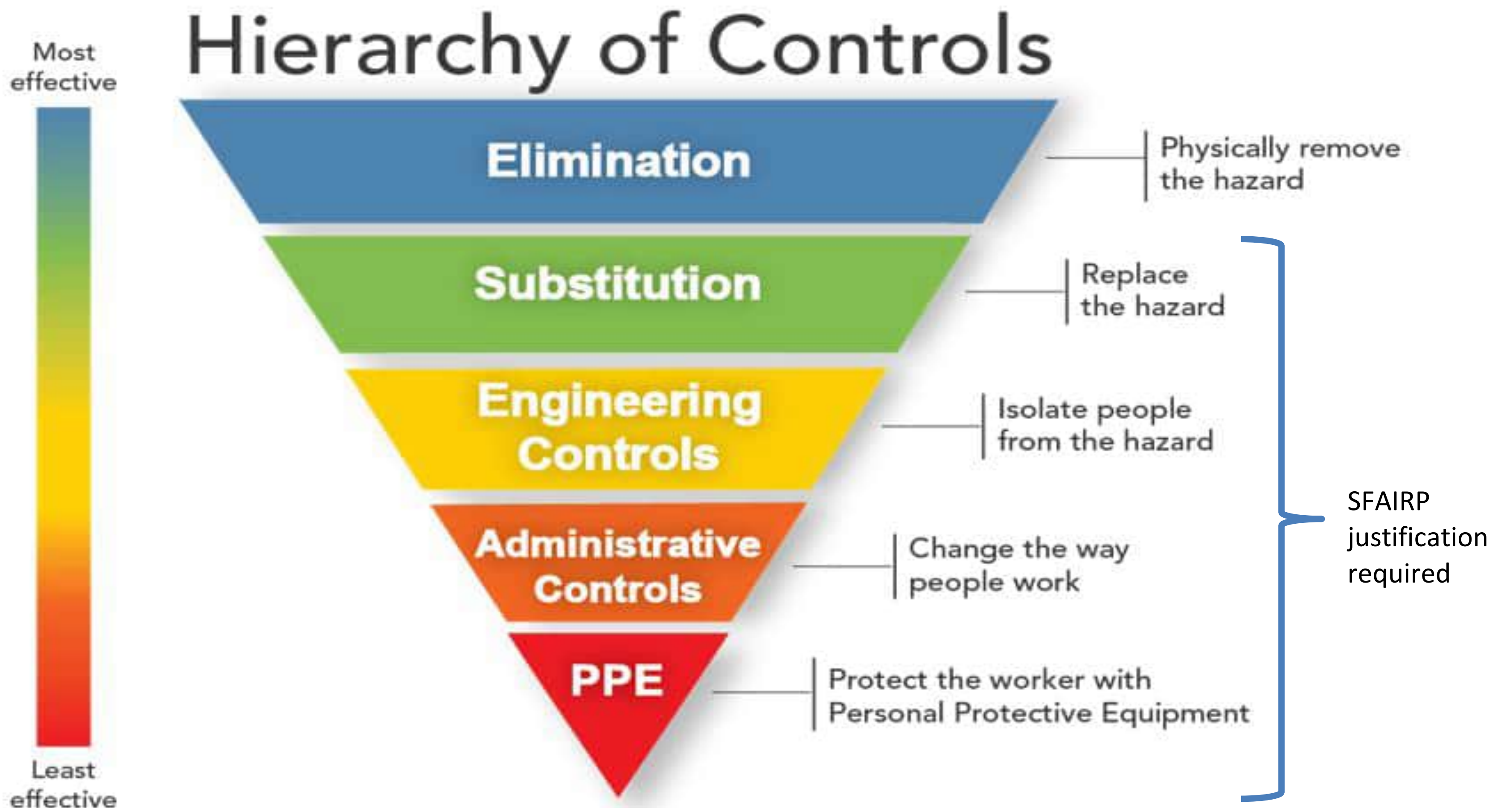
Step 2a - (Prior to workshops). Identify potential risks through review of previous projects, sample risk registers, workshops and using guidewords. The Template HSiD Register contains sample risks that may occur on typical projects. These should be reviewed along with the guidewords with a view to identifying any significant risks that may be particular to the project under review. (Populate columns 1-8 plus 9-12 where possible).

Step 2b - (During workshops). Emphasis should be placed on identifying additional risks of a nature particular to the project under review (rather than generic risks). The priority should be to identify high consequence and high probability risks first and to apply the hierarchy of controls. (Identify controls applicable and populate columns 1-8 plus 12).

Step 3 - (Post workshops). Evaluate risks using Risk Assessment Criteria and determine the best safety management strategy utilising the hierarchy of control and SFAIRP principles. (Populate columns 9-14).

Step 4 - (During design development). Ongoing review of hazards and implementation of proposed controls. Identify and confirm where controls have been implemented, assess residual risks, and document SFAIRP justification where required. (Populate columns 13-19).

Step 5 - (At completion of design). Document risk actions and residual risks for each package in Design Reports and Drawings and transmit completed risk register to client. (Populate columns 20-21) Complete SiD Report where required.



SMEC

Member of the Surbana Jurong Group

Residual Risk Scores	
1 to 6 - Low	Risks and controls are managed inside the project/business unit through normal day-to-day management
8 to 12 - Medium	Assign specific responsibility for control of risks (i.e. name responsible person)
15 to 16- High	Report risk to General Counsel/Head of Compliance together with risk treatment plan
20 to 25 - Extreme	Immediately report to General Counsel/Head of Compliance (GCHC) and devise risk treatment plan in conjuction with GCHC

RISK ACCEPTANCE CRITERIA

	CONSEQUENCE				
Safety	• Ailments not requiring treatment	• Injury or illness but person is able to return to normal duties either immediately or by the beginning of their next shift	• Temporary impairment - person will fully recover but is unable to undertake normal duties at the beginning of their next shift • Breach of Act/Regulation leading to an improvement notice being issued by a regulatory authority • Practice deviates from a Code of Practice or Compliance Code	• Permanent impairment and/or disability as a result of injury or illness • Breach of Act/Regulation leading to penalty notice issued by a regulatory authority • Multiple cases of Moderate consequence	• Fatality as a result of injury or illness • Breach of Act/Regulation leading to SMEC or a SMEC employee being charged by a court or tribunal • Multiple cases of Major consequence
Reputation	Self-improvement review required	Internal reviews required to reverse decline in reputation	Scrutiny required in the form of external reviews and/or investigations	Intense public, political and media scrutiny evidenced by front page headlines and/or television coverage.	Complete Loss of Integrity as a Valued Business Supplier eg found guilty of major breaches of Trade Practices Act
Financial	< $500,000	$500k - $2M	$2M - $5M	$5M - $10M	>$10M
Legal Compliance	Breaches rectified without ongoing issues with authorities	Notifications by Authorities of Potential Breaches	Breach of Law or Statute with potential penalties under $5M	Breach of Law or Statute with potential penalties in excess of $5M	Breach of Laws with potential for a criminal prosecution
Organisational Objectives	Very little consequence to achievement of strategic plan	Would require some adjustment to achieve strategic plan	Would require significant adjustment to achieve strategic plan	Would threaten achievement of the strategic plan	Would stop achievement of the strategic plan
	1	2	3	4	5

LIKELIHOOD	Description	%			Insignificant	Minor	Moderate	Major	Catastrophic
	• The event can be expected to occur in most circumstances • The event has occurred in the past (at least annually) • Circumstances are in train that will cause the event to happen	40-99%	5	Almost Certain	5	10	15	20	25
	• The occurrence of the event would not be considered unusual • The event has occurred in the past few years • Circumstances are in train that may cause the event to happen	15-39%	4	Above Average	4	8	12	16	20
	• The occurrence of the event is unusual • The event has occurred at least once in SMEC history	5-14%	3	Moderate	3	6	9	12	15
	• The event has not occurred in SMEC history • The event has occurred, infrequently, to similar organisations	1-5%	2	Rare	2	4	6	8	10
	• The event only occurs in exceptional circumstances • The event has not occurred in SMEC history • The event is not known to have occurred within similar organisations	Less than 1%	1	Very Rare	1	2	3	4	5

Appendix H Schedule of Quantities

Schedule of Quantities and Relative Cost Estimates
Byrons Lane Landslide Remediation
Shear Piles and Rock Fill - Steel Piles

Job No 30013154
Date 20/07/2022

Comments and Calcs

Item	Description	Units	Quantity	Comments and Calcs
1	**Preliminaries and General Items**			
	Establishment of plant to site	Item	1	Assumes barge, piling rig and excavator.
	Site Compound, Barriers, Security, Amenities	Item	1	
	Traffic Control	week	3	Assumes 3 weeks single lane closure
	Barge Hire	Day	5	Medium size barge envisaged to support large excavator mounted piling hammer.
2	**Quality Control, Survey, As-Built Drawings, Geotechnical Advice**			
	3D coordinated survey and set-out, as-builts	Item	1	
	Engineer Construction Supervision	week	3	Experienced engineer supervision
	Project Management	Item	1	
3	**Clearing and Environmental Control**			
	Erosion and Sediment Control	Item	1	Sediment and erosion control measures
	Environmental REF and monitoring	Item	1	
4	**Construct Shear Piles**			
	Excavate to remove rock armour from pile footprint	allow	1	Costing allowance for excavator working off barge.
	Supply and install 310UC158 steel piles with corrosion treatment applied to upper 4 m of each pile	m	564	310UC158 piles at 0.9 m centres = 47 piles. Piles @ 12m long.
5	**Earthworks and Rock Armouring and Rock Filling**			
	Vegetation clearance	m^2	500	Clear riverbank for rock armouring. Allow 500 m2.
	Excavate to form benches	m^3	250	0.6 m max height benches. Allow 250 m3
	Geotextile Seperation Fabric Strength Class E	m^2	1100	Laid and pinned loose beneath rock armour and rock fill and allowing for 500 mm overla
	Rock armour slope	m^3	300	700 mm to 1000 mm size rock
	Rock fill slope	m^3	800	100 mm to 500 mm size rock
6	**Other Items**			
	Repair pavement wearing course + line marking	m^2	300	50 m x 6 m width (including shoulder) = 300 m2
	Construct new slotted Type F concrete barrier	m	20	Allow 20 m cast in situ Type F barrier with slotted base with dowelled connection to exis
	Removal of Excavated Spoil - Off Site Disposal	m^3	300	Excess material removed from site.
	Supply and install TL3 Quadguard M10 barrier system	Item	1	As per drawings and specifications
	Provisional - supply and install additional 12m long shear piles in transition zone	Item	1	
	Provisional - wedge of rock armour in front of shear piles	m^3	25	700 mm to 1000 mm size rock

Excluded:
Long term maintenance
Temporary working platforms

Appendix I Product Specifications

DUREMAX® GFX

High Performance Surface Tolerant Glass Flake Epoxy — PC 256

FEATURES
- HIGH GLASS FLAKE CONTENT
- SUPERIOR RESIN TECHNOLOGY FOR SURFACE WETTING AND CORROSION RESISTANCE
- HIGH PERFORMANCE MAINTENANCE COATING FOR NEW OR EXISTING STEEL
- EXCELLENT BARRIER FOR IMMERSION OR SPLASH ZONE
- SELF PRIMING FINISH – HIGH SOLIDS AND HIGH BUILD FORMULATION
- GOOD ABRASION AND CHEMICAL RESISTANCE

USES

DUREMAX® GFX is a high solids, high build glass flake reinforced epoxy developed to deliver long term corrosion resistance. Ideally suited to protecting new steelwork from atmospheric and marine corrosion including coastal and off-shore structures, above and below the water-line.

The adhesion strength of DUREMAX® GFX allows it to be used as a high performance maintenance coating over hand, power tool or high-pressure water cleaned surface. DUREMAX® GFX can be topcoated with a wide range of coating types.

SPECIFICATIONS

AS 3750.1-1994 “Paints for steel structures - Epoxy mastic (two-pack) - For rusted steel”
AS 4352-2005 “Tests for Coating Resistance to Cathodic Disbondment”. Group A classification (When applied in two coats at 250 µm DFT per coat directly applied to abrasive blast cleaned steel - AS1627.4 Class 3)

RESISTANCE GUIDE

WEATHERABILITY	Will yellow with time and chalk on exterior exposure. Neither yellowing nor chalking detracts from the protective properties of the coating. Use a weatherable topcoat if required for appearance.	SOLVENTS	Resists splash and spillage of most hydrocarbon solvents, refined petroleum products and most common alcohols
HEAT RESISTANCE	Up to 120°C dry heat	WATER	Excellent resistance to immersion in fresh and salt water
SALTS	Excellent resistance to neutral and alkaline salts	ALKALIS	Good resistance to splash and spillage of strong alkalis
ACIDS	Suitable for splash and spillage of mild acids	ABRASION	Good when fully cured

TYPICAL PROPERTIES AND APPLICATION DATA (STANDARD HARDENER)

CLASSIFICATION	Two Pack Glass Flake Reinforced Epoxy
FINISH	Semi Gloss
COLOUR	Mid Grey and Black
COMPONENTS	Two
VOLUME SOLIDS	84% (Black)
VOC LEVEL	<210 g/L (Black)
FLASH POINT	>23°C
POT LIFE	90 minutes (4 litre kit, 25°C)
MIXING RATIO V/V	Part A : 4 Part B : 1
THINNER	920-08925 Dulux® Epoxy Thinner
PRODUCT CODE	775-H0095 Mid Grey 775-H0094 Black 976-H0096 Standard Hardener 976-H0126 Cold Cure Hardener

APPLICATION CONDITIONS

	Min	Max
Air Temp.	10°C	45°C
Substrate Temp.	10°C	45°C
Relative Humidity		85%
Concrete Moisture		<10%

COATING THICKNESS (MICRONS)

	Min	Max	Recommended
Wet film per coat (µm)	240	600	300
Dry film per coat (µm)	200	500	250

SUITABLE SUBSTRATES	Prepared rusty steel, aged tightly adhering coatings, prepared concrete Aluminium and galvanised steel
PRIMERS	Most Dulux® two pack primers
APPLICATION METHODS	Conventional, airless, or air assisted spray

DRYING CHARACTERISTICS AT 250 µm DRY FILM THICKNESS* (STANDARD HARDENER)

					OVERCOAT	
Temperature	Humidity	Touch	Handle	Full Cure	Min	Max[1]
10° C	50%	14 Hours	36 Hours	7 Days	36 Hours	4 Weeks
15° C	50%	10 Hours	24 Hours	7 Days	24 Hours	4 Weeks
25° C	50%	6 Hours	14 Hours	7 Days	14 Hours	4 Weeks

*These figures are a guide only, as ventilation, film thickness, humidity, thinning and other factors will influence the rate of drying.
[1]If the maximum overcoat interval is exceeded then the surface MUST be abraded to ensure maximum intercoat adhesion.

SPREADING RATE **with Standard Hardener** assuming no losses

3.4 square metres per litre equals 250 µm dry film thickness
NOTE: Practical spreading rates will vary depending on such factors as application method, ambient conditions, surface porosity and roughness.

DUREMAX® GFX

COLD CURE HARDENER

COATING THICKNESS (MICRONS)

	Min	Max	Recommended
Wet film per coat (µm)	240	600	300
Dry film per coat (µm)	200	500	250

SOLIDS BY VOLUME	84% (Black)
VOC LEVEL	<190 g/L (Black)
FLASH POINT	>23°C
POT LIFE	60 minutes (4 litre kit, 25°C)

APPLICATION CONDITIONS

	Min	Max
Air Temperature	5°C	45°C
Substrate Surface Temperature	5°C	45°C
Relative Humidity		85%
Concrete Moisture Content		<10%

DRYING CHARACTERISTICS AT 250 µm DRY FILM THICKNESS* (COLD CURE HARDENER)

Temperature	Humidity	Touch	Handle	Full Cure	OVERCOAT Min	OVERCOAT Max[1]
5° C	50%	14 Hours	28 Hours	7 Days	28 Hours	4 Weeks
10° C	50%	13 Hours	24 Hours	7 Days	24 Hours	4 Weeks
15° C	50%	12 Hours	18 Hours	7 Days	18 Hours	4 Weeks
25° C	50%	6 Hours	9 Hours	7 Days	9 Hours	4 Weeks

***These figures are a guide only, as ventilation, film thickness, humidity, thinning and other factors will influence the rate of drying

[1] **If the maximum overcoat interval is exceeded then the surface MUST be abraded to ensure maximum intercoat adhesion**

Use of fast or low temperature hardeners may result in increased yellowing and a reduction of gloss level

NOTE: Figures shown are for non-immersion conditions. Refer to PRECAUTIONS section for overcoating intervals and requirements for immersion service

SPREADING RATE
with Cold Cure Hardener
assuming no losses

3.4 square metres per litre equals 250 µm dry film thickness
NOTE: Practical spreading rates will vary depending on such factors as application method, ambient conditions, surface porosity and roughness.

TYPICAL SYSTEMS

This is a guide only and not to be used as a specification. Your specific project needs must be discussed with a Dulux Protective Coatings Consultant.

SURFACE	ENVIRONMENT	PREPARATION GUIDE	SYSTEM		DFT (µm)
STEEL – NEW OR MAINTENANCE	Immersion AS2312.1 Table C1 System EVH3	Abrasive blast clean AS1627.4 Class 3.0	1st Coat 2nd Coat	Duremax® GFX Duremax® GFX	250 µm 250 µm
STEEL – NEW	Very high corrosivity (AS2312.1 Cat C5) Exceeds System EHB6	Abrasive blast clean AS1627.4 Class 2.5	1st Coat 2nd Coat 3rd Coat	Zincanode® 402 Duremax® GFX Duremax® GFX	75 µm 250 µm 250 µm
STEEL – NEW	Very high corrosivity (AS2312.1 Cat C5) System EVH3	Abrasive blast clean AS1627.4 Class 2.5	1st Coat 2nd Coat 3rd Coat	Durepon® P14 Duremax® GFX	75 µm 400 µm
STEEL – MAINTENANCE	Exterior	Power tool clean AS1627.2 St 3 or Abrasive blast AS1627.4 Class 2	1st Coat 2nd Coat	Duremax® GFX Duremax® GFX	250 µm 250 µm
CONCRETE	Exterior/Interior	Remove release agents and other surface contaminants	1st Coat 2nd Coat	Duremax® GFX (Thin 10-15%) Duremax® GFX	250 µm 250 µm
ALUMINIUM	Exterior/Interior	Clean, degrease and abrade surface	1st Coat	Duremax® GFX	250 µm

NOTE: If application is by brush or roller, additional coats will be necessary to achieve the minimum DFT

DUREMAX® GFX

SURFACE PREPARATION	**Steel**: Round off all rough welds, sharp edges and remove weld spatter. Remove contaminants in accordance with AS1627.1 Part 2.2 with Gamlen CA 1 (a free-rinsing, alkaline detergent) according to the manufacturer's written instructions and all safety warnings. Abrasive blast clean to AS1627.4 Class 2.5 minimum. **Immersed steel**: Abrasive blast cleaned to AS1627.4 Class 3. Remove all dust by brushing or vacuum cleaning. **Steel where abrasive blast cleaning is not viable**: Rust, mill scale, oxide deposits and old paint films on metal surfaces must be removed by power tool cleaning according to AS1627.2. Coating performance is proportional to the degree of surface preparation. **Steel Maintenance**: Wash with Gamlen CA 1 according to the manufacturer's written instructions and all safety warnings. (Refer to AS1627.1 Part 2.2). Remove unsound coatings. Feather back edges to remove ridges. Abrade entire surface of tightly adhering remaining coating to provide a suitable key for the new coating system. Remove all red rust by power tool cleaning in accordance with AS/NZ 1627:2 Class 2. Remove all residues. Spot prime bare steel. **Concrete**: Concrete must be at least 28 days old before coating. Remove all laitance, form release, curing compounds, oil, grease and other surface contaminants. Fill any large cracks or voids using Luxepoxy® Filler.
APPLICATION	Stir each can thoroughly until the contents are uniform. Use of a power mixer is recommended. Mix the contents of both packs together thoroughly using a power mixer and allow to stand for 10 minutes. Remix thoroughly before using.
BRUSH/ROLLER	Apply even coats of the mixed material to the prepared surface. When brushing and rolling additional coats may be required to attain the specified thickness.
CONVENTIONAL SPRAY	Thinning is not normally required, however a small amount (5% or less by volume) of Dulux® Epoxy Thinner (920-08925) can be added. Typical Set-up — Graco AirPro: 1.8mm (239542); Pressure at Triton 308: 65-100 kPa (10-15 p.s.i.); Pressure at Gun: 385-420 kPa (55-60 p.s.i.)
AIRLESS SPRAY	Standard airless spray equipment such as a Graco Xtreme 45:1 or 56:1 with a fluid tip of 17–21 thou (0.43- 0.53mm) and an air supply capable of delivering 550-690 kPa (80 -100 psi) at the pump. Thinning is not normally required but up to 50ml/litre of Dulux® Epoxy Thinner (920-08925) may be added to ease application.
PRECAUTIONS	This is an industrial product designed for use by experienced Protective Coating applicators. Where conditions may require variation from the recommendations on this Product Data Sheet contact your nearest Dulux® Consultant for advice prior to painting. Do not apply in conditions outside the parameters stated in this document without the express written consent of Dulux® Australia. Freshly mixed material must not be added to material that has been mixed for some time. Do not apply at temperatures below 10°C when using Standard hardener or below 5°C when using Cold Cure hardener. Do not apply at relative humidity above 85% or when the surface is less than 3°C above the dewpoint. When used with a white or pastel colour the Cold Cure hardener will impart a yellow tone that will darken with time. When used for immersion conditions the maximum overcoat interval is 3 days at 25°C. The coating MUST be completely solvent free prior to being placed under immersion conditions as a tank lining. For best results in water immersion conditions replace Dulux® Epoxy Thinner (920-08925) with Dulux® CR Reducer (965-63020). In tidal areas early immersion will result in loss of some of the coating but this will not affect performance. Do not use as a primer over galvanised steel when using Cold Cure hardener as delamination can occur. Use of fast or low temperature hardeners may result in increased yellowing and a reduction of gloss level.
CLEAN UP	Clean all equipment with Dulux® Epoxy Thinner (920-08925) immediately after use.
OVERCOATING	Degrease with Gamlen CA 1 according to the data sheet. Test adhesion of existing coating by standard cross hatch adhesion test. If the coating fails, remove it. High-pressure water wash at 8.3 to 10.3 MPa (1,200-1,500 p.s.i.) to remove chalk and dust. Abrade surface to provide a good key for the new coating. Epoxies must be abraded if recoated outside the recoat window.
SAFETY PRECAUTIONS	**Read Data Sheet, SAFETY DATA SHEET and any precautions on container labels. SAFETY DATA SHEET is available from Customer Service (13 23 77) or www.duluxprotectivecoatings.com.au**
STORAGE	Store as required for a flammable liquid Class 3 in a bunded area under cover. Store in well-ventilated area away from sources of heat or ignition. Keep containers closed at all times.
HANDLING	As with any chemical, ingestion, inhalation and prolonged or repeated skin contact should be avoided by good occupational work practice. Eye protection approved to AS1337 should be worn where there is a risk of splashes entering the eyes. Always wash hands before smoking, eating, drinking or using the toilet.
USING	Use with good ventilation and avoid inhalation of spray mists and fumes. If risk of inhalation of spray mists exists, wear combined organic vapour/particulate respirator. When spraying, users must comply with their respective State Spray Painting Regulations.
FLAMMABILITY	This product is flammable. All sources of ignition must be eliminated in, or near the working area. DO NOT SMOKE. Fight fire with foam, CO_2 or dry chemical powder. On burning will emit toxic fumes.
WELDING	Avoid inhalation of fumes if welding surfaces coated with this paint. Grind off coating before welding.

COMPANY INFORMATION		PACKAGING, TRANSPORT AND STORAGE	
Dulux Protective Coatings a division of		PACKAGING	Available in 15 litre packs
DuluxGroup (Australia) Pty Ltd 1956 Dandenong Road, Clayton 3168 A.B.N. 67 000 049 427	DuluxGroup (New Zealand) Pty Ltd 150 Hutt Park Road, Lower Hutt, NZ A.B.N. 55 133 404 118	TRANSPORTATION WEIGHT	1.61 kg/litre (Average of components)
		DANGEROUS GOODS	Part A: Class 3 UN 1263 Part B: Class 8,3 UN 2734

Safety Barrier System Acceptance

QUADGUARD-M10 Crash Cushion - Permanent

	**Issue Date:** 16 December 2021	**Supplier:** Ingal Civil Products
	These conditions take precedence over any instructions in the Product Manual. These acceptance conditions should be read in conjunction with the Product Manual and Roads and Maritime Specification R132 – Safety Barrier Systems and Austroads Guide to Road Design Part 6:Roadside Design, Safety and Barriers. Roads and Maritime Services may withdraw or modify this acceptance at any time without notice. Users should refer to the Roads and Maritime Services website to ensure they have the latest version of the conditions related to this product. Acceptance of this product does not place any obligation on Roads and Maritime Services, or its contractors, to purchase or use the product.	

Status	Accepted – may be used on the classified road network
Product accepted	QUADGUARD-M10 Crash Cushion <u>Variants</u> Quadguard M Wide Variants that are NOT listed above are NOT recommended for acceptance.
Accepted speed	70 km/h (TL2) 100 km/h (TL3)

Tested Outcomes

Containment Level	Point of Redirection		Tested Article Length (m)	Anchor/Post Spacing (m)	Dynamic Deflection (m)	Working Width (m)	Notes
	Leading (m)	Trailing (m)					
MASH TL2	Entirely redirective		4.0	Refer drawings	N/A	N/A	
MASH TL3	Entirely redirective		6.71	Refer drawings	N/A	N/A	

Approved Connections

Crash Cushions or Terminals must be fitted to both ends of a barrier	
Public Domain Products	
W-Beam guardrail	Permitted - reverse impacts into the transition section can produce a greater occupant severity value than preferred. Where reverse impacts are possible (e.g. bidirectional traffic) a risk assessment must be completed and steps to mitigate the likelihood of reverse impact should be implemented.
Thrie-Beam guardrail	
Concrete Type F	Permitted
Proprietary Products	
	Refer to Safety Barrier acceptance conditions for approved proprietary connections

Design Guidance

This product must be installed and maintained in accordance with the Product Manual and Roads and Maritime specifications	
System length (m)	4.0 (Quadguard M10) (TL2) 6.71 (Quadguard M10 and Quadguard M Wide) (TL3)
System width (m)	0.610 (Quadguard M10) 1.755 (Quadguard M Wide)
Minimum distance to excavation	N/A
Slope limit	Side slope limit: (8%)
Systems conditions	Installation on top of a kerb is not recommended, however if installed on top of a kerb all system components must be free to operate.
Gore area use	Permitted
Pedestrian area use	Permitted – consider potential for snagging and deflection
Cycleway use	Permitted – consider potential for snagging and deflection
Frequent impact likely	Permitted
Remote location	Permitted
Median use	Permitted

Foundation Pavement Conditions					
Pavement Type	**Use**	**Max Accepted Speed (km/h)**	**Post/Pin Spacing (m)**	**Post/Pin Type**	**Pavement Construction**
Concrete	Permitted	100	Refer to Drawings	M20 x 180mm threaded rod with epoxy (Quadguard M10 & Quadguard M Wide)	Installation on concrete pavement or pad is permitted in accordance with the manufacturer's drawings (Quadguard M10 & Quadguard M Wide)
Deep lift asphaltic concrete					
Asphaltic concrete over granular pavement					
Flush seal over granular pavement					
Unsealed compacted formation	Not Permitted				

Note: Installation in pavement conditions not listed above have not been justified to the Roads and Maritime's satisfaction.

Appendix J Relevant Information

Big River Way
Slip on Clarence River North of Byrons Lane

Geotechnical Investigation
Factual Report

Report No: N2021031
Report Issued Date: 7/6/2021
Prepared by: Northern Pavements and Geotechnical

Report Registration

Report Title:	Geotechnical Investigation Report
Report Subtitle:	Big River Way – Slip on Clarence River North of Byrons lane
Report Number:	N2021031
Project Reference Number:	N2021031
Responsible Capability:	Northern Pavements and Geotechnical
Responsible Discipline:	Geotechnical Science
Report Authorisation:	Manager Pavements and Geotechnical Northern
Report Manager:	Geotechnical Scientist
Issue Number:	01
Version Date:	7/6/2021
Contact for this Report:	Rob Ticknor
Distribution List:	Shaun Gillespie

Report Prepared By:		**Report Reviewed By:**	
Name:	Rob Ticknor	Name:	David Groth
Title:	Geotechnical Scientist	Title:	Manager Pavements and Geotechnical
Team:	Engineering Services Northern	Team:	Engineering Services Northern
Unit:	Pavements and Geotechnical	Unit:	Pavements and Geotechnical
Date:	7/6/2021	Date:	7/6/2021

Note: The functions of the former State Government agency Roads and Maritime Services (RMS or Roads and Maritime) are now administered by Transport for NSW.

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Contents

Appendices

1 Introduction

This report presents the results of a geotechnical investigation undertaken to support design and construction for treatment of a slip on the Big River Way north of Byrons Lane along the Clarence River.

The work was requested by the TfNSW Project/Contract Manager Shaun Gillespie. The scope consisted of drilling two boreholes through the pavement with Standard Penetration Testing, in situ shear vane testing and sampling soils for Acid Sulfate Soils and for aggressivity testing.

This report provides the following information for each site:

- Details of material types and observations of groundwater inflows;
- Standard penetration tests to determine consistency and density of soils;
- Laboratory test results of samples for aggressivity and acid sulphate.

This report should be read in conjunction with the following investigation and design reports prepared for the adjacent slip on the same road (formerly the Pacific Highway).

- HW10 – Pacific Highway - Byrons Lane Slip Stage 4 Geotechnical Design, SMEC, Project Number 30011433, 5 May 2014.
- HW10 – Pacific Highway – Road Embankment Slip at Byrons Lane Tyndale, Stage 3 Remedial Work using Sheet Piles and H-Piles, Pavement and Geotechnical Engineering Section, Roads And Traffic Authority, Report No. G4054, 5/11/2010.

2 Site description

The site is located on the bank of the Clarence River on the Big River Way between Tyndale and Maclean. (See Figure 1). The site is north of Byrons Lane, immediately downstream of a larger river bank slip that was previously repaired.

Location Number	Borehole Position MGA Zone 56	Site Description
BH12	517797.377E 6732393.964N RL 4.928m AHD	In pavement adjacent to slip scarp
BH13	517806.491E 6732407.305N RL 4.920m AHD	In pavement adjacent to slip scarp

Table 1: Location and site description.

Appendix A includes a site location plan (Figure 1) and geotechnical investigation plan (Figure 2).

3 Field Investigation

Fieldwork for the investigation comprised drilling of two boreholes using a geotechnical rotary drilling rig. The borehole was advanced using auger drilling using a TC followed by wash bore drilling using a roller bit. Rock requiring core drilling was not encountered.

Sampling was undertaken using standard penetration testing (SPT) at 1.5m intervals which also provided information on material consistency and density. Undisturbed samples were collected in U75 tubes in soft materials. In situ vane shear testing was conducted in soft conditions. Hand Penetrometer testing was conducted on SPT and U75 samples. Hand vane shear testing was conducted on U75 samples. A scientific officer from TfNSW supervised the field work including sampling and logging. A detailed bore log and explanatory notes are provided in Appendix B. The SPT and undisturbed soil samples have been retained by TfNSW if additional testing is required. A selection of samples was sent to a NATA certified laboratory for aggressivity and acid sulfate testing. Laboratory test reports are included in Appendix C.

Survey of borehole levels and positions was provided by TfNSW Surveyors and is provided on the log sheets.

4 Laboratory Testing

4.1 Acid sulfate soil testing

Acid sulfate soils (ASS) are those which contain iron sulphides such as pyrite (FeS_2). Exposure of iron sulphides to water and oxygen leads to generation of sulphuric acid and subsequent mobilization of heavy metals such as aluminum and iron into water bodies. This affects water quality and can lead to death of aquatic organisms and deterioration of engineered structures.

Advice regarding implementation of an acid sulfate soils management plan is based on the national acid sulfate soils guidance manual produced by the Department of Agriculture and Water Resources (2018). For disturbed soil volumes of less than 1000t, an acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture (eg sand/gravel) ≥0.03% S or 18 mol H^+/t; medium texture (eg sandy clay) ≥0.06% S or 36 mol H^+/t; fine texture (eg clay) ≥0.1% S or 62 mol H^+/t.

One samples was selected from BH12 for acid sulfate soil analysis at the Environmental Analysis Laboratory in Lismore. Results are summarized in Table 2 and presented in Appendix C.

Site + Depth (m)	Soil Texture	pH_{KCl}	Potential Sulfidic Acidity mole H^+/t	TAA mole H^+/t	Net Acidity mole H^+/t	Lime Calc. kg $CaCO_3$/t DW
BH12 5.5-5.95	Medium	5.57	455	7	462	35

Table 2: Summary of Acid Sulfate Soil Analysis

Based on results of the testing, it is recommended that an acid sulfate management plan is prepared.

4.2 Soil aggressivity testing

Soil aggressivity testing was undertaken on selected samples to inform design of the concrete/steel elements of the footings. Testing was carried out by the Environmental Analysis Laboratory in Lismore with results presented in Appendix C. A summary of the findings is shown in Table 3 below.

Site	BH12
Sample Depth (m)	7.0-7.45
Texture Class	Fine
pH (in water)	8.19
EC (dS/m)	0.294
Resistivity (ohm.mm)	33,972
Chloride (mgCl/kg)	119
Sulfate (mgSO4/kg)	251
Chloride/Sulfate Ratio	0.5

Table 3: Results of Soil Aggressivity Analysis.

5 Discussion

Two geotechnical boreholes were adjacent to a slip on the river bank of the Clarence River on the Big River Way north of Byrons Lane. Standard Penetration Testing and in situ vane shear testing was conducted in the boreholes. Samples were submitted for acid sulfate soil and aggressivity testing.

The results of these investigations should be read in conjunction with the results of investigations conducted for the previous adjacent slip.

6 References

Australian Standard: AS 1726-1993, Geotechnical Site Investigations.

Sullivan L, Ward N, Toppler N and Lancaster G 2018, National Acid Sulphate Soils Guidance, Department of Agriculture and Water Resources, Canberra, ACT.

Appendix A. Site Location Plans

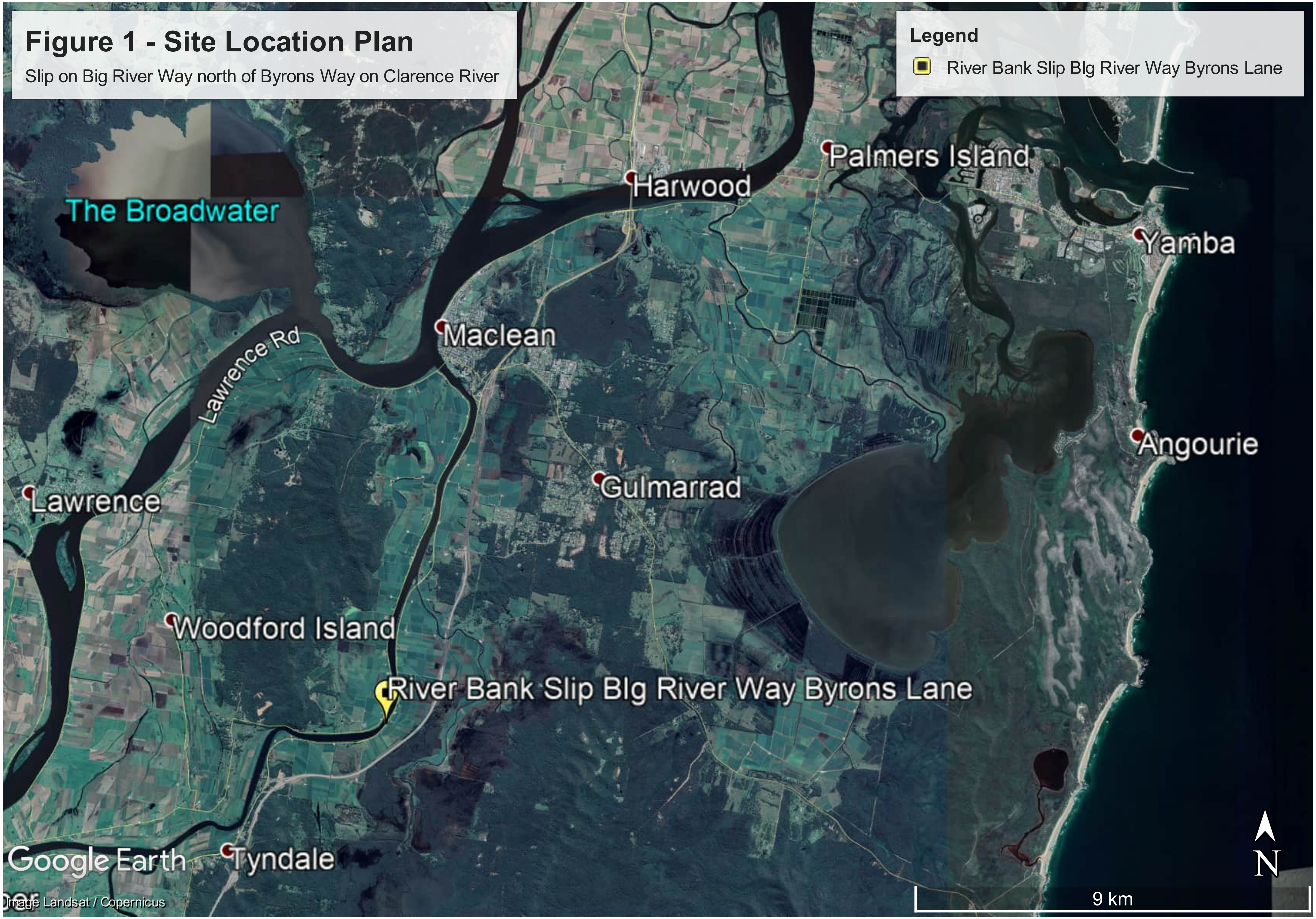

Figure 1 - Site Location Plan

Slip on Big River Way north of Byrons Way on Clarence River

0 5 10 20 30 40 50 Metres	REPORT No. 2021031	Date: 2/06/2021	N SCALES 1:1,000 @ A3	NSW GOVERNMENT Transport for NSW Infrastructure & Place - Northern Technical Services	Geotechnical Investigation plan FIGURE: 2
DESIGNED: RT REVIEWED: DG	CLIENT: Maintenance and Delivery north				

Path: C:\Users\ticknorr\Ticknor\03_Slopes\HW10 Byrons Lane\GIS\Byrons Lane Slip.mxd

Appendix B. Borehole Logs and Explanatory Notes

EXPLANATORY NOTES - DRILL & EXCAVATION LOGS

GENERAL

Information obtained from site investigations is recorded on log sheets. The "Cored Drill Hole Log" presents data from an operation where a core barrel has been used to recover material - commonly rock. The "Non-Core Drill Hole - Geological Log" presents data from an operation where coring has not been used and information is based on a combination of regular sampling and insitu testing. The material penetrated in non-core drilling is commonly soil but may include rock. The "Excavation - Geological Log" presents data and drawings from exposures of soil and rock resulting from excavation of pits, trenches, etc.

The heading of the log sheets contains information on Project Identification, Hole or Pit Identification, Location and Elevation. The main section of the logs contains information on methods and conditions, material substance description and structure presented as a series of columns in relation to depth below the ground surface which is plotted on the left side of the log sheet. The common depth scale is 8m per drill log sheet and about 3-5m for excavation logs sheets.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the identification of material boundaries in areas of partial sampling, the location of areas of core loss, description and classification of material, estimation of strength and identification of drilling induced fractures. Material description and classifications are based on SAA Site Investigation Code AS 1726 - 1993 with some modifications as defined below.

These notes contain an explanation of the terms and abbreviations commonly used on the log sheets.

DRILLING

Drilling & Casing

AS	Auger Screwing
AD/V	Auger Drilling with V-Bit
AD/T	Auger Drilling with TC Bit
WB	Wash-bore drilling
RR	Rock Roller
NMLC	NMLC core barrel
NQ	NQ core barrel
HMLC	HMLC core barrel
HQ	HQ core barrel

Drilling Fluid/Water

The drilling fluid used is identified and loss of return to the surface estimated as a percentage.

Drilling Penetration/Drill Depth

Core lifts are identified by a line and depth with core loss per run as a percentage. Ease of penetration in non-core drilling is abbreviated as follows:

VE	Very Easy
E	Easy
F	Firm
H	Hard
VH	Very Hard

Groundwater Levels

Date of measurement is shown.

Standing water level measured in completed borehole

Level taken during or immediately after drilling

Samples/Tests

D	Disturbed
U	Undisturbed
C	Core Sample
SPT	Standard Penetration Test
N	Result of SPT (* sample taken)
VS	Vane Shear Test
IMP	Borehole Impression Test
PBT	Plate Bearing Test
PZ	Piezometer Installation
HP	Hand Penetrometer

Angle/Orientation: Angle from horizontal and orientation to magnetic north.

EXCAVATION LOGS

Explanatory notes are provided at the bottom of drill log sheets. Information about the origin, geology and pedology may be entered in the "Structure and other Observations" column. The depth of the base of excavation (for the logged section) at the appropriate depth in the "Material Description" column. Refusal of excavation plant is noted should it occur. A sketch of the exposure may be added.

MATERIAL DESCRIPTION - SOIL

Classification Symbol - In accordance with the Unified Classification System (AS 1726-1993, Appendix A, Table A1)

Material Description - In accordance with AS 1726-1993, Appendix A2.3

Moisture Condition

D	Dry, looks and feels dry
M	Moist, No free water on remoulding
W	Wet, free water on remoulding

Consistency - In accordance with AS 1726-1993, Appendix A2.5

	Description	Su	HP
VS	Very Soft	≤ 12kPa	< 25kPa
S	Soft	12 - 25 kPa	25 - 50 kPa
F	Firm	25 - 50 kPa	50 - 100 kPa
St	Stiff	50 - 100 kPa	100 - 200 kPa
VSt	Very Stiff	100 - 200 kPa	200 - 400 kPa
H	Hard	≥ 200 kPa	≥ 400 kPa

Strength figures quoted are the approximate range of Unconfined Compressive Strength for each class.

Density Index (%) is estimated or is based on SPT results. Approximate N Value correlation is shown in right column.

	Description	Density Index	SPT Value
VL	Very Loose	< 15%	0 – 4
L	Loose	15 – 35%	4 – 10
MD	Medium Dense	35 – 65%	10 – 30
D	Dense	65 – 85%	30 – 50
VD	Very Dense	> 85%	> 50

MATERIAL DESCRIPTION - ROCK

Material Description

Identification of rock type, composition and texture based on visual features in accordance with AS 1726-1993, Appendix A3.1-A3.3 and Tables A6a, A6b and A7.

Core Loss

Is shown at the bottom of the run unless otherwise indicated.

Bedding

Description	**Spacing** (mm)
Thinly Laminated	< 6
Laminated	6 - 20
Very Thinly Bedded	20 - 60
Thinly Bedded	60 -200
Medium Bedded	200 - 600
Thickly Bedded	600 - 2000
Very Thickly Bedded	> 2000

Weathering - No distinction is made between weathering and alteration. Weathering classification assists in identification but does not imply engineering properties.

F	**Fresh**	Rock substance unaffected by weathering
SW	**Slightly Weathered**	Rock substance partly stained or discoloured. Colour and texture of fresh rock recognisable.
MW	**Moderately Weathered**	Staining or discolouration extends throughout rock substance. Fresh rock colour not recognisable.
HW	**Highly Weathered**	Stained or discoloured throughout. Signs of chemical or physical alteration. Rock texture retained.
EW	**Extremely Weathered**	Rock texture evident but material has soil properties and can be remoulded.

Strength - The following terms are used to described rock strength:

	Rock Strength Class	**Point Load Strength Index, Is(50)** (MPa)
EL	**Extremely Low**	< 0.03
VL	**Very Low**	0.03 - 0.1
L	**Low**	0.1 - 0.3
M	**Medium**	0.3 - 1.0
H	**High**	1.0 - 3.0
VH	**Very High**	3.0 - 10.0
EH	**Extremely High**	≥ 10.0

Strengths are estimated and where possible supported by Point Load Index Testing of representative samples. Test results are plotted on the graphical estimated strength by using:

- ○ Diametral Point Load Test
- ● Axial Point Load Test

Where the estimated strength log covers more than one range it indicates the rock strength varies between the limits shown.

MATERIALS STRUCTURE/FRACTURES

ROCK

Natural Fracture Spacing - A plot of average fracture spacing excluding defects known or suspected to be due to drilling, core boxing or testing. Closed or cemented joints, drilling breaks and handling breaks are not included in the Natural Fracture Spacing.

Visual Log - A diagrammatic plot of defects showing type, spacing and orientation in relation to core axis.

Defects	———	Defects open in-situ or clay sealed
	- - - - - - - -	Defects closed in-situ
	———	Breaks through rock substance

Additional Data - Description of individual defects by type, orientation, in-filling, shape and roughness in accordance with AS 1726-1993, Appendix A Table A10, notes and Figure A2.

Type	BP	Bedding Parting
	JT	Joint
	SM	Seam
	FZ	Fracture Zone
	SZ	Shear Zone
	VN	Vein
	FL	Foliation
	CL	Cleavage
	DL	Drill Lift
	HB	Handling Break
	DB	Drilling Break

Orientation - angle relative to the plane normal to the core axis.

Infilling	CN	Clean
	X	Carbonaceous
	Clay	Clay
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
	MS	Secondary Mineral
	MU	Unidentified Mineral
Shape	PR	Planar
	CU	Curved
	UN	Undulose
	ST	Stepped
	IR	Irregular
	DIS	Discontinuous
Roughness	POL	Polished
	SL	Slickensided
	S	Smooth
	RF	Rough
	VR	Very Rough

SOIL

Structures - Fissuring and other defects are described in accordance with AS 1726-1993, Appendix A2.6, using the terminology for rock defects.

Origin - Where practicable an assessment is provided of the probable origin of the soil, eg fill, topsoil, alluvium, colluvium, residual soil.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : N2021031
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517797.377, N: 6732393.964 ( ) | SURFACE ELEVATION : 4.928 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 30/4/21 | DATE COMPLETED : 30/4/21 | DATE LOGGED : 30/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING

Depth (m)	Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests
0.0–0.2	AD CASING (0.0–2.3)	0% Water LOSS	H	Not Observed	
0.2–0.5			F		
0.5–8.0	RR (2.3–8.0)		VE		
1.00–1.45					1.00m SPT 6, 4, 3 N*=7 1.45m
2.50–2.95					2.50m SPT 2, 2, 2 N*=4 2.95m
4.00–4.45					4.00m SPT 2, 3, 5 N*=8 4.45m
5.50–5.95					5.50m SPT 1, 0, 0 N*=0 5.95m
6.10					6.10m in-situ VS P=68kPa R=41kPA
6.70					6.70m in-situ VS P=68kPa R=27kPA
7.00					7.00m U75
7.40–7.50					7.40m Samp VS P=32kPa R=13.5kPA 7.50m

MATERIAL

Depth	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
0.00–0.20m		ASPHALTIC CONCRETE	M	VD	ROAD SURFACE
0.20–0.50m	GW	GRAVEL: dark grey to orange, fine to medium gravel, angular, with some fine to coarse grained sand	M	D	FILL
0.50–2.00m	SM	SILTY SAND: brown, fine grained sand, with medium plasticity fines and some clay	M	MD	
2.00–3.40m	ML	CLAYEY SILT: brown, low to medium plasticity	VM	S	ALLUVIUM
3.40–5.00m	CI	SILTY CLAY: brown mottled grey, medium plasticity, trace fine grained sand	VM	F to St	4.00: HP Samp = 150 kPa
5.00–6.00m	ML	SANDY CLAYEY SILT: grey, low to medium plasticity, fine grained sand, trace shell fragments	VM	S	ESTUARINE DEPOSITS; 5.50: HP Samp = 30 - 40 kPa
6.00–8.00m	CH	SILTY CLAY: dark grey, high plasticity, with some fine grained sand, trace shell fragments	> WL	S	7.40: HP Samp = 20 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517797.377, N: 6732393.964 ( ) SURFACE ELEVATION : 4.928 () ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Pioneer MOUNTING : Truck CONTRACTOR : NCD DRILLER : DB
DATE STARTED : 30/4/21 DATE COMPLETED : 30/4/21 DATE LOGGED : 30/4/21 LOGGED BY : AB CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water Loss	VE	Not Observed		8.0	CH	SILTY CLAY: dark grey, high plasticity, with some fine grained sand, trace shell fragments *(continued)*	> WL	S	
				8.50m U7575 8.95m						8.50: HP Samp = 30 kPa
										8.90: Samp VS P=48kPa R=15kPA
					9.0		From 9.0m, with some organics.			
					9.50m	CI	SILTY CLAY: grey, medium to high plasticity, trace fine grained sand, trace shell fragments	> Wp	St	
				10.00m U75	10.0					
				10.40m Samp VS P=177kPa R=45kPA 10.50m						10.40: HP Samp = 150 kPa
					11.0		From 11.0m, colour change to pale grey mottled brown.		F to St	11.00: ALLUVIUM
				11.50m SPT 2, 2, 3 N*=5 11.95m						11.95: HP Samp = 150 kPa
					12.0					
		E		13.00m SPT 4, 5, 7 N*=12 13.45m	13.0		13.0-13.5m, iron oxide zones up to 2mm.			13.00: HP Samp = 180 - 200 kPa
					14.0					
				14.50m SPT 3, 4, 7 N*=11 14.95m						14.50: HP Samp = 150 kPa
					15.0					
				16.00m	16.0					

TFNSW 42.1 LIB.GLB Log RTA NON-CORE DRILL HOLE N2021031 BYRONS LANE SLIP.GPJ <<DrawingFile>> 07/Jun/2021 11:22 10.02.00.04 Datgel Tools

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : N2021031
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517797.377, N: 6732393.964 ( ) | SURFACE ELEVATION : 4.928 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 30/4/21 | DATE COMPLETED : 30/4/21 | DATE LOGGED : 30/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	E	Not Observed	SPT 4, 2, 4 N*=6 16.45m	16.0 – 16.20m	CI	SILTY CLAY: grey, medium to high plasticity, trace fine grained sand, trace shell fragments *(continued)*	> Wp	F to St	
				17.50m SPT 3, 5, 5 N*=10 17.95m	16.20m – 17.80m	SP	SAND: pale grey, fine to medium grained sand, with some silt, clay and trace shell fragments, grading to SC - Sandy CLAY, grey, medium plasticity			ALLUVIUM 17.50: HP Samp = 160 kPa
				19.00m SPT 4, 5, 6 N*=11 19.45m 20.50m SPT 4, 5, 7 N*=12 20.95m 22.00m SPT 5, 6, 7 N*=13 22.45m	17.80m – 22.45m	CI	CLAY: pale grey to orange, grey, medium to high plasticity, trace fine grained sand			19.00: HP Samp = 150 - 180 kPa 20.50: HP Samp = 170 - 190 kPa
					22.45m		BOREHOLE BH12 TERMINATED AT 22.45 m Limit of Investigation			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : N2021031
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517806.491, N: 6732407.305 ( ) SURFACE ELEVATION : 4.920 () ANGLE FROM HORIZONTAL : 90°
RIG TYPE : Pioneer MOUNTING : Truck CONTRACTOR : NCD DRILLER : DB
DATE STARTED : 29/4/21 DATE COMPLETED : 29/4/21 DATE LOGGED : 29/4/21 LOGGED BY : AB CHECKED BY : RT

DRILLING: Drilling & Casing: AD to 5.50m (Casing to 2.30m); RR from 5.50m to 8.0m. Water: 0% Water Loss. Drilling Penetration: VH (0.0–0.1m), H (0.1–0.5m), VE (0.5–8.0m). Ground Water Levels: 29/04/21 at approx. 5.0m.

Depth (m)	Samples & Field Tests	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
0.0–0.20m			ASPHALTIC CONCRETE		VD	ROAD SURFACE
0.20–0.60m		GW	GRAVEL: dark grey, fine to coarse gravel, angular, with some fine to coarse grained sand, gravel is fresh sandstone	M	D	FILL
0.60–2.20m	1.00m SPT 6, 5, 3 N*=8 1.45m	SM	SILTY SAND: brown, fine grained sand, low plasticity From 1.8m, colour change to pale brown.	SM	MD	
2.20–3.50m	2.50m SPT 1, 2, 2 N*=4 2.95m	ML	CLAYEY SILT: brown, low plasticity		S	ALLUVIUM 2.50: HP Samp = 80 - 100 kPa
3.50–5.00m	4.00m SPT 2, 2, 4 N*=6 4.45m	CI	SILTY CLAY: brown mottled grey, medium plasticity	VM	F	4.00: HP Samp = 120 - 180 kPa
5.00–6.20m	5.50m SPT 1, 0, 0 N*=0 5.95m	ML	CLAYEY SILT: dark grey, medium plasticity, with some fine grained sand, trace shell fragments			ESTUARINE DEPOSITS 5.50: HP Samp = 20 kPa
6.20–8.0m	7.00m SPT 0, 0, 0 N*=0 7.45m	CH	CLAY: dark grey, high plasticity, trace fine grained sand sand, trace shell fragments	W	VS to S	7.00: HP Samp = 20 kPa 7.45: SPT dropped under hammer weight

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : N2021031
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517806.491, N: 6732407.305 ( ) | SURFACE ELEVATION : 4.920 () | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : DB

DATE STARTED : 29/4/21 | DATE COMPLETED : 29/4/21 | DATE LOGGED : 29/4/21 | LOGGED BY : AB | CHECKED BY : RT

DRILLING: Drilling & Casing: RR; Water: 0% Water LOSS

Drilling Penetration	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
VE		8.0	CH	CLAY: dark grey, high plasticity, trace fine grained sand sand, trace shell fragments *(continued)*	W		
	8.50m U75						8.50: HP Samp = 40 kPa
	8.90m Samp VS P=45kPa R=18kPA 9.00m	9.0					
		9.50m	CI-CH	SILTY CLAY: pale grey, medium to high plasticity	>Wp	S	ALLUVIUM
	10.00m SPT 0, 0, 2 N*=2 10.45m	10.0					10.00: HP Samp = 50 kPa
E		11.0				St	
	11.50m U75						11.50: HP Samp = 110 kPa
	11.90m						11.90: HP Samp = 110 kPa HV Samp P: 113 kPa R: 45 kPa
	12.00m SPT 2, 5, 6 N*=11 12.45m	12.0		From 12.0m, colour change to pale grey and orange, with some zones of extremely weathered, angular siltstone (?) gravels (soil strength).			12.45: HP Samp = 110 - 180 kPa
	13.00m SPT 5, 7, 8 N*=15 13.45m	13.0				VSt to St	13.00: HP Samp = 230 - 250 kPa
		14.0					
	14.50m SPT 4, 4, 8 N*=12 14.95m			14.5m, some zones of iron oxide coated 'joint' or 'fissure' structures in clay. From 14.7m, some silty sand zones up to 50mm thick.		St	14.50: HP Samp = 250 kPa
	16.00m	15.0–16.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : N2021031
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Tyndale Big River Way

POSITION : E: 517806.491, N: 6732407.305 ( ) SURFACE ELEVATION : 4.920 () ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Pioneer MOUNTING : Truck CONTRACTOR : NCD DRILLER : DB

DATE STARTED : 29/4/21 DATE COMPLETED : 29/4/21 DATE LOGGED : 29/4/21 LOGGED BY : AB CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	E		SPT 5, 5, 7 N*=12 16.45m	16.0	CI-CH	SILTY CLAY: pale grey, medium to high plasticity *(continued)*	>Wp	St	ALLUVIUM; 16.45: HP Samp = 220 - 270 kPa
				17.50m SPT 6, 8, 10 N*=18 17.95m	17.00m	SP	SAND: pale grey, medium grained sand, with trace silt, clay and shell fragments	W	MD	
				19.00m SPT 3, 4, 5 N*=9 19.45m	18.50m	SC	SANDY CLAY: pale grey, medium plasticity, with fine grained sand, and some sandy lenses to 20mm thickness		St	19.00: HP Samp = 120 kPa
				20.50m SPT 5, 7, 8 N*=15 20.95m; 22.00m SPT 6, 8, 10 N*=18 22.45m	20.00m	CI	SILTY CLAY: pale grey and orange, medium plasticity, with trace fine grained sand	>Wp	VSt	20.50: HP Samp = 180 - 240 kPa; 22.00: HP Samp = 220 - 250 kPa
				23.50m SPT 4, 4, 8 N*=12 23.95m	23.00m	SM	SANDY SILT: pale grey and orange, low plasticity, fine grained sand		St	23.50: HP Samp = 120 kPa
					23.95m					

BOREHOLE BH13 TERMINATED AT 23.95 m
Limit of Investigation

See Explanatory Notes for details of abbreviations & basis of descriptions.

TRANSPORT FOR NSW

Appendix C. Laboratory Reports

RESULTS OF ACID SULFATE SOIL ANALYSIS

1 sample supplied by Transport For NSW on 5/05/2021 . Lab Job No. K6526.
Analysis requested by Adam Brown. Your Job: N2021031.

3/76 Victoria Street GRAFTON NSW 2460

Sample Identification	EAL Lab Code	Texture	Moisture Content		Potential Sulfidic Acidity (Chromium Reducible Sulfur - CRS)			Actual Acidity (Titratable Actual Acidity - TAA)	Retained Acidity		Non-treated soil: Acid Neutralising Capacity (ANC_{BT})		Non-treated soil: Net Acidity	Non-treated soil: Lime Calculation
			(% moisture of total wet weight)	(g moisture / g of oven dry soil)	(% S_{cr})	(mol H^+/t)	pH_{KCl}	(mol H^+/t)	(%S_{NAS})	(mol H^+/t)	(% $CaCO_3$)	(mol H^+/t)	(mol H^+/t)	(kg $CaCO_3$/t DW)
Method Info.		**	**		*(In-house method S20)*		*(In-house method 16b)*		**		*(In-house method S14)*		**	**
BH12 5.5-5.95m	*K6526/1*	Medium	32.2	0.47	0.730	455	5.57	7	..	..	..	..	462	35

NOTES:

1. All analysis is reported on a dry weight (DW) basis, unless wet weight (WW) is specified.
2. Samples are dried and ground immediately upon arrival (unless supplied dried and ground).
3. Analytical procedures are sourced from Sullivan L, Ward N, Toppler N and Lancaster G. 2018. National acid sulfate soils guidance: national acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0.
4. The Acid Base Accounting Equation, where Acid Neutralising Capacity has not been corroborated by other data, is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity** (Eq. 3.2; Sullivan et al. 2018 - full reference above).
5. The Acid Base Accounting Equation for post-limed soil materials is **Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - (post treatment Acid Neutralising Capacity - initial Acid Neutralising Capacity)** (Eq. 3.3; Sullivan et al. 2018 - full reference above).
   While the Acid Neutralising Capacity of a soil material may not be included in the Net Acidity calculation (Note 4), it must be measured to give an Initial Acid Neutralising Capacity if verification testing is planned post-liming.
   The Inital Acid Neutralising Capacity must be provided by the client to enable EAL to produce Verification Net Acidity and Liming calculations for post-limed soil materials.
6. The Acid Base Accounting Equation, where Acid Neutralising Capacity has been corroborated by other data, is Net Acidity = Potential Acidity + Actual Acidity + Retained Acidity - Acid Neutralising Capacity (Eq. 3.1; Sullivan et al. 2018 - full reference above).
7. The lime calculation includes a Safety Factor of 1.5 as a safety margin for acid neutralisation (Sullivan et al. 2018). This is only applied to positive values. An increased Safety Factor may be required in some cases.
8. Retained Acidity is required when the pH_{KCl} < 4.5 or where jarosite has been visually observed.
9. A negative Net Acidity result indicates an excess acid neutralising capacity.
10. If insufficient mixing occurs during intial sampling, or during post-liming, or both: the Potential Sulfidic Acidity may be greater in the post-limed sample than in the intial sample; the post-liming Acid Neutralising Capacity may be lower in the post-limed sample than in the intial sample.
11. **An acid sulfate soil management plan is triggered by Net Acidity results greater than the texture dependent criterion: coarse texture ≥ 0.03% S or 18 mol H^+/t; medium texture ≥ 0.06% S or 36 mol H^+/t; fine texture ≥ 0.1% S or 62 mol H^+/t)** (Table 1.1; Sullivan et al. 2018 - full reference above)
12. For projects that disturb > 1000 t of soil material, the coarse trigger of ≥ 0.03% S or ≥ 18 mol H^+/t must be applied in accordance with Sullivan et al. (2018) (full reference above).
13. Acid sulfate soil texture triggers can be related to NCST (2009) textures: coarse and peats = sands to loamy sands; medium = clayey sand to light clays; fine = light medium to heavy clays (Sullivan et al. 2018 - full reference above).
14. Bulk density is required to convert liming rates to soil volume based results. Field bulk density rings can be submitted to EAL for bulk density determination.
15. A negative Net Acidity result indicates an excess acid neutralising capacity.
16. '..' is reported where a test is either not requested or not required. Where pH_{KCl} is < 4.5 or > 6.5, zero is reported for S_{NAS} and ANC in Net Acidity calculations, respectively.
17. Results refer to samples as received at the laboratory. This report is not to be reproduced except in full.
18. ** NATA accreditation does not cover the performance of this service.
19. Analysis conducted between sample arrival date and reporting date.
20. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).
21. Results relate to the samples tested.
22. This report was issued on 11/05/2021.

NATA
WORLD RECOGNISED ACCREDITATION
Accreditation No. 14960
Accredited for compliance with ISO/IEC 17025 - Testing

checked: ....
Graham Lancaster
Laboratory Manager

RESULTS OF SOIL ANALYSIS

1 samples supplied by Transport For NSW on 5/05/2021 . Lab Job No. K6527.
Analysis requested by Adam Brown. Your Job: N2021031
3/76 Victoria St GRAFTON NSW 2460

	Method	Sample 3 BH12 7.0-7.45m
	EAL job No.	***K6527/1***
Moisture (%)	*inhouse*	35
Texture	*See note 2 below.*	Fine
pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.19
Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.294
Resistivity (ohm.mm)	** Calculation	33,972
Resistivity (ohm.cm)	** Calculation (ohm.mm / 10)	3,397
Chloride (mg/kg)	** Water Extract - ISE (1:5 Water)	119
Chloride **(as %)**	** Calculation	0.012
Sulfate (mg/kg)	** Water Extract-APHA 3120 ICPOES	251
Sulfate **(as % SO_4)**	** Calculation	0.025
Chloride / Sulfate Ratio	** Calculation	0.5

Notes:

1. ppm = mg/kg dried soil
2. For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
3. All results as dry weight DW - soils were dried at 60°C for 48hrs prior to crushing and analysis.
4. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
5. Methods from Rayment and Lyons, 2011. Soil Chemical Methods - Australasia.CSIRO Publishing: Collingwood.
6. Based on Australian Standard AS: 2159-2009
7. Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). *Acid Sulfate Soils Laboratory Methods Guidelines*. QLD DNRME.
8. Analysis conducted between sample arrival date and reporting date.
9. ** NATA accreditation does not cover the performance of this service.
10. .. Denotes not requested.
11. This report is not to be reproduced except in full.
12. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal or on request).
13. Results relate only to the samples tested.
14. This report was issued on 18/05/2020.

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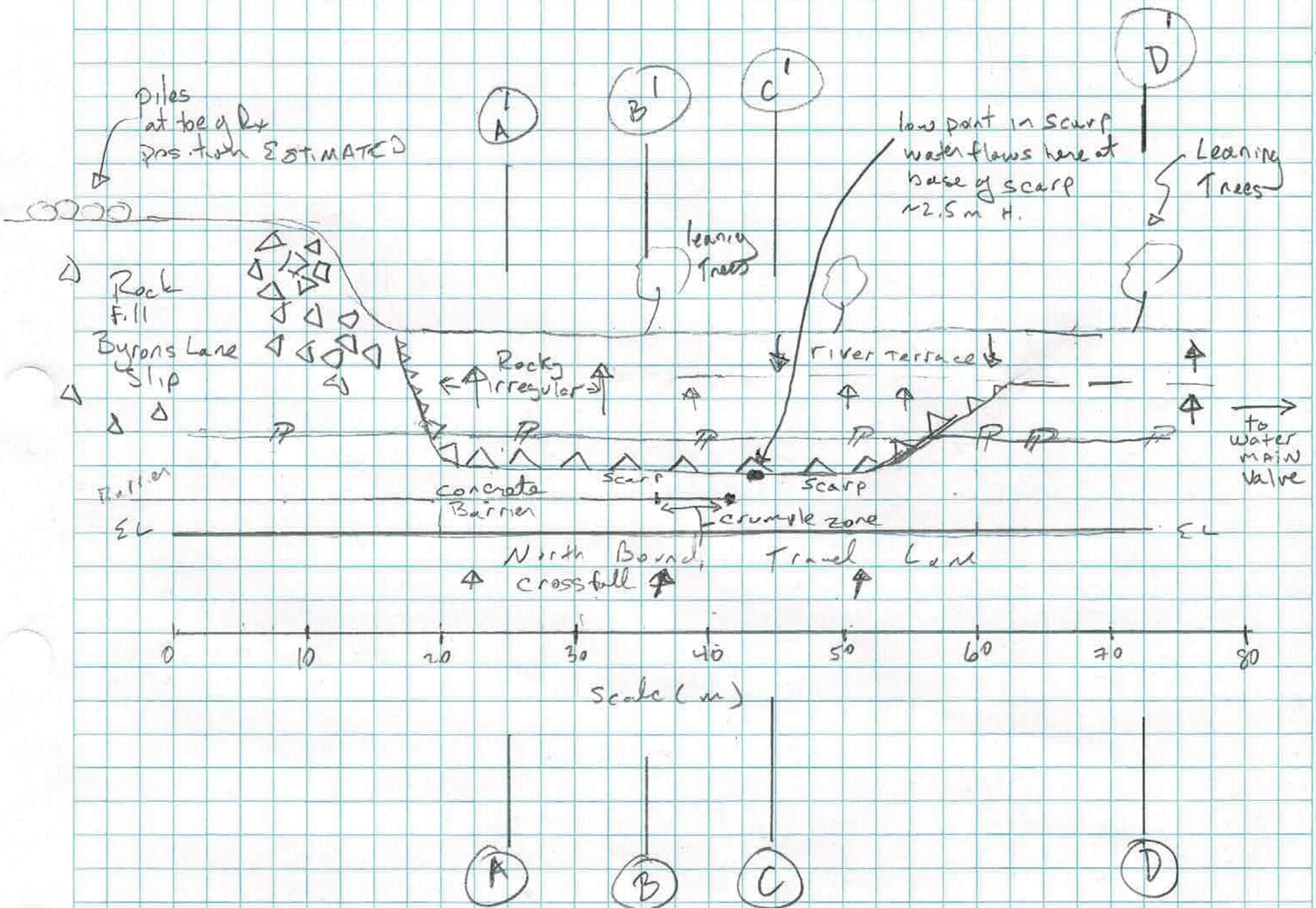
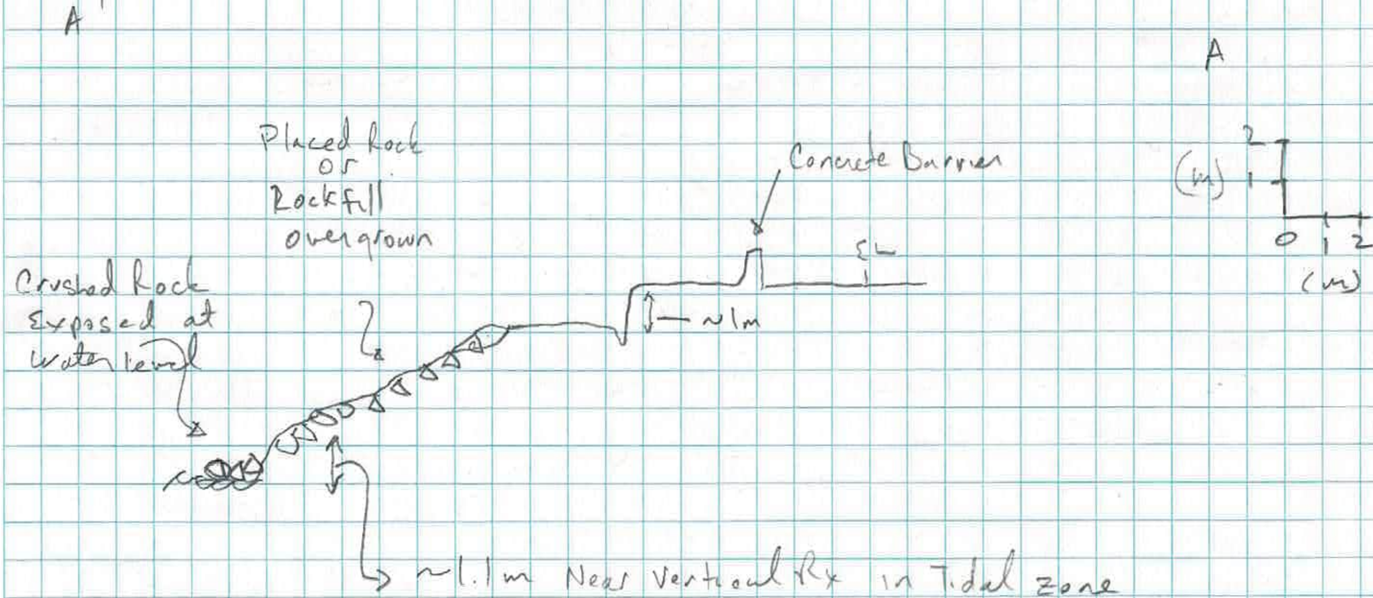
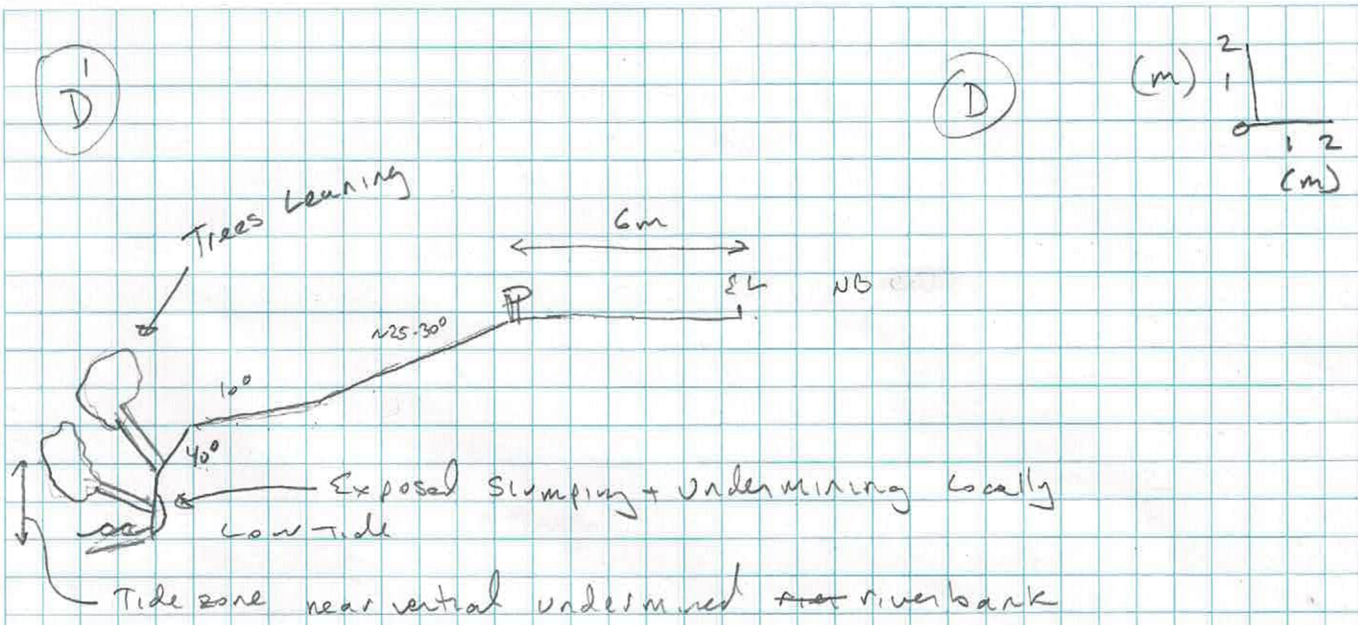
checked: ....
Graham Lancaster
Laboratory Manager

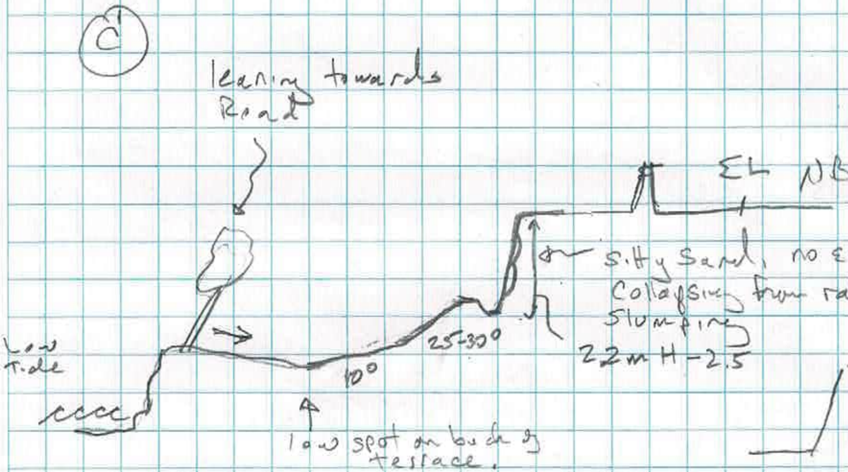
Slip ~40-43m Long



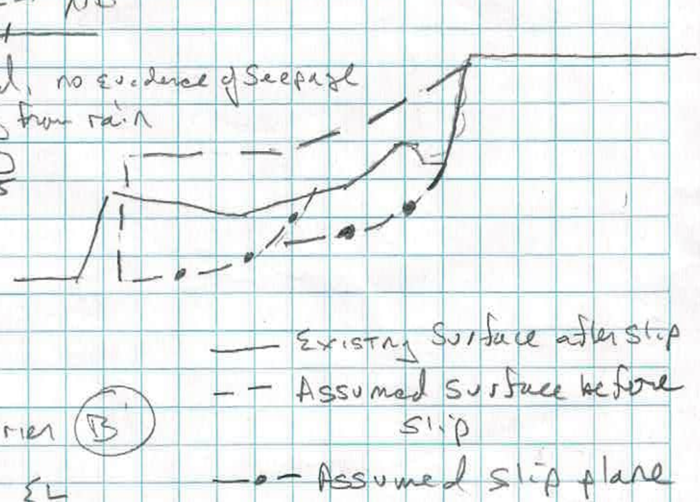


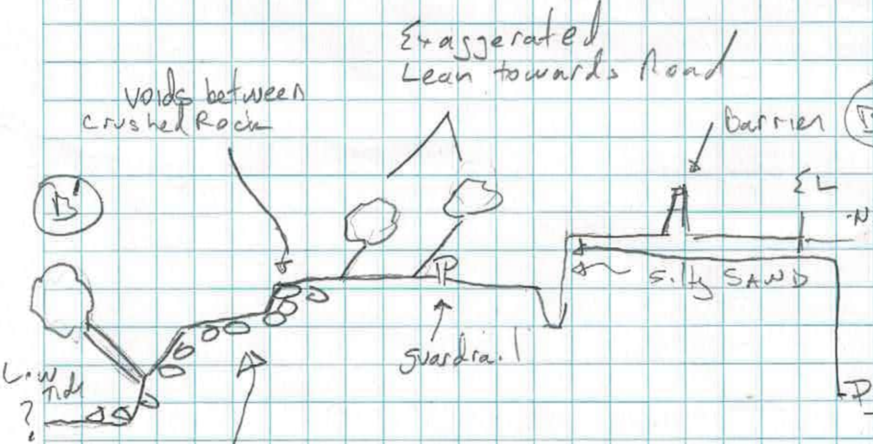
Appears Rock at Toe has moved, pushed towards river.
Some Large voids between Rock





Section C → river bank lower than D river bank protruding slightly compared to D





Pavement Exposed in Scarp

200mm Asphalt
300mm Sandy Gravel → Likely outside Edge of stabilized layer
Low strength/ weakly Cemented.

Crushed Rock with voids

Overgrown with mature trees.

Slip Appears to be in the River Bank above water level.
It Appears that river bank has pushed out due to lack of support.

Apparent Mechanisms

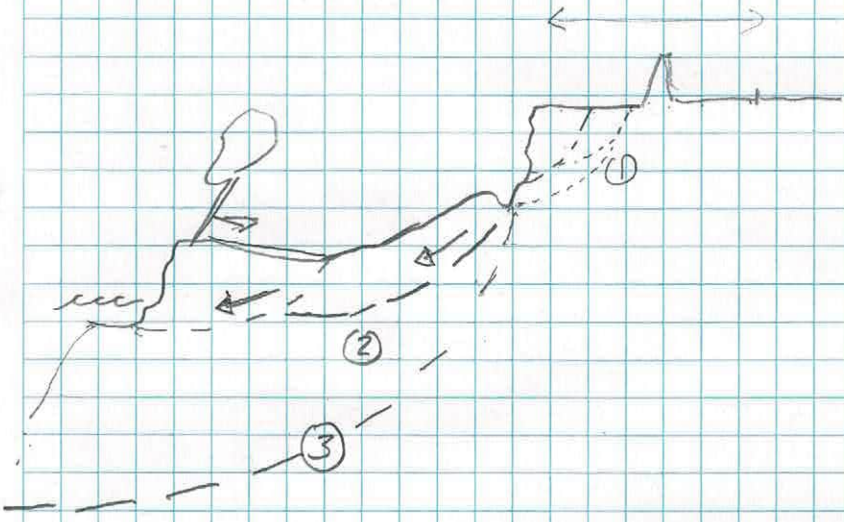
(1) Erosion of River Bank - Tidal Action
River flow
Turbulence from upstream Rock fill

(2) High water - potential increased river heights from recent RAIN

(3) Abandoned water MAIN - unlikely but worth checking

(4) Low strength Materials below river bench.

~ 6m Scarp to Edge Line



HAZARDS

(1) Collapse of Scarp - SANDY MATERIAL, erodes + slumps when wet, Creating void underpavement which eventually collapses.
rain - protect Scarp from rain + surface runoff
does Not Appear to have seepage within Scarp

(2) CONTINUED Slip → increases height of headwall scarp + potential for collapse
Slip headwall progresses towards Road
rain → protect from RAIN + surface flow from pavement
wet low strength Layer → cannot Act in short term

(3) Deep Slip into River channel -
we do NOT KNOW River Channel shape or if a deep weak layer is continuity

Slope Risk Analysis Summary Report Version 4 ?? 13900??

Page 1

Transport Roads & Maritime Services NSW Government

Slope Identification No.	Big River WAY - Byrons Lane Slip				Date	9/3/21		
Inspection Date	9/3/21		Completed By:	RT	Checked By:			
Slope Data	Slope Class	Slope below	Max Slope Height (m)	6	Av. Slope Angle (o)	30°	Material	Soil
	Description:		River Bank Slip North of Byrons Lane					
Location								
Roadloc Coordinates	Road No		Start Link No		Finish Link No		L or R?	
	C'way Code		Start Distance		Finish Distance		Length	
GPS Coordinates (WGS84/GDA94)	Start		Latitude		Longitude		Elevation	
	Finish		Latitude		Longitude		Elevation	
MGA Coordinates	Start		Zone		Easting		Northing	
	Finish		Zone		Easting		Northing	
Plan Reference No.					Plan Start Chainage		L or R?	
Locality Name	Byrons Lane							
Road Data	AADT		400 v/d	Year of Count	2021	Speed Limit (km/hr)		100
	No of Lanes	Prescribed Direction	1	Counter Direction	1	Sight Distance Adequate? (Y/N)		Y
Risk Analysis								
Hazard/Failure Mechanism	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Hazard Type	Slump	Slip	Deep Slip					
Failure Dynamics Ratings								
Scale of Failure Rating - for Volume (S1 - S5)	S4	S3	S2					
Scale of Failure Rating - for Block Size (S1 - S5)								
Velocity of Failure Rating (R1 - R5)	R1	R3	R4					
Likelihood Rating (L1 - L6)	L1	L2/L3	L4					
Consequence Class Ratings								
Temporal Probability (T1 - T5)	T4	T4	T4	→	TRAFFIC	Volumes	for Big	River Way
Vulnerability (V1 - V5)	V3	V2	V2		between	Tyndale	+ Mclean	
Consequence Class for Loss of Life (C1 - C5)	C4	C3	C3		derived	from	2021	Counts for
Consequence Class for property damage etc (C1 - C5)	C3	C3	C3		U2B	Noise Modelling		on
Risk Analysis Ratings								
Slope Attribute Score					Big River	Way	S of	Tyndale
Event Magnitude (M1 - M5)					and	on Pacific	Highway	RAMPS
Hazard Classification (H1 - H5)					at Tyndale.			
Assessed Risk Level (ARL1 - ARL5)	ARL1	ARL2+3	ARL4		NB+SB	is	~ 200	v/c/d

between Tyndale + Maclean.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH1
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517775.752, N: 6732376.884 (56 MGA94) | SURFACE ELEVATION : 5.143 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER :

DATE STARTED : 26/9/09 | DATE COMPLETED : 26/9/09 | DATE LOGGED : 26/9/09 | LOGGED BY : RT | CHECKED BY : RT

DRILLING

Depth (m)	Progress: Drilling & Casing	Progress: Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests
0.0 – 1.50	AD/V	N/A			
1.00 – 1.45					1.00m SPT 5, 3, 3 N=6 1.45m
2.50 – 2.95					2.50m SPT 1, 1, 2 N*=3 2.95m
3.10				26/09/09	
4.00 – 4.40			E		4.00m U75 4.40m
5.50 – 5.95					5.50m SPT 0, 0, 0 N*=0 5.95m

MATERIAL

Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
0.0		AC			ROAD SURFACE
– 1.00m	GP	SANDSTONE GRAVEL: pale brown Silty Gravel: red brown, dry, low plasticity.			
1.00m – 2.50m	SM	SILTY SAND: brown, fine grained sand, low plasticity, slightly moist. Silty sand: pale brown, slightly moist, low plasticity. Fine sand with silt and trace of clay.	M		1.80: Started firming up
2.50m – 3.10m	ML	CLAYEY SILT pale brown, mottled dark brown, medium plasticity, wet, firm, no clay.			2.50: SPT Recovery: 0.45 m; Dropped 70mm under hammer weight. 2.70: HP Samp = 1 kPa
3.10m – 5.50m	CH	SILTY CLAY grey brown, high plasticity	W	F	3.10: Per driller's: clayey silt 4.40: Bottom of U75 gravel wet
5.50m – 8.0	ML	CLAYEY SILT: dark grey, medium plasticity, with silty clay layers up to 20mm thick.		S	5.50: SPT Recovery: 0.45 m; Hammer weight.

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517775.752, N: 6732376.884 (56 MGA94) SURFACE ELEVATION : 5.143 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER :
DATE STARTED : 26/9/09 DATE COMPLETED : 26/9/09 DATE LOGGED : 26/9/09 LOGGED BY : RT CHECKED BY : RT

Depth (m)	Water	Drilling Penetration	Samples & Field Tests	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
8.0–8.50	N/A			ML	CLAYEY SILT: dark grey, medium plasticity, with silty clay layers up to 20mm thick. *(continued)*			
8.50–10.00			8.50m SPT 0, 0, 0 N*=0 8.95m	ML	CLAYEY SILT: dark grey, high plasticity, trace gravel, roots and shells.		S; St (from 9.40)	8.50: SPT Recovery: 0.45 m; Hammer weight 450mm. 8.70: HP Samp = 1 kPa. 9.40: Changed to pale grey. 9.50: Driller's note: 9-10m: needs to keep cleaning it out
10.00–11.50			10.00m U75	CH	SILTY CLAY: grey, high plasticity	W	F - St	10.00: Where stiff clay started above that clay strip. 11.20: Change to sandy clay
11.50–16.00		E	11.50m SPT 3, 4, 5 N*=9 11.95m; 13.00m U75; 14.50m SPT 3, 5, 8 N*=13 14.95m; 16.00m	CH	SILTY CLAY: pale grey, high plasticity, with highly weathered gravel, trace fine grained sand, in lenses. Some ironstones. Trace of dark brown rootlets. Clay with silt: pale grey, wet, high plasticity, with trace of oxidised gravel (orange, weathered). Clay: pale grey, moist, high plasticity, trace of root (5mm thick) and trace of orange oxidised silt/sand.	W; M (from 14.50)	F; F - St (from 14.50)	11.50: SPT Recovery: 0.45 m. 11.70: HP Samp = 1 kPa. 13.10: HP Samp = 1 kPa. 14.50: SPT Recovery: 0.45 m. 14.60: HP Samp = 2 kPa

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH1
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517775.752, N: 6732376.884 (56 MGA94) SURFACE ELEVATION : 5.143 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER :
DATE STARTED : 26/9/09 DATE COMPLETED : 26/9/09 DATE LOGGED : 26/9/09 LOGGED BY : RT CHECKED BY : RT

DRILLING: PROGRESS Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	MATERIAL: Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
	N/A	E		SPT 6, 8, 10 N*=18 (16.45m)	16.0	CI	SILTY SANDY CLAY: pale grey, orange brown, medium plasticity, fine to medium grained sand, trace oxidised gravel, and some clay layers up to 20mm. Colour in layers.	W	D	16.00: SPT Recovery: 0.45 m
				17.50m SPT 5, 9, 12 N*=21 (17.95m)	17.50m	CI	SILTY CLAYEY SAND: pale grey to dark grey, fine and medium grained sand, medium plasticity clay		D	17.50: SPT Recovery: 0.45 m
				19.00m SPT 5, 7, 7 N*=14 (19.45m)	19.00m	CH	CLAY: high plasticity, with silt, with EW, up to 5mm, oxidised red gravel		F - St	19.00: SPT Recovery: 0.45 m
				20.50m SPT 5, 6, 10 N*=16 (20.95m)	20.50m	CH	CLAY: pale grey, orange brown, mottled, high plasticity		St	20.50: SPT Recovery: 0.2 m 20.60: HP Samp = 3 kPa
				22.00m SPT 7, 10, 10 N*=20 (22.45m)	22.00m	CH	CLAY: brown grey, mottled orange brown, high plasticity, with silt, some stain.		F - St	22.00: SPT Recovery: 0.45 m 22.10: HP Samp = 3 kPa
					24.00m		BOREHOLEBH1 TERMINATED AT 24.00 m			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 13:59 8.30.003 Datgel CPT Tool gINT Add-In

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH2
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517732.245, N: 6732324.802 (56 MGA94) SURFACE ELEVATION : 5.239 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER :
DATE STARTED : 27/9/09 DATE COMPLETED : 27/9/09 DATE LOGGED : 27/9/09 LOGGED BY : RT CHECKED BY : RT

DRILLING: Drilling & Casing: HW Casing; Drilling Penetration: E; Ground Water Levels: 27/09/09, 8.45am

Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
	0.0		AC			ROAD SURFACE
		GP	GRAVEL			
	0.70m	SM	SILTY SAND: brown			
1.00m SPT 6, 6, 5 N=11 1.45m	1.00m	SM	SILTY SAND: brown, fine grained sand, low plasticity	D	D	2.20: Increasing clay in auger
2.50m SPT 1, 1, 1 N=2 2.95m	2.50m	ML	SANDY SILT AND CLAYEY SILT: pale orange brown, low plasticity, with rootlets up to 1mm. Silty sandy clay in auger.	M	F	
4.00m SPT 4, 6, 7 N=13 4.45m	4.00m		4.00 - 4.20m: Clay/silty clay: brown with mottled orange brown, high plasticity 4.20 - 4.40m: Sand, pale brown, medium grained with trace of silt.	M	St - VSt / MD	4.00: Plumbed tape - no free water at 4.00m 4.20: HP Samp = 2 - 3 kPa
5.50m SPT 2, 0, 0 N=0 5.95m	5.50m	SP	SAND: grey brown, fine grained sand, with silt Top: Sand with clay/clayey sand, grey brown, fine grained.	W	VL	5.50: Sand in Auger - very wet, bottom of Auger
7.00m U75	7.00m	CH	CLAY: grey, high plasticity	M - W	F	7.10: HP Samp = 1 kPa 7.40: Hammer weight
7.40m SPT 0, 0, 0 N=0 7.85m	7.50m	CH	CLAY /SILTY CLAY: grey, high plasticity, with silt, with snail/shell and rootlets	W	S	7.50: Shells to 5mm wide
	8.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 13:59 8.30.003 Datgel CPT Tool gINT Add-In

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH2
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517732.245, N: 6732324.802 (56 MGA94)	SURFACE ELEVATION : 5.239 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD / DRILLER :
DATE STARTED : 27/9/09 / DATE COMPLETED : 27/9/09	DATE LOGGED : 27/9/09 / LOGGED BY : RT	CHECKED BY : RT

DRILLING & CASING	DRILLING PENETRATION	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
HW Casing (to 10.20m)		8.05m U75 8.90m	8.0	CH	CLAY /SILTY CLAY: grey, high plasticity, with silt, with snail/shell and rootlets *(continued)*	W	S	8.60: HP Samp = 1 kPa
			8.90m		Clay with silt - S to A			
		9.00m SPT 0, 0, 0 N=0 9.45m	9.0	CH	CLAY /SILTY CLAY: grey, high plasticity, with silt, with fine gravel, and sand. Trace of shell fragments. With roots to 2mm.			9.00: Hammer; 9.70: Increasing stiffness
		10.00m SPT 0, 3, 4 N*=7 10.45m	10.00m	CH	CLAY: pale grey, high plasticity			10.00: SPT Recovery: 0.15 m; 10.10: HP Samp = 1 kPa; 10.20: Casing driven to 10.20m to stop silty clay collasping
	E	11.50m U75	11.50m	CH	CLAY: grey with orange brown, high plasticity, trace fine gravel, trace sand	M - W	F - St	
		11.90m SPT 5, 5, 8 N*=13 12.35m	12.0		Silty clay: pale grey, high plasticity with lenses of fine gravel stained orange brown. Fine grained sand and lenses of stiff clay.			11.90: SPT Recovery: 0.45 m; 12.00: HP Samp = 1 kPa
		13.00m SPT 5, 10, 13 N=23 13.45m	13.0		Clay: pale grey with orange brown staining, with some rootlets and some EW orange brown gravels to 4mm.	M		13.10: HP Samp = 3 kPa
		14.50m SPT 6, 8, 13 N=21 14.95m	14.0 - 15.0		Clay: pale grey with some orange brown staining, high plasticity, with trace of EW gravel.	M - W		14.60: HP Samp = 1 kPa
			16.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government — Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH2
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517732.245, N: 6732324.802 (56 MGA94)	SURFACE ELEVATION : 5.239 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD — DRILLER :
DATE STARTED : 27/9/09	DATE COMPLETED : 27/9/09	DATE LOGGED : 27/9/09 — LOGGED BY : RT — CHECKED BY : RT

DRILLING / MATERIAL

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
				16.10m SPT 4, 5, 9 N*=14 16.55m	16.0			16.00 - 16.30m: Clay: pale grey, high plasticity, trace of silt and fine sand. Some lenses of fine sand. Trace of rootlet. 16.30 - 16.35m: Sandy clay, pale grey, high plasticity 16.30 - 16.45m: Sandy clay to sand. 16.33 - 16.40m: Sand with clay/clayey sand, pale grey, medium plasticity. 16.40 - 16.45m: Sand with silt: brown, non-plastic.	M	VSt	16.10: SPT Recovery: 0.34 m 16.35: HP Samp = 2 kPa
					17.0					St	
				17.50m SPT 11, 13, 16 N*=29 17.95m		17.50m		SAND: pale and dark grey bands, fine to medium grained sand, low plasticity, with silt, trace clay, increasing clay content towards 17.950m. Tip: 30mm clayey sand.	W		17.50: SPT Recovery: 0.45 m
					18.0					MD	
				19.00m SPT 4, 3, 7 N*=10 19.45m	19.0			Clay and clayey silt interbedded: pale grey, high plasticity. Clayey silt lenses - 50 -100mm thick.			19.00: SPT Recovery: 0.45 m. HP in clay 19.10: HP Samp = 2 kPa 19.20: HP Samp = 1 kPa
		E			20.0		SP		M - W	F - St	
				20.50m SPT 5, 9, 9 N*=18 20.95m				Clay with silt: pale grey, orange brown stains, high plasticity. With lenses of EW fine gravel heavily stained of orange red. With silty clay lenses.			20.50: SPT Recovery: 0.45 m 20.60: HP Samp = 3 kPa
					21.0					VSt	
				22.00m SPT 6, 9, 10 N*=19 22.45m	22.0	22.00m		CLAY: pale grey, orange brown, high plasticity, with silt, with silty clay lenses and lamination.	M		22.00: SPT Recovery: 0.45 m 22.10: HP Samp = 2 kPa
					23.0		CH			St - VSt	
					24.0	24.00m		BOREHOLEBH2 TERMINATED AT 24.00 m			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 1 OF 4

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94) SURFACE ELEVATION : 5.172 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN
DATE STARTED : 23/9/09 DATE COMPLETED : 24/9/09 DATE LOGGED : 23/9/09 LOGGED BY : JT CHECKED BY : RT

Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency Relative Density	Structure & Other Observations
AD/T (0.0–2.5)	N/A	H			0.0		ROAD PAVEMENT			ROAD SURFACE
		E-F			0.30m	GW	SANDY GRAVEL / GRAVELLY SAND: brown, fine to coarse gravel, fine to coarse grained sand	D		FILL
		H			0.70m–0.80m					
				1.00m SPT 5, 3, 3 N*=6 1.45m	0.80m	SW	GRAVELLY SAND: red brown, fine to coarse grained sand			0.80: NW= 3.2m NW= 11.5m 1.00: SPT Recovery: 0.45 m
					1.20m	ML	SANDY SILT / SILTY SAND: dark brown, non plastic, fine grained sand			possibly TOPSOIL 1.20: Natural Topsoil Layer? possibly TOPSOIL
				2.50m SPT 1, 1, 1 N*=2 2.95m	1.80m	ML	SANDY SILT: pale brown, low plasticity, fine grained sand			ALLUVIUM 2.50: SPT Recovery: 0.45 m
RR (2.5–8.0)	0% LOSS				2.80m	CI	SILTY CLAY: brown, medium plasticity			
				3.20m SPT 3, 3, 3 N*=6 3.65m	3.20m	SM	SILTY SAND: Brown, fine grained sand, clay % present also		L	3.20: SPT Recovery: 0.45 m
				4.20m SPT 2, 6, 7 N*=13 4.65m	4.00m	SM	SILTY CLAY: orange brown, pale blue grey, medium plasticity		St	4.20: SPT Recovery: 0.45 m 4.30: HP Samp =196 kPa
		E	25/09/09		4.35m	SM	SILTY SAND: brown, fine grained sand Becoming coarse grained with depth	M	MD	
				5.20m SPT 1, 1, 2 N*=3 5.65m	5.10m		CLAYEY SILT: grey, low plasticity, some organic material present			5.20: SPT Recovery: 0.45 m 5.50: HP Samp =50 kPa
				6.20m SPT 0, 0, 0 N*=0 6.65m		ML	SILTY CLAY: dark grey, high plasticity		S / F	6.20: SPT Recovery: 0.45 m; * SPT penetrated 0.45m on weight of SPT hammer 6.50: HP Samp =50 kPa
				7.20m SPT 0, 0, 0 N*=0 7.65m			CLAY: as above except decrease in silt %. Also some shells present			7.20: SPT Recovery: 0.45 m 7.30: HP Samp =50 kPa 7.54: * SPT penetrated 0.45m on weight of drill rods only
					8.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 2 OF 4

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94)	SURFACE ELEVATION : 5.172 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD
DRILLER : T. MARTIN		
DATE STARTED : 23/9/09	DATE COMPLETED : 24/9/09	DATE LOGGED : 23/9/09
LOGGED BY : JT	CHECKED BY : RT	

DRILLING: PROGRESS (DRILLING & CASING: RR; WATER: 0% LOSS); DRILLING PENETRATION: E; GROUND WATER LEVELS; SAMPLES & FIELD TESTS; DEPTH (m)

MATERIAL: GRAPHIC LOG; CLASSIFICATION SYMBOL; MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components); MOISTURE CONDITION; CONSISTENCY / RELATIVE DENSITY; STRUCTURE & Other Observations

Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
8.20m SPT 0, 0, 0 N*=0 8.65m	8.0		CLAYEY SILT: grey, low plasticity, some organic material present *(continued)*		S / F	8.20: SPT Recovery: 0.45 m 8.30: HP Samp =50 kPa 8.52: * SPT penetrated 0.45m on rod weight only
9.20m SPT 0, 0, 0 N*=0 9.65m	9.0	ML	SANDY SILTY CLAY: dark grey, medium to high plasticity, fine and medium grained sand		F	9.20: SPT Recovery: 0.45 m 9.30: HP Samp =78 kPa 9.50: * SPT penetrated 0.45m on hammer weight.
10.20m SPT 0, 5, 6 N*=11 10.65m	10.0		CLAY: dark grey, high plasticity (note: material increasing in strength from 10.30m)		St / VSt	10.20: SPT Recovery: 0.45 m 10.50: HP Samp =196 - 290 kPa
11.20m SPT 4, 4, 8 N*=12 11.65m	11.0 (11.00m)		SANDY SILTY CLAY: yellow brown, pale grey mottled, low to medium plasticity, fine grained sand	M	St / VSt	11.20: SPT Recovery: 0.45 m 11.50: HP Samp =190 - 200 kPa
12.20m U50	12.0		Note: boundary uncertain CLAY: pale grey, high plasticity			12.50: HP Samp =245 - 294 kPa
12.60m SPT 4, 5, 9 N*=14 13.05m	13.0	CL-CI				12.60: SPT Recovery: 0.45 m 13.00: HP Samp =290 kPa
14.00m SPT 3, 6, 8 N*=14 14.45m	14.0		CLAY: pale grey, red brown and yellow brown mottled, some silty sandy layers present, high plasticity, fine and medium grained sand		VSt	14.00: SPT Recovery: 0.45 m 14.25: HP Samp =245 kPa
15.25m SPT 4, 6, 9 N*=15 15.70m	15.0		CLAY: pale grey high plasticity			15.25: SPT Recovery: 0.45 m 15.50: HP Samp =294 - 343 kPa
	16.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 3 OF 4

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94) | SURFACE ELEVATION : 5.172 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : T. MARTIN

DATE STARTED : 23/9/09 | DATE COMPLETED : 24/9/09 | DATE LOGGED : 23/9/09 | LOGGED BY : JT | CHECKED BY : RT

DRILLING / MATERIAL

Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
RR	0% LOSS	E			16.0	CL-CI	SANDY SILTY CLAY: yellow brown, pale grey mottled, low to medium plasticity, fine grained sand *(continued)*	M	VSt / H	
				16.75m SPT 5, 10, 13 N*=23 17.20m	17.0					16.75: SPT Recovery: 0.45 m; 17.00: HP Samp =343 - >400 kPa
					17.75m	SC	CLAYEY SAND: pale grey, yellow brown, fine and medium grained sand			
				18.25m U50	18.20m	ML	CLAYEY SILT: pale grey with some yellow brown, low plasticity, trace fine grained sand		VSt	18.50: HP Samp =245 kPa
				18.65m SPT 3, 5, 9 N*=14 19.10m	19.0					18.65: SPT Recovery: 0.45 m
				19.75m SPT 3, 5, 8 N*=13 20.20m	20.0		SILTY CLAY: pale grey and brown, medium plasticity, trace fine grained sand		St	19.75: SPT Recovery: 0.45 m; 20.00: HP Samp =147 kPa
				21.25m SPT 4, 6, 9 N*=15 21.70m	21.0		as above except High Plasticity		VSt	21.25: SPT Recovery: 0.45 m; 21.50: HP Samp =343 kPa
				22.75m SPT 2, 5, 7 N*=12 23.20m	23.0		SILTY SANDY CLAY: pale grey and orange brown mottled, medium plasticity, some fine grained sand		St	22.75: SPT Recovery: 0.45 m; 23.00: HP Samp =118 kPa
					24.0 (24.00m)					

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH3
FILE / JOB NO : 4054/1
SHEET : 4 OF 4

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek

POSITION : E: 517757.183, N: 6732344.758 (56 MGA94)	SURFACE ELEVATION : 5.172 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD	DRILLER : T. MARTIN
DATE STARTED : 23/9/09	DATE COMPLETED : 24/9/09	DATE LOGGED : 23/9/09	LOGGED BY : JT / CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% LOSS	E		24.25m SPT 3, 6, 7 N=13 24.70m	24.0		CI	SILTY CLAY: dark grey with some orange brown mottled, medium plasticity (24.75m)	M	VSt	24.25: SPT Recovery: 0.45 m 24.50: HP Samp =245 - 294 kPa
					25.0			BOREHOLEBH3 TERMINATED AT 24.75 m Note: A second hole was drilled to do Vane Shear Testing: See Log Sheet BH: 3A			
					26.0						
					27.0						
					28.0						
					29.0						
					30.0						
					31.0						
					32.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH3A
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : 1.3m Sth of BH:3

POSITION : E: 517748.036, N: 6732333.908 (56 MGA94) SURFACE ELEVATION : 5.235 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN

DATE STARTED : 25/10/09 DATE COMPLETED : 25/10/09 DATE LOGGED : 25/10/09 LOGGED BY : JT CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0						
					1.0			Note: For material description see BH:3			
					2.0						
					3.0			Vane Shear Test (VST) Vane = 65/130mm			
					4.0						
					5.0						
				5.65m In-situ VS P>63kPa							
					6.0						6.00: H.P. = 68 KPa
				6.55m In-situ VS P=43kPa R=6kPa							
					7.0					S	
				7.35m In-situ VS P=34kPa R=6kPa							
										S	
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH3A
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

PROJECT : Byrons Lane Slip
LOCATION : 1.3m Sth of BH:3

POSITION : E: 517748.036, N: 6732333.908 (56 MGA94) SURFACE ELEVATION : 5.235 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN
DATE STARTED : 25/10/09 DATE COMPLETED : 25/10/09 DATE LOGGED : 25/10/09 LOGGED BY : JT CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0						
				8.10m In-situ VS P=33kPa R=7kPa						S	
				8.40m U75 8.80m						S	8.70: H.P. = 69 KPa
					9.0						
				9.10m In-situ VS P=54kPa R=9kPa							
				10.00m In-situ VS P=54kPa R=21kPa	10.0						
				11.00m In-situ VS P>63kPa	11.0						
					12.0						
								Note: material onwards too stiff for Vane Shear Testing		F	
					13.0						
					14.0						
					15.0						
					16.0			BOREHOLEBH3A TERMINATED AT 16.00 m			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Cane Paddock

HOLE NO : BH4
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

POSITION : E: 517775.668, N: 6732330.415 (56 MGA94)	SURFACE ELEVATION : 3.161 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD / DRILLER : T. MARTIN
DATE STARTED : 30/9/09	DATE COMPLETED : 30/9/09	DATE LOGGED : 30/9/09 / LOGGED BY : JT / CHECKED BY : RT

DRILLING: PROGRESS (DRILLING & CASING: ADT 0.0–3.0 m, RR 3.0–8.0 m; WATER: N/A 0.0–3.0 m, 0% Polymer LOSS 3.0–8.0 m); DRILLING PENETRATION: E; GROUND WATER LEVELS: 30/09/09, drilled to 3.1 m

DEPTH (m)	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
0.0		ML	CLAYEY SANDY SILT: dark brown, fine, low to medium plasticity, fine grained sand			TOPSOIL
			As above except brown & medium plasticity			
1.00m		CI	SILTY CLAY: pale grey, orange brown mottled, medium plasticity	M	H	1.00: HW= 2.7m
	1.50m SPT 3, 6, 6 N=12 1.95m					1.50: SPT Recovery: 0.45 m
2.30m		SP	SAND: pale grey, fine and medium grained sand		L	
	3.00m SPT 2, 1, 1 N*=2 3.45m		As above except orange brown			3.00: SPT Recovery: 0.45 m
3.20m		SC	CLAYEY SAND: grey, fine and medium grained sand		VL	
3.50m		ML	CLAYEY SILT: dark grey, low plasticity, trace fine grained sand			
	3.70m SPT 0, 0, 0 N*=0 4.15m					3.70: SPT Recovery: 0.45 m 3.91: SPT penetrated on weight of SPT hammer 4.10: HP Samp =50 kPa
	4.35m In-situ VS P=[illegible] R=[illegible] 36					
5.00m		CI	SILTY CLAY: dark grey, medium plasticity	W	S	
	5.35m In-situ VS P=[illegible] R=[illegible] 5.70m U75 6.00m 31.5		Some shells present			
						6.00: HP Samp =50 kPa
	6.35m In-situ VS P=[illegible] R=8kPa 14.5					
7.20m		CI	CLAY: pale blue grey, some yellow brown mottled, high plasticity			
	7.35m In-situ VS P=[illegible] R=12kPa 7.70m U75 34		Only 80mm of U75 sample recovered			
8.00m						7.90: HP Samp =98 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:00 8.30.003 Datgel CPT Tool gINT Add-In

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH4
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Cane Paddock

POSITION : E: 517775.668, N: 6732330.415 (56 MGA94) SURFACE ELEVATION : 3.161 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Truck CONTRACTOR : NCD DRILLER : T. MARTIN
DATE STARTED : 30/9/09 DATE COMPLETED : 30/9/09 DATE LOGGED : 30/9/09 LOGGED BY : JT CHECKED BY : RT

DRILLING: PROGRESS — DRILLING & CASING: RR; WATER: 0% Polymer LOSS; DRILLING PENETRATION: m

DEPTH (m)	SAMPLES & FIELD TESTS	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
8.0		CH	SILTY CLAY: pale grey and orange brown mottled, high plasticity	W	VSt / H	ALLUVIUM
	8.35m [illegible] >63					
	8.70m SPT 5, 9, 12 N*=21 9.15m					8.70: SPT Recovery: 0.45 m
9.0						9.00: HP Samp =350 - >=400 kPa
10.0						
	10.70m SPT 4, 7, 9 N*=16 11.15m		As above - Predominently pale blue grey		VSt	10.70: SPT Recovery: 0.45 m
11.0						11.00: HP Samp >294 kPa
12.0						
	12.20m SPT 4, 5, 9 N*=14 12.65m					12.20: SPT Recovery: 0.45 m
						12.50: HP Samp =245 - 294 kPa
			As above			
13.0						
	13.70m SPT 4, 5, 6 N*=11 14.15m				St / VSt	13.70: SPT Recovery: 0.45 m
14.0			As above			14.00: HP Samp =196 - 245 kPa
14.20m		SM	SILTY SAND: pale grey, fine and medium grained sand, some coarse grain present			
14.80m		CH	SILTY CLAY: orange brown and pale grey, high plasticity		St	
15.0	15.20m SPT 8, 12, 26 N*=38					15.20: SPT Recovery: 0.45 m
						15.40: HP Samp =196 kPa
15.50m		CI	SANDY CLAY: pale grey, medium plasticity, fine and medium sand		VSt	15.60: HP Samp =245 - 294 kPa
15.65m	15.65m		BOREHOLEBH4 TERMINATED AT 15.65 m			
16.0						

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH5
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517709.412, N: 6732323.863 (56 MGA94) SURFACE ELEVATION : -4.741 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 7/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS - DRILLING & CASING	PROGRESS - WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			BARGE			
					0.9			WATER			
					5.6			ROCK BOULDERS			
					5.90m		CI	SILTY CLAY: pale brown, medium plasticity, slightly sandy	M		
				6.40m SPT 3, 4, 5 N*=9	6.40m		CI	SILTY CLAY: yellow brown, medium plasticity, with sand	M		6.40: SPT Recovery: 0.45 m
				6.85m 6.90m U75	6.70m			CLAY: pale blue grey, medium to high plasticity		St	
				7.30m			CI-CH	7.2m: with ironestone bands, mottled grey brown	M		7.30: HP Samp =180 kPa
					8.00m						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH5
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517709.412, N: 6732323.863 (56 MGA94)	SURFACE ELEVATION : -4.741 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 7/10/09	DATE COMPLETED :	DATE LOGGED :	LOGGED BY : MP
CHECKED BY : RT			

DRILLING: SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
	8.0	CI	CLAY: mottled red brown grey, medium plasticity, with ironstone gravel		St / VSt	
8.90m U75	9.0					8.90: HP Samp =300 kPa
9.30m	9.30m	CI	CLAY: grey mottled red brown, medium plasticity, with ironstone gravel	M	MD	
10.00m SPT 5, 9, 11 N*=20	10.0					10.00: SPT Recovery: 0.45 m 10.10: HP Samp =340 kPa
10.45m	11.0					
11.50m U75						
11.90m	12.0					11.90: HP Samp =350 kPa
	12.50m	SC	SAND: pale brown grey, fine grained sand, medium plasticity, with clay		MD	
13.00m SPT 5, 7, ? N*=? 5,7,12 N=19	13.0					13.00: SPT Recovery: 0.45 m
13.45m						
13.70m	14.0					
	14.20m	CI	SILTY CLAY: pale grey mottled brown, medium plasticity, with fine sand		St / VSt	
14.50m SPT 6, 6, 9 N*=15						14.50: SPT Recovery: 0.45 m
14.95m	15.0					
16.00m	16.0 / 16.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH5
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517709.412, N: 6732323.863 (56 MGA94) SURFACE ELEVATION : -4.741 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 7/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : MP CHECKED BY : RT

SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
SPT 5, 9, 10 N*=19 (16.00–16.45m)	16.0	CI	SILTY CLAY: pale grey mottled brown, medium plasticity, with fine sand, and ironstone gravel	M	VSt	16.00: SPT Recovery: 0.45 m
SPT 6, 9, 12 N*=21 (17.50m–17.95m)						17.50: SPT Recovery: 0.45 m
SPT 2, 7, 9 N*=16 (18.90m–19.35m)						18.90: SPT Recovery: 0.45 m
	20.20m	CH	CLAY (MARINE CLAY): dark grey and brown grey, high plasticity, with silt	M	VSt	
SPT 6, 8, 11 N*=19 (20.40m–20.85m)	20.50m	CH	CLAY (MARINE CLAY): grey, high plasticity	M	VSt	20.40: SPT Recovery: 0.45 m
SPT 4, 5, 9 N*=14 (21.90m–22.35m)					St	21.90: SPT Recovery: 0.45 m
SPT 6, 10, 12 N*=22 (23.20m–23.65m)	23.20m	CH	CLAY: grey, high plasticity, with silt		VSt	23.20: SPT Recovery: 0.45 m
	23.65m		BOREHOLEBH5 TERMINATED AT 23.65 m			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH6
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517767.757, N: 6732391.579 (56 MGA94) | SURFACE ELEVATION : -3.873 (AHD) | ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright
DATE STARTED : 8/10/09 | DATE COMPLETED : 8/10/09 | DATE LOGGED : 8/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0		DECK			
					0.9		WATER			
RR	20% Polymer LOSS	F		4.60m	4.60–4.80m	CI	SANDY CLAY: dark grey, very soft	M	VS	FILL 4.60: SPT sunk under hammer weight
		H		5.40m	4.80–7.00m		SANDSTONE BOULDERS/COBBLES		H	5.40: SPT bouncing
				7.50m SPT 2, 4, 4 N*=8 7.95m	7.00–8.00m	CL	CLAY: pale blue grey and brown, low plasticity, with some fine gravel	M	F / St	

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See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH6
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517767.757, N: 6732391.579 (56 MGA94) SURFACE ELEVATION : -3.873 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 8/10/09 DATE COMPLETED : 8/10/09 DATE LOGGED : 8/10/09 LOGGED BY : MP CHECKED BY : RT

Drilling & Casing	Water	Drilling Penetration	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency Relative Density	Structure & Other Observations
RR	0% Polymer LOSS (8.0–11.6)	F	VST	8.0–8.50m	CL	CLAY: pale blue grey and brown, low plasticity	M		8.00: HV Samp P: 110 kPa
			8.50m SPT 2, 6, 7 N=13 8.95m	8.50–9.30m	CL-CI	SANDY CLAY / CLAY: pale grey mottled, red brown, low to medium plasticity, with some fine gravel		St	
			10.10m U75 10.50m	9.30–11.00m	CL-CI	SANDY CLAY: mottled red brown grey, low to medium plasticity, with ironstone gravel		VSt	10.50: HP Samp =350 kPa
			11.60m SPT 4, 7, 8 N=15	11.00–11.80m	CI-CH	CLAY: pale grey to brown grey, medium to high plasticity		St - VSt	
	2% Polymer LOSS (11.6–13.3)		12.05m; 13.10m SPT 7, 11, 15 N*=26	11.80–13.30m	SP	SAND: pale brown, fine to medium grained sand		MD	
	0% Polymer LOSS (13.3–16.0)		13.55m	13.30–14.50m	CH	CLAY: pale grey mottled yellow brown, high plasticity		VSt	13.50: HP Samp = 320 kPa
			14.60m SPT 5, 5, 8 N*=13 15.05m	14.50–16.00m	CL-CI	SILTY CLAY: pale grey mottled yellow brown, low to medium plasticity, with some fine sand		St	

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH6
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517767.757, N: 6732391.579 (56 MGA94)	SURFACE ELEVATION : -3.873 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 8/10/09	DATE COMPLETED : 8/10/09	DATE LOGGED : 8/10/09	LOGGED BY : MP / CHECKED BY : RT

DRILLING | MATERIAL

Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
RR	5% Polymer LOSS	F		16.10m U75 16.50m	16.0	CL-CI	SILTY CLAY: yellow brown and grey, low to medium plasticity	M	St	16.50: HP Samp =150 kPa
				17.50m SPT 5, 8, 11 N*=19 17.95m	17.0–18.0		with some fine sand			
				18.90m SPT 2, 4, 5 N*=9 19.35m	18.60m	CL-ML	CLAYEY SILT / SILTY CLAY: pale brown mottled grey, low plasticity			
				20.40m SPT 4, 8, 7 N*=15 20.85m	20.00m	CL-CI	CLAY / SILTY CLAY: clay is pale and dark grey mottled brown, low to medium plasticity; clay is		St - VSt	
					20.85m		BOREHOLEBH6 TERMINATED AT 20.85 m			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH7
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Byrons Lane Slip

POSITION : E: 517732.596, N: 6732347.651 (56 MGA94)	SURFACE ELEVATION : -3.852 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 3/10/09	DATE COMPLETED :	DATE LOGGED :	LOGGED BY : RT/MP	CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
HW Casing (0.0–5.3)					0.0			DECK			
					0.9			WATER			
ROTARY (5.3–8.0)	20-30% Polymer LOSS (5.3–8.0)	H			5.3			BOULDERS/ SANDSTONE BLOCKS			
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH7
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Byrons Lane Slip

POSITION : E: 517732.596, N: 6732347.651 (56 MGA94) SURFACE ELEVATION : -3.852 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 3/10/09 DATE COMPLETED : DATE LOGGED : LOGGED BY : RT/MP CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
ROTARY	0% Polymer LOSS (to 8.50m)	H		8.0		BOULDERS/ SANDSTONE BLOCKS *(continued)*			
	0% Polymer LOSS (8.50–12.00m)	F	8.90m U75 9.30m	8.50m	CI	CLAY: pale grey, medium plasticity	M	St	FILL; 9.30: HP Samp = 300 kPa
				9.50m		with ferruginous sandstone fragments with geotextile pieces			
			10.30m SPT 3, 7, 9 N=16 10.75m; 11.60m U75	9.50m	CH	CLAY: pale grey, high plasticity		VSt	10.30: HP Samp = 200 kPa; 12.00: HP Samp =265 kPa
	10% Polymer LOSS (12.00–15.70m)		12.00m SPT 5, 6, 9 N=15 12.45m	12.10m	CL	SANDY CLAY: pale grey mottled, yellow brown, low plasticity		St / VSt	
			13.50m SPT 9, 11, 14 N=25 13.95m	13.00m	SC	CLAYEY SAND: pale grey mottled yellow, fine grained	M	MD	
			15.00m SPT 5, 7, 8 N=15 15.45m	14.60m	CL-CI	SANDY CLAY: pale grey brown mottled yellow, low to medium plasticity, with some silt		St / VSt	
				15.70m	CH	CLAY: pale grey mottled yellow brown, high plasticity		VSt	
				16.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH7
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Byrons Lane Slip

POSITION : E: 517732.596, N: 6732347.651 (56 MGA94) | SURFACE ELEVATION : -3.852 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 3/10/09 | DATE COMPLETED : | DATE LOGGED : | LOGGED BY : RT/MP | CHECKED BY : RT

Drilling & Casing	Water	Drilling Penetration	Ground Water Levels	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
ROTARY		F		16.50m U75 16.90m	16.0 – 18.00	CH	CLAY: pale grey mottled yellow brown, high plasticity *(continued)*	M	VSt	
				18.00m SPT 4, 5, 6 N=11 18.45m	18.00 – 19.00	CI	SILTY CLAY: pale grey mottled yellow brown, medium plasticity	M	St	
				19.40m SPT 6, 8, 10 N=18 19.85m	19.00 – 20.90	CL	SANDY CLAY /CLAYEY SAND: pale grey to blue grey mottled yellow brown, low plasticity	M	VSt	
				20.90m SPT 4, 7, 8 N=15 21.35m	20.90 – 21.35	CI	CLAY (MARINE CLAY): dark grey, medium plasticity	M	St / VSt	
					21.35		BOREHOLEBH7 TERMINATED AT 21.35 m			

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH8
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517748.614, N: 6732355.274 (56 MGA94) SURFACE ELEVATION : -5.496 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 11/10/09 DATE COMPLETED : DATE LOGGED : 11/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS - DRILLING & CASING	DRILLING: PROGRESS - WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			BARGE			
					0.9			WATER			
				3.70m SPT 2, 3, 5 N=8 4.15m	3.70		GC	CLAYEY GRAVEL: brown	M	L	3.70: (slumped material)
				6.50m SPT 3, 4, 5 N=9 6.95m	6.20m		CL	SANDY CLAY: pale grey to blue grey mottled brown, low plasticity, with fine gravel, with silt		St	
				8.00m	8.00m						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH8
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517748.614, N: 6732355.274 (56 MGA94) SURFACE ELEVATION : -5.496 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 11/10/09 DATE COMPLETED : DATE LOGGED : 11/10/09 LOGGED BY : MP CHECKED BY : RT

Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency Relative Density	Structure & Other Observations
U75 8.00–8.40m	8.0–10.50m	CI	SILTY CLAY: pale grey blue mottled red brown, medium plasticity, with ironstone gravel	M	St	8.40: HP Samp =180 kPa
9.50m SPT 3, 4, 9 N=13 9.95m						
11.00m SPT 3, 6, 8 N=14 11.45m	10.50m–12.50m	CI	CLAY: grey mottled red brown, medium plasticity, with ironstone gravel	M	St	12.40: HP Samp =240 kPa
12.50m U75 12.90m	12.50m–14.00m	CL	SANDY CLAY / CLAYEY SAND: pale grey mottled pale brown, low plasticity, fine grained sand	M	VSt / MD	
14.00m SPT 4, 6, 5 N=11 14.45m	14.00m–16.00m	ML	CLAYEY SILT / SANDY SILT: pale grey and brown, low plasticity	M	St	
15.50m SPT 3, 7, 6 N=13 15.95m						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government — Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH8
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

POSITION : E: 517748.614, N: 6732355.274 (56 MGA94) SURFACE ELEVATION : -5.496 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 11/10/09 DATE COMPLETED : DATE LOGGED : 11/10/09 LOGGED BY : MP CHECKED BY : RT

Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
	16.0	ML	CLAYEY SILT / SANDY SILT: pale grey and brown, low plasticity		St	
17.00m U75 17.40m	17.00m	CL-CI	SILTY CLAY pale grey brown, low to medium plasticity		VSt	17.40: HP Samp =260 kPa
18.50m SPT 3, 5, 10 N=15 18.95m; 20.00m SPT 2, 5, 7 N=12 20.45m	18.50m	ML	CLAYEY SILT: pale grey and brown, low plasticity, with some fine sand; with some clay layers	M	St / VSt	
21.50m	21.00m	CI-CH	CLAY (MARINE CLAY): dark grey, medium to high plasticity, with some silt		St	
21.95m SPT 4, 7, 7 N=14 22.40m	21.95m		BOREHOLEBH8 TERMINATED AT 21.95 m			

Depth scale: 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Government Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH9
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

POSITION : E: 517755.045, N: 6732369.932 (56 MGA94)	SURFACE ELEVATION : -4.079 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 9/10/09	DATE COMPLETED :	DATE LOGGED : 9/10/09	LOGGED BY : MP
CHECKED BY : RT			

DRILLING / MATERIAL

PROGRESS: DRILLING & CASING: RR. WATER: 20-30% Water LOSS (approx. 2.6–5.5 m); 5-10% Water LOSS (approx. 5.5–8.0 m). DRILLING PENETRATION: H (approx. 2.6–5.35 m); E (approx. 5.35–8.0 m).

SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
	0.0		BARGE			
			WATER			
			SANDSTONE BOULDERS/COBBLES			
4.90m SPT 0, 1, 6 N=7 5.35m	4.90m		CLAY AND SANDSTONE COBBLES: clay is dark grey; grey white		F	4.90: Slumped material
5.90m SPT 0, 2, 1 N=3 6.35m	5.50m	CI	SILTY CLAY / COBBLES SANDSTONE: clay is dark grey, medium plasticity, with some sand; cobbles is	W	S	
6.70m U75 7.10m; 7.10m [illegible] 34; 7.60m [illegible] 35 [illegible]	6.60m	CL-ML	CLAYEY SILT / CLAYEY SAND: silt is dark grey, low plasticity, trace gravel; sand is fine grained sand		S / VL	7.10: HP Samp =60 kPa
	8.00m					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW Transport Roads & Maritime Services

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NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH9
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517755.045, N: 6732369.932 (56 MGA94)	SURFACE ELEVATION : -4.079 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 9/10/09	DATE COMPLETED :	DATE LOGGED : 9/10/09	LOGGED BY : MP
CHECKED BY : RT			

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY / RELATIVE DENSITY	STRUCTURE & Other Observations
RR	0% Water LOSS	E		8.1 H-SITE VC P>63; 9.00m SPT 4, 5, 7 N=12	8.0 – 9.20m	CH	CLAY: pale grey, high plasticity	M	St	
RR	0% Water LOSS	F		9.45m; 9.50m U75; 9.90m	9.20m – 11.00m	CH	CLAY: grey mottled red brown, high plasticity, with ironstone gravel to 9.5m	M	St (to 9.5m), VSt	9.20: HP Samp =160 kPa; 9.90: HP Samp =240 kPa
RR	0% Water LOSS	F		11.00m SPT 3, 5, 7 N=12; 11.45m; 12.50m SPT 8, 12, 21 N=33	11.00m – 12.80m	CH	CLAY: pale grey, high plasticity	M	St (to 12.0m), H	
RR	5-10% Water LOSS	F		12.95m	12.80m – 14.00m	CI	SANDY CLAY: pale grey, medium plasticity	M	H	
RR	5-10% Water LOSS	F		14.00m SPT 6, 5, 7 N=12; 14.45m	14.00m – 15.20m	SC	CLAYEY SAND: grey, fine grained sand	M	MD	
RR	5-10% Water LOSS	F		15.50m U75; 15.90m	15.20m – 16.0	ML	CLAYEY SILT: pale grey mottled yellow brown, low plasticity	M	VSt	15.90: HP Samp =260 kPa

See Explanatory Notes for details of abbreviations & basis of descriptions.

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH9
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517755.045, N: 6732369.932 (56 MGA94) SURFACE ELEVATION : -4.079 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 9/10/09 DATE COMPLETED : DATE LOGGED : 9/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	5-10% Water LOSS	F			16.0	ML	CLAYEY SILT: pale grey mottled yellow brown, low plasticity *(continued)*	M		
					16.50m	CL-CI	SILTY CLAY: pale grey mottled yellow brown, low to medium plasticity		VSt	
				17.00m SPT 5, 8, 11 N=19 17.45m	17.0					
					18.00m	ML	CLAYEY SILT: pale grey mottled yellow brown, low plasticity, with some fine sand		St	
				18.50m SPT 2, 3, 6 N=9 18.95m	19.0					
				20.00m SPT 3, 2, 6 N=8 20.45m	20.0				F / St	
					21.00m	CI	CLAY: dark grey, medium plasticity, slightly silty		St	
				21.50m SPT 1, 3, 8 N=11 21.95m	21.95m		BOREHOLEBH9 TERMINATED AT 21.95 m			
					22.0					
					23.0					
					24.0					

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH10
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

POSITION : E: 517748.039, N: 6732333.899 (56 MGA94) | SURFACE ELEVATION : 5.232 (AHD) | ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 | MOUNTING : Truck | CONTRACTOR : NCD | DRILLER : Joel Wright
DATE STARTED : 29/9/09 | DATE COMPLETED : 29/9/09 | DATE LOGGED : 29/9/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING PROGRESS: DRILLING & CASING	DRILLING PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components)	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
ADIT (0.0–5.0)	N/A				0.0		ASPHALT			ROAD SURFACE
		E-F			0.30m		SANDY GRAVEL / GRAVELLY SAND: brown, (road base material)			FILL
					1.00m	SM	SILTY SAND: brown			
					1.30m	ML	SANDY SILT: dark brown, fine, low to non plasticity			1.30: Old Topsoil
					1.70m	ML	SANDY SILT as above except brown			ALLUVIUM
		E	30/09/09 (at ~4.2m)		2.50m	CI	SILTY CLAY: brown, fine, medium plasticity (Note: Material description not accurate due to no SPTs) (boundary uncertain due to augering) SAND: brown, fine and medium grained sand			2.50: HW=4.60m =5.60m
RR (5.0–8.0)	5% Water LOSS				5.50m	SM	SILTY SAND: grey, fine to medium grained sand			
				6.40m In-situ VS P=[illegible]kPa R=[illegible]kPa 44 8.5 7.30m In-situ VS P=[illegible]kPa R=10kPa 28.5	5.70m		SILTY CLAY: grey, some organic material present (Note: No material description due to continuous Vane Shear Tests. See BH3 log			

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH10
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517748.039, N: 6732333.899 (56 MGA94)	SURFACE ELEVATION : 5.232 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Truck	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 29/9/09	DATE COMPLETED : 29/9/09	DATE LOGGED : 29/9/09	LOGGED BY : MP / CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION: Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
RR	5% Water LOSS	E			8.0			SILTY CLAY: grey, some organic material present *(continued)*			
				8.25m In-situ VS P=[illegible] R=8kPa 33				(Note: No material description due to continuous Vane Shear Tests. See BH3 log			
					9.0						
				9.30m In-situ VS P=[illegible] R=14kPa 49							
					10.0						
				10.25m In-situ VS P=[illegible] R=23kPa 55				(Note: Vane Shear body started to slowly penetrate from 10.70m - stiffer material)			
				10.80m SPT 4, 8, 10 N=18				SILTY SANDY CLAY: greenish grey, fine grained sand, medium to high plasticity		VSt	10.90: HP Samp =294 kPa
					11.0		11.05m SC	CLAYEY SAND: pale grey, fine to medium grained sand		MD	
				11.25m			11.15m CI-CH	SANDY CLAY: pale grey yellow brown mottled, fine, medium to high plasticity		VSt	11.20: HP Samp =[illegible] kPa
					11.25m			BOREHOLEBH10 TERMINATED AT 11.25 m			
					12.0						
					13.0						
					14.0						
					15.0						
					16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH11
FILE / JOB NO : 4054/1
SHEET : 1 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517730.705, N: 6732373.388 (56 MGA94)	SURFACE ELEVATION : -7.934 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 12/10/09	DATE COMPLETED : 12/10/09	DATE LOGGED : 12/10/09	LOGGED BY : MP / CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
HW Casing (0.0–8.0)	N/A				0.0			BARGE			
					0.9			WATER			
					1.0						
					2.0						
					3.0						
					4.0						
					5.0						
					6.0						
					7.0						
					8.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH11
FILE / JOB NO : 4054/1
SHEET : 2 OF 3

POSITION : E: 517730.705, N: 6732373.388 (56 MGA94)	SURFACE ELEVATION : -7.934 (AHD)	ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD
DRILLER : Joel Wright		
DATE STARTED : 12/10/09	DATE COMPLETED : 12/10/09	DATE LOGGED : 12/10/09
LOGGED BY : MP	CHECKED BY : RT	

DRILLING / MATERIAL

Drilling & Casing	Water	Drilling Penetration	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description (Soil Type, Colour, Plasticity or Particle Characteristic, Secondary and Minor Components)	Moisture Condition	Consistency / Relative Density	Structure & Other Observations
HW Casing	N/A			8.0 – 8.50		WATER *(continued)*			
RR	0% Water LOSS	E	8.50m SPT 0, 0, 0 N=0 8.95m; 9.50m In-situ VS P=[illegible] R=[illegible] 31.5; 10.00m In-situ VS P=[illegible] 80; 10.60m U75	8.50 – 10.70m	CI	CLAY (MARINE CLAY): dark grey, medium plasticity, seashells, with fine sand & silt	M	S	
		F	11.00m; 12.00m SPT 5, 8, 9 N=17 12.45m	10.70m – 12.20m	CL-CI	SANDY CLAY: pale grey mottled red brown, low to medium plasticity, with fine ironstone gravel		VSt	11.00: HP Samp =380 kPa
	5-10% Water LOSS			12.20m – 13.50m		SAND: grey, fine to medium grained sand	W	MD	
			13.50m SPT 4, 6, 8 N=1[illegible] 13.95m	13.50m – 15.00m	ML	SANDY SILT: pale grey, low plasticity, with some clayey layers	M	St / VSt	
	0% Water LOSS		15.00m SPT 5, 8, 11 N=19 15.45m	15.00m – 16.0	CI	CLAY: pale grey mottled yellow, medium plasticity, with some silt and fine sand		VSt	

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH11
FILE / JOB NO : 4054/1
SHEET : 3 OF 3

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517730.705, N: 6732373.388 (56 MGA94) SURFACE ELEVATION : -7.934 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 12/10/09 DATE COMPLETED : 12/10/09 DATE LOGGED : 12/10/09 LOGGED BY : MP CHECKED BY : RT

Drilling & Casing	Water	Drilling Penetration	Samples & Field Tests	Depth (m)	Classification Symbol	Material Description	Moisture Condition	Consistency Relative Density	Structure & Other Observations
RR	0% Water LOSS	F	16.50m SPT 5, 9, 12 N=21 16.95m	16.0–17.50m	CI	CLAY: pale grey mottled yellow, medium plasticity, with some silt and fine sand *(continued)*	M	VSt	
			18.00m SPT 3, 4, 8 N=12 18.45m	17.50m–19.20m	CL-ML	SILTY CLAY / CLAYEY SILT: pale grey and brown, low plasticity, with fine sand	M	St	
			19.50m SPT 5, 6, 9 N=15 19.95m	19.20m–21.10m	CL-CI	CLAY: pale grey and brown, low to medium plasticity, trace silt, and fine ironstone gravel	M	St / VSt	
	10% Water LOSS		21.00m SPT 6, 6, 8 N=14 21.45m; 22.50m SPT 9, 13, 15 N=28 22.95m	21.10m–23.95m		SAND: pale brown and grey, fine to medium grained sand, with some clay	W	MD	
			23.50m SPT 8, 12, 21 N=33 23.95m			some river gravel	W	D	
				23.95m		BOREHOLEBH11 TERMINATED AT 23.95 m BOTTOM OF MARKER PIPE			

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517751.550, N: 6732366.995 (56 MGA94) SURFACE ELEVATION : -3.836 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 15/10/09 DATE COMPLETED : 15/10/09 DATE LOGGED : 15/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			TOP OF DECK			
					1.0			WATER LEVEL			
					1.25m			1.25m: BOTTOM OF DECK			1.50: - 13.0m: Steel Pipe
					3.70			SANDSTONE COBBLES / CLAYEY GRAVEL		L	3.70: - 13.0m: No sampling hole logged from cutting to the bottom of marker pole
					6.20m			SANDY CLAY		St	
					8.00m						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH12
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517751.550, N: 6732366.995 (56 MGA94)	SURFACE ELEVATION : -3.836 (AHD)	ANGLE FROM HORIZONTAL : 90°	
RIG TYPE : P160	MOUNTING : Barge	CONTRACTOR : NCD	DRILLER : Joel Wright
DATE STARTED : 15/10/09	DATE COMPLETED : 15/10/09	DATE LOGGED : 15/10/09	LOGGED BY : MP / CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0			SILTY CLAY		St	
					8.50m			SILTY CLAY			
					9.0						
					10.0						
					10.50m			CLAY		St	
					11.0						
					12.0						
					12.50m			SANDY CLAY / CLAYEY SAND			
					13.00m			BOREHOLEBH12 TERMINATED AT 13.00 m BOTTOM OF MARKER POLE			
					14.0						
					15.0						
					16.0						

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:03 8.30.003 Datgel CPT Tool gINT Add-In

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT | Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH13
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517745.042, N: 6732357.755 (56 MGA94) SURFACE ELEVATION : -2.137 (AHD) ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright

DATE STARTED : 14/10/09 DATE COMPLETED : 14/10/09 DATE LOGGED : 14/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					0.0			TOP OF DECK			
								WATER			
					1.25m			1.25m: BOTTOM OF DECK			1.80: - 9.0m: Steel Pipe 2.00: - 9.0m: No sampling hole logged from cuttings to install marker pole
								SANDSTONE BOULDERS / COBBLES			
					5.50m			SILTY CLAY			
					6.50m			CLAYEY SILT		S	
					8.00m						

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:03 8.30.003 Datgel CPT Tool gINT Add-In

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH13
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

POSITION : E: 517745.042, N: 6732357.755 (56 MGA94) SURFACE ELEVATION : -2.137 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 14/10/09 DATE COMPLETED : 14/10/09 DATE LOGGED : 14/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	DRILLING: PROGRESS – WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0			CLAY		St	
					9.0			9.00m BOREHOLEBH13 TERMINATED AT 9.00 m BOTTOM OF MARKER POLE			
					10.0						
					11.0						
					12.0						
					13.0						
					14.0						
					15.0						
					16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:03 8.30.003 Datgel CPT Tool gINT Add-In

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH14
FILE / JOB NO : 4054/1
SHEET : 1 OF 2

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

POSITION : E: 517735.446, N: 6732346.598 (56 MGA94) | SURFACE ELEVATION : -5.545 (AHD) | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : P160 | MOUNTING : Barge | CONTRACTOR : NCD | DRILLER : Joel Wright

DATE STARTED : 13/10/09 | DATE COMPLETED : 13/10/09 | DATE LOGGED : 13/10/09 | LOGGED BY : MP | CHECKED BY : RT

DRILLING: PROGRESS (DRILLING & CASING, WATER), DRILLING PENETRATION, GROUND WATER LEVELS, SAMPLES & FIELD TESTS

MATERIAL: DEPTH (m), GRAPHIC LOG, CLASSIFICATION SYMBOL, MATERIAL DESCRIPTION (Soil Type, Colour, Plasticity or Particle Characteristic; Secondary and Minor Components), MOISTURE CONDITION, CONSISTENCY RELATIVE DENSITY, STRUCTURE & Other Observations

Depth (m)	Material Description	Consistency / Relative Density	Structure & Other Observations
0.0	TOP OF DECK		
	WATER		
1.25m	bottom of deck		
	TOP OF MARKER POLE		1.30: - 9.2m: Steel Pipe
	CLAY: (slumped?)		5.40: - 9.2m: No sampling hole logged from cuttings to install marker pole
6.60m	BOULDERS / COBBLES		
7.50m	CLAY	St	

Depth scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0

RMS LIB 32.GLB Log RTA NON-CORE DRILL HOLE BYRONS_LANE_SLIP.GPJ <<DrawingFile>> 13/Mar/2012 14:04 8.30.003 Datgel CPT Tool gINT Add-In

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

NON-CORE DRILL HOLE - GEOLOGICAL LOG

PROJECT : Byrons Lane Slip
LOCATION : Shark Creek - Tyndale

HOLE NO : BH14
FILE / JOB NO : 4054/1
SHEET : 2 OF 2

POSITION : E: 517735.446, N: 6732346.598 (56 MGA94) SURFACE ELEVATION : -5.545 (AHD) ANGLE FROM HORIZONTAL : 90°
RIG TYPE : P160 MOUNTING : Barge CONTRACTOR : NCD DRILLER : Joel Wright
DATE STARTED : 13/10/09 DATE COMPLETED : 13/10/09 DATE LOGGED : 13/10/09 LOGGED BY : MP CHECKED BY : RT

DRILLING: PROGRESS – DRILLING & CASING	WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	MATERIAL: GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Colour, Plasticity or Particle Characteristic Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
					8.0			CLAY *(continued)*			
					8.30m			CLAY		St	
					9.0						
					9.20m			BOREHOLEBH14 TERMINATED AT 9.20 m			
					10.0						
					11.0						
					12.0						
					13.0						
					14.0						
					15.0						
					16.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

ROADS AND MARITIME SERVICES, NSW

NSW GOVERNMENT Transport Roads & Maritime Services

Appendix C

NSW DPI Fisheries consultation (and s199 referral comments)

23 November 2021

Ref: 4099-1012

NSW DPI Fisheries

Via email: *ahp.central@dpi.nsw.gov.au*

To whom it may concern

Consultation regarding remediation works for Byrons Lane Slip Stage V

Transport for NSW (TfNSW) proposes to carry out remediation works on the Clarence River embankment, adjacent to a section of Big River Way (Old Pacific Highway) in response to a significant rainfall event (declared natural disaster) in March 2021. The works are required to ensure that Big River Way remains a safe and trafficable transport route by remediation of the slope and riverbank profile to prevent further degradation of the road surface. The location of the works are shown in **Illustration 1.1** with works area for the proposal shown in **Illustration 1.2**.

The objectives of the proposed works are to:

- stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way;
- restore the riverbank profile;
- restore the pavement to the shoulder of Big River Way;
- undertake works to minimise traffic, environmental, social impacts; and
- ensure Big River Way remains a safe and trafficable transport route.

Key features of the proposal include:

- Project set up including establishment of a site compound and stockpile locations within close proximity to the site
- Establish traffic controls in vicinity of the site (to accommodate temporary restricted/closed lanes of Big River Way)
- Establish sedimentation and erosion controls on riverbank as required
- Cleaning of slip area including clearing of vegetation along slip restoration site
- Piling works (from road and/or river) to stabilise slope area
- Repair pavement shoulder of Big River Way

Construction is expected to commence in April 2022 and be completed by June 2023.

A site compound will be established within the road reserve on the eastern side of Big River Way approximately 500m north of the proposed works.

The works, including some construction works within a waterway, may require consideration of several matters listed in the *Fisheries Management Act 1994* relating to dredging and reclamation works (restoration of the riverbank profile and piling works within South Arm of the Clarence River) and temporarily obstructing minor fish passage (potential anchoring floating barge at work zone).

I am currently preparing a Review of Environmental Factors (REF) as per the requirements under Part 5 of the *Environmental Planning and Assessment Act 1979* for this project. It would be appreciated if you could provide any comments about this proposal.

TfNSW would be pleased to provide further information if required. In this regard, Shaun Gillespie may be contacted on 0413 368 288 or by email Shaun.Gillespie@transport.nsw.gov.au. Alternatively, you may contact me on 0407 237 985 or dhavilah@geolink.net.au.

Yours faithfully

David Havilah
Senior Ecologist
GeoLINK on behalf of Transport for NSW

Edwina Flower

From: Annette Comerford <annette.comerford@dpi.nsw.gov.au>
Sent: Thursday, 9 December 2021 11:27 AM
To: David Havilah; 'Shaun.Gillespie@transport.nsw.gov.au'
Cc: Robyn Leckenby
Subject: HPE CM: RE: Consultation regarding remediation works for Byrons Lane Slip Stage V

Follow Up Flag: Follow up
Flag Status: Flagged

Hi David,

I have received the email below and I'm wanting to know whether you are requesting comments for the preparation of a REF or a s199 consultation? Usually for a s199 consultation we would require the REF and a design.

The table below outlines actions that trigger section of the *Fisheries Management Act 1994* (FM Act). As the works look to involve the placement of rocks and / or other material within key fish habitat (i.e. below highest astronomical tide), then the dredging and reclamation provision of the FM Act will be triggered. As TfNSW is considered a Public Authority (other than a local government authority), the dredging and reclamation consultation provisions of s199 of the FM Act are relevant. If the proposal will involve impacts to marine vegetation including mangroves and/or their pneumatophores, then the proponent will require a separate permit under s205 of the FM Act.

Sections	Description of action	Legislative trigger
198-202	Dredge (digging) and / or reclamation (filling) of land permanently or periodically inundated by water (including wetlands).	Digging and / or filling below the Highest Astronomical Tide (~1m AHD) in estuaries. Digging and / or filling within the high bed of 3rd order and higher watercourses (based on 1:25,000 scale maps) and/or draining water from land for its reclamation. Digging and / or filling within Coastal Wetlands. Activities described in cl 226 *Fisheries Management (General) Regulation* 2019
205	Harming marine vegetation (seagrass, mangroves, and kelp)	Gather, cut, pull up, destroy, poison, dig up, remove, injure, or otherwise harm marine vegetation or any part of it. Activities described in cls 228-229 *Fisheries Management (General) Regulation* 2019
218-220	Obstructing free passage of fish, in waterways	Construction or alteration of a dam, floodgate, causeways, or weir or otherwise creation of an obstruction

The proposal should first aim to avoid impacts to fisheries resources, particularly key fish habitats. Where impacts to key fish habitats cannot be avoided, the preference is to impact less sensitive key fish habitats over more highly sensitive key fish habitats. Mangroves and other marine vegetation, as well as riparian vegetation should be avoided where possible. This is relevant both during construction and operation of the structure.

The design should incorporate 'soft' engineering options where possible, and where harder engineering options are required, an integrated approach using planting in combination with natural materials (logs, live stakes, live brush bundles etc.) is preferred. Where possible, rock voids above the tidal limit should be planted with Lomandras, and existing riparian vegetation at the top of the bank behind the proposed revetment should be augmented with additional plantings of native grasses, shrubs and trees. Components of the wall that provide minimal fish habitat, should be minimised.

DPI Fisheries' standard minimum information requirements for environmental assessment are clearly detailed in section 3.3 of the DPI Fisheries *Policy and guidelines for fish habitat conservation and management (Update 2013)*. Please ensure that the REF addresses these requirements. This will facilitate effective assessment of the proposal and reduce delays.

Please contact me on the details below if you have any questions.

Regards,

Annette Comerford | Fisheries Manager - Coastal Systems (North Coast)
Aboriginal Fishing and Marine and Coastal Environments
NSW Department of Primary Industries | Fisheries
1243 Bruxner Hwy | Wollongbar | Bundjalung Nation | NSW 2477
T: 02 6626 1395 | M: 0418 211 843 | E: annette.comerford@dpi.nsw.gov.au

PERMIT APPLICATION FORMS & FISH HABITAT POLICIES:
www.dpi.nsw.gov.au/fishing/habitat/protecting-habitats/toolkit
Submit permit applications via email to ahp.central@dpi.nsw.gov.au
NB: From date of receipt of application, please allow:
- 21 days for s199 Consultations
- 28 days for Permits, Consultations and Land Owner's Consent responses
- 40 days for Integrated Development Applications

KNOWN & EXPECTED DISTRIBUTION OF THREATENED FISH SPECIES:
www.dpi.nsw.gov.au/fishing/threatened-species/threatened-species-distributions-in-nsw

DPI Fisheries acknowledges that it stands on Country which always was and always will be Aboriginal land. We acknowledge the Traditional Custodians of the land and waters, and we show our respect for Elders past, present and emerging. We are committed to providing places in which Aboriginal people are included socially, culturally and economically through thoughtful and collaborative approaches to our work.

From: Robyn Leckenby <RLeckenby@geolink.net.au>
Sent: Tuesday, 23 November 2021 4:47 PM
To: DPI AHP Central Mailbox <ahp.central@dpi.nsw.gov.au>
Subject: Consultation regarding remediation works for Byrons Lane Slip Stage V

Hi,

On behalf of David Havilah, please see attached letter for your review.

With reference: Remediation works for Byrons Lane slip Stage V.

Regards,

Robyn Leckenby
Office Coordinator
P 02 6651 7666
W www.geolink.net.au

Quality solutions. Sustainable future.

Samuel Smith

From: Annette Comerford <annette.comerford@dpi.nsw.gov.au>
Sent: Tuesday, 21 June 2022 12:00 PM
To: Edwina Flower
Subject: C22/364 RE: s199 referral request - Byrons Lane Slip Stage V

Hi Edwina,

DPI Fisheries is responsible for ensuring that fish stocks are conserved and that there is "no net loss" of key fish habitats upon which they depend. To achieve this, the Coastal Systems Unit assesses activities under Parts 4 and 5 of the *Environmental Planning and Assessment Act 1979* in accordance with the objectives of the *Fisheries Management Act 1994* (FM Act), the aquatic habitat protection and threatened species conservation provisions in Parts 7 and 7A of the FM Act, and the *Policy and Guidelines for Fish Habitat Conservation and Management (2013 Update)* (DPI Fisheries P&G). In addition, DPI Fisheries is responsible for ensuring the sustainable management of commercial fishing and aquaculture, quality recreational fishing and the continuation of Aboriginal cultural fishing within NSW.

Key fish habitats are defined within the DPI Fisheries P&G and are graded by 'type' on the basis of their sensitivity, or their importance to the survival of fish (refer to section 3.2 of the DPI Fisheries P&G for further information). The DPI Fisheries impact mitigation hierarchy is to first avoid impacts to key fish habitats. Where avoidance is impossible or impractical, then proposals should minimise impacts to key fish habitats. All unavoidable impacts should be appropriately mitigated and offset. Where impacts cannot be avoided, justification is required to account for why options of lesser impact are not available or have been discounted.

As discussed now, DPI Fisheries is primarily interested in the works within Key Fish Habitat. Of course, we always encourage best practice erosion and sediment controls for the whole works, but in order to assess the potential impacts to key fish habitat within the section that takes place within key fish habitat, are you able to provide a sketch / plan for these works and provide the scope of works, dimensions, materials and methodology at this site.

Please call me if you have any questions.

Regards,

Annette Comerford | Fisheries Manager - Coastal Systems (North Coast)
Aboriginal Fishing and Marine and Coastal Environments
NSW Department of Primary Industries | Fisheries
1243 Bruxner Hwy | Wollongbar | Widjabal Wiabal Country (Bundjalung Nation) | NSW 2477
T: 02 6626 1395 | M: 0418 211 843 | E: annette.comerford@dpi.nsw.gov.au

PERMIT APPLICATION FORMS & FISH HABITAT POLICIES:
www.dpi.nsw.gov.au/fishing/habitat/protecting-habitats/toolkit
Submit permit applications via email to ahp.central@dpi.nsw.gov.au
NB: From date of receipt of application, please allow:
- 21 days for s199 Consultations
- 28 days for Permits, Consultations and Land Owner's Consent responses
- 40 days for Integrated Development Applications

KNOWN & EXPECTED DISTRIBUTION OF THREATENED FISH SPECIES:
www.dpi.nsw.gov.au/fishing/threatened-species/threatened-species-distributions-in-nsw

DPI Fisheries acknowledges that it stands on Country which always was and always will be Aboriginal land. We acknowledge the Traditional Custodians of the land and waters, and we show our respect for Elders past, present and emerging. We are committed to providing places in which Aboriginal people are included socially, culturally and economically through thoughtful and collaborative approaches to our work.

From: Annette Comerford
Sent: Friday, 17 June 2022 5:02 PM

To: Edwina Flower <EFlower@geolink.net.au>
Subject: RE: s199 referral request - Byrons Lane Slip Stage V

Hello Edwina,

I'll give you a call on Monday.

I just wanted to check that you hadn't forgotten to send the plans for these works?

Regards,

Annette Comerford | Fisheries Manager - Coastal Systems (North Coast)
Aboriginal Fishing and Marine and Coastal Environments
NSW Department of Primary Industries | Fisheries
1243 Bruxner Hwy | Wollongbar | Widjabal Wiabal Country (Bundjalung Nation) | NSW 2477
T: 02 6626 1395 | M: 0418 211 843 | E: annette.comerford@dpi.nsw.gov.au

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From: Edwina Flower <EFlower@geolink.net.au>
Sent: Thursday, 9 June 2022 12:35 PM
To: DPI AHP Central Mailbox <ahp.central@dpi.nsw.gov.au>
Cc: David Havilah <DHavilah@geolink.net.au>
Subject: s199 referral request - Byrons Lane Slip Stage V

To Whom It May Concern

On behalf of Transport for NSW please see attached documentation (letter and Review of Environmental Factors) in relation to the section 199 referral request for the Byrons Lane Slip Stage V project.

Please contact me if you require any further information.

Kind regards,

Edwina Flower
Environmental Planner

GeoLINK
Quality solutions. Sustainable future.
P 02 6687 7666
W www.geolink.net.au

Please note my standard workdays are Tuesday, Wednesday & Thursday

OUR REF: C22/364

20 July 2022

Ian Drinkwater
Transport for NSW
Level 3, 76 Victoria Street
GRAFTON NSW 2460
Via email: ian.drinkwater@transport.nsw.gov.au, eflower@geolink.net.au

Dear Mr Drinkwater

Re: s199 Referral # C22/364 for dredging and reclamation work associated with bank stabilisation works within the South Arm of the Clarence River, adjacent to Lot 16 DP 877827, Big River Way, Tyndale, Clarence Valley LGA

Reference is made to Transport for NSW's proposal to undertake dredging and reclamation works associated with the above-mentioned project forwarded to DPI Fisheries on 9 June 2022 and additional information provided 23 June 2022.

DPI Fisheries, a division within the Department of Primary Industries, assesses applications for dredging and reclamation works, harm marine vegetation, and obstruction of fish passage in accordance with Part 7 of the *Fisheries Management Act 1994* (FM Act) and the *Policy and Guidelines for Fish Habitat Conservation and Management (2013 Update)* (DPI Fisheries P&G).

Section 199 of the FM Act (refer to Attachment 1) is applicable to this proposal because it pertains to dredging and reclamation works to be undertaken by a public authority. Section 199 requires the proposal to be referred to the Minister for Primary Industries and that the public authority considers any matters concerning the proposed works raised by the Minister.

DPI Fisheries has reviewed the subject project outlined in the application, in particular, the Transport for NSW document titled *Byrons Lane Slip Stage V, Review of Environmental Factors* dated June 2022, the Transport for NSW document titled *100% Geotechnical Detailed Design Report: Byrons Lane Slip, Big River Way, Tyndale Geotechnical Design* dated 6 June 2022, and the Transport for NSW working drawings titled *Byrons Lane Slip Remediation – General Arrangement Plan* dated 10 June 2022.

It is understood that the proposal will include remediation of a 40m long riverbank slip by installing a row of sheet piles at the toe of a new rock revetment wall to reinstate the slumped riverbank profile at this location within the South Arm of the Clarence River (refer to Attachment 3).

DPI Fisheries has no objection to the proposed works. In accordance with Section 199 (1)(b) of the FM Act, the matters raised within Attachment 2 of this notice must be considered. These matters are to ensure that impacts to key fish habitats will be avoided or minimised to a level consistent with the requirements of DPI Fisheries P&G and relate to the Department's responsibilities for ensuring fish stocks are conserved and that there is "no net loss" of key fish habitats upon which they depend. The protection of key fish habitats provides for viable commercial fishing and aquaculture, quality recreational fishing and the continuation of Aboriginal cultural fishing. Should Transport for NSW choose not to consider these matters, Transport for NSW should contact DPI Fisheries prior to undertaking the works.

If you have any queries, please contact Annette Comerford, Fisheries Manager, Coastal Systems (North Coast) on 02 6626 1395 or annette.comerford@dpi.nsw.gov.au.

Yours sincerely

Annette Comerford
Fisheries Manager - Coastal Systems (North Coast)
Aboriginal Fishing and Marine and Coastal Environments, Primary Industries NSW

Cc: **Peter Henwood,** A/Clarence District Fisheries Officer
Brad Harrison, Fisheries Conservation Compliance Officer

Attachment 1

***Fisheries Management Act 1994* No 38**

Part 7 Division 3 Section 199

199 Circumstances in which a public authority (other than local authority) may carry out dredging or reclamation

(1) A public authority (other than a local government authority) must, before it carries out or authorises the carrying out of dredging or reclamation work:

(a) give the Minister written notice of the proposed work, and

(b) consider any matters concerning the proposed work that are raised by the Minister within 21 days after the giving of the notice (or such other period as is agreed between the Minister and the public authority).

(2) Any such public authority is to notify the Minister of any dredging or reclamation work that it proposes to carry out or authorise despite any matter raised by the Minister. The Minister may, within 14 days after being so notified, refer any dispute to the Minister responsible for the public authority. If the dispute cannot be resolved by those Ministers, it is to be referred to the Premier for resolution.

(3) In this section, public authority includes the Minister administering the *Crown Land Management Act 2016*.

Division of Primary Industries, DPI Fisheries
1243 Bruxner Hwy, WOLLONGBAR NSW 2477
Tel: 02 6626 1395 ABN 19 948 325 463 www.dpi.nsw.gov.au

Attachment 2

MATTERS FOR CONSIDERATION UNDER s199 of the *Fisheries Management Act 1994*

Administration

1. DPI Fisheries recommend that a copy of relevant approval documentation be carried by the proponent or their contractor operating on-site.
Reason – A DPI Fisheries Compliance Officer may wish to check that the works are being undertaken in accordance with relevant approvals.

2. The subject works, including the final built design, should be consistent with the proposal outlined in the s199 referral to DPI Fisheries by Transport for NSW on 9 June 2022 and additional information provided 23 June 2022. Any proposed changes to the final design should be discussed with DPI Fisheries prior to implementation.
Reason – This s199 consultation has been prepared following an assessment of the potential impacts of the described works upon the aquatic and neighbouring environments. Other works, which were not described in the referral have not been assessed and may have significant adverse impacts.

Erosion and sediment control

3. Sediment entering into waterways can directly impact on key fish habitats. DPI Fisheries recommend that Transport for NSW ensures that:
- Erosion and sediment mitigation devices are erected and managed in accordance with all applicable requirements of the Blue Book (i.e. Landcom [2004], *Managing Urban Stormwater: Soils and Construction* [4th Edition]) (www.landcom.nsw.gov.au/news/publications-and-programs/the-blue-book.aspx);
- A floating boom and attached silt curtain are used and maintained to isolate the work site and minimise the impacts of turbidity and mobilised sediment during the construction; and
- Stockpiles are located away from adjacent on water land[1], and riparian and aquatic vegetation[2].
Reason – To ensure that sediment generated by the exposure of soil is not transported into the aquatic environment.

---

[1] "Water land" means land submerged by water:
a) whether permanently or intermittently, or
b) whether forming an artificial or natural body of water,
and includes *wetlands* and any other land prescribed by the regulations.

Wetlands include marshes, mangroves, swamps, or other areas that form a shallow body of water when inundated intermittently or permanently with fresh, brackish or salt water, and where the inundation determines the type and productivity of the soils and the plant and animal communities.

[2] "Aquatic vegetation" is a term used to describe native vegetation that inhabits freshwater but does not include noxious weeds within the meaning of the *Noxious Weeds Act* 1993.

Timing of works for low flows and low tides

4. Appropriately timing the works for periods of low flow can assist erosion and sediment control at the site. DPI Fisheries recommend that Transport for NSW ensures that works are undertaken during periods of low flows in the waterway and when Bureau of Metrological forecast for the Northern Rivers district forecast region (available at: www.bom.gov.au/nsw/forecasts/map.shtml) indicates several days of clear, dry weather.
Reason – Timing the works for appropriate conditions can reduce delays and minimise impacts on the aquatic environments.

Instream works

5. Instream works can impact on key fish habitats. DPI Fisheries recommend that Transport for NSW ensures:
- The avoidance of machinery entering or working from the waterway unless in accordance best management practice;
- That machinery is appropriately cleaned, degreased and serviced prior to use at the site and entry into the waterway; and
- That Emergency Spill Kits appropriate for containing and cleaning up petroleum and solvent product spills within waterways be available on site at all times during works.
Reason – To reduce the threat of an unintended pollution incident impacting upon the aquatic environment.

Armouring works

6. Poorly designed or constructed bank protection works can have an immediate and lasting impact on key fish habitats. DPI Fisheries recommend that Transport for NSW ensures that:
- Only clean rock is used at the site;
- Rock forming bank armouring is placed into position using a rock grab or excavator; and
- The rock used for bank armouring be underlaid by geotextile fabric.
Reason – To avoid fines, clay and other sediment un-necessarily entering the waterway and ensure rock armouring is constructed using Best Management Practice techniques.

Post works rehabilitation of site

7. DPI Fisheries recommend that Transport for NSW ensures that the site is rehabilitated and stabilised at the completion of the works including:
- Removal of surplus construction materials and temporary structures from the site (other than silt fences and other erosion and sediment control devices);
- Undertaking plantings of *Lomandra hystrix* along the toe and top of the banks of the waterway for 5 metres upstream and downstream of the work footprint; and
- Appropriate maintenance of erosion and sediment control devices until the vegetation has successfully established and the site has stabilised.
Reason – To ensure that habitats are restored as quickly as possible, public safety is not compromised, aesthetic values are not degraded and sediment inputs into the waterway are reduced.

Fish kill contingency

8. DPI Fisheries maintains a fish kill database. To limit the potential of a fish kill incident, DPI Fisheries recommends that the proponent be advised to undertake a visual inspection of the waterway for dead or distressed fish (indicated by fish gasping at the water surface, fish crowding in pools or at the creek's banks) twice daily during the works. Observations of dead or distressed fish should be immediately reported to the Contact Officer by Transport for NSW. If a fish kill occurs, DPI Fisheries recommend works cease until the issue causing the kill is rectified.
Reason – Fish kills are also potentially contentious incidents from the public perspective. DPI Fisheries needs to be aware of fish kills so that it can assess the cause and recommend ways to mitigate further incidents in consultation with relevant authorities. Work practices may need to be modified to reduce the impacts upon the aquatic environment.

Attachment 3

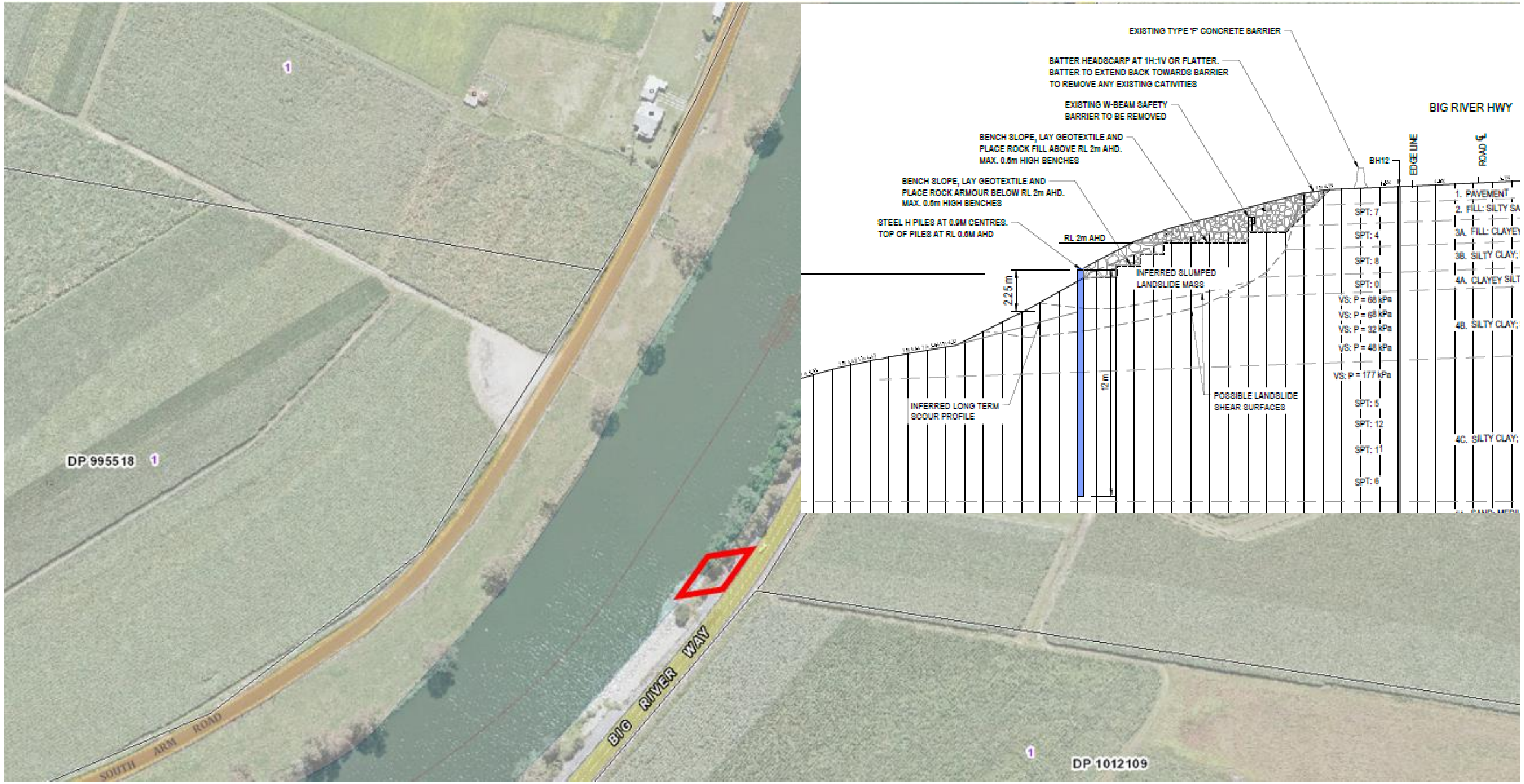

Figure 1: Plan showing location of works and typical section of works.

Appendix D

Consideration of section 171 factors and matters of national environmental significance and Commonwealth land

Section 171 Checklist

In addition to the requirements of the Is an EIS required? guideline (DUAP 1995/1996) and the Roads and Related Facilities EIS Guideline (DUAP 1996) as detailed in the REF, the following factors, listed in section 171 of the Environmental Planning and Assessment Regulation 2021, have also been considered to assess the likely impacts of the proposal on the natural and built environment.

Factor		Impact
a	Any environmental impact on a community? The community would not be affected through declines in the local environment as a result of the proposal. Extensive mitigation measures have been designed to reduce environmental impacts on the community to negligible levels (refer to **Section 6**).	Negligible
b	Any transformation of a locality? Temporary transformations of the locality will occur but are restricted to the site and comprise of: • Construction and operation of site compound/stockpile. • Aspects of the proposal including temporary road diversion and piling works. • Presence and operation of heavy machinery. After completion of the work, permanent transformation would be associated with the new piling associated with restoration of the riverbank profile and restoration of Big River Way pavement shoulder. No significant transformation of the locality would occur as a result of the proposal.	Negligible
c	Any environmental impact on the ecosystems of the locality? The ecosystems of the locality would not be affected through declines in local environmental values (e.g. Biodiversity, physical environment) as a result of the proposal. Extensive mitigation measures have been designed to reduce environmental impacts (refer to **Section 6**).	Negligible
d	Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality? The aesthetic, recreational, scientific or other environmental qualities or value of the locality are not expected to be impacted by the proposal. The character of the general area would largely remain the same post-construction and no significant visual impact or recreational impediment is expected. No reduction in the quality of environmental values associated with noise, water, soil and air quality or significant decreases in biodiversity are likely to occur due to the mitigation measures provided in **Section 6** of this REF. No significant changes to the locality are expected to occur.	Negligible
e	Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations? The proposal would not have any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations.	Negligible
f	Any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)? With effective implementation of the safeguards provided in **Section 6** of this REF, the proposal is not considered likely to significantly endanger any habitat of protected fauna.	Negligible
g	Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air? With effective implementation of the safeguards provided in **Section 6** of this REF, the proposal is not considered likely to significantly endanger any species of animal, plant, or other form of life.	Negligible
h	Any long-term effects on the environment?	Negligible

	Factor	Impact
	No significant negative long-term impacts are considered likely with effective implementation of the proposed mitigation measures in **Section 6** of this REF.	
i	Any degradation of the quality of the environment? No significant degradation of the quality of the environment is expected with effective implementation of the safeguards in **Section 6** of this REF.	Negligible
j	Any risk to the safety of the environment? The proposal is unlikely to pose any significant risk to the safety of the environmental attributes outlined in **Section 6**. Any possible impacts would be minimised with the implementation of the safeguards in **Section 6** of this REF.	Negligible
k	Any reduction in the range of beneficial uses of the environment? The proposal is not likely to result in any reduction in the range of beneficial uses of the environment.	Negligible
l	Any pollution of the environment? Waste materials, fuel spills and sediment have the potential to cause pollution to the environment. However, given the proposed safeguards detailed in **Section 6** of this REF, pollution to the environment is unlikely to occur.	Negligible
m	Any environmental problems associated with the disposal of waste? All waste generated by the proposal would be disposed of in a manner which would not damage or disturb any native flora or fauna or the physical environment. The disposal of waste would be in accordance with Transport and EPA approved methods of waste disposal. Safeguards detailed in **Section 6** of this REF would protect the environment from problems associated with all waste disposal.	Negligible
n	Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply? The proposal does not create any demand for resources that are in short supply nor is it likely to result in an increased demand on any natural resources that are likely to become in short supply. Transport would attempt to draw supplies and resources from established suppliers having appropriate environmental approvals and standards.	Negligible
o	Any cumulative environmental effect with other existing or likely future activities? The proposal would have minor cumulative impacts (e.g., resource consumption) but is unlikely to significantly contribute to any cumulative impacts.	Negligible
p	Any impact on coastal processes and coastal hazards, including those under projected climate change conditions? The proposal is not expected to have any impacts to coastal processes and coastal hazards, including those under projected climate change conditions.	Negligible
q	Applicable local strategic planning statements, regional strategic plans or district strategic plans made under the Act, Division 3.1, The overarching strategic plan for this region is the North Coast Region Plan (NCRP) 2036. The project aligns with goals and directions outlined in the plan which relate to; management of natural hazards and climate change, as well as providing a thriving, interconnected economy that is achieved through strengthened regionally significant rail corridors.	North Coast Region Plan (NCRP) 2036
r	Other relevant environmental factors. This REF has examined and taken into account to the fullest extent possible all matters affecting or likely to affect the environmental by reason of the proposed activity.	In considering the potential impacts of this proposal all relevant environmental factors have been considered, refer to Chapter 6 of this assessment.

Matters of National Environmental Significance and Commonwealth land

Under the environmental assessment provisions of the *EPBC Act*, the following matters of national environmental significance and impacts on Commonwealth land are required to be considered to assist in determining whether the proposal should be referred to the Australian Government Department of Agriculture, Water and the Environment.

A referral is not required for proposed actions that may affect nationally-listed threatened species, endangered ecological communities and migratory species. Impacts on these matters are still assessed as part of the REF in accordance with Australian Government significant impact criteria and taking into account relevant guidelines and policies.

Factor		Impact
a	Any impact on a World Heritage property? The proposal is not in proximity (10 km search radius) to any World Heritage Properties and as such the proposal is not expected to impact on any World Heritage Properties.	Nil
b	Any impact on a National Heritage place? The proposal is not in proximity (10 km search radius) to any National Heritage places and as such the proposal is not expected to impact on any National Heritage places.	Nil
c	Any impact on a wetland of international importance? The proposal is not in proximity (10 km search radius) to any Wetlands of International Importance, and as such the proposal is not expected to impact on any Wetlands of International Importance.	Nil
d	Any impact on a listed threatened species or communities? Habitat for two threatened ecological communities (TECs), 72 threatened species, and 40 migratory species is identified within 10 km of the site. No nationally listed threatened flora species or TECs were recorded in the site survey. No nationally listed threatened fauna species were recorded in the site survey. Several nationally listed threatened fauna species are considered to have a moderate likelihood of occurrence at the site. With consideration of the above information, no nationally listed threatened biodiversity matters are likely to be significantly affected by the proposal.	Negligible
e	Any impacts on listed migratory species? No nationally listed migratory species were recorded in the site survey. It is likely that several listed species (e.g. Satin Flycatcher, Lathams Snipe) may utilise the site on an opportunistic or seasonal basis. However, the site does not provide any important foraging or breeding habitat for any migratory species. With consideration of the above information, no nationally listed migratory species are likely to be significantly affected by the proposal.	Nil
f	Any impact on a Commonwealth marine area? The proposal is not in proximity (10 km search radius) to any Commonwealth marine areas and as such the proposal is not expected to impact upon any Commonwealth marine areas.	Nil
g	Does the proposal involve a nuclear action (including uranium mining)? The proposal does not involve a nuclear action.	Nil
h	Additionally, any impact (direct or indirect) on the environment of Commonwealth land? Three Commonwealth lands being Australian Telecommunications Commission, Australian Telecommunications Corporation and Commonwealth Trading Bank are listed as occurring within 10 km of the subject site. The proposal however is not expected to impact upon these lands.	Nil

Appendix E

Transport Procedure for Aboriginal cultural heritage consultation and investigation (PACHCI) and Native Title consultation

abn: 71 098 971 209
w: www.ntscorp.com.au

15 June 2022

Our ref: NTS164

Ian Drinkwater
Project/Contract Manager
Transport for NSW
Level 3, 76 Victoria Street
Grafton NSW 2460

By email only: ian.drinkwater@transport.nsw.gov.au

Dear Mr Drinkwater,

Re: Big River Way, Tyndale – Remediation of Slip Site

1 I refer to your notification of 16 May 2022, issued under section 24KA of the *Native Title Act 1993* (Cth) (**NTA**) regarding the proposed remediation of a landslip site on the western side of the Big River Way at Tyndale, NSW.

2 NTSCORP Limited (**NTSCORP**) acted for the Yaegl People in their successful Native Title Determination Applications (Federal Court Proceedings NSD6052/1998 and NSD168/2011) which were determined by the Federal Court on 25 June 2015 and 31 August 2017. NTSCORP continues to act for the Yaegl Traditional Owners Aboriginal Corporation RNTBC (**YTOAC**) (the registered native title body corporate) that holds native title on trust for the Yaegl People.

3 The proposed works described above form part of Transport for New South Wales' (**Transport**) 'Byrons Lane Stage V – Slip Remediation Project'.

4 It is expected that the proposed works will take approximately five months to complete.

5 We understand that the proposed works will involve:

(a) the establishment of erosion and sediment control measures within the Clarence River for the duration of the works;

(b) the anchoring of a 5-10 metre barge on the bed and banks of the Clarence River;

(c) the anchoring of a 10-15 metre ferry on the bed or banks of the Clarence River;

(d) the installation of piles into the riverbed of a height equal to or less than the mean high tide water level; and

(e) the removal of scour protection rock placed from a previous slip remediation project to allow the driving of piles.

6 Once the proposed works are completed, the erosion and sediment control measures will be removed from the Clarence River.

Comments on the proposed works

7 Yaegl People's native title rights have been recognised over the waters, bed and banks of the Clarence River where the works are proposed to occur, pursuant to *Yaegl People #2* (NSD168/2011).

8 The proposed works are also in close proximity to lands and waterways over which Yaegl People's native title rights and interests have been recognised.

Cultural Heritage

9 The lands and waterways within the Yaegl Native Title Determination Area are of immense cultural significance to Yaegl People.

10 The directors of YTOAC hold significant concerns about the location of the proposed works. In particular, the proposed works are within extremely close proximity to known cultural and spiritual sites.

11 For these reasons, we are instructed that a further site visit is required between YTOAC and Transport discuss the location and nature of the proposed works, before they occur.

12 In accordance with YTOAC's Schedule of Fees for services, and section 60AB of the NTA, it is appropriate for a fee for service to be paid for this site visit.

13 YTOAC reserves the right to make further comments in relation to the proposed act following this site visit.

Cultural Heritage Assessment and Monitoring

14 Should the proposed works proceed, it is essential for Transport to regularly consult with YTOAC to ensure the project does not interfere with culturally significant areas and Yaegl People's native title rights are taken into consideration.

15 Further, given the high cultural significance of the location of the proposed works, YTOAC requests that cultural heritage officers be engaged for the duration of the works.

16 Contact for the purpose of arranging cultural heritage officers can be made through YTOAC CEO, William Walker, at ceo@yaegltoacrntbc.org.au.

17 Should the proposed works uncover any Aboriginal objects, Transport and any contractors should cease all work at the site until YTOAC has been consulted and assessed the objects, in compliance with the State of New South Wales' cultural heritage requirements.

Non-extinguishment of native title

18 Pursuant to s 24KA(4) of the NTA, the non-extinguishment principles applies to the proposed works.

Compensation

19 Compensation for works conducted under Subdivision K of the NTA may be payable. Yaegl People reserve the right to bring future claims for compensation in respect of the proposed works. In this respect, we request documentation outlining the precise nature and location of the works following their completion for YTOAC's records.

20 We look forward to hearing from you in relation to these comments.

21 If you have any questions regarding the above, please do not hesitate to contact the undersigned.

Yours sincerely,

Helen Orr
Solicitor
NTSCORP Limited

18 August 2022

Shaun Gillespie
Project Manager
Transport for NSW

Dear Shaun,

Preliminary assessment results for the Byron's Lane Slip Stage V based on Stage 1 of the *Procedure for Aboriginal cultural heritage consultation and investigation* (the procedure).

The project, as described in the Stage 1 assessment checklist, was assessed as being unlikely to have an impact on Aboriginal cultural heritage.

The assessment is based on the following due diligence considerations:

- The project works are within the existing road corridor and disturbed areas (disturbed zones).
- The project is unlikely to harm known Aboriginal objects or places (AHIMS sites).
- The AHIMS search indicated that there are no recorded Aboriginal sites within the study area.
- The study area does contain landscape features that indicate the presence of Aboriginal objects, based on the Office of Environment and Heritage's *Due diligence Code of Practice for the Protection of Aboriginal objects in NSW* and the Roads and Maritime Services' procedure, however, the cultural heritage potential of the study area appears to be reduced due to past disturbances in the form of the construction of the current road corridor and seasonal flood events.
- There is an absence of sandstone rock outcrops likely to contain Aboriginal art.
- No artefacts or other items of cultural significance were identified during the physical site inspection.

Your project may proceed in accordance with the environmental impact assessment process, as relevant, and all other relevant approvals.

If the scope of your project changes you must contact me and your regional environmental staff Kate Dallimore to reassess any potential impacts on Aboriginal cultural heritage.

If any potential Aboriginal objects (including skeletal remains) are discovered during the course of the project, all works in the vicinity of the find must cease. Follow the steps outlined in the Transport for NSW *Unexpected Heritage Items Procedure*.

For further assistance in this matter do not hesitate to contact me.

Yours sincerely

Lee Davison

Lee Davison
Aboriginal Community and Heritage Partner

Project area location

Ms. Orr
NTSCORP Limited
Level 1, 44–70 Rosehill Street
Redfern NSW 2016

29 July 2022

Dear Ms. Orr,

Re: Big River Way, Tyndale – Remediation of Slip Site

We refer to your letter dated 15 June 2022 in response to the notification issued under section 24KA of the *Native Title Act 1993* (Cth) (**NTA**) by Transport for NSW (**TfNSW**) on 16 May 2022.

Thank you for identifying that the proposed works are in close proximity to known cultural and spiritual sites of the Yaegl People and for confirming that the members of the Yaegl Traditional Owners Aboriginal Corporation RNTBC (**YTOAC**) are willing to meet with TfNSW to further discuss the location and nature of the works before they occur.

TfNSW is agreeable to meeting further with representatives from the YTOAC including an onsite visit. TfNSW's Garry Ferguson, Manager, Aboriginal Engagement and Ian Drinkwater, Project Manager, will be in contact with YTOAC CEO, William Walker, to arrange for this to occur.

Thank you for bringing to our attention that a fee for service is payable in respect of a further site visit. TfNSW generally applies the "*Roads and Maritime Services Procedure for Aboriginal Cultural Heritage Consultation and Investigation*", otherwise known as the PACHCI, to ensure compliance with the State of New South Wales' cultural heritage requirements and promote state-wide consistency. The PACHCI specifies the fees payable for engagement of Aboriginal knowledge holders and site officers in archaeological and cultural values assessments particularly where an Aboriginal Heritage Impact Permit is required.

TfNSW believes that there is benefit in state-wide consistency in the payment of fees when engaging Aboriginal people in the PACHCI process.

TfNSW recognises that native title rights and interests are often broader than the matters within the scope of the PACHCI on many projects. We also recognise there is benefit in taking the opportunity to keep Native Title Holders informed and inviting input to ensure that the effect of projects on the full range of native title rights and interests are understood and discussed.

It will be beneficial for our project team to connect with YTOAC on Country to gain an appreciation of their native title rights and interests relating to the project location and how they might be best considered during project development and delivery.

Transport is prepared to pay a fee for service to two representatives of the YTOAC in the amount of $165 per hour per representative, for a minimum of four hours, to participate in the meeting and proposes that work methods including requirements for further consultation and site inspections are addressed during the meeting.

Should the State of New South Wales' cultural heritage requirements be triggered and engagement of Aboriginal knowledge holders and site officers in archaeological and cultural values assessments is required, TfNSW is prepared to pay the fees specified in the PACHCI.

TfNSW also notes that under the Schedule of Fees, an amount of $450 is payable with respect to activities concerning the exercise of certain procedural rights pursuant of 24KA(7) of the NTA. Upon the YTOAC completing the enclosed tax invoice in the amount of $450 and forwarding a copy via email to ian.drinkwater@transport.nsw.gov.au, TfNSW will effect payment within 28 days of receipt.

Yours sincerely,

Ian Drinkwater

Ian Drinkwater
Project Manager
Project Services, Northern
0418 207 457

TRANSPORT FOR NSW
ABN : 18804239602
12/231 Elizabeth Street Sydney NSW 2000

Recipient Created Tax Invoice & Adjustment Note

Invoice No.
Invoice Date:
Address:

Supplier ABN :
Recipient
Contact #

If you have any queries, please phone 133 877 or email to tss.procurement@transport.nsw.gov.au

As agreed, we have settled the following goods and services as detailed below:

Invoice Date	Invoice No.	Order No./ Description	Amount

Total Net Value
GST
Total

The GST is payable by the supplier.
This is not a remittance advice and payment will be made in accordance to the payment terms.

Account Name:

BSB:

Account Number:

Appendix F

Statutory consultation checklists

Transport and Infrastructure SEPP 2021

Certain development types

Development type	Description	Yes / No	If 'yes' consult with	TISEPP clause
Car Park	Does the project include a car park intended for the use by commuters using regular bus services?	No	-	Section 2.110 (former ISEPP cl. 95A)
Bus Depots	Does the project propose a bus depot?	No	-	Section 2.110 (former ISEPP cl. 95A)
Permanent road maintenance depot and associated infrastructure	Does the project propose a permanent road maintenance depot or associated infrastructure such as garages, sheds, tool houses, storage yards, training facilities and workers' amenities?	No	-	Section 2.110 (former ISEPP cl. 95A)

Development within the Coastal Zone

Development type	Description	Yes / No	If 'yes' consult with	TISEPP clause
Development with impacts on certain land within the coastal zone	Is the proposal within a coastal vulnerability area and is inconsistent with a certified coastal management program applying to that land?	No	-	Section 2.14 (former ISEPP cl. 15A)

Council related infrastructure or services

Development type	Potential impact	Yes / No	If 'yes' consult with	TISEPP clause
Stormwater	Are the works likely to have a *substantial* impact on the stormwater management services which are provided by council?	No	-	Section 2.10(1)(a) (former ISEPP cl.13(1)(a))
Traffic	Are the works likely to generate traffic to an extent that will *strain* the capacity of the existing road system in a local government area?	No	-	Section 2.10(1)(b) (former ISEPP cl.13(1)(b))
Sewerage system	Will the works involve connection to a council owned sewerage system? If so, will this connection have a *substantial* impact on the capacity of any part of the system?	No	-	Section 2.10(1)(c) (former ISEPP cl.13(1)(c))
Water usage	Will the works involve connection to a council owned water supply system? If so, will this require the use of a *substantial* volume of water?	No	-	Section 2.10(1)(d) (former ISEPP cl.13(1)(d))
Temporary structures	Will the works involve the installation of a temporary structure on, or the enclosing of, a public place which is under local	Yes. Construction of a temporary road diversion.	Clarence Valley Council has been consulted.	Section 2.10(1)(e) (former ISEPP cl.13(1)(e))

Development type	Potential impact	Yes / No	If 'yes' consult with	TISEPP clause
	council management or control? If so, will this cause more than a *minor* or *inconsequential* disruption to pedestrian or vehicular flow?			
Road & footpath excavation	Will the works involve more than *minor* or inconsequential excavation of a road or adjacent footpath for which council is the roads authority and responsible for maintenance?	Yes. A section of Big River Way requires repair works to damaged areas of the pavement shoulder as a result of the slip.	Clarence Valley Council has been consulted.	Section 2.10(1)(f) (former ISEPP cl.13(1)(f))

Local heritage items

Development type	Potential impact	Yes / No	If 'yes' consult with	TISEPP clause
Local heritage	Is there is a local heritage item (that is not also a State heritage item) or a heritage conservation area in the study area for the works? If yes, does a heritage assessment indicate that the potential impacts to the heritage significance of the item/area are more than minor or inconsequential?	No	-	Section 2.11 (former ISEPP cl.14)

Flood liable land

Development type	Potential impact	Yes / No	If 'yes' consult with	TISEPP clause
Flood liable land	Are the works located on flood liable land? If so, will the works change flood patterns to more than a *minor* extent?	No	-	Section 2.12 (former ISEPP cl.15)
Flood liable land	Are the works located on flood liable land? (to any extent). If so, do the works comprise more than minor alterations or additions to, or the demolition of, a building, emergency works or routine maintenance?	Yes	State Emergency Services has been consulted.	Section 2.13 (former ISEPP cl.15AA)

Public authorities other than councils

Development type	Potential impact	Yes / No	If 'yes' consult with	TISEPP clause
National parks and reserves	Are the works adjacent to a national park or nature reserve, or other area reserved under the *National Parks and Wildlife Act 1974*, or on land acquired under that Act?	No	-	Section 2.15(2)(a) (former ISEPP cl.16(2)(a))
National parks and reserves	Are the works on land in Zone E1 National Parks and Nature Reserves or in a land use zone equivalent to that zone?	No	-	Section 2.15(2)(b) (former ISEPP cl. 16(2)(b))

Development type	Potential impact	Yes / No	If 'yes' consult with	TISEPP clause
Aquatic reserves	Are the works adjacent to an aquatic reserve or a marine park declared under the *Marine Estate Management Act 2014*?	No	-	Former ISEPP cl.16(2)(c)
Sydney Harbour foreshore	Are the works in the Sydney Harbour Foreshore Area as defined by the *Sydney Harbour Foreshore Authority Act 1998*?	No	-	Former ISEPP cl.16(2)(d))
Bush fire prone land	Are the works for the purpose of residential development, an educational establishment, a health services facility, a correctional centre or group home in bush fire prone land?	No	-	Former ISEPP cl.16(2)(f))
Artificial light	Would the works increase the amount of artificial light in the night sky and that is on land within the dark sky region as identified on the dark sky region map? (Note: the dark sky region is within 200 kilometres of the Siding Spring Observatory)	No	-	Section 2.15(2)(d) (former ISEPP cl.16(2)(g))
Defence communications buffer land	Are the works on buffer land around the defence communications facility near Morundah? (Note: refer to Defence Communications Facility Buffer Map referred to in clause 5.15 of Lockhardt LEP 2012, Narrandera LEP 2013 and Urana LEP 2011.	No	-	Section 2.15(2)(e) (former ISEPP cl. 16(2)(h))
Mine subsidence land	Are the works on land in a mine subsidence district within the meaning of the *Mine Subsidence Compensation Act 1961*?	No	-	Section 2.15(2)(f) (former ISEPP cl. 16(2)(i))

Appendix G

TISEPP 2021 (previously ISEPP 2007) Notification

23 November 2021

Ref: 4099-1011

The General Manager
Clarence Valley Council
Locked Bag 23
GRAFTON NSW 2460

To whom it may concern

Consultation regarding remediation works for Byrons Lane Slip Stage V

Transport for NSW (TfNSW) proposes to carry out remediation works on the Clarence River embankment, adjacent to a section of Big River Way (Old Pacific Highway) in response to a significant rainfall event (declared natural disaster) in March 2021. The works are required to ensure that Big River Way remains a safe and trafficable transport route by remediation of the slope and riverbank profile to prevent further degradation of the road surface. The location of the works are shown in **Illustration 1.1** with key aspects of the proposal shown in **Illustration 1.2**.

The objectives of the proposed works are to:

- stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way;
- restore the riverbank profile;
- restore the pavement to the shoulder of Big River Way;
- undertake works to minimise traffic, environmental, social impacts; and
- ensure Big River Way remains a safe and trafficable transport route.

Under the State Environmental Planning Policy (Infrastructure) 2007, Transport for NSW is required to consult with Clarence Valley Council under clause 13 and 15 due to the potential impacts to 'Council related infrastructure or services' and 'development with impacts on flood liable land'.

Key features of the proposal include:

- Project set up including establishment of a site compound and stockpile locations within close proximity to the site
- Establish traffic controls in vicinity of the site (to accommodate temporary restricted/closed lanes of Big River Way)
- Establish sedimentation and erosion controls on riverbank as required
- Cleaning of slip area including clearing of vegetation along slip restoration site
- Piling works (from road and/or river) to stabilise slope area
- Repair and restoration of pavement shoulder of Big River Way

Construction is expected to commence in April 2022 and be completed by June 2023.

I am currently preparing a Review of Environmental Factors (REF) as per the requirements under Part 5 of the *Environmental Planning and Assessment Act 1979* for this project. It would be appreciated if you could provide any comments about this proposal.

TfNSW would be pleased to provide further information if required. In this regard, Shaun Gillespie may be contacted on 0413 368 288 or by email Shaun.Gillespie@transport.nsw.gov.au. Alternatively, you may contact me on 0407 237 985 or dhavilah@geolink.net.au.

Yours faithfully

David Havilah
Senior Ecologist
GeoLINK on behalf of Transport for NSW

23 November 2021

Ref: 4099-1013

NSW State Emergency Services

Via email: erm@ses.nsw.gov.au; mcl.ops@ses.nsw.gov.au; ulm.ops@ses.nsw.gov.au

To whom it may concern

Consultation regarding remediation works for Byrons Lane Slip Stage V

Transport for NSW (TfNSW) proposes to carry out remediation works on the Clarence River embankment, adjacent to a section of Big River Way (Old Pacific Highway) in response to a significant rainfall event (declared natural disaster) in March 2021. The works are required to ensure that Big River Way remains a safe and trafficable transport route by remediation of the slope and riverbank profile to prevent further degradation of the road surface. The location of the works are shown in **Illustration 1.1** with works area for the proposal shown in **Illustration 1.2**.

The objectives of the proposed works are to:

- stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way;
- restore the riverbank profile;
- restore the pavement to the shoulder of Big River Way;
- undertake works to minimise traffic, environmental, social impacts; and
- ensure Big River Way remains a safe and trafficable transport route.

State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) enables the works to be undertaken as development without consent pursuant to Clause 111 and Clause 8 of ISEPP. Under Clause 15AA a public authority is required to consult with NSW State Emergency Services (SES) due to development on flood liable land.

Key features of the proposal include:

- Project set up including establishment of a site compound and stockpile locations within close proximity to the site
- Establish traffic controls in vicinity of the site (to accommodate temporary restricted/closed lanes of Big River Way)
- Establish sedimentation and erosion controls on riverbank as required
- Cleaning of slip area including clearing of vegetation along slip restoration site
- Piling works (from road and/or river) to stabilise slope area
- Repair pavement shoulder of Big River Way

Construction is expected to commence in April 2022 and be completed by June 2023.

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Yours faithfully

David Havilah
Senior Ecologist
GeoLINK on behalf of Transport for NSW

23 November 2021

Ref: 4099-1001

Roads and Maritime Northern Region
PO Box 576
GRAFTON NSW 2460

To whom it may concern

Consultation regarding remediation works for Byrons Lane Slip Stage V

Transport for NSW (TfNSW) proposes to carry out remediation works on the Clarence River embankment, adjacent to a section of Big River Way (Old Pacific Highway) in response to a significant rainfall event (declared natural disaster) in March 2021. The works are required to ensure that Big River Way remains a safe and trafficable transport route by remediation of the slope and riverbank profile to prevent further degradation of the road surface. The location of the works are shown in **Illustration 1.1** with works area for the proposal shown in **Illustration 1.2**.

The objectives of the proposed works are to:

- stabilise the bank of the South Arm River associated with the project to prevent further erosion along the edge of Big River Way;
- restore the riverbank profile;
- restore the pavement to the shoulder of Big River Way;
- undertake works to minimise traffic, environmental, social impacts; and
- ensure Big River Way remains a safe and trafficable transport route.

Under the State Environmental Planning Policy (Infrastructure) 2007, Transport for NSW is required to consult with NSW Maritime under clause 16 due to a *fixed or floating structure in or over navigable waters*. Of relevance to NSW Maritime, the proposed works may require floating a barge and anchoring at the proposed work zone to carry out piling works associated with restoration of the riverbank profile within the Clarence River (South Arm).

Key features of the proposal include:

- Project set up including establishment of a site compound and stockpile locations within close proximity to the site
- Establish traffic controls in vicinity of the site (to accommodate temporary restricted/closed lanes of Big River Way)
- Establish sedimentation and erosion controls on riverbank as required
- Cleaning of slip area including clearing of vegetation along slip restoration site
- Piling works (from road and/or river) to stabilise slope area
- Repair and restoration of pavement shoulder of Big River Way

Construction is expected to commence in April 2022 and be completed by June 2023.

I am currently preparing a Review of Environmental Factors (REF) as per the requirements under Part 5 of the *Environmental Planning and Assessment Act 1979* for this project. It would be appreciated if you could provide any comments about this proposal.

TfNSW would be pleased to provide further information if required. In this regard, Shaun Gillespie may be contacted on 0413 368 288 or by email Shaun.Gillespie@transport.nsw.gov.au. Alternatively, you may contact me on 0407 237 985 or dhavilah@geolink.net.au.

Yours faithfully

David Havilah
Senior Ecologist
GeoLINK on behalf of Transport for NSW

14 December 2021

David Havilah
Senior Ecologist
GeoLINK

email: dhavilah@geolink.net.au and Shaun.Gillespie@transport.nsw.gov.au

Dear Mr Havilah

Re: Remediation Works for Byrons Lane Slip Stage V

Thank you for your letter dated 23 November 2021 requesting Transport for NSW (TfNSW) Maritime comment on Transport for NSW (TfNSW) proposal to carry out remediation works on the Clarence River embankment adjacent to a section of Big River Way (Old Pacific Highway) in response to a significant rainfall event (declared natural disaster) in March 2021.

TfNSW - Maritime advises that the proposal as per the supplied documentation has been assessed as having minimal impact on the safety of navigation under the Marine Safety Act 1998 and have no objections to the above-mentioned proposal.

NSW Maritime requests the following conditions to be considered in preparation of the REF:

1. Any works impacting on navigation during the construction phase must seek TfNSW Maritime support.
2. A full scope of works relating to on-water operations including dates is to be provided to *navigationadvicenorth@transport.nsw.gov.au* 21 days prior to works commencing so a Marine Notice can be prepared and published on the Maritime website.
3. Any work vessels associated with the project must comply with the relevant NSW marine legislation.
4. Any work vessels and crew associated with the project must comply with the Marine Safety (Domestic Commercial Vessels) National Law Act 2012.
5. Any submerged hazards, cables, wires, silt curtains etc must be marked with yellow aqua buoys (sign written "Warning – Submerged Hazard"). These aqua buoys must be lit with a yellow flashing light if hazards are present before sunrise and after sunset.

Should you require any further assistance please direct all future correspondence to navigationadvicenorth@transport.nsw.gov.au

Yours sincerely

LMHourigan.

Lynda Hourigan
Project Governance Officer
Maritime
Greater Sydney

Appendix H

Transport Construction Noise Estimator

MEMO

To:	Shaun Gillespie		
CC:			
From:	Kate Dallimore	Date:	22 October 2021
Ref:	P.0068426	Pages:	10
Subject:	Construction Noise - Byron's Lane Slip Stage V Project, Big River Way, Tyndale, NSW.		

Issue

Construction noise from the Byron's Lane Slip Stage V Project, Big River Way, Tyndale, NSW.

Background

TfNSW proposes to carry out remediation works on the Clarence River embankment in response to a significant rainfall (declared natural disaster) event in March 2021. The Clarence River is located adjacent to the Big River Way (Old Pacific Highway) and the eastern riverbank forms the western embankment for the Big River Way at the proposed remediation site.

The slip is located approximately 33.44 km north of Grafton in the Clarence Valley Council (CVC) local government area and is located approximately 540m north-east of Byron's Lane.

The Clarence Riverbank was adjacent to the Big River Way was inspected on 9th March 2021 by TfNSW Geotechnical Officers after the slope subsidence was initially identified by Road Maintenance inspections. Observations identified embankment subsidence and increased cracking mechanisms within the road shoulder. This site is located within the area in which previous riverbank slope stability treatments have been required. The last repairs completed was carried out in 2017.

The proposal is funded by a state road and natural disaster program and is expected to cost $4M for delivery.

The proposed project site is approximately 100m in length and extends from the Big River Way into the Clarence River – South Arm.

The primary objective of the proposal is to ensure that the Big River Way remains a safe and trafficable transport route by preventing further degradation of the road surface from subsidence risk associated with the ALR1 risk rating slope

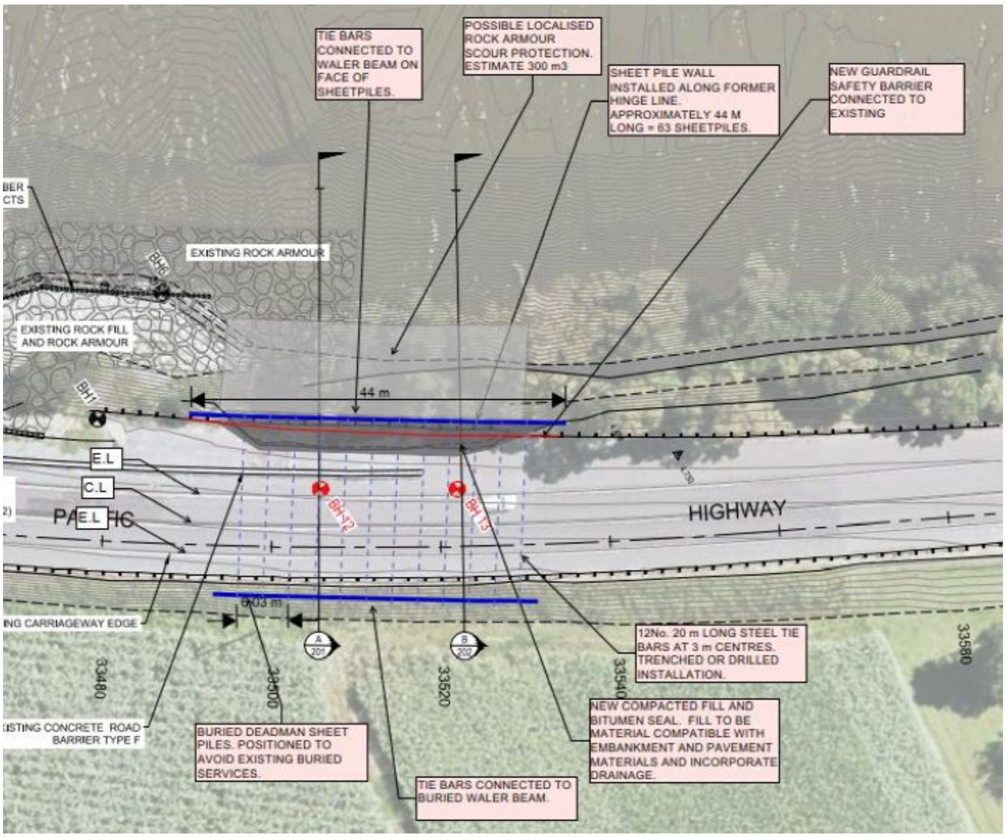
Summary of Treatment Options

The 80% Geotechnical Interpretive and Design options report outlines 4 possible options & construction sequences. Below is a summary of each option.

Option 1A – Cantilever Sheet Piled Retaining Wall

Description

Concept Option 1A seeks to retain the road embankment by installing a row of cantilevered steel sheet piles along the alignment of the existing landslide headscarp. The approximate length of the wall is 42 m and comprises AZ46-700N sheet piles, at least 16 m in length, embedded within the stiff clays.



Construction Sequence

The following construction sequence is anticipated for the sheet piles:

1. Set up traffic control, close northbound lane.
2. Construct a temporary working platform for excavator mounted or crane mounted sheet piling rig.
3. Install sheet piles using hydraulic impact hammers or vibratory hammers. The stability of the site and adjacent riverbanks may be sensitive to vibrations and consideration should be given to alternate installation methods such as jacking.
4. Fill voids and reinstate pavement and bitumen wearing course to prevent surface water ingress.
5. Extend concrete safety barrier.

Requirements to install rock armour scour protection including any necessary clearing to the vegetated riverbank are to be discussed and confirmed with TfNSW."

Option 1B – Anchored Sheet Piled Retaining Wall

Description

Concept Option 1B seeks to retain and regain the failed embankment by installing a row of sheet piles on the riverside of the headscarp, through the landslide. In this location, the sheet piles are supporting weak, slumped landslide materials and are expected to require a row of anchors to control displacements.
The concept design is a 40 m long sheet piled retaining wall comprising approximately 12 m long sheet piles. A the second row of deadman sheet piles (5 m long) is proposed to be located on the opposite side of the road, positioned to avoid buried services (Telstra and water main). A row of steel tie bars anchors the retaining wall to the deadman via horizontal waler beams.

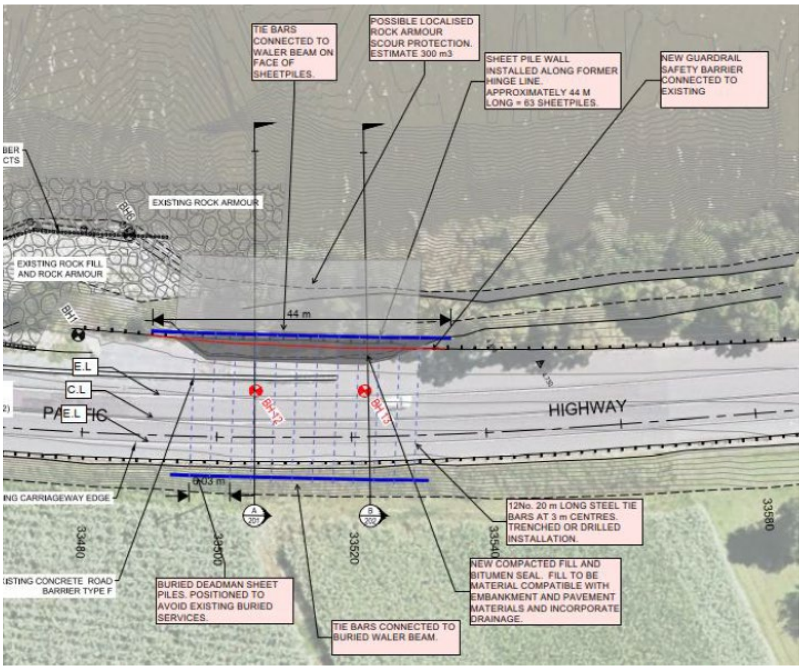


Figure 1:

Option 2 – Contiguous Pile Wall

Description

Concept Option 2 seeks to retain the road embankment by installing a row of contiguous piles. The piles are proposed to be installed using a continuous flight auger (CFA) drilling rig. The approximate length of the wall is 42 m and comprises 750 mm diameter piles at close (1200 mm to 1400 mm) centres. The piles are proposed to be positioned approximately 1.5 m back from the existing headscarp, primarily to allow the piles to be installed without further temporary stability or casing requirements. The headscarp is proposed to be battered and rock armoured.

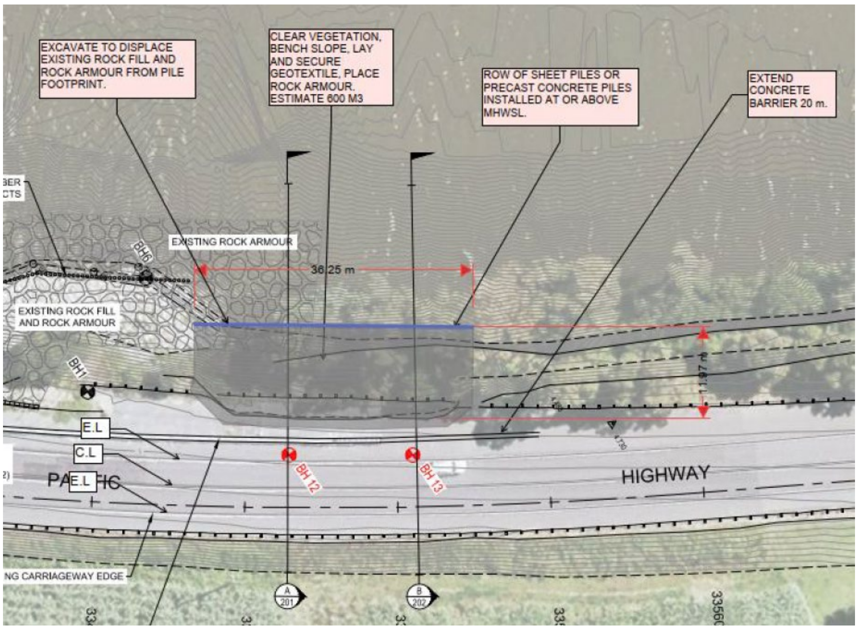


Figure 2:

Option 3 – Shear Piles and Rock Fill

Description

Concept Option 3 is similar to the adjacent, previous landslide remediation. It seeks to retain the road embankment and riverbank by installing a row of shear piles within the lower riverbank and backfilling behind the piles with rockfill and rock armour to reinstate the slumped riverbank profile and prevent further landslide regression towards the carriageway.

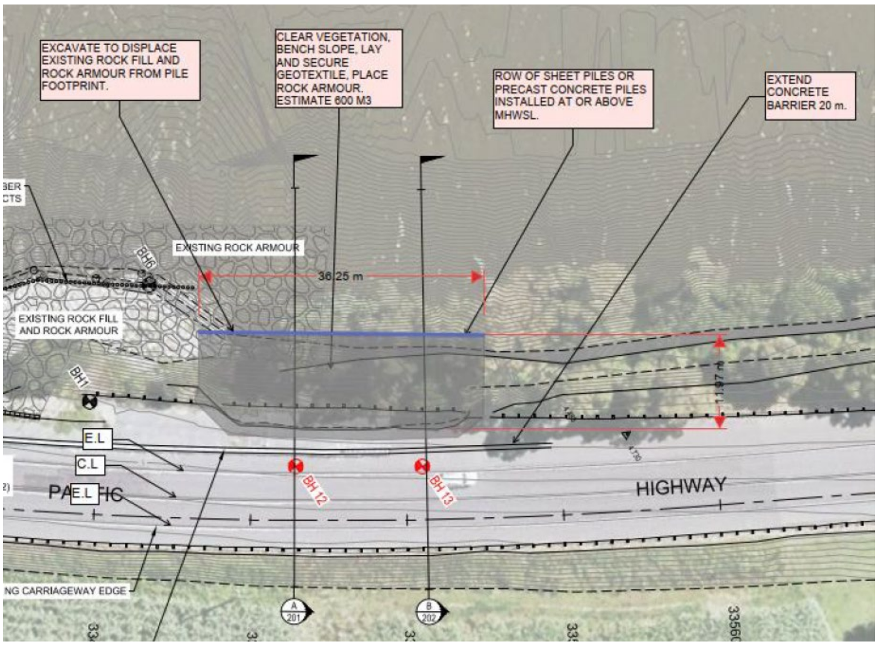


Figure 3:

Option 4 - Micro Pile and Gabion Wall

Description

Concept Option 4 seeks to retain the road embankment with a gabion basket retaining wall founded on a piled footing. Two rows of precast, driven, reinforced concrete piles are proposed to be installed and connected to a reinforced concrete pad footing. The gabion baskets are to be founded on a concrete footing.
Temporary battered excavations are required to facilitate the construction of the reinforced concrete footing and gabion baskets.

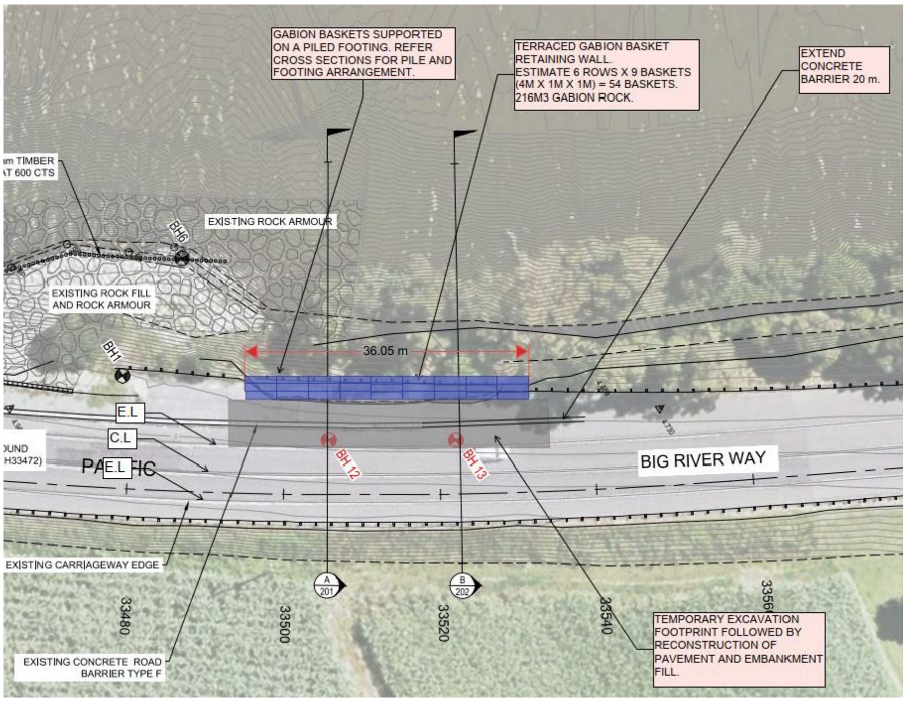


Figure 4:

Construction Methodology

An indicative methodology of the proposed works is:

Initial project set-up and cleaning of slip area.

1. Locate all services (including communication and potentially life-threatening services such as electrical, gas, fuel, etc.) and have a current dial before you always dig (DBYD) plans on-site.
2. Establish a site compound within the road reserve on the eastern side of the Pacific Highway approximately 500 m north of the proposed works.
3. Establish traffic control management following an approved traffic control guidance plan.
4. Establish sedimentation and erosion controls on river embankments as required.
5. Remove weeds and native regrowth along with the proposed slip restoration site.
6. Poison weeds at identified sites before removal and mulching to ensure mulch material reused at the site is inert.
7. Cut select trees to stump level as required for access for riverbank remediation using a cut and grab excavator located on the temporarily closed road travel lane. This is to reduce weight on the batter and gain access to the slope.
8. Vegetation will be placed in the tree mulcher located on the closed travel lane and either temporarily stockpiled for reuse onsite or taken to a co-generation plant for re-use or disposed of at a licensed waste facility. All mulch reused on-site would be to aid regeneration of the top of the bank; the mulch is to be spread at no more than 100mm thick across the top of the bank.
9. Loose material and slip debris to be removed from slip (no excavation below current surface level). This material is to be taken to a temporary stockpile area for treatment if required and then disposed of at a licensed waste facility.

Piling Works Situation 1 – Piling works with access from the road

1. Establish road travel lane restriction to Big River Way with an approved traffic control management plan
2. Construction a platform within the closed lanes of the Big River Way to support a piling rig.
3. Establish a piling rig on site.

4. Undertake piling works as specified by Geotechnical design requirements to stabilise slope area.

Piling Works Situation 2 – Piling works with access from River

1. Install access to the lower bank and river adjacent to the identified slip area.
2. Assemble and launch a barge at an external boat ramp site approved by the TfNSW Local Environmental Officer, float to slip area and anchor.
3. Float barge to work zone by towing behind a suitable boat and anchored in place.
4. Ensure navigation lights and waterway markers are in place and operational.
5. Establish floating sedimentation and control boom and attached silt curtain around the barge and proposed area of disturbance to isolate the works site. The silt curtain would be weighted to the bed and secured to accommodate the tidal flow.
6. Undertake piling works as specified by Geotechnical design requirements to stabilise slope area.

Restoration of Riverbank profile

1. Install access to the lower bank and river adjacent to the identified slip area.
2. Assemble and launch a barge at an external boat ramp site approved by the TfNSW Local Environmental Officer, float to slip area and anchor.
3. install floating boom(s) around slip within the river.
4. Place rock from onto Rock to be delivered directly to river embankment within the proposed work zone and then immediately placed onto the slope. This would be completed by excavator located on the temporarily closed road travel lane or using the barge-mounted excavator. There would be no stockpiling of incoming rock material.
5. Place and push rock armours (600 mm to 800 mm) into the underlying alluvium at the toe to achieve firm toe restraint.

Restoration of Big River Way Pavement

1. Patch out/repair areas of pavement shoulder that have suffered distress due to the loss of formation support.
2. Repair and/or reinstate existing safety barriers.

Plant and Equipment

Plant and equipment that would be used for the project include, but is not limited to, the following:

- Low loader.
- Excavators.
- Tipper trucks.
- Light vehicles for staff movement to and from the site.
- Traffic control devices.
- Small plant items (chain saw, mulch head, chipper, and generators)
- Concrete agitator trucks and pump
- Earthworks heavy plant items.
- Construction rollers
- Road broom
- Bitumen spray truck
- Punt/boat to ferry staff to riverbank/check environmental controls
- Tree mulcher

Additional items dependent on Geotechnical Engineering Design

- Piling rig (to be determined)
    - Continuous flight auger (CFA) drilling rig
    - Sheet pile
- Barges (to be determined)

Working Hours

The proposed works would be undertaken during the working hours as follows:

- Monday-Friday: 7:00am to 6.00pm
- Saturday: 7.00 am to 6.00 pm (note extended working hours)
- Sunday and Public Holidays: no work

However, work may be undertaken outside of the working hours on weekends or nights to minimise traffic impacts on the community. If it is determined that work outside the nominated hours is required, an assessment would be undertaken to determine the safeguards and mitigations required.

Noisy works will be undertaken following RMS "Construction Noise and Vibration Guideline" (August 2016).

Construction Noise Assessment

A distance-based noisiest plant noise assessment was undertaken for this construction site using a bored piling rig as a selected representative for the works.

Methodology

The detailed noise impact assessment is undertaken using *RMS Construction Noise Estimator. xlsm* as per section 6.2 Construction Noise and Vibration Guideline August 2016.

The representative noise environment was assessed as category R0 using the "Representative Noise Environ" tab for both sites. The background noise levels during the day, evening and night periods are then estimated to be 30, 30 and 30 dB(A) respectively.

The Environmental Protection Authority's construction noise management levels for the day, day(OOHW) evening and night are 40, 35, 35 and 35 dB(A) respectively (refer to the Construction Noise Guideline).

Note that extended working hours are required and that the night period will not be applicable as works are expected to only occur during daylight hours of the extended construction hours.

The "*RMS Construction Noise Estimator. Xlsm"* firstly identifies an affected distance for nearby residents for the relevant time period (i.e. standard hours, OOWH or night hours). The affected distance is defined as the distance up to which noise levels are expected to exceed the Noise Management Level (NML) as defined by the Environmental Protection Agency Interim Construction Noise Guidelines.

The number of residents that are located within the affected distance of the proposed works is then identified.

Then for all residents located within the affected distance, the "*RMS Construction Noise Estimator.xlsm"* identifies recommended additional mitigation measures corresponding to the degree of noise impact.

A distance-based noisiest plant assessment was undertaken for both situations as below:

Working during the day out of hours work (OOWH) periods – Rural Area – Line of sight

The affected distance is 760m for rural areas with isolated dwellings where this work is taking place. There are 8 residents located within 760m of the works which are affected receivers during day (OOHW) periods.

The "*RMS Construction Noise Estimator.xlsm*" identifies residents are impacted by construction noise to higher degrees at distances less than 525 metres from the works.

There are 5 affected receivers at distances less than 525 metres from the works and recommended mitigation measures are summarised in Table 1 below.

LAeq(15minute) noise level above background noise(LA90)

	Noticeable 5 to 10 dB(A)	Clearly Audible 10 to 20 dB(A)	Moderately intrusive 20 to 30 dB(A)	Highly intrusive > 30 dB(A)
Mitigation distance	760m to 525m	525m to 250m	250m to 120m	Less than 120m
Number of residents less than the distance	3	2	2	1
Notification requirements		Notification Respite period (R1) Duration respite	Notification Respite period (R1) Duration respite	Notification Respite period (R1) Duration respite Phone calls Specific Notification

Table 1: Summary of resident notification requirements for (OOHW) day works

The predicted noise level at the nearest receiver can be up to 60 dB(A) when the proposed works are being undertaken, which is 25 dB(A) above the noise management level of 35 dB(A).

Working during standard working hours day periods – Rural Area – Line of sight

The affected distance during day periods is 525m for rural areas with isolated dwellings where this work is taking place. There are 5 residents located within 525m of the works which are affected receivers during day periods.

The "*RMS Construction Noise Estimator.xlsm*" identifies residents are impacted by construction noise to higher degrees at distances less than 250 metres from the works.

There are 3 affected receivers at distances less than 250metres from the works and recommended mitigation measures are summarised in Table 2 below.

LAeq(15minute) noise level above background noise(LA90) exceedance

	Noticeable 5 to 10 dB(A)	Clearly Audible 10 to 20 dB(A)	Moderately intrusive 20 to 30 dB(A)	Moderately intrusive > 30 dB(A)
Mitigation distance			250m to 120m	Less than 120m
Number of residents less than the distance			2	1
Notification requirements			Notification	Notification

Table 2: Summary of resident notification requirements for standard working hour day works

The predicted noise level at the nearest receiver can be up to 60 dB(A) when the proposed works are being undertaken, which is 20 dB(A) above the noise management level of 40 dB(A).

Recommendation

The additional mitigation measures below are recommended in addition to relevant standard mitigation measures found in Appendix B of the *RMS Construction Noise and Vibration Guideline 2016* (see attachment).

The recommended additional mitigation measures for the works are:

If works are required to be completed during OOHW day periods for each section:

- Letterbox drops are to be completed to all residents located within the rural area less than 525 metres from the works.
- Contact sensitive receivers within 525 metres to inform occupants about the proposed works and offer respite as per Table 1.

If works are required to be completed during standard working hours for each section:

- Letterbox drops are to be completed to all residents located less than 250 metres from the works.
- Contact sensitive receivers within 120 metres to inform occupants about the proposed works as per Table 2.

Kate Dallimore

Senior Environment & Sustainability Officer – Northern

Environment and Sustainability

Transport for NSW

Attachments

Noise assessment maps – Receiver locations

Distance-Based Assessment – Nosiest Plant – Bored Piling Rig & line of sight to the receiver

Distance-Based Assessment – Nosiest Plant – Bored Piling Rig & line of sight to the receiver

Standard Mitigation Measures – Appendix B of the RMS Construction Noise and Vibration Guideline 2016

Byron’s Lane Slip Stage V - Construction Noise Assessment Maps


470m
South Arm
S Arm Rd
200m
530m
80m
Byrons Lane Slip
530m
S Arm Rd
Ocean Ave
S Arm Rd
South Arm
191m
530m
A1

Distanced Based Assessment (Noisiest Plant)

Please pick from drop-down list in orange cells

Noise area category		R0
RBL or L_{A90} Background level (dB(A))	Day	30
	Evening	30
	Night	30
$L_{Aeq(15minute)}$ Noise Mangement Level (dB(A))	Day	40
	Day (OOHW)	35
	Evening	35
	Night	35
Noisiest plant		Bored Piling Rig
Is there line of sight to receiver?		Yes

Steps for Screening Assessment:
1. Schedule noisy works to occur in standard hours where possible or before 11pm and implement Standard Measures.
2. Select the representative noise area category (cell C8). The worksheet titled 'Representative Noise Environ.' provides a number of examples to help select the noise area category.
3. Select the noisiest plant (cell C15). If not found in drop-down list, refer to 'Source List' and select a representative plant with equivalent sound power level.
4. Is there line of sight to receiver? Select the appropriate scenario from the drop down list (cell C17). Solid barrier can be in the form of road cutting, solid construction hoarding, acoustic curtain, timber lapped and capped fence, shipping container, site office, etc. Please note that vegetation and trees are not considered to be a form of solid barrier.
5. Determine if there are any receivers within the affected distance (undeveloped or developed areas) for each relevant time period (cells C24 to C33 for residential receiver or cells F40 to F89 for non-residential receivers)
   (a) If there are no affrected receivers within the affected distance and the project's impact duration is less than 3 weeks: document the background noise levels, noise management levels and the affected distances for the noisiest plant in an internal memo or letter.
   (b) if there are no affected receivers within the affected distance and the project's impact duration is more than 3 weeks: proceed to use the estimator to predict noise levels at the worst affected receiver, then document background noise levels, noise management levels and the predicted noise levels from the noisiest plant at the worst affected receiver in an internal memo or letter.
   (c) if there are a few affected receivers and the project's impact duration is greater than three and less than six weeks: proceed to use the estimator to predict noise levels and mitigation measures at all receivers to inform the consultation.
   (d) proceed with the following steps to undertake a distance based assessment if there are a few affected receivers or many affected receivers and the project's impact duration is less than 3 weeks .
   (e) undertake a detailed noise assessment if there are a few affected receivers and the project's impact duration is greater than 6 weeks or there are many receivers and the project's impact duration is greater than 3 weeks.
(Note that suitable noise management levels for other noise-sensitive businesses not identified in the Construction Noise Estimator should be

Steps for Distance Based Assessment:
6. Identify the affected distance corresponding to the NML (see step #5).
7. Identify and implement standard mitigation measures where feasible and reasonable. Include any shielding implemented as part of the standard mitigation measures by changing the selection in the 'Is there line of sight to receiver' drop-down list.
8. Identify if there are any receivers that are within the additional mitigation measures distances and identify feasible and reasonable measures at each receiver (rows 24 to 33 & columns D to columns R for residential receiver or rows 40 to 89 & columns G to R for non residential receiver).
9. Where night works are involved, identify sleep disturbance affected distance (cells S27 and S32).
10. Document the outcomes of these steps.

Abbreviation	Measure
N	Notification (letterbox drop or equivalent
SN	Specific notifications
PC	Phone calls
IB	Individual briefings
RO	Respite offer
R1	Respite period 1
R2	Respite period 2
DR	Duration respite
AA	Alternative accommodation
V	Verification

Note that spot check verification of noise levels and individual briefings are not required for projects with less than 3 weeks impact duration

Note: If the subject plant cannot be found on the drop down list of noisiest plant (cell C16), then choose one with equivalent sound power level and make a note in the assessment memo / report. See 'Sources' worksheet for all plant contained in the database.

Residential receiver

			$L_{Aeq(15minute)}$ noise level above background (L_{A90})												$L_{Aeq(15minute)}$ 75 dB(A) or greater (Highly affected)			Sleep disutrbance L_{Amax} 65 dB(A)
			5 to 10 dB(A) Noticeable			10 to 20 dB(A) Clearly audible			20 to 30 dB(A) Moderately intrusive			> 30 dB(A) Highly intrusive						
		Affected distance (m)	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Affected distance (m)
Undeveloped green fields, rural areas with isolated dwellings	Day	525							N	250	50	N	120	60	N, PC, RO	25	75	
	Day (OOHW)	760				N, R1, DR	525	40	N, R1, DR	250	50	N, R1, DR, PC, SN	120	60	N, PC, RO	25	75	
	Evening	760				N, R1, DR	525	40	N, R1, DR	250	50	N, R1, DR, PC, SN	120	60	N, PC, RO	25	75	
	Night	760	N	760	35	N, R2, DR	525	40	N, PC, SN, R2, DR	250	50	AA, N, PC, SN, R2, DR	120	60	N, PC, RO	25	75	175
	Highly Affected	25													N, PC, RO	25	75	
Developed settlements (urban and suburban) or over water	Day	690							N	305	50	N	135	60	N, PC, RO	30	75	
	Day (OOHW)	1010				N, R1, DR	690	40	N, R1, DR	305	50	N, R1, DR, PC, SN	135	60	N, PC, RO	30	75	
	Evening	1010				N, R1, DR	690	40	N, R1, DR	305	50	N, R1, DR, PC, SN	135	60	N, PC, RO	30	75	
	Night	1010	N	1010	35	N, R2, DR	690	40	N, PC, SN, R2, DR	305	50	AA, N, PC, SN, R2, DR	135	60	N, PC, RO	30	75	200
	Highly Affected	30													N, PC, RO	30	75	

Non-residential receiver
Undeveloped green fields, rural areas with isolated dwellings

	Standard hours			$L_{Aeq(15minute)}$ noise level above NML						LAeq(15minute) 75 dB(A) or greater (Highly affected)		
				<10 dB(A)			10 to 20 dB(A)					
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Classroom at schools and other educational institutions	Day	55	175				N	75	65	N, PC, RO	25	75
Hospital wards and operating theatres	Day	65	75							N, PC, RO	25	75
Place of worship	Day	55	175				N	75	65	N, PC, RO	25	75
Active recreation	Day	65	75							N, PC, RO	25	75
Passive recreation	Day	60	120				N	45	70	N, PC, RO	25	75
Industrial premise	Day	75	25							N, PC, RO	25	75
Offices, retail outlets	Day	70	45							N, PC, RO	25	75

	OOHW			$L_{Aeq(15minute)}$ noise level above NML											
				< 5 dB(A)			5 to 15 dB(A)			15 to 25 dB(A)			> 25 dB(A)		
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Hospital wards and operating theatres	Evening	65	75				N, R1, DR	45	70	N, R1, DR	14	80	N, R1, DR, PC, SN	4	90
	Night	65	75	N	75	65	N, R2, NR	45	70	N, PC, SN, R2, DR	14	80	AA, N, PC, SN, R2, DR	4	90
Place of worship	Evening	55	175				N, R1, DR	120	60	N, R1, DR	45	70	N, R1, DR, PC, SN	14	80
	Night	55	175	N	175	55	N, R2, NR	120	60	N, PC, SN, R2, DR	45	70	AA, N, PC, SN, R2, DR	14	80
Active recreation	Evening	65	75				N, R1, DR	45	70	N, R1, DR	14	80	N, R1, DR, PC, SN	4	90
Passive recreation	Evening	60	120				N, R1, DR	75	65	N, R1, DR	25	75	N, R1, DR, PC, SN	8	85
Industrial premise	Evening	75	25				N, R1, DR	14	80	N, R1, DR	4	90	N, R1, DR, PC, SN	1	100
	Night	75	25	N	25	75	N, R2, NR	14	80	N, PC, SN, R2, DR	4	90	AA, N, PC, SN, R2, DR	1	100
Offices, retail outlets	Evening	70	45				N, R1, DR	25	75	N, R1, DR	8	85	N, R1, DR, PC, SN	3	95
	Night	70	45	N	45	70	N, R2, NR	25	75	N, PC, SN, R2, DR	8	85	AA, N, PC, SN, R2, DR	3	95

Non-residential receiver
Developed settlements (urban and suburban) or over water

	Standard hours			$L_{Aeq(15minute)}$ noise level above NML						LAeq(15minute) 75 dB(A) or greater (Highly affected)		
				<10 dB(A)			10 to 20 dB(A)					
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Classroom at schools and other educational institutions	Day	55	200				N	85	65	N, PC, RO	30	75
Hospital wards and operating theatres	Day	65	85							N, PC, RO	30	75
Place of worship	Day	55	200				N	85	65	N, PC, RO	30	75
Active recreation	Day	65	85							N, PC, RO	30	75
Passive recreation	Day	60	135				N	50	70	N, PC, RO	30	75
Industrial premise	Day	75	30							N, PC, RO	30	75
Offices, retail outlets	Day	70	50							N, PC, RO	30	75

	OOHW			$L_{Aeq(15minute)}$ noise level above NML											
				< 5 dB(A)			5 to 15 dB(A)			15 to 25 dB(A)			> 25 dB(A)		
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Hospital wards and operating theatres	Evening	65	85				N, R1, DR	50	70	N, R1, DR	17	80	N, R1, DR, PC, SN	5	90
	Night	65	85	N	85	65	N, R2, NR	50	70	N, PC, SN, R2, DR	17	80	AA, N, PC, SN, R2, DR	5	90
Place of worship	Evening	55	200				N, R1, DR	135	60	N, R1, DR	50	70	N, R1, DR, PC, SN	17	80
	Night	55	200	N	200	55	N, R2, NR	135	60	N, PC, SN, R2, DR	50	70	AA, N, PC, SN, R2, DR	17	80
Active recreation	Evening	65	85				N, R1, DR	50	70	N, R1, DR	17	80	N, R1, DR, PC, SN	5	90
Passive recreation	Evening	60	135				N, R1, DR	85	65	N, R1, DR	30	75	N, R1, DR, PC, SN	9	85
Industrial premise	Evening	75	30				N, R1, DR	17	80	N, R1, DR	5	90	N, R1, DR, PC, SN	2	100
	Night	75	30	N	30	75	N, R2, NR	17	80	N, PC, SN, R2, DR	5	90	AA, N, PC, SN, R2, DR	2	100
Offices, retail outlets	Evening	70	50				N, R1, DR	30	75	N, R1, DR	9	85	N, R1, DR, PC, SN	3	95
	Night	70	50	N	50	70	N, R2, NR	30	75	N, PC, SN, R2, DR	9	85	AA, N, PC, SN, R2, DR	3	95

Transport Roads & Maritime Services

Distanced Based Assessment (Noisiest Plant)

Please pick from drop-down list in orange cells

Noise area category		R0
RBL or L_{A90} Background level (dB(A))	Day	30
	Evening	30
	Night	30
$L_{Aeq(15minute)}$ Noise Mangement Level (dB(A))	Day	40
	Day (OOHW)	35
	Evening	35
	Night	35
Noisiest plant		Chainsaw
Is there line of sight to receiver?		Yes

Steps for Screening Assessment:
1. Schedule noisy works to occur in standard hours where possible or before 11pm and implement Standard Measures.
2. Select the representative noise area category (cell C8). The worksheet titled 'Representative Noise Environ.' provides a number of examples to help select the noise area category.
3. Select the noisiest plant (cell C15). If not found in drop-down list, refer to 'Source List' and select a representative plant with equivalent sound power level.
4. Is there line of sight to receiver? Select the appropriate scenario from the drop down list (cell C17). Solid barrier can be in the form of road cutting, solid construction hoarding, acoustic curtain, timber lapped and capped fence, shipping container, site office, etc. Please note that vegetation and trees are not considered to be a form of solid barrier.
5. Determine if there are any receivers within the affected distance (undeveloped or developed areas) for each relevant time period (cells C24 to C33 for residential receiver or cells F40 to F89 for non-residential receivers)
   (a) If there are no affected receivers within the affected distance and the project's impact duration is less than 3 weeks: document the background noise levels, noise management levels and the affected distances for the noisiest plant in an internal memo or letter.
   (b) if there are no affected receivers within the affected distance and the project's impact duration is more than 3 weeks: proceed to use the estimator to predict noise levels at the worst affected receiver, then document background noise levels, noise management levels and the predicted noise levels from the noisiest plant at the worst affected receiver in an internal memo or letter.
   (c) if there are a few affected receivers and the project's impact duration is greater than three and less than six weeks: proceed to use the estimator to predict noise levels and mitigation measures at all receivers to inform the consultation.
   (d) proceed with the following steps to undertake a distance based assessment if there are a few affected receivers or many affected receivers and the project's impact duration is less than 3 weeks .
   (e) undertake a detailed noise assessment if there are a few affected receivers and the project's impact duration is greater than 6 weeks or there are many receivers and the project's impact duration is greater than 3 weeks.

(Note that suitable noise management levels for other noise-sensitive businesses not identified in the Construction Noise Estimator should be

Steps for Distance Based Assessment:
6. Identify the affected distance corresponding to the NML (see step #5).
7. Identify and implement standard mitigation measures where feasible and reasonable. Include any shielding implemented as part of the standard mitigation measures by changing the selection in the 'Is there line of sight to receiver' drop-down list.
8. Identify if there are any receivers that are within the additional mitigation measures distances and identify feasible and reasonable measures at each receiver (rows 24 to 33 & columns D to columns R for residential receiver or rows 40 to 89 & columns G to R for non residential receiver).
9. Where night works are involved, identify sleep disturbance affected distance (cells S27 and S32).
10. Document the outcomes of these steps.

Abbreviation	Measure
N	Notification (letterbox drop or equivalent
SN	Specific notifications
PC	Phone calls
IB	Individual briefings
RO	Respite offer
R1	Respite period 1
R2	Respite period 2
DR	Duration respite
AA	Alternative accommodation
V	Verification

Note that spot check verification of noise levels and individual briefings are not required for projects with less than 3 weeks impact duration

Note: If the subject plant cannot be found on the drop down list of noisiest plant (cell C16), then choose one with equivalent sound power level and make a note in the assessment memo / report. See 'Sources' worksheet for all plant contained in the database.

Residential receiver

			$L_{Aeq(15minute)}$ noise level above background (L_{A90})												$L_{Aeq(15minute)}$ 75 dB(A) or greater (Highly affected)			Sleep disutrbance L_{Amax} 65 dB(A)
			5 to 10 dB(A) Noticeable			10 to 20 dB(A) Clearly audible			20 to 30 dB(A) Moderately intrusive			> 30 dB(A) Highly intrusive						
		Affected distance (m)	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Measures	Within distance (m)	Mitigation level (dB(A))	Affected distance (m)
Undeveloped green fields, rural areas with isolated dwellings	Day	525							N	250	50	N	120	60	N, PC, RO	25	75	
	Day (OOHW)	760				N, R1, DR	525	40	N, R1, DR	250	50	N, R1, DR, PC, SN	120	60	N, PC, RO	25	75	
	Evening	760				N, R1, DR	525	40	N, R1, DR	250	50	N, R1, DR, PC, SN	120	60	N, PC, RO	25	75	
	Night	760	N	760	35	N, R2, DR	525	40	N, PC, SN, R2, DR	250	50	AA, N, PC, SN, R2, DR	120	60	N, PC, RO	25	75	120
	Highly Affected	25													N, PC, RO	25	75	
Developed settlements (urban and suburban) or over water	Day	690							N	305	50	N	135	60	N, PC, RO	30	75	
	Day (OOHW)	1010				N, R1, DR	690	40	N, R1, DR	305	50	N, R1, DR, PC, SN	135	60	N, PC, RO	30	75	
	Evening	1010				N, R1, DR	690	40	N, R1, DR	305	50	N, R1, DR, PC, SN	135	60	N, PC, RO	30	75	
	Night	1010	N	1010	35	N, R2, DR	690	40	N, PC, SN, R2, DR	305	50	AA, N, PC, SN, R2, DR	135	60	N, PC, RO	30	75	135
	Highly Affected	30													N, PC, RO	30	75	

Non-residential receiver
Undeveloped green fields, rural areas with isolated dwellings

	Standard hours			$L_{Aeq(15minute)}$ noise level above NML <10 dB(A)			10 to 20 dB(A)			LAeq(15minute) 75 dB(A) or greater (Highly affected)		
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Classroom at schools and other educational institutions	Day	55	175				N	75	65	N, PC, RO	25	75
Hospital wards and operating theatres	Day	65	75							N, PC, RO	25	75
Place of worship	Day	55	175				N	75	65	N, PC, RO	25	75
Active recreation	Day	65	75							N, PC, RO	25	75
Passive recreation	Day	60	120				N	45	70	N, PC, RO	25	75
Industrial premise	Day	75	25							N, PC, RO	25	75
Offices, retail outlets	Day	70	45							N, PC, RO	25	75

		OOHW			$L_{Aeq(15minute)}$ noise level above NML < 5 dB(A)			5 to 15 dB(A)			15 to 25 dB(A)			> 25 dB(A)		
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Hospital wards and operating theatres	Evening	65	75				N, R1, DR	45	70	N, R1, DR	14	80	N, R1, DR, PC, SN	4	90
	Night	65	75	N	75	65	N, R2, NR	45	70	N, PC, SN, R2, DR	14	80	AA, N, PC, SN, R2, DR	4	90
Place of worship	Evening	55	175				N, R1, DR	120	60	N, R1, DR	45	70	N, R1, DR, PC, SN	14	80
	Night	55	175	N	175	55	N, R2, NR	120	60	N, PC, SN, R2, DR	45	70	AA, N, PC, SN, R2, DR	14	80
Active recreation	Evening	65	75				N, R1, DR	45	70	N, R1, DR	14	80	N, R1, DR, PC, SN	4	90
Passive recreation	Evening	60	120				N, R1, DR	75	65	N, R1, DR	25	75	N, R1, DR, PC, SN	8	85
Industrial premise	Evening	75	25				N, R1, DR	14	80	N, R1, DR	4	90	N, R1, DR, PC, SN	1	100
	Night	75	25	N	25	75	N, R2, NR	14	80	N, PC, SN, R2, DR	4	90	AA, N, PC, SN, R2, DR	1	100
Offices, retail outlets	Evening	70	45				N, R1, DR	25	75	N, R1, DR	8	85	N, R1, DR, PC, SN	3	95
	Night	70	45	N	45	70	N, R2, NR	25	75	N, PC, SN, R2, DR	8	85	AA, N, PC, SN, R2, DR	3	95

Non-residential receiver
Developed settlements (urban and suburban) or over water

	Standard hours			$L_{Aeq(15minute)}$ noise level above NML <10 dB(A)			10 to 20 dB(A)			LAeq(15minute) 75 dB(A) or greater (Highly affected)		
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Classroom at schools and other educational institutions	Day	55	200				N	85	65	N, PC, RO	30	75
Hospital wards and operating theatres	Day	65	85							N, PC, RO	30	75
Place of worship	Day	55	200				N	85	65	N, PC, RO	30	75
Active recreation	Day	65	85							N, PC, RO	30	75
Passive recreation	Day	60	135				N	50	70	N, PC, RO	30	75
Industrial premise	Day	75	30							N, PC, RO	30	75
Offices, retail outlets	Day	70	50							N, PC, RO	30	75

		OOHW			$L_{Aeq(15minute)}$ noise level above NML < 5 dB(A)			5 to 15 dB(A)			15 to 25 dB(A)			> 25 dB(A)		
	Period	NML	Affected distance (m)	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))	Measure	Within distance (m)	Mitigation level (dB(A))
Hospital wards and operating theatres	Evening	65	85				N, R1, DR	50	70	N, R1, DR	17	80	N, R1, DR, PC, SN	5	90
	Night	65	85	N	85	65	N, R2, NR	50	70	N, PC, SN, R2, DR	17	80	AA, N, PC, SN, R2, DR	5	90
Place of worship	Evening	55	200				N, R1, DR	135	60	N, R1, DR	50	70	N, R1, DR, PC, SN	17	80
	Night	55	200	N	200	55	N, R2, NR	135	60	N, PC, SN, R2, DR	50	70	AA, N, PC, SN, R2, DR	17	80
Active recreation	Evening	65	85				N, R1, DR	50	70	N, R1, DR	17	80	N, R1, DR, PC, SN	5	90
Passive recreation	Evening	60	135				N, R1, DR	85	65	N, R1, DR	30	75	N, R1, DR, PC, SN	9	85
Industrial premise	Evening	75	30				N, R1, DR	17	80	N, R1, DR	5	90	N, R1, DR, PC, SN	2	100
	Night	75	30	N	30	75	N, R2, NR	17	80	N, PC, SN, R2, DR	5	90	AA, N, PC, SN, R2, DR	2	100
Offices, retail outlets	Evening	70	50				N, R1, DR	30	75	N, R1, DR	9	85	N, R1, DR, PC, SN	3	95
	Night	70	50	N	50	70	N, R2, NR	30	75	N, PC, SN, R2, DR	9	85	AA, N, PC, SN, R2, DR	3	95

NSW GOVERNMENT