Napier Ex Prison Retaining Wall Assessment

Concept Design Report

Land Information New Zealand

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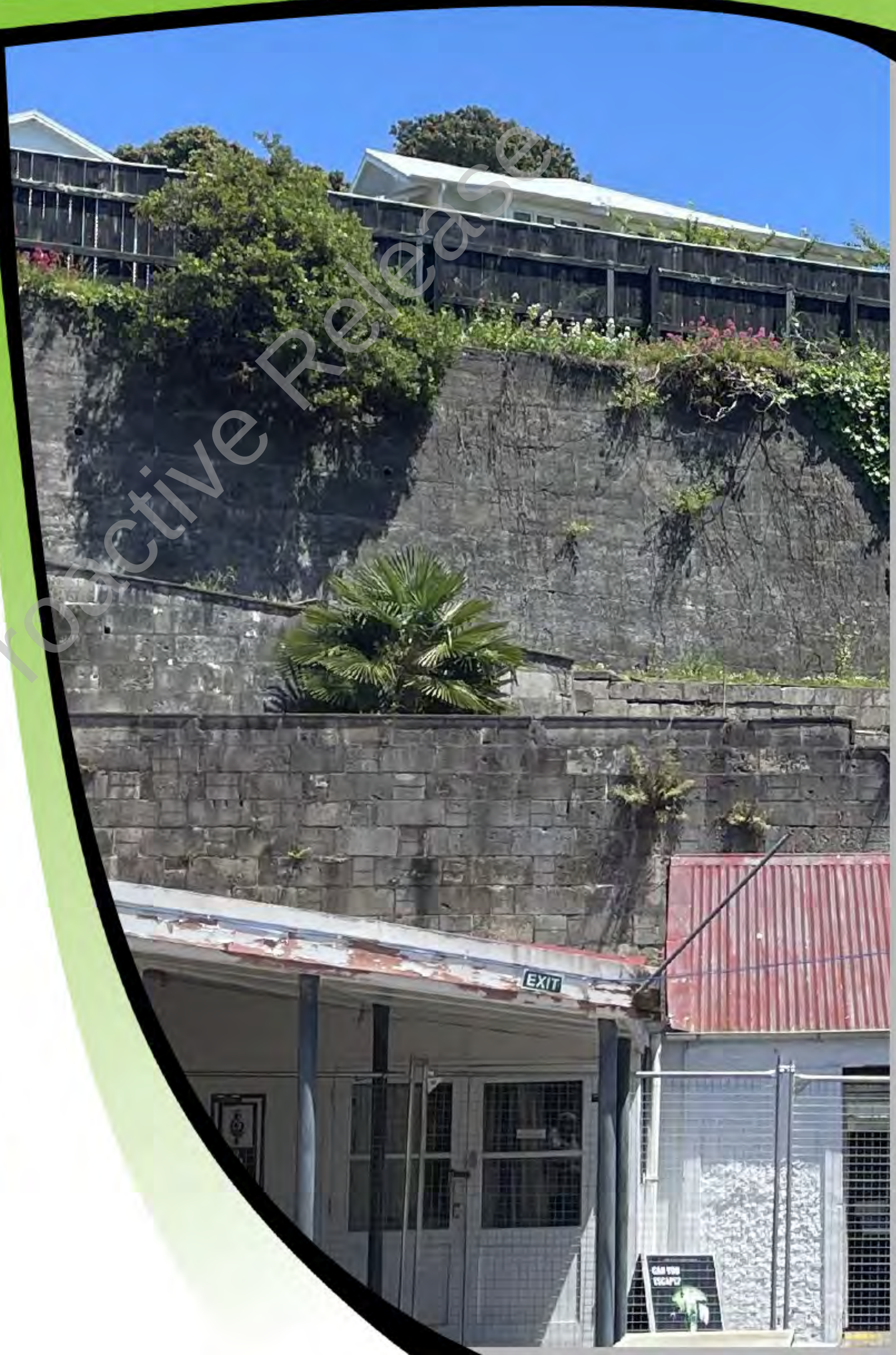

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1 Introduction

1.1 Overview

Land Information New Zealand (LINZ) previously engaged Aurecon New Zealand Limited (Aurecon) to undertake a geotechnical assessment of all the retaining walls at their Napier Ex Prison site located at 55 Coote Road, Napier. Under Contract Variation #5, Aurecon has now been engaged by LINZ to develop concept remedial designs for some of the retaining walls on the site identified during the original geotechnical retaining wall assessment.

The site is a Napier City Council heritage site containing the old Napier Prison which is currently being used as a tourist attraction. The prison comprises several single storey buildings, yards, a masonry perimeter wall and several retaining walls of varying sizes. One of the retaining walls (RW10) is integral to a building within the prison. The site also comprises two residential properties outside of the prison masonry wall that are currently occupied at 1/57 and 2/57 Coote Road.

Aurecon's scope of service for this report has been undertaken in accordance with Contract Variation #5, Contract Reference – Ex Napier Prison Retaining Wall Assessment, signed by Matthew Bradley of LINZ on 20 January 2023. This report should be read as a whole and Aurecon's Explanatory Statement is given in Section 1.4.

1.2 Previous Works

Aurecon's previous works undertaken for LINZ on the Napier Ex Prison site are summarised in the sections below.

1.2.1 Initial Site Works

Aurecon attended site between 14 and 17 March 2022 to undertake condition assessments for all the retaining walls at the Napier Ex Prison. From these onsite condition assessments, an assessment table was produced which included the heights, lengths, thicknesses, rakes, preliminary remediation options and other wall information for the 23 retaining walls identified.

This assessment is presented in Aurecon's Memorandum '520969 – Napier Ex-Prison – Retaining Wall Assessment' dated 8 April 2022.

1.2.2 Desktop Retaining Wall Risk Assessment

Aurecon undertook a qualitative risk assessment of the 23 walls identified during the initial site works. From this assessment, the walls were ranked in order of their Critical Risk Rating (CRR), a risk scale which considers each walls condition and consequence of failure. Further geotechnical recommendations were also provided with this risk assessment including next steps and a concept-level discussion on a ground anchor or soil nail with waler beams remedial design for Retaining Wall RW10.

This risk assessment is presented in Aurecon's Memorandum '520969 – Napier Ex-Prison – Retaining Wall Assessment – Stage 2 Risk Assessment' dated 5 September 2022.

1.2.3 Perimeter Wall Condition Survey

Aurecon attended site on 5 July 2022 to undertake a non-intrusive visual condition survey of the Napier Ex Prison masonry perimeter wall. In summary, minor structural damage was observed, and it was advised that the wall does not pose a significant risk to the occupants of the site or the public. However, minor structural repairs were also recommended from this survey.

This condition survey is presented in Aurecon's Letter '520969 – Napier Ex-Prison – Perimeter Wall – Condition Survey Report', dated 8 September 2022.

1.2.4 Site Laser Scan Survey

Aurecon attended site between 15 and 19 August 2022 to undertake a laser scan survey of the site. The survey was conducted to determine the proximity of nine retaining walls to the parcel boundary. From this survey, a point cloud model of the site and a drawing of the retaining wall locations, 520969-0000-DRG-UU-0002-0, was produced.

This survey is presented in Aurecon's Memorandum '520969 – Napier Prison Retaining Wall Assessment – Laser Scan Survey', reference 520969-0000-MEM-UU-0001, dated 9 May 2022. This Memorandum and the retaining wall location drawing are also appended to Aurecon's Desktop Retaining Wall Risk Assessment referenced in Section 1.2.2 of this report.

1.2.5 Site Walkover and Site Meeting

Under Contract Variation #4, Aurecon attended site on 22 November 2022 for a site walkover and meeting with the neighbouring property owners which may be affected by any remedial works to the retaining walls at the site. A concept sketch was also produced for information which was presented to the neighbours during the meeting.

After discussion with the neighbours, LINZ and New Zealand Heritage Properties Limited, the scope of further works was defined. This scope is discussed in Section 1.3.

1.3 Scope

1.3.1 Remedial Works Scope

The following retaining walls have been considered in this Concept Design Report;

- Group 1 – RW10, RW11, RW12 and RW17
- Group 2 – RW6 and the existing slip
- Group 3 – RW19

1.3.2 Report Scope

This Geotechnical Concept Design Report presents two concept remedial designs for the Group 1 retaining walls including concept drawings, design assumptions and an optioneering assessment of the two designs. This report is intended to be presented to LINZ and New Zealand Heritage Properties Limited and amended once the preferred design is selected. The two Group 1 concept remedial designs both comprise the installation of soil nails through the retaining walls to provide additional stability. The main difference between the designs is that one comprises an active mesh spanning between the soil nails while the other comprises horizontal waler beams. Concept remedial design recommendations are also provided for Group 2 and Group 3.

1.4 Explanatory Statement

We have prepared this report in accordance with the brief as provided. The contents of the report are for the sole use of the Client and no responsibility or liability will be accepted to any third party. Data or opinions contained within the report may not be used in other contexts or for any other purposes without our prior review and agreement.

The recommendations in this report are based on site observations at specific locations with limited site coverage. Only a finite amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground across the site has been inferred using experience and judgment and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

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2 Site Conditions

2.1 Site Description

The main features of the site are as follows:

- The site located at 55 Coote Road, Bluff Hill, Napier 4110 and the site is historically listed.
- The site comprises a singular property title, Lot 1 DP 22991, with a total area of 1.61 hectares.
- The Napier Ex Prison is located near the southwest corner of the site. The prison is approximately 50m by 50m with a perimeter wall along the eastern and northern boundaries and retaining walls along the western and southern boundaries. The prison comprises several single storey buildings and yards.
- A vegetated downhill slope is present to the east of the prison. This slope is approximately 23m high and 40m long (Napier City Council, 2023). Marine Parade runs along the base of this slope. This slope continues along the northern edge of the site becoming lower as Coote Road, located at the base of the slope to the north, runs uphill from Marine Parade.
- Two occupied dwellings owned by LINZ, 1/57 and 2/57 Coote Road, are present on the site to the north of the prison outside of the prison perimeter wall.
- The main site entrance is on Coote Road at the northwest corner of the site. A curved driveway runs from this entrance to the prison carpark which is on the northern side of the prison. An uphill and downhill slope are present to the east and west of the driveway, respectively.
- A total of 23 retaining walls were identified at the site, the most significant of which are along the southern, eastern and western boundaries of the prison. Along the western and southern boundaries, the retaining walls extend up to approximately 12m and 9m above the prison ground level, respectively. The approximately 2m high retaining wall below the eastern boundary supports the prison building platform. The retaining wall locations across the site are presented in Appendix A along with the Risk Rating each wall was assigned in Aurecon's Memorandum '520969 – Napier Ex-Prison – Retaining Wall Assessment – Stage 2 Risk Assessment'.
- Residential dwellings are present above the retaining walls to the west and south of the prison. The properties which are supported by these retaining walls are located at 27 Clyde Road, 29 Clyde Road, 10 Hukarere Road, 12 Hukarere Road and 16 Hukarere Road.
- An existing slip with an approximate plan area of 150m^2 is present above the site access driveway to east. This slip is above Retaining Wall RW6, a stone block gravity retaining wall.

2.2 Regional Geology

The geology of the centre of the site and the prison location is mapped as 'Late Pliocene Scinde Island Formation' and described as 'calcareous, cross-bedded sandstone and limestone' by Geological and Nuclear Science (GNS Science, 2013). The geology to the east of the prison, is mapped as 'Holocene ocean beach deposits' and described as 'unconsolidated marine gravel, sand and mud on modern beaches'. The geology of the northwest corner of the site, Bluff Hill and Hospital Hill has been mapped as 'early Pleistocene river, lake and intertidal deposits' and described as 'lacustrine and fluvial sediments'. The mapped geology is present in Figure 1.

Figure 1: GNS Science (2013) mapped geology of the Napier Ex Prison site, 1:250k scale.

2.3 Seismicity

2.3.1 GNS Active Fault Database

A review of the GNS Active Faults Database (GNS Science, 2016) indicates that many small faults within 30km of the site are present to the south. Larger faults are also present within 50km of the site to the west. These larger faults to the west are summarised in Table 1.

Table 1: Large mapped fault lines to the west of the site, GNS Science (2016).

Name	Distance from site	Recurrence Interval	Slip Rate	Single Event Displacement
Patoka Fault	~32km west	Less than 2,000 years	Moderate	Moderate
Mohaka Fault	~36km west	Less than 2,000 years	Moderate	Moderate
Ruahine Fault	~42km west	2,000 to 3,500 years	Moderate	Unknown

2.3.2 Design Seismic Events

The importance level of the concept remedial designs has been selected to match that of the dwellings near the retaining walls and the prison. Therefore, in accordance with Table 3.2 of the New Zealand structural loadings standard (NZS 1170.0:2002), the remedial designs will be Importance Level 2 (IL2). A 50-year design life has also been selected for the designs, again to match the nearby dwellings. Therefore, in accordance with Table 3.3 of NZS 1170.0:2002, a 1-in-500 year Ultimate Limit State (ULS) earthquake event will be considered for design. Aurecon has adopted the MBIE Module 1 guidelines (2021) recommendation for this ULS event, and the design seismic parameters are detailed in Table 2 below.

Table 2: Design ULS seismic event for the Napier Ex Prison site.

Event	Magnitude	PGA
1-in-500 year – ULS	M_w 7.1	0.58g

2.3.3 1931 Napier Earthquake Observations

The retaining walls around the prison were construction in the early 1900s, however the exact construction date is unknown (Napier Prison Tours, 2023). Historical images show the retaining walls were constructed between 1909 and 1943. The 7.7M_w Napier earthquake occurred in 1931. Therefore, given the time period the retaining walls could have been constructed and the absence of earthquake damage repairs observed at the site, the walls have likely not experienced a large seismic event.

3 Geotechnical Investigations

3.1 General

No intrusive ground investigation has been conducted for this Concept Design Report. Therefore, at this stage of design, the ground conditions have been assumed from historical photos of the site and a review of the readily available information on the New Zealand Geotechnical Database (NZGD, 2023).

3.2 Historical Site Photos

An early photo of the prison appears to the show a cut slope with exposed rock in the retaining wall locations to the west and south of the prison as shown in Figure 2 (Napier Prison Tours, 2023). Another photo shows a cut slope with exposed rock at the Centennial Gardens approximately 200m north of the site as shown in Figure 3 (Napier Prison Tours, 2023). The Centennial Gardens have the same mapped geology as the site and the area was used as a rock quarry.

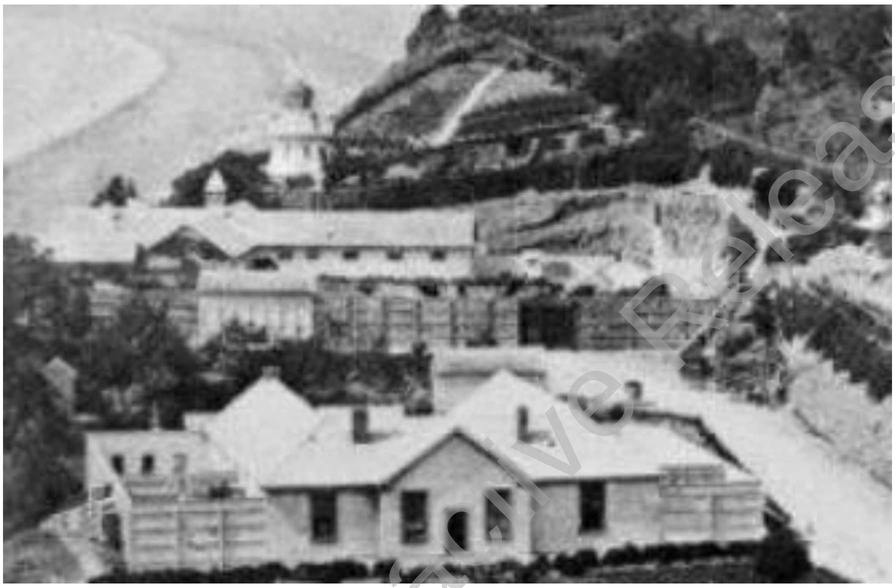

Figure 2: Napier Prison in the 19th Century (Napier Prison Tours, 2023).

Figure 3: Centennial Gardens, previously the Napier Prison quarry, in the early 20th Century (Napier Prison Tours, 2023).

3.3 New Zealand Geotechnical Database (NZGD) Review

A review the readily available information on the NZGD (2023, reviewed 22 February) has identified 14 shallow hand augers approximately 800m northwest from the site. This ground investigation data is the closest available data in an area with similar geology to the site. These hand augers encountered 0.1m to 0.85m of topsoil overlying predominately sandy silt to the termination depths which ranged from 0.3m to 3.7m. No deep ground investigation data is available near the site in areas with similar geology.

3.4 Site Inspection Observations

Aurecon geotechnical engineers have inspected the site on three occasions. The first inspection occurred between 14 and 17 March 2022, the second on 22 November 2022 and the third on 17 February 2023. The third inspection occurred after Tropical Cyclone Gabrielle and the prison could not be accessed during this site inspection. Site observations made during these inspections which could provide information on the ground conditions at the site are detailed in the sections below.

3.4.1 Tension Cracks above Retaining Wall RW10

During the first and second site inspections, tension cracks were observed in the silt above Retaining Wall RW10. Single tension cracks were measured to be up to approximately 0.2m wide and 0.4m deep. These cracks have likely formed within a silt backfill between the gravity Retaining Wall RW10 and a cut rock face after movement of the retaining wall. Photos of these tension cracks are presented in Figures 4 and 5.

Figure 4: Tension cracks in the inferred silt backfill behind Retaining Wall RW10 during the site inspection between 14 and 17 March 2022.

Figure 5: Tension cracks in the inferred silt backfill behind Retaining Wall RW10 during the site inspection on 24 November 2022.

3.4.2 Exposed Rock Faces on Access Driveway

During the site inspections, approximately vertical rock faces were observed above the site access driveway, likely exposed during the construction of the driveway. These limestone rock faces are likely similar to other cut slopes at the site including those covered by the retaining walls around the prison. Photos of these rock faces are presented in Figures 6 and 7.

Figure 6: Exposed cut limestone rock face along site access driveway on 22 November 2022.

Figure 7: Exposed cut limestone rock face along site access driveway on 22 November 2022.

3.4.3 Slip Above Retaining Wall RW6

During the site inspections, a slip above Retaining Wall RW6 and the site access driveway was observed. This slip had originally occurred before the Aurecon site inspections. It appears Retaining Wall RW6 was constructed after the other nearby retaining walls, and possibly after the slip had originally occurred. Matting and broken service pipes were also observed on the slip. Silt was observed over the non-vegetated sections of the slip, indicating that the natural slopes around the site likely have a surficial silt layer.

During the site inspection between 14 and 17 March 2022, small pieces of debris were observed on top of and below Retaining Wall RW6 indicating ongoing erosion as shown in Figure 8. During the inspection on 22 November 2022, the vegetation on the slip had increased from the previous inspection and more debris was observed at the base of the slip and the retaining wall as shown in Figure 9. During the inspection on 17 February 2023, larger pieces of debris were observed below the existing slip as shown in Figure 10. This larger debris fall was likely caused by rainfall events between 22 November 2022 and 17 February 2023, including Typical Cyclone Gabrielle.

Figure 8: Retaining Wall RW6, the existing slip and loose debris during the site inspection between 14 and 17 March 2022.

Figure 9: Retaining Wall RW6 and the existing slip with increased vegetation cover on 22 November 2022.

Figure 10: Retaining Wall RW6, the existing slip and larger pieces of debris on 3 March 2023.

4 Engineering Considerations

4.1 General

LINZ has engaged Aurecon to develop concept remedial designs for the high-risk retaining walls at their Napier Ex Prison site. This section of the report presents Aurecon's design assumptions at this design stage, the concept designs for each wall group, concept design drawings and an optioneering assessment for the two concept remedial designs for the Group 1 retaining walls. The concept remedial designs are as follows:

- Group 1 (RW10, RW11, RW12 and RW17) – Soil nail stabilisation with;
  - Active mesh
  - Waler beams
- Group 2 (RW6 and existing slip) – MacMat R reinforced geomat stabilisation
- Group 3 (RW19) – Soil nail stabilisation with active mesh

4.2 Ground Model

From the limited available geotechnical information for the site, Aurecon has assumed a ground model for the concept design stage. This ground model is presented in Table 3 and describes the assumed ground conditions behind the retaining walls at the Napier Ex Prison site. The soil nails will be drilled through this profile. The ground conditions below the prison have not been described as they do not affect the soil nail design.

Table 3: Assumed ground model for concept design.

Geotechnical Unit	Assumed Horizontal Unit Thickness	Description
Unit 1	~0m – 3.5m	Silt (retaining wall backfill)
Unit 2	~20m+	Weathered sandstone/limestone
Notes: (1) Ground model to be revised after project-specific ground investigation. (2) Depths and soil/rock types stated have been assumed for concept design.		

4.3 Group 1 (RW10, RW11, RW12 and RW17) Concept Design

4.3.1 Design Intent

The remedial design intent for Group 1 is to stabilise Retaining Walls RW10, RW11, RW12 and RW17 to minimise ongoing wall movements, provide additional capacity against overturning, and protect the public and the prison structures from falling wall debris.

4.3.2 Design Parameters and Assumptions

The following sections outline the key assumptions and design parameters considered in Aurecon's concept level soil nail design for Group 1.

Wall geometries and soil parameters

The soil nail design is based on the following geometries and soil parameters:

- The wall geometries used for the analysis and design drawings were obtained from the laser scan survey discussed in Section 1.2.4.
- Two wall cross-sections were analysed during the concept design calculations. These cross-sections were selected as the retained height of both walls within the section were near their maximum.
- As stated in Section 4.2, the ground model at this stage of design has been assumed. The silt backfill has been given conservative soil parameters as the design will rely on the stability provided by the soil nails. The failure surface has been assumed to run through the silt backfill.
  - **Silt backfill**; γ = 18kN/m^3, c' = 2kPa, Φ' = 28°
- The masonry walls themselves have also been assumed to provide minimal stability, as the soil nails will be relied on.
- A 300kPa grout/ground ultimate bond strength has been assumed. A 0.65 reduction factor has been applied to this bond for the static and seismic loading in accordance with FHWA:2015 Table 6.3.

Soil nails

The soil nail design is based on the following:

- Ischeback hollow Titan 40/16 bars have been assumed for the design as they are readily available. These bars have external and internal diameters of 40mm and 16mm, respectively. These soil nails have a reduced yield strength of 341kN with a 0.65 reduction factor in accordance with FHWA:2015 Table 6.3. The full soil nail bar properties are presented in Appendix B.
- A drill and grout-rock bond diameter of 90mm has been assumed to allow for drilling through the active mesh.
- Two soil nail layouts have been designed, one for active mesh and one for waler beams. The active mesh soil nail layout requires soil nails at the top and bottom of the walls to hold down the mesh. The active mesh soil nails have also been arranged in a diamond pattern to provide more resistance against debris falling between the walls and the mesh. The waler beam soil nail layout requires the soil nails to be arranged in approximately horizontal lines. As soil nails are not required at the top and bottom of the walls for this layout, the total amount of soil nails is reduced.
- The soil nail lengths have been sized in 3m increments.
- The horizontal and vertical spacing of the soil nails were determined from the stability analysis discussed below.

4.3.3 Design Loads

Two design loads cases have been considered:

- **Static Load Case –** Access to the top of the lower retaining walls is very restricted and the dwellings above retaining walls RW12 and RW17 have large setbacks relative to the wall heights. Therefore, a surcharge has not been considered.
- **Seismic Load Case –** In accordance with NZGS/MBIE Module 6 – Seismic Retaining Wall Design, a 0.5 reduction factor has been applied to the PGA given in Table 2. This factor has been selected as RW10 is integral to one of the prison buildings. A surcharge has also not been considered for this load case.

4.3.4 Stability Calculations

The software Slope/W (Version 11.2.1.23288) has been used to conduct the stability analysis on the two cross-sections, soil nail arrangements and design load cases. The two walls included in each cross-section have been analysed separately. The Factors of Safety (FoS) of the critical slip surfaces for the active mesh and waler beam soil nail arrangements are presented in Table 4 and 5, respectively. The Slope/W sections analysed are presented in Appendix C and details on the soil nail designs used to achieve the required FoS are presented in Section 4.3.5 below.

Table 4: Slope/W Factors of Safety for the active mesh soil nail arrangement.

Cross-Section	Wall analysed	Static Loading	Seismic Loading
Required FoS	-	1.5	1.2
Cross-Section 1	RW10	1.92	1.79
Cross-Section 1	RW11	2.46	2.36
Cross-Section 2	RW10	1.76	1.63
Cross-Section 2	RW12	2.80	2.52

Table 5: Slope/W Factors of Safety for the waler beam soil nail arrangement.

Cross-Section	Wall analysed	Static Loading	Seismic Loading
Required FoS	-	1.5	1.2
Cross-Section 1	RW10	1.65	1.50
Cross-Section 1	RW11	2.02	1.87
Cross-Section 2	RW10	1.52	1.37
Cross-Section 2	RW12	2.15	1.93

4.3.5 Soil Nail Design

Table 6 below outlines the soil nail design parameters for both the active mesh and waler beam arrangements. These soil nail arrangements are presented in the sketches in Appendix D.

Table 6: Group 1 soil nail design parameters.

Parameter	Value	Note
Bar type	40/16	Ischebeck Titan bar selected for availability.
Nominal outside diameter	40mm	-
Nominal inside diameter	16mm	-
Yield strength	525kN	-
Reduced yield strength	341kN	0.65 reduction factor in accordance with FHWA:2015 Table 6.3.
Free length	3.0m	Sized to be greater than assumed silt fill thickness. Soil nail bars are to be sleeved or denso taped. A casing will be required to ensure grout loss is minimised through the soil portion of the borehole.
Bond length	6.0m	Length in competent rock.

Parameter	Value	Note
Total soil nail length	At least 9.0m	Bond length + Free length + approximately 0.5m on face.
Grout/ground bond capacity (6.0m length)	510kN	300kPa grout/ground bond assumed.
Reduced grout/ground bond capacity (6.0m length)	330kN	0.65 reduction factor in accordance with FHWA:2015 Table 6.3.
Approximate vertical soil nail spacing	2.0m	-
Approximate horizontal soil nail spacing	2.5m	-

4.3.6 Mesh and Plate Design

The maximum calculated soil nail load was 202kN for the active mesh arrangement. Therefore, a TECCO G65/4 mesh and P33/50 N spike plates (products of Geobrugg) have been selected to resist this load while reducing the visual impact on the wall (the smallest compatible spike plates have been selected for this mesh). The technical data sheets for these products are in provided in Appendix E. The soil nail bars may need to be trimmed and protected as per manufacturer's guidance.

4.3.7 Waler Beam Design

A concept waler beam design has been produced by Aurecon Structural Engineers. The design was based on the soil nail loads obtained during the stability analysis. This design comprises two back-to-back 230PFC beams spanning between the soil nails. Waler beam spans were made as continuous as possible, however, breaks in the spans were required due to corners on the retaining walls and the varying heights of the walls.

4.3.8 Concept Design Sketches and Design Visualization

Concept design sketches for the active mesh and waler beam remedial designs are presented in Appendix D. From these sketches, photos taken by Aurecon during the site inspections have been edited to show how the designs may appear once constructed. These edited photos are presented in Appendix F within the Concept Design Package and were requested to support consultation with Napier City Council and New Zealand Heritage Properties Limited.

4.3.9 Optioneering Assessment of Concept Remedial Designs

An optioneering assessment has been undertaken on the active mesh and waler beam concept remedial designs. This assessment was undertaken to present the relative positives and negatives of the two options to assist with the selection of the preferred remedial option. The results of this assessment are presented in Table 7 below.

Table 7: Optioneering assessment of the concept remedial designs for the Group 1 retaining walls.

Concept Remedial Option	Advantages	Disadvantages
Soil nails with active mesh	■ Performance and safety – Geobrugg TECCO mesh is a well-established system which has been used in combination with soil nails to stabilise rock faces, soil slopes and existing retaining structures worldwide. – The mesh facing is a high redundancy system. Loads on the mesh around the centre of the wall can be transferred to the four adjacent soil nails. If a soil nail was to fail, the load can transfer to the six adjacent soil nails. – The active mesh is capable of supporting small localised failures in rock faces or walls. – As the walls on site continue to deteriorate over time, debris falling off the walls poses a risk to the public. The mesh will hold in large debris reducing the risk to the public. – During construction while installing the soil nails, the walls will be covered by mesh. This will protect the contractors during construction from falling debris. – Soils nails with active mesh have a slim profile and are visually less intrusive than a waler beam system. ■ Design flexibility – Soil nails do not have to be vertically aligned to pin down the mesh. Therefore, soil nails can be positioned around features such as abrupt changes in the walls and the buildings that back onto the retaining walls.	■ Construction cost and time – More soil nails are likely required comparing to the waler beam remedial design. Therefore, this design option will likely have a higher cost and construction time.

Concept Remedial Option	Advantages	Disadvantages
Soil nails with waler beams	▪ Construction cost and time – As the full wall faces are not covered, less soil nails are likely required with this remedial design. Therefore, this design option will likely have a lower cost and construction time. ▪ Maintenance – The waler beams can be painted for extra corrosion protection.	▪ Performance and safety – Waler beams with soil nails are typically used for new or temporary retaining walls rather than to remediate existing walls. – Horizontal waler beams with soil nails are typically installed over structural elements which can transfer loads vertically such as sheet piles, timber poles or vertical waler beams. The Group 1 retaining walls are very likely unreinforced and therefore have a relatively low capacity in terms of transferring shear forces vertically. – Debris falling from the walls has not been addressed with the waler beam remedial option. Restricted access areas below the walls may still be required post-construction with this design option. – Brittle failure of wall faces remains a possibility as this solution is not providing any confinement to the walls. ▪ Design flexibility – As the waler beams are straight horizontal elements, spans will end at any wall corners. Short spans will also have to be used to accommodate for changes in the wall heights and features backing on to the retaining walls. Even if features on the site do not directly touch the walls, walers beams may not fit in areas as the beams and the soil nail heads both protrude from the walls. ▪ Appearance – The top of the waler beams will collect leaves and other pieces of vegetation. Birds could also perch on top or within the waler beams. – The waler beams and soil nail heads significantly protrude from the walls.

4.3.10 Future Design Refinements

Potential design refinements between concept design and detailed design are presented in the below sections.

Grout/ground ultimate bond strength

Currently there is a high level of uncertainty in the grout/ground ultimate bond strength as no testing has been conducted. For detailed design, the adopted grout/ground ultimate bond strength will be based on testing which may lead to changes in the design soil nail bond lengths. For the concept design, the bond length has been sized to provide a similar capacity to the tensile strength of the soil nail bars based an assumed grout/ground ultimate bond strength of 300kPa.

Full scale testing will be required to confirm embedment, grout interface and pull-out resistance. Production Quality Assurance (QA) testing will also be required as per relevant codes and guidance documentation.

Ground model

No intrusive ground investigation has been conducted at the time of writing this Concept Design Report. A ground investigation will be required between the concept and detailed designs. The results of this ground investigation may lead to significant changes in the site ground model, which in turn may lead to significant changes in the soil nail design. Changes to the ground model may include soil parameters, soil types and layer thicknesses.

Soil nail design and layout

Once the ground model and grout/ground ultimate bond strength have been refined based on testing and ground investigation results, the soil nail design and layout can be refined. The purpose of this refinement would be to reduce construction costs while ensuring the required design capacity is still achieved. Soil nail types, vertical spacings, horizontal spacings and lengths may change. The number of soil nails is likely to increase, rather than decrease. Acceptance (sacrificial), production and QA testing will need to be specified.

Accounting for buildings and other site features

A prison building, shed, holding cell and brick wall have been observed backing onto the Group 1 retaining walls. Other features on the site also come within close proximately to the walls. At the concept design stage, these features have not been accounted for in the concept design sketches. For detailed design, these features will be accounted for leading to a more detailed soil nail layout. Some soil nail installation from within the structures will likely be necessary.

4.4 Group 2 (RW6 and Existing Slip) – Concept Design

4.4.1 Wall Details

Retaining Wall RW6 is a stone block gravity retaining wall situated on the uphill side of the site access driveway (western side). In Aurecon's Memorandum '520969 – Napier Ex-Prison – Retaining Wall Assessment – Stage 2 Risk Assessment', the wall was assessed to be in a fair condition and likely recently constructed after the slip above. Photos of the wall are presented in Figures 8, 9 and 10.

During the initial site works described in Section 1.2.1, the following wall details were assessed (all dimensions are approximate):

- 13m length

- Height ranging from 1.6m to 1.3m
- Head slope over 30°

4.4.2 Slip Details

During the site inspections, an existing slip was observed above Retaining Wall RW6. The slope where this slip had occurred was benched and matting and broken service pipes were observed on the slope. Observations of this slip over time are detailed in Section 3.4.3. In summary, debris has continued to fall from this slop onto the top of Retaining Wall RW6 and the site access driveway. Photos of the slip are presented in Figures 8, 9 and 10.

4.4.3 Recommended Remedial Design

As the condition of Retaining Wall RW6 has been assessed as fair, replacement or remediation of this wall is not recommended. Aurecon recommends the existing slip is remediated by installing MacMat R, a reinforced geomat, over the slope. MacMat R is product by Maccaferri, which is designed to control slope erosion. This geomat needs to be pinned down with shallow soil nails, ideally while works occur elsewhere on the site. The MacMat R brochure by Maccaferri is included in Appendix G.

4.5 Group 3 (RW19) – Concept Design

4.5.1 Wall Details

Retaining Wall RW19 is a stone block gravity retaining wall situated below the prison along the eastern edge. The failure of this wall poses a low risk to life but a high risk to the prison building foundations and services. This wall is noted to be in a deteriorated condition. A photo of this wall taken during the initial site works is presented in Figure 11.

Due to overhead vegetation cover from the trees to the east of the prison, Retaining Wall RW19 could not surveyed from the point cloud model of the site. However, during the initial site works described in Section 1.2.1, the following wall details were assessed (all dimensions are approximate):

- 27m length
- Height ranging from 2m to 1.4m
- A head slope of 30° to 45°

In Aurecon's Memorandum '520969 – Napier Ex-Prison – Retaining Wall Assessment – Stage 2 Risk Assessment', it was noted that the failure of Retaining Wall RW20 at the northernmost end may cause Retaining Wall RW19 to be undermined.

Figure 11: Retaining Wall RW19 during the initial site works between 14 and 17 March 2022.

4.5.2 Recommended Remedial Design

Due to the deteriorated condition of Retaining Wall RW19, Aurecon recommends that maintenance is undertaken on the wall by removing vegetation. We note that there is the potential to adversely affect the wall by vegetation clearance. In addition to maintenance, if the wall is to be preserved, the installation of soil nails with active mesh is recommended. The soil nail design for this wall could be based on the detailed soil nail design for the Group 1 retaining walls once completed. Active mesh is recommended to prevent individual blocks falling out of the wall. Visual effects of the active mesh have been assessed as low due to the wall being below the prison and covered by vegetation from most viewpoints. Alternatively, Retaining Wall RW19 could be demolish and replaced with a timber pole retaining wall, but the feasibility of this option will need to be confirmed once intrusive ground investigations are completed.

5 Ground Investigation

A ground investigation is required for the detailed design of the remedial options discussed within this report. The recommended ground investigation method is to conduct a soil nail installation trial. During this trial, the spoil from the soil nail drilling can be observed to determine a ground profile behind the walls. Once trial soil nails are installed, load tests can be conducted to determine an appropriate design grout/ground ultimate bond strength. A detailed ground investigation plan can be produced on confirmation of the preferred remedial options.

6 Concept Design Package

A Concept Design Package was produced as part of this Concept Design Report for the Group 1 retaining walls. The intent of this package was to provide LINZ, Napier City Council and New Zealand Heritage Properties Limited with a presentation on how the remedial design options could affect the site. This package is provided in full in Appendix F.

7 References

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Appendix A
Site Map

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Toitū Te Whenua
Land Information
New Zealand

CLIENT	PRELIMINARY NOT FOR CONSTRUCTION	ALL DIMENSIONS APPROXIMATE ONLY	SCALE	SIZE	TITLE	SITE LOCATION PLAN
			NTS	-		
	FIGURE	FIGURE 1	BY		REFERENCE	BACKGROUND IMAGE RETRIEVED FROM: HTTP://WWW.GIS.NAPIER.GOVT.NZ/INTRAMAPS80/DEFAULT.HTM?PROJECT=NCC&MODULE=PROPERTY
			A. HILLS			
	PROJECT	NAPIER PRISON – RETAINING WALL ASSESSMENT	REVIEWED			
			J. MUIRSON			
			DATE		FIGURE No.	PROJECT: 520969 · WBS: 000 · TYPE: FIG · DISC: GE · NUMBER: 01 · REV: A
			5 SEPTEMBER 2022			

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CLIENT: Toitū Te Whenua Land Information New Zealand

PRELIMINARY NOT FOR CONSTRUCTION | ALL DIMENSIONS APPROXIMATE ONLY

FIGURE	FIGURE 2
PROJECT	NAPIER PRISON – RETAINING WALL ASSESSMENT
SCALE	NTS
SIZE	-
BY	A. HILLS
REVIEWED	J. MUIRSON
DATE	5 SEPTEMBER 2022
TITLE	RETAINING WALL OVERALL RISK RATINGS
REFERENCE	BACKGROUND IMAGE RETRIEVED FROM: HTTP://WWW.GIS.NAPIER.GOVT.NZ/INTRAMAPS80/DEFAULT.HTM?PROJECT=NCC&MODULE=PROPERTY

FIGURE No.	PROJECT	WBS	TYPE	DISC	NUMBER	REV
	520969	000	FIG	GE	02	A

Appendix B
Titan Micropile Guide

Micropiles from ISCHEBECK® TITAN

- The piling solution for difficult ground conditions
- Can be installed in confined spaces
- Caseless micropile with capacity in excess of 3660 kN

Ischebeck Titan injection piles are ideal for use as tension piles, mini piles and root piles (pali radice) in micropiling situations.

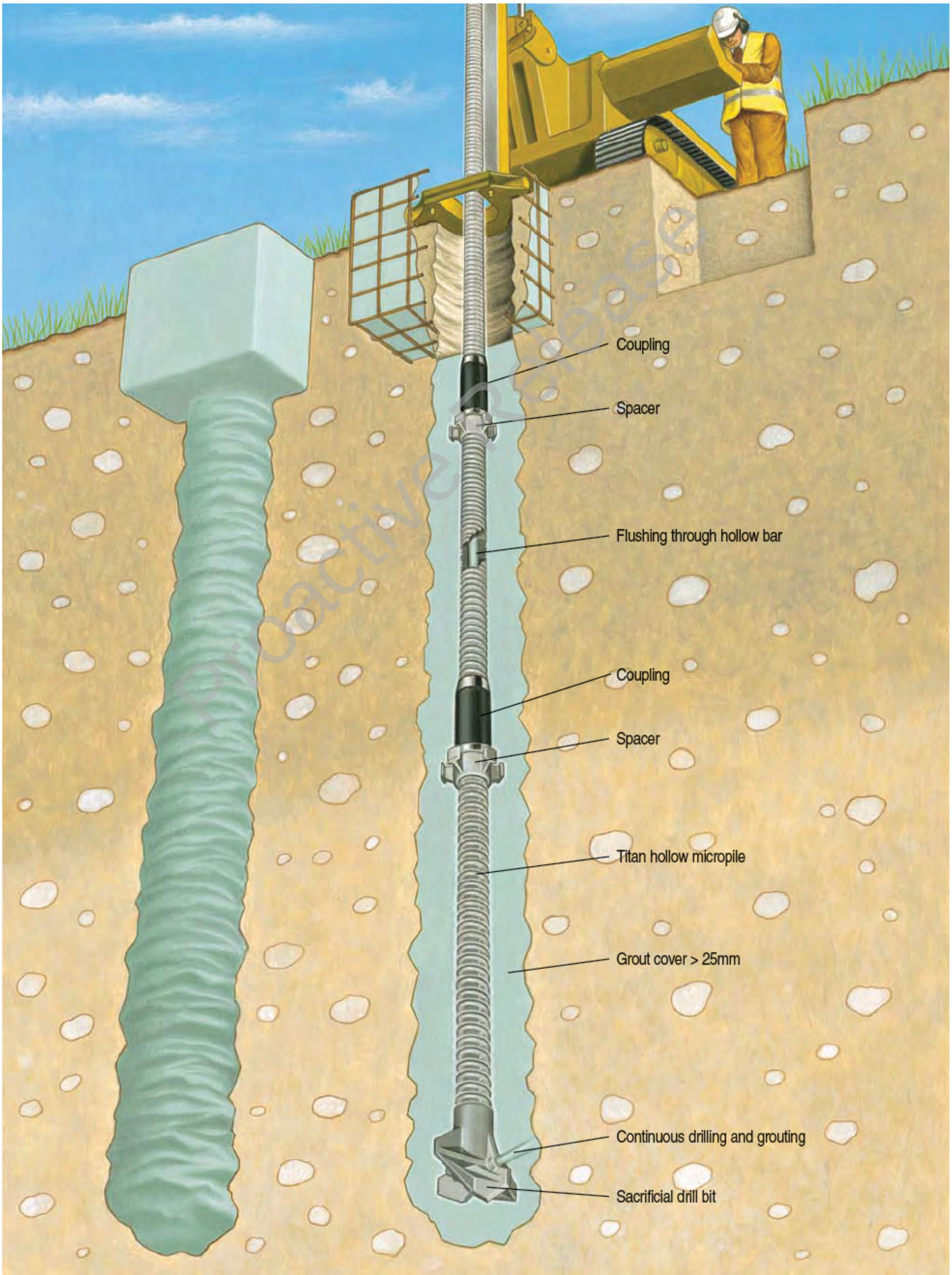
Ischebeck Titan micropiles consist of a continuously threaded, hollow stem steel reinforcement tendon combined with an OPC grout body of a minimum 25 N/mm^2 strength. The profiled surface of the grout body transfers tension and/or compression forces into the ground.

Ischebeck Titan micropiles comply with the new European standard DIN EN 14199.

Advantages over conventional piles

- Works in compression and tension
- Does not require temporary casing
- Improved mechanical ground/grout interaction reduces overall depth
- Dramatically increased production rates
- Lightweight rotary percussive drilling equipment
- Installed in confined spaces
- Permits top down jet grouting in saturated clays and silts complete with re-bar
- Perfect as pali radice for invisible structural repairs
- Bayonet fixing eliminates pile trimming and facilitates remote de-coupling
- Self drilling micropiles provide a range of working loads from 110kN to 3,660 kN
- Minimal noise
- Low vibration
- Minimal spoil

ISCHEBECK®
TITAN



Micropiles for basement construction

ISCHEBECK TITAN

The Little Boltons

The owners of this exclusive property decided to build a new basement and totally rebuild the interior of the existing structure. The new six metre deep basement would extend under the front and rear gardens as well as beneath the house itself, a total area of around 315m^2.

The rebuilding of the interior required the removal of all internal elements from ground floor to roof level, including floors, ceilings and stairs. Front, rear and side elevations were retained and temporarily supported during construction.

Access to the site was only possible from the front of the property and so large openings were formed through the front and rear walls with sway frames being installed to facilitate plant access.

Before demolition and construction commenced in earnest, Ischebeck Titan micropiles with reinforced concrete pile caps were installed at the four corners and two sets in the centre of the property to support the sway frames. The piles were temporarily braced at intervals as the basement's excavation progressed to assure stability of the support.

Zero piles were installed adjacent to party and garden boundary walls. These were used to provide temporary support to the existing retained structure and to provide lateral restraint for the Ischebeck Titan micropiles.

Ground conditions comprised approximately five metres of sandy silts overlying three metres of medium-dense sandy gravels which, in turn, overlaid the London Clay. Ground water level was at approximately 6 metres below existing ground level.

Micropiles for basement construction

ISCHEBECK TITAN

Prior to excavation, and following a successful early testing programme to assure feasibility, Ischebeck Titan self-drilling micropiles, designed to work in tension and compression, were installed to enable the basement floor to withstand gravitational and uplift forces.

In what was the first use of a bayonet coupling in the UK, the micropiles were installed from the original ground level, some 6 metres above the intended finished depth of the basement.
Rather than leaving the entire pile in place, as would be required using temporary cased piles, the 6 metre drill string is uncoupled at the bayonet fixing by simply reversing the drilling direction, leaving the slab's reinforcing micropile in place at the 6 metre depth and below, but enabling the drill string to be removed, and re-used, from the slab to ground level.

This method of micropile installation delivered huge benefits to both the excavation and concrete substructure programme, and also for health and safety issues. Other benefits include; no trimming down of the piles, no risk of pile damage from plant impact and no obstructions to excavation plant. Lorry movements are minimal, which offers environmental benefits, as there is very limited spoil created during installation and the cement grout is delivered dry and mixed on site. The method of installation is very quick and was ideal for these ground conditions, as conventional piles would have required temporary casing.

Cruikshank Street

The construction of a 3.5m deep basement at a private residence in London made full use of Ischebeck Titan micropiles. Some 150No. 6m long 73/45 micropiles were installed using a cross-cut drill bit. The micropiles formed an integral part of the substructure with the base and ground floors.

- 150No. 6.5m 73/45 micropiles
- 175mm cross-cut drill bit
- Gravels over sand overlying stiff clay

Tregunter Road

Construction of a double basement to the front and rear of the garden and under the existing house. Ischebeck Titan micropiles were used as temporary works in two forms; Firstly for soil retention and then for support to stabilise the sway frames to allow for plant access. Approximately 50No. 8m 127/111 piles were installed using a 220mm drill bit for the soil retention and 30No. 9m 40/20 piles were installed for the sway frames.

- 40/20 and 127/111 micropiles installed into dense gravels
- Confined access
- 127/111 tendon exposed and used as part of permanent works

Sellwood Terrace

Redevelopment and conversion of two adjoining properties into a single prestigious residence. To accommodate a new basement the end property had to be demolished and rebuilt, but this left the problem of excavating the 4.5m deep basement adjacent to the neighbouring property and garden/boundary wall on the other side. Traditional underpinning would have proved a costly and risky operation and bored piling was ruled out as the client wanted to maximise the basement's footprint.

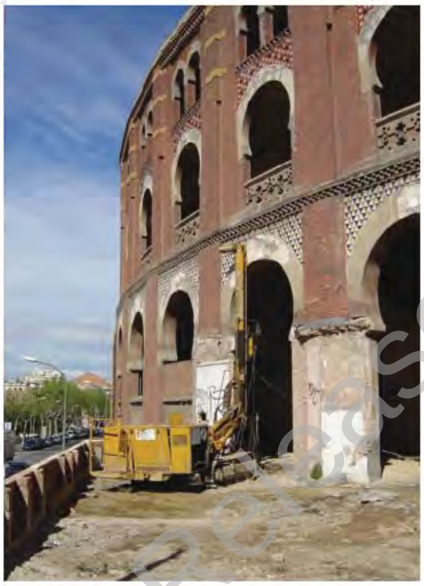
- 7.5m 127/111 micropiles installed
- Piles installed both vertically and raked
- Grout broken off front of piles to maximise footprint

Arthur Road

Construction of basement to the rear of garden to accommodate a swimming pool. Ischebeck Titan micropiles were used as temporary works for soil retention as an alternative to traditional underpinning. 127/111 piles used in conjunction with temporary 30/14 ground anchors installed under the existing house. This eliminated the need to prop internally, thus freeing up workspace, allowing improvement on the programme. Approximately 40No. 9m 127/111 piles were installed using a 220mm drill bit for the soil retention and 20No. 9m 30/14 ground anchors.

- 127/111 micropiles plus 30/14 ground anchors
- Quicker and safer than traditional methods of soil retention
- Micropiles raked under the house to maximise basement footprint

Arenas de Barcelona



This impressive project to create a new commercial centre with underground parking within the historic façade of Barcelona's main bullring admirably demonstrates the potential of Ischebeck Titan micropiles. Consultation at the early stages of project design was the key to its success..

In order to retain the original structure's imposing and symbolic façade, it was supported by micropile columns installed at intervals around the structure. Parallel in-situ concrete beams were used inside and outside to distribute the weight of the freestanding façade. The interior of the structure was removed and excavation commenced to create the five levels of underground parking.

- 21m 73/53 Micropiles
- Underpinning Roman bullring
- Historic façade retained

Stratford Road

Private housing development to build eco-friendly home. Micropiles used to anchor house's split-level base slab. Total of 36No. vertical and raked 30/11 combi-coated micropiles installed through boulder clay and sandstone to 9m depth. Restricted access required mini Marini Voyager drilling rig with MA100 rotary percussive head.

- Restricted access
- Anchor split-level base slab
- 30/11 combi-coated micropiles

Crossflats

Collapsed retaining wall very close to the wing wall of a house required stabilisation. A concrete block initially poured to prevent further collapse of the road edge. Scheme combined 40/16 micro piles and 30/11 soil nails to stabilise road whilst spoil material excavated. Piles installed at 0.5m intervals through concrete block to about 12m in the underlying soft material and then into sandstone, creating contiguous piled wall. As spoil material excavated in front of vertical wall rows of soil nails were installed to prevent any lateral movement. Soil nails installed to 9m into sandstone.

- Combined micropile/soil nail solution
- 40/16 micropiles to 12m. 30/11 soil nails to 9m
- Contiguous piled wall

Micropiles for new build foundations

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Charlestown of Aberlour

Housing development constructed using mass concrete strip foundations directly onto the rockhead. Area of the final two houses, however, had approximately 6m of fill overlying the rockhead, requiring an alternative solution.

A working pile load of 170kN was established by the consulting engineers and a pile length of 7m was agreed. The micropiles were drilled through the overlying fill and 1m into the rockhead using a 70mm button type sacrificial drill bit.

26No. Ischebeck Titan 40/20 micropiles were installed in one 9-hour shift.

- 40/20 black micropiles
- 170kN working load
- 7m piles drilled through to rockhead

Broomhead Park

Private housing development comprising two-storey flats of timber frame construction. Ground conditions of made ground and clay over sandstone dictated that foundations be stabilised. A total of 29No. 30/16 black micropiles installed to depth of 9m using 95mm hardened clay drill bit. Piles used in compression to vertical load of 75kN.

- 30/16 black micropiles
- Vertical pile load 75kN in compression
- Made ground and clay over sandstone

Dufftown

Private housing development of fourteen new timber framed homes constructed on former quarry site. Ground conditions of up to 15.5m of made ground on very strong limestone demanded that foundations be stabilised. A total of 52No. 40/20 black micropiles installed to depths of 17m and 10.5m using 70mm button drill bit. Piles used in compression to vertical load of 170kN.

- 40/20 black micropiles
- Vertical pile load 170kN in compression
- Made ground on very strong limestone

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Micropiles for telecommunications mast foundations

Once permission has been granted for a telecommunication mast, it is important to get the mast operational as soon as possible.

Typically 4No. 12m long Ischebeck Titan 40/20 micropiles are installed to form part of the mast's foundation. This eliminates the need for a reinforced concrete base.

As there is a limited import of material, there is minimal disturbance to the surrounding environment.

The four micropiles are usually installed on the morning of day one. The increased production rates help to allow operational activity within three days of entry to the site.

- Ideal for remote sites
- Top detail of pile adapted to fit direct to cabin
- Rapid production rates allow early operational activity

Micropiles for tower crane base

Demonstrating the versatility of the Ischebeck Titan solution, this retail construction project utilised 40/16 micropiles to anchor the base of a tower crane on ground consisting of clay overlying gravelly clay. The micropiles were installed as groups of four in several locations throughout the development site.

- 40/16 micropiles
- 150mm hardened clay drill bit
- Clay overlying gravelly clay

Micropiles for gantry base foundations

ISCHEBECK TITAN®

Highway

MS4 signal gantry bases and foundations for signal upgrade on M40 between junctions 9 and 11. Ischebeck Titan provided micropile foundations where bases were situated over harder/rocky material which would prevent installation of contractor's auger piles. Eleven bases installed, each with 8No. 10m long 40/16 micropiles with ultimate load carrying capacity of 660kN. Drill mounted on excavator arm and drilled mostly from hard shoulder which enabled crash barriers to remain in place. The work was successfully carried out under a single lane closure and has led to further contracts.

- Motorway signal upgrade
- 40/16 micropiles
- Single lane closure

Rail

Approximately twenty GSRM bases have been constructed for Network Rail as part of the emergency communications network which allows the driver to talk to the control station. The bases have been constructed using 40/20 micropiles to an average of 12m depending on underlying ground conditions. Each base has between 4No. and 8No. micro piles depending on size of the antenna required.

- 40/20 micropiles
- Network Rail communications antennae
- Average 12m depth

Project Omega

This scheme was part of a waste water treatment works upgrade, which involved installing tension micropiles through the concrete slab of a new filter tank. They were designed as anti-flotation piles due to the proximity of the sea, with an ultimate load of 900kN. A washer plate with a spherical collar nut above and below the plate was cast into the slab. The 13m long 52/26 Ischebeck Titan micropiles were installed through the overlying clay into weathered sandstone.

- 115mm button type drill bit
- 13m 52/26 black tension micropiles
- 56No. permanent micropiles

Ormont

Project involved demolition of an existing bungalow and subsequent construction of a much larger bungalow on same site. Part of the scheme involved the construction of a large basement beneath the dwelling to accommodate a gym and cinema. Some 77No. micropiles were installed, working in tension and compression to secure the reinforced basement floor slab. Working loads of up to 450kN were required, using drill bit diameters of up to 280mm in the London Clay.

- Permanent works using black tendons
- 40/16, 52/26 and 73/53 micropiles installed
- Bearing plate with dual spherical collar nuts cast into slab

Drilled and pressure grouted micropiles

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Titan micropiles are installed using a standard, rotary percussive drill rig in a one visit drilling operation. The installation procedure uses a grout flush to stabilise the annulus, consequently eliminating the use of casings. This type of installation is free from vibration and has a low noise level. Titan micropiles require smaller holes and work with small rigs which means less drill spoil and lower mobilisation costs.

The grout body takes care of the radial friction in the soil, the stiffness against buckling and the corrosion protection. By using spacers (centralisers) at each coupler, a minimum grout cover of 20mm is achieved. The soil mechanics of the Titan micropiles, in comparison to standard reinforced concrete piles (DIN 4014), show very little settlement due to their very good soil friction (typical settlement less than 5mm under design load). Due to excellent mechanical bond between the grout body and the soil, the movement required to activate the friction is in the range of just a few millimetres.

The hollow steel section is far superior to a solid rod of the same cross section and steel quality with respect to bending, shear and surface friction.

The material for the production of Titan micropiles is approved micro alloy constructional steel.

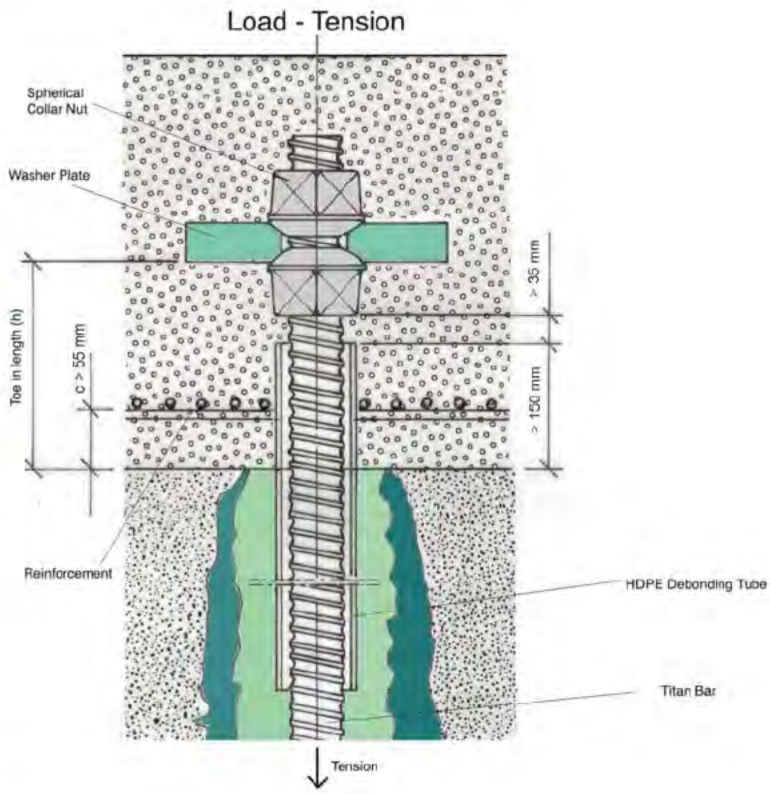
In the thread production process, the material strength of the micro alloy steel is increased by cold forming without causing brittleness.

Titan micropiles comply with the European standard for micropiles EN BS 14199.

As with reinforced concrete, these ribs induce an equal crack distribution in the grout. Excavated pile grout bodies reinforced with Titan micropiles have shown that up to 1.25 of the design load the characteristic crack widths are below the permissible value of 0.1 mm as required for reinforcement .

This proves that the system complies with DIN 4128 9.2 and that single corrosion protection of minimum 20 mm cover, as with reinforced concrete, is sufficient.

Typical head detail



To calculate load carrying capacity

The load bearing length, L, of the pile is determined by grout body diameter, D, the ultimate soil friction, Tult, surface of the grout body and the safety factor.

End bearing capacity of Titan micropiles can be ignored.

Skin friction values should be taken from site investigations and tests.

Bond lengths for tension or tension and compression piles

$$L = \frac{Tw \times Fs}{\pi \times D \times Tult}$$

Tw - Safe working load
Fs - Factor of safety
π - 3.142
D - Drill bit diameter + enhancement factor
Tult - Skin friction

Example:

100kN tension load in sand with 110mm drill bit

$$\frac{100kN \times 3}{\pi \times (0.11 + 0.05) \times 150kN/m}$$

$$\frac{300.00}{75.41}$$

3.97m long bond length

Please note that calculations may vary according to different national standards and regulations.

Compression only

Compression only piles have the ability to spread the load over the steel section and the grout body as a composite pile.

Load taken on grout (safe)

$$\text{Area of grout} \times \frac{\text{strength of grout}}{4}$$

$40N/mm^2$ grout after 28 days

$$(\text{Area of grout} - \text{Area of bar}) \times \frac{40N/mm}{4}$$

For 200mm drill bit - (No enhancement factor)

$$(200^2 - 52^2) \times \frac{\pi}{4} \times \frac{40}{4}$$

$$(40{,}000 - 2{,}704) \times \frac{\pi}{4} \times 10$$

= 293kN

Load taken on steel

$$\frac{\text{Yield strength of steel}}{2}$$

Yield of 52/26 micropile is 730kN

$$\frac{730}{2}$$

= 365kN

Total safe working load of pile in compression only

Load taken on grout + load taken on steel

293 + 365 = 658kN

Anchor/pile type	Unit	TITAN 30/16	TITAN 30/14	TITAN 30/11	TITAN 40/20	TITAN 40/16	TITAN 52/26	TITAN 73/56	TITAN 73/53	TITAN 73/45	TITAN 73/35	TITAN 103/78	TITAN 103/51	TITAN 127/111
Nominal outside diam.	mm	30	30	30	40	40	52	73	73	73	73	103	103	127
Nominal inside diam.	mm	16	14	11	20	16	26	56	53	45	35	78	51	111
Ultimate load	kN	245	275	320	540	660	925	1035	1160	1585	1865	2270	3660	2320
Yield point	kN	190	220	260	425	525	730	830	970	1270	1430	1800	2670	2030
Yield stressT0,2	N/mm^2	560	585	625	590	590	585	610	590	560	530	565	470	585
Cross section (A)	mm^2	340	375	415	730	900	1250	1360	1615	2260	2710	3140	5680	3475
Weight	kg/m	2.70	2.87	3.29	5.60	7.17	9.87	10.75	13.20	17.80	21.20	25.30	44.60	28.90
Thread left/right hand		left	left	left	left	left	left or right	right	right	right	right	right	right	right
Lengths	m	3/4	3/4	2/3/4	3/4	2/3/4	3	6.25	3	3	4	3	3	3

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Ischebeck Titan

Founded in Germany over 120 years ago, Ischebeck Titan is renowned internationally for its aluminium formwork and false work, trench support systems and ground engineering products.

Ischebeck Titan has introduced many innovations to the world's construction and civil engineering industries, creating a range of products which enhance safety, productivity and efficiency on site.

Design excellence, precision engineering and quality materials ensure compliance with all relevant performance standards.

Product Availability

Substantial stocks of equipment ensure ex-stock availability across virtually all products. National headquarters are strategically located to achieve 48-hour delivery on most items. Products are available for both hire and outright purchase.

Technical Support

Technical support is designed to maximise the benefits of using Ischebeck Titan products in all areas of safety, productivity, economy and efficiency.

Advice is available at all stages of a project, including concept development, input on applications, production rates, budget design, costings and on-site support. Guidance on industry special European and national standards is also available.

ISM International Society for Micropiles

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ISCHEBECK NEW ZEALAND

Appendix C
Slope W Sections

Directory: C:\Users\Chris.Scott\Aurecon Group\LINZ Engineering Panel - 520969 - Ex Napier Prison\5. Concept Design Development_Variation 5\2. Calculations\SlopeW\Mesh\

Horz Seismic Coef.:

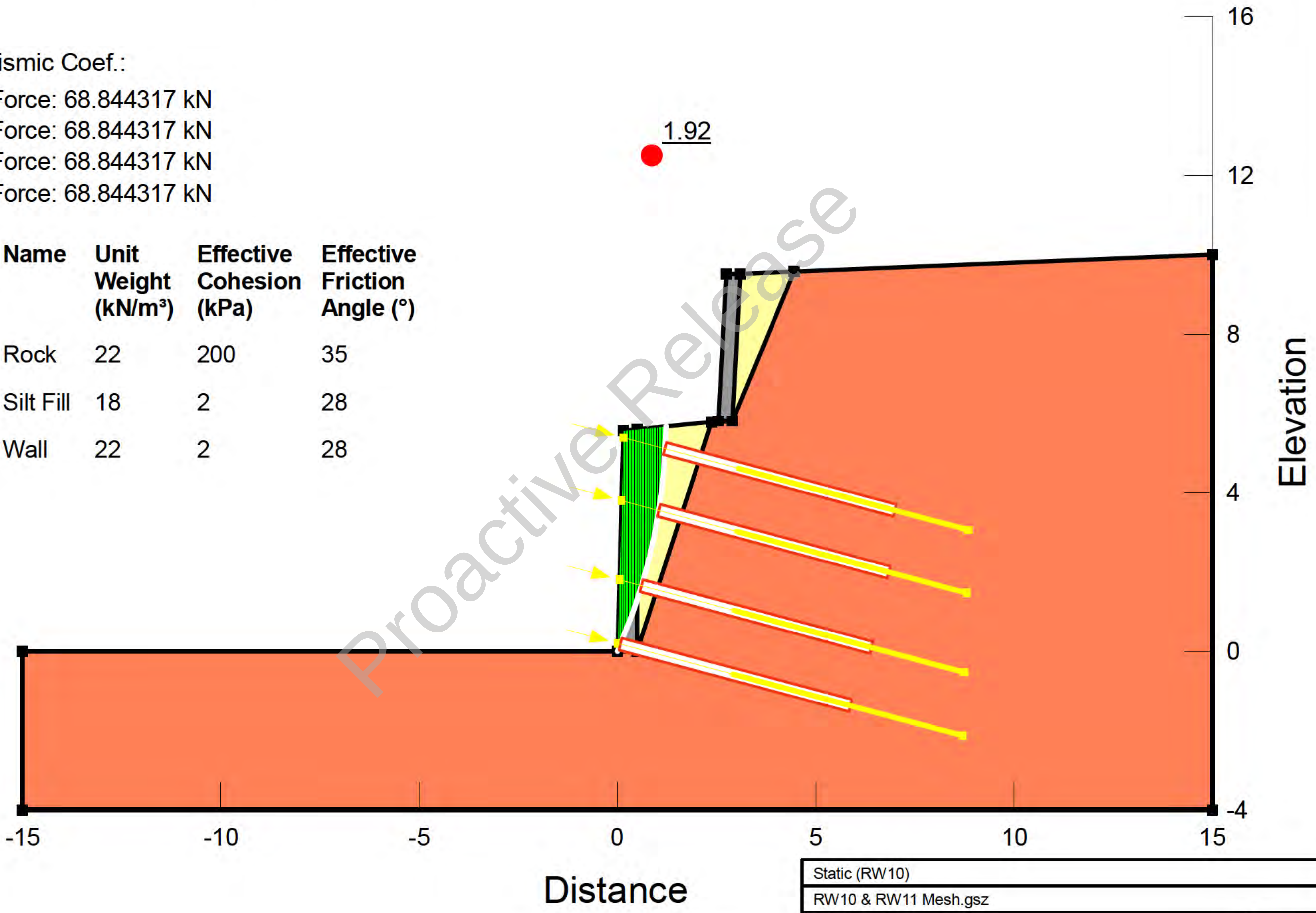
Pullout Force: 68.844317 kN

Pullout Force: 68.844317 kN

Pullout Force: 68.844317 kN

Pullout Force: 68.844317 kN

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Rock	22	200	35
	Silt Fill	18	2	28
	Wall	22	2	28



Static (RW10)	
RW10 & RW11 Mesh.gsz	
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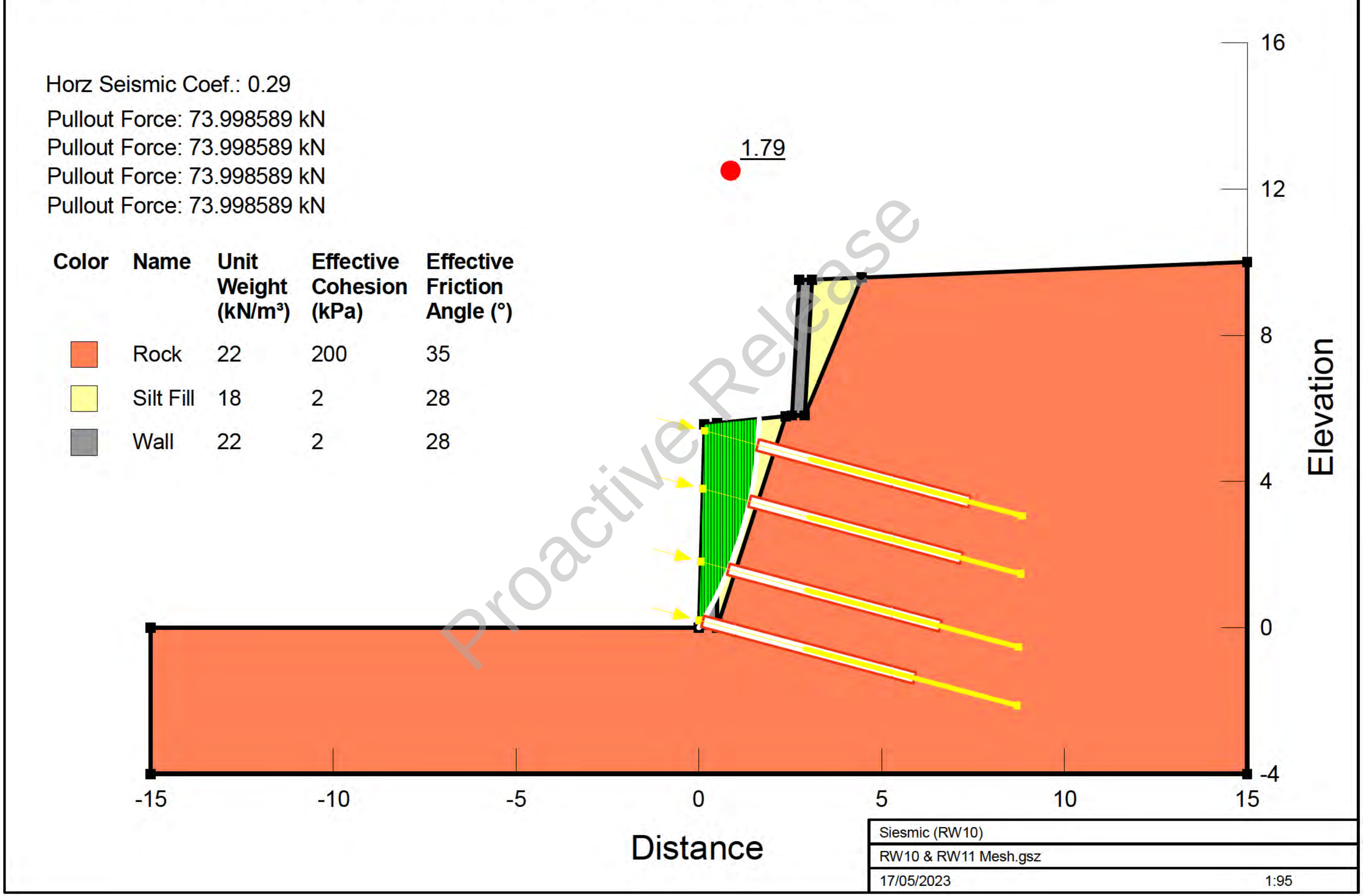

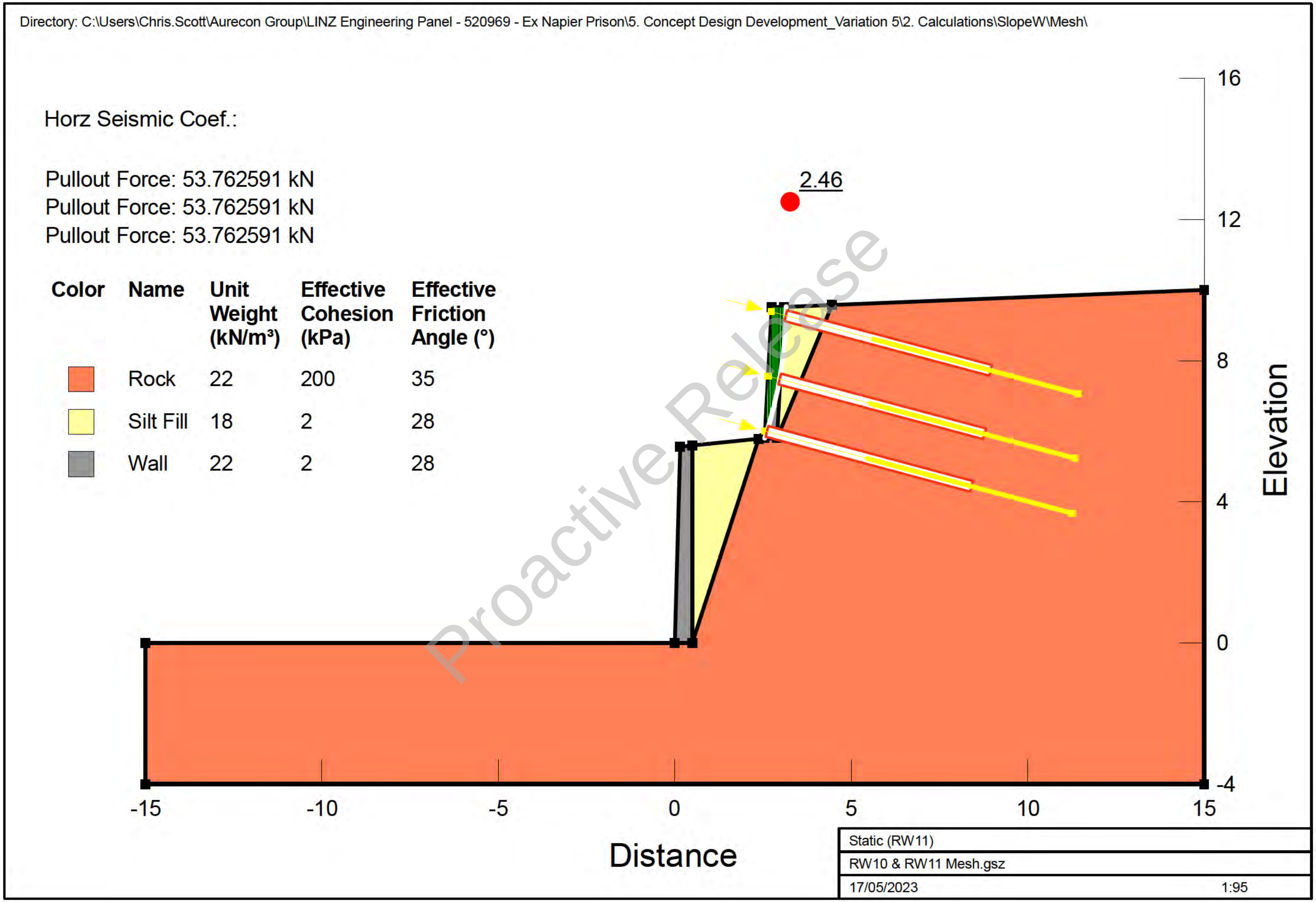
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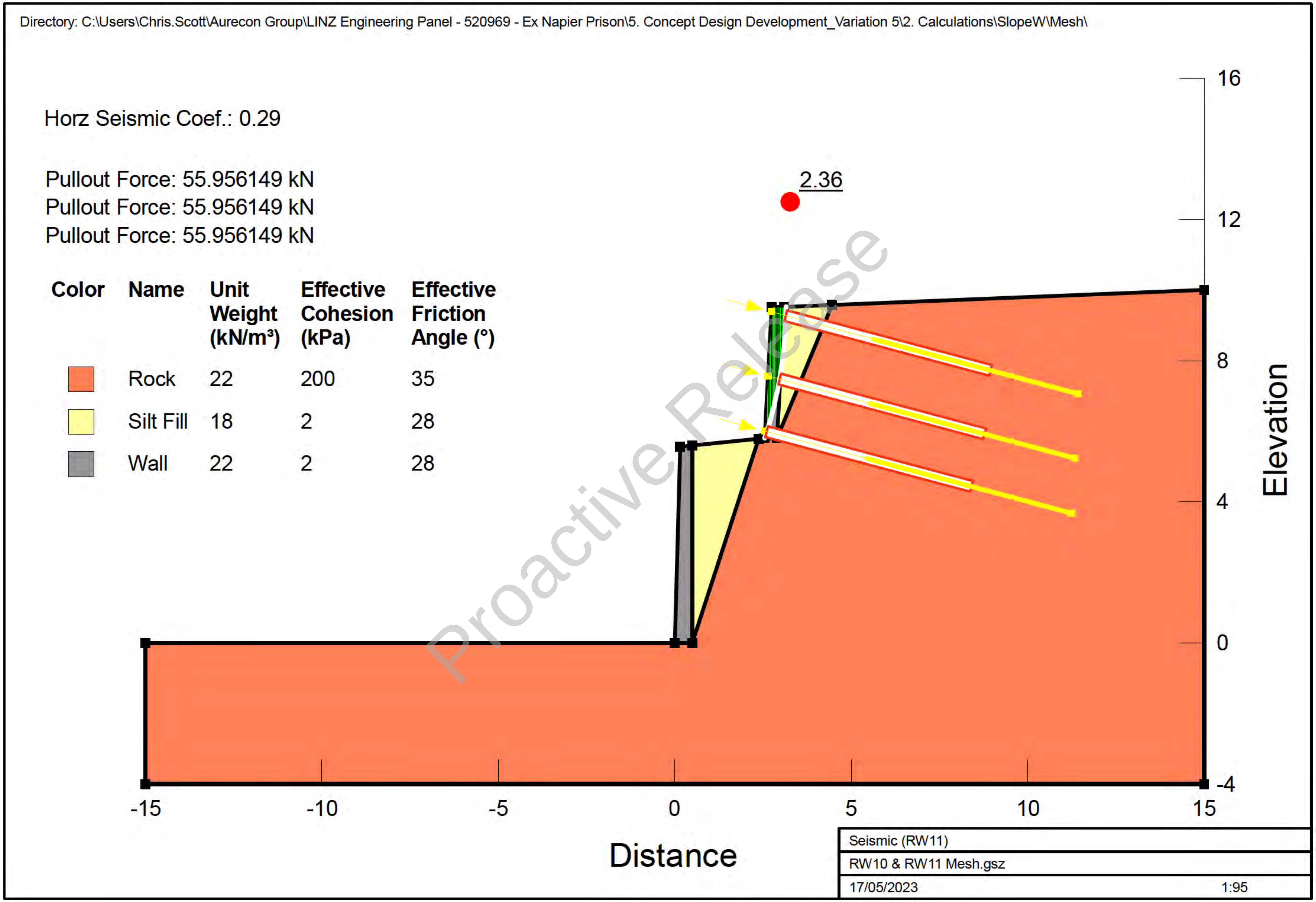
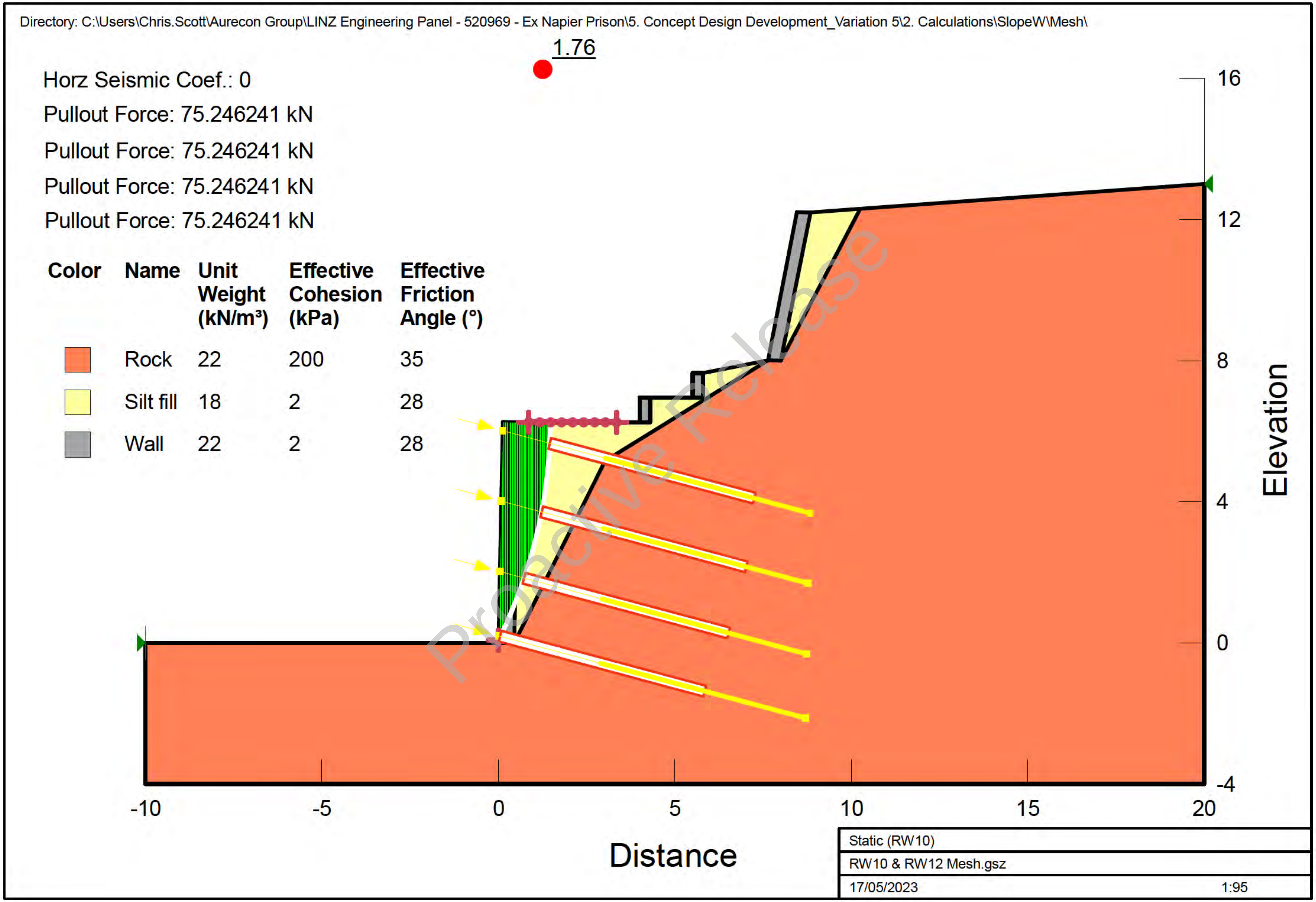
Horz Seismic Coef.:
Pullout Force: 53.762591 kN
Pullout Force: 53.762591 kN
Pullout Force: 53.762591 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt Fill 18 2 28
Wall 22 2 28
2.46
16
12
8
4
0
-4
Elevation
-15
-10
-5
0
5
10
15
Distance
Static (RW11)
RW10 & RW11 Mesh.gsz
17/05/2023
1:95
Proactive Release



Directory: C:\Users\Chris.Scott\Aurecon Group\LINZ Engineering Panel - 520969 - Ex Napier Prison\5. Concept Design Development_Variation 5\2. Calculations\SlopeW\Mesh\
Horz Seismic Coef.: 0.29
Pullout Force: 55.956149 kN
Pullout Force: 55.956149 kN
Pullout Force: 55.956149 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt Fill 18 2 28
Wall 22 2 28
2.36
16
12
8
4
0
-4
Elevation
-15
-10
-5
0
5
10
15
Distance
Proactive Release
Seismic (RW11)
RW10 & RW11 Mesh.gsz
17/05/2023
1:95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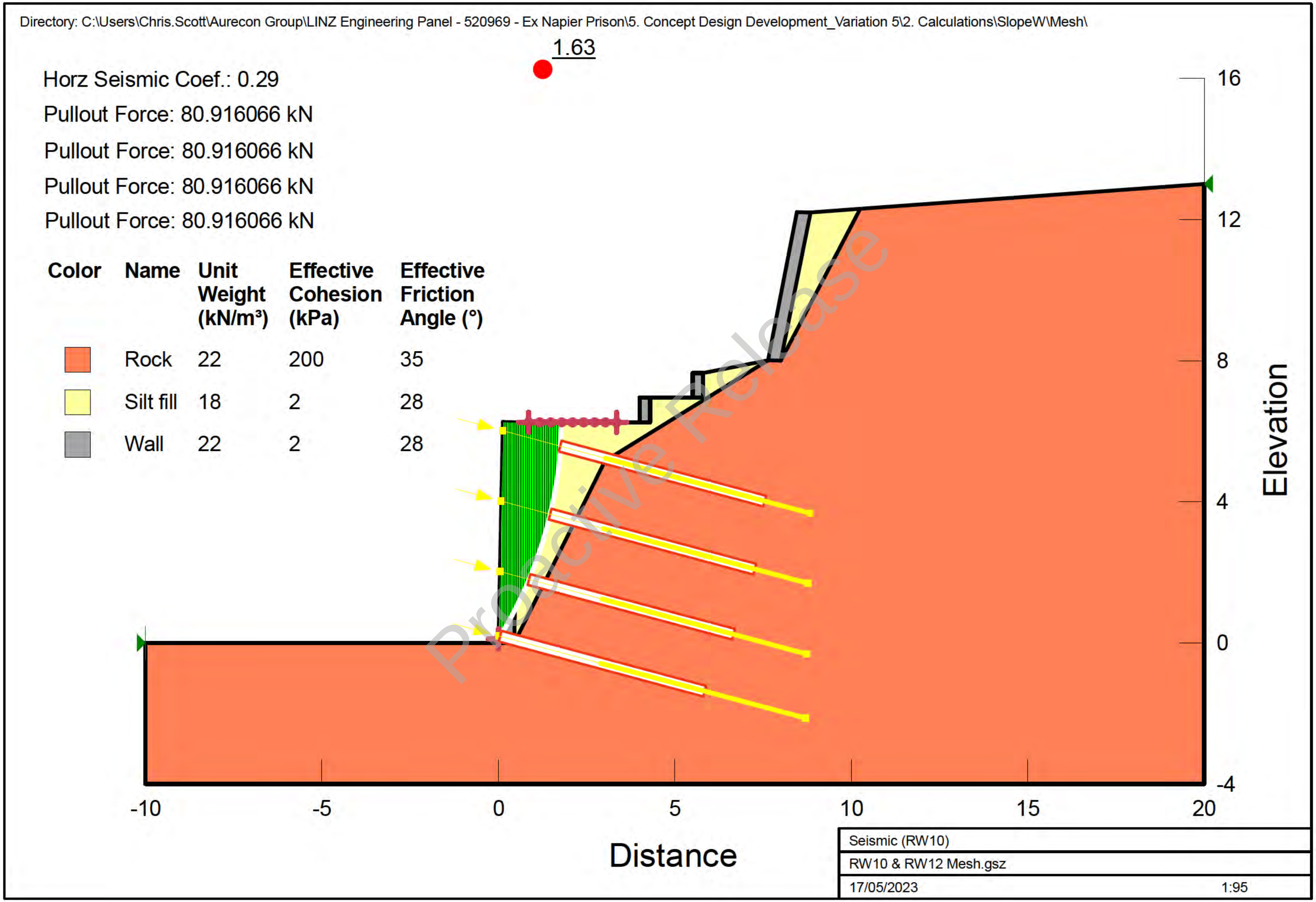
1.76
Horz Seismic Coef.: 0
Pullout Force: 75.246241 kN
Pullout Force: 75.246241 kN
Pullout Force: 75.246241 kN
Pullout Force: 75.246241 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Proactive Release
Static (RW10)
RW10 & RW12 Mesh.gsz
17/05/2023
1:95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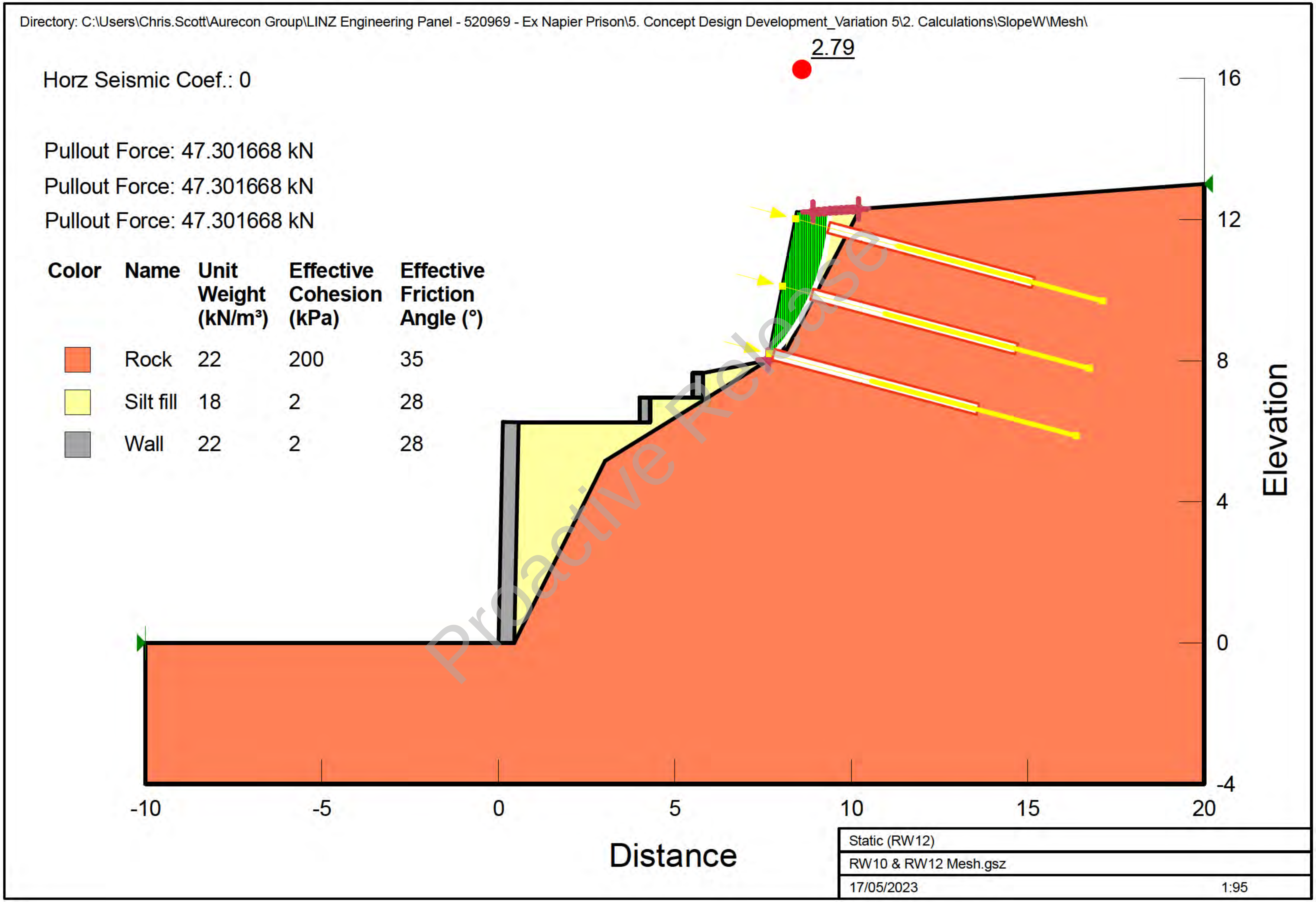
1.63
Horz Seismic Coef.: 0.29
Pullout Force: 80.916066 kN
Pullout Force: 80.916066 kN
Pullout Force: 80.916066 kN
Pullout Force: 80.916066 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
Proactive Release
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Seismic (RW10)
RW10 & RW12 Mesh.gsz
17/05/2023
1:95



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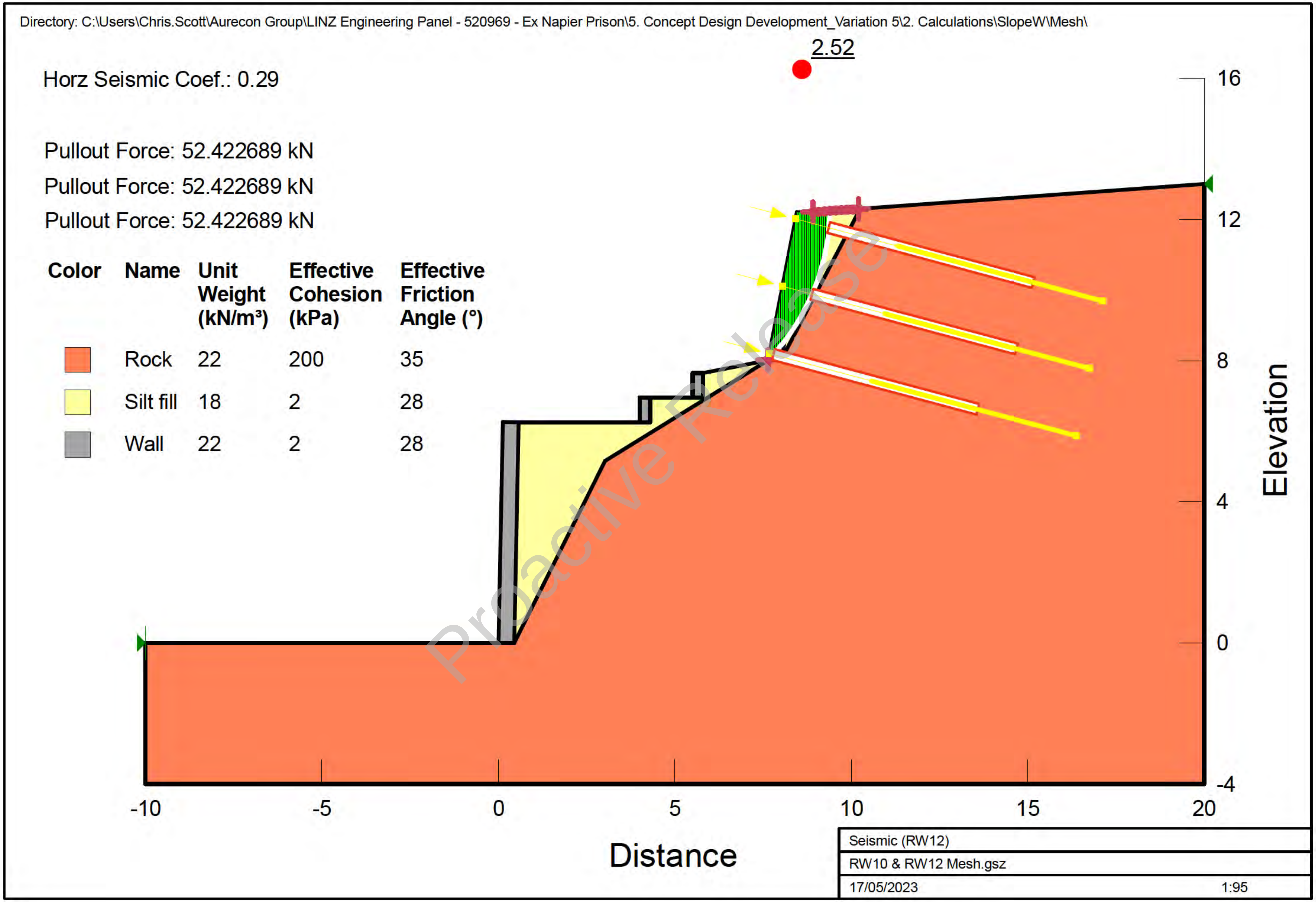
2.79
Horz Seismic Coef.: 0
Pullout Force: 47.301668 kN
Pullout Force: 47.301668 kN
Pullout Force: 47.301668 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Static (RW12)
RW10 & RW12 Mesh.gsz
17/05/2023
1:95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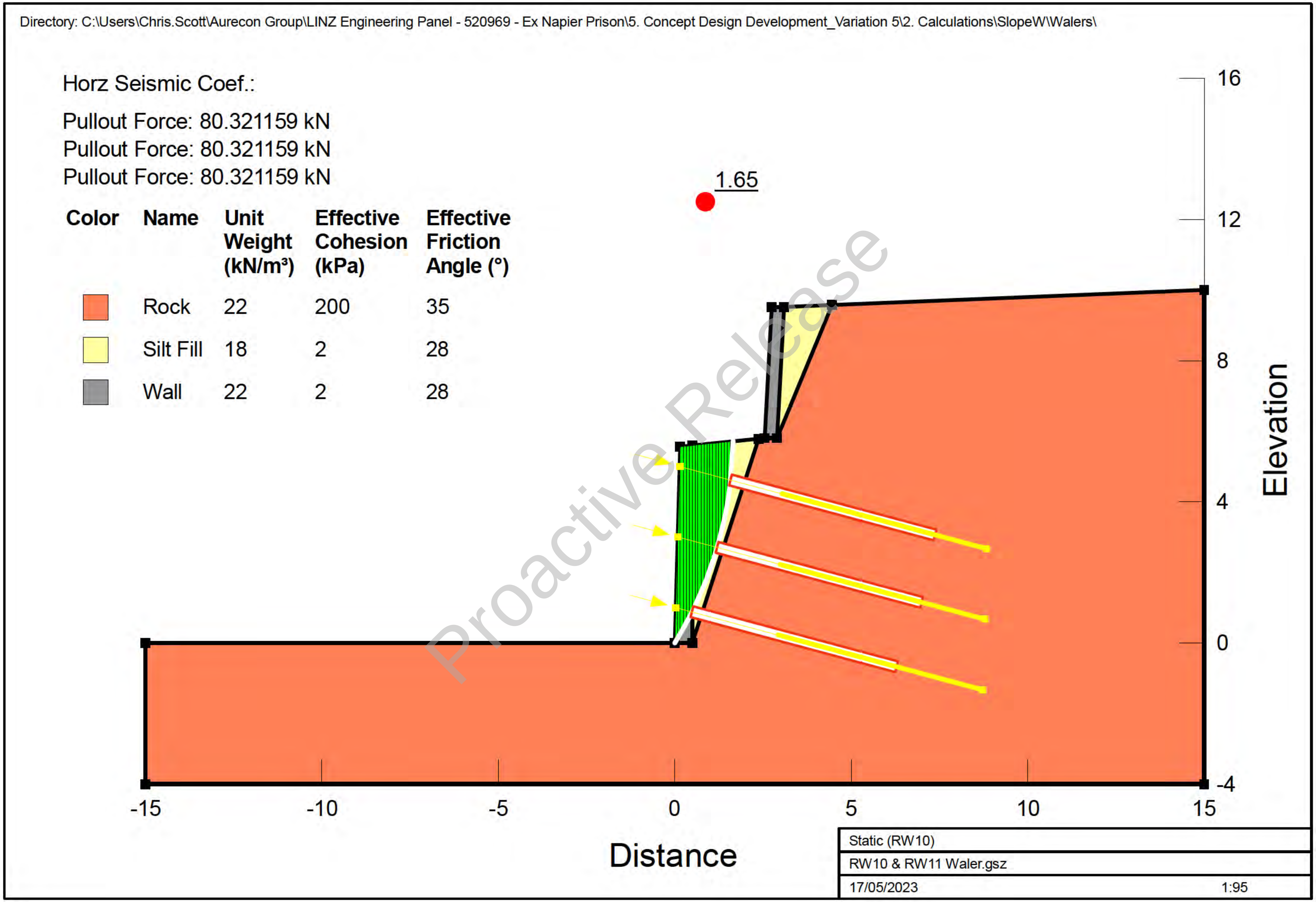
2.52
Horz Seismic Coef.: 0.29
Pullout Force: 52.422689 kN
Pullout Force: 52.422689 kN
Pullout Force: 52.422689 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Seismic (RW12)
RW10 & RW12 Mesh.gsz
17/05/2023
1:95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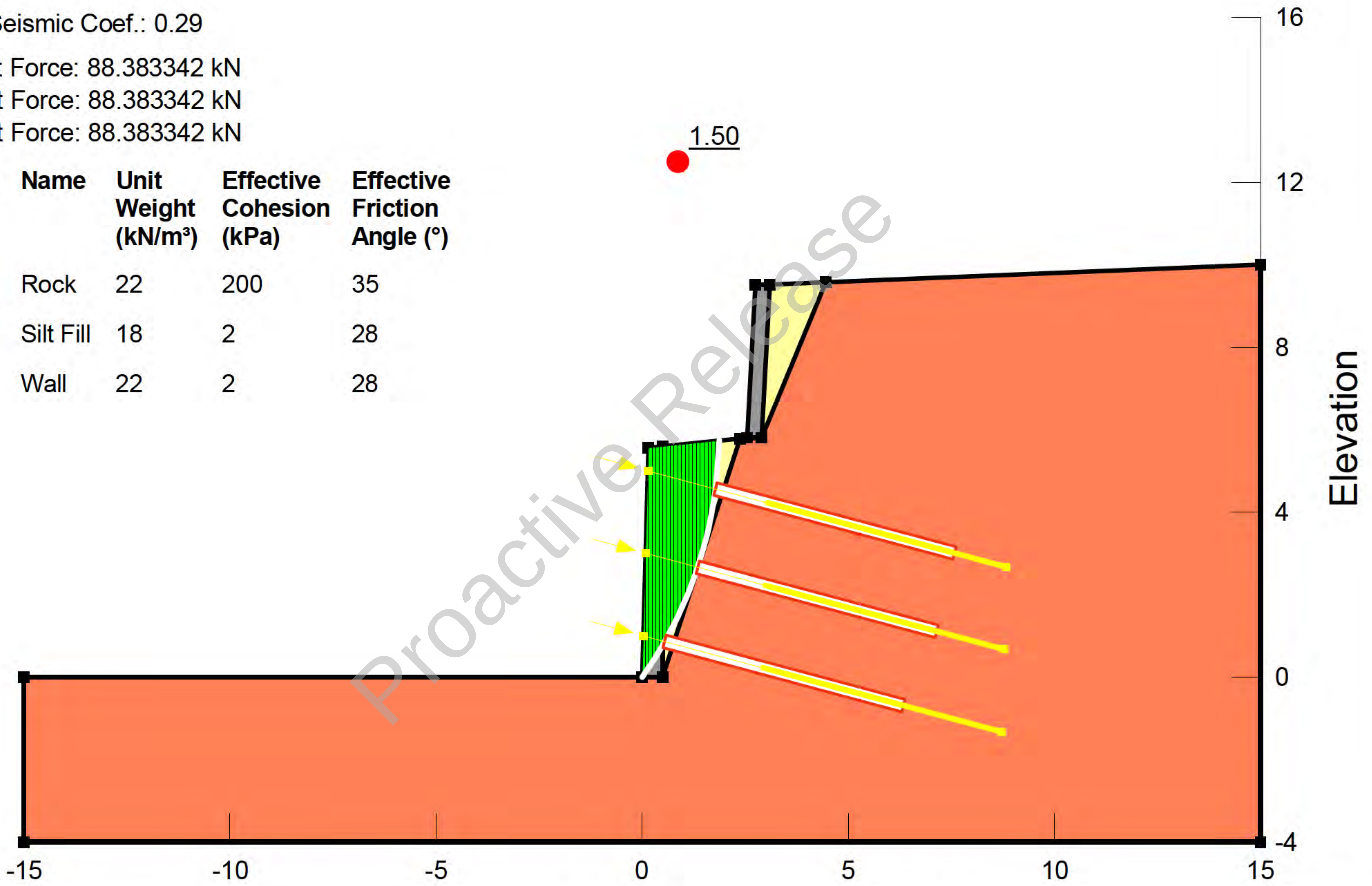
Horz Seismic Coef.:
Pullout Force: 80.321159 kN
Pullout Force: 80.321159 kN
Pullout Force: 80.321159 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt Fill 18 2 28
Wall 22 2 28
1.65
Proactive Release
16
12
8
4
0
-4
Elevation
-15
-10
-5
0
5
10
15
Distance
Static (RW10)
RW10 & RW11 Waler.gsz
17/05/2023
1:95

Directory: C:\Users\Chris.Scott\Aurecon Group\LINZ Engineering Panel - 520969 - Ex Napier Prison\5. Concept Design Development_Variation 5\2. Calculations\SlopeW\Walers\

Horz Seismic Coef.: 0.29

Pullout Force: 88.383342 kN
Pullout Force: 88.383342 kN
Pullout Force: 88.383342 kN

Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Rock	22	200	35
	Silt Fill	18	2	28
	Wall	22	2	28



Seismic (RW10)

RW10 & RW11 Waler.gsz

17/05/2023 1:95

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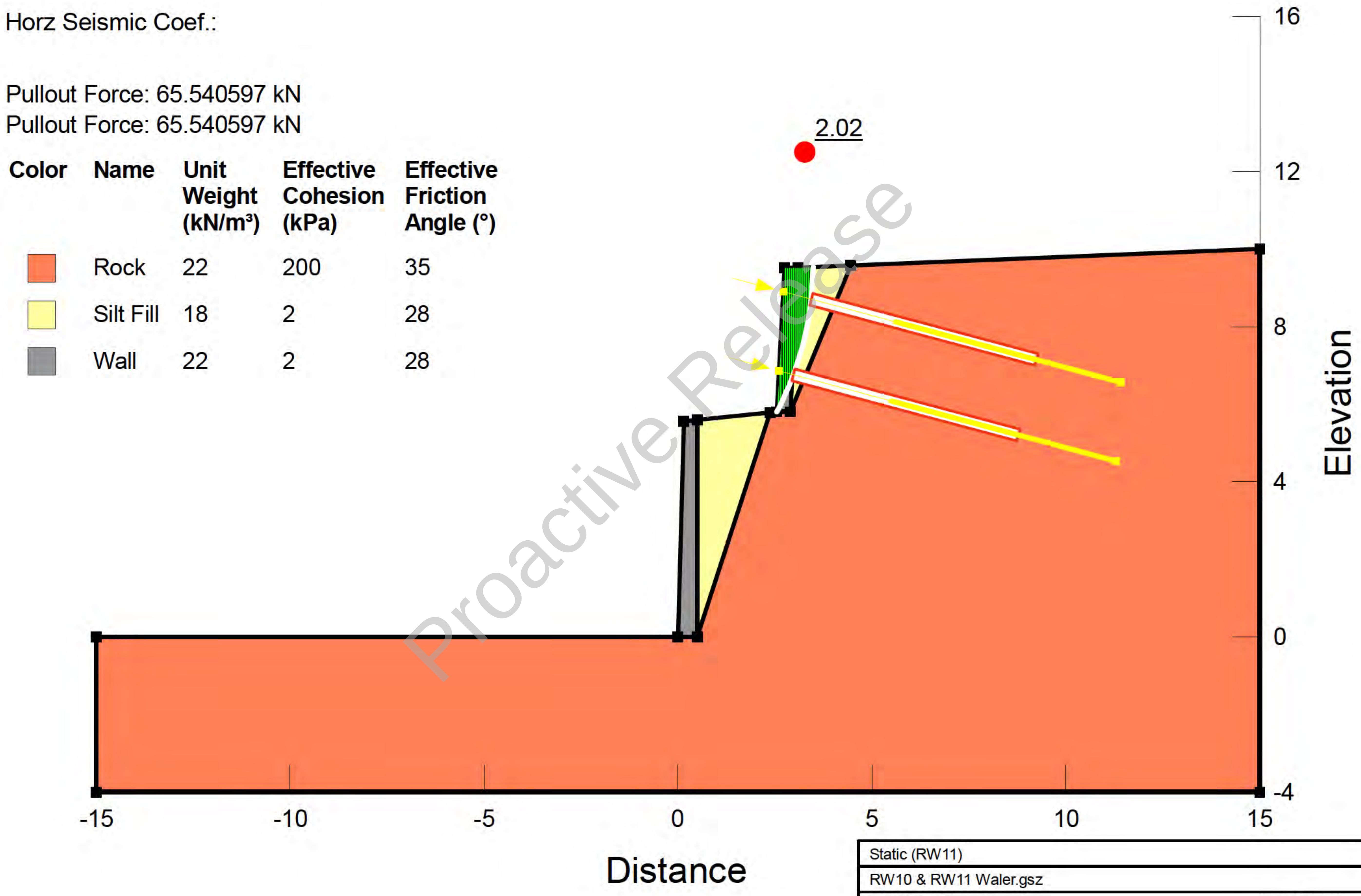


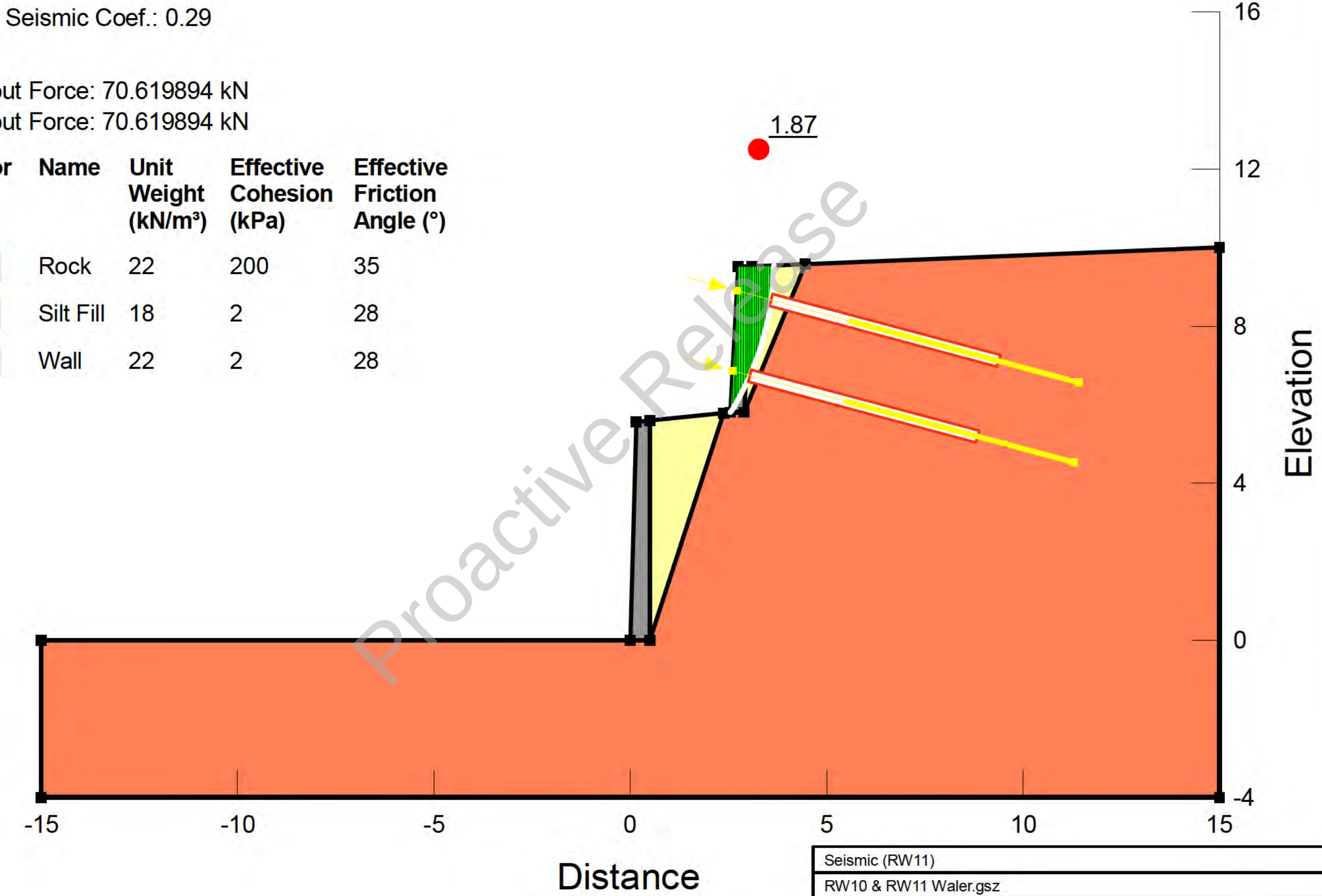
Static (RW11)	
RW10 & RW11 Waler.gsz	
17/05/2023	1:95

Directory: C:\Users\Chris.Scott\Aurecon Group\LINZ Engineering Panel - 520969 - Ex Napier Prison\5. Concept Design Development_Variation 5\2. Calculations\SlopeW\Walers\

Horz Seismic Coef.: 0.29

Pullout Force: 70.619894 kN
Pullout Force: 70.619894 kN

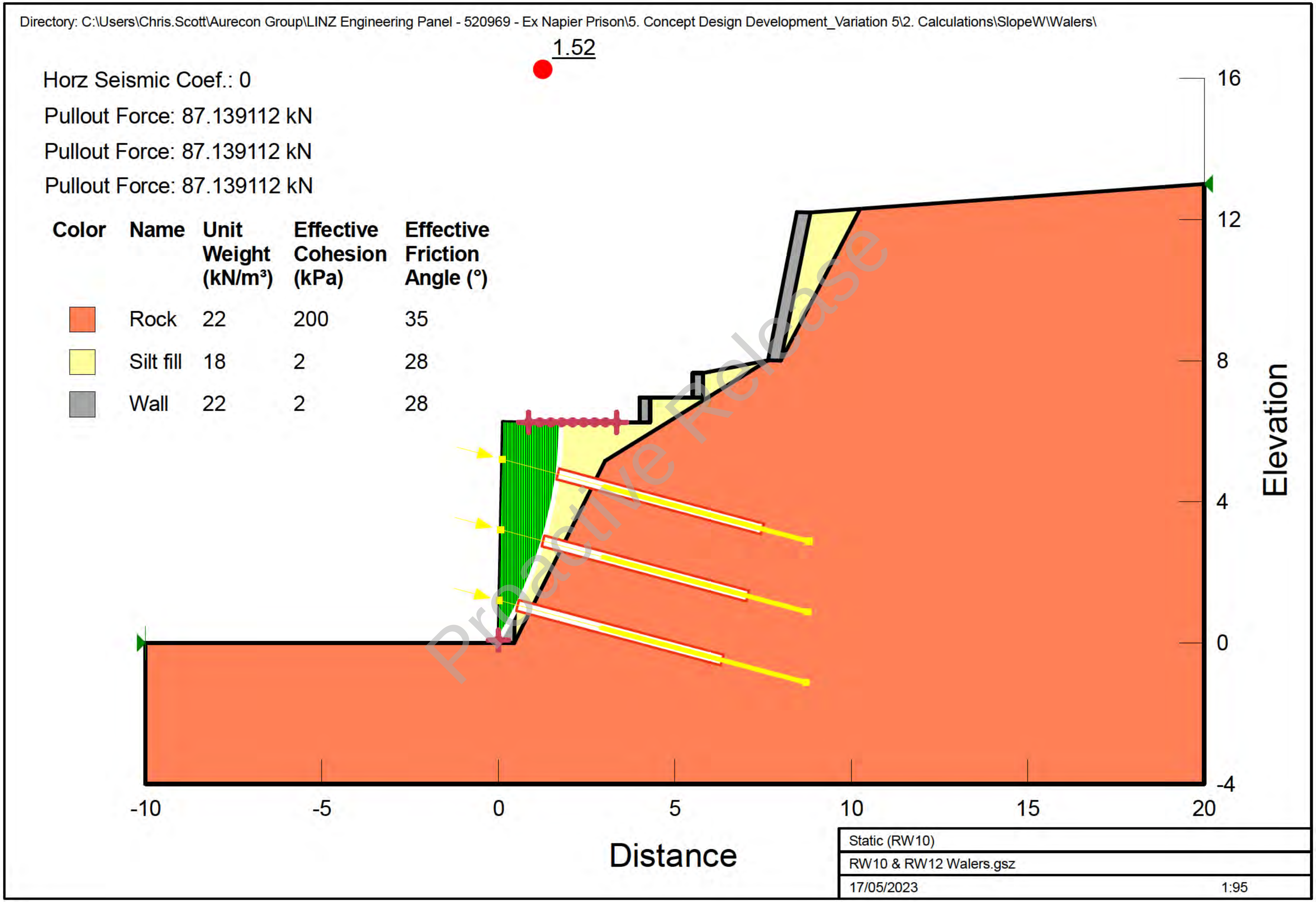
Color	Name	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
(orange)	Rock	22	200	35
(yellow)	Silt Fill	18	2	28
(grey)	Wall	22	2	28



Seismic (RW11)

RW10 & RW11 Waler.gsz

17/05/2023 1:95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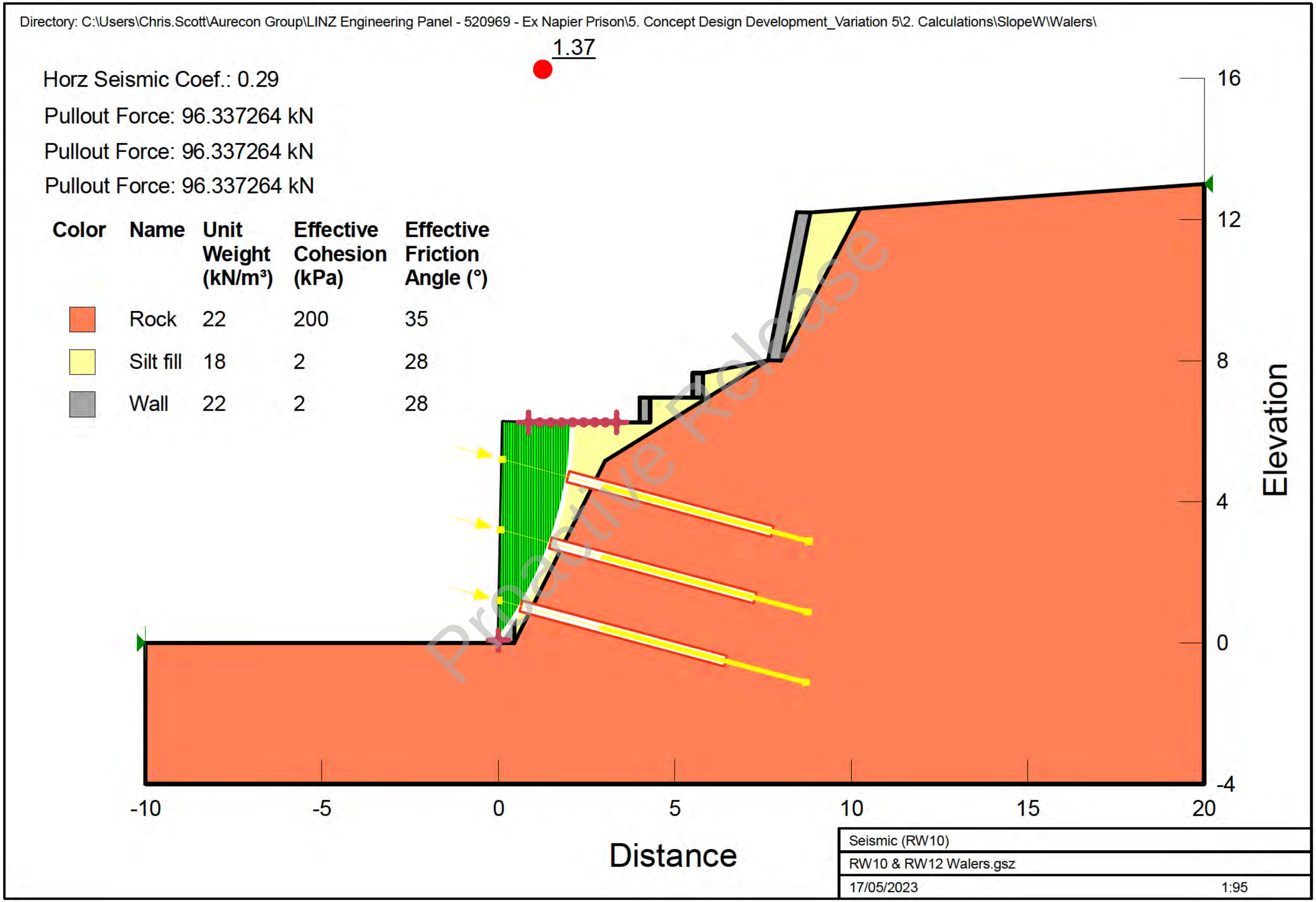
1.52
Horz Seismic Coef.: 0
Pullout Force: 87.139112 kN
Pullout Force: 87.139112 kN
Pullout Force: 87.139112 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Static (RW10)
RW10 & RW12 Walers.gsz
17/05/2023
1:95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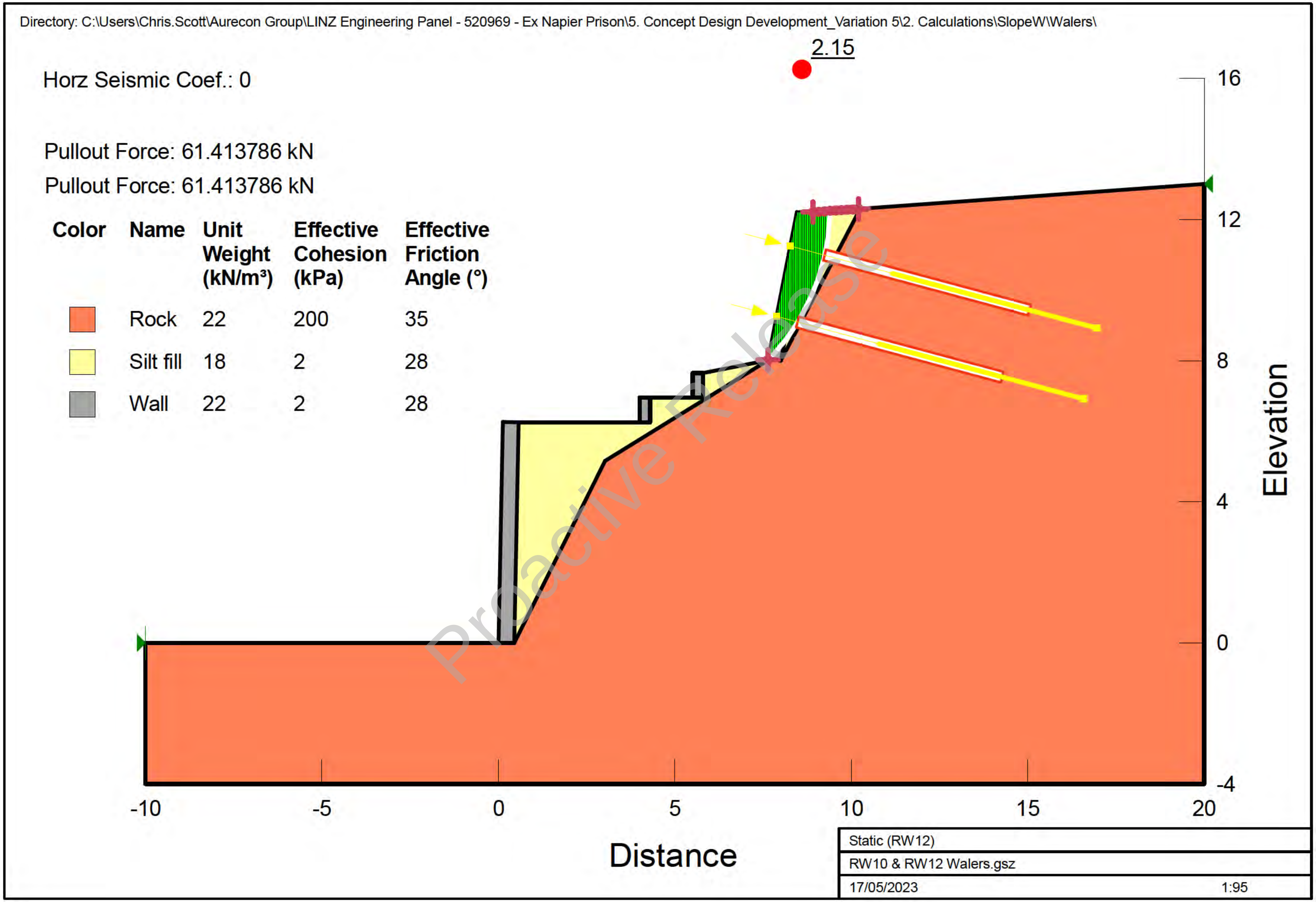
1.37
Horz Seismic Coef.: 0.29
Pullout Force: 96.337264 kN
Pullout Force: 96.337264 kN
Pullout Force: 96.337264 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Proactive Release
Seismic (RW10)
RW10 & RW12 Walers.gsz
17/05/2023
1:95



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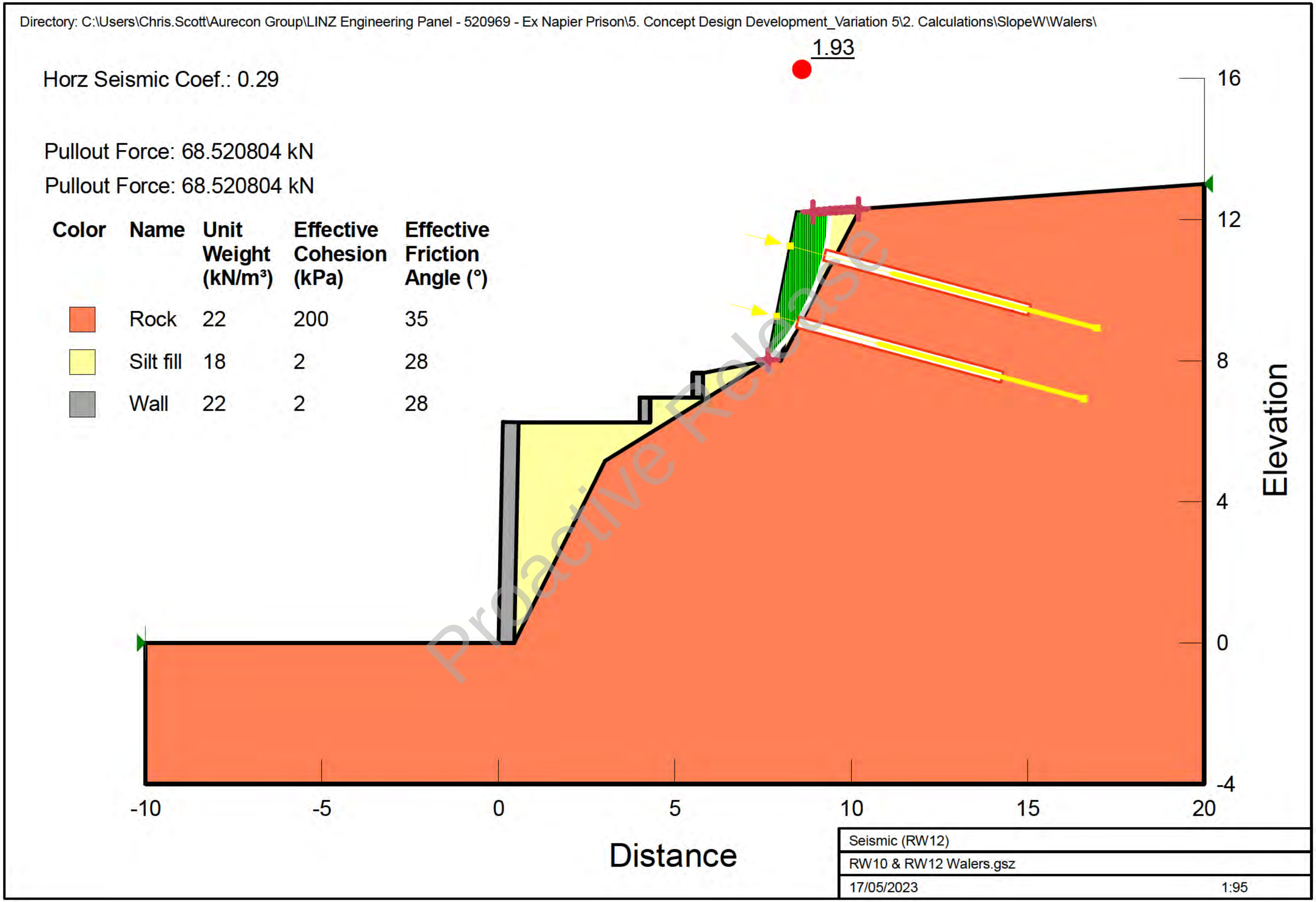
2.15
Horz Seismic Coef.: 0
Pullout Force: 61.413786 kN
Pullout Force: 61.413786 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Proactive Release
Static (RW12)
RW10 & RW12 Walers.gsz
17/05/2023
1:95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Horz Seismic Coef.: 0.29
Pullout Force: 68.520804 kN
Pullout Force: 68.520804 kN
Color
Name
Unit Weight (kN/m³)
Effective Cohesion (kPa)
Effective Friction Angle (°)
Rock 22 200 35
Silt fill 18 2 28
Wall 22 2 28
16
12
8
4
0
-4
Elevation
-10
-5
0
5
10
15
20
Distance
Seismic (RW12)
RW10 & RW12 Walers.gsz
17/05/2023
1:95

Appendix D
Concept Design Sketches

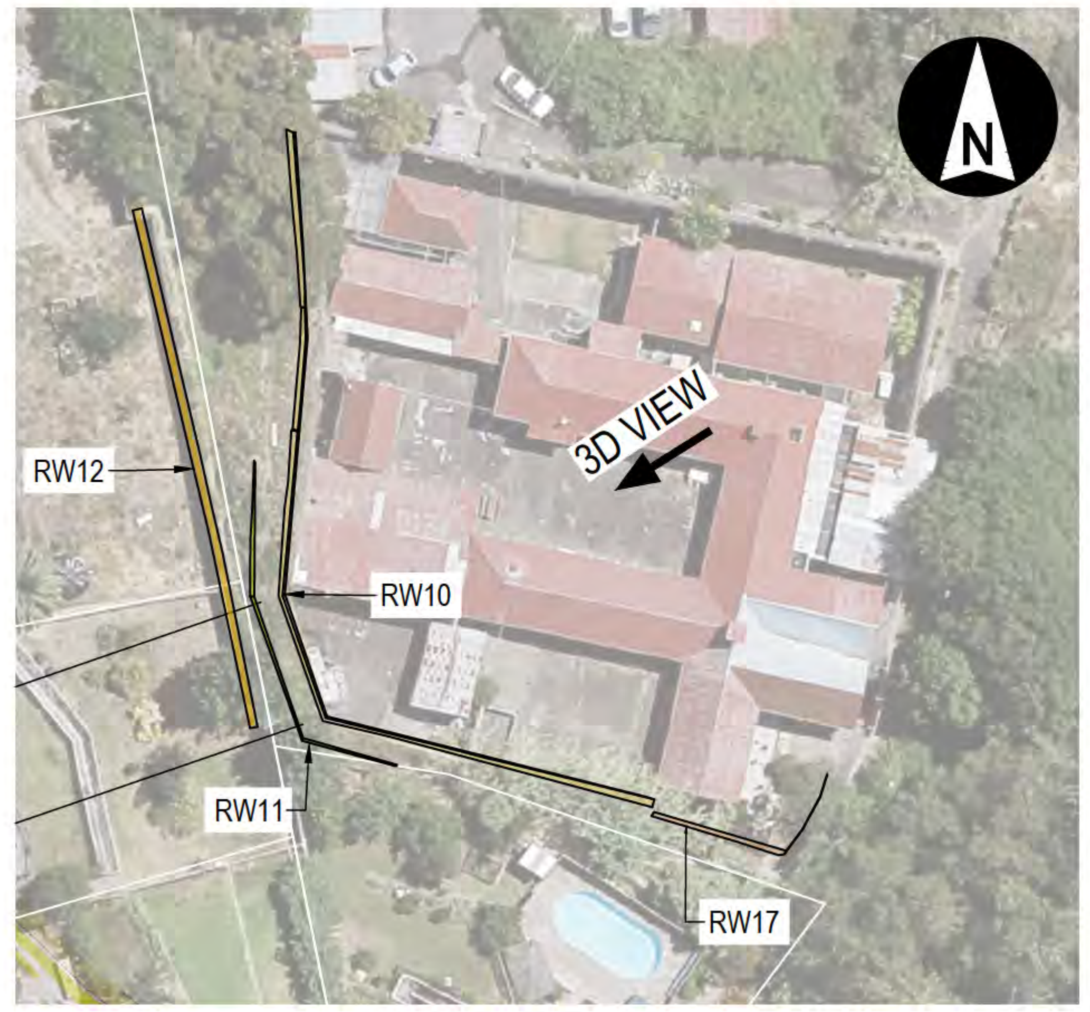
SURVEYED BY: AURECON NZ LTD
JOB REFERENCE: P520969 EX NAPIER PRISON
DATE OF SURVEY: 15/08/2022-18/08/2022
PRIMARY SURVEY EQUIPMENT: LEICA RTC 360 SCANNER
SECONDARY SURVEY EQUIPMENT: LEICA GPS

DATUM: HORIZONTAL: HAWKES BAY 2000
VERTICAL: NEW ZEALAND VERTICAL DATUM 2016
ORIGIN POINT: DJMA, 3RD ORDER, SOURCE LINZ GEODETIC DATABASE.

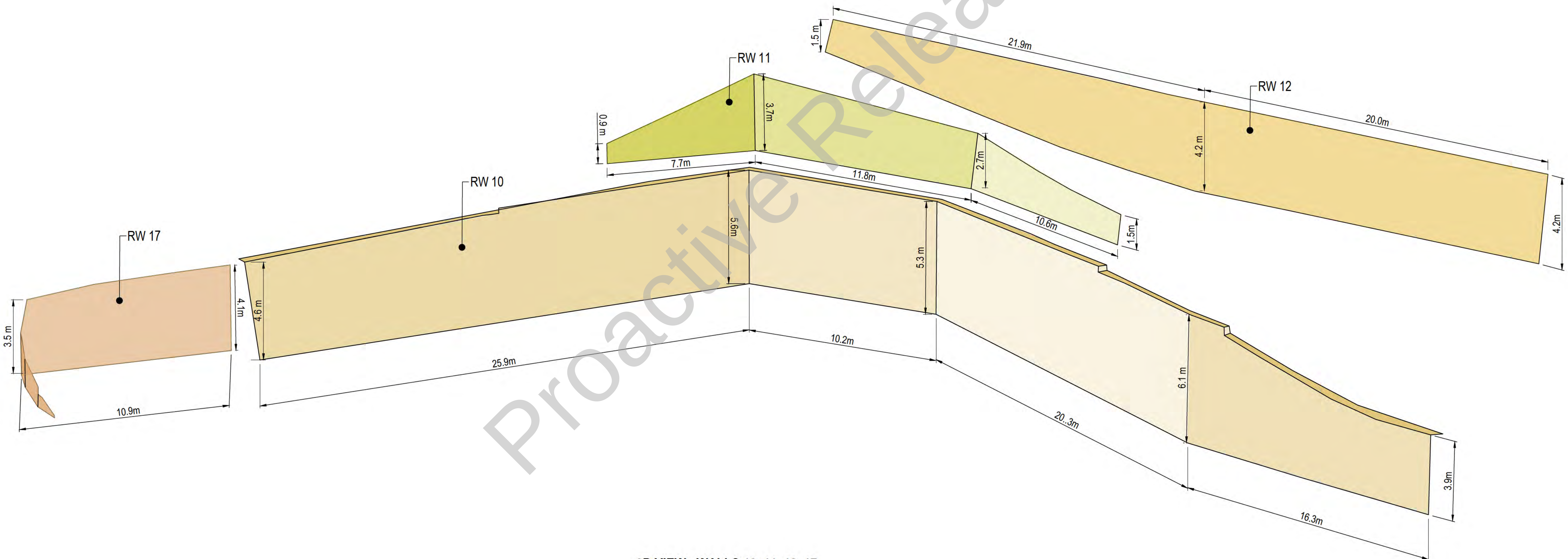
RETAINING WALLS: RW10, RW11, RW12 AND RW17 POSITIONS AND DIMENSIONS SHOWN HAVE BEEN CREATED FROM POINTS TAKEN FROM THE LASER SCAN COMPLETED ON SITE. SECTIONS OF THE WALL COVERED IN VEGETATION HAVE BEEN EXTRAPOLATED TO INFERRED POSITIONS BASED OFF REPORTS/PHOTOS. THEREFORE THE LATERAL EXTENTS OF THE RETAINING WALLS SHOWN THAT ARE COVERED IN VEGETATION SHOULD ONLY BE USED FOR MODELLING APPLICATIONS FIT FOR THAT DATA'S PURPOSE.

RETAINING WALLS

WALL	MAX. HEIGHT (m)	APPROX. FACE AREA (m²)
RW 10	6.1	360
RW 11	3.7	79
RW 12	4.2	150
RW 17	4.1	41



LOCATION PLAN
1:500



3D VIEW - WALLS 10, 11, 12, 17
1:100

SCALE 1:400 (4 0 8 16m)

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www.aurecongroup.com

CLIENT	REV	DATE	REVISION DETAILS	APPROVED
	A	2023-01-23	ISSUE FOR INFORMATION	

SCALE	SIZE
AS SHOWN	A1

DRAWN: R DAWSON
DESIGNED: C SCOTT
REVIEWED: T REVELL

INFORMATION
NOT FOR CONSTRUCTION

APPROVED
DATE

PROJECT: NAPIER PRISON RETAINING WALL ASSESSMENT
TITLE: 3D WALL SKETCH

DRAWING No.	PROJECT No.	AREA	TYPE	DISC	NUMBER	REV
	520969	0000	SKT	GG	0002	A

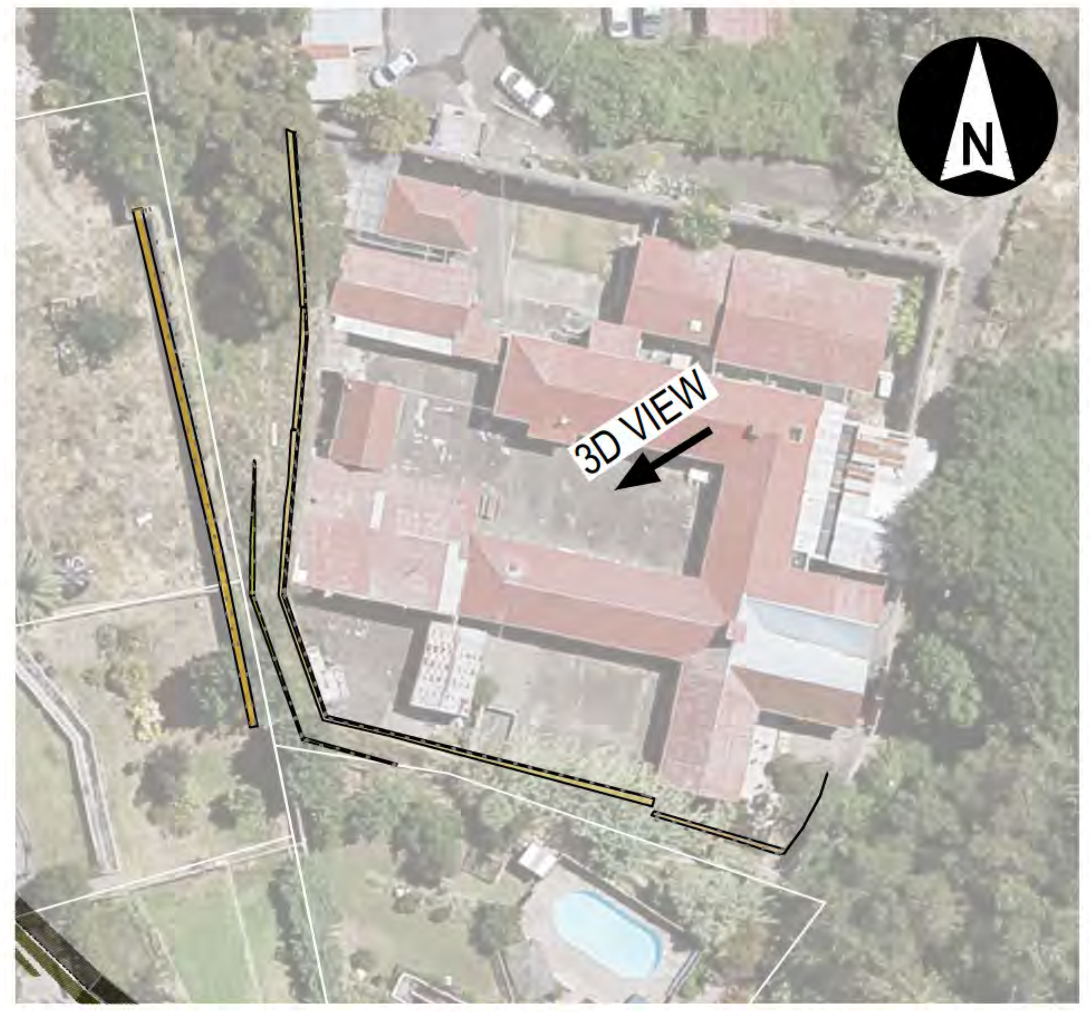
SURVEYED BY: AURECON NZ LTD
JOB REFERENCE: P520969 EX NAPIER PRISON
DATE OF SURVEY: 15/08/2022-18/08/2022
PRIMARY SURVEY EQUIPMENT: LEICA RTC 360 SCANNER
SECONDARY SURVEY EQUIPMENT: LEICA GPS

DATUM: HORIZONTAL: HAWKES BAY 2000
VERTICAL: NEW ZEALAND VERTICAL DATUM 2016
ORIGIN POINT: DJMA, 3RD ORDER, SOURCE LINZ GEODETIC DATABASE.

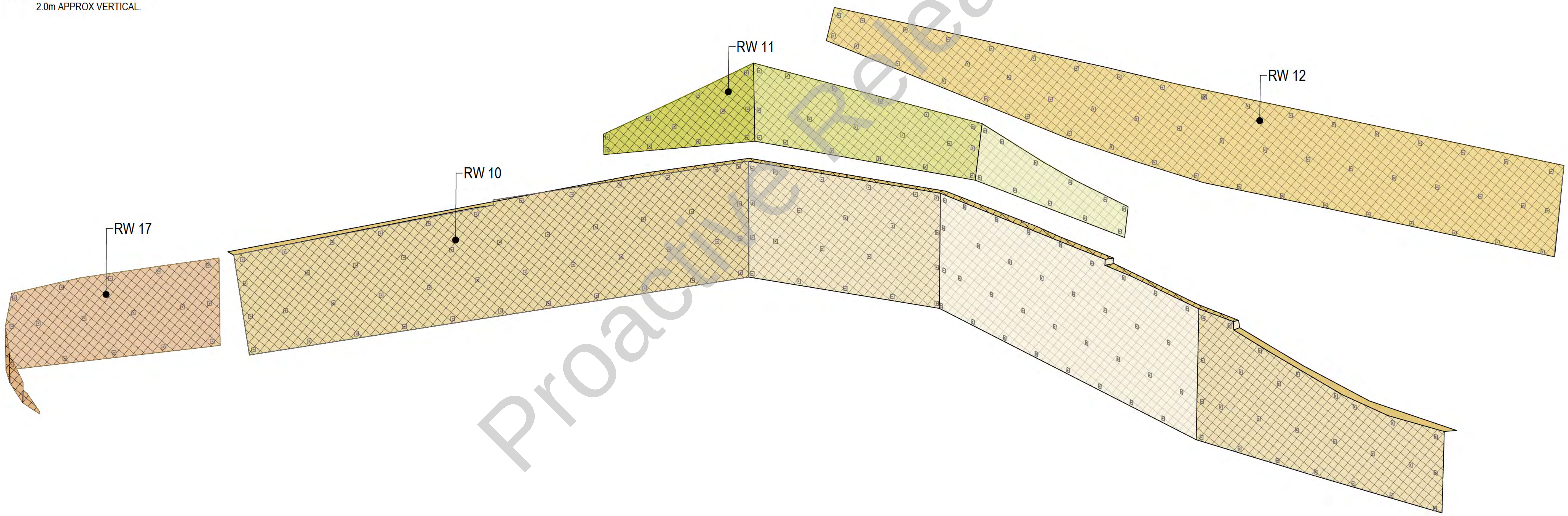
RETAINING WALLS: RW10, RW11, RW12 AND RW17 POSITIONS AND DIMENSIONS SHOWN HAVE BEEN CREATED FROM POINTS TAKEN FROM THE LASER SCAN COMPLETED ON SITE. SECTIONS OF THE WALL COVERED IN VEGETATION HAVE BEEN EXTRAPOLATED TO INFERRED POSITIONS BASED OFF REPORTS/PHOTOS. THEREFORE THE LATERAL EXTENTS OF THE RETAINING WALLS SHOWN THAT ARE COVERED IN VEGETATION SHOULD ONLY BE USED FOR MODELLING APPLICATIONS FIT FOR THAT DATA'S PURPOSE.

RETAINING WALL ANCHORS	
WALL #	ANCHORS REQUIRED
RW 10	127
RW 11	40
RW 12	52
RW 17	16
TOTAL	235

NOTE:
ANCHOR SPACINGS: 2.5m APPROX. HORIZONTAL
2.0m APPROX VERTICAL.



LOCATION PLAN
1:500



3D VIEW - WALLS 10, 11, 12, 17
1:100

4 0 8 16m
SCALE 1:400

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CLIENT	REV	DATE	REVISION DETAILS	APPROVED
	A	2023-01-23	ISSUE FOR INFORMATION	

SCALE	SIZE
AS SHOWN	A1

DRAWN: R DAWSON
DESIGNED: C SCOTT
REVIEWED: T REVELL

INFORMATION
NOT FOR CONSTRUCTION

APPROVED
DATE

PROJECT: NAPIER PRISON RETAINING WALL ASSESSMENT

TITLE: 3D WALL ANCHOR REQUIREMENTS WITH MESH

DRAWING No.: PROJECT No. 520969 – AREA 0000 – TYPE SKT – DISC GG – NUMBER 0003 – REV A

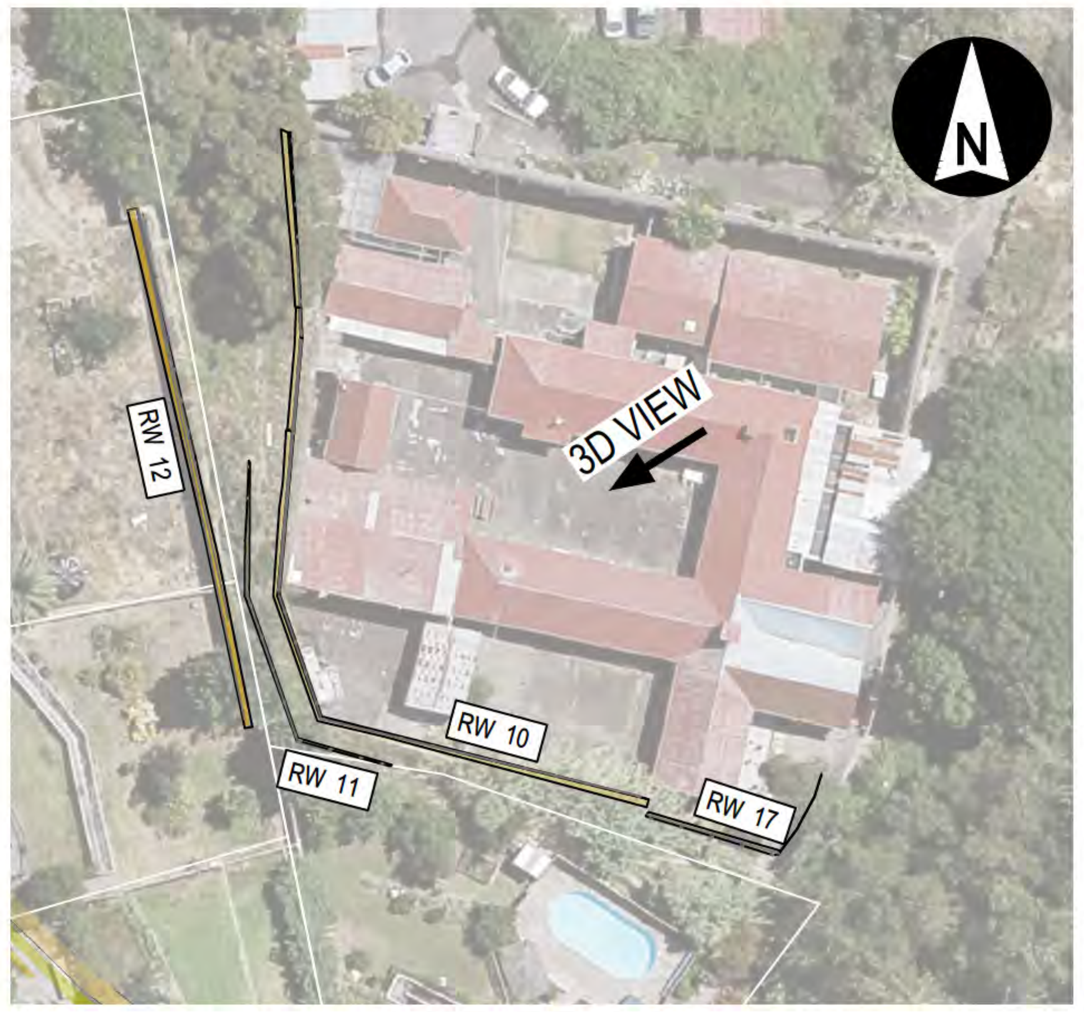
SURVEYED BY: AURECON NZ LTD
JOB REFERENCE: P520969 EX NAPIER PRISON
DATE OF SURVEY: 15/08/2022-18/08/2022
PRIMARY SURVEY EQUIPMENT: LEICA RTC 360 SCANNER
SECONDARY SURVEY EQUIPMENT: LEICA GPS

DATUM: HORIZONTAL: HAWKES BAY 2000
VERTICAL: NEW ZEALAND VERTICAL DATUM 2016
ORIGIN POINT: DJMA, 3RD ORDER, SOURCE LINZ GEODETIC DATABASE.

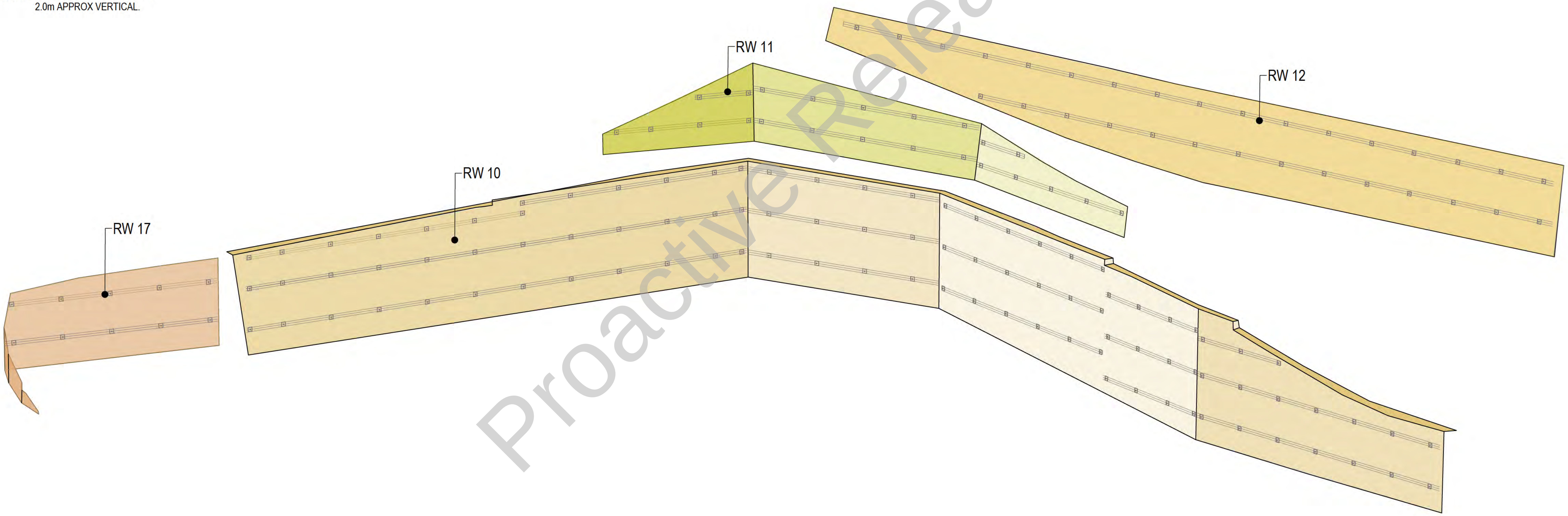
RETAINING WALLS: RW10, RW11, RW12 AND RW17 POSITIONS AND DIMENSIONS SHOWN HAVE BEEN CREATED FROM POINTS TAKEN FROM THE LASER SCAN COMPLETED ON SITE. SECTIONS OF THE WALL COVERED IN VEGETATION HAVE BEEN EXTRAPOLATED TO INFERRED POSITIONS BASED OFF REPORTS/PHOTOS. THEREFORE THE LATERAL EXTENTS OF THE RETAINING WALLS SHOWN THAT ARE COVERED IN VEGETATION SHOULD ONLY BE USED FOR MODELLING APPLICATIONS FIT FOR THAT DATA'S PURPOSE.

RETAINING WALL ANCHORS	
WALL #	ANCHORS REQUIRED
RW 10	93
RW 11	23
RW 12	31
RW 17	10
TOTAL	157

NOTE:
ANCHOR SPACINGS: 2.5m APPROX. HORIZONTAL
2.0m APPROX VERTICAL.



LOCATION PLAN
1:500



3D VIEW - WALLS 10, 11, 12, 17
1:100

4 0 8 16m
SCALE 1:400

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CLIENT	REV	DATE	REVISION DETAILS	APPROVED
	A	2023-01-23	ISSUE FOR INFORMATION	

SCALE	SIZE
AS SHOWN	A1

DRAWN: R DAWSON
DESIGNED: C SCOTT
REVIEWED: T REVELL

INFORMATION
NOT FOR CONSTRUCTION

APPROVED
DATE

PROJECT: NAPIER PRISON RETAINING WALL ASSESSMENT

TITLE: 3D WALL
ANCHOR REQUIREMENTS
WALER BEAM OPTION

DRAWING No.	PROJECT No.	AREA	TYPE	DISC	NUMBER	REV
	520969	0000	SKT	GG	0004	A

Appendix E
Mesh and Plate Specs

CE European Technical Approval ETA-17/0117

GEOBRUGG BRUGG
Safety is our nature

TECHNICAL DATA SHEET

High-tensile steel wire mesh TECCO® G65/4

TECCO® high-performance steel wire mesh	
Mesh shape:	rhomboid
Diagonal:	x · y = 83 · 138 mm (+/-3%)
Mesh width:	D_i = 63 mm (+/-3%)
Angle of mesh:	ε = 49°
Total height of mesh:	h_{tot} = 15 mm (+/-1 mm)
Clearance of mesh:	h_i = 7 mm (+/-1 mm)
No. of meshes longitudinal:	n_l = 7.2 pcs/m
No. of meshes transversal:	n_q = 12.0 pcs/m

TECCO® steel wire	
Wire diameter:	d = 4.0 mm
Tensile strength:	$f_t \geq$ 1'770 N/mm²
Material:	high-tensile steel wire
Tensile resistance of a wire:	Z_w = 22 kN

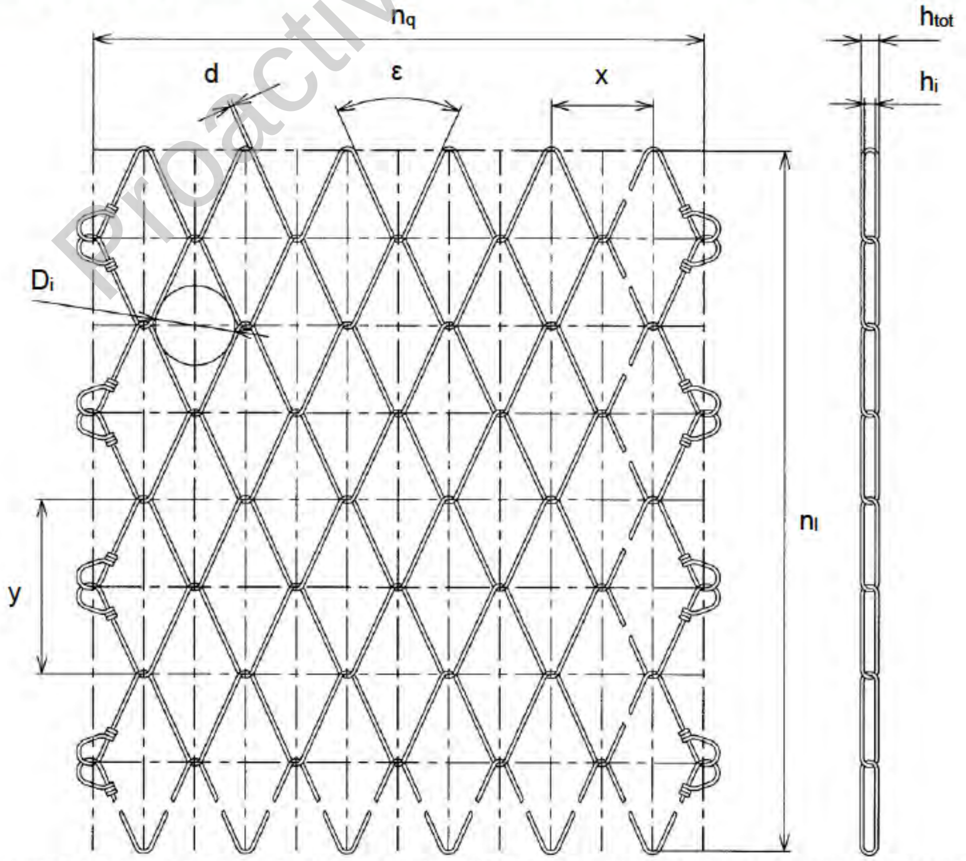
TECCO® corrosion protection	
Corrosion protection:	GEOBRUGG SUPERCOATING®
Compound:	95% Zn / 5% Al
Coating:	min. 150 g/m²
≤ 5% dark brown rust in salt spray test according to EN ISO 9227:	2'500 hours (ETA-17/0117)

Load capacity	
Tensile strength of mesh:	$Z_k \geq$ 250 kN/m' *)
Bearing resistance against puncturing:	$D_R \geq$ 280 kN / 370 kN *)
Bearing resistance against shearing-off:	$P_R \geq$ 140 kN / 185 kN *)
Bearing resistance against slope-parallel tensile stress:	$Z_R \geq$ 50 kN / 75 kN *)
Elongation in longitudinal tensile strength test:	δ < 6.0 % *)
Classification according to EAD 230025-00-0106	group 1, class A (P33 and P66)

TECCO® mesh standard roll	
Roll width:	b_{Roll} = 3.5 m
Roll length:	l_{Roll} = 20 m
Total surface per roll:	A_{Roll} = 70 m²
Weight per m²:	g = 3.3 kg/m²
Weight per mesh roll:	G_{Roll} = 231 kg
Mesh edges:	mesh ends knotted

*) As in EAD 230025-00-0106 and referring to TÜV Rheinland LGA test report 01/2014 using spike plate P33 / P66

TECCO® G65/4



Rockfall, slides, mudflows and avalanches are natural events and therefore cannot be calculated. This is why it is impossible to determine or guarantee absolute safety for persons and property with scientific methods. This means that to provide the protection we strive for, it is imperative to maintain and service protective systems regularly and appropriately. Moreover, the degree of protection can be diminished by events that exceed the absorption capacity of the system as calculated to good engineering practice, failure to use original parts or corrosion (i.e., from environmental pollution or other outside influences).

DECLARATION OF PERFORMANCE FOR THE PRODUCT TECCO® G65/4 1301 - CPR - 1273

Unique identification code of the product type:

High-Tensile Steel Wire Mesh System TECCO® G65/4, System Drawing GE-1006

Intended use:

High tensile steel mesh system for retaining of unstable slopes.

Manufacturer:

Geobrugg AG
Aachstrasse 11
8590 Romanshorn
SWITZERLAND

System of assessment and verification of consistency of performance (AVCP):

System 1

European Assessment:

European Organisation for Technical Approvals: EAD 230025-00-0106

European Technical Assessment: ETA 17/0117

CE Certificate of Conformity: 1301 - CPR - 1273

Notified body: TSÚS, Building Testing and Research Institute, Bratislava, Slovak Republic (No 1301)

Declared performance:

Tensile strength: 250 kN/m
Bearing Resistance against Puncturing: 280 kN (P33) / 370 kN (P66)
Bearing resistance against shearing-off: 140 kN (P33) / 185 kN (P66)
Bearing Resistance against Slope-Parallel Tensile Stress: 50 kN (P33) / 75 kN (P66)
Elongation in longitudinal tensile strength test: δ < 6.0 %
Classification according to EAD 230025-00-0106 Class / Group: A / 1

Swiss Guideline / Federal Office of the Environment:

Specific Technical Documentation:

Manual incl. System drawing, technical data sheet

The performance of the product identified above is in conformity with the set of declared performances. This declaration of performance is issued, in accordance with regulation (EU) No 305/2011, under the sole responsibility of the manufacturer identified above.

Signed for and on behalf of the manufacturer by
Armin Roduner, Technical Department
17.04.2020
Signature:

GEOBRUGG
BRUGG
Safety is our nature

CE

19

Geobrugg AG
Aachstrasse 11, 8590 Romanshorn, SWITZERLAND

High-Tensile Steel Wire Mesh System
TECCO® G65/4

Tensile strength: 250 kN/m

Bearing Resistance against Puncturing: 280 kN (P33) / 370 kN (P66)

Bearing resistance against shearing-off: 140 kN (P33) / 185 kN (P66)

Bearing Resistance against Slope-Parallel Tensile Stress: 50 kN (P33) / 75 kN (P66)

Elongation in longitudinal tensile strength test: δ < 6.0 %

Classification according to EAD 230025-00-0106 Class / Group: A / 1

High tensile steel mesh system for retaining of unstable slopes.

ETA 17/0117
1301 - CPR - 1273

EAD 230025-00-0106
Notified body: TSÚS (No. 1301)

www.geobrugg.com

TECHNICAL DATA SHEET

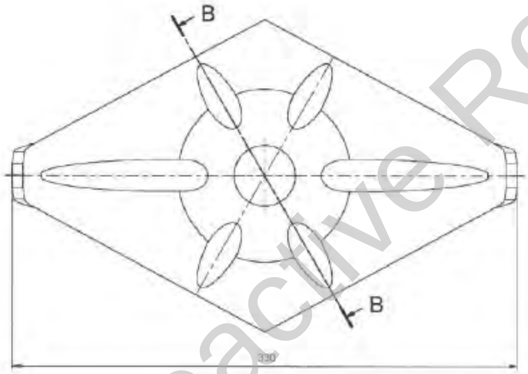
Spike plate P33/40 N and P33/50 N for high-tensile steel wire mesh TECCO® / SPIDER®

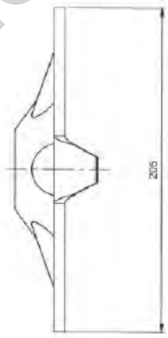
Spike plate P33	
Length:	330 mm
Width:	205 mm
Thickness:	7 mm
Hole diameter:	40 mm / 50 mm
Length of the spikes:	min. 20 mm
Weight:	2.2 kg
Geometry:	diamond
Longitudinal bending resistance:	≥ 2.5 kNm

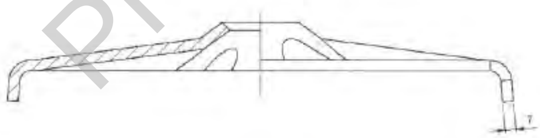
Spike plate P33 Steel	
Steel quality:	S355J according to EN 10025-2

Spike plate P33 corrosion protection	
Corrosion protection:	hot-dip galvanized based on EN ISO 1461
Layer thickness in average:	55 µm

Spike plate P33/40N, P33/50N







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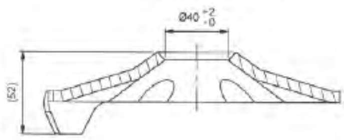

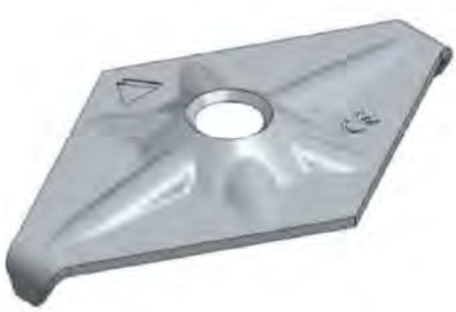

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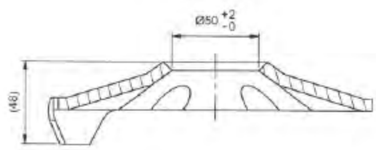

Appendix F
Concept Design Package

Ex Napier Prison – Concept Design Development

Concept Design Package

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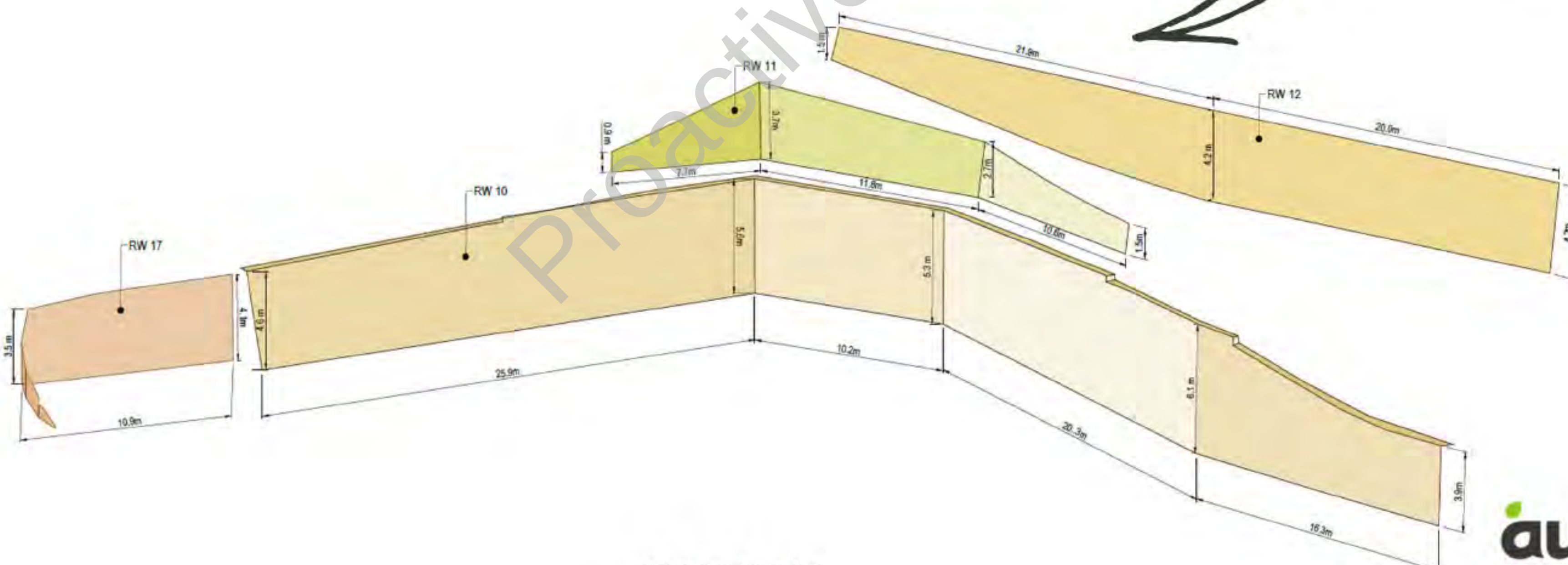
HERITAGE NEW ZEALAND
POUHERE TAONGA

Toitū Te Whenua
Land Information
New Zealand

LOCATION PLAN



3D VIEW - WALLS 10, 11, 12, 17

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Soil Nail Waler Beam Wall

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Soil Nail Waler Beam Wall

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Sumner, Christchurch

Titirangi, New Zealand

Source: Earth Stability. Retrieved 14 March 2023 from
Earth Stability - for underpinning, drilling rock and retaining walls with rope access to EQC standards, Case Studies

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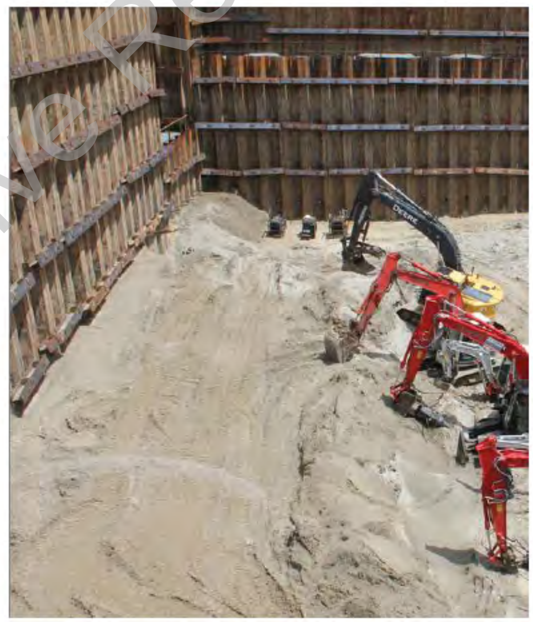
Dartmouth, USA



Source: Earth Anchoring Suppliers, LLC. Retrieved 14 March 2023 from
EAS Case History: Tieback Wall - Commercial Building - The Northeast's CHANCE Helical Pile Distributor (earthanchoring.com)

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TECCO G65/4 mesh wall with P33/50 N spike plates

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TECCO G65/4 mesh wall with P33/50 N spike plates

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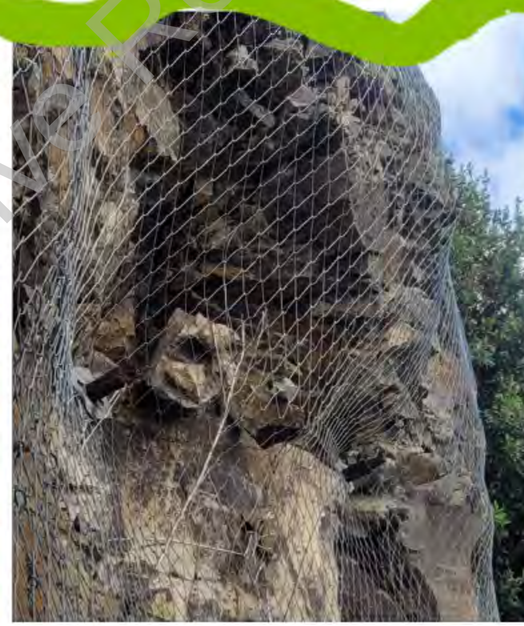
Sumner, Christchurch



Sumner, Christchurch

Sumner, Christchurch

Source: Geobrugg. Retrieved 14 March 2023 from [Sumner Stainless 2019 - Geobrugg]

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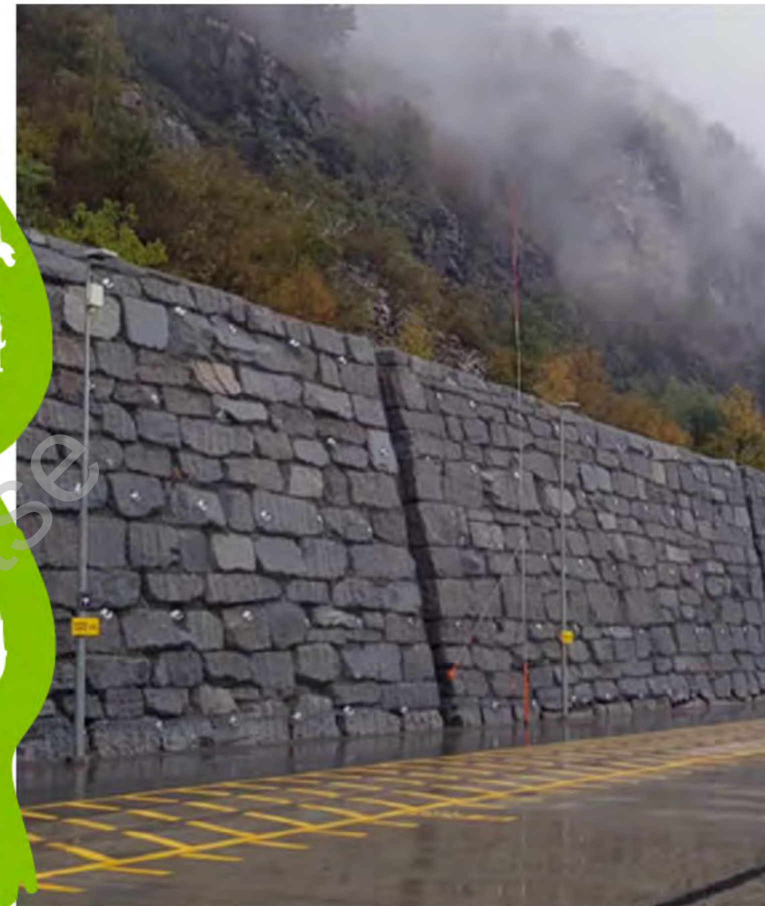

Biasca, Switzerland

Source: Geobrugg. Retrieved 14 March 2023 from

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Althengstett, Germany

Source: Geobrugg. Retrieved 14 March 2023 from Hermann-Hesse-Bahn Althengstett Tunnel Forst 2019 - Geobrugg

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Optioneering Assessment – Soil Nails with Active Mesh

Advantages	Disadvantages
Performance and Safety • Mesh covers the entity of the walls • High redundancy system • Reduced risk to contractors and the public from falling debris	Construction Cost and Time • Increased construction cost and time due to more anchors being required.
Design Flexibility • Anchors can be easily be placed around buildings and other features on the site.	

Optioneering Assessment – Soil Nails with Waler Beams

Advantages	Disadvantages
Construction Cost and Time • Reduced construction cost and time due to less anchors being required.	**Performance and Safety** • Does not address falling debris. • Lower redundancy. • Not widely used to remediate retaining walls.
Maintenance • Waler beams can be painted to improve corrosion resistance.	**Design Flexibility** • Anchor placement is limited by waler beam arrangement. **Appearance** • Waler beams may collect vegetation • Waler beams protrude from the walls

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Appendix G
MacMat R Brochure

MACCAFERRI

MacMat® R

Reinforced geomats for soil stabilization

MacMat®R is a three-dimensional geomat that can be applied as an erosion control mat for sloped embankments, channel linings and soil-veneer applications.
It was developed to meet the need for an erosion control material which was both strong and environmentally acceptable. **MacMat®R** is provided in various styles and thicknesses to meet the needs for several different applications and situations.

MacMat®R is a geocomposite manufactured with a reinforcement (generally a double twist steel wire mesh but also polymeric geogrids reinforcement) inside the geomat, to provide tensile mechanical strength and a stronger form of erosion protection, better ensuring the stability of the top-soil on both sliding surfaces (polymeric geomembranes), roadway embankments, drainage ditches, channels and other areas susceptible to erosion damages.

MacMat®R has several advantages:

- *The continuity of the lining is easily achieved by lacing the edges together with binding wire or metal rings without overlapping and minimising wastage.*
- *In many standard situations a simple fold into the top of the slope of an anchor trench could be used, being wooden stakes or other anchors sufficient to anchor the wire mesh to the ground.*
- *The double twist wire mesh protects the geomat from any potential damage limiting those to a single mesh opening.*
- *The steel reinforcement provides high stiffness to the geocomposite and an uniform adherence to the subsoil providing better protection of the covered surface.*
- *It may be easily fixed to any thicker lining or bottom protection (gabions, mattresses, etc.) providing a better and continuous protection and anchorage where the erosion is usually more critical or the stresses are concentrated.*
- *The combined use of a geocomposite reduces by 50% the installation costs.*
- *The steel wire mesh provides the lining with a high punch resistance (20-25 kN) and offer a very strong barrier to any wild animal (like coypu) that will burrow through the composite causing damage along river banks.*

The MacMat®R behaviour and performances

MacMat®R increase the soil's resistance to erosion by providing an environment that enhances the growth of vegetation through the mat. Initially the geomat blanket works to shield the soil slope from the effects of wind and rainfall, preventing the soil from washing out before the vegetation has a chance to become established. Then, as the vegetation matures, the roots anchor the mat to the soil to provide a superior soil reinforcement strength, capable of handling steeper embankment slopes and higher run-off flow velocities. In soil-veneer application on smooth sliding surfaces the reinforcement of the geocomposite provides the additional structural function to guarantee the required strength to achieve the equilibrium in long term service conditions. Due to the high roughness and permeability of the geocomposite **MacMat®R**, the pretreated surface allows for a more natural deposition of sediment discharged by the flow and offers a good retention to hydroseeding, without altering the natural existing conditions.

MACCAFERRI

MacMat® R

Slopes & Rockfall protection

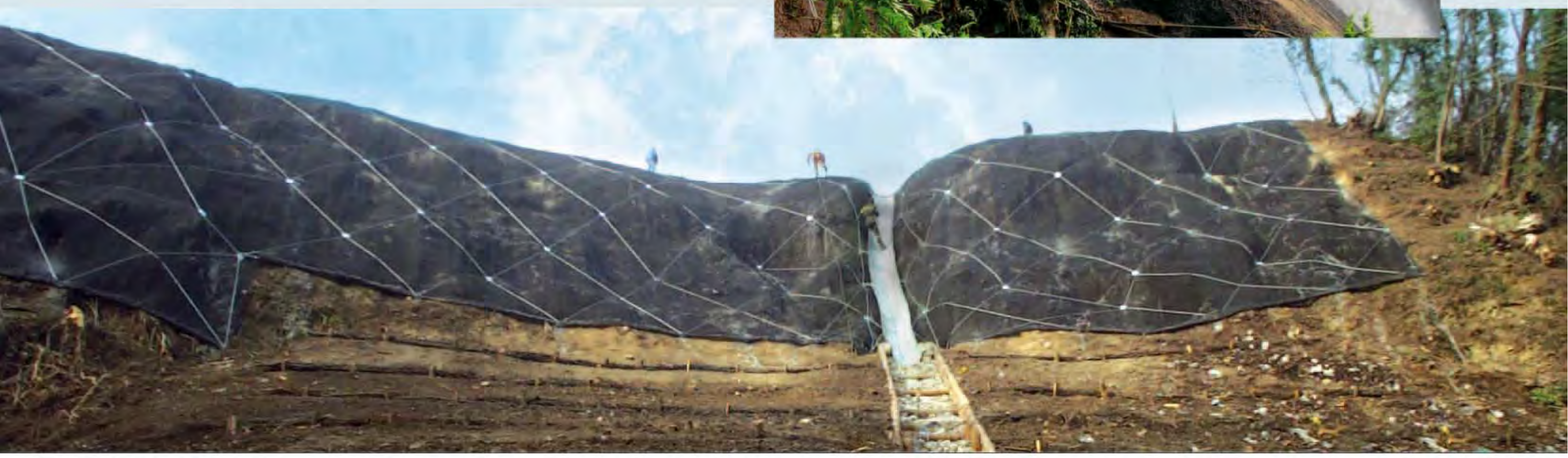
The soil erosion on embankments is a serious problem, especially when failure can cause a structural damage. Relying on the vegetation growth alone is very unpredictable, as it is extremely difficult to achieve a full vegetation coverage, leaving exposed areas vulnerable to erosion.

MacMat®R protects the soil surface by:

- *protecting exposed areas from direct impact of raindrops;*
- *protecting seeded topsoil from washing out before vegetation Is established;*
- *reinforcing the root system and binding the soil surface;*
- *Reducing the velocity and volume of runoff by increasing the water seepage into the soil.*
- *Increase the cohesion of the soil layer where it's placed.*

MacMat®R is used to promote vegetation growth and reinforce the topsoil usually in combination with rockfall protection dedicated system to provide a full impact solution. Typical applications include the lining of highway and railway embankments, and in general any slope subject to erosion. Even though the slope may he preseeded before the installation of the geomat, it can also be seeded after the installation (hydroseeding), obtaining the same excellent vegetation growth.

MacMat®R facilitates the installation on steep slopes using soil nails or anchors.
The strength of the mesh allows the intermediate anchor points to be widely spaced over the surface of the revetment and can provide reinforcement efficency to the slope when laid in combination with nails and other soil reinforcement technologies.



Landfill applications

The stabilitation of soil on smooth inclined surfaces is a very typical problem to be faced during the design of a cover of a landfill site. In such a situation the contribution of the friction between the soil and the membrane is very low (up to limit values of 8-10°) and tensile strength and retention capacity is required for the composite to be placed on top of the geomembrane. In addition to this primary structural function the geocomposite provides an efficient protection of the geomembrane itself against puncture damage occuring during the soil placement.

MacMat®R improves the efficency of the lining system by:

- *Increasing the shear resistance along the soil 's surface;*
- *providing the strength required to guarantee the equilibrium conditions;*
- *minimising the stress applied directly to the geomembrane from external loadings;*
- *protecting the geomembrane from puncturing damage during the soil placement;*
- *allowing the growth of vegetation in order to provide an environmentally friendly aspect and an efficient UV protection to the sealing membrane.*

Hydraulic works & Waterproofing applications

Channel erosion is the result of a slow deterioration of the soil bank as a direct result of the hydraulic shear stresses acting on the soil's surface.

MacMat®R protects the channel from erosion by:

- *increasing the shear resistance along the soil 's surface;*
- *reducing the velocity of flow along the channel section;*
- *limiting the loss a fine soil particles;*
- *protecting the bank integrity from wild animal intrusion.*

MacMat®R provides also a good support for vegetative soil on smooth surface working as stabilization layer on Geomembrane and Geocomposite barriers used currently in waterproofing applications.

MACCAFERRI

MacMat®R

Installation notes

MacMat®R is manufactured with a surface having both a rough and a smooth side. The material shall be unrolled along the slope having the smooth side in contact with the soil. Before the placement of the mat the sub-soil will be well graded and finished to achieve a smooth even surface leaving the last 4/5 cm of sub-base soil loose (eventually a seeding will be done in this phase). The mat will be anchored to the soil with metallic or timber pins according to the application.
The mat can be fixed by simply anchoring the metallic mesh to the ground; as an alternative, embedding the mat in a trench excavated at the top of the slope (check the dimension of the trench in case of structural use of the reinforced mat).
In the case of channel linings please ensure that:

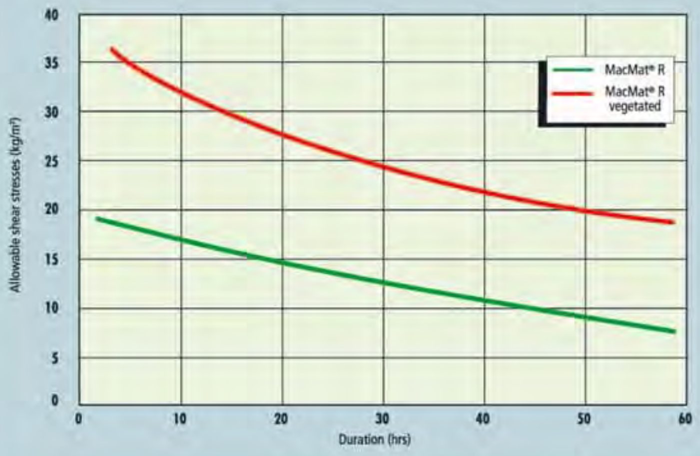
- *The mat is layed parallel to the direction of the flow for smaller channels and perpendicular to the direction of flow for larger channels with steeper slopes;*
- *the joints between two following rolls must be made in the same direction of the flow, overlapping the end of each roll on the top of the beginning of the second one.*

More detailed information about any detail and sketches or typical drawings are available by contacting our technical teams.

Research & development

To determine **MacMat®R** performance under various hydraulic conditions, a series of tests have been carried at Utah State University (USA) to evaluate the anti-erosion capability of the geocomposite during a flow; the allowable shear stresses on the geoomposite have been evaluated according to different durations of the flood event. The diagram on the right side reports the results of this research about vegetated and unvegetated mats.

More detailed information about these tests are available on request contacting our technical teams.



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