B

Appendix B – Geotechnical Interpretive Report

Sensitivity: General

SH1 Rolleston Access Improvement

Geotechnical Interpretive Report

Prepared for New Zealand Transport Agency Waka Kotahi (NZTA)
Prepared by Beca Limited

7 October 2024

Contents

Appendices

Revision History

Revision Nº	Prepared By	Description	Date
1	Nellie Yung Ryder O'Neill	For Issue	07/10/2024

Document Acceptance

Action	Name	Signed	Date
Prepared by	Nellie Yung Ryder O'Neill		07/10/2024
Reviewed by	Richard Young		07/10/2024
Approved by	David Aldridge		07/10/2024
on behalf of	Beca Limited		

1 Introduction

New Zealand Transport Agency Waka Kotahi (NZTA) is proposing to improve the transport safety in and around the growing population of Rolleston. Beca Limited (Beca) has been commissioned by NZTA to undertake the transport safety improvements for the Rolleston Access Improvement project. The scope of the work undertaken by Beca is outlined in 8832 SH1 Rolleston Access Improvements Pre-Implementation and Implementation Standard Form Agreement for Professional Services dated September 2023.

The purpose of this report is to summarise the geotechnical assessment undertaken at the preliminary design stage for the development of the Rolleston transport safety improvements. This geotechnical interpretive report presents the following:

- Interpretation and assessment of results, written appraisal of ground and water conditions, analyses, presentation of design parameters and earthworks and structure foundation recommendations;
- Preliminary design details to establish cut and fill slopes, foundation treatments, construction staging and progress constraints plus slip remedial works;
- The location and extent of any additional investigations/testing required to complete the final design and implementation of the recommended option;
- Recommendations on geotechnical parameters to be used for the design and construction of the project.

This report should be read in conjunction with Rolleston Access Improvement – Geotechnical Factual Report (Beca, 2024a) and Rolleston Access Improvement – Preliminary Geotechnical Appraisal Report (Beca, 2024b).

2 Proposed Development

The overall Rolleston Access Improvement Project is a NZTA led project that will improve the transport safety in and around the growing population of Rolleston, the Project comprises two packages:

- Package 1 - SH1 / Dunns Crossing Road Roundabout and associated works.
- Package 2 - Overpass and balance of the works.

Package 1 involves the construction of a two-lane roundabout and associated works to support the safe transport movement along SH1, Dunns Crossing and Walkers Roads. The associated works includes the closure of Dunns Crossing Road to SH1 and cycle subway. The cycle subway will provide for a safe crossing of the State Highway at the Walkers Road / Dunns Crossing Road roundabout. The subway connects the proposed Burnham Cycleway (along Runners Road) with the Rolleston residential area and a walking and cycling connection to the expanding industrial area and shared use paths along Walkers Road and Two Chain Road.

Package 2 involves the construction of an overpass and a balance of works to support the safe transport movement along SH1, Rolleston Drive North and Jones Road. The balance works includes the closure of Rolleston Drive North and SH1 intersection, closure of Hoskyns Road and SH1 intersection and service and access lanes to the overpass.

3 Site Location and Description

The site is located along SH1 and the adjoining roads in Rolleston, which is approximately 20 km southwest of Christchurch CBD. The site is relatively flat with an elevation of approximately 57 m RL (Lyttleton Vertical Datum, LVD 1937). Apart from shallow irrigation channels, the closest water feature is Baileys Creek which flows in a southeast direction and is located approximately 6 km south of site at its closest point.

Figure 1 shows the extent of the proposed improvements (highlighted blue) in relation to the wider Canterbury area. Preliminary drawings are included in Appendix A showing the works along SH1 between the proposed roundabout to the west of Rolleston and overpass to the north, as well as work on the adjoining streets; Rolleston Drive, Jones Road and Hoskyns Road.

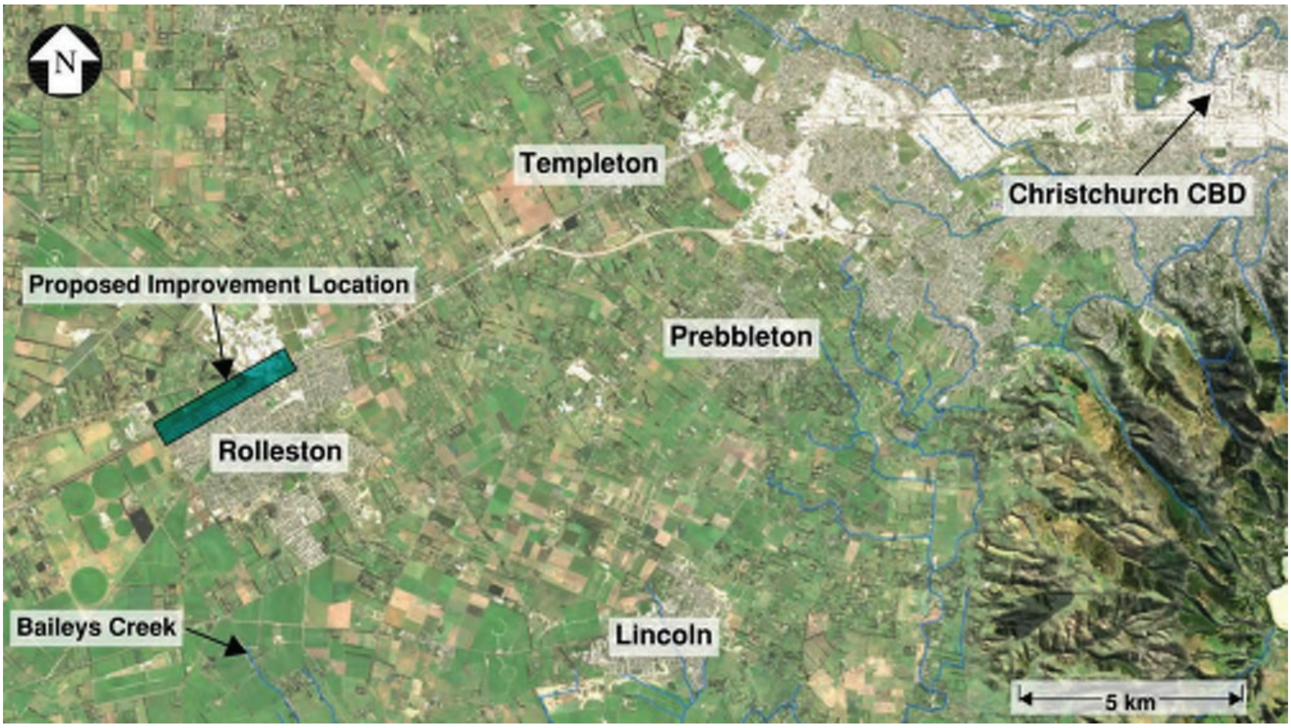

Figure 1: Site Location (Image sourced from Canterbury Maps, 2024)

4 Site Geology

The published 1:250,000 geological map for the Christchurch area (Forsyth, P. J; Barrell, D. J. A; Jongens, R., 2008) shows the site to be underlain by two geological units. The proposed new roundabout to the west of the site is underlain by Quaternary aged, brownish-grey river alluvial sands and gravel deposit of late Pleistocene age (Q2a). The proposed overpass is underlain by Holocene river deposits comprising unweathered gravel, sand, silt, and clay (Q1a). Figure 2 shows the geology underlying the site.

The New Zealand Active Faults database (GNS Science, 2024) indicates the nearest mapped active fault is the Greendale Fault, oriented west to east, approximately 2.5 km north of the site. The recurrence interval for the Greendale Fault is stated to be between 10,000 to 20,000 years and is indicated to have a low slip rate. The Greendale Fault was the source of the Mw 7.1 Darfield earthquake that occurred on 4 September 2010 and was not previously recorded in the fault source models for the New Zealand National Seismic Hazard Model (NSHM). There is a possibility that unidentified faults with low slip rates exist in the area but are obscured beneath the thick sediments of the Canterbury Plains (Stirling, et al., 2012).

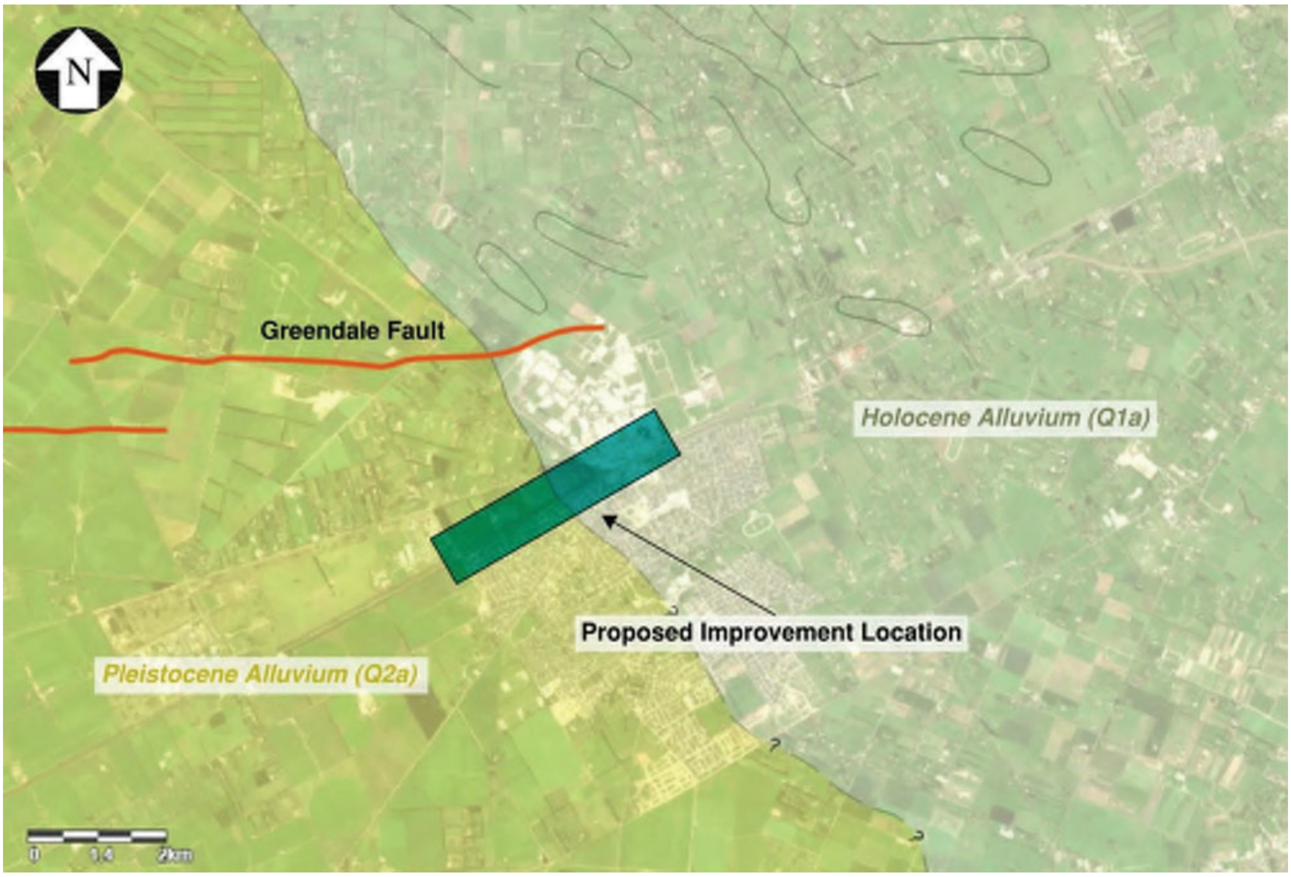

Figure 2: Mapped Geology of the Site (GNS Science, 2024)

5 Geotechnical Investigation

The geotechnical investigation commenced on 17th June 2024 and was completed by 9th August 2024. The investigation locations are shown in Appendix A. The results of this investigation are presented in Rolleston Access Improvement – Geotechnical Factual Report (Beca, 2024a).

The geotechnical investigation comprised:

- 5 machine boreholes to depths between 15.0 to 30.0 m below ground level (m bgl) with Standard Penetration Tests (SPTs) carried out at nominal 1.5 m intervals
  - 3 of the machine boreholes were installed with a piezometer to monitor groundwater levels
  - 2 of the machine boreholes were installed with a PVC casing grouted in place to allow for downhole shear wave testing to be subsequently undertaken
- 2 hand augers to depths to 0.5 m bgl
- 33 machine excavated test pits to depths between 0.6 to 4.0 m bgl
- 23 machine excavated pavement pits to depths between 0.5 to 1.0 m bgl
- Scala penetrometer testing was undertaken at all hand auger, machine excavated test pit and pavement pit locations
- Collection of bulk samples and associated laboratory testing

Based on the quantity and spread of exploratory holes in the geotechnical investigations and uniformity of test results, no further geotechnical investigations are considered necessary for detailed design.

6 Ground Model

6.1 Ground Conditions

The ground model has been assessed based on the geotechnical site investigation data. The ground conditions encountered during the geotechnical site investigation were consistent with the mapped geology, generally comprising of alluvial silts and sands overlying sandy gravel at depth. The ground conditions are relatively consistent across the site with the depth to sandy gravel varying slightly across the site. The generalised ground profile for the site is presented in Table 1.

Embankment fill (Unit 0) was only present within the noise bund situated above ground level and running parallel to the SH, and was only encountered in HA01 and HA02. Topsoil (Unit 1a) was encountered at the ground surface in areas where no prior development had occurred. Fill material (Unit 1b) was found at the ground surface consisting of sandy gravel and was predominantly encountered at the northern end of the proposed overpass between SH1 and Jones Road. The in situ soils comprise a thin layer of loose to medium dense silty gravel or silty sand with minor amounts of organics and trace cobbles (Unit 2), which overlay an unproven thickness of dense to very dense sandy gravel to cobbly sandy gravel with some silt (Unit 3).

Table 1: Generalised Ground Profile

Unit No.	Description	Depth to Top of Layer (m)	Thickness (m)	Scala Penetrometer (blows/50mm)	SPT N (blows/ 300mm)
0	Loose sandy SILT/silty SAND [Embankment FILL]	-	-	1 – 2	-
1a	Loose sandy SILT/silty fine SAND, minor gravel, trace organics [TOPSOIL]	0	0.05 – 0.45 [0.2]	1 – 3	-
1b	Loose sandy GRAVEL/GRAVEL, trace organics, trace silt [FILL]	0 – 3 [0]	0.2 – 0.8 [0.5]	2	-
2	Loose to medium dense silty SAND/silty GRAVEL, minor organics, trace cobbles	0.05 – 0.7 [0.3]	0.15 – 0.8 [0.3]	1 – 2	-
3	Dense to very dense SAND, GRAVEL and COBBLE, silty to some silt	0.1 – 1.5 [0.5]	Unproven	1 – 10+	29 – 50+ [50+]

[ ] indicates typical value adopted for design.

6.2 Groundwater Conditions

The depth to groundwater within the piezometers installed in the boreholes was measured between two to eight weeks following their installation and development. Where piezometers were not installed, the depth to groundwater in two of the boreholes (BH02 and BH04) was measured following completion of drilling. At the time of the measurements the boreholes were cased over their full depths and the boreholes had not been developed to remove drilling muds or other fluids added during the drilling process, hence the water level is indicative only and does not allow for the interpretation of water levels or vertical gradients between individual units. Table 2 summarises the highest groundwater level recorded in each of the boreholes.

Table 2: Groundwater Measurements

Borehole ID	Date of Measurement	Depth to Groundwater (m bgl)	Groundwater Level (m RL)[1]	Type of Measurement (Borehole or Piezometer)	Screened Depth (m bgl)
BH01	21/08/2024	9.77	48.83	Piezometer	10 to 15
BH02	04/07/2024	13.75	41.65	Borehole	-
BH03	21/08/2024	11.98	43.32	Piezometer	10 to 15
BH04	09/08/2024	14.60	41.90	Borehole	-
BH05	21/08/2024	11.91	44.09	Piezometer	10 to 15

[1] RL in terms of NZVD2016

7 Geotechnical Design Parameters

7.1 Soil Parameters

The soil parameters for the in-situ materials have been derived based on correlations to in-situ tests, along with past design experience with these soils at other sites in Rolleston. The parameters adopted for geotechnical analyses are summarised in Table 3.

The ground conditions encountered are predominantly coarse grained (cohesionless), therefore undrained shear strength values have not been assigned for short term load cases. No soil parameters have been assigned for the topsoil as it is assumed it will be stripped during construction.

Table 3: Soil Parameters

Unit No.	Description	Unit Weight, γ (kNm^{-3})	Friction Angle, Φ' (°)	Cohesion, c' (kPa)	Youngs Modulus (MPa)
A	Imported Engineered Fill [AP65]	21	35	-	80
0	Loose sandy SILT/silty SAND [Embankment FILL][1]	17	26	0	-
1a	Loose sandy SILT/silty fine SAND, minor gravel, trace organics [TOPSOIL]	-	-	-	-
1b	Loose sandy GRAVEL/GRAVEL, trace organics, trace silt [FILL]	17	30	0	10
2	Loose to medium dense SILT, SAND and GRAVEL, minor organics, trace cobbles	19	35	0	20
3	Dense to very dense SAND, GRAVEL and COBBLE, silty to some silt	21	39	0	120

7.2 Groundwater Levels

The subsurface conditions of the site can be described as undifferentiated gravel with no confining layers or artesian aquifers, and the hydraulic gradient slopes downward. The groundwater elevation contours for the site, sourced from Canterbury Maps (2024), are shown in Figure 3.

Figure 3: Groundwater Piezometric Contours (RL in terms of metres above sea level)

A review of the groundwater measurements at the site was completed in the Rolleston Access Improvement – Preliminary Geotechnical Appraisal Report (Beca, 2024b). No groundwater data was available for the proposed roundabout within 350 km. The previous investigations near the proposed overpass indicated the groundwater levels ranged from 4.8 to 17.8 m bgl (49.9 to 35.1 m RL, LVD2016). It was inferred that the shallow groundwater readings were likely drilling induced in the boreholes and unlikely to reflect the actual groundwater depth as published maps suggest the depth to groundwater is greater than 6 m (ECan, 2017).

The data collected during the 2024 geotechnical investigation indicates the groundwater is generally 9.7 m to 14.6 m bgl which equates to 48.8 to 41.9 m RL (NZVD2016). The highest levels were recorded shortly after a rainfall event during winter. The groundwater level may rise to higher levels than those recorded following high intensity rainfall events or wet periods, conversely the groundwater levels may be lower than those recorded in drier periods. The depth to groundwater varies between the roundabout and overpass with the shallowest groundwater measurement of 9.7 m bgl (48.8 m RL, NZVD2016) at the roundabout site and deepest groundwater measurement of 14.6 m bgl (41.9 m RL, NZVD2016) at the overpass site.

A design groundwater level of 9.5 m depth was adopted for geotechnical analyses.

7.3 Infiltration

An assessment of the ground infiltration characteristics of the site has been made to inform the development of flood and stormwater design. The assessment showed the ground infiltration characteristics are variable with location and depth. The assessment, including recommended design infiltration rates and factors of safety, is detailed in the Rolleston Access Improvements Infiltration Testing Memorandum attached in Appendix B.

8 Design Basis

8.1 Design Life and Importance Level

A design life of 100 years and an Importance Level (IL) of IL 3 have been assessed for the proposed overpass and subway structures that cross the SH. For the retaining walls that support the noise bund adjacent to the SH, a design life of 100 years and IL2 has been adopted based on the Bridge Manual (NZTA, 2022).

8.2 Seismic Design Criteria

8.2.1 Site Subsoil Class

The site subsoil class was assessed for the site in accordance with NZS 1170.5:2004 and is dependent on the depth of soils or rock at the site.

The geological map for the Christchurch area (Forsyth, P; Barrell, D; Jongens, R., 2008) indicates that dense alluvial materials are likely to continue beyond 100 m depth. This aligns with extensive geophysical investigations that have been undertaken throughout the Canterbury Region to aid in a wider regional site period characterisation. Wotherspoon et. al. (2016) found that site periods away from the Canterbury foothills should be classified as Site Class D in accordance with NZS 1170.5 (Standards New Zealand, 2004).

This is corroborated by the natural period derived from the site specific shear wave velocity measurements in the boreholes for the overpass, which is interpreted to exceed 0.6 seconds.

Based on the geotechnical site investigation encountering dense to very dense sandy gravel at depth and due to the expected thickness of alluvial deposits overlying the basement rock, Site Class D – Deep Soil has been adopted for design.

8.2.2 Seismic Loading

The seismic accelerations for the design of the proposed structures have been determined in accordance with the Bridge Manual (NZTA, 2022). Table 4 presents the seismic loading inputs for design.

Table 4: Geotechnical Seismic Loading Inputs

Parameter	Input
Method	Bridge Manual, Third edition, Amendment 4, Section 6.2.3
Site Subsoil Class	D
Site Location	Rolleston
Structural Importance Level	2 or 3
Structural Design Life	100 Years
Structural Type	Retaining Walls and Bridge
Spectral Shape Factor	1.12
Hazard Factor	0.3

Limited guidance is available for deriving Peak Ground Acceleration (PGA) for Importance Level (IL) 3 structures in Christchurch with both the Bridge Manual (NZTA, 2022) and NZGS Module 1 (2021) not providing information for 1/1000-year annual probabilities of exceedance. Therefore, the PGA has been derived in accordance with Section 6.2.3 of the Bridge Manual and NZS 1170.5. Corresponding displacements calculated for soil structures will be conservative due to PGA being weighted to a magnitude 7.5 earthquake.

In line with Section 5.1.2 of the Bridge Manual (NZTA, 2022) the Collapse Avoidance Limit State (CALS) has been derived by scaling the Damage Control Limit State (DCLS) return period factor (Ru) by 1.5. Similarly, the Serviceability Limit State (SLS) has been derived by scaling the DCLS return period factor (Ru) by 0.25.

Table 5 presents the seismic loadings for the design of the IL2 retaining walls adjacent to SH1.

Table 5: Seismic Design Loadings for Earth Retaining Structure

Design Event	Annual Probability of Exceedance	Return Period Factor (R_u)	Weighted Peak Ground Acceleration (g)	Effective Magnitude (M_w)
CALS	1/1500	1.5	0.50	7.5
DCLS	1/500	1.0	0.34	
SLS	1/25	0.25	0.08	

Table 6 presents the seismic loadings for the design of the IL3 subway and overpass structures.

Table 6: Seismic Design Loadings for Overpass Structure

Design Event	Annual Probability of Exceedance	Return Period Factor (R_u)	Weighted Peak Ground Acceleration (g)	Effective Magnitude (M_w)
CALS	-	1.95	0.66	7.5
DCLS	1/1000	1.3	0.44	
SLS	1/50	0.33	0.11	

9 Liquefaction and Cyclic Softening

9.1 Overview

Liquefaction describes the short-term loss of strength of a loosely packed coarse grained (cohesionless) soil below the water table during an earthquake or other dynamic loading. Liquefaction occurs when the soil particles are sheared and try to contract during dynamic loading, temporarily raising pore water pressures and reducing the effective stress between particles to near zero. This causes the affected soil to behave essentially like a liquid until the excess pore pressures are dissipated.

Liquefaction can have several significant effects where it occurs, including large lateral displacements (lateral spreading), post liquefaction settlements (due to the densification and loss of material to the surface) and potentially large and uneven settlement of shallow founded structures.

9.2 Liquefaction Risk

The geological map for the Christchurch area (Forsyth, P. J; Barrell, D. J. A; Jongens, R., 2008) indicates that dense alluvial materials are likely to continue beyond 100 m depth. The observed seismic performance during the Canterbury Earthquake Sequence (CES) has been described in the Rolleston Access Improvement – Preliminary Geotechnical Appraisal Report (Beca, 2024b) and found that there was no observed liquefaction or lateral spread in the site area.

Recent geotechnical investigations encountered dense to very dense alluvial soils from below the groundwater surface to depths of 30 m bgl, which predominantly consisted of gravel and cobbles with varying proportions of sands and silt. Investigation results within the boreholes consistently recorded SPT N blow counts of 50+. The downhole shear wave velocity (Vs) results typically indicated Vs of no less than 300 m/s, with average values greater than 500 m/s. Based on the depth to groundwater, and the density of the site soils, both SPT N and Vs based analyses indicate that the site has a negligible risk of liquefaction. Hence the site soils are not considered susceptible to lateral spread or liquefaction induced settlement.

10 Subway

10.1 Introduction

The subway is an approximate 28 m long structure that passes beneath SH1 Main South Road providing pedestrian access between Dunns Crossing Road and Walkers Road. During concept design, three different structural forms were considered for the proposed subway including a box culvert, a trapezoidal culvert and a bridge under the carriageway. Further information regarding the different options is discussed in detail within the Structures Options Report - Dunns Crossing Road Subway and Minor Structures (Beca, 2024c).

10.2 Proposed Structure

The chosen structure is a box culvert comprising precast concrete sections that can be segmentally constructed. Around the structure and adjacent to the approach ramps, cut slopes have adopted a batter angle of 1V:3H to accommodate planting / vegetation. If required slopes could be steepened but would need to be assessed during detailed design.

A concept sketch of the proposed subway is shown in Figure 4.

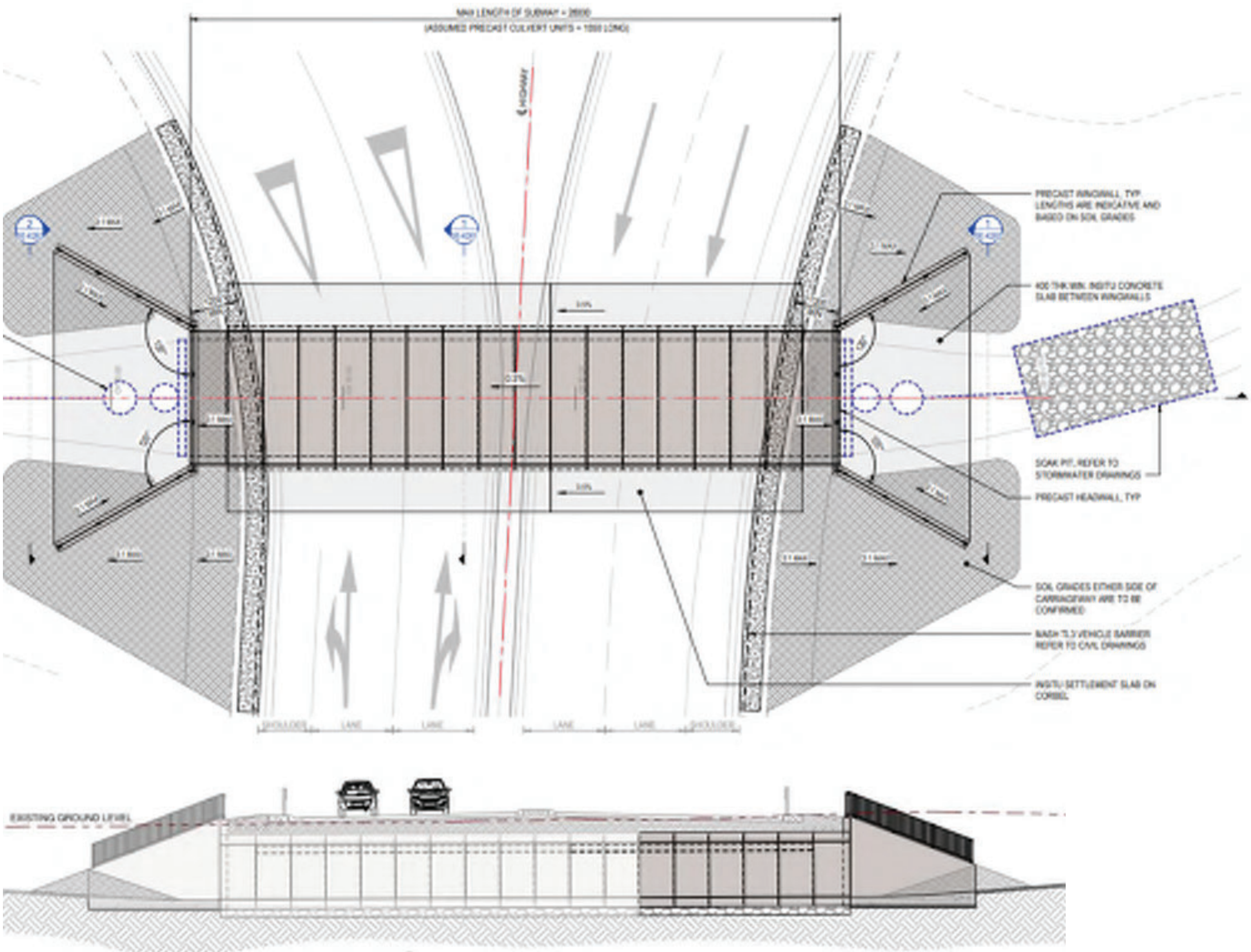

Figure 4: Subway Plan and Long Section

10.3 Foundation Design

10.3.1 Earth Pressure

The static earth pressures acting on the wingwalls was estimated based on the earth pressure coefficients by Eurocode7 NAVFAC (2004). The height of the wingwall considered was 3.7 m at the highest point with no sloping backfill behind the wingwall and Imported Engineered Fill (Unit A) soil parameters were used to derive the earth pressure coefficients. An interface friction coefficient of 0.67 was assumed for the concrete interface.

- K_a = 0.23
- K_o = 0.43

The seismic earth pressures for the wingwalls were calculated based on a stiff wall (Wood & Elms, 1990).

- DCLS = 95 kN/m
- CALS = 140 kN/m

An assessment for the maximum compaction pressures acting behind the culvert and wingwalls was undertaken following CIRIA C516 (2000). Assumptions for the loadings included:

- 1,500 kg vibratory roller
- Roller width of 1 m
- Imported Engineered Fill (Unit A) soil parameters
- Wall height of 3.7 m

The additional pressures induced by compaction loading behind the wingwall, in addition to the at-rest earth pressure, is estimated to be 24 kPa to a depth of 2.7 m. Below 2.7 m, only the at-rest earth pressure is acting.

10.3.2 Bearing Capacity

The box culvert will effectively replace the existing soil and is fully encased by the surrounding soils and proposed to be founded on 300 mm well compacted GAP65 structural fill overlying the dense to very dense gravels. As such, bearing capacity shear failure of the soils beneath the box culvert is not expected. A preliminary assessment of settlement has been carried out using the RocScience software Settle3 (version 5.023) to estimate the total settlement for static loading conditions and as a basis for estimating the modulus of subgrade reaction (soil springs).

10.3.3 Settlement

The box culvert dimensions of 28 m x 5 m x 4 m (length, width, depth) have been modelled in Settle3 software assuming a Boussinesq stress distribution. An indicative dead load of 21 kPa with live loading of 52 kPa was applied to the soil due to the box culvert loading which, based on the initial stiffness of the soil, resulted in less than 5 mm of settlement. However, as there is a net unloading for the box culvert (i.e. the soil weight removed during construction is more than the box culvert loading) the settlement due to culvert induced loading will be a function of the ‘rebound’ stiffness of the soil, which is expected to be small, less than the calculated 5mm.

10.3.4 Modulus of Subgrade Reaction

The modulus of subgrade reaction, also referred to as ‘soil springs’, is used by structural designers to model the load to deformation behaviour of soils. It is computed by comparing the ratio of imposed pressure on the soil, to the deflection of the soil. Based on the estimated settlement of 5 mm and indicative loading of 73 kPa, the modulus of subgrade reaction is estimated to be 14,600 kN/m^3. It is recommended that for design a value of 15,000 kN/m^3 is adopted and a sensitivity check on the structure considering 50% and 200% of this value is undertaken.

10.4 Subway Construction Considerations

Site won material could be reused as engineered fill around the box culvert and behind the wingwalls provided that it is appropriately selected and placed. Material larger than 65 mm should be screened and removed from fill that is to be placed below the box culvert and apron slab foundations. The native sandy gravels contain cobbles that may influence the layer thickness and plant needed to compact them and removal of these larger materials may be required.

We recommend that the fill intended to support structures be placed in horizontal lifts, not exceeding 200 mm in loose thickness, and be compacted to at least 95% of the maximum dry density, as determined by the heavy compaction test (NZS 4402:1986 Test 4.1.2). Structural fill (imported or site won) should be clean, well graded granular AP65 material and free of organics and debris. The Geotechnical Engineer should approve the fill material prior to placement.

An allowance for compaction and construction plant induced lateral loads will be included in the design of retaining structures. Location and situation-specific loading conditions estimated to be higher than the above, such as heavy crane loads near temporary cuts, will need to be considered individually by the Contractor, as appropriate.

All construction plant, and all other vehicles having a mass exceeding 1,500kg shall be kept at least 2 m away from the back of the culvert and wingwall facing. Within 2 m of the culvert and wingwall facing, the plant used for compacting the fill material shall be restricted to:

- Vibrating rollers having a mass per metre width of roll not exceeding 1,300kg with total mass not exceeding 1,500 kg
- Vibrating plate compactors having a mass not exceeding 300 kg
- Vibro tampers having a mass not exceeding 75 kg

11 Overpass

11.1 Introduction

The overpass is an approximate 100 m long three-span bridge crossing over SH1 between Rolleston Drive and Jones Road. During concept design, the foundation options considered for the proposed overpass included bored reinforced concrete piles, driven steel piles and shallow raft foundations. Further information regarding the different options is discussed in detail within the Structures Options Report - Overpass Rolleston Access Improvements (Beca, 2024d). A Mechanically Stabilised Earth (MSE) wall is proposed at both ends of the bridge to minimise the area needed to form the approach embankments. The MSE wall is independent of the bridge abutments, which are supported on piles.

11.2 Proposed Foundation

The chosen foundation solution comprises 1500 mm diameter bored reinforced concrete piles at the piers and southern abutment, and a 1200 mm diameter bored reinforced concrete pile at the northern abutment to meet the structural demands. A concept sketch of the proposed long section for the site is shown in Figure 5.

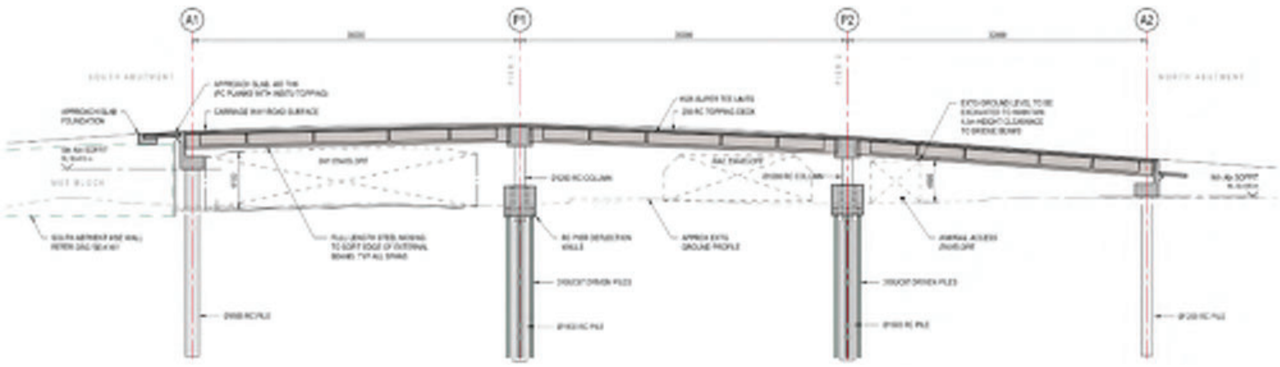

Figure 5: Overpass Long Section

The preliminary structural axial compressive demands are presented in Table 7. The axial compressive demands are taken at the top of the pile (close to ground level) for both the pier and abutment piles and do not account for pile self-weight.

Table 7: Preliminary Structural Axial Loads

	South Abutment	South Pier	North Pier	North Abutment
Pile diameter	1,500 mm	1,500 mm	1,500 mm	1,200 mm
SLS axial load	4,520 kN	8,090 kN	7,510 kN	4,200 kN
ULS axial load	6,910 kN	11,360 kN	10,430 kN	5,820 kN

11.3 Foundation Design

11.3.1 Pile Axial Compressive Capacity

An assessment of the axial compressive capacity has been undertaken using the CivilTech software AllPile (version 7.23a) for the proposed bored pile sizes (1200 mm and 1500 mm). The following assumptions were adopted for the assessment:

- Permanent steel casing was modelled (δ=20º).
- A single pile was modelled and group effects have not been considered.
- The top 2 m of skin friction was ignored to account for soil disturbance during construction.
- Maximum unit end bearing in dense gravels was limited to 12 MPa (API, 2002).

No liquefaction-induced settlement or settlement from the consolidation of the soils beneath the approach embankments / MSE walls is expected based on an assumed construction sequence (which will be confirmed during detailed design). Hence over the design life of the structure, down drag loads have not been considered in the current design of the piles.

The axial compressive capacity considers both skin friction and end bearing for both static and seismic cases and is dependent on careful construction of the piles. The design case at SLS is governed by the tolerable (SLS) settlement being limited to 25mm and at this limited displacement the mobilised axial capacity is less than the ultimate. No strength reduction factor has been applied to the SLS capacity as the method followed a displacement-based design approach. It is recommended that the sensitivity of the structural design be checked against a range of SLS capacities based on the range of soil stiffnesses given below. A geotechnical strength reduction factor of 0.56 in accordance with AS2159 (2009) is to be applied to the ULS capacities for comparison with Load and Resistance Factor Design (LRFD) based demands.

For the SLS cases, it is recommended that vertical p – delta curves (springs) be modelled beneath each pile. The spring stiffness can be derived by dividing the capacity by the estimated settlement including a sensitivity check considering a range of 50% to 200% of the settlement. It is recommended that the difference in spring stiffness be considered between spans, and transversely on a single pile across the row of piles at a pier or abutment to thoroughly assess the potential effect of differential settlement.

The assessed geotechnical axial compressive capacity compared against the pile demands calculated for preliminary design are shown in Table 8.

Table 8: Preliminary Geotechnical Pile Axial Compressive Capacity Summary

Detail	Pile Location		
	North Abutment	South Pier	North Pier and South Abutment
Minimum Pile Length (m)	15	18.5	15
Pile Diameter (mm)	1,200	1,500	1,500
Critical Factored Structural Axial Demand[1] (kN)	**4,200 (SLS)** **5,820 (ULS)**	**8,090 (SLS)** **11,360 (ULS)**	**7,510 (SLS)** **10,430 (ULS)[5]**
Unfactored Pile Weight (kN)	360	660	565
Factored Pile Weight[2] (kN)	360 (SLS) 490 (ULS)	660 (SLS) 890 (ULS)	565 (SLS) 763 (ULS)
Unfactored Skin Friction (kN)	1,100	2,000	1,370
Unfactored Tip Resistance (kN)	13,570	21,200	21,200
SLS capacity (kN) - limiting displacement to 25mm	6,420	8,780	8,475
Factored ULS Capacity[3] (kN)	8,210	12,995	12,640
Dependable Capacity[4] (kN)	**6,060 (SLS)** **7,730 (ULS)**	**8,120 (SLS)** **12,100 (ULS)**	**7,910 (SLS)** **11,880 (ULS)**

Notes:
[1] Structural demand provided by the Structural Engineer excludes pile self-weight.
[2] Pile weight load factor of 1.0 for SLS and 1.35 for ULS.
[3] Strength reduction factor of 0.56 for the ULS case has been applied.
[4] Dependable capacity determined by the difference in capacity and factored pile self-weight for SLS and ULS cases.
[5] Critical factored structural axial demand for North Pier.

11.3.2 Lateral Pile/Bridge Design

Preliminary pile lateral capacity has been assessed using non-linear springs derived by P-Y (horizontal force/displacement) curves generated within the Ensoft LPile 2022 software package to represent both elastic stiffness and lateral capacity. These springs will be used by the Structural Engineers to model pile response in structural analysis software.

The soil profile was modelled using the Sand (Reese, et al., 1974) with nonlinear springs derived for a 1200 mm diameter and a 1500 mm diameter pile at vertical spacing of 1 m assuming no group effects. The proposed P-Y curves have been supplied to the Structural Engineer and a sensitivity check on stiffness considering 50 to 200% was recommended. The springs provided were for preliminary design use and further development of these springs may be required during detailed design as structural design develops.

11.4 MSE and Approach Embankments

11.4.1 Introduction

For the purposes of the current preliminary phase of design simplifying assumptions have been made regarding the configuration and characteristics of the approach embankments and MSE walls and slopes. The intent is to allow the design to progress with due regard for geotechnical considerations.

As the design develops it will be necessary to review these assumptions and confirm the final details. For example, assumptions have been made regarding the MSE walls, however these may be a design-build element that would need to be designed by the supplier.

11.4.2 Settlement

A preliminary settlement analysis for the approach embankments was undertaken using the RocScience software Settle3 (Version 5.023) to estimate their total settlement. The estimated total settlement is less than 25 mm, with immediate settlement typically taken to be 90% of the total in coarse grained soils. A nominal amount of consolidation settlement is anticipated for the site. Whilst the estimated total settlement is relatively low, there is potential for cyclic loading, such as from vehicles, vibration and/or thermal effects. Cyclic loading can cause additional settlement up to 1.5 times the total settlement (Burland & Burbidge, 1985).

11.4.3 Global Slope Stability

11.4.3.1 General Approach

The global slope stability assessment was conducted in accordance with the Bridge Manual with design loads of 12kPa for normal static case and 24kPa for overload static case. Limit equilibrium slope stability analyses were performed using GeoStudio Slope/W (2024.2.0) software package and the Morgenstern-Price method. A pseudo static approach was adopted for modelling seismic loading.

Seismic induced slope displacements are assessed by comparing the critical (yield) PGA to the design PGA. The 50th percentile displacement is assessed under DCLS and CALS loading in accordance with the Bridge Manual. The displacements have been assessed by taking the upper bound of the following methods by:

- Jibson (2007)
- Ambraseys & Menu (1988)
- Ambraseys & Srbulov (1995)

The focal depth and source distance for the Ambraseys & Srbulov (1995) method was assumed to be 6 km and 24 km for the Canterbury Earthquake Region, respectively.

11.4.3.2 Design Cases and Design Loads

Table 9 provides a summary of the design cases and loads assessed as part of the limit equilibrium analysis.

Table 9: Slope Stability Design Cases

Design Case	Target Factor of Safety	Description
Static – Long Term	1.5	Long-term operational conditions encountered by the MSE structure, approach embankments and reinforced slopes. These include normal traffic loads (12 kPa) and long-term water levels (9.5 m bgl). Effective stress parameters are used for all materials.
Static – Short Term	1.2	Short-term analysis of conditions encountered on an irregular basis. These include oversized traffic loads (24 kPa), or potential construction works as well as extreme hydrological conditions associated with flood events (assumed groundwater rises to 0.5 m bgl). Effective stress parameters are used for all materials.
Seismic	1.0 or displacement-based approach if < 1.0	A pseudo-static seismic analysis undertaken with the design peak horizontal ground acceleration, as described in Section 8.

11.4.3.3 Geogrid Reinforcing

Geosynthetic reinforcing is proposed within the embankments and behind the abutment to improve stability where there is insufficient space to construct an unreinforced slope. For preliminary design and modelling purposes Tensar RE580 has been adopted as the geosynthetic reinforcing and has been modelled in Slope/W considering the inbuilt reinforcing parameters. The choice of reinforcing will need to be reviewed and confirmed during detailed design. Slope modelling inputs for the reinforcing are:

- Ultimate tensile capacity = 137 kN/m
- Geogrid reinforcing installed within imported engineered fill
- Geogrid layers spaced at 0.5 m vertical centres
- Geogrid length of 8 m

11.4.3.4 Slip Surface Locations

Slope stability analyses have assessed both longitudinal and transverse sections at the southern abutment where the MSE wall is proposed. Circular slip surfaces have been used and the analyses have considered local failures in front of the abutment, as well as larger global failures. The transverse section considered a stormwater basin located 2 m away from the MSE wall, featuring a berm with a batter angle of 1V:3H.

11.4.3.5 Slope Stability Assessment Results

Table 10 summarises the results of the global slope stability assessment in the longitudinal and transverse sections, and the local slope stability for the longitudinal section. Output from critical slope stability slip circles are presented in Appendix C.

Table 10: Slope Stability Analysis Results

Load Case	Min Factor of Safety (FoS)	Seismic Induced Displacement Limit	Slope/W FoS
Global Longitudinal – 8m geogrid length			
Static – HN	1.5	-	2.1
Static – HO	1.2	-	2.0
Seismic – SLS 0.11g	1.0	-	1.7
Seismic – DCLS 0.44g	1.0	-	1.0
Seismic CALS – 0.66g	-	50 mm	0.7 [<10 mm]
Seismic – Yield PGA	-	-	0.44g
Global Transverse			
Static – HN	1.5	-	2.1
Static – HO	1.2	-	2.0
Static - Flood	1.2	-	1.8
Seismic – SLS 0.11g	1.0	-	1.7
Seismic – DCLS 0.44g	1.0	-	1.0
CALS – 0.66g	-	50 mm	0.7 [<10 mm]
Seismic – Yield PGA	-	-	0.44g
Local Longitudinal – 8m geogrid length			
Static – HN	1.5	-	2.6
Static – HO	1.2	-	2.8
Seismic – SLS 0.11g	1.0	-	2.3
Seismic – DCLS 0.44g	1.0	-	1.3
Seismic CALS – 0.66g	1.0	-	1.0
Seismic – Yield PGA	-	-	-

[ ] values in parentheses are the seismic induced displacements.

11.4.4 Internal Stability

A preliminary assessment for the internal stability of the MSE wall was undertaken in Slope/W including 'local' slip surfaces and the results are captured in Table 10. Based on the geogrid vertical spacing of 0.5 m and the specified ultimate tensile strength of the geogrid (137 kN/m), the factors of safety indicate adequate internal stability of the MSE wall. However, this will need to be reviewed and confirmed during detailed design as the internal stability depends on the facing unit for the MSE wall and geogrid adopted for construction.

11.5 Overpass Construction Considerations

- Bored cast-in-situ piles are typically constructed by drilling a hole supported by either temporary casing or a support fluid (bentonite or similar), installing reinforcement and then placing concrete through a tremie into the base of the hole, displacing the drilling fluid in the process. Experience from previous construction of such piles in New Zealand has shown that the risk of hole instability through alluvial soils (especially below the groundwater table) is significant when adopting a temporary casing or support fluid approach, and permanent casings provide a more reliable outcome, although the steel / soil interface has a corresponding reduction in shaft friction.
- The contractor's methodology will need to consider, as necessary, the advancement of the casing through dense gravels. The effects from noise and vibration during construction will need to be addressed and adverse effects on any adjacent works or properties managed. This includes the installation and withdrawal of any proposed temporary works or staging that the contractor would install to facilitate construction of the bridge.
- During casing installation, cobbles, boulders or other obstructions could be encountered that hinder advancement of the casing.
- A precast driven plug at the pile toe during driving of the steel casing (if adopted) with associated Pile Driver Analysis (PDA) would provide a reliable means of proving end bearing.
- It is recommended that excavated soils within the bored pile be logged by a suitably qualified and experienced individual to confirm an appropriate pile termination depth.
- To achieve the design outcomes it is necessary that the base and steel casing of bored piles be cleaned of loose and otherwise unsuitable material and that this be confirmed prior to placement of concrete.
- Undercutting of unsuitable surficial material may be required prior to embankment construction.
- Two samples were taken from the boreholes; one above the groundwater at depth 4.7 m bgl and one below the groundwater at depth 15.1 m bgl. Samples were tested for soil pH, chloride content and electrical conductivity. The results are summarised in the Rolleston Access Improvement – Geotechnical Factual Report (Beca, 2024a). The results indicate the soil condition is non-corrosive in accordance with SNZ TS 3404:2018.

12 Noise Bund Retaining Wall

12.1 Background

Retaining walls are proposed into an existing noise bund parallel to the southbound lane of SH1 to facilitate widening of the road. Timber post and panel retaining walls are proposed at the required locations. Timber walls were selected based on a high level, qualitative assessment of value-for-money; improved sustainability compared to concrete or steel options; and to facilitate a wall form that can be constructed in a spatially constrained area between SH1 and adjacent property boundaries.

A formal departure will be required from NZTA to accept the use of timber retaining walls for the project, as the design life of timber is assessed to be less than the 100-year design life required by the Bridge Manual (NZTA, 2022). For this project, a reduction to a 50-year design working life is proposed to enable the use of H5 treated timber pole and rail retaining walls. The use of timber pole retaining walls aligns with the intent and examples presented within the ‘NZTA Standardised Design solutions for use on State Highway Roads of National Significance’ (NZTA, 2024).

The currently proposed timber pole walls are considered IL2 structures with retained heights no greater than 1.5 m. Some lengths of the walls will be over 1 m in height and hence, to meet typical design requirements, would require fall protection. However, where the walls are less than 1m high fall protection would not be required.

The area above the walls is relatively inaccessible, being constrained between SH1 and a fence abutting private properties. It is currently densely vegetated and the intention is to re-establish vegetation above the retaining walls along the noise bund, which would require minimal maintenance.

At present it is proposed that consideration be given to omitting fall protection along the top of the walls and this will be discussed with NZTA Waka Kotahi. To mitigate the risk of unplanned visits in these areas, end fences could be constructed. Where temporary planned work is required, specific job safety measures could be adopted to mitigate the fall from height risk.

12.2 Cantilever Wall Design

The locations and typical dimensions of the timber pole retaining walls are summarised in Table 11. Dimensions are based on the preliminary design and will need to be reviewed and confirmed in the next design stage.

Table 11: Retaining Wall Summary

Work Package	SH Route Position (RP) RP-01S-0365	Length (m)	Typical Retaining Wall Height (m)
Package 1	5.148 to 5.565	17	1.5
Package 2	2.005 to 2.065	60	1.0
Package 2	1.460 to 1.565	105	1.5

The cantilever retaining wall analysis was carried out using Geosolve software WALLAP. Design of the timber pole and lagging was undertaken in accordance with NZS AS 1720.1:2022 and load factors from the Bridge Manual (NZTA, 2022). For preliminary design a critical cross section was assessed that considered:

- A retained height of 1.5 m
- The weight from a further 0.5 m of fill above the wall to reflect the increased height of the noise bund
- No live loading above the top of the wall

- A factor of safety on the embedment depth of the pole > 1.5, and deflection at the top of the wall < 20 mm for permanent static load cases
- A factor of safety on the embedment depth of the pole > 1.0, and deflection at the top of the wall < 150 mm for temporary seismic load cases

Based on the assessment of the critical cross section, the design requires 200 mm small end diameter (SED) high density timber poles installed at 1.2 m centre-to-centre spacing. An overall minimum pole length of 3.6 m was assessed with an embedment depth of 2.1 m bgl, founded within a 400 mm diameter bored hole and concreted in place.

For the design features given above, the typical retained height has been considered over the full length of the wall, however, wall heights can be refined during detailed design, with embedment depths reduced where the retained height decreases.

A temporary cut will need to be formed behind the proposed retaining walls to provide sufficient space for construction. The Contractor will need to determine a safe batter angle as part of their temporary works but this will be restricted from crossing the adjacent private property boundary or affecting the existing fencing along the crest of the noise bund. Temporary supports may be required by the Contractor if batter angles are expected to cross the boundaries of private property. Material removed during the temporary cuts could be retained and reused as site won backfill behind the retaining walls; unsuitable and excess material can be cut-to-waste.

13 Pavement Design

Scala Penetrometer / Dynamic Cone Penetrometer blow counts across the site range from 2 to 30 blows per 100 mm. The subgrade can be split into two typical zones, greenfield or virgin ground and pavement pit subgrade. Under the existing pavement is a horizon of lower subbase dense fill underlain by the natural gravel subgrade. The natural gravel subgrade was typically encountered between 0.5 to 0.7 m bgl which recorded typical Scala blow counts of between 3 to 8 per 100 mm.

The greenfield locations have typically lower Scala blow counts due to the presence of silty sandy topsoil. Below the top 200 to 300 mm of topsoil typical Scala blow counts of 3 to 8 per 100 mm were recorded.

Based on the Scala blow counts for the gravel, below any surficial soils, a CBR of 8% can be adopted for pavement design.

14 Applicability

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

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A

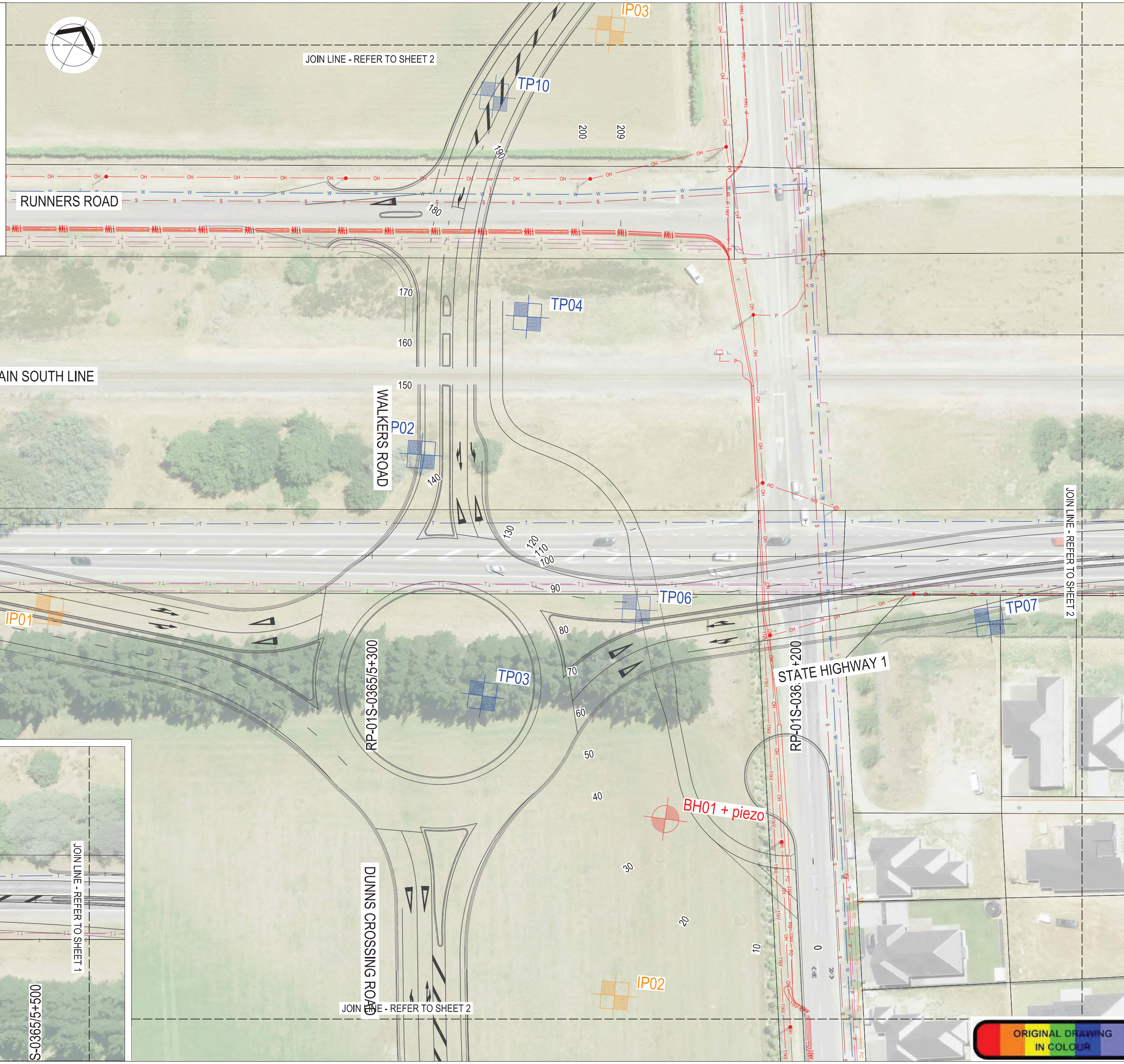
Appendix A – Investigation Location Plan

TESTING LEGEND

PP	PAVEMENT PIT - TO 1m BGL
TP	TEST PIT
IP	INFILTRATION PIT - to 4m max BGL
ST	EXISTING SOAK PIT INFILTRATION TEST
BH	BOREHOLE
UT	UTILITY TRENCH BY CORDE

LEGEND

BOUNDARY	
EXISTING SERVICES	
OVERHEAD POWER	OH
11kV UG POWER	11kV
ORION UG	P
ENABLE	FO
CHORUS	T
ONE NZ	T
WATER MAIN	W
STORMWATER	SW
SEWER	S
STOCK WATER RACE	WR
DUCT	
POWER POLE	
STREET LIGHT	
ENABLE CHAMBER/DROP DUCT	



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B	FINAL - FOR INVESTIGATION	BP	RY	DA	13.03.24
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D	UPDATED PIT LOCATION - POST INVESTIGATION	RA	NY	RY	02.10.24

Original Scale (A1)	1:500	Design	B. PETERSON 12.03.24
		Drawn	R. ANDERSON 12.03.24
Reduced Scale (A3)	1:1000	Dsg Verifier	R. YOUNG 12.03.24
		Dwg Check	M. HARRIS 12.03.24

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Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 1 OF 14

Discipline: CIVIL ENGINEERING

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TESTING LEGEND

- PP — PAVEMENT PIT - TO 1m BGL
- TP — TEST PIT
- IP — INFILTRATION PIT - to 4m max BGL
- ST — EXISTING SOAK PIT INFILTRATION TEST
- BH — BOREHOLE
- UT — UTILITY TRENCH BY CORDE

LEGEND

BOUNDARY

EXISTING SERVICES

OVERHEAD POWER	OH
11kV UG POWER	11kV
ORION UG	P
ENABLE	FO
CHORUS	T
ONE NZ	T
WATER MAIN	W
STORMWATER	SW
SEWER	S
STOCK WATER RACE	WR
DUCT	
POWER POLE	
STREET LIGHT	
ENABLE CHAMBER/DROP DUCT	

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TESTING LEGEND

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- TP — TEST PIT
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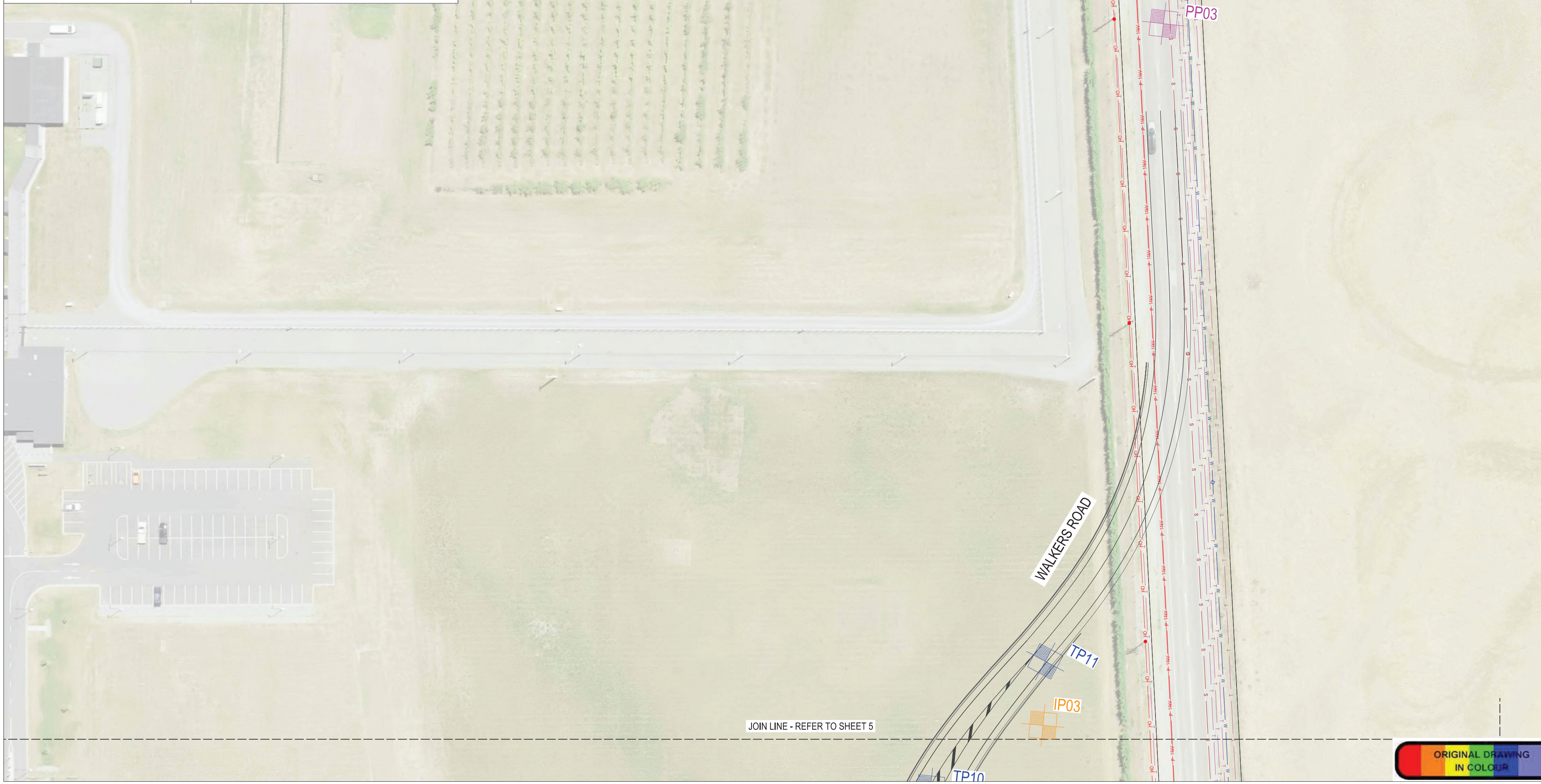
- ST — EXISTING SOAK PIT INFILTRATION TEST
- BH — BOREHOLE
- UT — UTILITY TRENCH BY CORDE

LEGEND

BOUNDARY

EXISTING SERVICES

- OVERHEAD POWER (OH)
- 11kV UG POWER (11kV)
- ORION UG (P)
- ENABLE (FO)
- CHORUS (T)
- ONE NZ (T)
- WATER MAIN (W)
- STORMWATER (SW)
- SEWER (S)
- STOCK WATER RACE (WR)
- DUCT
- POWER POLE
- STREET LIGHT
- ENABLE CHAMBER/DROP DUCT



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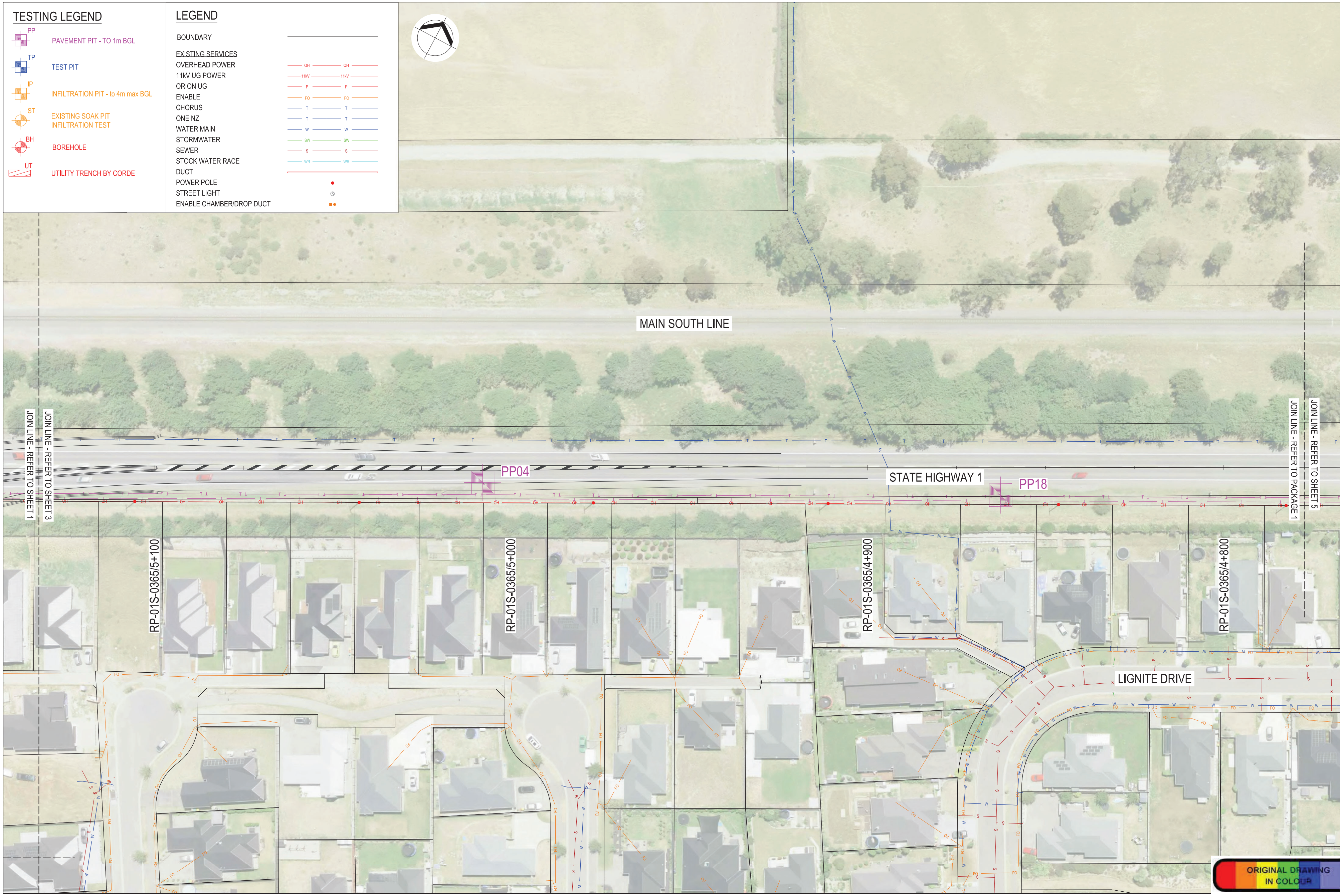

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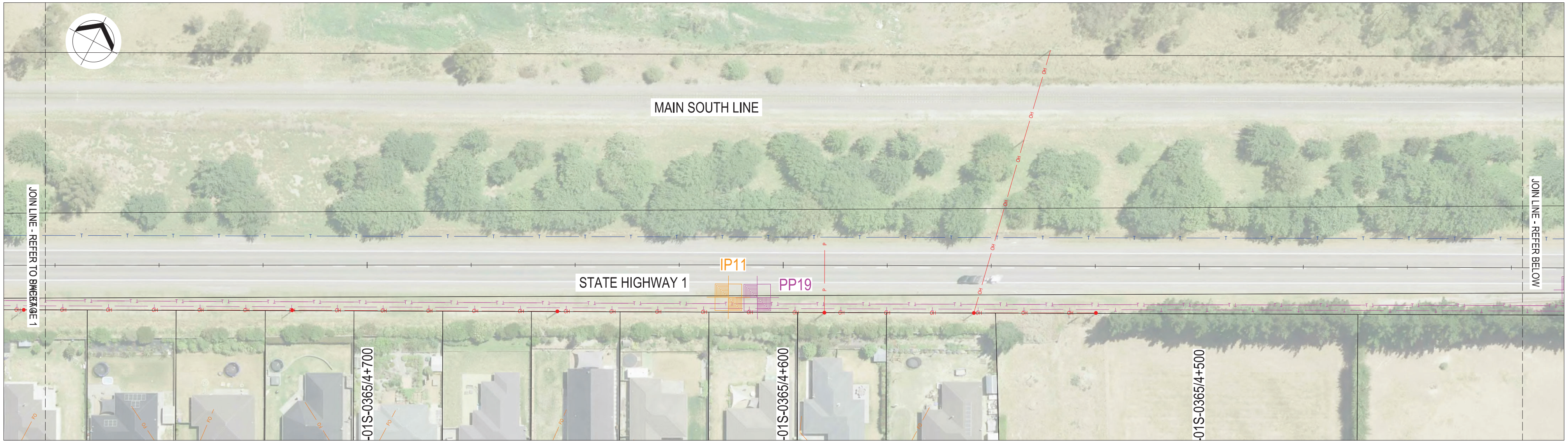

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LEGEND

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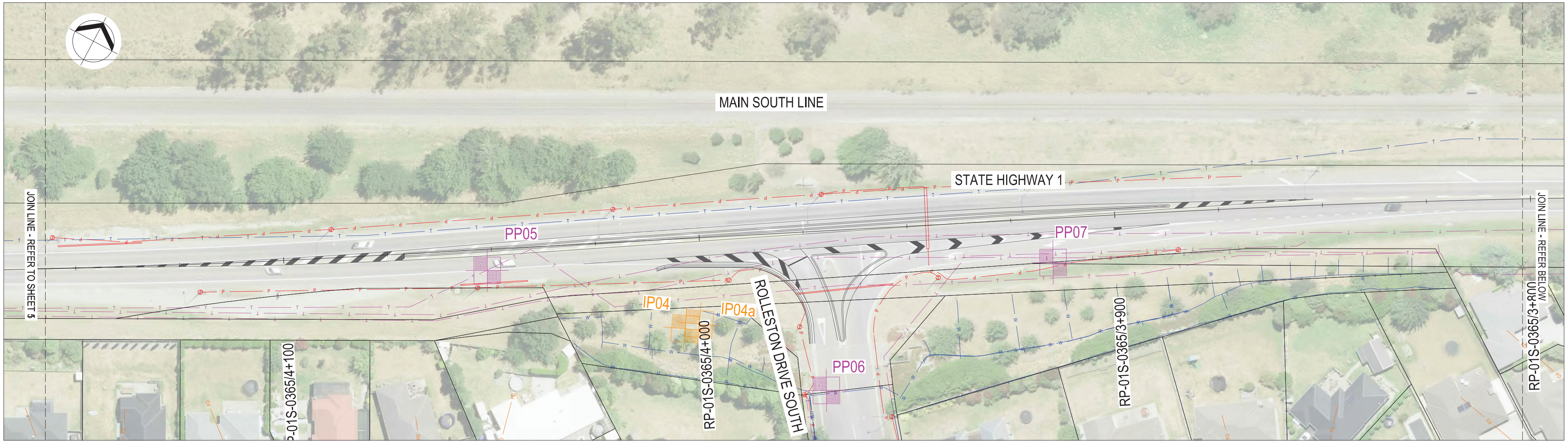

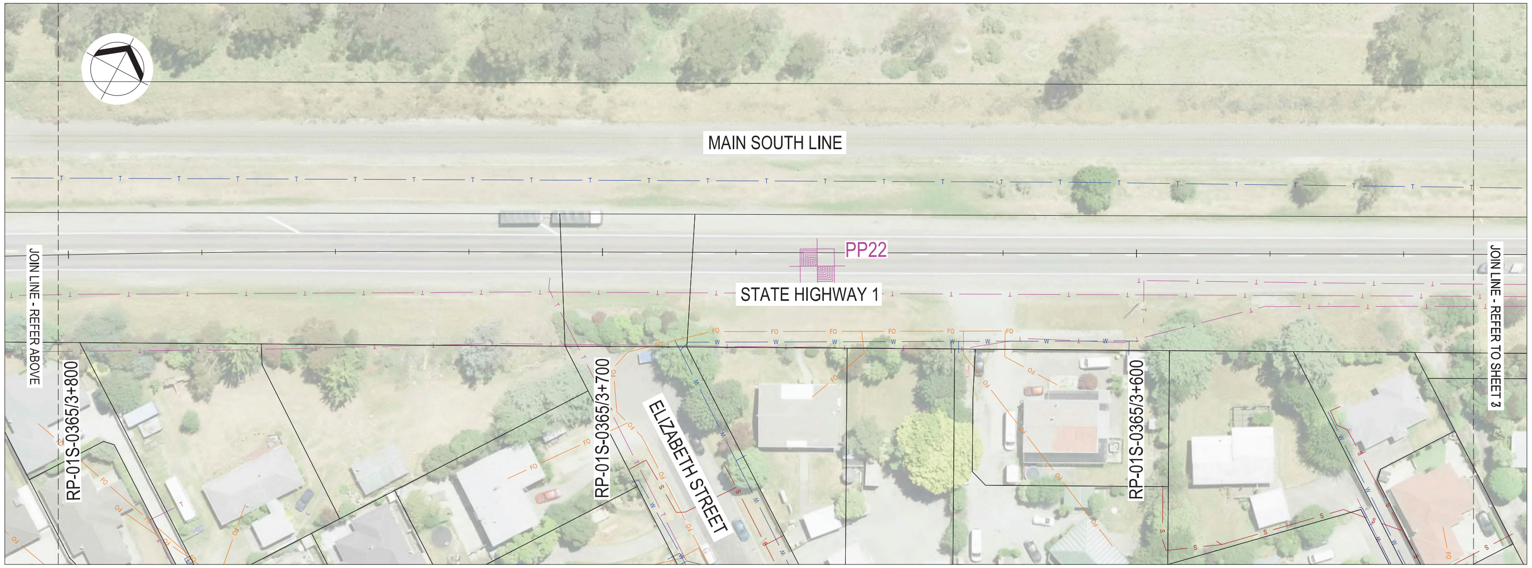

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Original Scale (A1) 1:500	Design	B. PETERSON	12.03.24
	Drawn	R. ANDERSON	12.03.24
Reduced Scale (A3) 1:1000	Dsg Verifier	R. YOUNG	12.03.24
	Dsg Check	M. HARRIS	12.03.24

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Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 6 OF 14

Discipline: CIVIL ENGINEERING

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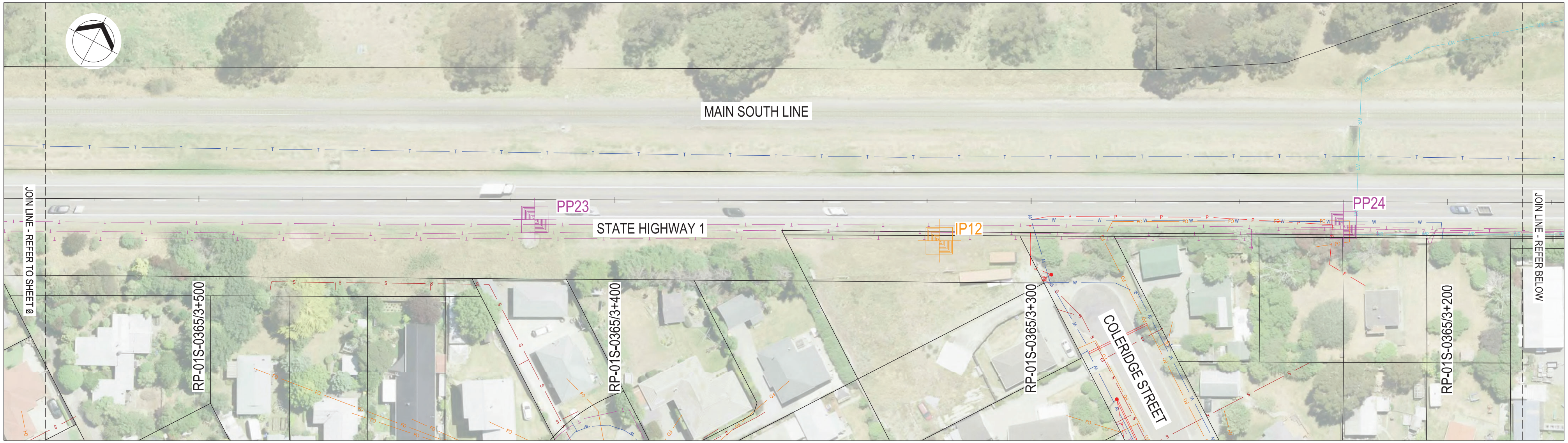

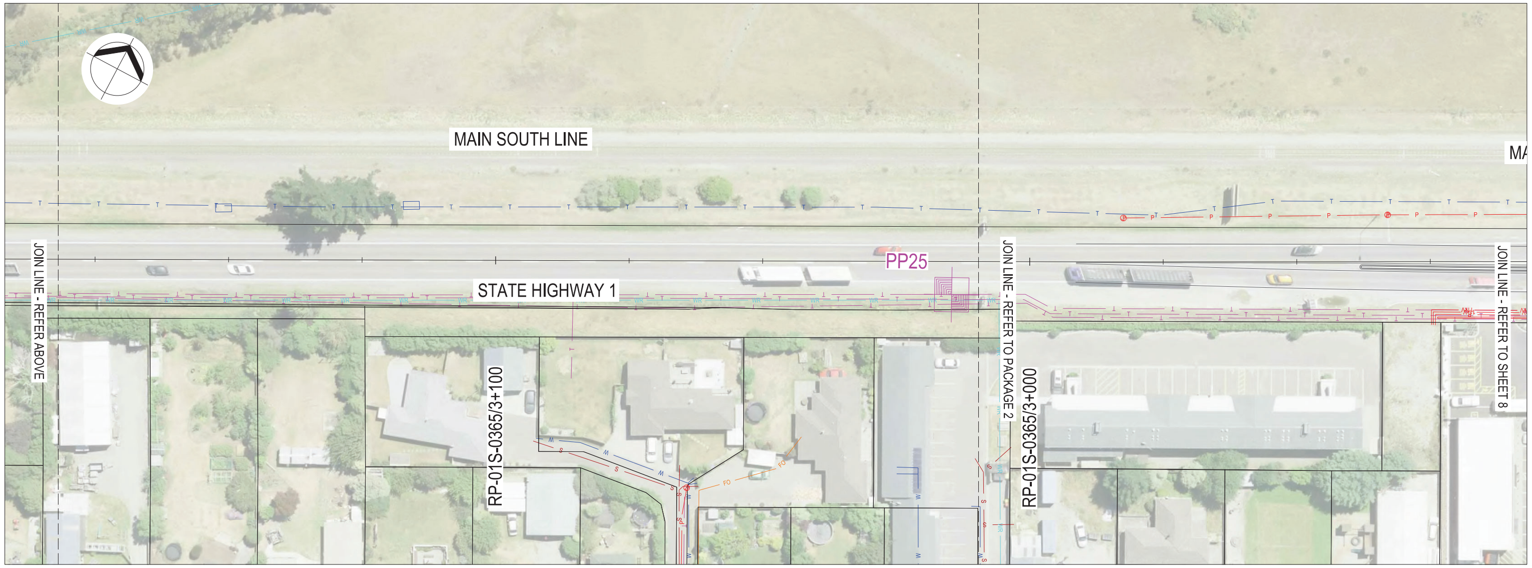

TESTING LEGEND

- PP – PAVEMENT PIT - TO 1m BGL
- TP – TEST PIT
- IP – INFILTRATION PIT - to 4m max BGL
- ST – EXISTING SOAK PIT INFILTRATION TEST
- BH – BOREHOLE
- UT – UTILITY TRENCH BY CORDE

LEGEND

BOUNDARY

EXISTING SERVICES

- OVERHEAD POWER (OH)
- 11kV UG POWER (11kV)
- ORION UG (P)
- ENABLE (FO)
- CHORUS (T)
- ONE NZ (T)
- WATER MAIN (W)
- STORMWATER (SW)
- SEWER (S)
- STOCK WATER RACE (WR)
- DUCT
- POWER POLE
- STREET LIGHT
- ENABLE CHAMBER/DROP DUCT

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Design	B. PETERSON	12.03.24	Approved For Construction*
Drawn	R. ANDERSON	12.03.24	
Dsg Verifier	R. YOUNG	12.03.24	
Drg Check	M. HARRIS	12.03.24	Date

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Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 7 OF 14

Discipline: CIVIL ENGINEERING

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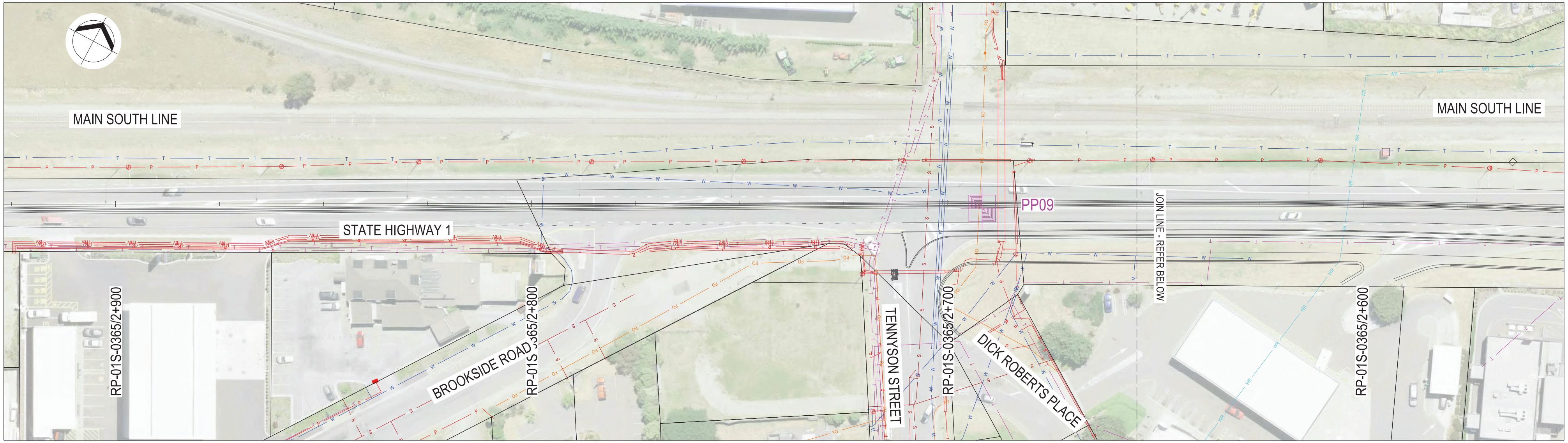

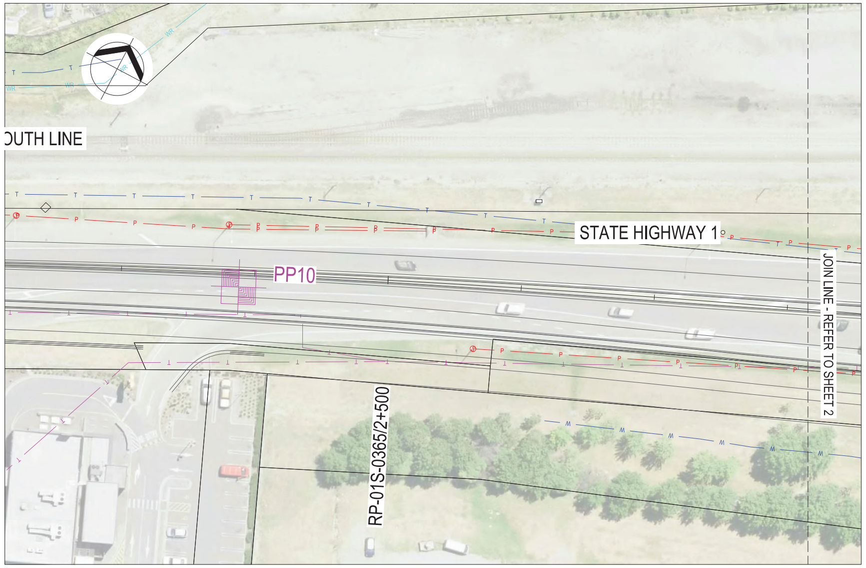

TESTING LEGEND

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TP	TEST PIT
IP	INFILTRATION PIT - to 4m max BGL
ST	EXISTING SOAK PIT INFILTRATION TEST
BH	BOREHOLE
UT	UTILITY TRENCH BY CORDE

LEGEND

BOUNDARY	
EXISTING SERVICES	
OVERHEAD POWER	OH
11kV UG POWER	11kV
ORION UG	P
ENABLE	FO
CHORUS	T
ONE NZ	T
WATER MAIN	W
STORMWATER	SW
SEWER	S
STOCK WATER RACE	WR
DUCT	
POWER POLE	
STREET LIGHT	
ENABLE CHAMBER/DROP DUCT	

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Reduced Scale (A3) 1:1000	Dsg Verifier	R. YOUNG	12.03.24
	Drg Check	M. HARRIS	12.03.24

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Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 8 OF 14

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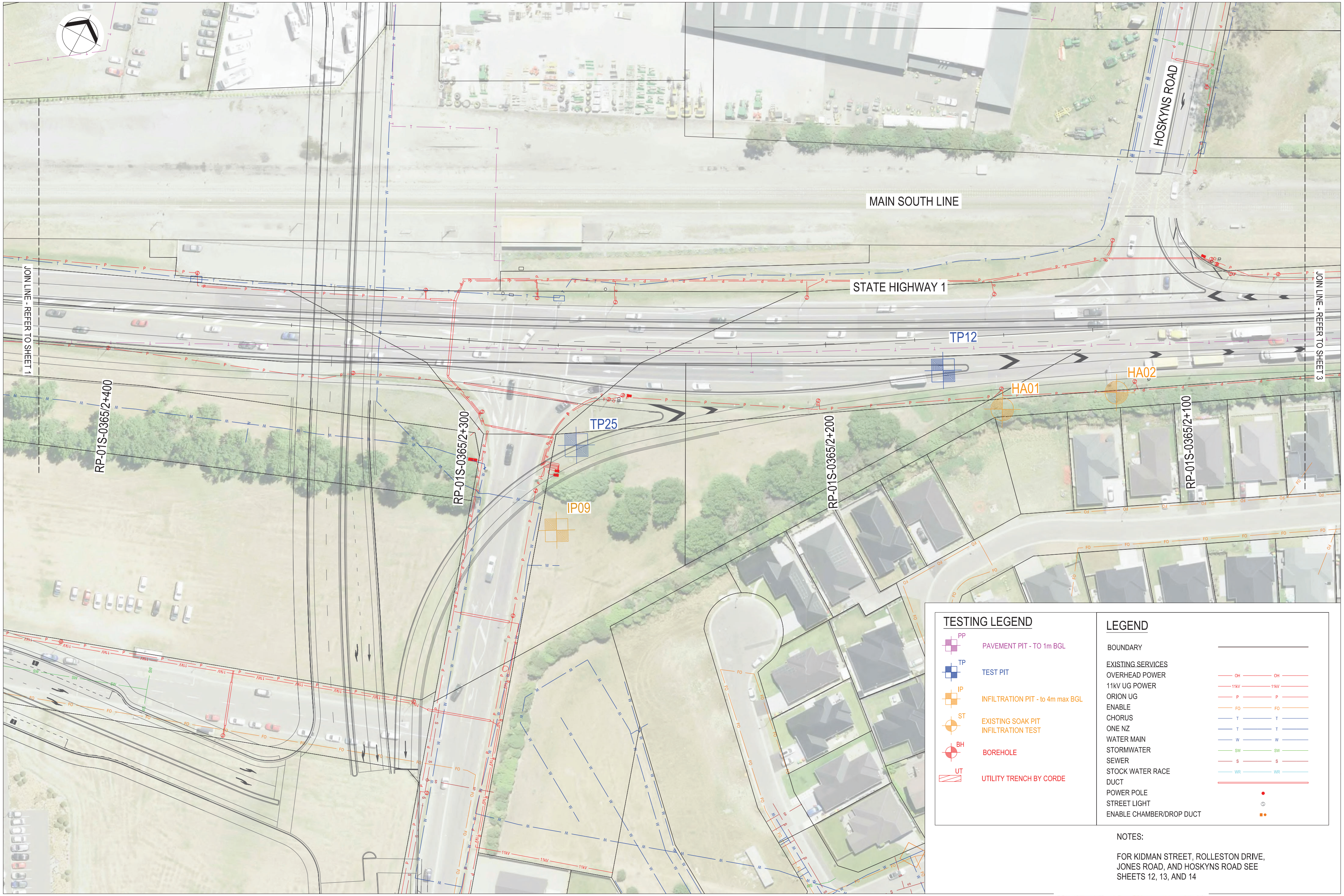

NOTES:

FOR KIDMAN STREET, ROLLESTON DRIVE, JONES ROAD, AND HOSKYNS ROAD SEE SHEETS 12, 13, AND 14

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Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 9 OF 14

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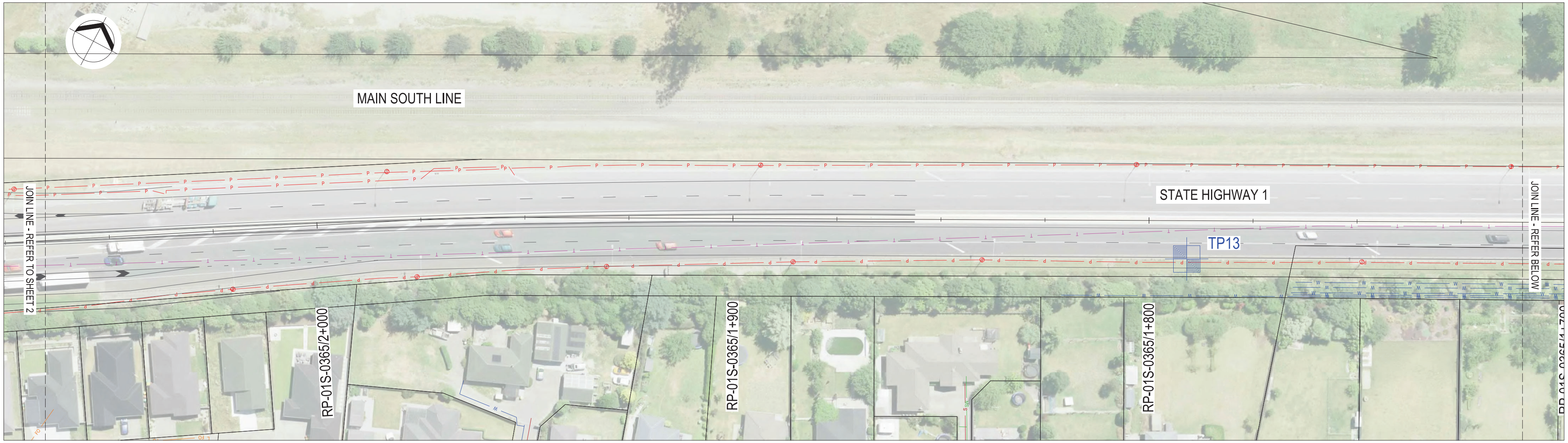

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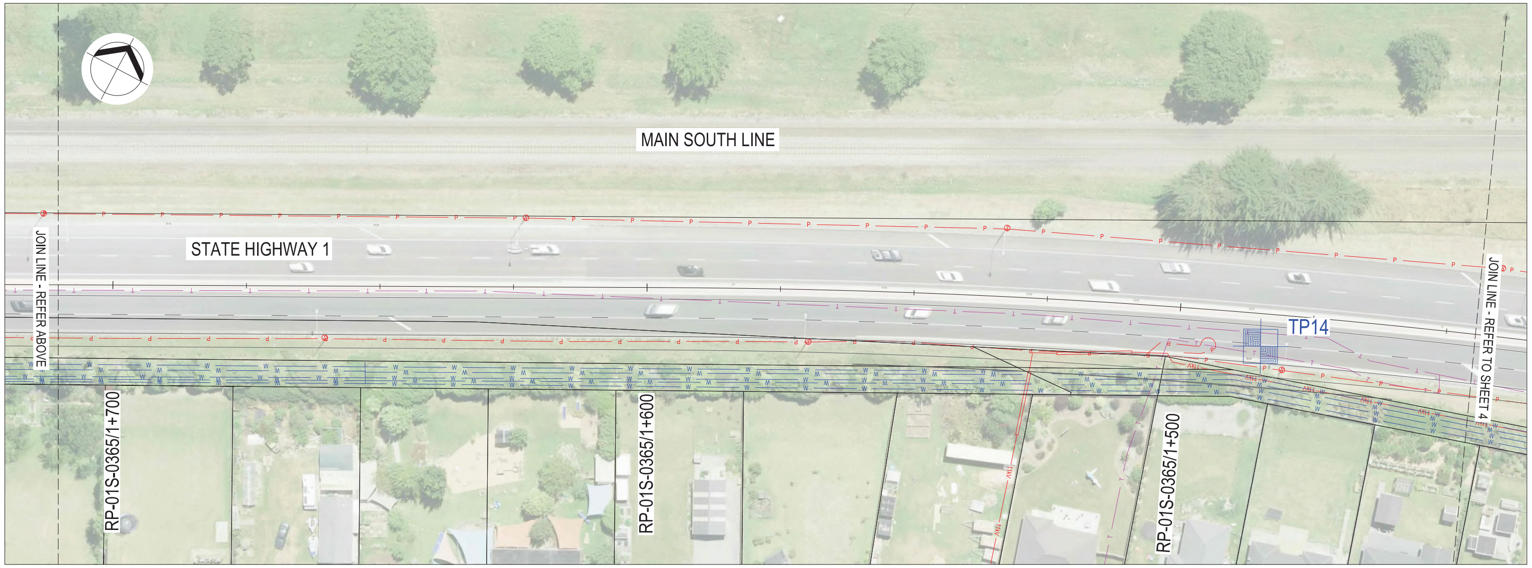

TESTING LEGEND

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- TP — TEST PIT
- IP — INFILTRATION PIT - to 4m max BGL
- ST — EXISTING SOAK PIT INFILTRATION TEST
- BH — BOREHOLE
- UT — UTILITY TRENCH BY CORDE

LEGEND

BOUNDARY

EXISTING SERVICES
- OVERHEAD POWER (OH)
- 11kV UG POWER (11kV)
- ORION UG (P)
- ENABLE (FO)
- CHORUS (T)
- ONE NZ (T)
- WATER MAIN (W)
- STORMWATER (SW)
- SEWER (S)
- STOCK WATER RACE (WR)
- DUCT
- POWER POLE
- STREET LIGHT
- ENABLE CHAMBER/DROP DUCT

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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 10 OF 14

Discipline: CIVIL ENGINEERING

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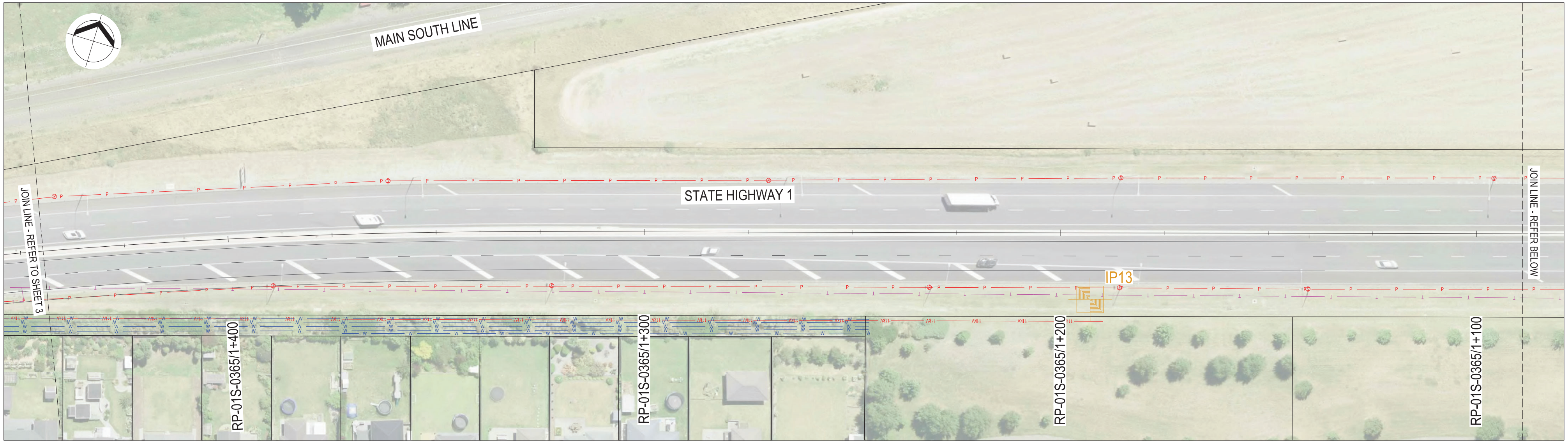

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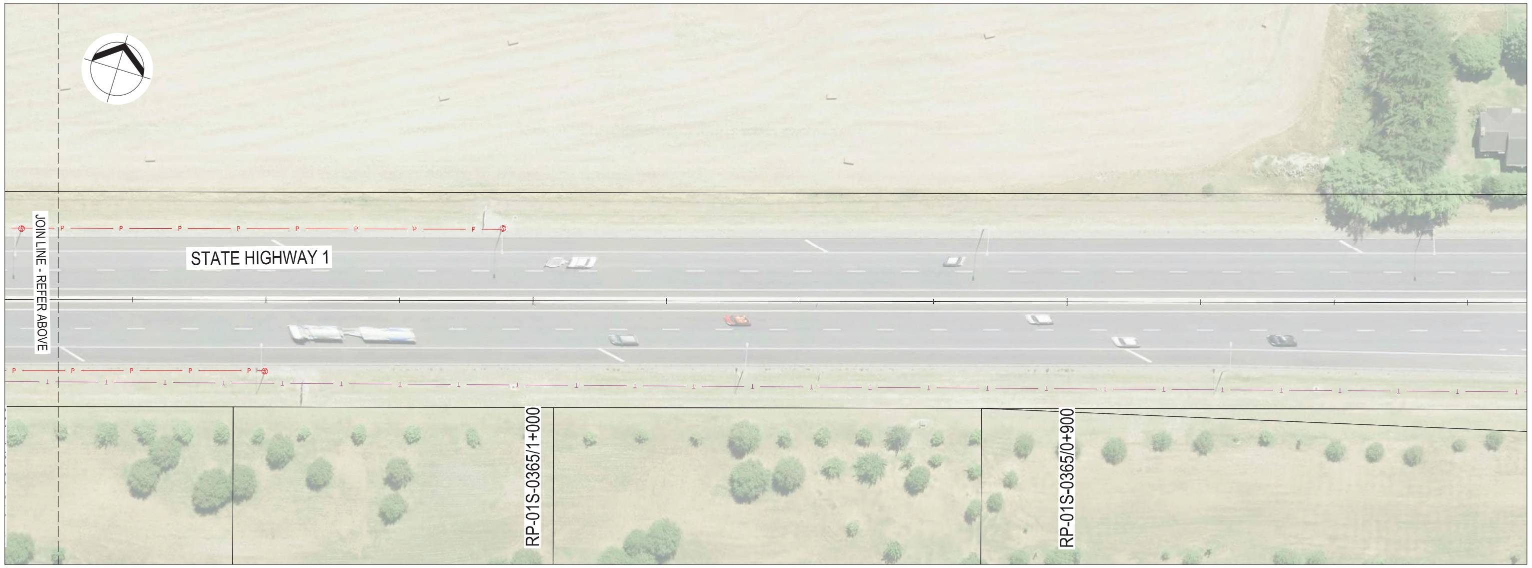

TESTING LEGEND

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- TP — TEST PIT
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LEGEND

BOUNDARY

EXISTING SERVICES

OVERHEAD POWER	OH
11kV UG POWER	11kV
ORION UG	P
ENABLE	FO
CHORUS	T
ONE NZ	T
WATER MAIN	W
STORMWATER	SW
SEWER	S
STOCK WATER RACE	WR
DUCT	
POWER POLE	
STREET LIGHT	
ENABLE CHAMBER/DROP DUCT	

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Drawn	R. ANDERSON	12.03.24
Dsg Verifier	R. YOUNG	12.03.24
Dsg Check	M. HARRIS	12.03.24

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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 11 OF 14

Discipline: CIVIL ENGINEERING

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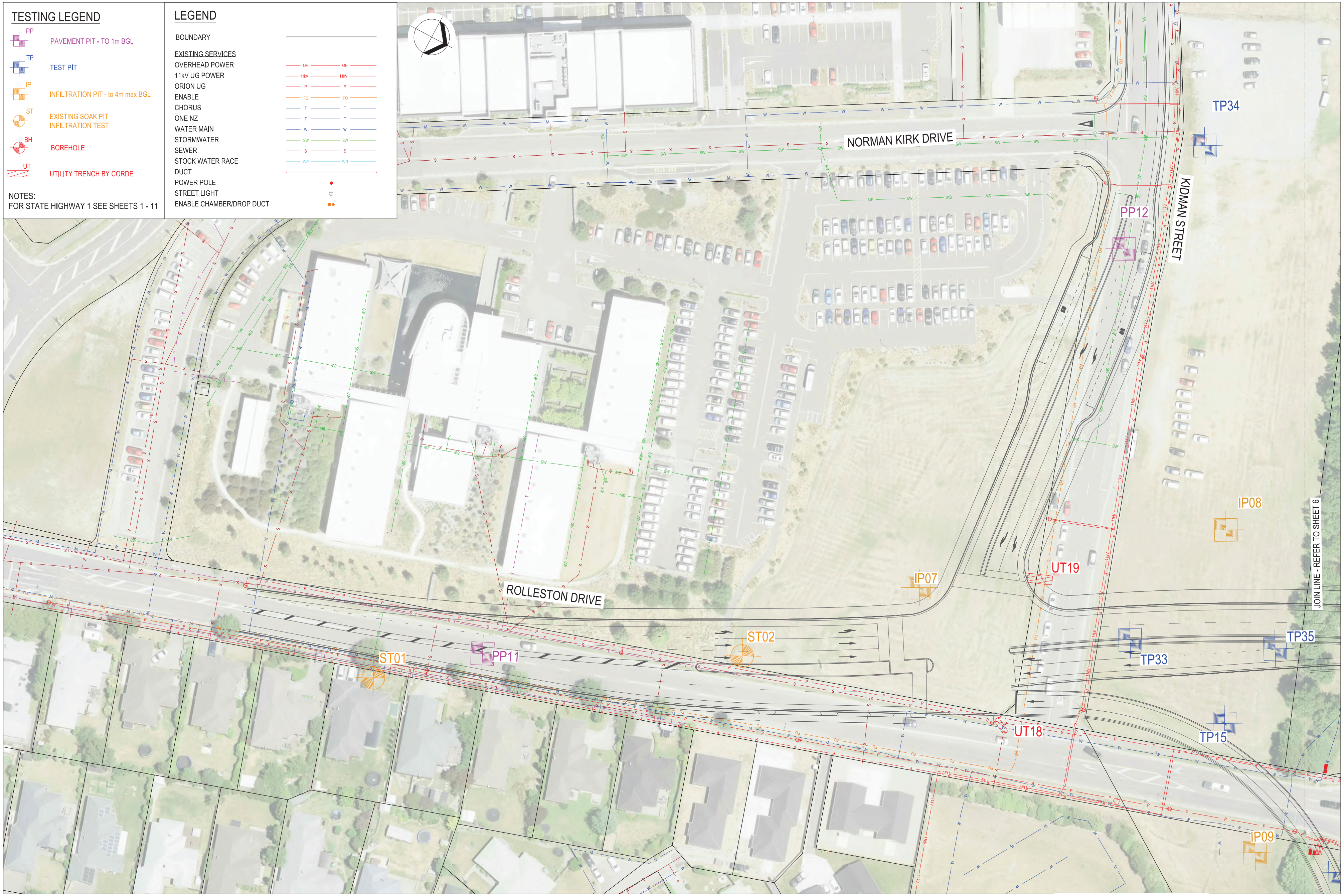

TESTING LEGEND

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- TP — TEST PIT
- IP — INFILTRATION PIT - to 4m max BGL
- ST — EXISTING SOAK PIT INFILTRATION TEST
- BH — BOREHOLE
- UT — UTILITY TRENCH BY CORDE

NOTES:
FOR STATE HIGHWAY 1 SEE SHEETS 1 - 11

LEGEND

BOUNDARY

EXISTING SERVICES
- OVERHEAD POWER (OH)
- 11kV UG POWER (11kV)
- ORION UG (P)
- ENABLE (FO)
- CHORUS (T)
- ONE NZ (T)
- WATER MAIN (W)
- STORMWATER (SW)
- SEWER (S)
- STOCK WATER RACE (WR)
- DUCT
- POWER POLE
- STREET LIGHT
- ENABLE CHAMBER/DROP DUCT

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Reduced Scale (A3) 1:1000	Dsg Verifier	R. YOUNG	12.03.24
	Drg Check	M. HARRIS	12.03.24

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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: SH1 ROLLESTON ACCESS IMPROVEMENTS

Title: SITE INVESTIGATIONS SHEET 12 OF 14

Discipline: CIVIL ENGINEERING

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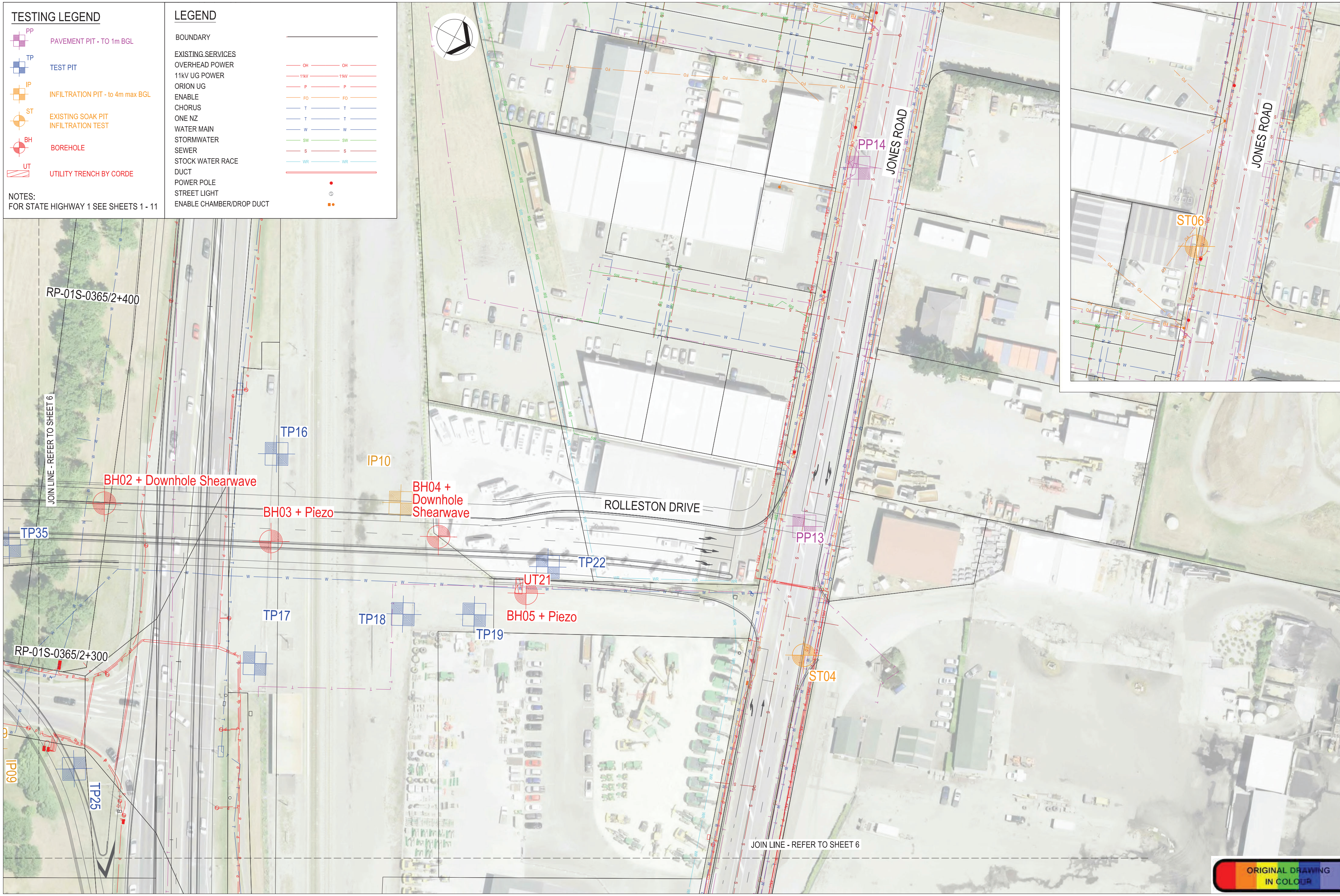
NOTES:
FOR STATE HIGHWAY 1 SEE SHEETS 1 - 11

LEGEND

BOUNDARY

EXISTING SERVICES

- OVERHEAD POWER — OH
- 11kV UG POWER — 11kV
- ORION UG — P
- ENABLE — FO
- CHORUS — T
- ONE NZ — T
- WATER MAIN — W
- STORMWATER — SW
- SEWER — S
- STOCK WATER RACE — WR
- DUCT
- POWER POLE
- STREET LIGHT
- ENABLE CHAMBER/DROP DUCT



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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

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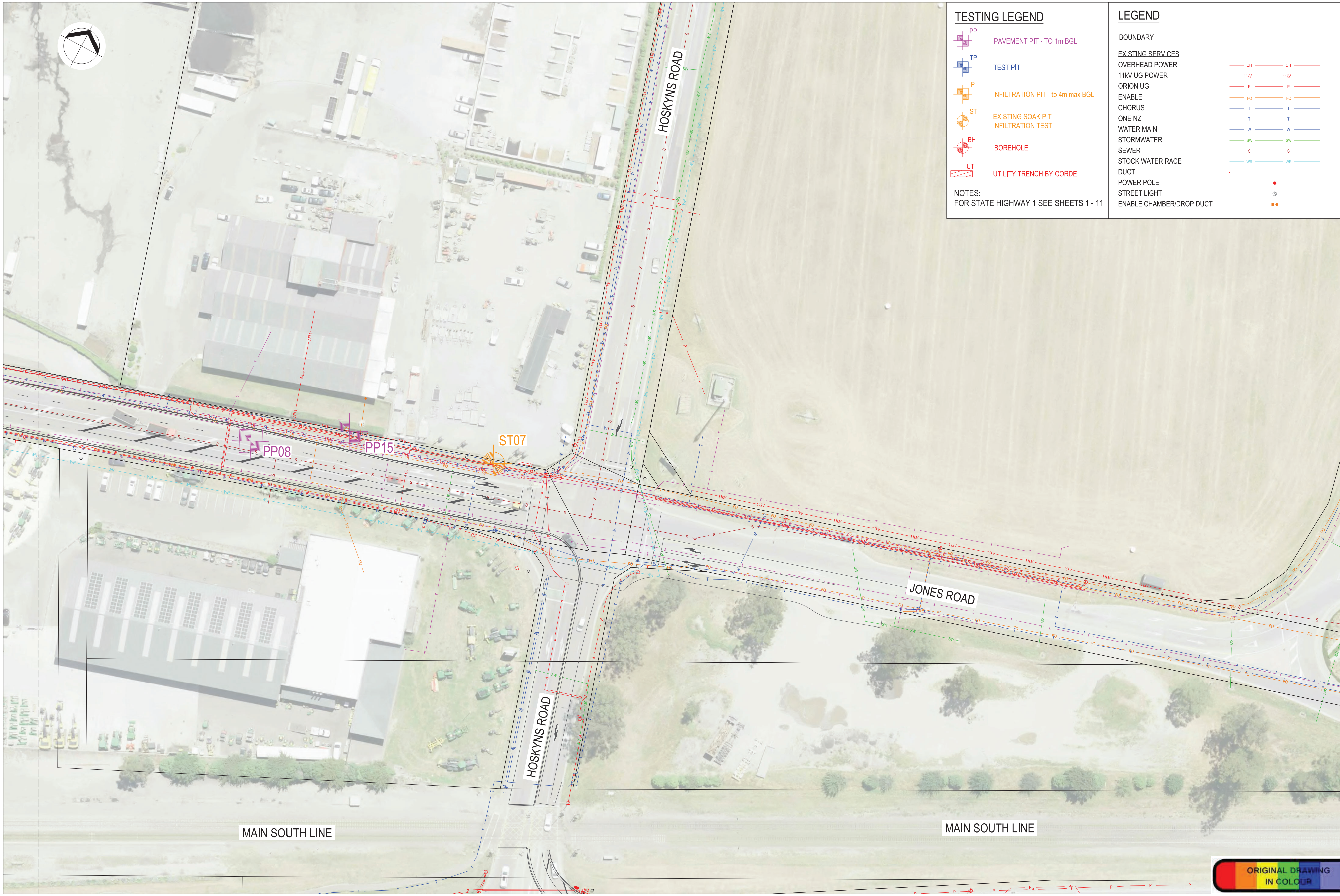

TESTING LEGEND

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- BH — BOREHOLE
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NOTES:
FOR STATE HIGHWAY 1 SEE SHEETS 1 - 11

LEGEND

BOUNDARY

EXISTING SERVICES
- OVERHEAD POWER — OH
- 11kV UG POWER — 11kV
- ORION UG — P
- ENABLE — FO
- CHORUS — T
- ONE NZ — T
- WATER MAIN — W
- STORMWATER — SW
- SEWER — S
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	Drg Check	M. HARRIS	12.03.24

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B

Appendix B – Rolleston Access Improvements Infiltration Testing Memo

Memorandum

To:	Steve Harvey	**Date:**	16 August 2024
From:	Leeza Becroft	**Our Ref:**	3338703-691807897-6320
Copy:	Mike Thorley, Brad Peterson	**:**	
Subject:	Memorandum on Infiltration Testing for Rolleston Access Improvement Project		

1 Introduction

This memorandum summarises infiltration testing undertaken at a range of site across Rolleston for the Rolleston Access Improvement Project over the period 17 June to 1 August 2024. The New Zealand Transport Agency / Waka Kotahi (NZTA) has engaged Beca Ltd (Beca) to undertake design of a number of road improvements at Rolleston along State Highway 1 (SH1).

The main components of design are:

- Two-lane roundabout at intersection of State Highway 1 and Walkers Road / Dunns Crossing Road including stormwater infiltration devices and subway below SH1 for shared pathway.
- Flyover connecting Rolleston Drive North with Jones Road including stormwater infiltration device.
- Changes at additional intersections to remove right-turns across traffic.
- Various additional stormwater discharge via infiltration devices to accommodate additional apron.

This memo provides the measured infiltration rates measured on site, representative of the vertical minimum saturated infiltration rate for each of the tested locations and a factored design infiltration rate.

2 Site investigations

2.1 General

Beca has recently undertaken ground investigations at the site including a number of infiltration tests to investigation ground capacity for stormwater infiltration. Several piezometers were also installed to investigate groundwater levels. The physical works for the ground investigation was undertaken by Corde Ltd, and the full description of the investigations is reported in the Geotechnical Factual Report currently being prepared (Beca, 2024). The infiltration pit tests, and piezometer locations, and concept stormwater basin locations are shown in Attachment A.

2.2 Infiltration testing

Infiltration testing was carried out in accordance with the Ministry of Business, Innovation and Employment (MBIE) Acceptable Solutions and Verification Methods E1/VM1 (Surface Water), Section 9.0.2 (2017).

Testing was conducted using the falling head test method, in test pits, at depths ranging from 1.5 to 2.7m bgl within gravels with varying quantities of sand and silt (further details summarised in Table 2-1) and logs provided in the factual report (Beca, 2024).

Table 2-1: Infiltration pit details

Infiltration Pit ID	Test Date	Easting	Northing	Infiltration Test Depth (m bgl)	Tested soil description
IP01	18/06/2024	5172119	1547537	1.9	Cobbly GRAVEL, some sand.
IP02	1/07/2024	5172102	1547698	2.2	Sandy GRAVEL, some cobbles, trace silt.
IP03	1/08/2024	5172302	1547589	2.3	Sandy GRAVEL, some cobbles, trace silt.
IP04	24/06/2024	5172765	1548747	1.5	Sandy GRAVEL, some cobbles, minor silt.
IP07	25/06/2024	5173425	1550268	1.6	Sandy GRAVEL, some cobbles, minor silt.
IP08	25/06/2024	5173493	1550213	1.5	Sandy GRAVEL, some cobbles, minor silt.
IP09	25/06/2024	5173543	1550289	1.8	Cobbly sandy GRAVEL, trace silt.
IP10	24/07/2024	5173612	1550173	1.8	Sandy GRAVEL, trace cobbles, trace silt.
IP11	5/07/2024	5172484	1548207	2.2	Cobbly GRAVEL, some fine to coarse sand, trace silt.
IP12	15/07/2024	5173106	1549337	2.7	Sandy GRAVEL, trace cobbles, trace silt.
IP13	10/07/2024	5174046	1551239	2.2	Sandy GRAVEL, some cobbles, trace silt.

Notes:
Coordinates obtained using a handheld GPS are provided in NZTM2000, with an accuracy of +/- 3 m.
m bgl (metres below ground level)

Groundwater was not encountered in any of the infiltration pits (see Section 2.4 for nearby groundwater levels).

The water level change during testing was measured manually using a dip meter, and automatically using a Levelogger. The infiltration pits were pre-soaked for a period of 60 minutes prior to testing. This was achieved by filling the pits onsite using a 10,000L water tanker. In pits IP01, IP02, IP03 and IP11, the 60minute pre-soak was not able to be achieved due to initial high rates of infiltration and a limited water supply. In these pits, the minimum pre-soak was 20minutes.

Infiltration testing was conducted, and the test results are summarised in Table 2-2 and detailed infiltration testing results are presented in Attachment B. The infiltration rates reported here are the minimum stabilised rates observed on site without a factor of safety applied. Where required, the infiltration rates have been smoothed slightly to account for site and measurement error.

Table 2-2: Summary of infiltration testing

Infiltration Pit ID	Location	Pre-soak duration (min)	Test Duration (min)	Infiltration Test Depth (m bgl)	Water Level at Start (m above base)	Measured Infiltration Rate (mm/hr)
IP01	West of Roundabout	30	16	1.9	0.52	660
IP02	South of Roundabout	20	18	2.2	0.8	1,882
IP03	North of Roundabout	20	6	2.3	0.3	2,100
IP04	West end of Rolleston Dr	60	68	1.5	1.25	268
IP07	Kidman St – Rolleston Dr interception	60	57	1.6	0.72	389
IP08	Soth of SH1, west of Rolleston Dr	60	119	1.5	0.7	243
IP09	Soth of SH1, east of Rolleston Dr	60	10	1.8	0.73	2,325
IP10	North of SH1, west of Rolleston Dr	50	36	1.8	0.51	497
IP11	50m north of Breccia St	30	20	2.2	0.7	588
IP12	North-western end of Coleridge St	60	70	2.7	0.7	334
IP13	100m north of north end of Colebrook Dr	60	80	2.2	0.58	41

The range in observed infiltration rates reflects the heterogeneity of the alluvial soils in the area. Small changes in fines content in the soils can result in large changes in the infiltration performance. Land use can also locally increase compaction which also affects infiltration capacity of soils.

The average of the observed stabilised infiltration rate, which typically occurs towards the end of an infiltration test, are typically suitable for infiltration basin design sizing purposes and are summarised in Table 2-2 and will need an appropriate factor of safety to be applied to account for long term clogging, uncertainty and consequence of failure.

2.3 Piezometers

Single standpipe piezometers have been installed in several of the boreholes drilled on site. These piezometers were generally screened into alluvial gravels at 10-15m and are summarised in Table 2-3.

Table 2-3: Piezometers installation summary

BH ID	Location	Easting	Northing	Ground Level (m RL)	Total Depth (m bgl) [m RL]	Screen interval (m bgl) [mRL]
BH01	East of Roundabout	1547688	5172144	58.6	15.0 [43.6]	10-15 [48.6 – 43.6]
BH03	SH1 Rolleston Dr Interception	1550200	5173585	55.3	15.0 [40.3]	10-15 [45.3 – 40.3]
BH05	South-east of 801 Jones Road	1550179	5173655	56.0	15.0 [41.0]	10-15 [46.0 – 41.0]

Notes:
RL (Relative Level)
Ground levels sourced from Canterbury Maps with an accuracy of +/- 0.5 m.
Coordinates obtained using a handheld GPS are provided in NZTM2000, with an accuracy of +/- 3 m.
m bgl (metres below ground level)
Borehole inclination is 90º from horizontal.

2.4 Groundwater levels

The depth to groundwater was measured in the piezometers described in Section 2.3 on 12 July and 12 August 2024. The piezometers had been developed 2 days to 30 days prior to the water measurement. The groundwater levels are summarised in Table 2-4.

Automated groundwater level logging is proposed at the piezometers, and is due to be commenced shortly.

Table 2-4: Groundwater measurements

Borehole/ Piezometer ID	Date & Time of Measurement	Depth to Groundwater (m bgl)	Groundwater Level (m RL)	Type of Measurement (Borehole or Piezometer)
BH01	12/07/2024 9:00am	11.4	47.2	Piezometer
BH03	12/08/2024 10:20am	12.42	42.88	Piezometer
BH05	12/08/2024 9:30am	13.15	42.85	Piezometer

Notes:
RL (Relative Level)
m bgl (metres below ground level)

3 Mounding

The groundwater levels observed on site are sufficiently deep (>10m bgl at the site) that a mounding assessment is not required for the proposed stormwater discharge to land.

4 Factors of Safety (FoS)

The assessment of an appropriate design infiltration rate is based on the minimum stabilised measured rate, observed at each infiltration location during the testing. There is large uncertainty in the long-term performance of an infiltration device due to the extrapolation of a short-term (6 mins to 2 hours) infiltration test compared to actual performance during rainfall events which can result in multi-day infiltration events as stormwater is treated and discharged to land. Things that reduce infiltration capacity over longer time periods include, the uncertainty in whether the soils were fully saturated during site-testing, mounding that may occur, clogging of the system by siltation, compaction, and any reduction in basin performance due to poor quality assurance during construction.

For stormwater infiltration device design purposes, CIRIA SuDS Manual (2015) provides a range of factors of safety (FoS) that can be applied to the measured infiltration rates. These FoS are listed in Table 4-1.

The consequence of failure for the Rolleston Access Improvement project may include major inconvenience to road-users, i.e. flooding of a major highway (SH1) and/or local roads in Rolleston, depending on the secondary flow path from the infiltration devices. We therefore recommend that a FoS of 10 is applied to the measured rates on site, where possible. Where the civil designer considers that the risk of failure consequence can be appropriately managed, and the client has agreed to the proposed risk mitigations, a FoS of 5 can be applied.

Table 4-1: Suggested factors of safety for use in hydraulic design of infiltration systems (CIRIA, 2015).

TABLE 25.2 Suggested factors of safety, F, for use in hydraulic design of infiltration systems (designed using Bettess (1996). Note: not relevant for BRE method)

Size of area to be drained	Consequences of failure		
	No damage or inconvenience	Minor damage to external areas or inconvenience (eg surface water on car parking)	Damage to buildings or structures, or major inconvenience (eg flooding of roads)
< 100 m²	1.5	2	10
100–1000 m²	1.5	3	10
> 1000 m²	1.5	5	10

Considering the tested rates and factor of safety, the recommended design infiltration rate for each location is listed in Table 4-2.

Table 4-2: Design infiltration rates (FoS of 10 and 5, as per CIRIA, 2015)

Piezometer ID	Location	Measured Infiltration Rate (mm/hr)	Factored Infiltration Rate FoS 5 (mm/hr)	Factored Infiltration Rate FoS 10 (mm/hr)
IP01	Roundabout	660	132	66
IP02	Roundabout	1,882	376	188
IP03	Roundabout	2,100	420	210
IP04	SH1	268	54	27
IP07	SH1	389	78	39
IP08	SH1	243	49	24
IP09	SH1	2,325	465	232
IP10	SH1	497	100	50
IP11	SH1	588	118	59
IP12	SH1	334	67	33
IP13	SH1	41	8	4

The following design recommendations below are based our observations from the recent site investigations and testing, and from our previous experience with infiltration device design inputs:

- Infiltration devices should be installed approximately 0.5 m into the freer draining gravel strata (generally found at approximately 2 m depth) and avoid being founded in fill and/or lower permeability strata as this will compromise infiltration.
- Infiltration Devices inverts should be founded more than 3 m clear the water table as this may affect infiltration.
- We recommend that washed and suitably graded drainage aggregate (free of fines) be used in the infiltration devices.
- We recommend the base of the infiltration devices are unlined (i.e., no geotextile used).
- Refer to the DSI recommendations regarding the presence of fill materials and/or contaminated soils in the infiltration devices. Lining of the sides of the infiltration devices to prevent direct contact with side cut soils may be required.

5 Construction Recommendations

The following general construction recommendations are based on the site investigation, testing, and analysis, as well as our experience with similar construction:

- Excavation for the infiltration devices shall be undertaken in a manner to avoid direct compaction and potential clogging of the subgrade intended for water infiltration (i.e., sandy gravel alluvium).
- Excavation of the infiltration devices should extend into the freer draining sandy gravel strata to the depth specified by the Designer by approximately 0.5 m.
- The base of the infiltration device should be unlined (i.e., no geotextile used).
- The sides of infiltration devices should be graded and lined to prevent the mobilisation of fines and direct contact with the soils.
- Follow DSI findings regarding contaminated soils which may include lining the sidewalls of the infiltration devices with an impermeable liner to avoid risk of contaminant mobilisation.
- Clean and washed drainage aggregate free of fines should be utilised within the infiltration devices.

- Proof testing of infiltration rate of the soils at the time of construction should be undertaken to verify design assumptions.
- Infiltration devices should avoid being founded in silt layers, or in silty gravels as this may reduce actual infiltration rates.
- Drainage materials should be reviewed by the project geotechnical engineer.

The actual infiltration performance of the infiltration devices are expected to decrease over time due to clogging with fine sediment and silt. Actual performance will be subject to construction techniques and quality, ground conditions, actual groundwater levels and the water quality entering the infiltration devices.

6 Summary

Beca has undertaken infiltration testing in various locations across Rolleston to support the stormwater drainage design for additional road apron proposed as part of the Rolleston Access Improvement project.

Infiltration rates vary significantly across site, as is typical for alluvial soils like that encountered at site. Testing found infiltration rates were generally better in strata at approximately 2 m depth, although measured rates onsite ranged from 41 mm/hr to 2325 mm/hr with an average of 850 mm/hr across eleven tests.

Only the infiltration rate measured directly at the site of the proposed infiltration device should be used in design, and a suitable factor of safety of between 5-10 is adopted based on those set out in CIRIA (2015).

Construction recommendations are provided in this memo, and include avoiding compaction of the subgrade materials, using suitable drainage aggregate free of fines, addressing contamination issues should they be present and conduct proof testing of the infiltration devices at the time of construction.

Actual infiltration performance may vary and will be subject to construction techniques and quality, ground conditions, actual groundwater levels and the volume of sediment and water quality entering the infiltration devices.

Leeza Becroft

Senior Hydrogeologist

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Email: Leeza.Becroft@beca.com

Attachments

Attachment A – Ground Investigation Locations Plans (Refer Appendix A of Geotechnical Interpretive Report)

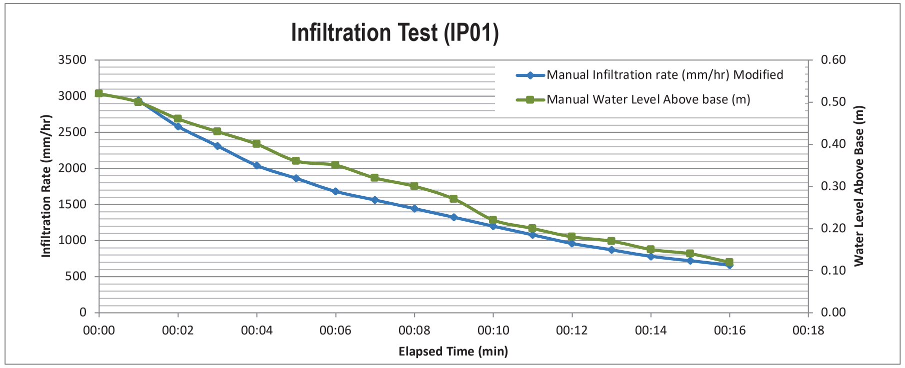
Attachment B – Infiltration Rate Calculation Sheets

Location ID: IP01 Rolleston Access Improvement
Project Number: 3338703

Name:	IP01
Date Testing:	18/06/2024
Field Rep:	RO
Author:	GT
Checked:	LB

Depth of test pit (m)	1.9
Length of test pit (m)	2.5
Width of test pit (m)	1.5
Test pit area (m2)	3.75

Infiltration (mm/hr)	
Minimum	660



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
18/06/2024	00:00:00	1.38	0.520	1.380	0.00	0	0	0.00				
18/06/2024	00:01:00	1.4	0.500	1.400	1.00	20	49	0.0167	1200.0	2940.0	20	
18/06/2024	00:02:00	1.44	0.460	1.440	2.00	40	43	0.0167	2400.0	2580.0	60	
18/06/2024	00:03:00	1.47	0.430	1.470	3.00	30	38.5	0.0167	1800.0	2310.0	90	
18/06/2024	00:04:00	1.5	0.400	1.500	4.00	30	34	0.0167	1800.0	2040.0	120	
18/06/2024	00:05:00	1.54	0.360	1.540	5.00	40	31	0.0167	2400.0	1860.0	160	
18/06/2024	00:06:00	1.55	0.350	1.550	6.00	10	28	0.0167	600.0	1680.0	170	
18/06/2024	00:07:00	1.58	0.320	1.580	7.00	30	26	0.0167	1800.0	1560.0	200	
18/06/2024	00:08:00	1.6	0.300	1.600	8.00	20	24	0.0167	1200.0	1440.0	220	
18/06/2024	00:09:00	1.63	0.270	1.630	9.00	30	22	0.0167	1800.0	1320.0	250	
18/06/2024	00:10:00	1.68	0.220	1.680	10.00	50	20	0.0167	3000.0	1200.0	300	
18/06/2024	00:11:00	1.7	0.200	1.700	11.00	20	18	0.0167	1200.0	1080.0	320	
18/06/2024	00:12:00	1.72	0.180	1.720	12.00	20	16	0.0167	1200.0	960.0	340	
18/06/2024	00:13:00	1.73	0.170	1.730	13.00	10	14.5	0.0167	600.0	870.0	350	
18/06/2024	00:14:00	1.75	0.150	1.750	14.00	20	13	0.0167	1200.0	780.0	370	
18/06/2024	00:15:00	1.76	0.140	1.760	15.00	10	12	0.0167	600.0	720.0	380	
18/06/2024	00:16:00	1.78	0.120	1.780	16.00	20	11	0.0167	1200.0	660.0	400	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment

Testing Notes:

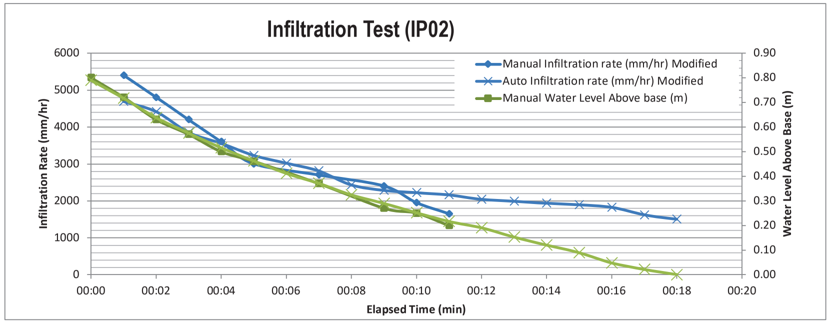
- The pit was soaked with one truck which was completely emptied without the water level reaching 0.75 m bgl. The truck went to refill and in that time pit emptied. Another 8000L of water was emptied into pit and the test was conducted upon emoyting the tanker into the pit.
- Water levels were monitored using only manual dipper
- Groundwater not encountered
- Silt accumulation on base of pit after water drained

Location ID: ITP02 Rolleston Access Improvement
Project Number: 3338703

Name:	IP02
Date Testing:	1/07/2024
Field Rep:	RO
Author:	GT
Checked:	LB

Depth of test pit (m)	2.2
Length of test pit (m)	2.6
Width of test pit (m)	1.6
Test pit area (m2)	4.16

Infiltration (mm/hr)	
Minimum	1,882



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
1/07/2024	00:00:00	1.4	0.800	1.400	0.00	0	0	0.00				
1/07/2024	00:01:00	1.48	0.720	1.480	1.00	80	90	0.0167	4800.0	5400.0	80	
1/07/2024	00:02:00	1.57	0.630	1.570	2.00	90	80	0.0167	5400.0	4800.0	170	
1/07/2024	00:03:00	1.63	0.570	1.630	3.00	60	70	0.0167	3600.0	4200.0	230	
1/07/2024	00:04:00	1.7	0.500	1.700	4.00	70	60	0.0167	4200.0	3600.0	300	
1/07/2024	00:05:00	1.74	0.460	1.740	5.00	40	50	0.0167	2400.0	3000.0	340	
1/07/2024	00:07:00	1.83	0.370	1.830	7.00	90	90	0.0333	2700.0	2700.0	430	
1/07/2024	00:09:00	1.93	0.270	1.930	9.00	100	80	0.0333	3000.0	2400.0	530	
1/07/2024	00:10:00	1.95	0.250	1.950	10.00	20	32.5	0.0167	1200.0	1950.0	550	
1/07/2024	00:11:00	2	0.200	2.000	11.00	50	27.5	0.0167	3000.0	1650.0	600	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
1/07/2024	00:00:00	1.41	0.790	1.410	0.00	0	0	0.00				
1/07/2024	00:01:00	1.48	0.716	1.484	1.00	73.9	78.2	0.0167	4434.0	4692.0	73.9	
1/07/2024	00:02:00	1.56	0.638	1.562	2.00	78.2	73.5	0.0167	4692.0	4410.0	152.1	
1/07/2024	00:03:00	1.63	0.575	1.625	3.00	63.2	64.2	0.0167	3792.0	3852.0	215.3	
1/07/2024	00:04:00	1.68	0.515	1.685	4.00	59.3	59.3	0.0167	3558.0	3558.0	274.6	
1/07/2024	00:05:00	1.74	0.462	1.738	5.00	53.8	53.8	0.0167	3228.0	3228.0	328.4	
1/07/2024	00:06:00	1.79	0.411	1.789	6.00	50.3	50.3	0.0167	3018.0	3018.0	378.7	
1/07/2024	00:07:00	1.83	0.371	1.829	7.00	40.5	46.8	0.0167	2430.0	2808.0	419.2	
1/07/2024	00:08:00	1.88	0.324	1.876	8.00	46.8	40.5	0.0167	2808.0	2430.0	466	
1/07/2024	00:09:00	1.91	0.290	1.910	9.00	34.4	38	0.0167	2064.0	2280.0	500.4	
1/07/2024	00:10:00	1.95	0.252	1.948	10.00	37.7	37	0.0167	2262.0	2220.0	538.1	
1/07/2024	00:11:00	1.98	0.216	1.984	11.00	35.5	36	0.0167	2130.0	2160.0	573.6	
1/07/2024	00:12:00	2.01	0.190	2.010	12.00	26.1	34	0.0167	1566.0	2040.0	599.7	
1/07/2024	00:13:00	2.05	0.152	2.048	13.00	37.9	33.1	0.0167	2274.0	1986.0	637.6	
1/07/2024	00:14:00	2.08	0.121	2.079	14.00	31.8	32.2	0.0167	1908.0	1932.0	669.4	
1/07/2024	00:15:00	2.11	0.089	2.111	15.00	31.2	31.5	0.0167	1872.0	1890.0	700.6	
1/07/2024	00:16:00	2.15	0.048	2.152	16.00	41.6	30.4	0.0167	2496.0	1824.0	742.2	
1/07/2024	00:17:00	2.18	0.021	2.179	17.00	26.8	27	0.0167	1608.0	1620.0	769	
1/07/2024	00:18:00	2.20	0.000	2.200	18.00	21	25	0.0167	1260.0	1500.0	790	

Testing Notes:

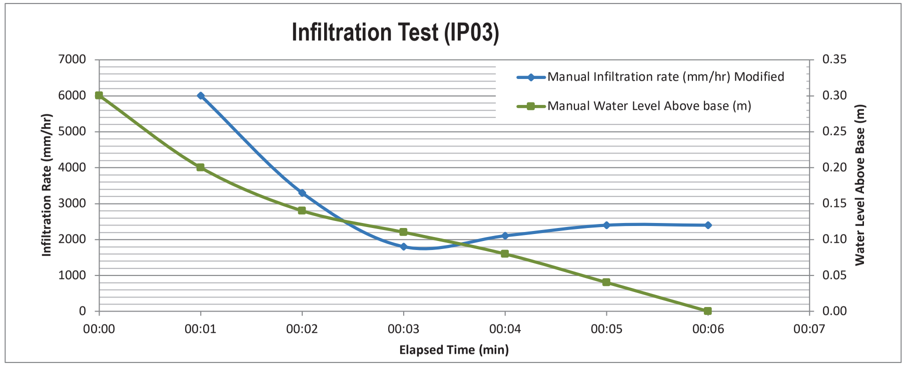
- Pre-soak conducted, level maintained at 0.5 metres above base of pit after 10,000 litre tanker was emptied approximately 20 minutes upon which the test was conducted
- Water levels were monitored using manual dipper and levelogger
- Pre-soak terminated after 20 mins (completion of 10,000L tanker) due to time constraints
- Bucket was placed at the bottom of the pit for water pour and remained in pit during test
- Groundwater not encountered

Location ID: IP03 Rolleston Access Improvement
Project Number: 3338703

Name:	IP03
Date Testing:	1/08/2024
Field Rep:	NY
Author:	GT
Checked:	LB

Depth of test pit (m)	2.4
Length of test pit (m)	3.0
Width of test pit (m)	2.2
Test pit area (m2)	6.60

Infiltration (mm/hr)	
Minimum	2,100



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
1/08/2024	00:00:00	2.1	0.300	2.100	0.00	0	0	0.00				
1/08/2024	00:01:00	2.2	0.200	2.200	1.00	100	100	0.0167	6000.0	6000.0	100	
1/08/2024	00:02:00	2.26	0.140	2.260	2.00	60	55	0.0167	3600.0	3300.0	160	
1/08/2024	00:03:00	2.29	0.110	2.290	3.00	30	30	0.0167	1800.0	1800.0	190	
1/08/2024	00:04:00	2.32	0.080	2.320	4.00	30	35	0.0167	1800.0	2100.0	220	
1/08/2024	00:05:00	2.36	0.040	2.360	5.00	40	40	0.0167	2400.0	2400.0	260	
1/08/2024	00:06:00	2.4	0.000	2.400	6.00	40	40	0.0167	2400.0	2400.0	300	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment

No levelogger used

Testing Notes:

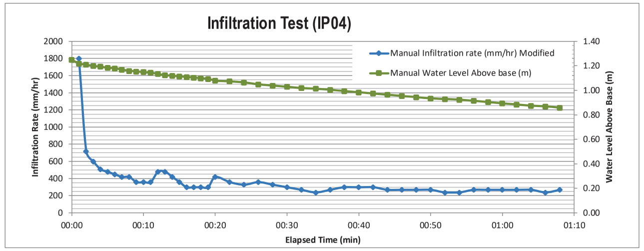
- Pre-soak conducted, level dropped below base of pit after 3,000 litres was poured approximately 1 hour before it was refilled for 15 minutes with 7,000 litres upon which the test was conducted
- Water levels were monitored using manual dipmeter
- Pre-soak terminated upon exhaustion of the water tank
- Groundwater not encountered

Location ID: IP04 Rolleston Access Improvement
Project Number: 3338703

Name:	IP04
Date Testing:	24/06/2024
Field Rep:	NY
Author:	GT
Checked:	LB

Depth of test pit (m)	1.5
Length of test pit (m)	2.1
Width of test pit (m)	1.6
Test pit area (m2)	3.36

Infiltration (mm/hr)	
Minimum	268



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
24/06/2024	00:00:00	0.25	1.250	0.250	0.00	0	0	0.00				
24/06/2024	00:01:00	0.28	1.220	0.280	1.00	30	30	0.0167	1800.0	1800.0	30	
24/06/2024	00:02:00	0.29	1.210	0.290	2.00	10	12	0.0167	600.0	720.0	40	
24/06/2024	00:03:00	0.3	1.200	0.300	3.00	10	10	0.0167	600.0	600.0	50	
24/06/2024	00:04:00	0.305	1.195	0.305	4.00	5	8.5	0.0167	300.0	510.0	55	
24/06/2024	00:05:00	0.315	1.185	0.315	5.00	10	8	0.0167	600.0	480.0	65	
24/06/2024	00:06:00	0.32	1.180	0.320	6.00	5	7.5	0.0167	300.0	450.0	70	
24/06/2024	00:07:00	0.33	1.170	0.330	7.00	10	7	0.0167	600.0	420.0	80	
24/06/2024	00:08:00	0.34	1.160	0.340	8.00	10	7	0.0167	600.0	420.0	90	
24/06/2024	00:09:00	0.345	1.155	0.345	9.00	5	6	0.0167	300.0	360.0	95	
24/06/2024	00:10:00	0.35	1.150	0.350	10.00	5	6	0.0167	300.0	360.0	100	
24/06/2024	00:11:00	0.355	1.145	0.355	11.00	5	6	0.0167	300.0	360.0	105	
24/06/2024	00:12:00	0.365	1.135	0.365	12.00	10	8	0.0167	600.0	480.0	115	
24/06/2024	00:13:00	0.375	1.125	0.375	13.00	10	8	0.0167	600.0	480.0	125	
24/06/2024	00:14:00	0.38	1.120	0.380	14.00	5	7	0.0167	300.0	420.0	130	
24/06/2024	00:15:00	0.385	1.115	0.385	15.00	5	6	0.0167	300.0	360.0	135	
24/06/2024	00:16:00	0.39	1.110	0.390	16.00	5	5	0.0167	300.0	300.0	140	
24/06/2024	00:17:00	0.395	1.105	0.395	17.00	5	5	0.0167	300.0	300.0	145	
24/06/2024	00:18:00	0.4	1.100	0.400	18.00	5	5	0.0167	300.0	300.0	150	
24/06/2024	00:19:00	0.405	1.095	0.405	19.00	5	5	0.0167	300.0	300.0	155	
24/06/2024	00:20:00	0.42	1.080	0.420	20.00	15	7	0.0167	900.0	420.0	170	
24/06/2024	00:22:00	0.425	1.075	0.425	22.00	5	12	0.0333	150.0	360.0	175	
24/06/2024	00:24:00	0.435	1.065	0.435	24.00	10	11	0.0333	300.0	330.0	185	
24/06/2024	00:26:00	0.45	1.050	0.450	26.00	15	12	0.0333	450.0	360.0	200	
24/06/2024	00:28:00	0.46	1.040	0.460	28.00	10	11	0.0333	300.0	330.0	210	
24/06/2024	00:30:00	0.47	1.030	0.470	30.00	10	10	0.0333	300.0	300.0	220	
24/06/2024	00:32:00	0.48	1.020	0.480	32.00	10	9	0.0333	300.0	270.0	230	
24/06/2024	00:34:00	0.485	1.015	0.485	34.00	5	8	0.0333	150.0	240.0	235	
24/06/2024	00:36:00	0.495	1.005	0.495	36.00	10	9	0.0333	300.0	270.0	245	
24/06/2024	00:38:00	0.505	0.995	0.505	38.00	10	10	0.0333	300.0	300.0	255	
24/06/2024	00:40:00	0.515	0.985	0.515	40.00	10	10	0.0333	300.0	300.0	265	
24/06/2024	00:42:00	0.525	0.975	0.525	42.00	10	10	0.0333	300.0	300.0	275	
24/06/2024	00:44:00	0.535	0.965	0.535	44.00	10	9	0.0333	300.0	270.0	285	
24/06/2024	00:46:00	0.545	0.955	0.545	46.00	10	9	0.0333	300.0	270.0	295	
24/06/2024	00:48:00	0.555	0.945	0.555	48.00	10	9	0.0333	300.0	270.0	305	
24/06/2024	00:50:00	0.565	0.935	0.565	50.00	10	9	0.0333	300.0	270.0	315	
24/06/2024	00:52:00	0.57	0.930	0.570	52.00	5	8	0.0333	150.0	240.0	320	
24/06/2024	00:54:00	0.575	0.925	0.575	54.00	5	8	0.0333	150.0	240.0	325	
24/06/2024	00:56:00	0.585	0.915	0.585	56.00	10	9	0.0333	300.0	270.0	335	
24/06/2024	00:58:00	0.595	0.905	0.595	58.00	10	9	0.0333	300.0	270.0	345	
24/06/2024	01:00:00	0.605	0.895	0.605	60.00	10	9	0.0333	300.0	270.0	355	
24/06/2024	01:02:00	0.615	0.885	0.615	62.00	10	9	0.0333	300.0	270.0	365	
24/06/2024	01:04:00	0.625	0.875	0.625	64.00	10	9	0.0333	300.0	270.0	375	
24/06/2024	01:06:00	0.63	0.870	0.630	66.00	5	8	0.0333	150.0	240.0	380	
24/06/2024	01:08:00	0.64	0.860	0.640	68.00	10	9	0.0333	300.0	270.0	390	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment

No levelogger used

Testing Notes:

- Pre-soak conducted, level dropped below base of pit after 10,000 litre tanker was emptied approximately 40 minutes before it was refilled for 20 minutes reaching a level of 1.25 metres above base of pit upon which the test was conducted

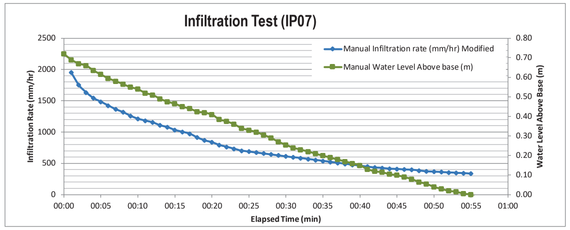
- The bucket was lowered into the bottom of the pit and water was poured at a fast rate. Potentially disturbed the pit walls and caused fines to settle to bottom.
- Water levels were monitored using only manual dipper
- Pre-soak terminated on reach of target time
- Test terminated due to time constraints
- Groundwater not encountered

Location ID: IP07 Rolleston Access Improvement
Project Number: 3338703

Name:	IP07
Date Testing:	25/06/2024
Field Rep:	RO
Author:	GT
Checked:	LB

Depth of test pit (m)	1.6
Length of test pit (m)	1.6
Width of test pit (m)	2.1
Test pit area (m2)	3.36

Infiltration (mm/hr)	
Minimum	389



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
25/06/2024	00:00:00	0.88	0.720	0.880	0.00	0	0	0.00				
25/06/2024	00:01:00	0.91	0.690	0.910	1.00	30	32.55	0.0167	1800.0	1953.0	30	
25/06/2024	00:02:00	0.93	0.670	0.930	2.00	20	29.25	0.0167	1200.0	1755.0	50	
25/06/2024	00:03:00	0.94	0.660	0.940	3.00	10	27.25	0.0167	600.0	1635.0	60	
25/06/2024	00:04:00	0.965	0.635	0.965	4.00	25	25.75	0.0167	1500.0	1545.0	85	
25/06/2024	00:05:00	0.985	0.615	0.985	5.00	20	24.75	0.0167	1200.0	1485.0	105	
25/06/2024	00:06:00	1.005	0.595	1.005	6.00	20	23.75	0.0167	1200.0	1425.0	125	
25/06/2024	00:07:00	1.02	0.580	1.020	7.00	15	22.75	0.0167	900.0	1365.0	140	
25/06/2024	00:08:00	1.035	0.565	1.035	8.00	15	22	0.0167	900.0	1320.0	155	
25/06/2024	00:09:00	1.05	0.550	1.050	9.00	15	21	0.0167	900.0	1260.0	170	
25/06/2024	00:10:00	1.06	0.540	1.060	10.00	10	20.25	0.0167	600.0	1215.0	180	
25/06/2024	00:11:00	1.08	0.520	1.080	11.00	20	19.75	0.0167	1200.0	1185.0	200	
25/06/2024	00:12:00	1.09	0.510	1.090	12.00	10	19.25	0.0167	600.0	1155.0	210	
25/06/2024	00:13:00	1.11	0.490	1.110	13.00	20	18.5	0.0167	1200.0	1110.0	230	
25/06/2024	00:14:00	1.125	0.475	1.125	14.00	15	18	0.0167	900.0	1080.0	245	
25/06/2024	00:15:00	1.135	0.465	1.135	15.00	10	17.25	0.0167	600.0	1035.0	255	
25/06/2024	00:16:00	1.15	0.450	1.150	16.00	15	16.75	0.0167	900.0	1005.0	270	
25/06/2024	00:17:00	1.16	0.440	1.160	17.00	10	16.25	0.0167	600.0	975.0	280	
25/06/2024	00:18:00	1.175	0.425	1.175	18.00	15	15.25	0.0167	900.0	915.0	295	
25/06/2024	00:19:00	1.18	0.420	1.180	19.00	5	14.5	0.0167	300.0	870.0	300	
25/06/2024	00:20:00	1.19	0.410	1.190	20.00	10	14	0.0167	600.0	840.0	310	
25/06/2024	00:21:00	1.215	0.385	1.215	21.00	25	13.25	0.0167	1500.0	795.0	335	
25/06/2024	00:22:00	1.225	0.375	1.225	22.00	10	12.75	0.0167	600.0	765.0	345	
25/06/2024	00:23:00	1.24	0.360	1.240	23.00	15	12.25	0.0167	900.0	735.0	360	
25/06/2024	00:24:00	1.26	0.340	1.260	24.00	20	11.75	0.0167	1200.0	705.0	380	
25/06/2024	00:25:00	1.27	0.330	1.270	25.00	10	11.5	0.0167	600.0	690.0	390	
25/06/2024	00:26:00	1.28	0.320	1.280	26.00	10	11.25	0.0167	600.0	675.0	400	
25/06/2024	00:27:00	1.295	0.305	1.295	27.00	15	11	0.0167	900.0	660.0	415	
25/06/2024	00:28:00	1.31	0.290	1.310	28.00	15	10.75	0.0167	900.0	645.0	430	
25/06/2024	00:29:00	1.33	0.270	1.330	29.00	20	10.5	0.0167	1200.0	630.0	450	
25/06/2024	00:30:00	1.345	0.255	1.345	30.00	15	10.25	0.0167	900.0	615.0	465	
25/06/2024	00:31:00	1.36	0.240	1.360	31.00	15	10	0.0167	900.0	600.0	480	
25/06/2024	00:32:00	1.37	0.230	1.370	32.00	10	9.75	0.0167	600.0	585.0	490	
25/06/2024	00:33:00	1.38	0.220	1.380	33.00	10	9.5	0.0167	600.0	570.0	500	
25/06/2024	00:34:00	1.39	0.210	1.390	34.00	10	9.25	0.0167	600.0	555.0	510	
25/06/2024	00:35:00	1.4	0.200	1.400	35.00	10	9	0.0167	600.0	540.0	520	
25/06/2024	00:36:00	1.41	0.190	1.410	36.00	10	8.75	0.0167	600.0	525.0	530	
25/06/2024	00:37:00	1.42	0.180	1.420	37.00	10	8.5	0.0167	600.0	510.0	540	
25/06/2024	00:38:00	1.43	0.170	1.430	38.00	10	8.25	0.0167	600.0	495.0	550	
25/06/2024	00:39:00	1.44	0.160	1.440	39.00	10	8	0.0167	600.0	480.0	560	
25/06/2024	00:40:00	1.45	0.150	1.450	40.00	10	7.75	0.0167	600.0	465.0	570	
25/06/2024	00:41:00	1.47	0.130	1.470	41.00	20	7.5	0.0167	1200.0	450.0	590	
25/06/2024	00:42:00	1.48	0.120	1.480	42.00	10	7.25	0.0167	600.0	435.0	600	
25/06/2024	00:43:00	1.485	0.115	1.485	43.00	5	7.15	0.0167	300.0	429.0	605	
25/06/2024	00:44:00	1.495	0.105	1.495	44.00	10	6.95	0.0167	600.0	417.0	615	
25/06/2024	00:45:00	1.5	0.100	1.500	45.00	5	6.85	0.0167	300.0	411.0	620	
25/06/2024	00:46:00	1.51	0.090	1.510	46.00	10	6.75	0.0167	600.0	405.0	630	
25/06/2024	00:47:00	1.52	0.080	1.520	47.00	10	6.65	0.0167	600.0	399.0	640	
25/06/2024	00:48:00	1.535	0.065	1.535	48.00	15	6.45	0.0167	900.0	387.0	655	
25/06/2024	00:49:00	1.545	0.055	1.545	49.00	10	6.25	0.0167	600.0	375.0	665	
25/06/2024	00:50:00	1.56	0.040	1.560	50.00	15	6.15	0.0167	900.0	369.0	680	
25/06/2024	00:51:00	1.57	0.030	1.570	51.00	10	6.05	0.0167	600.0	363.0	690	
25/06/2024	00:52:00	1.58	0.020	1.580	52.00	10	5.95	0.0167	600.0	357.0	700	
25/06/2024	00:53:00	1.585	0.015	1.585	53.00	5	5.85	0.0167	300.0	351.0	705	
25/06/2024	00:54:00	1.595	0.005	1.595	54.00	10	5.75	0.0167	600.0	345.0	715	
25/06/2024	00:55:00	1.6	0.000	1.600	55.00	5	5.65	0.0167	300.0	339.0	720	
25/06/2024	00:56:00	1.62	-0.020	1.620	56.00	20	20	0.0167	1200.0	1200.0	740	
25/06/2024	00:57:00	1.635	-0.035	1.635	57.00	15	15	0.0167	900.0	900.0	755	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment

No levelogger used

Testing Notes:
- Pre-soak conducted, level maintained at 0.85 metres above base of pit for 1 hour upon which the test was conducted
- Water levels were monitored using only manual dipper
- Pre-soak terminated on reach of target time
- Bucket remained at bottom of pit during water pour
- Fines settled to bottom of pit upon completion of tes
- Groundwater not encountered

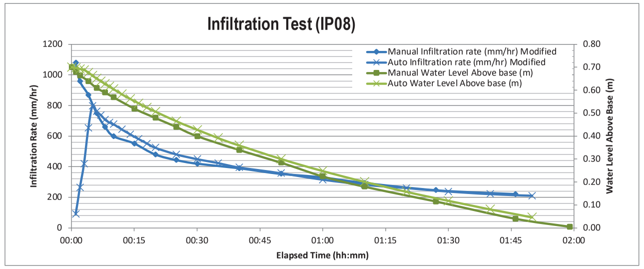
Sensitivity: General

Location ID: IP08 Rolleston Access Improvement
Project Number: 3338703

Name:	IP08
Date Testing:	25/06/2024
Field Rep:	RO
Author:	GT
Checked:	LB

Depth of test pit (m)	1.5
Length of test pit (m)	2.0
Width of test pit (m)	1.6
Test pit area (m2)	3.20

Infiltration (mm/hr)	
Minimum	243



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
25/06/2024	00:00:00	0.8	0.700	0.800	0.00	0	0	0.00				
25/06/2024	00:01:00	0.82	0.680	0.820	1.00	20	18	0.0167	1200.0	1080.0	20	
25/06/2024	00:02:00	0.835	0.665	0.835	2.00	15	16	0.0167	900.0	960.0	35	
25/06/2024	00:04:00	0.86	0.640	0.860	4.00	25	29	0.0333	750.0	870.0	60	
25/06/2024	00:06:00	0.89	0.610	0.890	6.00	30	25	0.0333	900.0	750.0	90	
25/06/2024	00:08:00	0.91	0.590	0.910	8.00	20	22	0.0333	600.0	660.0	110	
25/06/2024	00:10:00	0.93	0.570	0.930	10.00	20	20	0.0333	600.0	600.0	130	
25/06/2024	00:15:00	0.98	0.520	0.980	15.00	50	46	0.0833	600.0	552.0	180	
25/06/2024	00:20:00	1.02	0.480	1.020	20.00	40	40	0.0833	480.0	480.0	220	
25/06/2024	00:25:00	1.06	0.440	1.060	25.00	40	37	0.0833	480.0	444.0	260	
25/06/2024	00:30:00	1.1	0.400	1.100	30.00	40	35	0.0833	480.0	420.0	300	
25/06/2024	00:40:00	1.16	0.340	1.160	40.00	60	65	0.1667	360.0	390.0	360	
25/06/2024	00:50:00	1.215	0.285	1.215	50.00	55	59	0.1667	330.0	354.0	415	
25/06/2024	01:00:00	1.275	0.225	1.275	60.00	60	55	0.1667	360.0	330.0	475	
25/06/2024	01:10:00	1.32	0.180	1.320	70.00	45	49	0.1667	270.0	294.0	520	
25/06/2024	01:27:00	1.385	0.115	1.385	87.00	65	70	0.2833	229.4	247.1	585	
25/06/2024	01:46:00	1.46	0.040	1.460	106.00	75	70	0.3167	236.8	221.1	660	
25/06/2024	01:59:00	1.495	0.005	1.495	119.00	35	39	0.2167	161.5		695	
						695.000	695.000					

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
25/06/2024	00:00:00		0.700	0.800	0.00	0	0	0.00				
25/06/2024	00:01:00		0.699	0.802	1.00	1.5	1.5	0.0167	90.0	90.0	1.5	
25/06/2024	00:02:00		0.693	0.807	2.00	5.6	4.4	0.0167	336.0	264.0	7.1	
25/06/2024	00:03:00		0.689	0.812	3.00	4.4	7	0.0167	264.0	420.0	11.5	
25/06/2024	00:04:00		0.678	0.822	4.00	10.9	10.9	0.0167	654.0	654.0	22.4	
25/06/2024	00:05:00		0.664	0.836	5.00	13.3	13.3	0.0167	798.0	798.0	35.7	
25/06/2024	00:06:00		0.652	0.848	6.00	12.7	12.7	0.0167	762.0	762.0	48.4	
25/06/2024	00:07:00		0.640	0.860	7.00	11.8	12.3	0.0167	708.0	738.0	60.2	
25/06/2024	00:08:00		0.628	0.872	8.00	11.7	11.8	0.0167	702.0	708.0	71.9	
25/06/2024	00:09:00		0.617	0.883	9.00	11.5	11.5	0.0167	690.0	690.0	83.4	
25/06/2024	00:10:00		0.605	0.895	10.00	11.3	11.3	0.0167	678.0	678.0	94.7	
25/06/2024	00:12:00		0.583	0.917	12.00	21.9	21.5	0.0333	657.0	645.0	116.6	
25/06/2024	00:14:00		0.5627	0.937	14.00	20.7	20.4	0.0333	621.0	612.0	137.3	
25/06/2024	00:16:00		0.5433	0.957	16.00	19.4	19.4	0.0333	582.0	582.0	156.7	
25/06/2024	00:18:00		0.5246	0.975	18.00	18.7	18.4	0.0333	561.0	552.0	175.4	
25/06/2024	00:20:00		0.507	0.993	20.00	17.6	17.5	0.0333	528.0	525.0	193	
25/06/2024	00:25:00		0.4652	1.035	25.00	41.8	40	0.0833	501.6	480.0	234.8	
25/06/2024	00:30:00		0.4277	1.072	30.00	37.5	37.5	0.0833	450.0	450.0	272.3	
25/06/2024	00:35:00		0.3924	1.108	35.00	35.3	35.3	0.0833	423.6	423.6	307.6	
25/06/2024	00:40:00		0.3603	1.140	40.00	32.1	33	0.0833	385.2	396.0	339.7	
25/06/2024	00:50:00		0.3007	1.199	50.00	59.6	59.6	0.1667	357.6	357.6	399.3	
25/06/2024	01:00:00		0.2482	1.252	60.00	52.5	52.5	0.1667	315.0	315.0	451.8	
25/06/2024	01:10:00		0.2011	1.299	70.00	47.1	47.1	0.1667	282.6	282.6	498.9	
25/06/2024	01:20:00		0.1577	1.342	80.00	43.4	43.4	0.1667	260.4	260.4	542.3	
25/06/2024	01:30:00		0.1181	1.382	90.00	39.6	39.6	0.1667	237.6	237.6	581.9	
25/06/2024	01:40:00		0.0811	1.419	100.00	37	37	0.1667	222.0	222.0	618.9	
25/06/2024	01:50:00		0.0461	1.454	110.00	35	35	0.1667	210.0	210.0	653.9	

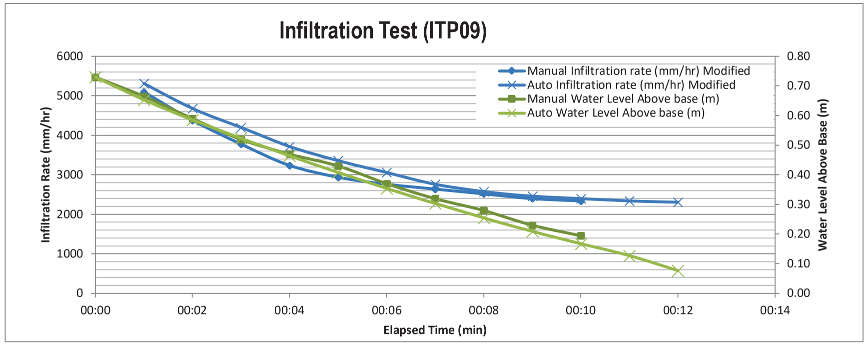
Testing Notes:
- Pre-soak conducted for 1 hour, level maintained at 0.75 metres above base of pit
- Water levels were monitored using manual dipper and levelogge
- Pre-soak terminated on reach of target time
- Bucket was initially placed at bottom of pit for water pour. Removed after 20 mins due to time constraints and the water was directly poured into the pit - potentially disturbing the pit walls and causing fines to settle to bottom.
- Fines settled to bottom of pit upon completion of tes
- Groundwater not encounterec

Location ID: IP09 Rolleston Access Improvement
Project Number: 3338703

Name:	IP09
Date Testing:	25/06/2024
Field Rep:	RO
Author:	GT
Checked:	LB

Depth of test pit (m)	1.8
Length of test pit (m)	2.1
Width of test pit (m)	1.6
Test pit area (m2)	3.36

Infiltration (mm/hr)	
Minimum	2325



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
25/06/2024	00:00:00	1.07	0.730	1.070	0.00	0	0	0.00				
25/06/2024	00:01:00	1.135	0.665	1.135	1.00	65	85	0.0167	3900.0	5100.0	65	
25/06/2024	00:02:00	1.21	0.590	1.210	2.00	75	73	0.0167	4500.0	4380.0	140	
25/06/2024	00:03:00	1.28	0.520	1.280	3.00	70	63	0.0167	4200.0	3780.0	210	
25/06/2024	00:04:00	1.33	0.470	1.330	4.00	50	54	0.0167	3000.0	3240.0	260	
25/06/2024	00:05:00	1.37	0.430	1.370	5.00	40	49	0.0167	2400.0	2940.0	300	
25/06/2024	00:06:00	1.43	0.370	1.430	6.00	60	46	0.0167	3600.0	2760.0	360	
25/06/2024	00:07:00	1.48	0.320	1.480	7.00	50	44	0.0167	3000.0	2640.0	410	
25/06/2024	00:08:00	1.52	0.280	1.520	8.00	40	42	0.0167	2400.0	2520.0	450	
25/06/2024	00:09:00	1.57	0.230	1.570	9.00	50	40	0.0167	3000.0	2400.0	500	
25/06/2024	00:10:00	1.605	0.195	1.605	10.00	35	39	0.0167	2100.0	2340.0	535	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
25/06/2024	00:00:00		0.730	1.070	0.00	0	0	0.00				
25/06/2024	00:01:00		0.654	1.146	1.00	76.2	88.5	0.0167	4572.0	5310.0	76.2	
25/06/2024	00:02:00		0.586	1.214	2.00	68.1	78	0.0167	4086.0	4680.0	144.3	
25/06/2024	00:03:00		0.524	1.276	3.00	62	70	0.0167	3720.0	4200.0	206.3	
25/06/2024	00:04:00		0.465	1.336	4.00	59.2	62	0.0167	3552.0	3720.0	265.5	
25/06/2024	00:05:00		0.409	1.391	5.00	55.8	56	0.0167	3348.0	3360.0	321.3	
25/06/2024	00:06:00		0.355	1.445	6.00	54	51	0.0167	3240.0	3060.0	375.3	
25/06/2024	00:07:00		0.304	1.496	7.00	51.1	46	0.0167	3066.0	2760.0	426.4	
25/06/2024	00:08:00		0.255	1.545	8.00	48.7	43	0.0167	2922.0	2580.0	475.1	
25/06/2024	00:09:00		0.209	1.591	9.00	45.8	41	0.0167	2748.0	2460.0	520.9	
25/06/2024	00:10:00		0.168	1.632	10.00	41.4	40	0.0167	2484.0	2400.0	562.3	
25/06/2024	00:11:00		0.127	1.673	11.00	40.7	39	0.0167	2442.0	2340.0	603	
25/06/2024	00:12:00		0.077	1.723	12.00	50	38.5	0.0167	3000.0	2310.0	653	

Testing Notes:

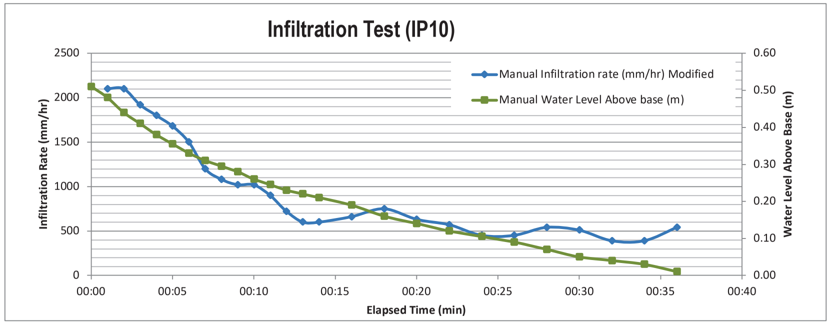
- Pre-soak conducted, level dropped below base of pit after 10,000 litre tanker was emptied approximately 25 minutes before it was refilled for 25 minutes reaching a level of 0.75 metres above base of pit upon which the test was conducted
- Water levels were monitored using manual dipper and levelogger
- Pre-soak terminated on reach of target time
- Bucket was placed at the bottom of pit for water pour
- Groundwater not encountered

Location ID: IP10 Rolleston Access Improvement
Project Number: 3338703

Name:	IP10
Date Testing:	24/07/2024
Field Rep:	RO
Author:	GT
Checked:	LB

Depth of test pit (m)	2.1
Length of test pit (m)	2.8
Width of test pit (m)	2.1
Test pit area (m2)	5.88

Infiltration (mm/hr)	
Minimum	497



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
24/07/2024	00:00:00	1.59	0.510	1.590	0.00	0	0	0.00				
24/07/2024	00:01:00	1.62	0.480	1.620	1.00	30	35	0.0167	1800.0	2100.0	30	
24/07/2024	00:02:00	1.66	0.440	1.660	2.00	40	35	0.0167	2400.0	2100.0	70	
24/07/2024	00:03:00	1.69	0.410	1.690	3.00	30	32	0.0167	1800.0	1920.0	100	
24/07/2024	00:04:00	1.72	0.380	1.720	4.00	30	30	0.0167	1800.0	1800.0	130	
24/07/2024	00:05:00	1.745	0.355	1.745	5.00	25	28	0.0167	1500.0	1680.0	155	
24/07/2024	00:06:00	1.77	0.330	1.770	6.00	25	25	0.0167	1500.0	1500.0	180	
24/07/2024	00:07:00	1.79	0.310	1.790	7.00	20	20	0.0167	1200.0	1200.0	200	
24/07/2024	00:08:00	1.805	0.295	1.805	8.00	15	18	0.0167	900.0	1080.0	215	
24/07/2024	00:09:00	1.82	0.280	1.820	9.00	15	17	0.0167	900.0	1020.0	230	
24/07/2024	00:10:00	1.84	0.260	1.840	10.00	20	17	0.0167	1200.0	1020.0	250	
24/07/2024	00:11:00	1.855	0.245	1.855	11.00	15	15	0.0167	900.0	900.0	265	
24/07/2024	00:12:00	1.87	0.230	1.870	12.00	15	12	0.0167	900.0	720.0	280	
24/07/2024	00:13:00	1.88	0.220	1.880	13.00	10	10	0.0167	600.0	600.0	290	
24/07/2024	00:14:00	1.89	0.210	1.890	14.00	10	10	0.0167	600.0	600.0	300	
24/07/2024	00:16:00	1.91	0.190	1.910	16.00	20	22	0.0333	600.0	660.0	320	
24/07/2024	00:18:00	1.94	0.160	1.940	18.00	30	25	0.0333	900.0	750.0	350	
24/07/2024	00:20:00	1.96	0.140	1.960	20.00	20	21	0.0333	600.0	630.0	370	
24/07/2024	00:22:00	1.98	0.120	1.980	22.00	20	19	0.0333	600.0	570.0	390	
24/07/2024	00:24:00	1.995	0.105	1.995	24.00	15	15	0.0333	450.0	450.0	405	
24/07/2024	00:26:00	2.01	0.090	2.010	26.00	15	15	0.0333	450.0	450.0	420	
24/07/2024	00:28:00	2.03	0.070	2.030	28.00	20	18	0.0333	600.0	540.0	440	
24/07/2024	00:30:00	2.05	0.050	2.050	30.00	20	17	0.0333	600.0	510.0	460	
24/07/2024	00:32:00	2.06	0.040	2.060	32.00	10	13	0.0333	300.0	390.0	470	
24/07/2024	00:34:00	2.07	0.030	2.070	34.00	10	13	0.0333	300.0	390.0	480	
24/07/2024	00:36:00	2.09	0.010	2.090	36.00	20	18	0.0333	600.0	540.0	500	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment

No levelogger used

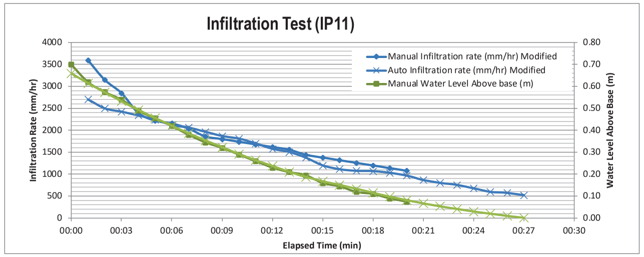
Testing Notes:
- Pre-soak conducted, level dropped below base of pit after 10,000 litre tanker was emptied approximately 25 minutes before it was refilled for 25 minutes emptying 20,000 L total before test began
- Water levels were monitored using manual dipper
- Pre-soak terminated on reach of target time
- Bucket was placed at the bottom of pit for water pour
- Groundwater not encountered

Location ID: IP11 Rolleston Access Improvement
Project Number: 3338703

Name:	IP11
Date Testing:	5/07/2024
Field Rep:	NY
Author:	GT
Checked:	LB

Depth of test pit (m)	2.2
Length of test pit (m)	2.2
Width of test pit (m)	1.7
Test pit area (m2)	3.74

Infiltration (mm/hr)	
Minimum	588



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
5/07/2024	00:00:00	1.500	0.700	1.500	0.00	0	0	0.00				
5/07/2024	00:01:00	1.580	0.620	1.580	1.00	80	60	0.0167	4800.0	3600.0	80	
5/07/2024	00:02:00	1.625	0.575	1.625	2.00	45	52.5	0.0167	2700.0	3150.0	125	
5/07/2024	00:03:00	1.660	0.540	1.660	3.00	35	47.5	0.0167	2100.0	2850.0	160	
5/07/2024	00:04:00	1.710	0.490	1.710	4.00	50	40	0.0167	3000.0	2400.0	210	
5/07/2024	00:05:00	1.745	0.455	1.745	5.00	35	37	0.0167	2100.0	2220.0	245	
5/07/2024	00:06:00	1.780	0.420	1.780	6.00	35	36	0.0167	2100.0	2160.0	280	
5/07/2024	00:07:00	1.820	0.380	1.820	7.00	40	34	0.0167	2400.0	2040.0	320	
5/07/2024	00:08:00	1.855	0.345	1.855	8.00	35	31	0.0167	2100.0	1860.0	355	
5/07/2024	00:09:00	1.880	0.320	1.880	9.00	25	30	0.0167	1500.0	1800.0	380	
5/07/2024	00:10:00	1.910	0.290	1.910	10.00	30	29	0.0167	1800.0	1740.0	410	
5/07/2024	00:11:00	1.940	0.260	1.940	11.00	30	28	0.0167	1800.0	1680.0	440	
5/07/2024	00:12:00	1.970	0.230	1.970	12.00	30	27	0.0167	1800.0	1620.0	470	
5/07/2024	00:13:00	1.990	0.210	1.990	13.00	20	26	0.0167	1200.0	1560.0	490	
5/07/2024	00:14:00	2.005	0.195	2.005	14.00	15	24	0.0167	900.0	1440.0	505	
5/07/2024	00:15:00	2.040	0.160	2.040	15.00	35	23	0.0167	2100.0	1380.0	540	
5/07/2024	00:16:00	2.055	0.145	2.055	16.00	15	22	0.0167	900.0	1320.0	555	
5/07/2024	00:17:00	2.080	0.120	2.080	17.00	25	21	0.0167	1500.0	1260.0	580	
5/07/2024	00:18:00	2.090	0.110	2.090	18.00	10	20	0.0167	600.0	1200.0	590	
5/07/2024	00:19:00	2.110	0.090	2.110	19.00	20	19	0.0167	1200.0	1140.0	610	
5/07/2024	00:20:00	2.125	0.075	2.125	20.00	15	18	0.0167	900.0	1080.0	625	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
5/07/2024	00:00:00	1.54	0.660	1.540	0.00	0	0	0.00				
5/07/2024	00:01:00	1.5851	0.615	1.585	1.00	45.1	45.1	0.0167	2706.0	2706.0	85.1	
5/07/2024	00:02:00	1.6268	0.573	1.627	2.00	41.7	41.7	0.0167	2502.0	2502.0	126.8	
5/07/2024	00:03:00	1.6672	0.533	1.667	3.00	40.4	40.4	0.0167	2424.0	2424.0	167.2	
5/07/2024	00:04:00	1.7062	0.494	1.706	4.00	39	39	0.0167	2340.0	2340.0	206.2	
5/07/2024	00:05:00	1.7436	0.456	1.744	5.00	37.4	37.4	0.0167	2244.0	2244.0	243.6	
5/07/2024	00:06:00	1.7787	0.421	1.779	6.00	35.1	35.3	0.0167	2106.0	2118.0	278.7	
5/07/2024	00:07:00	1.8131	0.387	1.813	7.00	34.4	34.4	0.0167	2064.0	2064.0	313.1	
5/07/2024	00:08:00	1.8459	0.354	1.846	8.00	32.8	32.8	0.0167	1968.0	1968.0	345.9	
5/07/2024	00:09:00	1.8771	0.323	1.877	9.00	31.2	31.2	0.0167	1872.0	1872.0	377.1	
5/07/2024	00:10:00	1.9075	0.293	1.908	10.00	30.4	30.2	0.0167	1824.0	1812.0	407.5	
5/07/2024	00:11:00	1.9359	0.264	1.936	11.00	28.4	28.4	0.0167	1704.0	1704.0	435.9	
5/07/2024	00:12:00	1.962	0.238	1.962	12.00	26.1	26.3	0.0167	1566.0	1578.0	462	
5/07/2024	00:13:00	1.9894	0.211	1.989	13.00	27.4	25.1	0.0167	1644.0	1506.0	489.4	
5/07/2024	00:14:00	2.0126	0.187	2.013	14.00	23.2	23	0.0167	1392.0	1380.0	512.6	
5/07/2024	00:15:00	2.0319	0.168	2.032	15.00	19.3	20	0.0167	1158.0	1200.0	531.9	
5/07/2024	00:16:00	2.0487	0.151	2.049	16.00	16.8	18.6	0.0167	1008.0	1116.0	548.7	
5/07/2024	00:17:00	2.0665	0.134	2.067	17.00	17.8	18	0.0167	1068.0	1080.0	566.5	
5/07/2024	00:18:00	2.0843	0.116	2.084	18.00	17.8	17.8	0.0167	1068.0	1068.0	584.3	
5/07/2024	00:19:00	2.1019	0.098	2.102	19.00	17.6	17.2	0.0167	1056.0	1032.0	601.9	
5/07/2024	00:20:00	2.1183	0.082	2.118	20.00	16.4	16.2	0.0167	984.0	972.0	618.3	
5/07/2024	00:21:00	2.1325	0.068	2.133	21.00	14.2	14.5	0.0167	852.0	870.0	632.5	
5/07/2024	00:22:00	2.1459	0.054	2.146	22.00	13.4	13.4	0.0167	804.0	804.0	645.9	
5/07/2024	00:23:00	2.1585	0.042	2.159	23.00	12.6	12.6	0.0167	756.0	756.0	658.5	
5/07/2024	00:24:00	2.1698	0.030	2.170	24.00	11.3	11.3	0.0167	678.0	678.0	669.8	
5/07/2024	00:25:00	2.1796	0.020	2.180	25.00	9.8	10	0.0167	588.0	600.0	679.6	
5/07/2024	00:26:00	2.1895	0.011	2.190	26.00	9.9	9.6	0.0167	594.0	576.0	689.5	
5/07/2024	00:27:00	2.1982	0.002	2.198	27.00	8.7	8.7	0.0167	522.0	522.0	698.2	

Testing Notes:
- Pre-soak conducted, level maintained at 0.7 metres above base of pit for 30 mins upon which the test was conducted
- Water levels were monitored using manual dipper and logge
- Pre-soak terminated after 30 mins due to time constraints
- Bucket remained at bottom of pit during water pou
- Bucket remained in pit during tes
- Groundwater not encounterec

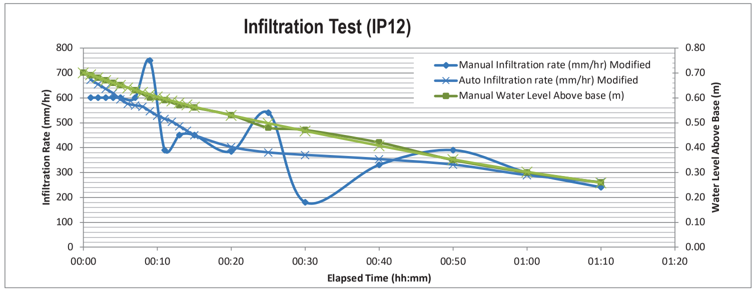
Sensitivity: General

Location ID: IP12 Rolleston Access Improvement
Project Number: 3338703

Name:	IP12
Date Testing:	15/07/2024
Field Rep:	NY
Author:	GT
Checked:	LB

Depth of test pit (m)	2.7
Length of test pit (m)	1.7
Width of test pit (m)	2.2
Test pit area (m2)	3.74

Infiltration (mm/hr)	
Minimum	334



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
15/07/2024	00:00:00	2.000	0.700	2.000	0.00	0	0	0.00				
15/07/2024	00:01:00	2.010	0.690	2.010	1.00	10	10	0.0167	600.0	600.0	10	
15/07/2024	00:02:00	2.020	0.680	2.020	2.00	10	10	0.0167	600.0	600.0	20	
15/07/2024	00:03:00	2.030	0.670	2.030	3.00	10	10	0.0167	600.0	600.0	30	
15/07/2024	00:04:00	2.040	0.660	2.040	4.00	10	10	0.0167	600.0	600.0	40	
15/07/2024	00:05:00	2.050	0.650	2.050	5.00	10	10	0.0167	600.0	600.0	50	
15/07/2024	00:07:00	2.070	0.630	2.070	7.00	20	20	0.0333	600.0	600.0	70	
15/07/2024	00:09:00	2.100	0.600	2.100	9.00	30	25	0.0333	900.0	750.0	100	
15/07/2024	00:11:00	2.110	0.590	2.110	11.00	10	13	0.0333	300.0	390.0	110	
15/07/2024	00:13:00	2.130	0.570	2.130	13.00	20	15	0.0333	600.0	450.0	130	
15/07/2024	00:15:00	2.140	0.560	2.140	15.00	10	15	0.0333	300.0	450.0	140	
15/07/2024	00:20:00	2.170	0.530	2.170	20.00	30	32	0.0833	360.0	384.0	170	
15/07/2024	00:25:00	2.220	0.480	2.220	25.00	50	45	0.0833	600.0	540.0	220	
15/07/2024	00:30:00	2.230	0.470	2.230	30.00	10	15	0.0833	120.0	180.0	230	
15/07/2024	00:40:00	2.280	0.420	2.280	40.00	50	55	0.1667	300.0	330.0	280	
15/07/2024	00:50:00	2.350	0.350	2.350	50.00	70	65	0.1667	420.0	390.0	350	
15/07/2024	01:00:00	2.400	0.300	2.400	60.00	50	50	0.1667	300.0	300.0	400	
15/07/2024	01:10:00	2.440	0.260	2.440	70.00	40	40	0.1667	240.0	240.0	440	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
15/07/2024	00:00:00	2	0.700	2.000	0.00	0	0	0.00				
15/07/2024	00:01:00	2.0076	0.692	2.008	1.00	7.6	11.2	0.0167	456.0	672.0	7.6	
15/07/2024	00:02:00	2.0187	0.681	2.019	2.00	11.1	10.9	0.0167	666.0	654.0	18.7	
15/07/2024	00:03:00	2.0296	0.670	2.030	3.00	10.9	10.6	0.0167	654.0	636.0	29.6	
15/07/2024	00:04:00	2.0399	0.660	2.040	4.00	10.3	10.3	0.0167	618.0	618.0	39.9	
15/07/2024	00:05:00	2.0498	0.650	2.050	5.00	9.9	9.9	0.0167	594.0	594.0	49.8	
15/07/2024	00:06:00	2.0593	0.641	2.059	6.00	9.5	9.6	0.0167	570.0	576.0	59.3	
15/07/2024	00:07:00	2.0688	0.631	2.069	7.00	9.5	9.5	0.0167	570.0	570.0	68.8	
15/07/2024	00:08:00	2.0782	0.622	2.078	8.00	9.4	9.4	0.0167	564.0	564.0	78.2	
15/07/2024	00:09:00	2.0873	0.613	2.087	9.00	9.1	9.1	0.0167	546.0	546.0	87.3	
15/07/2024	00:10:00	2.0955	0.605	2.096	10.00	8.2	8.8	0.0167	492.0	528.0	95.5	
15/07/2024	00:11:00	2.1043	0.596	2.104	11.00	8.8	8.6	0.0167	528.0	516.0	104.3	
15/07/2024	00:12:00	2.1123	0.588	2.112	12.00	8	8.4	0.0167	480.0	504.0	112.3	
15/07/2024	00:13:00	2.1207	0.579	2.121	13.00	8.4	8.1	0.0167	504.0	486.0	120.7	
15/07/2024	00:14:00	2.1282	0.572	2.128	14.00	7.5	7.8	0.0167	450.0	468.0	128.2	
15/07/2024	00:15:00	2.1363	0.564	2.136	15.00	8.1	7.5	0.0167	486.0	450.0	136.3	
15/07/2024	00:20:00	2.1708	0.529	2.171	20.00	34.5	33.5	0.0833	414.0	402.0	170.8	
15/07/2024	00:25:00	2.2026	0.497	2.203	25.00	31.8	31.7	0.0833	381.6	380.4	202.6	
15/07/2024	00:30:00	2.2335	0.467	2.234	30.00	30.9	30.9	0.0833	370.8	370.8	233.5	
15/07/2024	00:40:00	2.2928	0.407	2.293	40.00	59.3	59	0.1667	355.8	354.0	292.8	
15/07/2024	00:50:00	2.3481	0.352	2.348	50.00	55.3	55.3	0.1667	331.8	331.8	348.1	
15/07/2024	01:00:00	2.3974	0.303	2.397	60.00	49.3	48.3	0.1667	295.8	289.8	397.4	
15/07/2024	01:10:00	2.4419	0.258	2.442	70.00	44.5	43.5	0.1667	267.0	261.0	441.9	

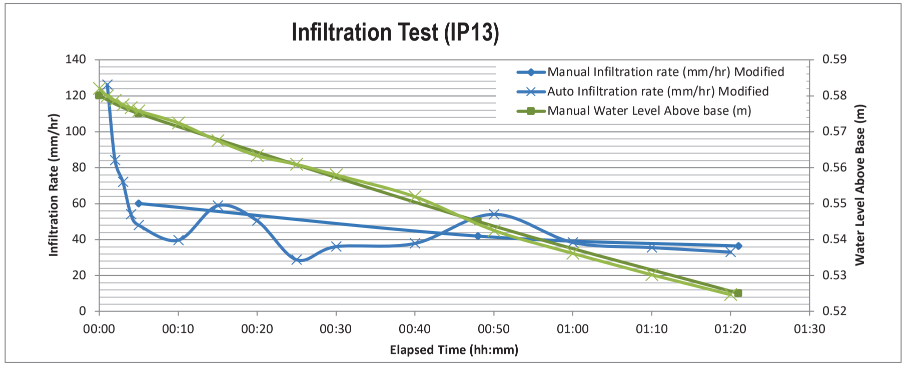
Testing Notes:
- Pre-soak conducted, level maintained at 1.0 metre above base of pit
- Water levels were monitored using manual dipper and logger
- Pre-soak terminated after 1 hour
- Bucket remained at bottom of pit during water pour
- Test terminated due to time constraints
- Groundwater not encountered

Location ID: IP13 Rolleston Access Improvement
Project Number: 3338703

Name:	IP13
Date Testing:	10/07/2024
Field Rep:	NY
Author:	GT
Checked:	LB

Depth of test pit (m)	2.2
Length of test pit (m)	1.0
Width of test pit (m)	2.0
Test pit area (m2)	2.00

Infiltration (mm/hr)	
Minimum	41



Manual Test Readings

Date	Manual Test Time Interval	Manual Test measurement (m)	Manual Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Manual Infiltration rate (mm/hr)	Manual Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
10/07/2024	00:00:00	1.62	0.580	1.620	0.00	0	0	0.00				
10/07/2024	00:05:00	1.625	0.575	1.625	5.00	5	33.5	0.0833	60.0	60.0	5	
10/07/2024	00:48:00	1.655	0.545	1.655	48.00	30	34.5	0.7167	41.9	41.9	35	
10/07/2024	01:21:00	1.675	0.525	1.675	81.00	20	32.5	0.5500	36.4	36.4	55	

Automatic Logger Test Readings

Date	AutoTest Time Interval	Manual Test measurement (m)	Auto Water Level Above base (m)	WL bgl (m)	Lapsed Time (min)	Change level (mm)	Change level (mm) Modified	Change time (hr)	Auto Infiltration rate (mm/hr)	Auto Infiltration rate (mm/hr) Modified	Cumulative infiltration (mm)	Comment
10/07/2024	00:00:00	1.618	0.582	1.618	0.00	0	0	0.00				
10/07/2024	00:01:00	1.6201	0.580	1.620	1.00	2.1	2.1	0.0167	126.0	126.0	0.1	
10/07/2024	00:02:00	1.6213	0.579	1.621	2.00	1.2	1.4	0.0167	72.0	84.0	1.3	
10/07/2024	00:03:00	1.6226	0.577	1.623	3.00	1.3	1.2	0.0167	78.0	72.0	2.6	
10/07/2024	00:04:00	1.6234	0.577	1.623	4.00	0.8	0.9	0.0167	48.0	54.0	3.4	
10/07/2024	00:05:00	1.6243	0.576	1.624	5.00	0.9	0.8	0.0167	54.0	48.0	4.3	
10/07/2024	00:10:00	1.6276	0.572	1.628	10.00	3.3	3.3	0.0833	39.6	39.6	7.6	
10/07/2024	00:15:00	1.6325	0.568	1.633	15.00	4.9	4.9	0.0833	58.8	58.8	12.5	
10/07/2024	00:20:00	1.6367	0.563	1.637	20.00	4.2	4.2	0.0833	50.4	50.4	16.7	
10/07/2024	00:25:00	1.6391	0.561	1.639	25.00	2.4	2.4	0.0833	28.8	28.8	19.1	
10/07/2024	00:30:00	1.6421	0.558	1.642	30.00	3	3	0.0833	36.0	36.0	22.1	
10/07/2024	00:40:00	1.6481	0.552	1.648	40.00	6	6.3	0.1667	36.0	37.8	28.1	
10/07/2024	00:50:00	1.6575	0.543	1.658	50.00	9.4	9	0.1667	56.4	54.0	37.5	
10/07/2024	01:00:00	1.6639	0.536	1.664	60.00	6.4	6.4	0.1667	38.4	38.4	43.9	
10/07/2024	01:10:00	1.6698	0.530	1.670	70.00	5.9	5.9	0.1667	35.4	35.4	49.8	
10/07/2024	01:20:00	1.6753	0.525	1.675	80.00	5.5	5.5	0.1667	33.0	33.0	55.3	

Testing Notes:
- Pre-soak conducted, level maintained at 0.7 metres above base of pit after 1,500 litre tanker was emptied
- Water levels were monitored using manual dipper and levelogger
- Pre-soak terminated after 1 hour
- Bucket was placed at the bottom of the pit for water pour
- Groundwater not encountered

C

Appendix C – Slope Stability Analysis Results

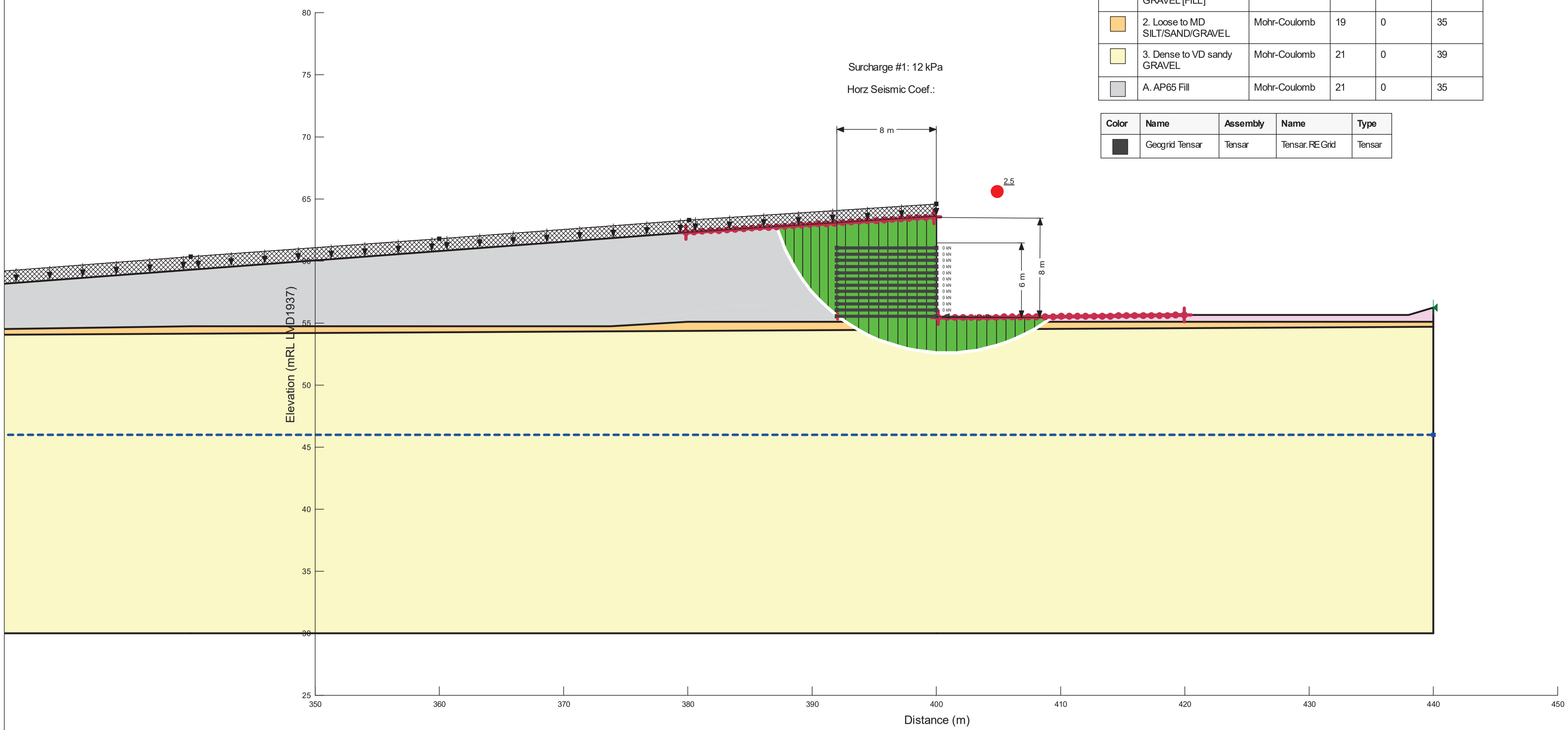
Horz Seismic Coef.:

Method: Morgenstern-Price

Longitudinal Global Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar. RE Grid	Tensar



Beca

Rolleston Access Improvements

Rolleston Access - MSE Wall Global Stability REV1.gsz
1.1 Static - HN (8m length)

3338703

Date: 02/10/2024

Scale: 1:500

DO NOT SCALE

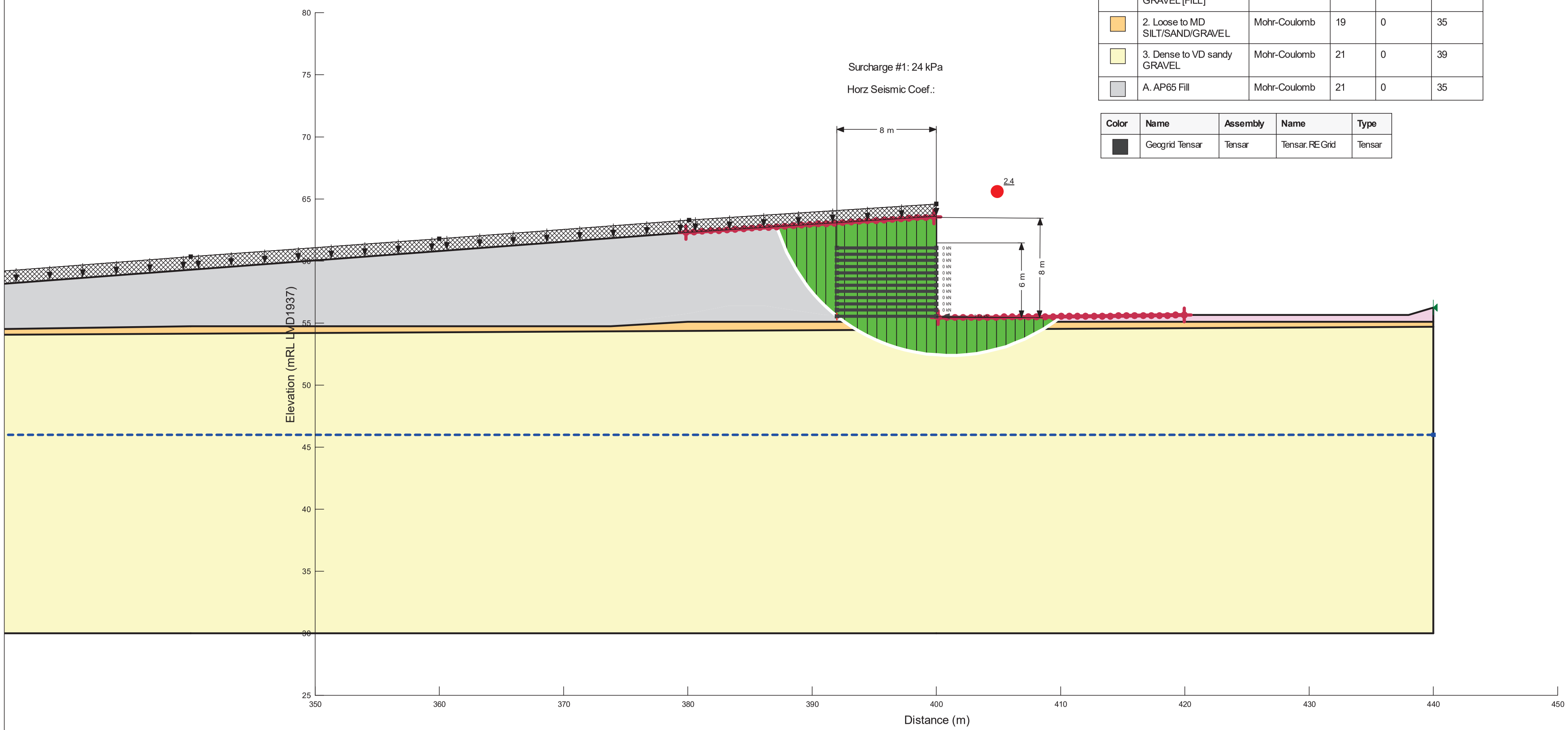
Horz Seismic Coef.:

Method: Morgenstern-Price

Longitudinal Global Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.RE Grid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.2 Static - HO (8m length)	3338703	Date: 02/10/2024
			Scale: 1:500	

DO NOT SCALE

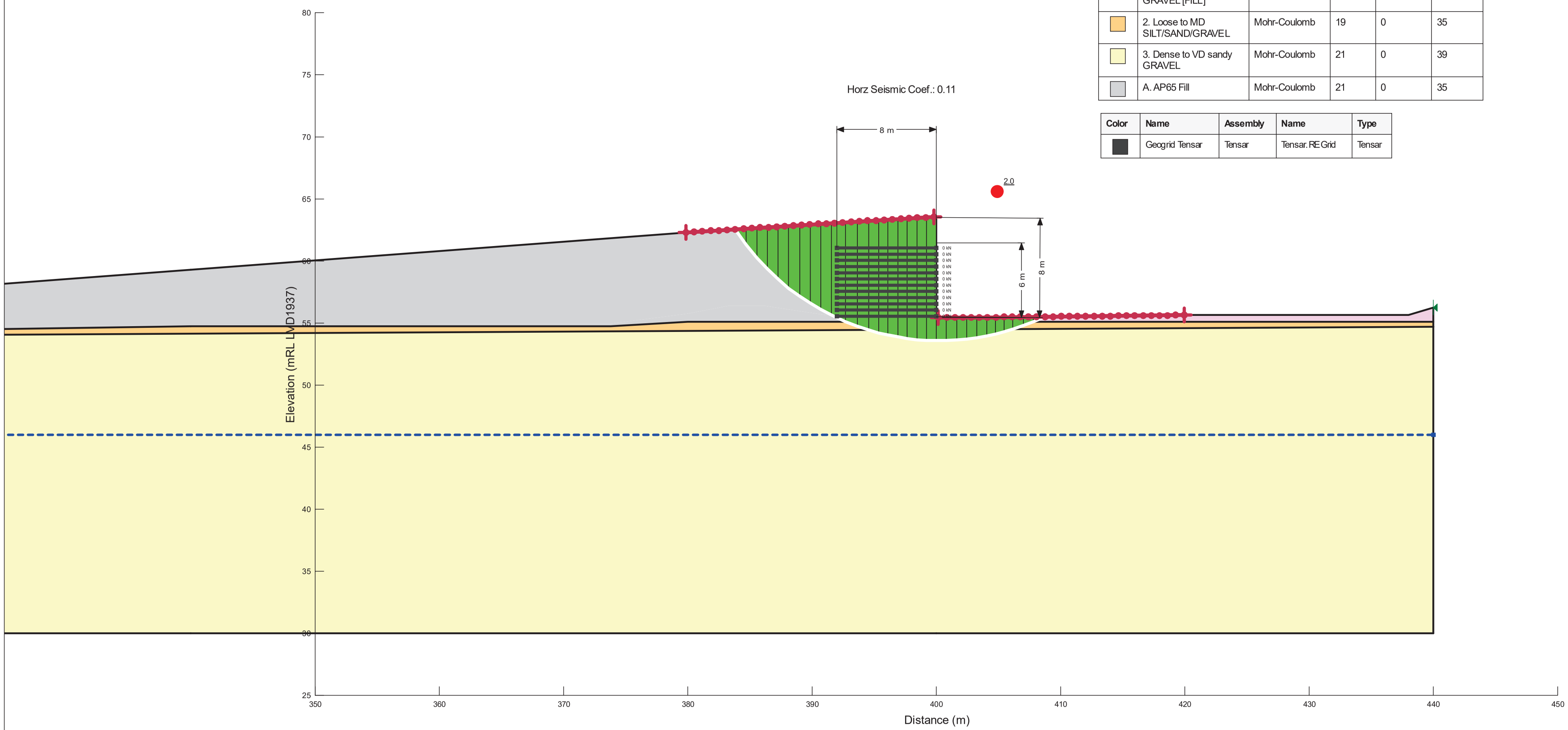
Horz Seismic Coef.: 0.11

Method: Morgenstern-Price

Longitudinal Global Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar RE Grid	Tensar



Rolleston Access Improvements

Rolleston Access - MSE Wall Global Stability REV1.gsz
2.1 Seismic - SLS 0.11g (8m length)

3338703

Date: 02/10/2024

Scale: 1:500

DO NOT SCALE

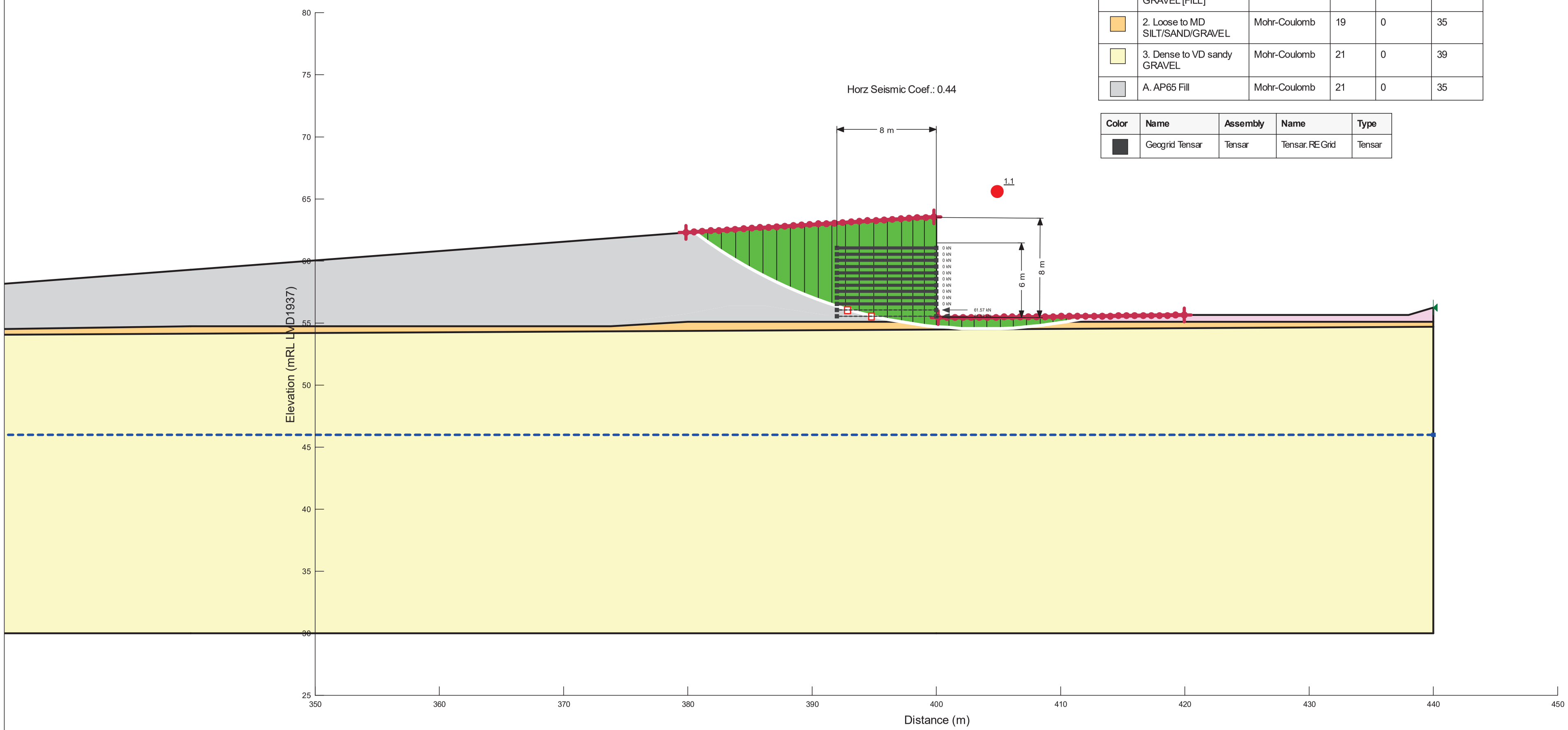
Horz Seismic Coef.: 0.44

Method: Morgenstern-Price

Longitudinal Global Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar. RE Grid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 2.2 Seismic - DCLS 0.44g (8m length)	3338703	Date: 02/10/2024
			Scale: 1:500	

DO NOT SCALE

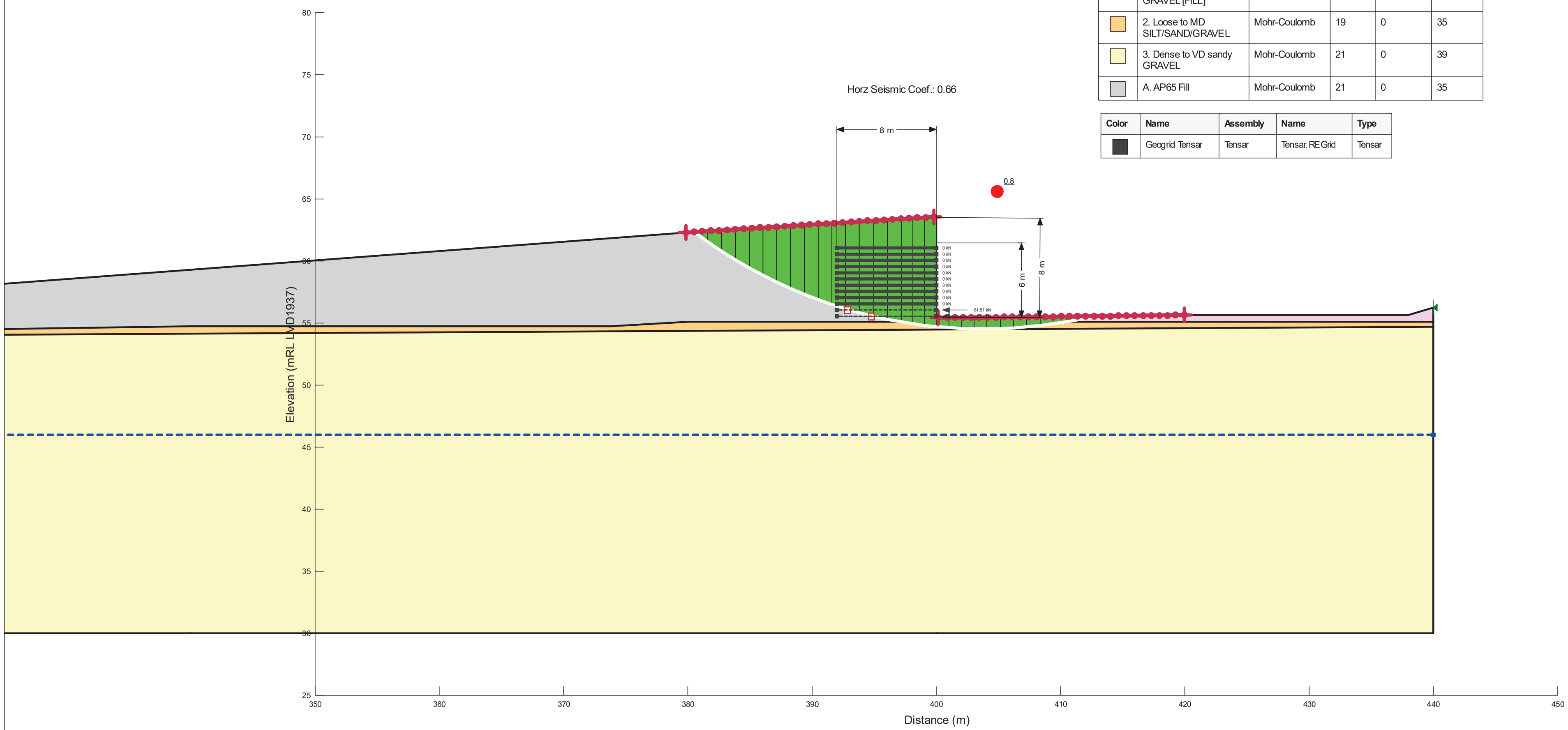
Horz Seismic Coef.: 0.66

Method: Morgenstern-Price

Longitudinal Global Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar. RE Grid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 2.3 Seismic - CALS 0.66g (8m length)	3338703	Date: 02/10/2024
			Scale: 1:500	

DO NOT SCALE

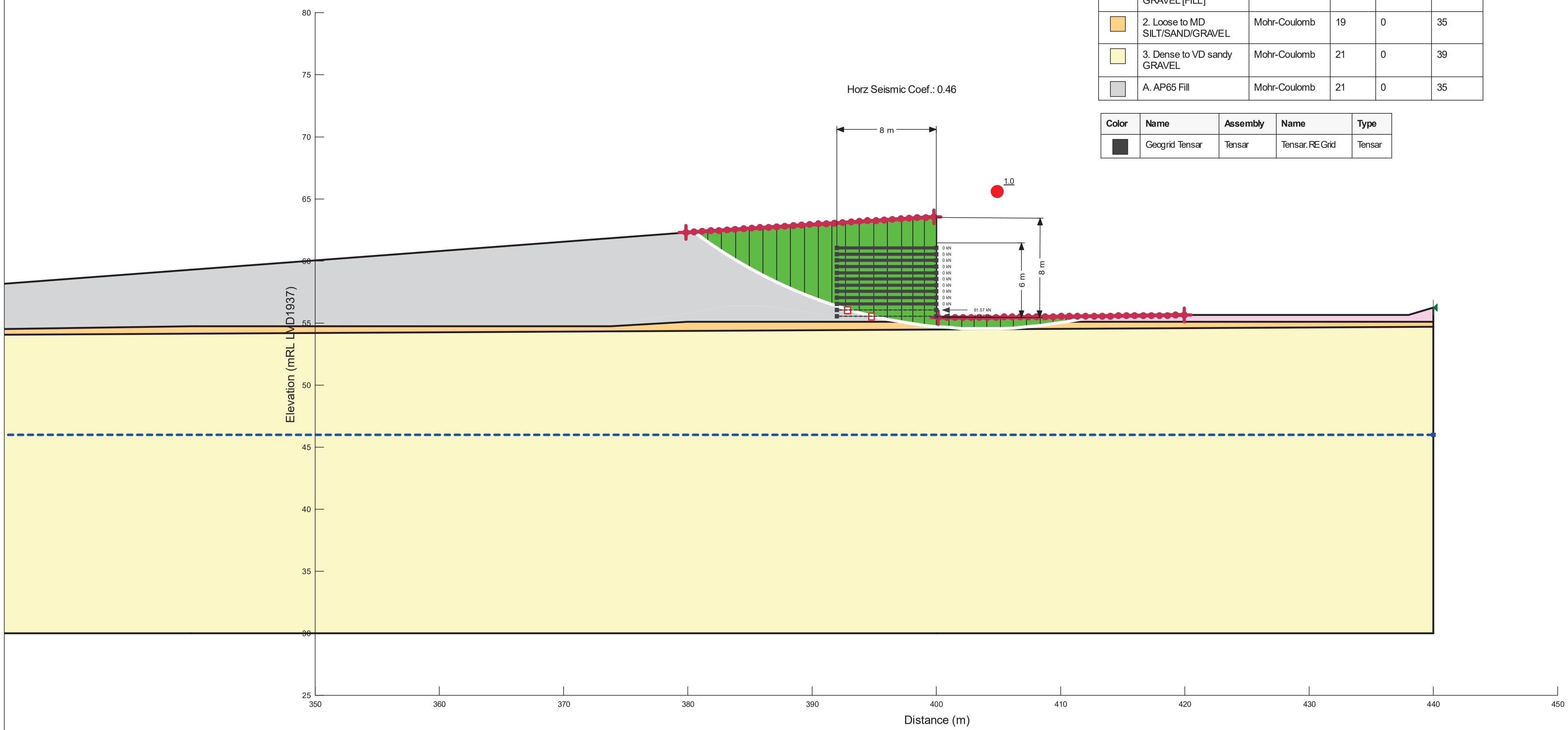
Horz Seismic Coef.: 0.46

Method: Morgenstern-Price

Longitudinal Global Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.RE Grid	Tensar



Beca

Rolleston Access Improvements

Rolleston Access - MSE Wall Global Stability REV1.gsz
2.4 Seismic - Yield PGA 0.43g (8m length)

3338703

Date: 02/10/2024

Scale: 1:500

DO NOT SCALE

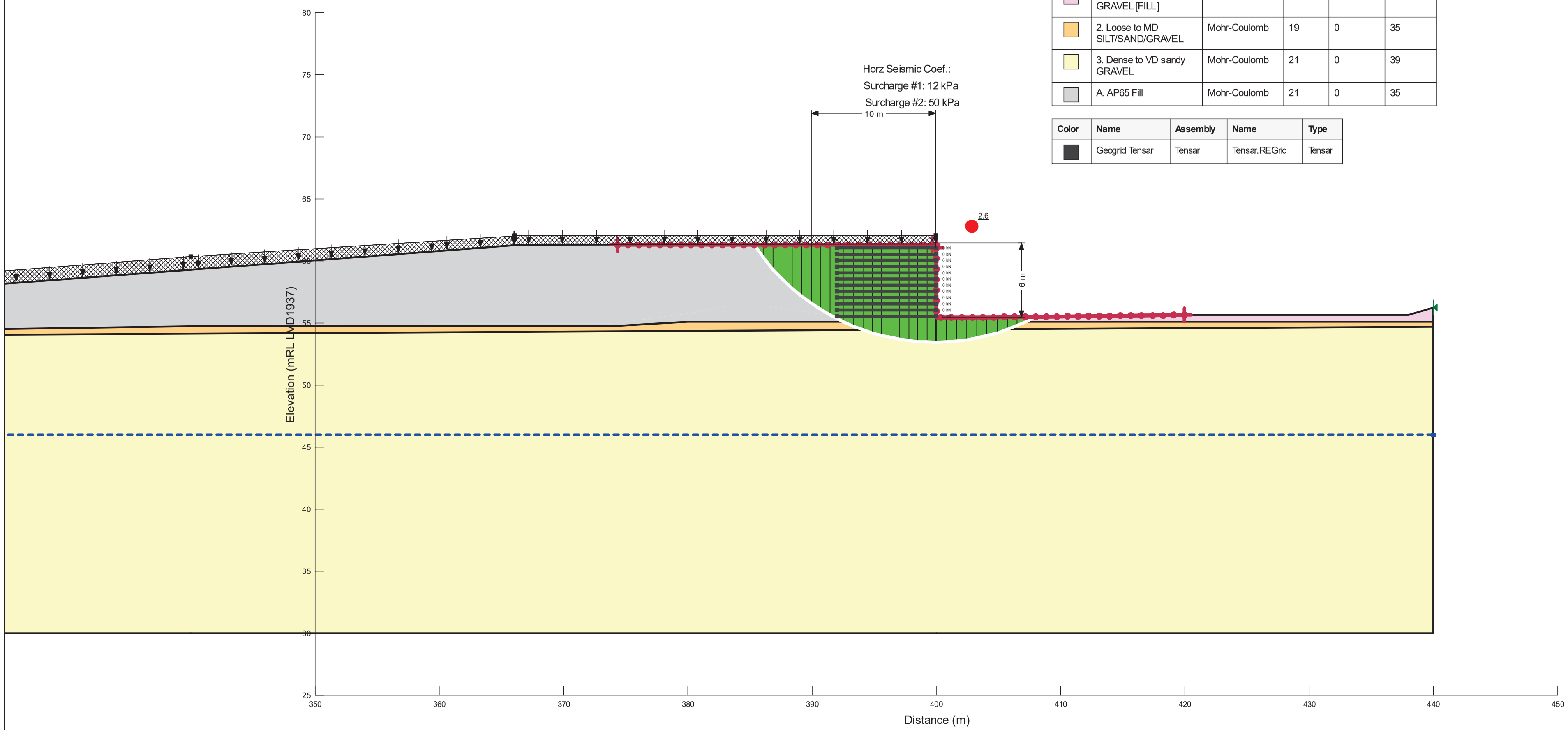
Horz Seismic Coef.:

Method: Morgenstern-Price

Longitudinal Local Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.1 Static - HN (Local)	3338703 — Date: 02/10/2024 Scale: 1:500

DO NOT SCALE

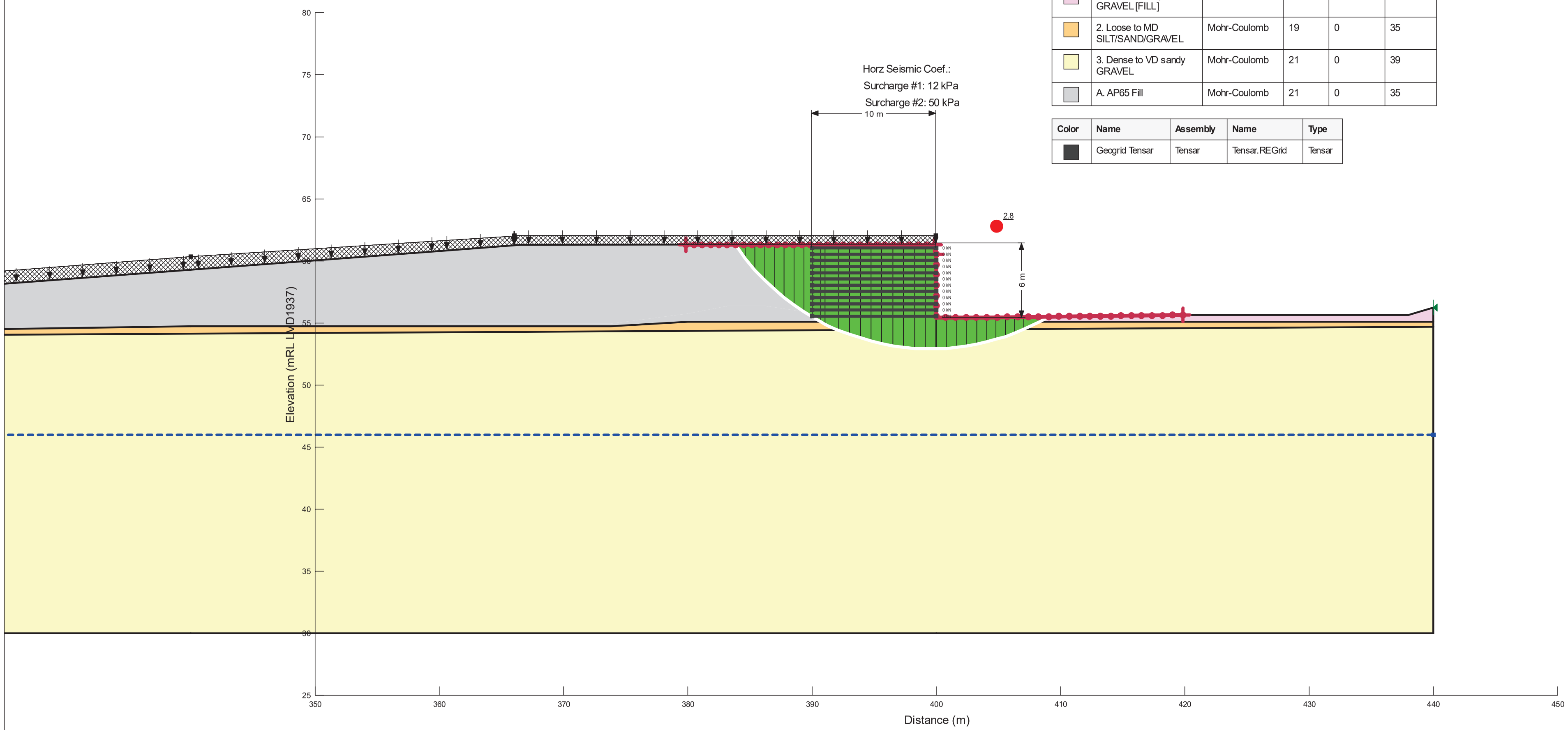
Horz Seismic Coef.:

Method: Morgenstern-Price

Longitudinal Local Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Rolleston Access Improvements

Rolleston Access - MSE Wall Global Stability REV1.gsz
1.2 Static - HO (Local)

3338703

Date: 02/10/2024

Scale: 1:500

DO NOT SCALE

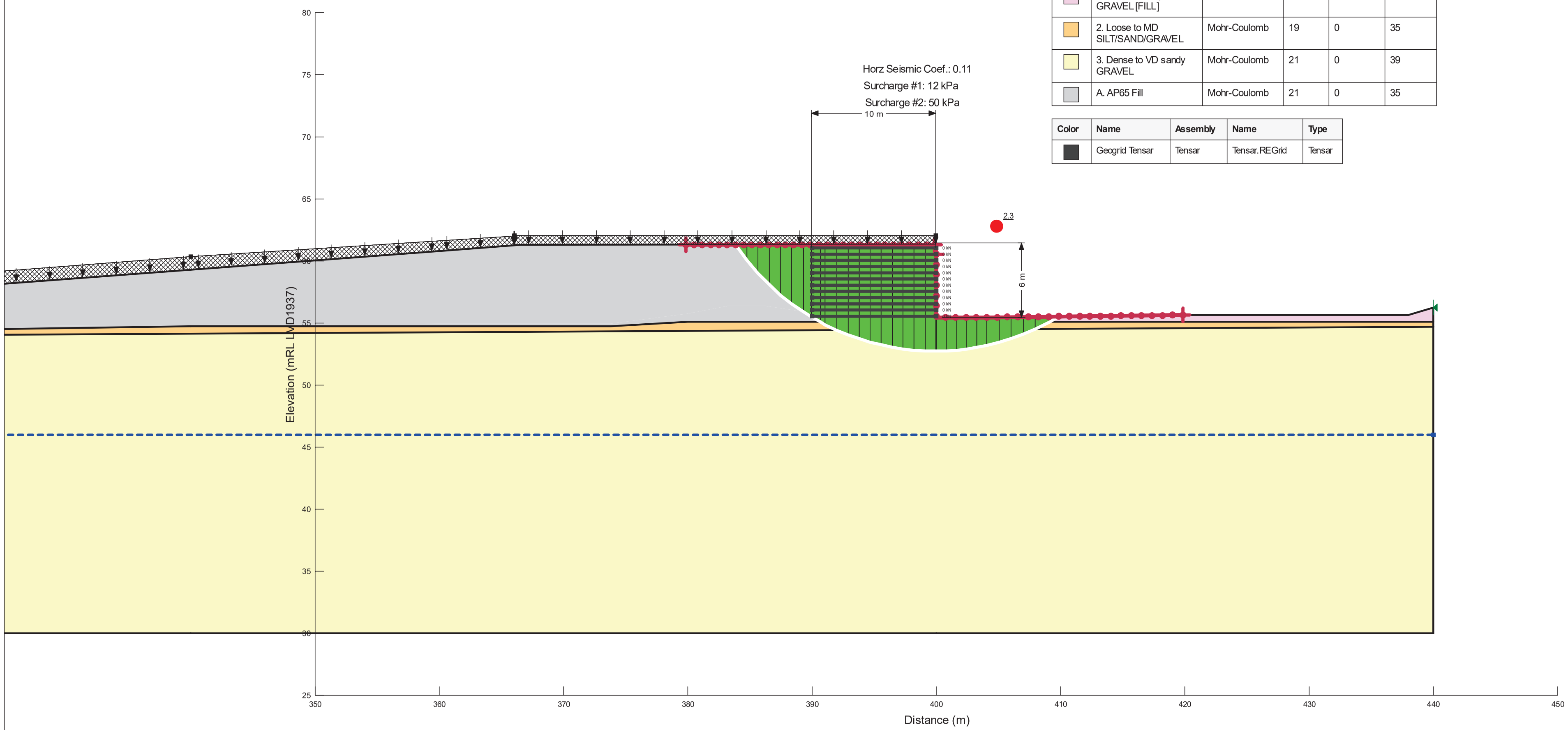
Horz Seismic Coef.: 0.11

Method: Morgenstern-Price

Longitudinal Local Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Rolleston Access Improvements

Rolleston Access - MSE Wall Global Stability REV1.gsz
2.1 Seismic - SLS 0.11g (Local)

3338703

Date: 02/10/2024

Scale: 1:500

DO NOT SCALE

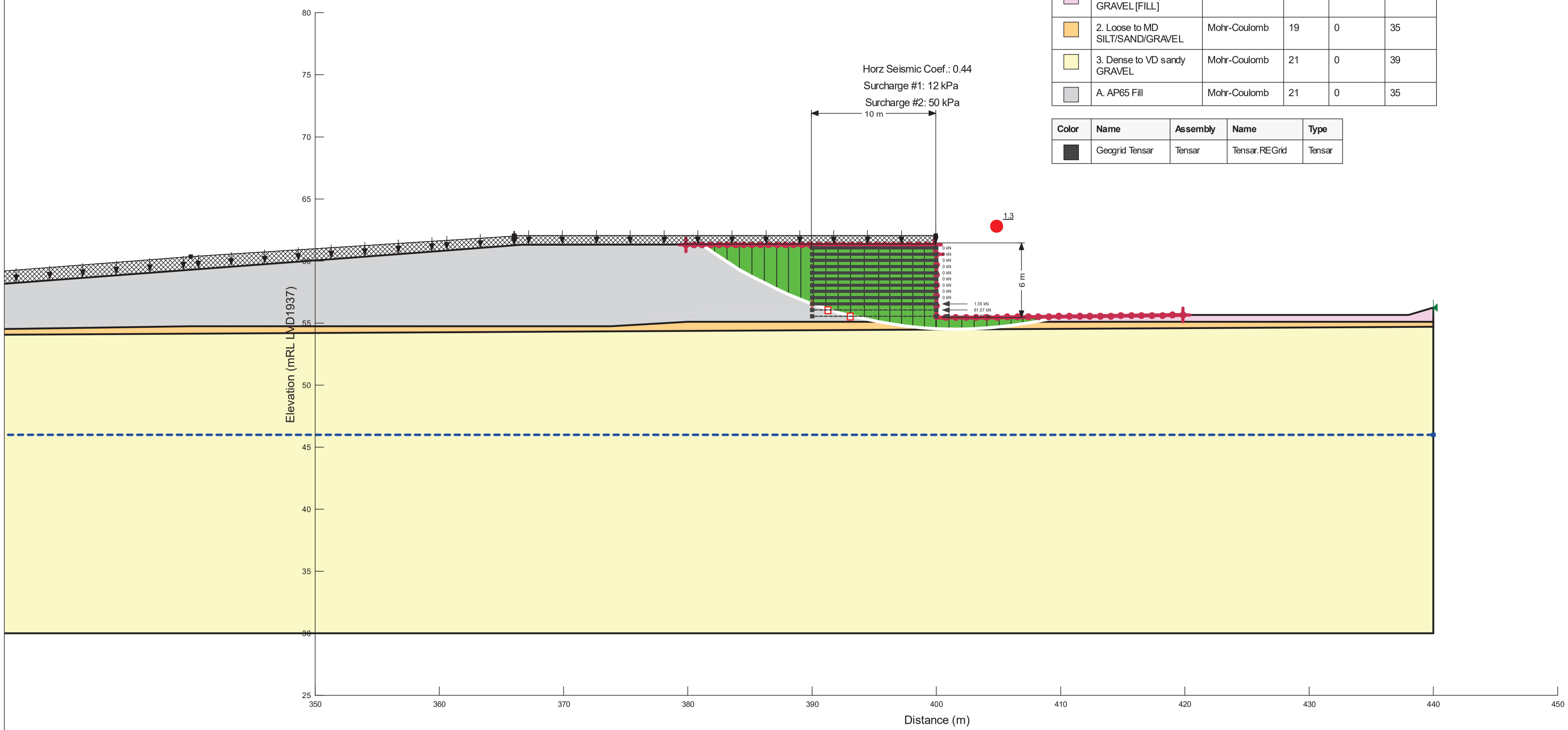
Horz Seismic Coef.: 0.44

Method: Morgenstern-Price

Longitudinal Local Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
(pink)	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
(orange)	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
(light yellow)	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
(grey)	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
(dark grey)	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 2.2 Seismic - DCLS 0.44g (Local)	3338703	Date: 02/10/2024
			Scale: 1:500	

DO NOT SCALE

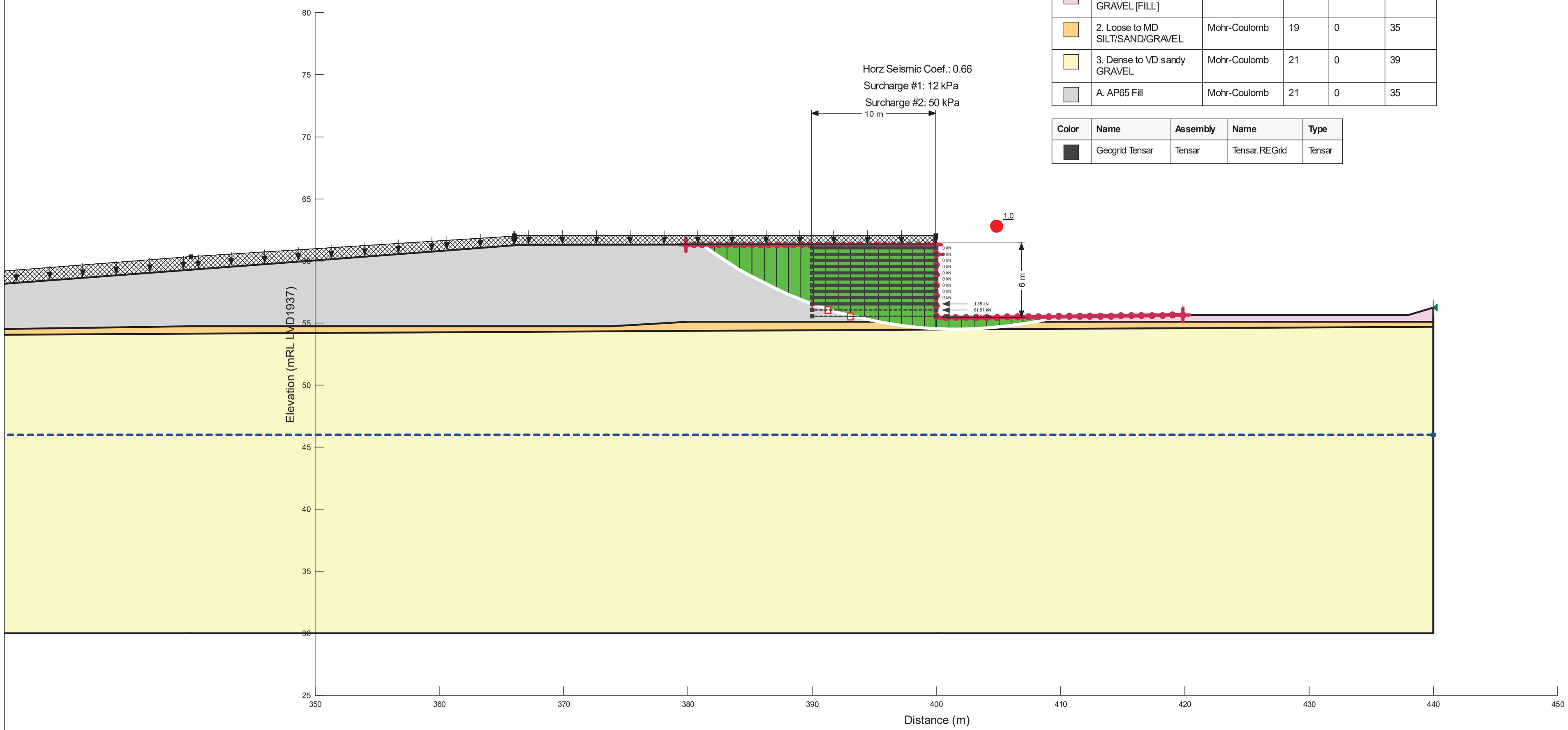
Horz Seismic Coef.: 0.66

Method: Morgenstern-Price

Longitudinal Local Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 2.3 Seismic - CALS 0.66g (Local)	3338703	Date: 02/10/2024
			Scale: 1:500	

DO NOT SCALE

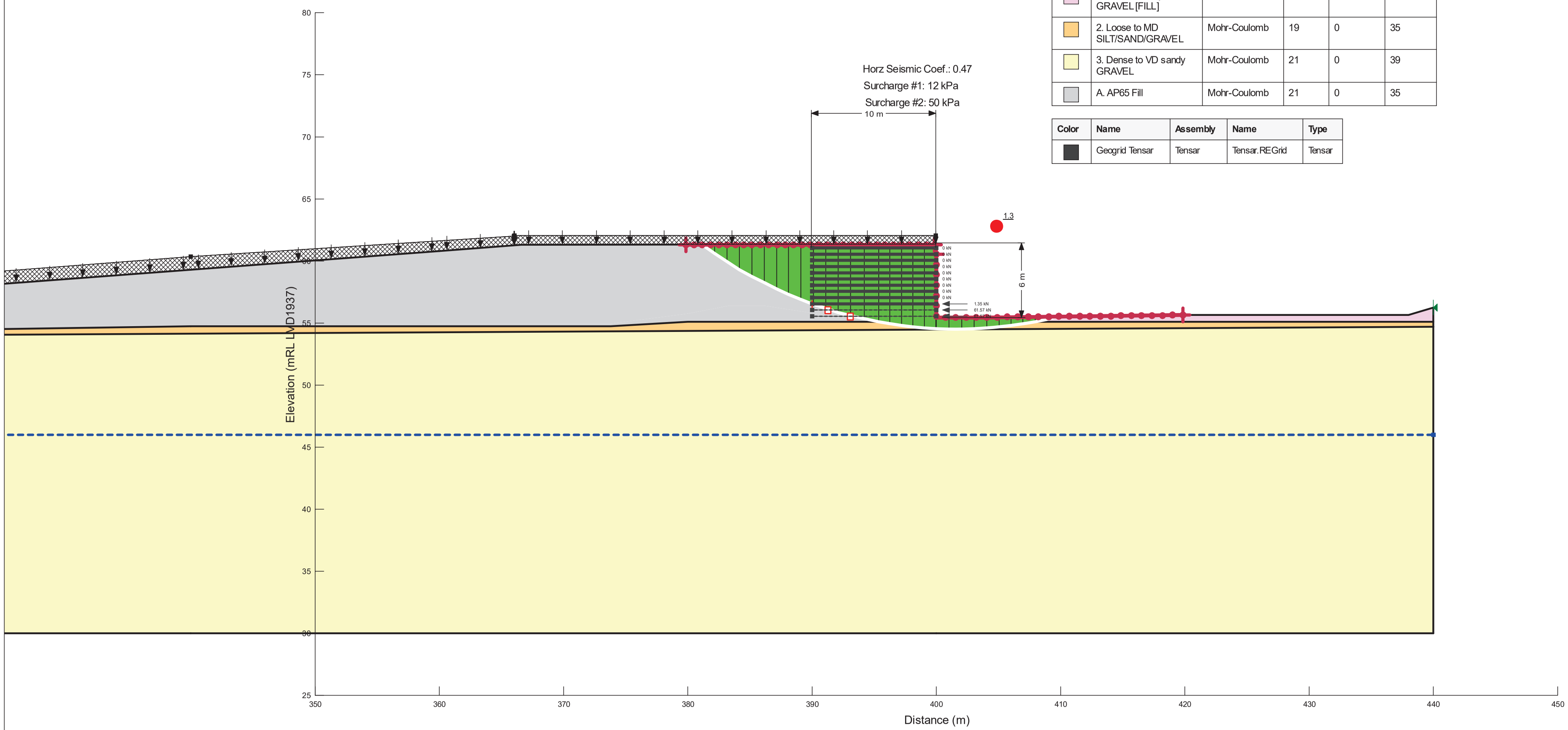
Horz Seismic Coef.: 0.47

Method: Morgenstern-Price

Longitudinal Local Stability

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	1b. Loose sandy GRAVEL [FILL]	Mohr-Coulomb	17	0	30
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39
	A. AP65 Fill	Mohr-Coulomb	21	0	35

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 2.4 Seismic - Yield PGA 0.47g (Local)	3338703 / Scale: 1:500 / Date: 02/10/2024

DO NOT SCALE

Transverse Global Stability

Horz Seismic Coef.:

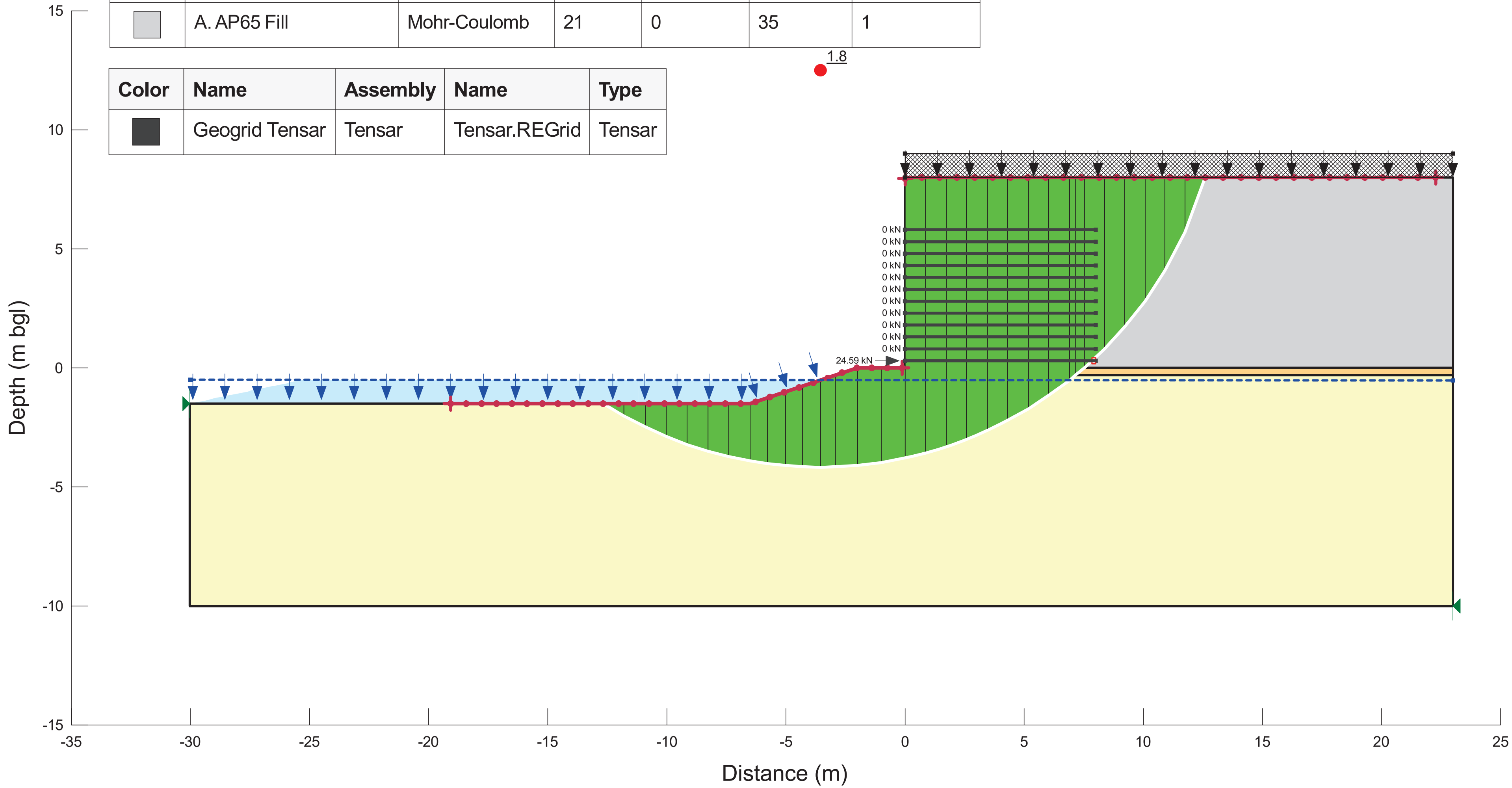
Method: Morgenstern-Price

Surcharge #1: 12 kPa

Horz Seismic Coef.:

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35	1
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39	1
	A. AP65 Fill	Mohr-Coulomb	21	0	35	1

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.1.1 Static - HN (Transverse)	3338703	Date: 02/10/2024
			Scale: 1:250	

DO NOT SCALE

Transverse Global Stability

Horz Seismic Coef.:

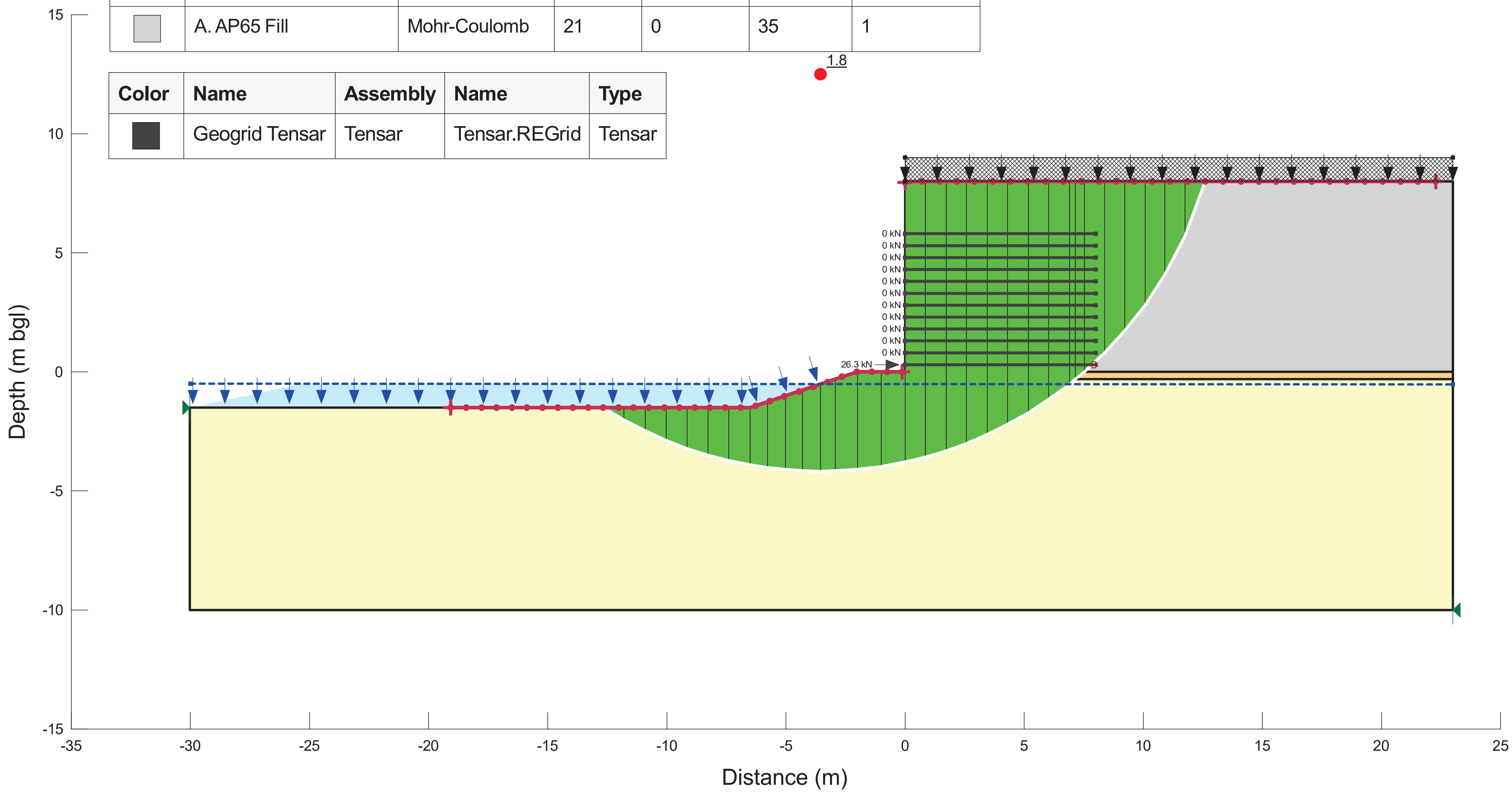
Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35	1
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39	1
	A. AP65 Fill	Mohr-Coulomb	21	0	35	1

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar

Surcharge #1: 24 kPa

Horz Seismic Coef.:



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.1.2 Static - HO (Transverse)	3338703	Date: 02/10/2024
			Scale: 1:250	

DO NOT SCALE

Transverse Global Stability

Horz Seismic Coef.:

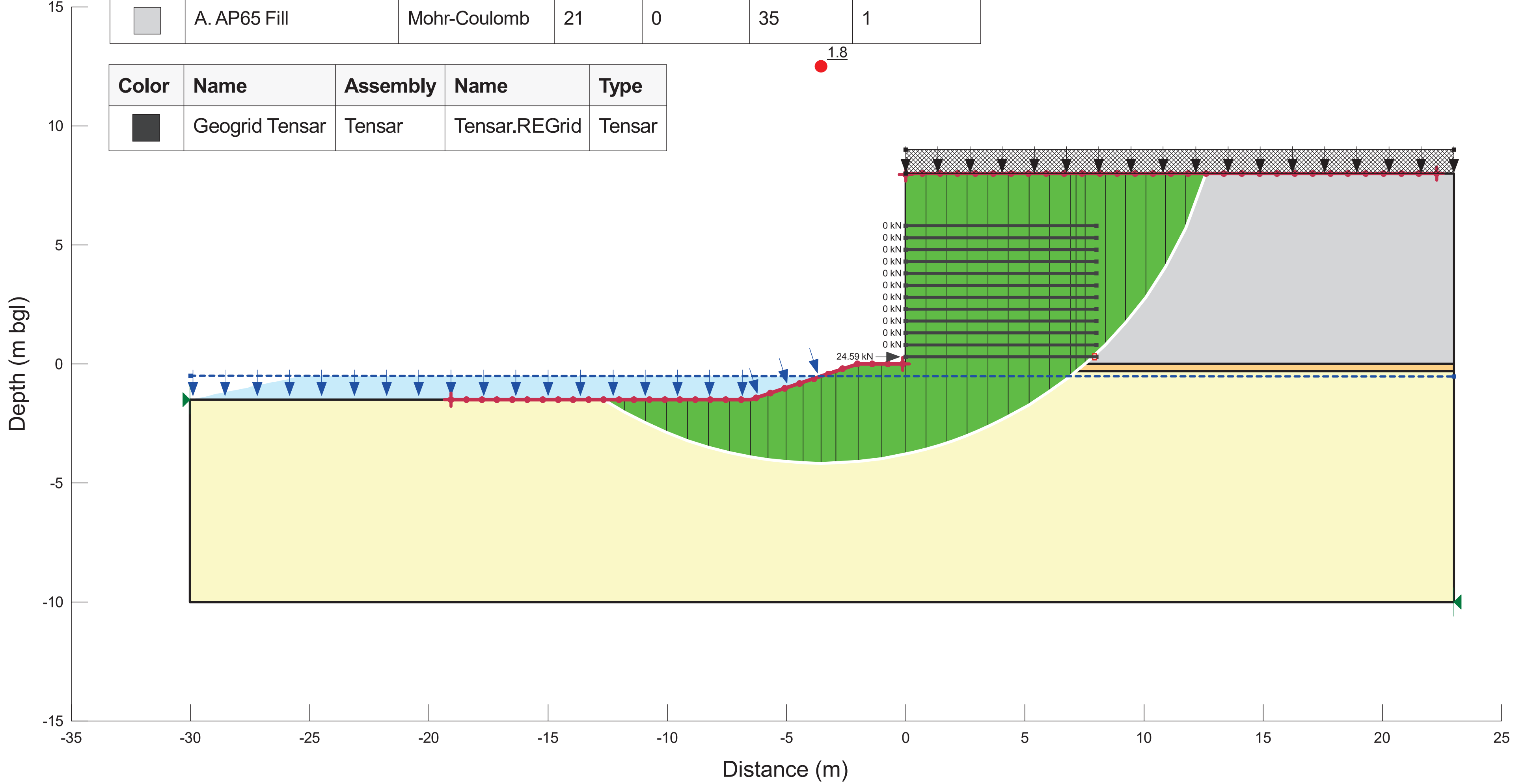
Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35	1
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39	1
	A. AP65 Fill	Mohr-Coulomb	21	0	35	1

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar

Surcharge #1: 12 kPa

Horz Seismic Coef.:



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.1.3 Static - Flood (Transverse)	3338703	Date: 02/10/2024
			Scale: 1:250	

DO NOT SCALE

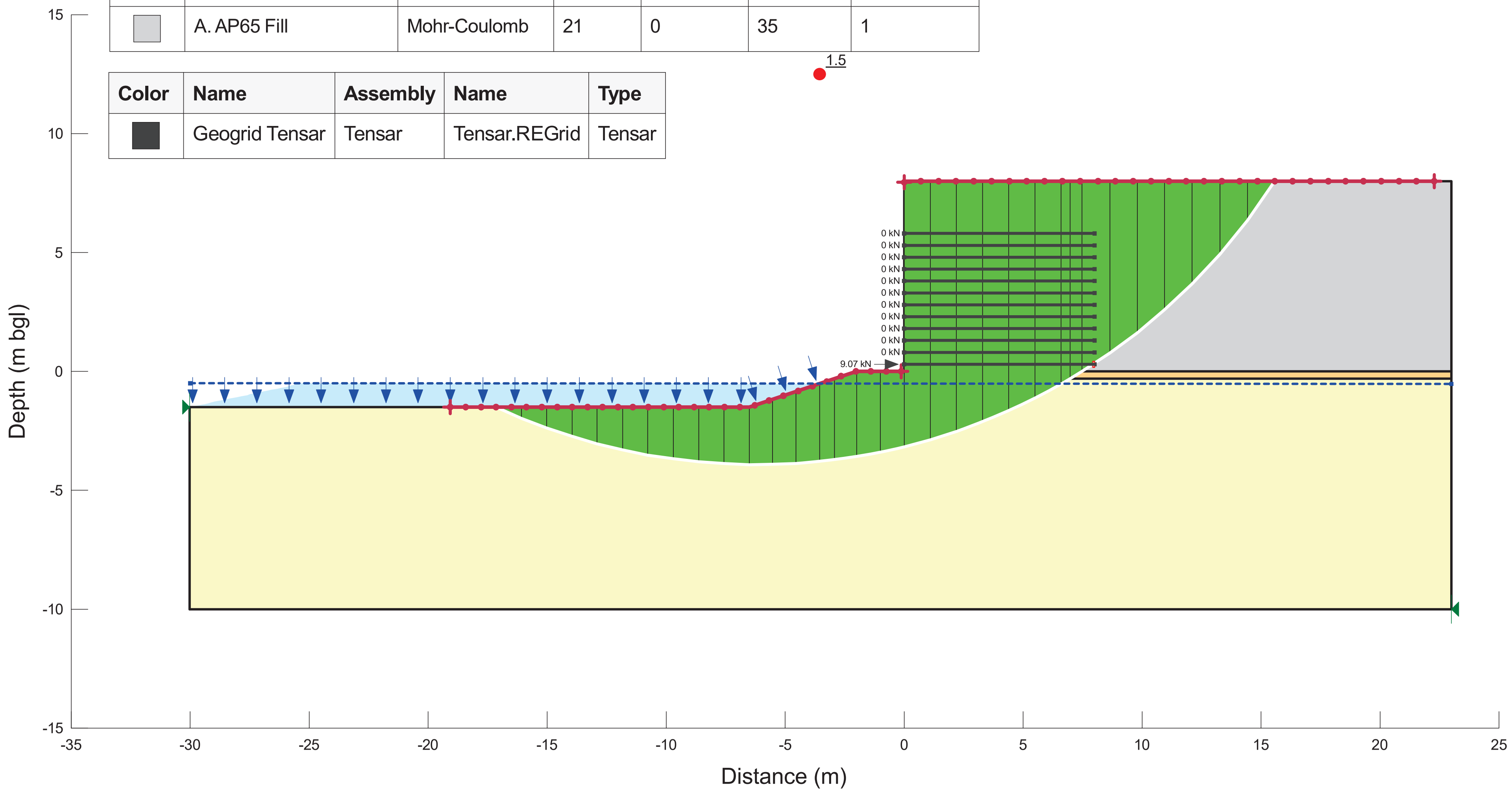
Transverse Global Stability

Horz Seismic Coef.: 0.11

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35	1
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39	1
	A. AP65 Fill	Mohr-Coulomb	21	0	35	1

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.2.1 Static - SLS 0.11g (Transverse)	3338703	Date: 02/10/2024
			Scale: 1:250	

DO NOT SCALE

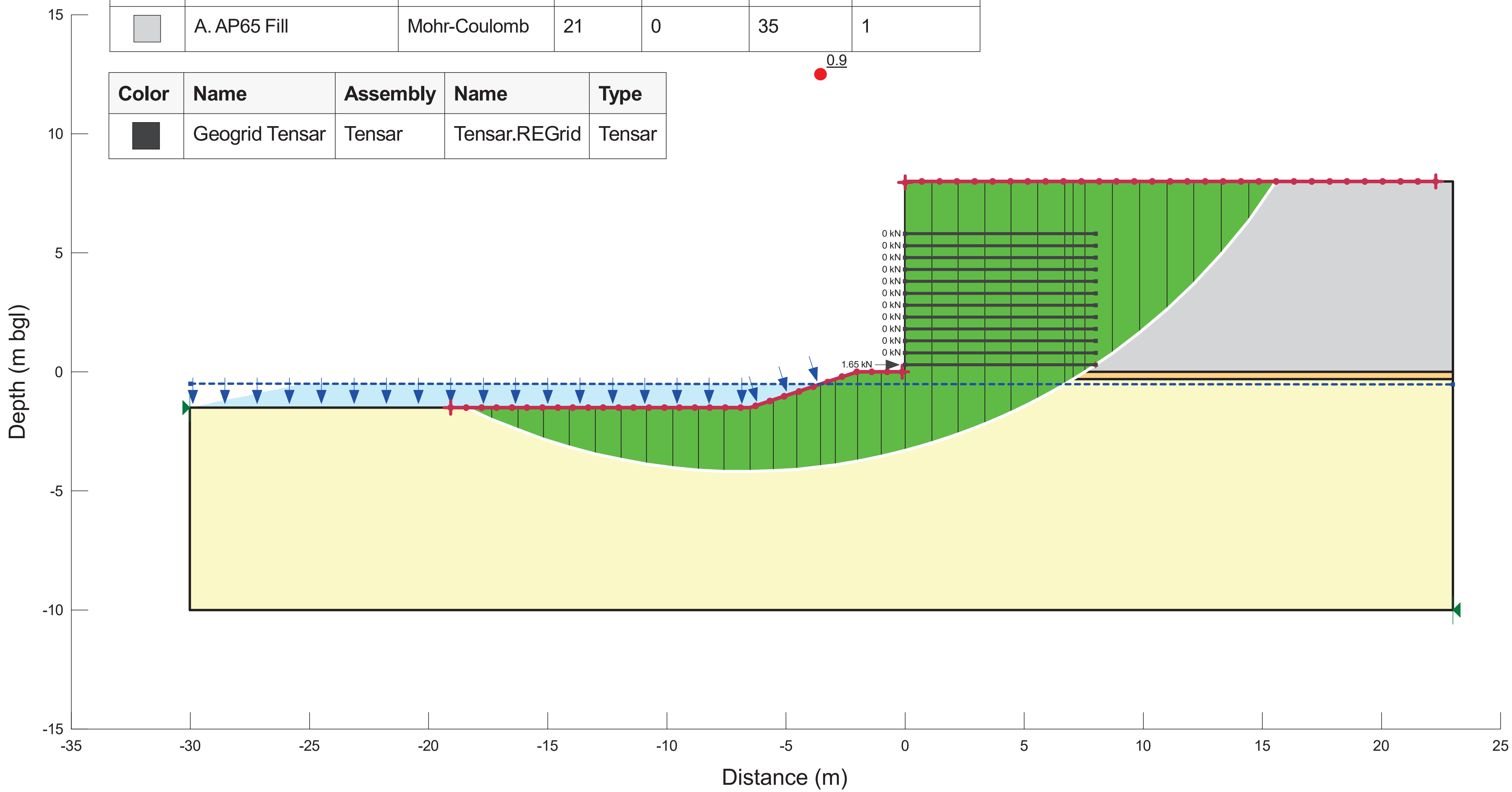
Transverse Global Stability

Horz Seismic Coef.: 0.44

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35	1
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39	1
	A. AP65 Fill	Mohr-Coulomb	21	0	35	1

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.2.2 Static - DCLS 0.44g (Transverse)	3338703	Date: 02/10/2024
			Scale: 1:250	

DO NOT SCALE

Transverse Global Stability

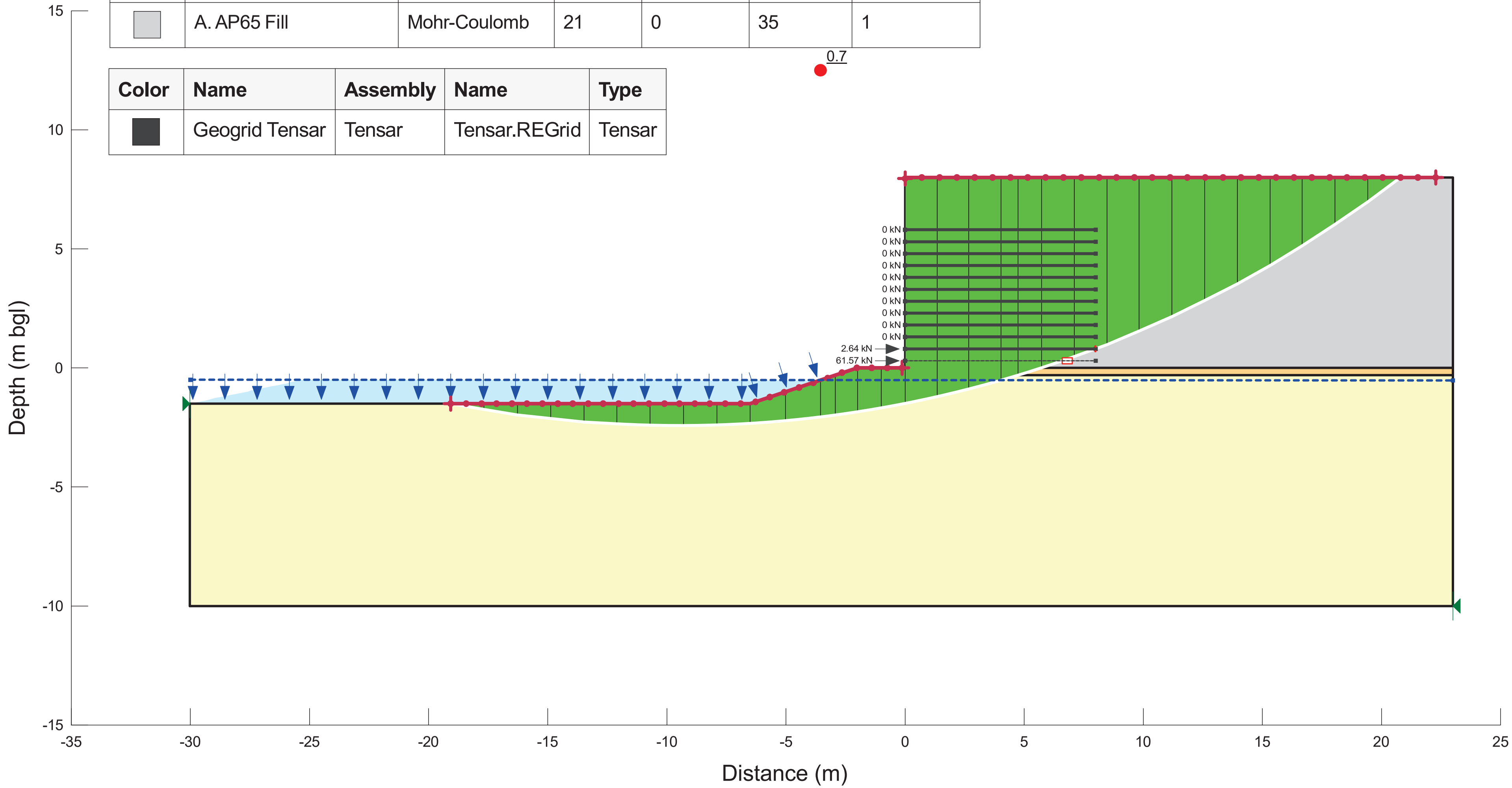
Horz Seismic Coef.: 0.66

Method: Morgenstern-Price

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	2. Loose to MD SILT/SAND/GRAVEL	Mohr-Coulomb	19	0	35	1
	3. Dense to VD sandy GRAVEL	Mohr-Coulomb	21	0	39	1
	A. AP65 Fill	Mohr-Coulomb	21	0	35	1

Color	Name	Assembly	Name	Type
	Geogrid Tensar	Tensar	Tensar.REGrid	Tensar

Horz Seismic Coef.: 0.66



Beca	Rolleston Access Improvements	Rolleston Access - MSE Wall Global Stability REV1.gsz 1.2.3 Static - CALS 0.66g (Transverse)	3338703	Date: 02/10/2024
			Scale: 1:250	

DO NOT SCALE