# Isthmus Group Limited

# Geotechnical Assessment Report for Stage 2 Resource Consent Application

# Titirangi Summit Project, Gisborne

**Project Reference: 13364**
**24.08.2021**
**Revision: 1**

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## DOCUMENT CONTROL

| Version | Issued For: | Date | Prepared By | Reviewed By |
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| 0 | Resource Consent | 24/08/2021 |  <br>Joel Pollock<br>Senior Engineering Geologist<br>*BSc Earth Science and Geography* |  <br>Rob Haskell<br>Geotechnical Group Manager<br>*BEng, MEngNZ* |

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# 1 INTRODUCTION

LDE Ltd has been engaged by Isthmus Group Limited on behalf of Gisborne District Council to provide geotechnical documentation to support a resource consent application for Stage 2 of a development at Titirangi Summit, Gisborne, comprising of a new 772m$^2$ building that incorporates the existing gun emplacement and includes a kiosk/café, toilets, a community space, and an observatory on Tītīrangi Reserve.

Resource Consents (LU-2019-108839-00, LL-2019-109004-00 and NC-2019-109005-00) were granted for Stage 1 of the project which is now complete. The initial works were demolition and removal of an observatory and cutting down of the summit. The ground was battered up to the gun emplacement that has been retained.

Earthworks associated with the Stage 2 works, as shown by consent plans (Isthmus, 16 August 2021) and relevant to geotechnical consideration, are primarily cut to remove the soil around the north and east sides of the gun emplacement, excavate the platform to finished ground level, and excavate for foundations or retaining structures, as required. After construction, landscape filling is proposed around the sides and periphery of the building. Assuming cut materials can be reused as site-won fill, a budget of -1094m$^3$ is indicated (Figure 1).


Figure 1: Snip of Earthworks Plan. Source: Isthmus Architects

# 2 EXISTING GEOTECHNICAL REPORT

One existing geotechnical report was completed for the Stage 1 earthworks and the building area prior to detailed design of the building and site layout:

- Titirangi Summit Development, Part Lots 2 & 3 DP 5159 – Geotechnical Investigation Report; LDE, 2018 (LDE Ltd, 2018).

The investigation work consisted of a desktop study, a site walkover geomorphological appraisal, and geotechnical testing including boreholes, cone penetration tests (CPTu), test pits and logging of exposures. Limit equilibrium slope stability analyses were completed modelling the site after completion of the proposed Stage 1 earthworks.

The report concluded that a suitable building platform exists in the cut down area with provisions for:

- Isolation of buildings from the edges of the cut platform by a distance five times the slope's height, with grading of the intervening ground.
- A generic setback of 10m (assuming the highest envisioned cut slope following earthworks) from the edges of the cut platform.
- Construction of engineered retaining structures to support the cut slopes.
- Deepening of foundations near slope edges.
- Further cutting down of the ground to marry the cut surface to the adjacent ground.

# 3 GEOTECHNICAL DISCUSSION OF STAGE 2 PROPOSAL

The geotechnical report's (LDE Ltd, 2018) description of the Stage 1 development aligns with the completed work as summarised in 2020 survey documentation (Civil Project Solutions (CPS), 11 May 2020), although batter slopes up the gun emplacement remain that were not described. The Stage 2 works as proposed will essentially complete the full scope of cut earthworks described in the 2018 report. No further work is required for the cut earthworks proposed for Stage 2.

The building proposed extends beyond the generic 10m building cut platform setback that was recommended. However, the survey data shows that in most areas the slopes between the cut platform and adjacent ground are less than 1.0m in height. Following the recommendation to isolate structures by a distance five times the slope's height, the setback can be regarded as being no more than 5m. Elsewhere, retaining walls are proposed on the southeast side and around the north through southwest sides of the building to support slopes and fill (Figure 2). The siting of the building with the proposed engineered retaining walls, appears to comply with the recommendations of the geotechnical report (LDE Ltd, 2018).

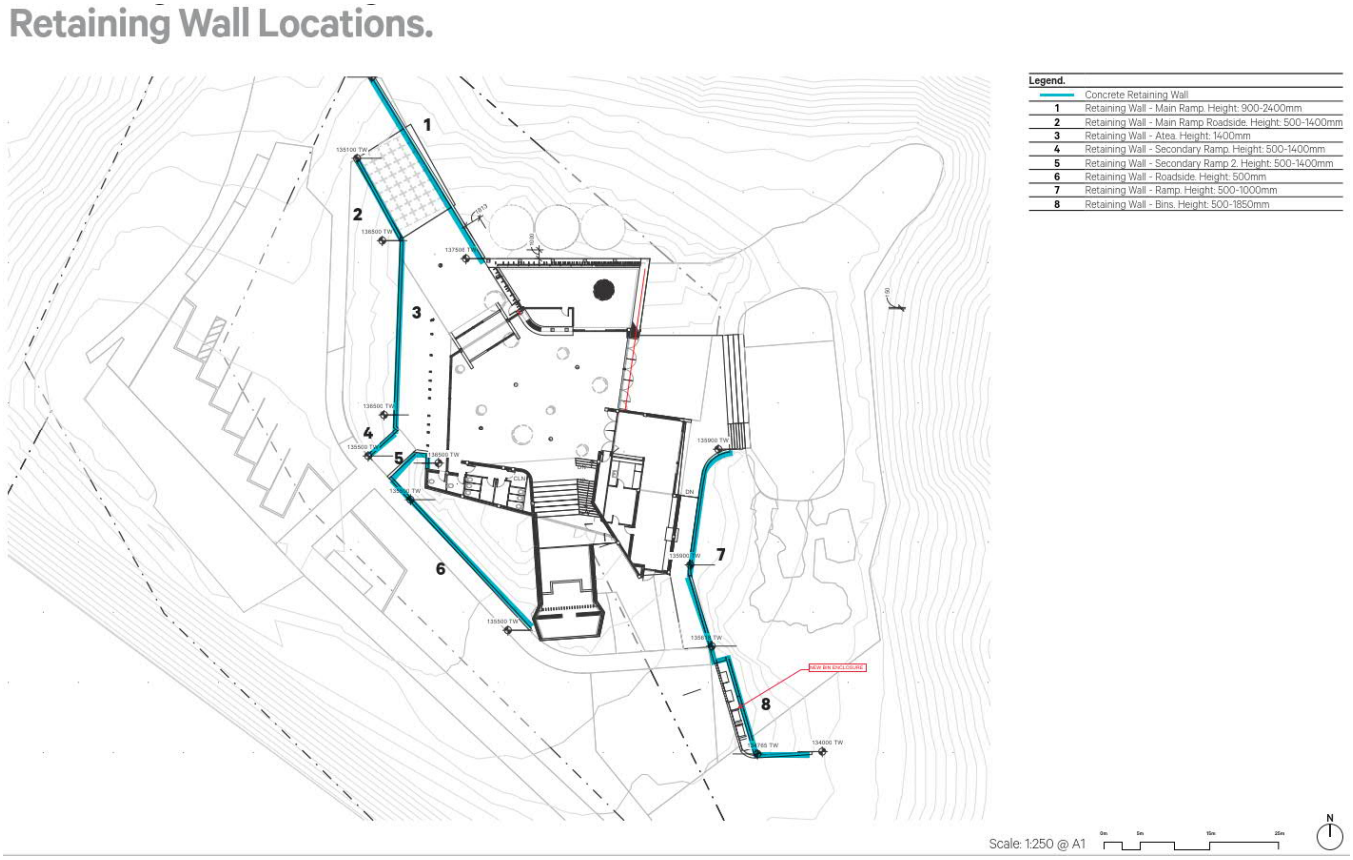



Figure 2: Snip of Retaining Wall plan. Source: Isthmus Architects.

Placement of fill onsite was not recommended. Despite this, the landscape filling proposed in Stage 2 around the periphery of the building is generally considered minor and not likely to have ill effect on stability. In two areas the effects of the filling on the stability of the adjacent slopes must be considered by numerical modelling. These are on the north side of the building where the fill exceeds 2m and on the east side of the development adjacent to the night viewing platform (Figure 3).

**Appendix 2.**
**Earthworks Plan.**

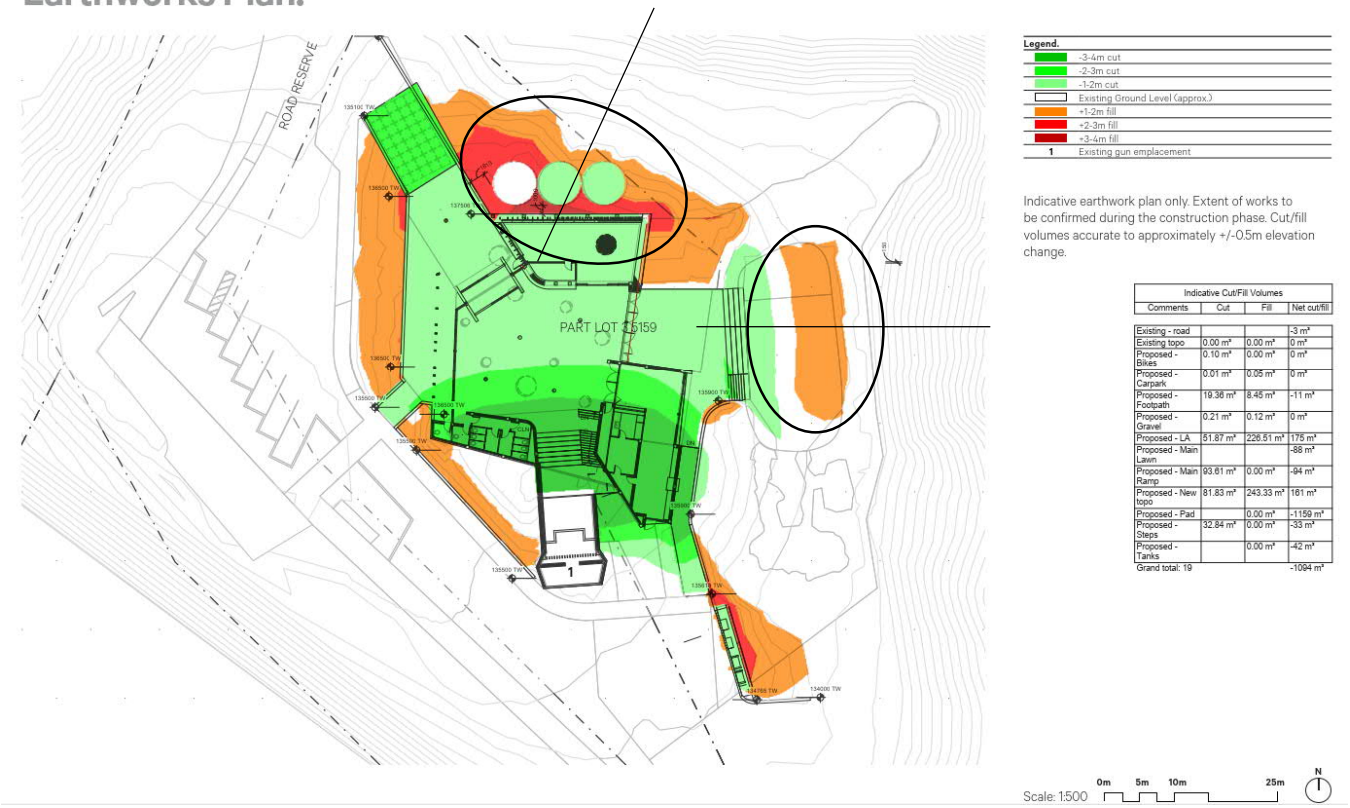



Figure 3: Annotated snip of Cut/Fill earthworks Plan showing areas of filling (ovals) requiring geotechnical stability consideration and indicative cross sections (lines). Source: Isthmus Architects.

# 4 CONCLUSIONS

The recommended geotechnical assessment of the stability of the slopes with proposed filling is considered unlikely to change the scope or outcome of the Stage 2 resource consent application. If the works are found to pose an instability risk, the filling will be either omitted and the fill cut-to-waste, or additional mitigation measures recommended.

No further geotechnical investigation is considered necessary. A new geotechnical cross section to the north-northeast can be devised using test data already collected. The existing cross section to the east can be utilised to consider the filling near the east slope (refer above to Figure 3.

We consider the additional geotechnical assessment can be summarised in a new report specific to the developed design of the building and submitted with the Building Consent application.

In summary, the existing geotechnical report and the conclusions within are considered sufficient to accompany the application for Resource Consent for the Stage 2 application.

# 5 LIMITATIONS

The ground conditions described in this are professional opinion based on existing geotechnical data and a review of supplied development plans. Additional information that may affect the recommendations made in this report should be forwarded to LDE Ltd.

This report was prepared in general accordance with current standards, codes and practice at the time of this report. These may be subject to change.

This report has been prepared for Isthmus, on behalf of Gisborne District Council, for the purpose of supporting an application for Resource Consent for Stage 2 of the development. It is not to be relied upon or used out of context by any other person without further reference to the Gisborne Geotechnical Section of Land Development and Engineering Ltd.

# 6 REFERENCES

Civil Project Solutions (CPS). (11 May 2020). *Kaiti Hill- GIsborne Te Panuku Tu Titirangi Summit Topographic Survey (Set).* Gisborne: LDE.

Isthmus. (16 August 2021). *Te Panuku Tu. Resource Consent. Design Package.* Isthmus.

LDE Ltd. (2018). *Titirangi Summit Development, Part Lots 2 & 3 DP 5159 – Geotechnical Investigation Report.* Gisborne: LDE.

# Appendix A

## 2018 LDE GEOTECHNICAL REPORT

# TITIRANGI SUMMIT DEVELOPMENT

# PART LOTS 2 & 3 DP 5159, TITIRANGI DRIVE, GISBORNE

## GEOTECHNICAL INVESTIGATION REPORT

Project Reference: 13364
14 June 2018

# EXECUTIVE SUMMARY

Based on the investigation and appraisal of the site reported herein, the following key conclusions and recommendations have been drawn with respect to the stability of the Titirangi Summit with a proposed cutting down of the landform to the level of the Summit carpark:

1. The Titirangi summit is occupied by the James Cook Observatory, associated infrastructure, and a World War 2 gun emplacement. A carpark has been formed on its western side and benches exist on its southern and eastern sides. Moderately steep to steep slopes exist beyond these features.
2. The subsurface investigation work confirms that parts of the observatory and its associated infrastructure (paths/retaining walls) have been built over various thicknesses of non-engineered fill, in turn overlying Mangatuna Formation geology, some of which is prone to creep instability and landslippage. Parts of the observatory and its associated paths/retaining walls have been damaged by movement in these soils.
3. With the proposed cutting down of the site to the approximate level of the summit carpark (highest point), the instability issues and geology responsible for the damage to the existing observatory and associated infrastructure will be essentially removed, with only minor amounts of problematic soil expected to remain which can be remediated.
4. Based on survey data, a large flat platform measuring approximately 2280m$^2$ in area will be created. This area excludes the existing summit carpark, area occupied by the gun emplacement and the bench (forestry skid site) areas located on the southeast, east and northeast sides of the landform.
5. Relict cut slopes up to some 2m in height may remain below the new platforms edge (i.e. it won't daylight at the same level of the benches and platforms surrounding the site). The cut will however daylight out of the natural slope at its north/northwest end and onto the highpoint of the summit carpark.
6. A low risk of fault rupture or liquefaction was identified at the site.
7. Instability has historically and recently affected the steep natural and man-made slopes surrounding the site. The majority of this limited to shallow-seated landslippage and erosion. Deeper-seated instability (isolated from site) exists further to the west and northwest of the site, although evidence shows this primarily occurred in historic fill materials.
8. Stability analyses indicate that the proposed platform is fundamentally stable, with only minor risk of instability occurring in the outside edges of the new platform.
9. Assuming a conservative building set-back distance of 10m in from the perimeter of the new platform, an area of at least 700m$^2$ is still expected to be available for building purposes without any slope stabilisation requirements.

10. The remaining steep sections of slope between the proposed platform and surrounding carpark/skid site benches (up to some 2m in height) are expected to be able to be battered to a low gradient, retained or engineered to a suitable standard.
11. Some soil remediation may be required to link any future building proposal to the existing gun emplacement, given the likelihood of fill materials existing around the sides and rear of the feature.
12. Reticulation is recommended for wastewater and stormwater disposal.
13. A building specific ground investigation is will be required to be undertaken as part of any building consent application once the particular building proposal is known. Recommendations made in this report may be able to be made as part of that work.

This executive summary must not be taken out of context with the balance of this report. Additional recommendations and considerations are made in the body of the report, which provide the context for the above key findings relating to the site under consideration.

# CONTENTS

# 1 INTRODUCTION

Land Development & Exploration Ltd (LDE) was engaged to undertake a geotechnical investigation on the summit of Titirangi, Titirangi Drive, Gisborne. The site is currently occupied by the James Cook Observatory and historic World War II defence installations.

The main purpose of the investigation was to characterise the engineering geology of the site, determine the sites stability with a proposed lowering of the summit, and to provide geotechnical recommendations for its development.

In accordance with the GDC minimum requirements, consideration of the potential for settlement associated with earthquake-induced liquefaction was also an objective.

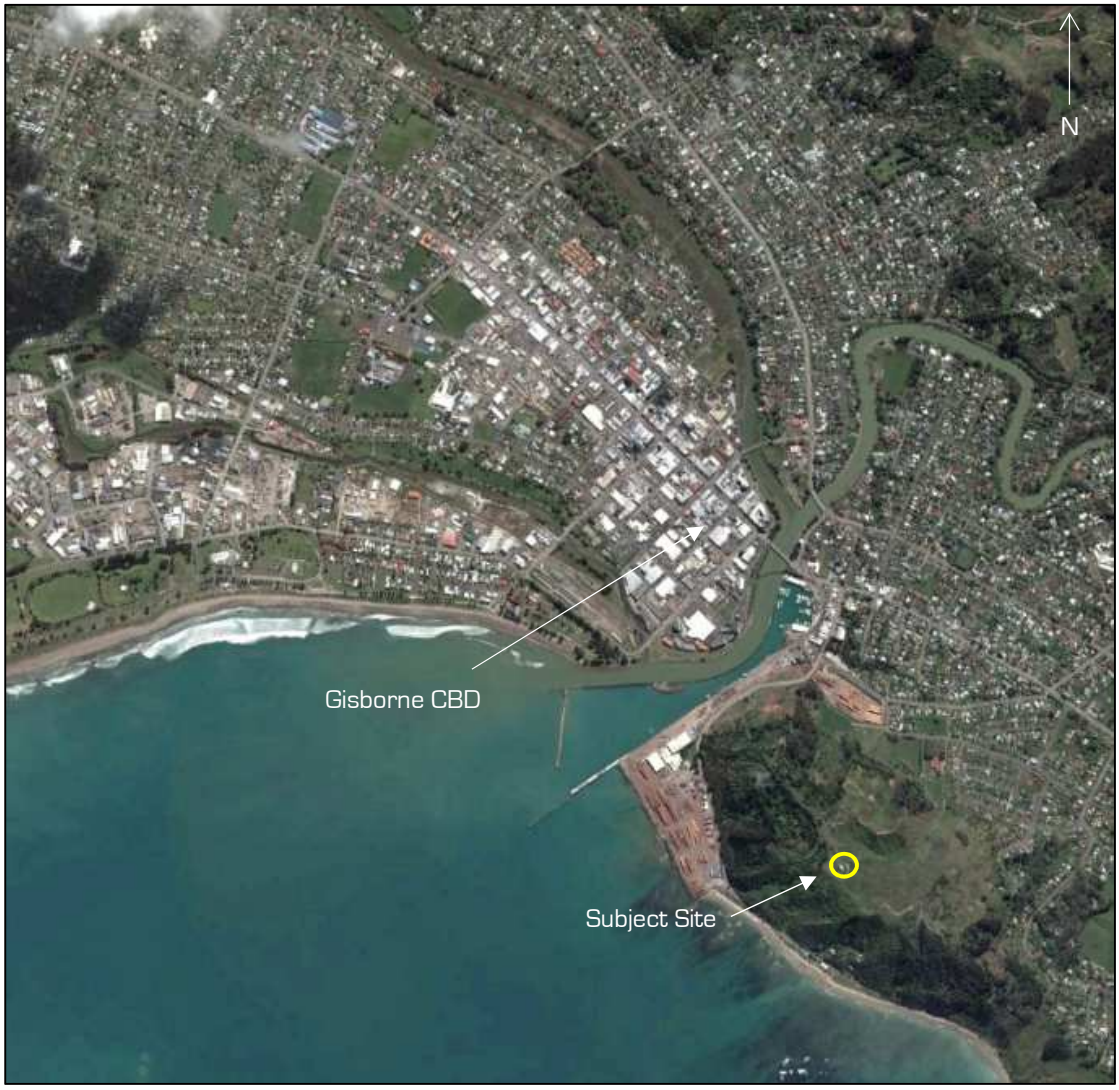



Figure 1: Location of site (Source: Google Earth).

# 2 SITE CHARACTERISTICS

The subject site is located on the summit of Titirangi, which is approximately 1.5km south-southeast of the Gisborne City Central Business District, and up to some 140m above sea level (Figure 1). The hilltop forms a high point on the backbone of a prominent northwest-southeast trending ridgeline. A spur leads off the side of the ridgeline down to the west towards the Eastland Port log yard and another down to the east towards the suburb of Kaiti. The upper reaches of gullies generally occupy the land between these features although man-made benches associated with a formation of the Titirangi summit carpark and Titirangi Drive occupy the western (seaward side) side of the summit. A bench formed in 1942 and increased in size again in 2015, extends around the northeastern, eastern and southern sides of the site (Figure 2, 3 & Figure 5). Steep cut slopes exist at the back of these benches.


Figure 2: Subject site (circled in yellow) and surrounding land (source: Tairawhiti Maps).

The James Cook Observatory is positioned at the peak of the summit, surrounded by a World War II gun emplacement recessed into the slope below and to the south-southeast; telecommunication poles to the northwest and northeast; a water supply tank, septic tank and its disposal field to the northeast; and a low-height retaining wall and grassed car-parking area on the observatory's seaward (western) side above Titirangi Drive and the Titirangi public carpark. A set of concrete steps lead from the carpark up to the main observatory entrance.

The observatory is surrounded by a grassed 2m to 8m wide low gradient zone between 4˚ and 10˚. Beyond the gently sloping zone, the slopes have highly variable gradients ranging between 0˚ to in excess of 45˚. The steepest and lowest gradients are generally associated with modification through earthworks and installation of steps, retaining walls and carparks (Figure 3, Figure 4 & Figure 5). The steeper side slopes of Titirangi below the summit area to the northeast and southeast have been planted densely in native trees and shrubs.


Figure 3: View south at summit. Forestry cut below to left and Titirangi Drive /Summit carpark at extreme right. Accessway up to observatory at bottom right.

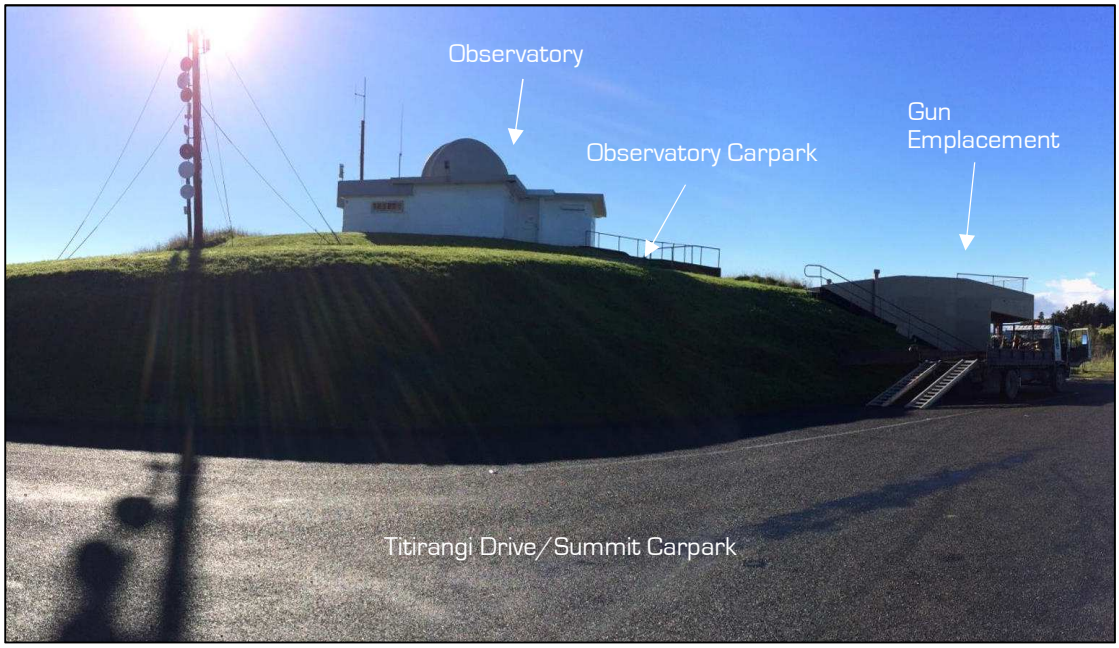



Figure 4: View of observatory towards the east (towards suburb of Kaiti) from Summit Carpark. Gun emplacement is visible at the right of the photograph.

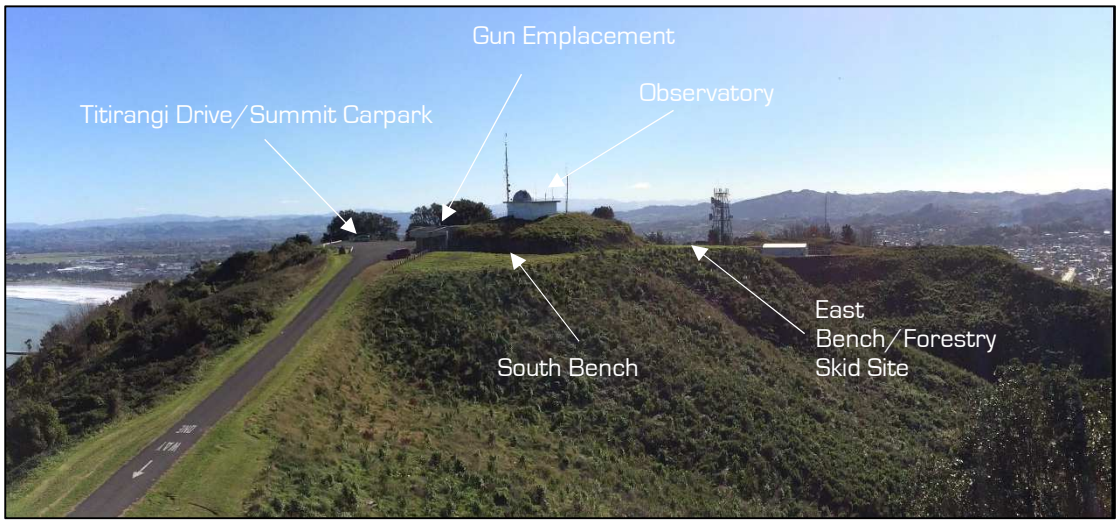



Figure 5: View north towards subject site. Forestry cut in front of and right of building. Gun emplacement and Titirangi Drive/Summit carpark below and left of observatory.

# 3 Development Proposal

We understand that the summit is proposed to be cut down to form a broad platform at a level equivalent to the highest point of the summit carpark (approximate elevation of 135m above sea level). Based on survey data, this would create approximately 2280m$^2$ of new flat area that excludes the existing summit carpark, all flat land associated with the formation of the forestry skid site to the southeast, east, and northeast of the observatory and the area occupied by the gun emplacement. The approximate extent of the new platform is illustrated in Figure 6.

With the cutting down of the site, the existing observatory, telecommunications towers, associated retaining walls and any in-ground installations (power supply, existing septic tank and disposal field, in-ground installations) will be removed. The gun emplacement is, however, scoped to remain. Whilst any future building proposal is yet to be confirmed, we understand that a one or two storey building will be located centrally within the newly created platform and possibly incorporate the historic gun emplacement into its design.

Based on the survey information, the proposed cut level will be up to some 2.0m higher than the bench present on the northeastern, eastern and southeastern side of the observatory, and approximately 0.5m to 1.0m higher than the level of the floor of the gun emplacement and the sloping carpark at the Titirangi Drive (northwest extent).

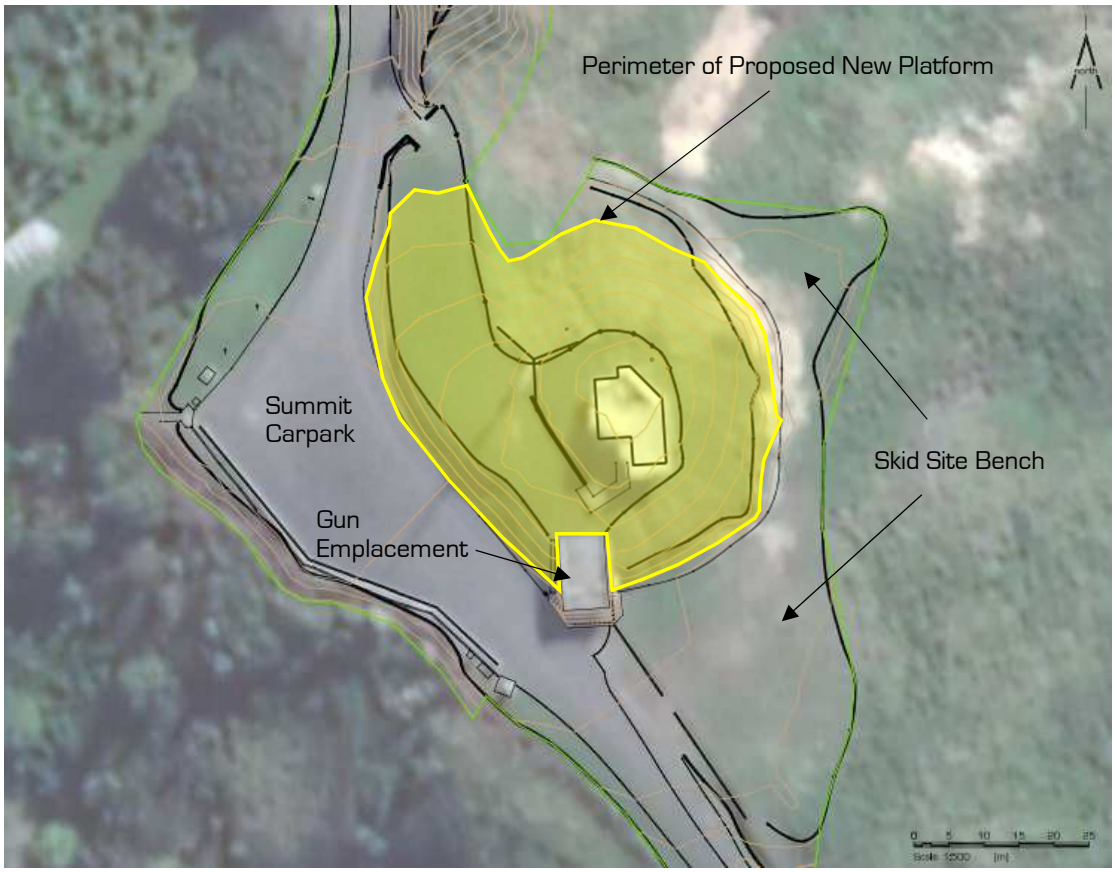



Figure 6: Survey plan of site showing approximate outline (yellow line) of flat area which will be created by cutting site down to level of summit carpark.

# 4 INVESTIGATION

A substantial amount of geotechnical investigation work was carried out in 2017 for the Gisborne District Council on this site. That work has been utilised as part of this assessment. Complimentary testing has also been carried out to target areas specific to the current proposal.

Our investigation of the site included the following work:

1. A desktop study of projects in the LDE database within the vicinity.
2. A review of historical aerial and oblique photographs dating back to 1942.
3. A review of pertinent geological maps and published and unpublished geological papers.
4. A walkover geomorphological appraisal.
5. One direct push machine borehole put down to 7m depth.
6. Four electronic cone penetrometer tests (CPT's) put down to refusal (5m to 13m depth).
7. Three machine excavated test pits (TP's) put down to depths between 0.5m and 1.4m next to the observatory. Measurements of the undrained shear strength were

taken at regular intervals within cohesive soils exposed within the test pits using a calibrated shear vane.

8. Seventeen 50mm hand augered boreholes put down to target depths of up to 5m. Measurements of the undrained shear strength were taken at 200mm intervals within cohesive soils encountered down through the boreholes using a calibrated shear vane.
9. Two dynamic penetrometer tests put down to up to 5m depth or refusal with measurements taken in 50mm increments.
10. The mapping of three geological exposures.
11. Slope profiling.
12. The development of geological cross sections through the site.
13. Numeric stability analyses under elevated water levels and seismic loads.

The locations of the subsurface investigations are shown on the attached Geotechnical Investigation Plan. Logs of the CPT's, test pits, boreholes and penetrometer tests are attached as appendices.

The field work was completed in the autumns of 2017 and 2018.

# 5 Ground Conditions

## 5.1 General

The nature of the ground beneath the site is summarised below and in the appended cross sections. It is based on an integration of published and unpublished data, the geomorphology of the site, surface exposures of the underlying geology, and subsurface investigations carried out at discrete locations. The nature of the ground between the investigation points is inferred and may vary from that described. For details of the materials encountered and measurements of their respective strengths, please review to the appended investigation logs.

## 5.2 Geology

The 1:250,000 geological map of the region[1] shows the site as being underlain by the Pleistocene Age Mangatuna Formation overlying Miocene bedrock. The Mangatuna Formation unit has been categorised through more detailed study[2] as the Calhome Member,

[1] Mazengarb C. and Speden I. (compilers) 2000: "Geology of the Raukumara area. Institute of Geological and Nuclear Sciences 1:250,000 geological map 6".
[2] G. Neef, W.A. Watters & A.R. Edwards (1996) The Mid-Castlecliffian Mangatuna Formation of the Gisborne district, North Island, New Zealand, New Zealand Journal of Geology and Geophysics, 39:4, 551-558.

essentially comprising mudstone with intercalated tephra's, ignimbrite, paleosols and minor gravel.

## 5.3 Subsurface Conditions

### 5.3.1 Summary

Our investigations identified materials that are generally consistent with the detailed description of the Calhome Member, although no mudstone or paleosols were encountered. Non-engineered fill was also found to exist on top of these soils in a number of locations.

### 5.3.2 Non-engineered Fill, Topsoil & Rhyolitic Tephra

In summary, our investigations encountered a unit of non-engineered fill and topsoil ranging in thicknesses of between 0.2m and 1.2m immediately adjacent to the observation building. In general, the thicker fill units were found on the southern side of the observatory. In addition to this, the testing found that the fill material extends under the southern side of the observatory.

Away from the observatory, fill materials up 2.7m in thickness were identified on the outside edge of the slope above Titirangi Drive and up to 2.0m thick on the outside edge of the skid site bench. Fill up to 4.0m thick is expected behind the back wall of the gun emplacement . Only minor thicknesses of fill were found below the site to the north (back towards Gisborne City). Aerial photography also indicates a large amount of fill was placed to the west of the site along the seaward side of the summit carpark. This area is isolated from the subject site.

The fill material generally comprises mixtures of light brown to greenish brown clay and silty clay, black sandy silt and fine gravel with some foreign material (glass/nails and gravel). Undrained shear strength testing returned values as low as 46kPa, indicating a firm (low to moderate) strength.

The topsoil (generally buried beneath fill) comprises of sandy silt with some pumiceous sand. The undrained shear strength of the topsoil unit predominantly ranges between 60kPa and 100kPa indicating a moderate strength regime.

A 0.2m thick horizon of brown, loose pumice sand containing some silt was identified between 0.5m and 0.7m depth in machine borehole MBH1, put down some 6.0m south of the observatory.

### 5.3.3 Pleistocene Mangatuna Formation

Beneath the layers of non-engineered fill, topsoil and rhyolitic tephra the testing encountered a thick unit of the complex Pleistocene Mangatuna Formation. Our investigation indicates that this geology in general dips at a low angle of some 5˚ to the west/northwest, although localised near-surface bedding is indicated to slope south/southwest.

More specifically, the testing indicates that the summit is underlain by clay and silty clay ranging between 4m and 6m in thickness. Undrained shear strength testing within the unit generally returned values ranging between 20kPa and 200kPa, indicating a variable firm to hard strength regime. The lowest values, identified in exposures 1 to 3 at the forestry skid site rear slope, show that the unit reduces drastically in response to moisture. Furthermore, a set of shear surfaces (slip planes) dipping at 30˚ were found within this material at 2.6m and 2.8m depth within machine borehole MBH1.Based on surficial evidence of movement of footpaths and buildings It is likely that these dip to the south (towards the rear of the gun emplacement).

Beneath the clay, light brown to orange brown sand and gravel layers were identified between 4.0m and 6.5m depth beneath the hilltop. The material was observed to daylight the rear batter slopes of the forestry skid site on the inland side of the observatory, indicating the unit dips to the southwest. Dynamic penetrometer values ranging between 2 and 6 blows/50mm, and estimated SPT $N_{60}$ values gained from the CPT's between 15 and 20, are indicative of a medium dense to dense regime.

Beneath the sand and gravel units the CPT's indicate that clay and silt-rich materials with relatively high undrained shear strength values ranging between 100kPa and 250kPa (very stiff to hard) prevail down to between 11m and 13m depth beneath the observatory site.

Beneath 11m to 13m depth, high density sandy silt and silty sand was encountered. Geological exposures showing cemented loess and/or rhyolitic tephra that correlate well with the depths of these units are located some 50m to the northeast and 120m to the northwest of the site. SPT equivalent N60 values generally ranging up from 20 (medium dense) to in excess of 50 (very dense) are indicative of a very weak rock.

### 5.3.4 Tertiary Bedrock

Tertiary bedrock was not encountered in the testing put down as part of this investigation. However, the LDE database and geomorphological evidence indicates that the Miocene rock exists at about 40m depth beneath the site and dips at between 28˚ and 35˚ degrees to the northwest.

### 5.3.5 Exposed Geology After Completion of Proposed Earthworks

With the cutting down of the site and remediation of soils around the gun emplacement, all non-engineered fill, topsoil, rhyolitic tephra and most of the upper clay rich Mangatuna Formation is expected to be removed from the footprint of the new cut platform. This includes the unit containing the slip surfaces behind the gun emplacement. A portion of the upper clay-rich unit, the sand and gravel unit and the top of a lower clay-rich unit (all part of the Mangatuna Formation) are expected to be exposed at cut level (Figure 11).

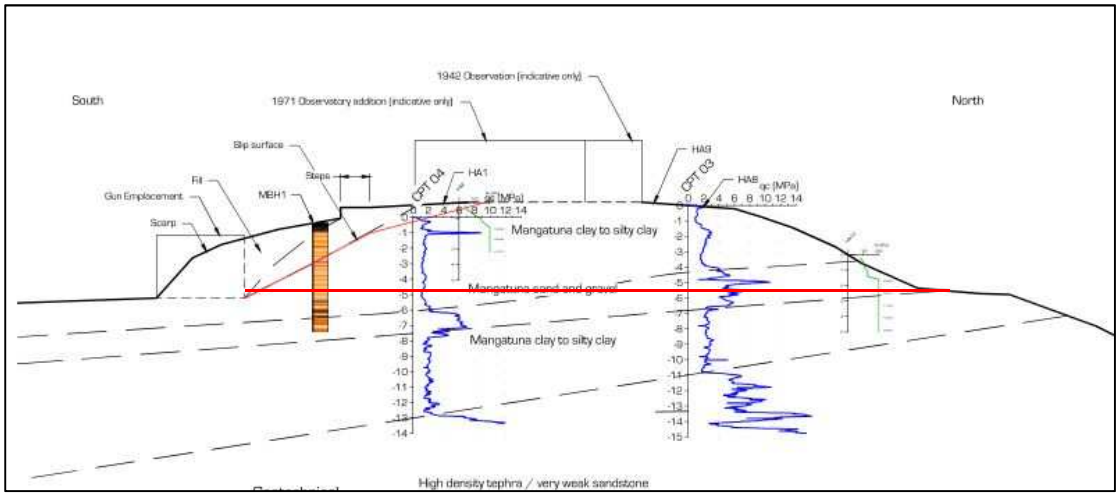



Figure 7: North-South cross section through site showing approximate proposed cut level (red line).

## 5.4 Soil Moisture Profile and Groundwater Conditions

The watertable was not encountered within 13m of the surface. No springs or any other evidence of the permanent watertable daylighting out of the hillside were identified. All drainage paths within the hillside about the site were dry and are only known to drain surface water. Therefore, for the purposes of the proposed development, the permanent water table is expected to exist at no less than 20m depth beneath the site and will not likely be encountered during the earthworks.

Following cutting down of the site, the moisture content of the near surface soils is expected to be higher during the winter months or extended periods of wet weather resulting in their saturation at times, especially where surficial ponding occurs above the clay-rich Mangatuna Formation soils. The extent of the wetting front will be dependent on the duration of the period of rainfall, but may extend down some 1m from the surface. The depth of surface wetting is expected to increase down-slope of the site to some 3m to 4m, especially within the fill materials. Complete saturation of the ridge is not expected given the low permeability of the clay-rich capping layers and the natural drainage path which the underlying sand and gravel layers are expected to provide.

## 5.5 Seismic Subsoil Category

We consider that the site is a Class C shallow soil site as defined by NZS 1170.5 (2004) "Structural Design Actions: Part 5: Earthquake actions – New Zealand". This based on the deep testing results, likely depth to bedrock and the determination of the site period in accordance with the methodology outlined in Section 3.1.3.7 of NZS1170.5

# 6 Natural Hazards and Ground Deformation Potential

## 6.1 General

This section summarises our assessment of the natural hazards within the property as generally defined in the Building Act (2004) and the potential risk that these present to the building in terms of vertical and lateral ground deformation. This section also includes our assessment of ground beneath the building site which is outside the definition of "Good Ground" as defined by the Compliance Document for the NZ Building Code, NZS3604 (2011) "Timber Framed Buildings" and NZS4229 (2013) "Concrete Masonry Buildings Not Requiring Specific Engineering Design". This is any ground which could foreseeably experience movement of 25mm or greater for any reason including one or a combination of compressible ground, land instability, ground creep, subsidence, seasonal swelling and shrinking, frost heave, changing groundwater level, erosion, dissolution of soil in water, and the effect of tree roots.

## 6.2 Earthquake Hazards

### 6.2.1 Earthquake Shaking

The Ministry of Business Innovation & Environment released draft guidelines for Earthquake Geotechnical Engineering Practice in March 2016 for adopting a revised methodology of determining peak ground accelerations. These guidelines are now in common use.

In accordance with the guidelines and assuming future building importance level 2 structure standard design life of 50 years, and a Seismic Subsoil Category C, Ultimate Limit State (ULS) and Serviceability Limit State (SLS) peak ground accelerations (PGA) of 0.37g and 0.13g respectively have been determined for the site. The design earthquake magnitude (Mw) for Gisborne is 6.4.

### 6.2.2 Fault Line Surface Rupture

The 1:250 00 geological map[1] and GNS NZ Geology Webmap and Active Faults Database[3] do not show any faults passing beneath or within the vicinity of the site.

A generally lineal feature extending northwest from the gun emplacement through the area now occupied by the summit carpark and down the side of a spur within the 1943 image (Figure 8) initially suggests the presence of a fault, however aerial imagery taken in 1942 and 1953 show the first 60m of the feature is man-made and the remainder to be the headscarp of moderately deep-seated landslip zone within a gully to the west (Figure 9). There were no other features indicative of a fault trace encountered in our assessment. We therefore consider that the surface fault line rupture risk to be low.

[3] http://data.gns.cri.nz/geology/

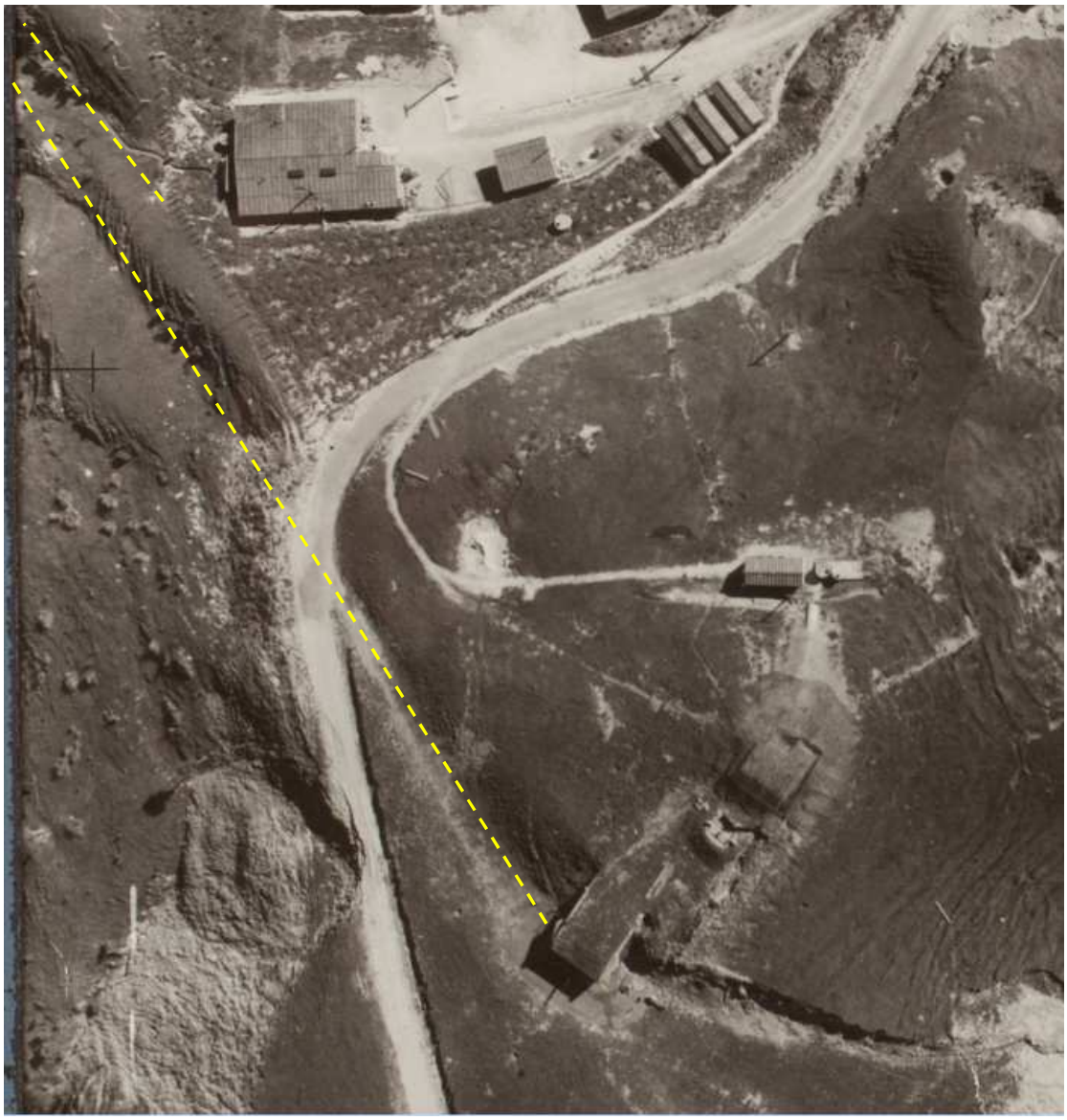


Figure 8: 1943 image showing lineal feature extending northwest of the gun emplacement (image supplied courtesy of Tairawhiti Museum).

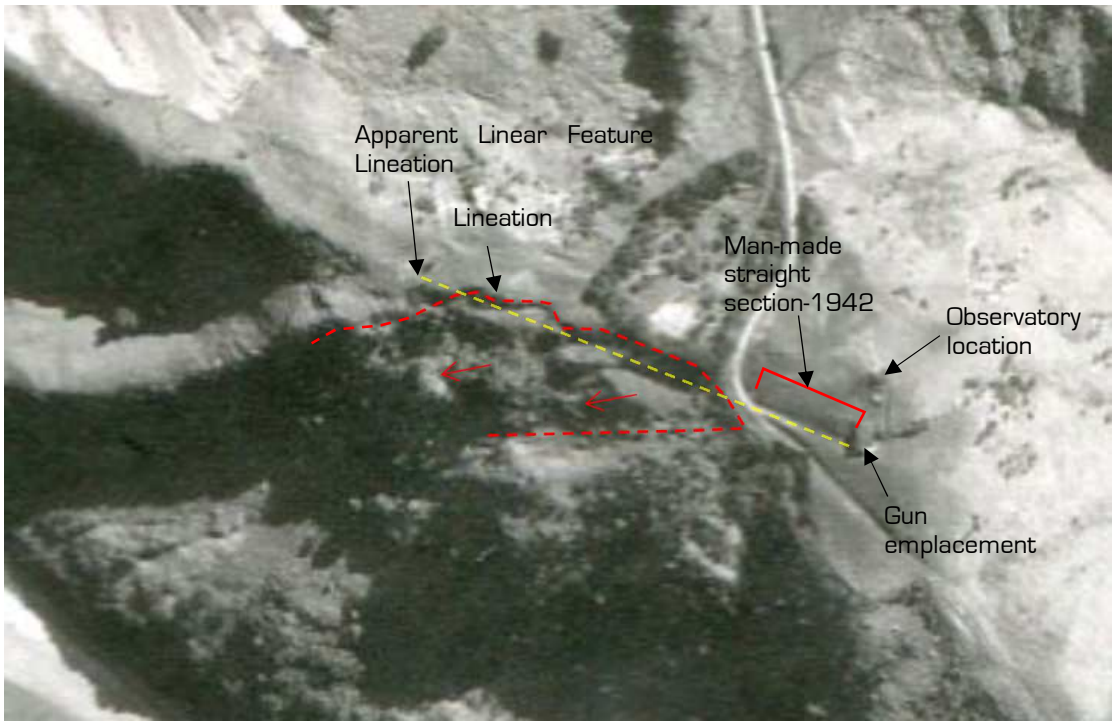



Figure 9: 1953 aerial image showing lineation to northwest of gun emplacement is combination of man-made earthworks and headscarp of isolated landslippage.

## 6.3 Liquefaction

Sandy or silty soils which are prone to liquefaction were not encountered beneath the site. Saturated conditions were also not encountered within 13m of the surface of the site (CPT holes were measured using a dip meter) and no evidence of saturated conditions (e.g. springs, or permanently running water courses) were encountered on the side slopes of the ridge. The bedrock is also expected to exist at 40m depth. Therefore, the conditions required for liquefaction are not present.

## 6.4 Consolidation Settlement

A considerable amount of damage to the existing observatory and associated footpaths is evident with a large amount considered to have occurred as result of consolidation of non-engineered fill. Detail of this damage is outlined in section 6.4.2 of our June 2017 Report.

With the proposed cutting down of the site, the majority of the of compressible ground which we consider is primary responsible for the damage to the Observatory, is expected to be removed. There is a possibility that some fill material will remain on the outside western edge (summit carpark side – above Titirangi Drive) of the new platform, as well as behind and around the sides of the gun emplacement. These volumes are however not expected to be significant and easily remediated (if required).

## 6.5 Slope Instability

### 6.5.1 Assessment Methodology

The stability of the site has been assessed based on existing evidence of movement within the observatory building, site testing results, the geomorphology of the surrounding slopes, and numerical stability analyses carried out using specialist geotechnical software on cross sections developed for the underlying engineering geology. The location of the cross section profiles are shown on the investigation plan and are presented in the attached appendices. The material strength parameters used in the analyses are provided in Table 1 below . These were generally derived from published and unpublished correlation charts and tables for the particular materials encountered in the investigation, with consideration for the behaviour of the materials with long-term loading, and their strength under likely worst-case moisture content levels.

The numerical analyses have been carried out on cross sections through the four most critical slopes to the north, east, south and southwest under likely worst-case groundwater conditions over the life of the structure (design conditions), prevailing groundwater conditions, and ULS and SLS seismic conditions. The soil strength parameters used in the analyses are presented in Table 1. For the design seismic scenarios the cohesive soils were modelled in the undrained shear strength values were used in the seismic models for the cohesive soil units.

Table 1: Soil Strength Parameters

| Material | γ (kN/m³) | C' (kPa) | Ø' (°) | Su (kPa) |
|---|---|---|---|---|
| Non-engineered Fill | 18 | 2 | 25 | - |
| Firm Clay | 19 | 3 | 24 | 25 |
| Stiff To Very Stiff Clay | 19 | 4 | 26 | 75 |
| Very Stiff To Hard Clay | 19 | 7 | 30 | 150 |
| Medium Dense To Dense Sand & Gravel | 20 | 1 | 35 | - |
| High Density Cemented Tephra/Very Weak Sandstone | UCS = 1MPa | GSI = 60, IRC = 7 | | |

Minimum factor of safety criteria used in the analyses were a Factor of Safety ≥1.5 for design groundwater conditions and ≥1.2 for extreme groundwater conditions, and ≥1.0 for seismic conditions. The slope stability analysis summaries are attached to this report.

### 6.5.2 Geomorphological Assessment

The bony ridge beneath the summit and steep slopes adjacent to the hilltop site are indicative that the deeper slope-forming materials have relatively high strength and are fundamental stable.

Historic aerial photography indicates that a large amount of fill material was placed on the western edge of what is now the summit carpark as part of the 1942 site earthworks. An arcuate failure of the slope (Figure 8) in the fill materials is evident on the outside edge of what was at the time a roadway. Some ongoing soil creep is also occurring to the north of this fill zone (evident on site) resulting in the lateral movement of nib walls/edging along the western edge of the summit carpark. The proposed new build site is located at least 20m to the east of the historic fill/instability zone. zone. and is thus considered to be sufficiently isolated from it.

Historic and recent shallow seated landslippage has occurred on the natural steeper hillside slopes below the subject area, with the most recent occurring to the northeast on a very steep area of slope below the skid site bench. It is our opinion that instability is a result of saturation due to point discharge of surface water run-off over this zone combined with the low strength fill and surficial natural soils in this area. More competent material is exposed in the slip face and with the re-direction of surface water occurring , no further movement has occurred in this zone. This type of failure does however occur relatively frequently on Titirangi.

The cut slopes made into the hillside below the observatory to the southeast, east and northeast have been affected by erosion and shallow seated landslippage since their formation (Figure 10 & Figure 11). The cut slope has recessed back up to some 1m to 2m towards the observatory at the top of the slope.

Figure 10: Eastern cut slope below observatory shortly after completion in 2015.

Figure 11: Eastern cut slope in May 2017 showing cut face affected by erosion and shallow seated landslippage since original earthworks.

Following the proposed earthworks the cut slopes will be reduced to less than 2m in height. Despite this, based on the nature of the materials exposed and their inclination to instability it is considered likely that these slopes will continue to recess unless preventative measures are undertaken.

### 6.5.3 Numeric Stability Assessment

The numeric stability analyses incorporate the data from additional testing carried out in key areas and reflect the proposed cutting down of the site.

The physical evidence of movement and also zones of inherent stability are generally consistent with the findings of the numerical stability analyses.

With the cutting down of the site, a significant amount of the low strength soils, non-engineered fill and soils which have been affected by landslippage or subsidence will be removed. Based on the survey data, the lower part of the cut slope on the northeast, east and southeast sides of the site (slopes at back of skid site bench) will remain. These are expected to range up to 2.0m in height above the current skid level platform.

Under design ground water conditions, no slope movement is shown to occur (i.e. all FoS values >1.0). Factor of safety values less than 1.5 were however returned. Whilst the majority of these are isolated to the existing slope edge areas outside of the proposed new platform edge, surfaces extending up to 1.5m into the new platform are indicated where the cut slopes remain at the immediate edge of the new platform.

Under the worst possible ground water conditions considered to have the potential to develop, FoS values less than 1.2 were returned in all four slopes. Results are however similar to the existing groundwater model, in that surfaces only extend up to 2.5m into the new platform from its edge where cut slopes remain, and the remainder are isolated from the site.

Under both serviceability limit state (SLS) and ultimate limit state (ULS) seismic loads some yielding is shown to occur within the outside edges of the summit carpark and within the bench on the eastern (skid site) side of the site, however, no slip surfaces are shown to extend into the new proposed platform.

These potential movements have been taken into consideration in the engineering recommendations (Section 7) of this report.

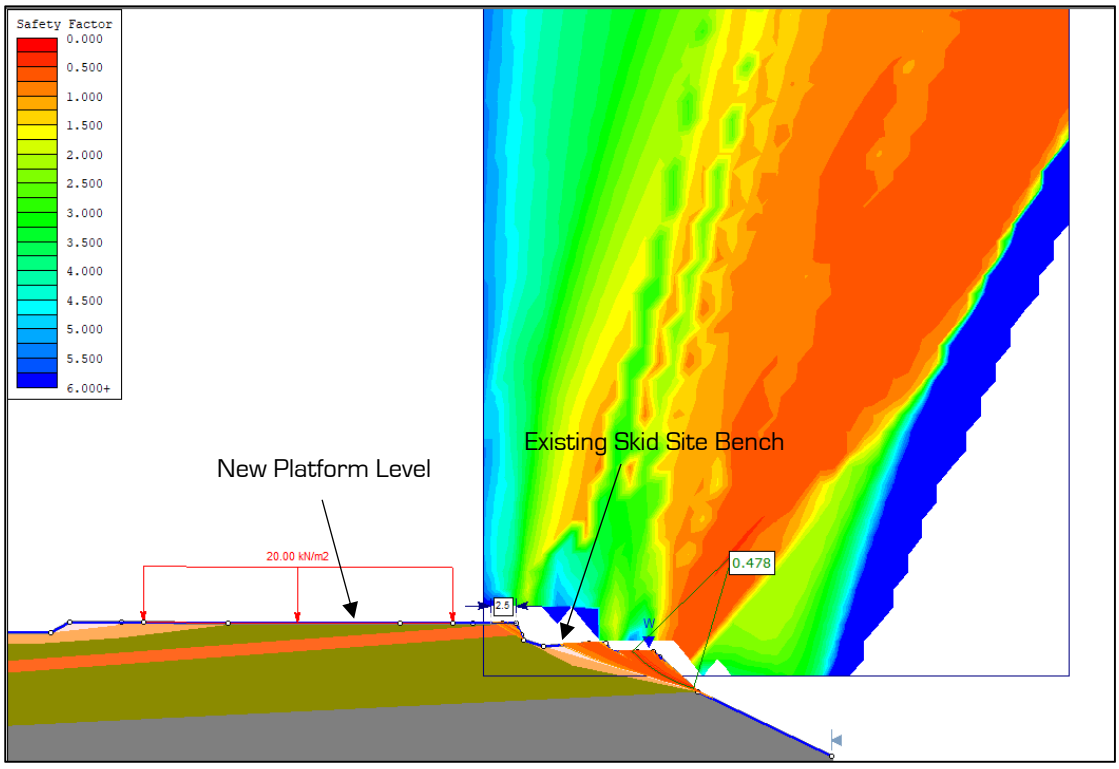



Figure 12: Eastern slope model under extreme groundwater conditions showing potential failure zones on edges of existing skid site bench and proposed new platforms.

## 6.6 Erosion

The soils exposed in the cut slopes to the south and east of the site (areas where 1942 and 2015 earthworks were undertaken) have been affected by erosion due to over-steepening, surface run-off and lack of vegetation (Figure 11). Whilst the majority of these slopes will be removed as part of the site cut-down process, slopes up to 2m high will remain. It is our opinion that erosion will continue in these slopes without remedial works being undertaken.

## 6.7 Ground Shrinkage and Swelling Potential

Plastic soils can be subject to shrinkage and swelling due to soil moisture content variations which can result in apparent heaving and settlement of buildings, particularly between seasons.

The clay-rich soils expected to be exposed at the proposed cut level appear to be moderately to highly plastic soils with a liquid limit of about 70% based on their physical characteristics determined during the investigation. These material are considered moderately to highly reactive, or subject to shrink-swell movements in response to changing moisture regime. A seam of sandy gravel is also expected to daylight in parts of the platform. This material is expected to have a low shrinkage and swelling potential. Consideration of the soil reactivity, particularly where foundations will span over low-reactive materials and high-reactive

materials potentially causing significant differential settlement, will need to be taken into account for future development.

### 6.8 Tree Root Deformation

There are presently no trees within the vicinity of the proposed platform, which would have the potential to result in building settlement due to the uptake of water from the tree roots or ground heave from tree root growth. Care should be taken with any future plantings around the building as the clay-rich soils at this site are particularly susceptible to shrinkage via water uptake which can cause damage to adjacent building foundations

## 7 Engineering Recommendations

### 7.1 General

It should be appreciated that the recommendations given below are based on the surface and subsurface conditions encountered at the time of the investigation. In addition to the possible variations in the subsurface conditions away from the investigation points within and around the site, changes to the site levels can have a dramatic effect on the recommendations given. Furthermore, cuts below the site can significantly jeopardise its stability and the recommendations made, unless an appropriate measure is put in place to restore the stability of the slope. Accordingly, we should be contacted prior to commencing any earthworks within the slopes to assess how this may affect the subject development. We should also be contacted immediately should the ground conditions encountered vary from that described in this report. The recommendations provided are one solution. Other solutions may be feasible, subject to review of this report by a suitably qualified geotechnical engineer.

### 7.2 Building Site Development

#### 7.2.1 Platform Development

The cutting down of the site as proposed will significantly increase the area flat or low angle land considered to be suitable for building purposes. The current significant issues of land instability affecting the existing observatory building, associated footpaths, retaining walls and accessway are expected to be essentially eliminated. Some low strength fill/disturbed soil is still expected to remain behind and around the sides of the gun emplacement and along the western edge of the new platform. This is expected to be able to be easily identified and remediated during site development.

The cut slopes which will remain at the northeastern, eastern, southern and western edges of the new platform, will remain at risk of localised landslippage and erosion. Options to address this are as follows:

- Isolate future buildings from the top edge of these slopes by 5 times the slope height and batter the intervening ground so it falls away from the building at allow gradient. Assuming a set-back distance of 10m from the top edge of these slopes, a large area of at least 700m$^2$ is expected to still be available for building purposes( Figure 13). Reduction of this set-back distance is expected to be easily obtained as most remnant slopes about the edge of the new platform will be less than 2m in height, this includes where linking up with the of rear of the gun emplacement may occur. With this option, it is expected that the batter slopes will be cut a low angle of up to some 10˚, which is expected to be able to be vegetated and readily maintained (mowable). This option will not require any engineering retaining installations.
- Construction of engineered retaining structures (e.g. timber pole retaining walls, gravity walls comprising gabion baskets or mechanically stabilised earth (MSE) walls) to support the cut slopes. Timber pole retaining walls are expected to be the most viable option as some of the supporting land below the batter slopes is considered to be at risk of failure. With the retaining walls, encroachment of buildings towards the slope edges is likely to be viable (if required).
- Deepening of foundations near slope edges (deep piling/underpinning of concrete floor foundations).
- Further cutting of the summit to marry the proposed cut into the existing lower bench surfaces.

Other options may be viable subject to the particular building proposal.

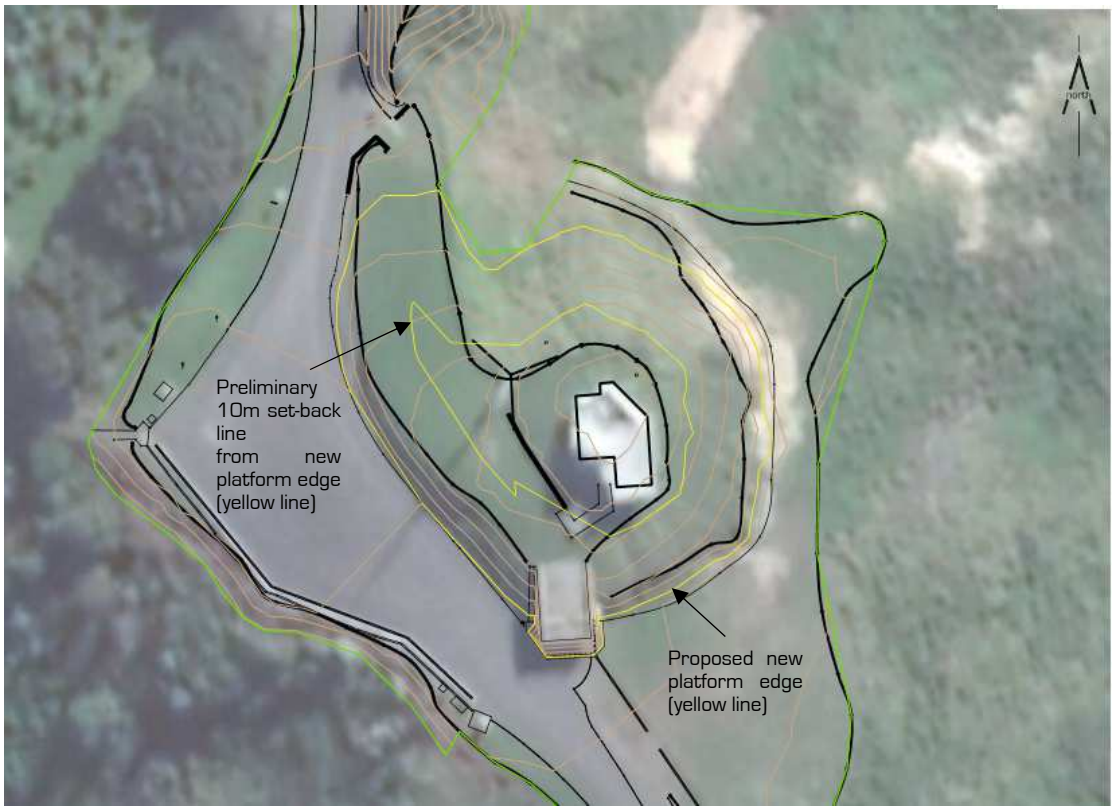



Figure 13: Aerial image showing approximate outline of proposed new platform if hill was to be cut down to approximately 98m above sea level and area of building zone available assuming a conservative 10m set-back from the edge of the building platform.

### 7.2.2 Fill Disposal

Large volumes of fill will need to be disposed of with the cutting down of the site. Placement of fill on the slopes around the site (apart from small volumes for landscaping purposes) is not recommend given the identified stability issues in the slopes further away from the summit.

## 7.3 Bearing Capacity and Foundation Design

Based on preliminary test data, a minimum ultimate, factored (ULS) and allowable bearing capacity of 300kPa, 150kPa and 100kPa is expected to exist within the natural soils at cut level. Higher bearing capacities are expected to be available. There is also potential that fill material will still remain around the sides and back of the gun emplacement that may need to be removed and replaced with engineered fill or have foundations designed to extend through the fill materials. These aspects will need to be confirmed at the building consent stage once the building proposal is known and the earthworks are complete.

For preliminary design purposes foundation depth extending to at least 0.7m beneath the platform level is expected to minimise the risk of foundation damage as a result of shrinkage

and swelling in the near surface soils. This can be refined as part of the building consent stage investigation.

## 7.4 Surface and Wastewater Disposal

Given the significant history of landslippage and slope movement on the steeper slopes surrounding the site and level of risk associated with discharging wastewater and stormwater onto them, we strongly recommend reticulation of these services to the bottom of the slope either to the east or west of the site, and connection into an existing stormwater of wastewater network. With reticulation, a degree of futureproofing is expected if expansion of buildings occurs, and valuable land is not taken up by treatment/attenuation systems or wastewater disposal fields. Furthermore, the natural soils around the site have low permeability , which presents a further difficulty for on-site wastewater disposal.

Disposal using soakage pits is not recommended due to the negative effect that this can have on the stability of the site. Given the clay-rich (low permeability) nature of the ground, they are also not expected to function well.

## 7.5 Tree Planting

A significant amount of native tree planting has occurred on the slopes surrounding the site, which we strongly support. Tree planting near buildings is however not recommend given the potential for damage to foundations through root growth and moisture uptake. For preliminary planning, a minimum horizontal distance of at least 1.0 times the mature height of the tree is recommended. With careful planning and installation of preventative measures such as root barriers, this set-back may be able to be reduced.

## 7.6 Site Maintenance

Prompt repair of plumbing leaks should be undertaken. Blocked, broken or faulty spouting should be attended to immediately.

The discharge of uncontrolled surface water over the site and surrounding slopes should be avoided at all costs.

Areas of slope movement and/ or erosion which may occur in the vicinity of the site should be assessed to determine the possible cause and implications that it may have on the stability of the building site. Remediation measures to limit the potential for further loss of land may need to be implemented to protect the value of the property.

# 8 Other Considerations

This report has been prepared exclusively for the Gisborne District Council with respect to the particular brief given to us. Information, opinions and recommendations contained in it cannot be used for any other purpose or by any other entity without our review and written consent. Land Development & Exploration Ltd accepts no liability or responsibility whatsoever for or in respect of any use or reliance upon this report by any third party.

This report was prepared in general accordance with current standards, codes and practice at the time of this report. These may be subject to change.

Opinions given in this report are based on visual methods, and subsurface investigations at discrete locations. It must be appreciated that the nature and continuity of the subsurface materials between these locations are inferred and that actual conditions could vary from that described herein. We should be contacted immediately if the conditions are found to differ from that described in this report.

This report should be read in its entirety to understand the context of the opinions and recommendations given.

Our analyses and opinions of the stability of the site have been based on the site geomorphology and ground conditions at the time of the investigation. Alteration of the slope gradients by cutting or filling could result in significant changes to the stability of the site which could be detrimental. We should be contacted immediately if there are any proposed changes to the slope profile, as well as the incidence of landslippage within the vicinity of the site.

For and on behalf of LDE Ltd

Report prepared by:

Ross Cumming

*MIPENZ*

*Senior Engineering Geologist*

Report reviewed by:

Joel Pollock

*Senior Engineering Geologist*

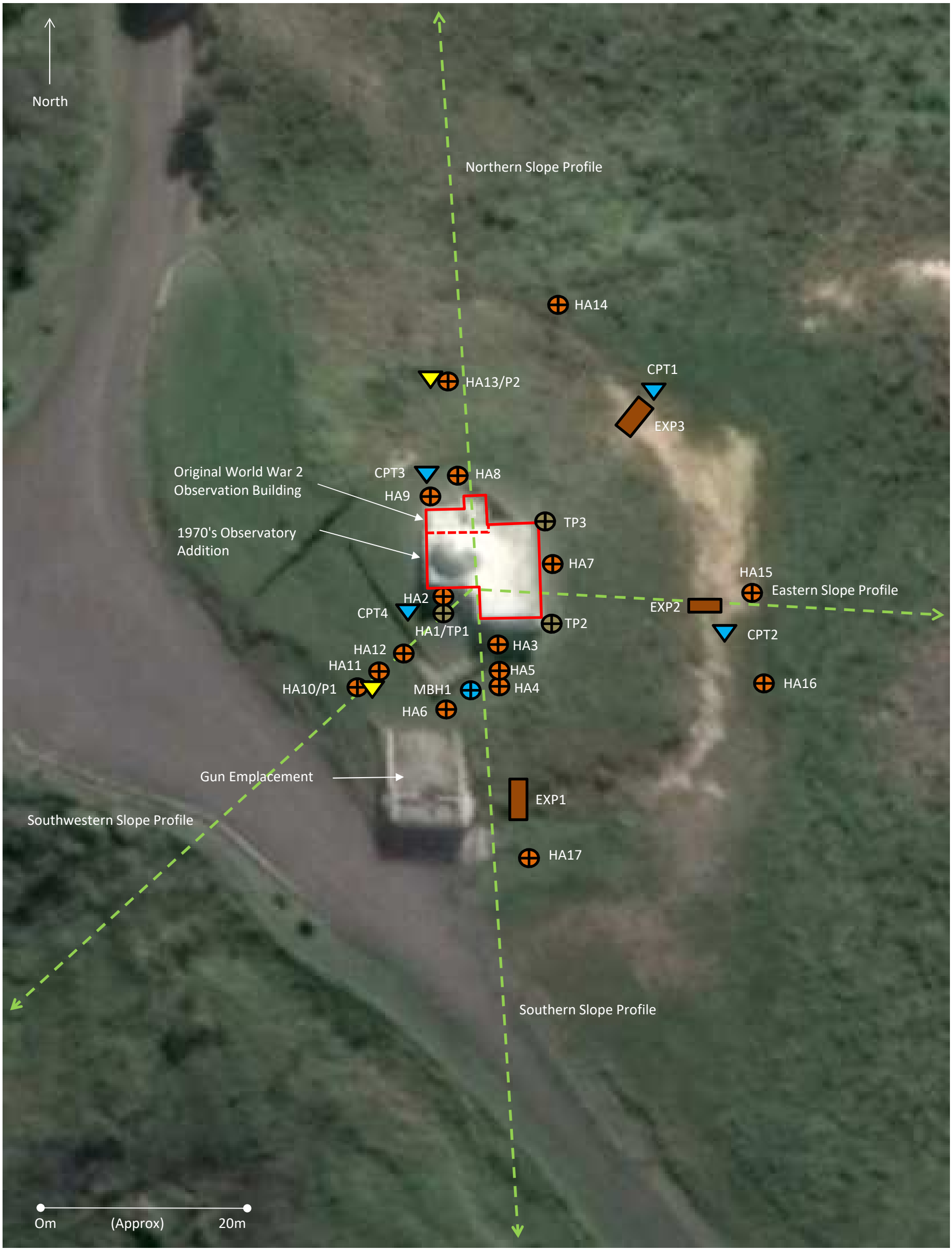
Report authorised by:

Georg Winkler

*MEngNZ, CPEng*

*Engineering Geologist-Geotechnical Engineer*

\\lde-ad01\Projects\13300 to 13399\13364 Titirangi Observatory Titirangi Drive Gisborne\April 2018 Full Development\GEOTECH\Report\13364 Titirangi Summit Cut-Down Geotechnical Investigation Report RGC 120618 NJP review.docx

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| | | CHECKED | NJP |
| | | DATE | 11-Jun-18 |
| | | PROJECT | 13364 |

North direction and boundary locations are approximate only

Contractor shall check all dimensions on site prior to work commencing

## Legend

CPT 01 — qc (MPa) 0 4 8 — Cone penetrometer testing reading (bearing tip pressure, Qc MPa)

HA 01 — Su (kPa) 0 100 200 — Handauger borehole shear vane testing reading (kPa)

P1 — Blows/50mm 0 5 10 — Scala penetrometer test results (Blows/50mm penetration

Headscarp

Existing surface profile

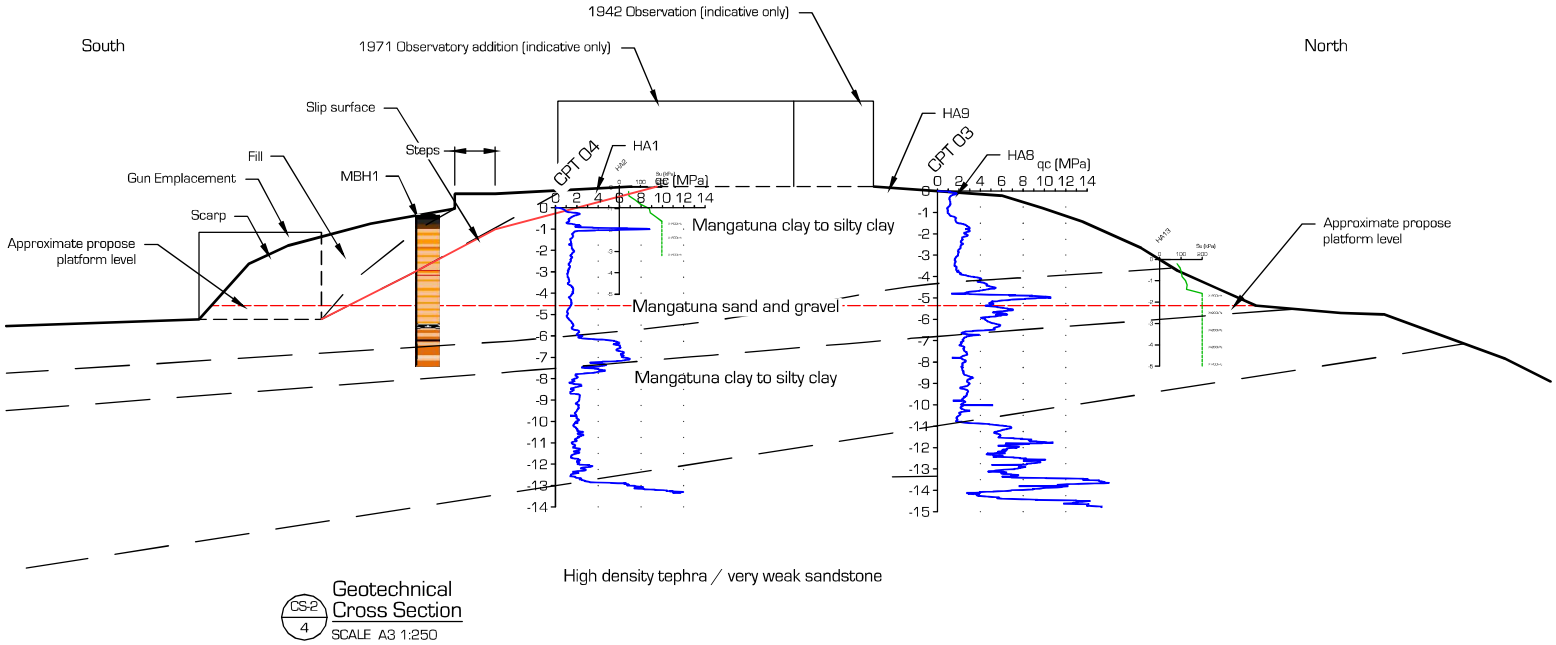
Inferred boundary layer

Possible slip surface

Inferred Water table

**Note:**
The engineering geology of the site summarised in this drawing is based on an integration of published and unpublished data, the geomorphology of the site, surface exposures of the underlying geology, and subsurface investigations carried out at discrete locations in accordance with our brief and the intended purpose. The nature of the ground between the investigation points is inferred and may vary from that described. For details of the materials encountered and measurements of their respective strengths please review the investigation logs. Use of the geotechnical information for other purposes should be with care. During construction the ground conditions should be checked by the Engineer or Engineer's representative or other Suitably Qualified Person to confirm inferences made. Should the ground conditions be found to vary then the Engineer should be notified immediately.

**Note:**
All soil and rock strengths classified in accordance with "NZ Geotechnical Society Field Description of Soil and Rock"




CS-2 / 4 — Geotechnical Cross Section

SCALE A3 1:250

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| PROJECT | James Cook Observatory<br>Titirangi Drive<br>Gisborne |
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| LDE LAND DEVELOPMENT & EXPLORATION LTD. | |
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| DRAWN: | GB |
| DATE: | 30.05.17 |
| CHECKED: | |
| SCALE A3: | 1:250 |
| PROJECT STATUS | Construction |
| PROJECT: | 13364 |
| SHEET: | 2 of 2 |
| DRAWING No: | 13364-1 |
| REV: | 0 |

| No. | REVISION | BY | DATE |
|---|---|---|---|

North direction and boundary locations are approximate only

Contractor shall check all dimensions on site prior to work commencing

Legend

CPT 01 qc (MPa) 0 4 8 — Cone penetrometer testing reading (bearing tip pressure, Qc MPa)

HA 01 Su (kPa) 0 100 200 — Handauger borehole shear vane testing reading (kPa)

P1 Blows/50mm 0 5 10 — Scala penetrometer test results (Blows/50mm penetration

Headscarp

Existing surface profile

Inferred boundary layer

Possible slip surface

Inferred Water table

Note:
The engineering geology of the site summarised in this drawing is based on an integration of published and unpublished data, the geomorphology of the site, surface exposures of the underlying geology, and subsurface investigations carried out at discrete locations in accordance with our brief and the intended purpose. The nature of the ground between the investigation points is inferred and may vary from that described. For details of the materials encountered and measurements of their respective strengths please review the investigation logs. Use of the geotechnical information for other purposes should be with care. During construction the ground conditions should be checked by the Engineer or Engineer's representative or other Suitably Qualified Person to confirm inferences made. Should the ground conditions be found to vary then the Engineer should be notified immediately.

Note:
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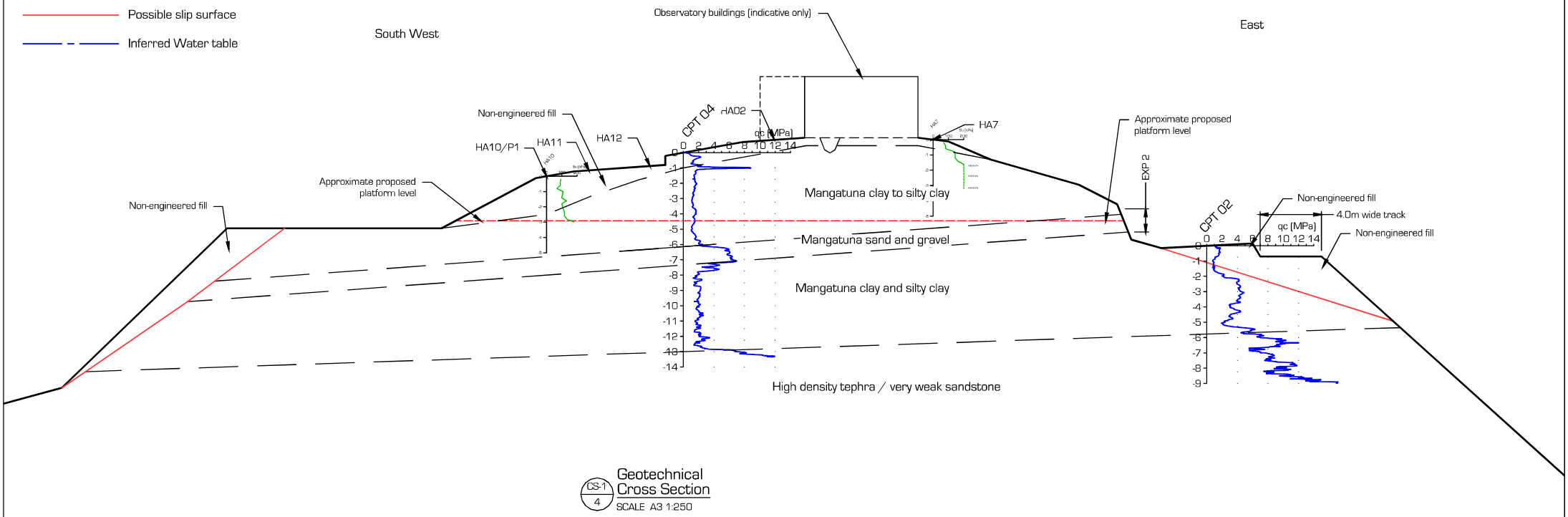


CS-1 / 4 Geotechnical Cross Section
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DRAWING No: 13364-1 REV: 0

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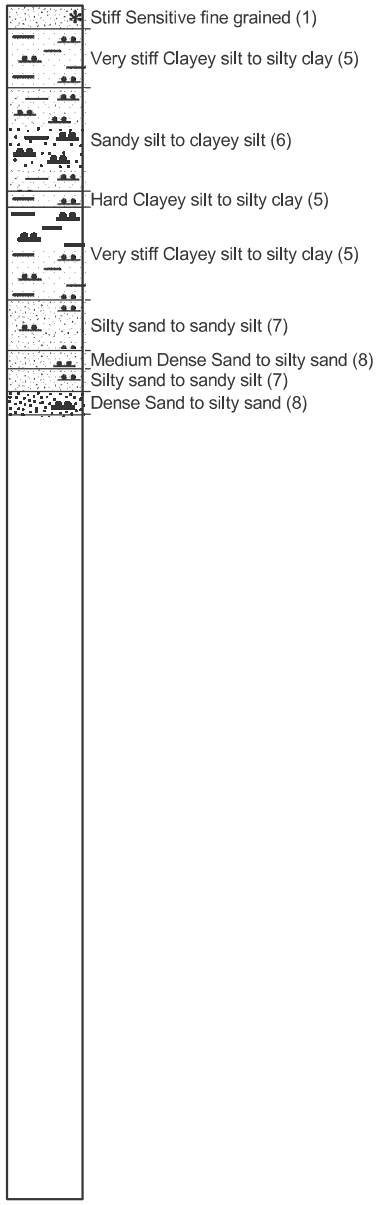


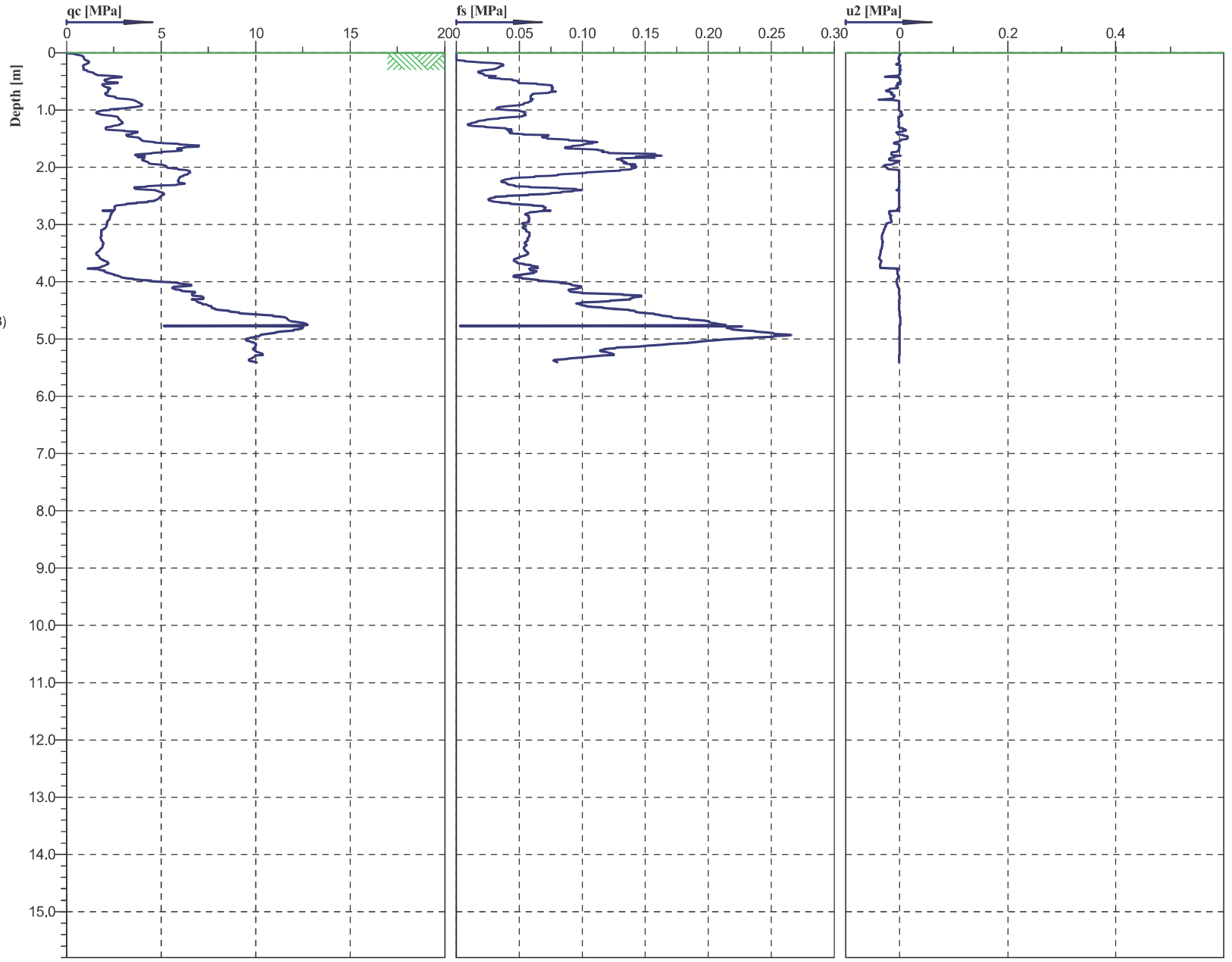



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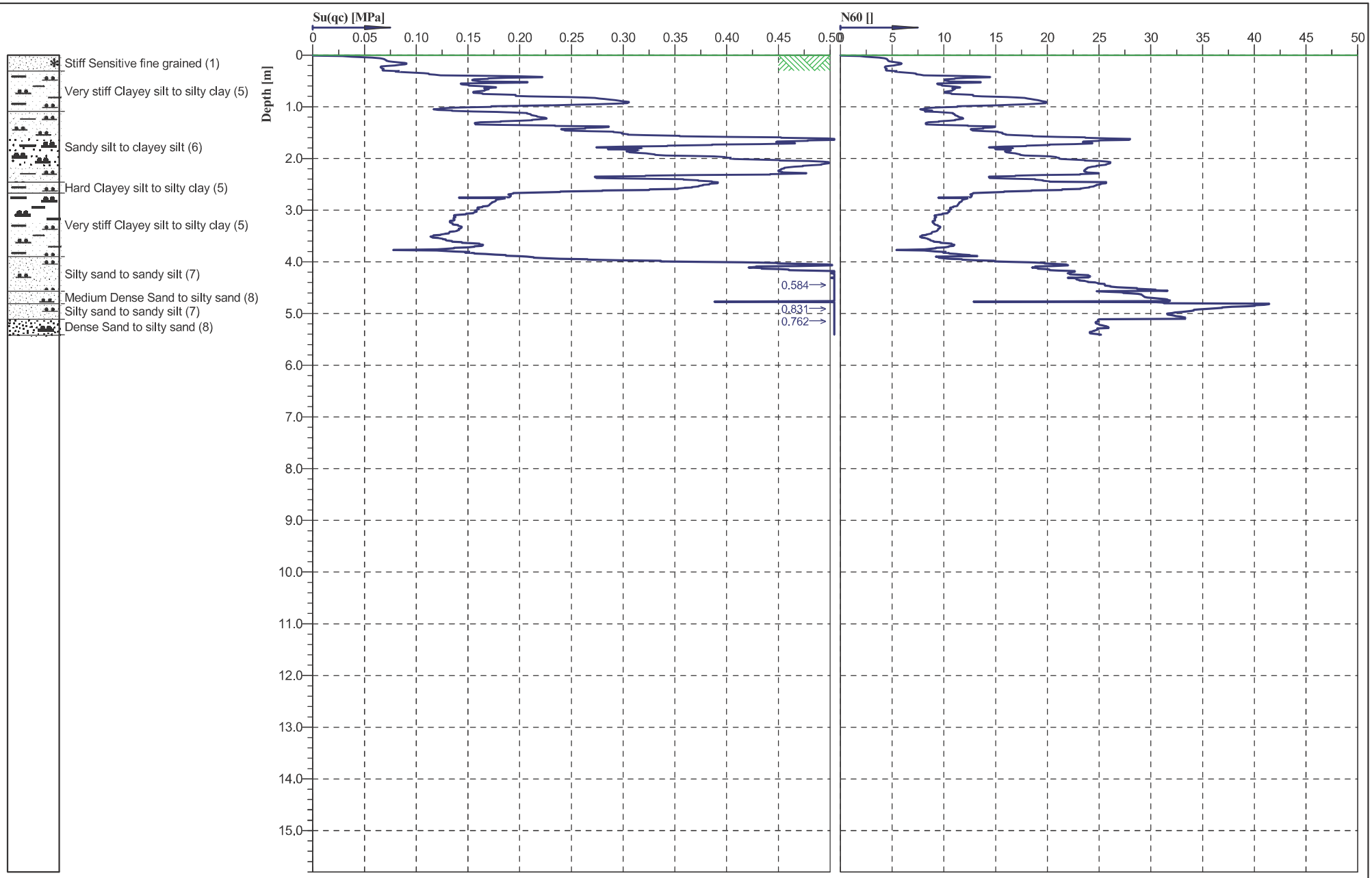


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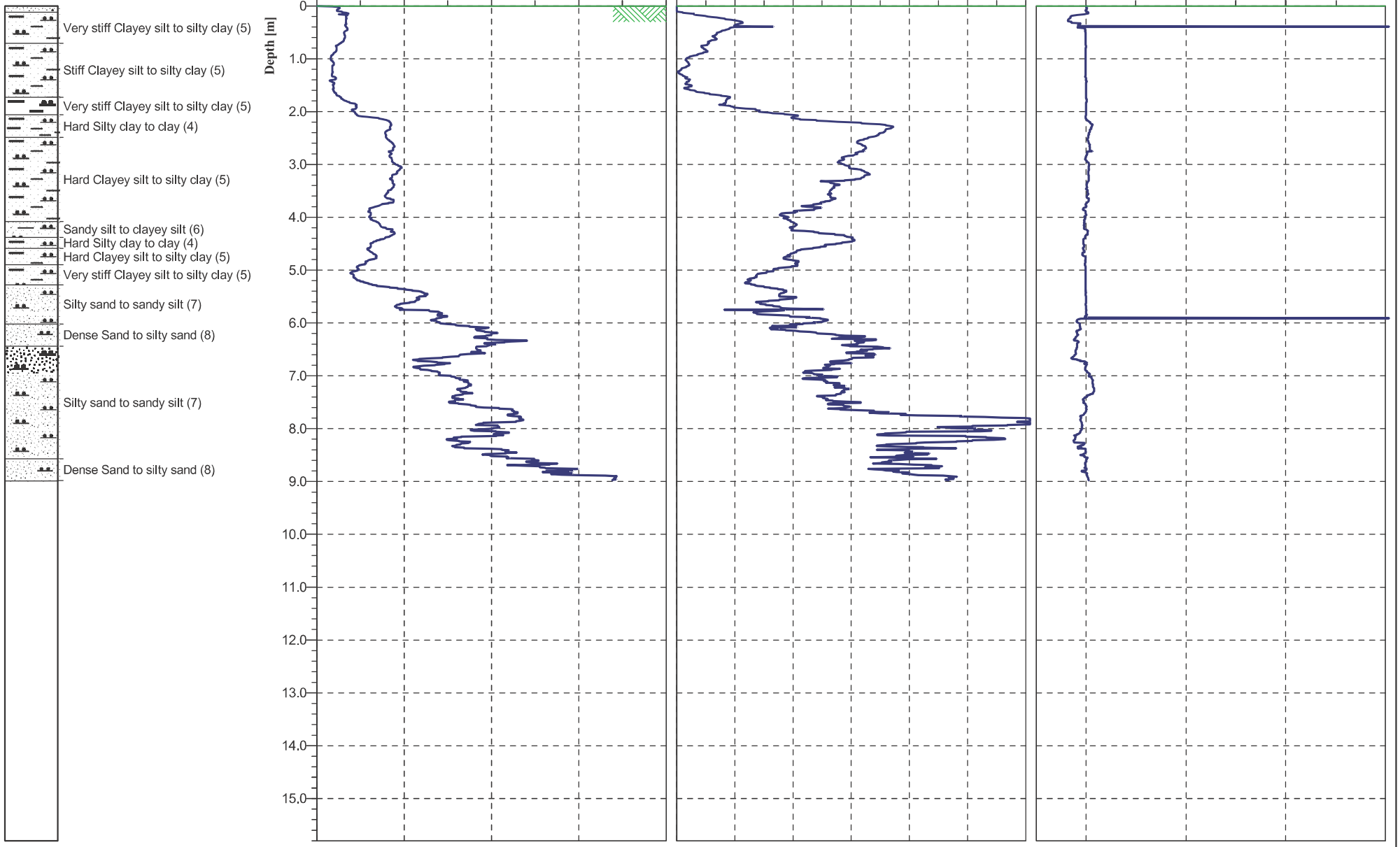



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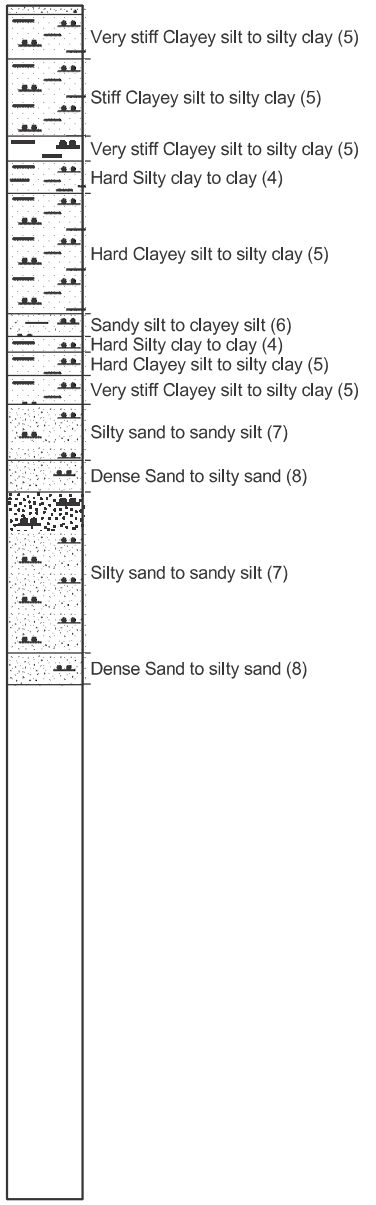


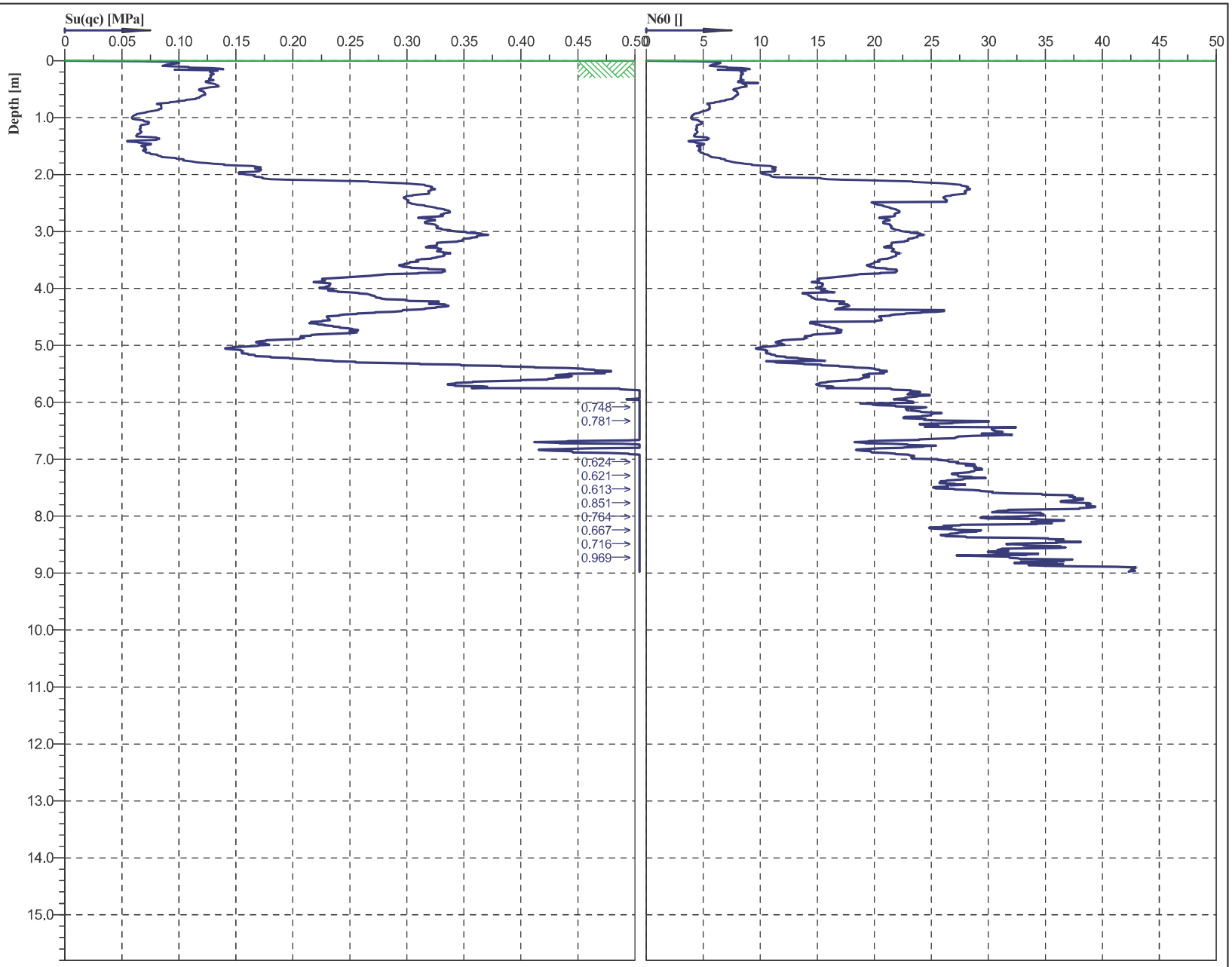



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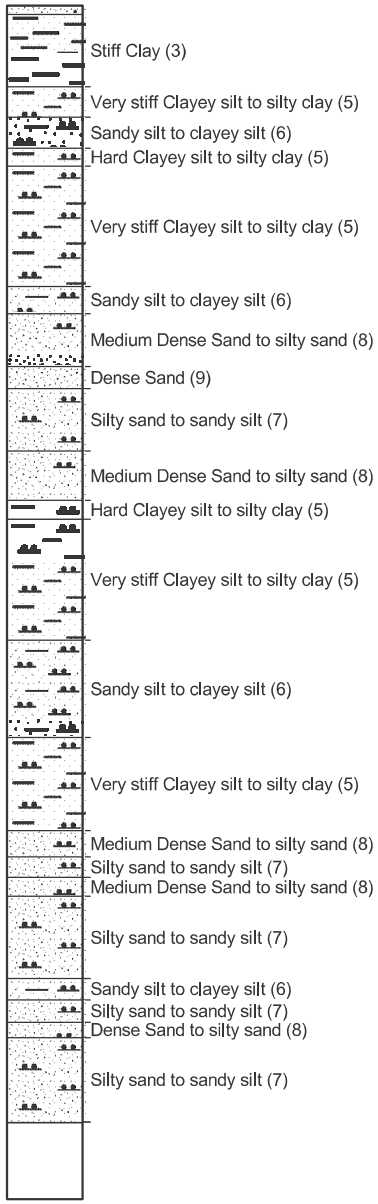


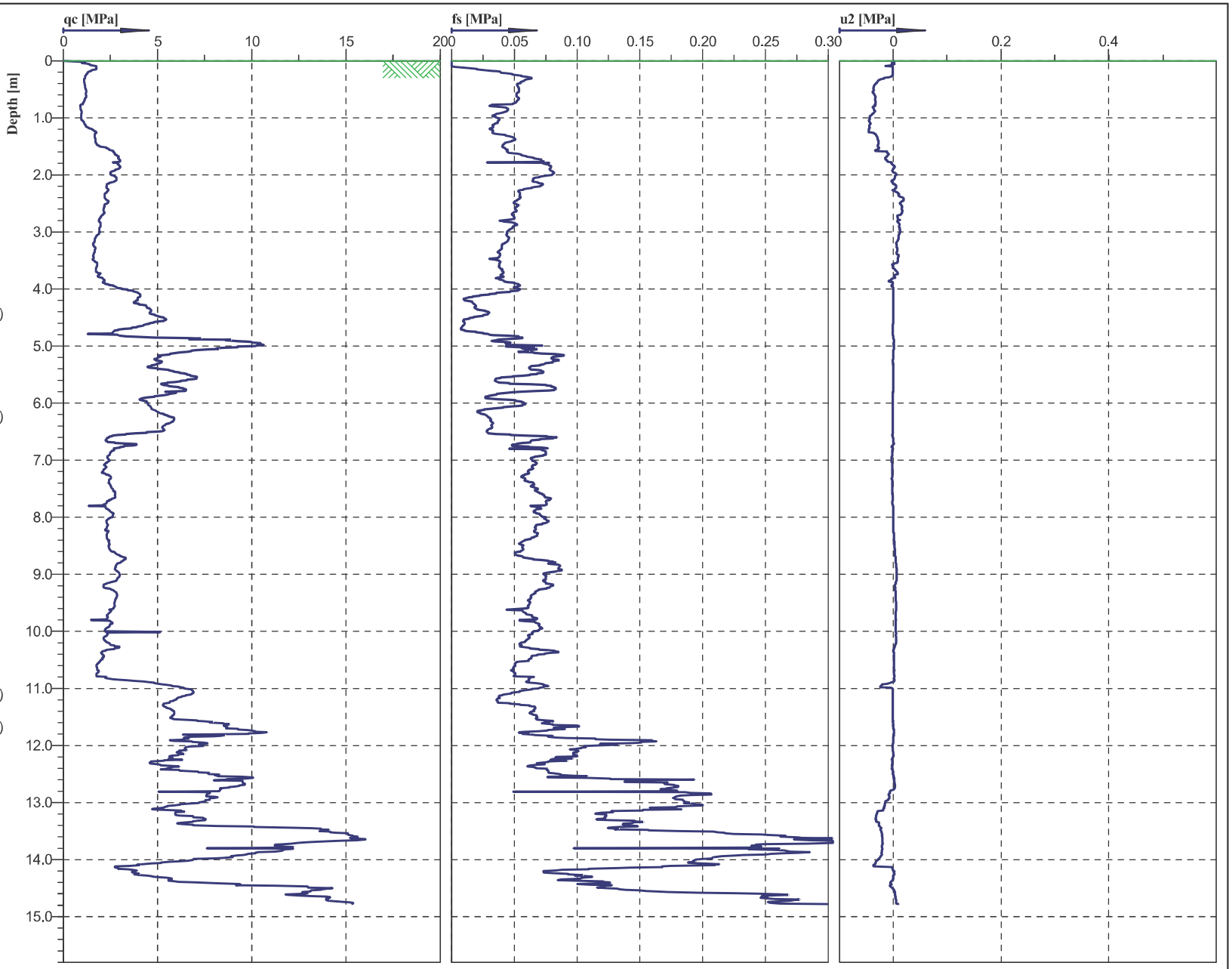



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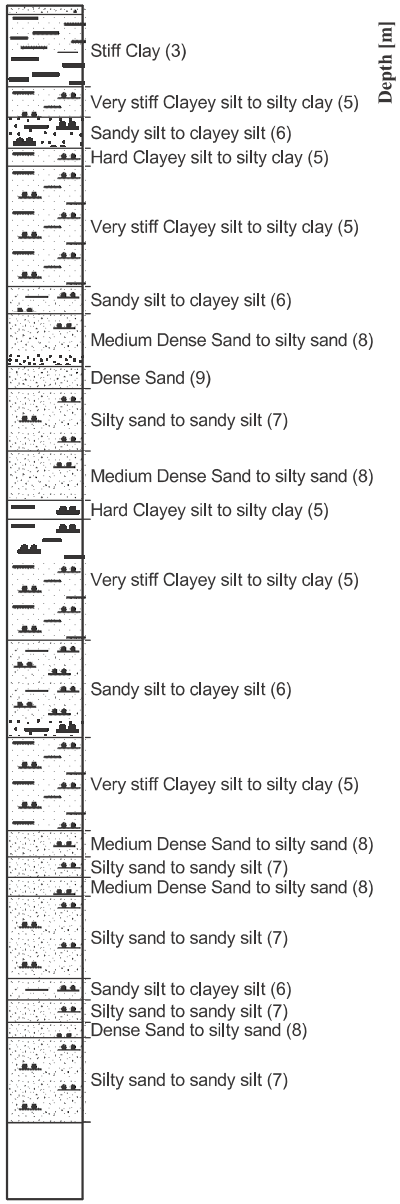


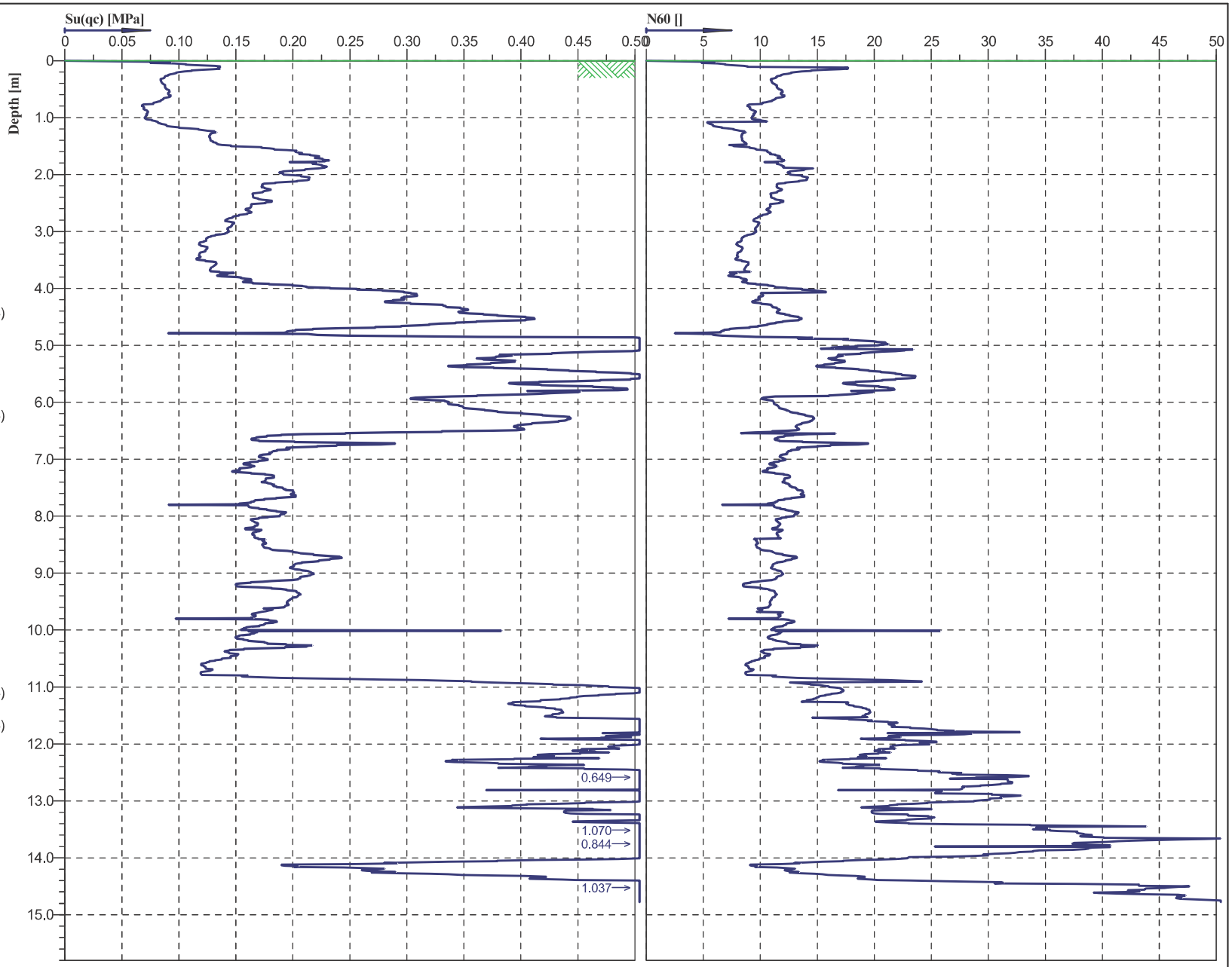



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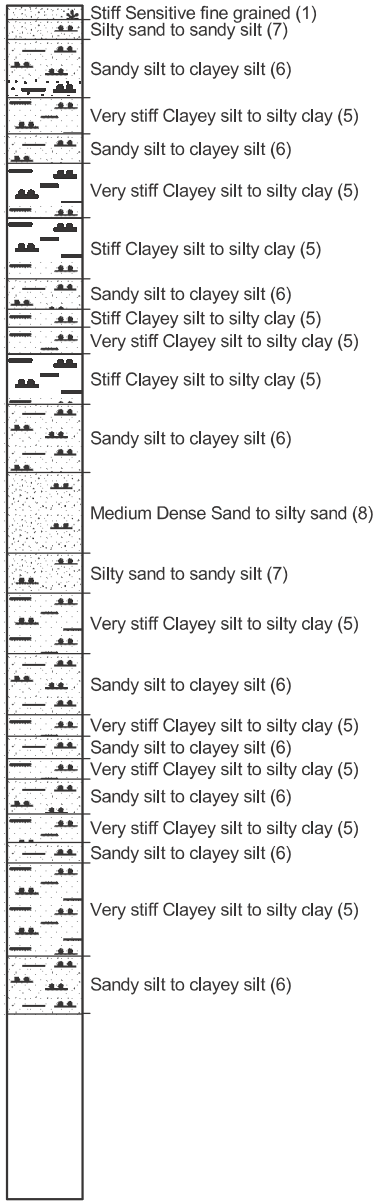
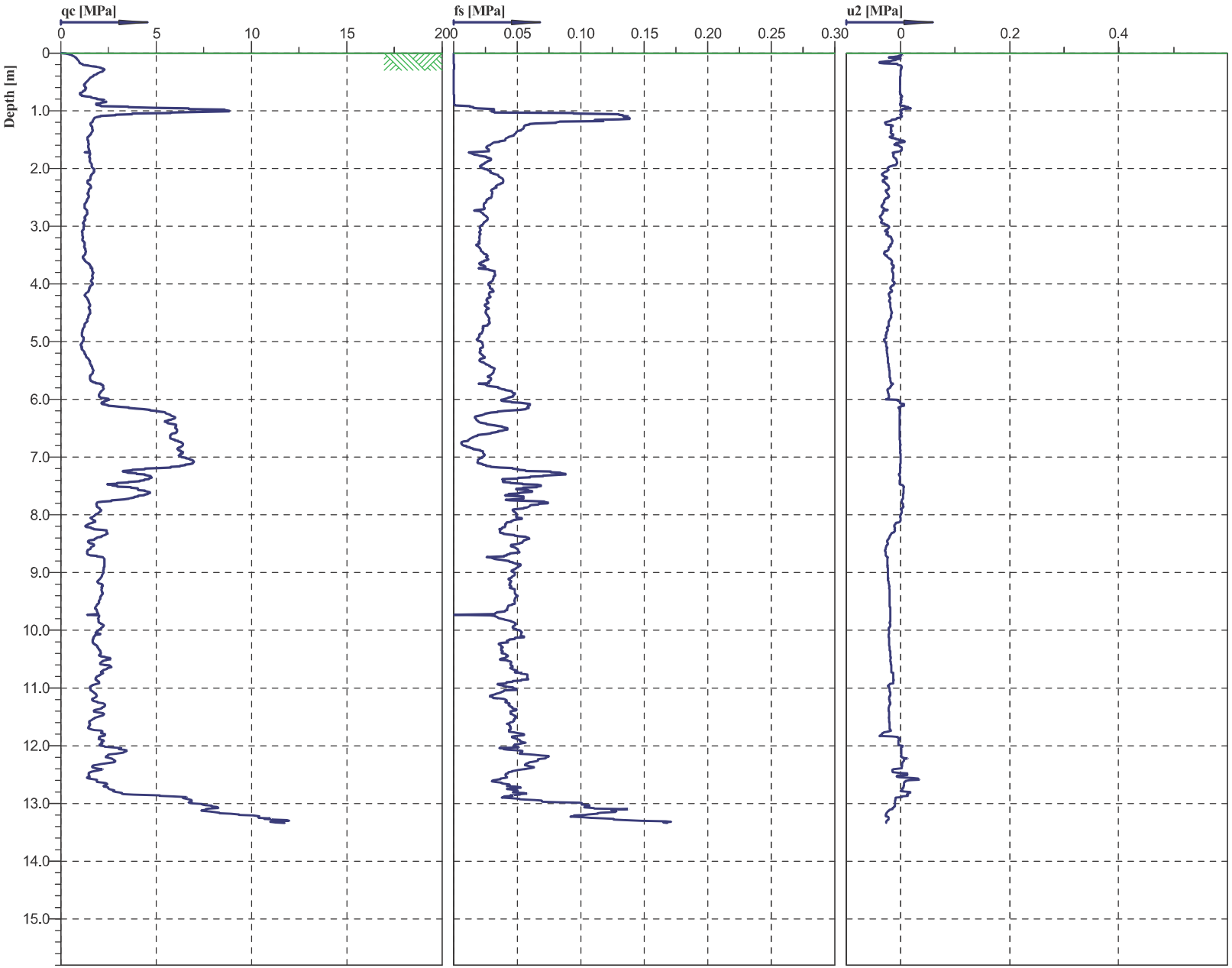
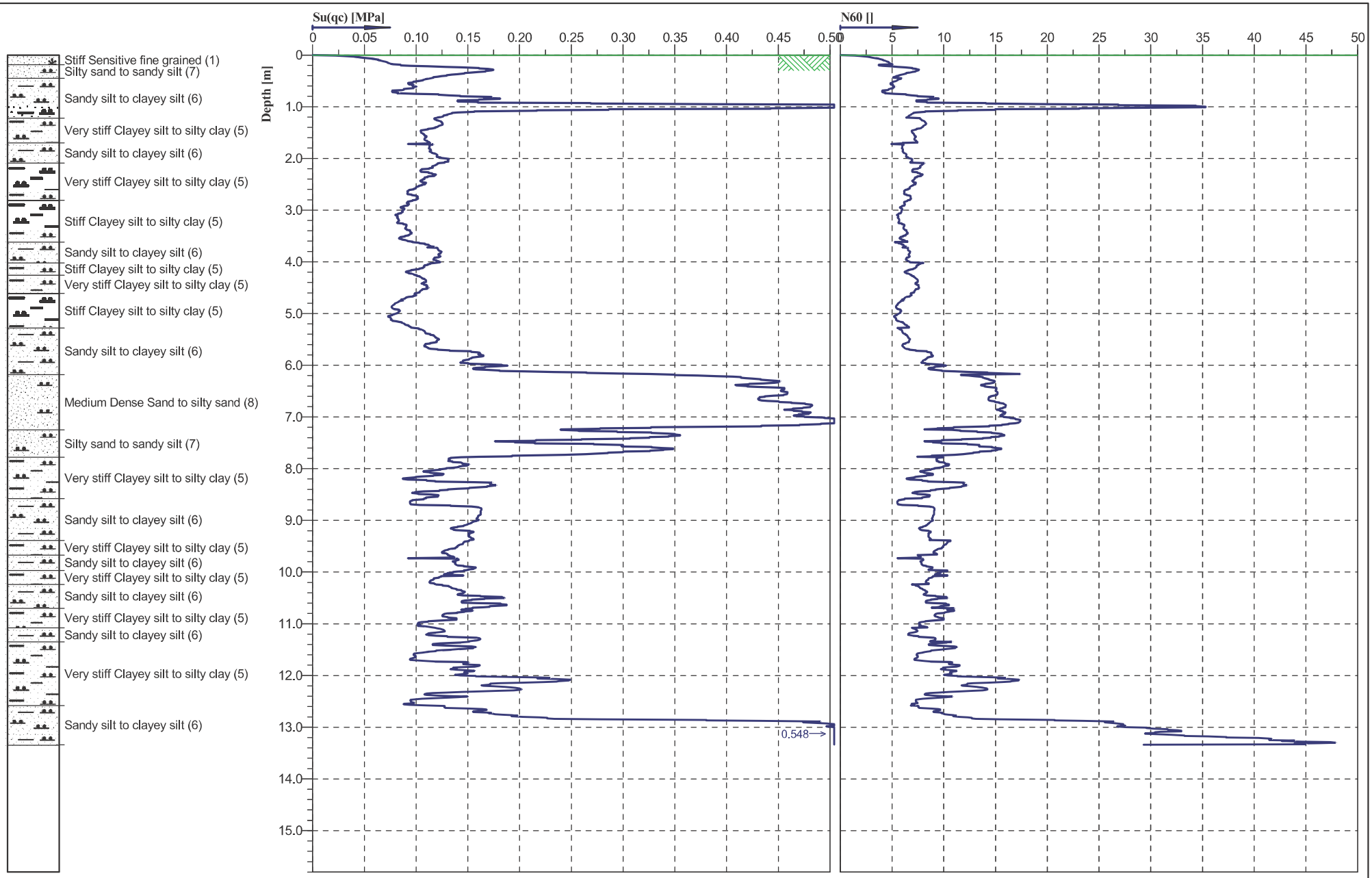




Cone No: 4614
Tip area [cm2]: 10
Sleeve area [cm2]: 150

| | | | |
|---|---|---|---|
| Location: Titirangi Observatory, Titirangi Drive, Gisborne | Position: | Ground level: 0.00 | Test no: CPT04 |
| Project ID: 13364 | Client: Gisborne District Council | Date: 27/4/2017 | Scale: 1 : 100 |
| Project: Geotechnical Investigation | | Page: 1/1 | Fig: |
| Refusal due to rig lift. | | File: CPT04.cpt | |




U2

Cone No: 4614
Tip area [cm2]: 10
Sleeve area [cm2]: 150

| | | | |
|---|---|---|---|
| Location: Titirangi Observatory, Titirangi Drive, Gisborne | Position: | Ground level: 0.00 | Test no: CPT04 |
| Project ID: 13364 | Client: Gisborne District Council | Date: 27/4/2017 | Scale: 1 : 100 |
| Project: Geotechnical Investigation | | Page: 1/1 | Fig: |
| Refusal due to rig lift. | | File: CPT04.cpt | |

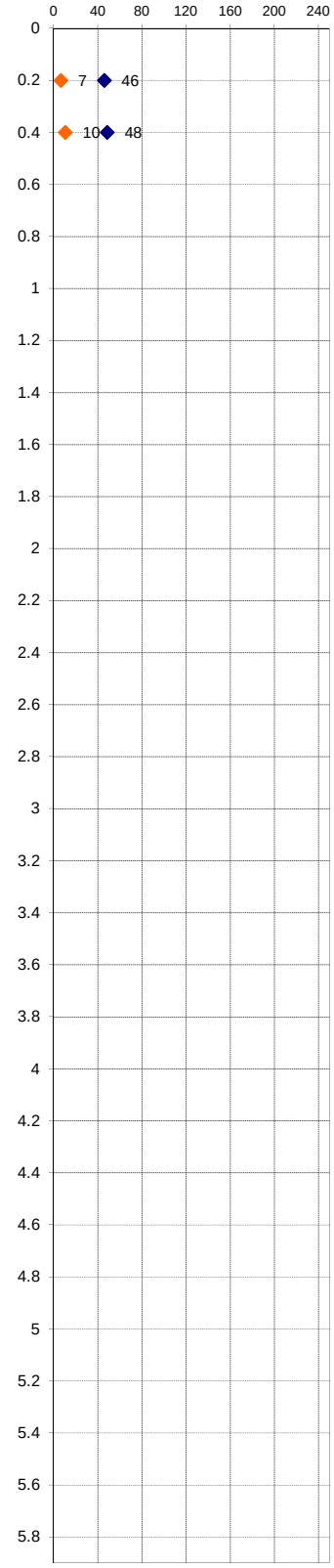
# BOREHOLE LOG

**BOREHOLE No:** **HA1**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | F | SILT, clayey, some sand and fine well rounded gravel, dark grey to black, firm, moist | Non-engineered fill |
| 0.3 | | | | Sharp contact | |
| 0.4 | | | | End of borehole @ 0.4m due to sharp high density contact (foundation) | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

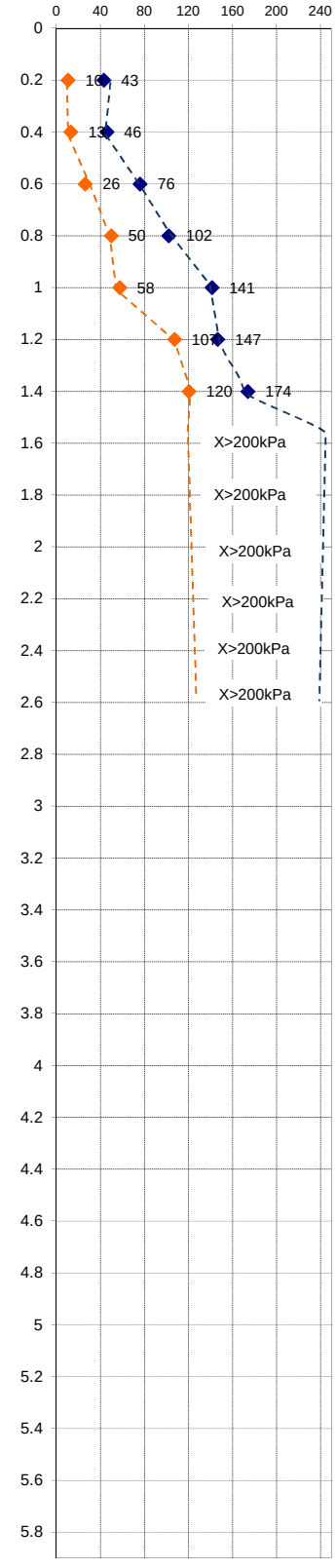
# BOREHOLE LOG

**BOREHOLE No:** HA2

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 – 0.3 | | M | F | SILT, clayey, some sand and fine well rounded gravel, dark grey to black, firm, moist | Non-engineered Fill |
| 0.4 – 0.5 | | M | F-St | CLAY, rare silt, light brown, firm to stiff, moist | Pleistocene Age Mangatuna Formation |
| 0.6 | | | St | Stiff | |
| 0.8 | | | VSt | Very Stiff | |
| 1.2 | | | | some orange brown patches | |
| 1.4 | | D-M | | dry to moist | |
| 1.6 | | | H | Hard | |
| 2.4 | | D-M | H | SILT, rare clay, orange brown, hard, dry to moist | |
| 2.5 | | | | End of borehole @ 2.5m<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

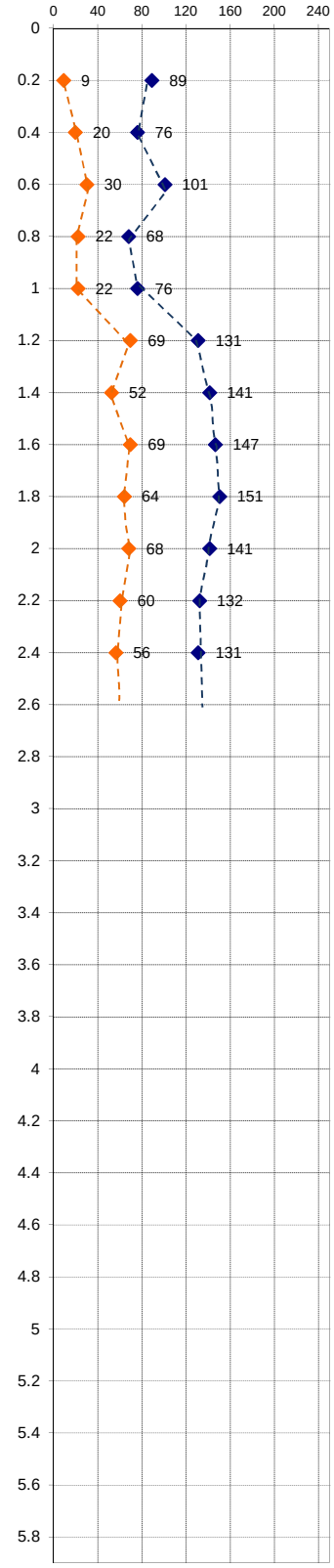
# BOREHOLE LOG

**BOREHOLE No:** HA3

| | | | |
|---|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** | 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** | 27/04/2017 |
| | | **Hole completed:** | 27/04/2017 |
| **Co-ordinates:** mN mE | **Drill method:** 50mm handauger | **Drilled by:** | RGC |
| | | **Logged by:** | RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 – 1.1 | | M | St | SILT, some gravel (well rounded- fine), sand, and clay, black to light brown, stiff, moist | Non-Engineered Fill |
| 0.6 – 1.1 | | | D-M | rare whitish brown medium to coarse pumiceous sand, dry to moist | |
| 1.2 – 2.4 | | VSt | M | CLAY, rare to some silt, light brown to light orange brown, plastic, very stiff, moist | Pleistocene Age Mangatuna Formation |
| 2.5 | | | | End of borehole @ 2.5m<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** **HA4**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | | | SILT, some gravel (well rounded- fine), sand and clay, black to light brown, stiff, moist | Non-Engineered Fill |
| 0.1 | | | | | |
| 0.2 | | | | End of borehole @ 0.2m due to sharp high density contact<br>Likely concrete (potentially hollow) | |
| 0.3 | | | | | |
| 0.4 | | | | | |
| 0.5 | | | | | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | | |
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| 5.4 | | | | | |
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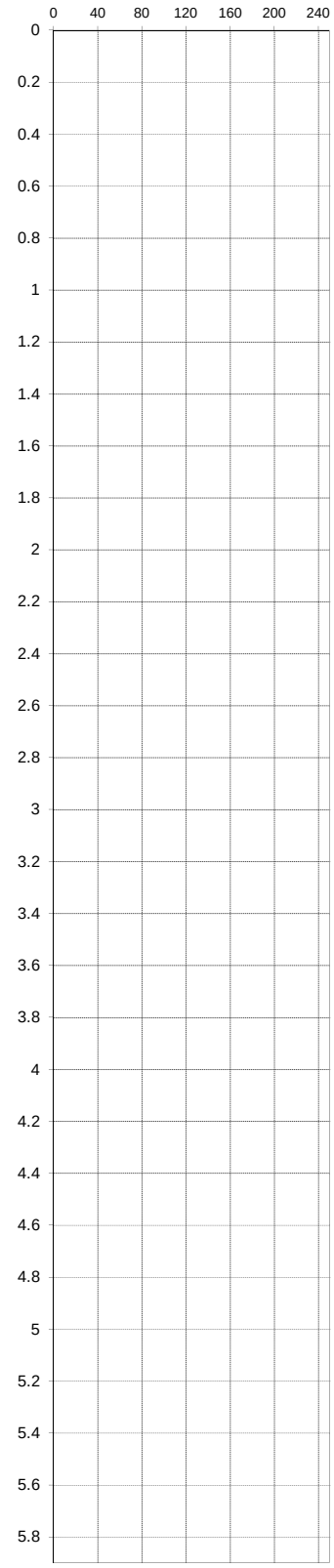
| 5.7 | | | | | |
| 5.8 | | | | | |
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

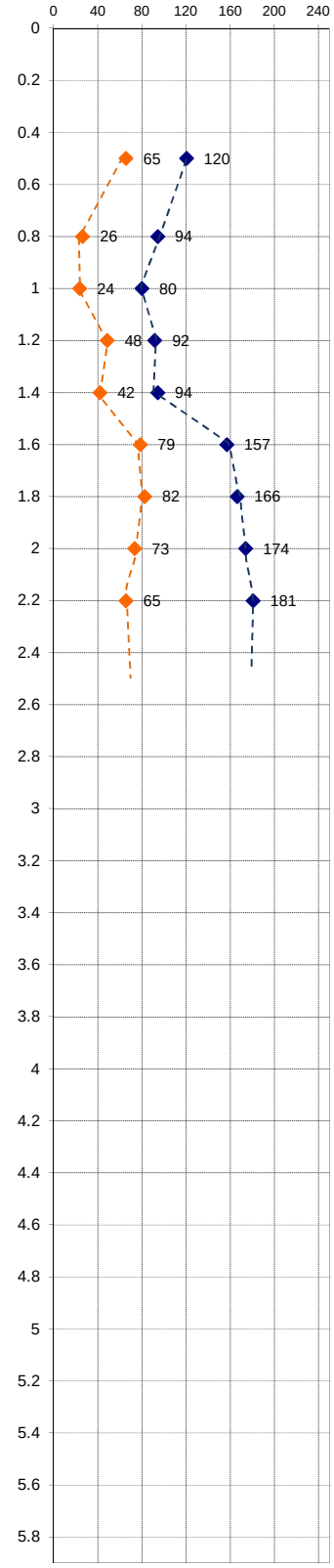
# BOREHOLE LOG

**BOREHOLE No:** HA5

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 – 0.3 | | M | VL | SAND (beach), some silt and clay, rare fine brick fragment, black, grey and light brown, very loose, moist | Non-Engineered Fill |
| 0.4 – 1.1 | | M | Vst | SILT, contains patches of light brown clay, black, very stiff, moist<br>stiff | |
| 1.2 | | W | St | SILT, rare fine well rounded gravel and sand (coarse beach), stiff, wet | Mixed Original Topsoil & imported Fill |
| 1.3 – 2.3 | | M | St | CLAY, rare to some silt, light brown to light orange brown, plastic, stiff, moist | Pleistocene Age Mangatuna Formation |
| 1.6 – 2.4 | | | VSt | Very stiff | |
| 2.5 | | | | End of borehole @ 2.5m<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** **HA6**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | VL | SILT, some concrete (fine to coarse gravel size) sand and clay, contains cavities, grey and black, very loose, moist | Non-engineered fill |
| 0.1 | | | | | |
| 0.2 | | | | End of borehole @ 0.2m<br>Cannot advance due concrete/aggregate density | |
| 0.3 | | | | | |
| 0.4 | | | | | |
| 0.5 | | | | | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | | |
| 1.1 | | | | | |
| 1.2 | | | | | |
| 1.3 | | | | | |
| 1.4 | | | | | |
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| 2.0 | | | | | |
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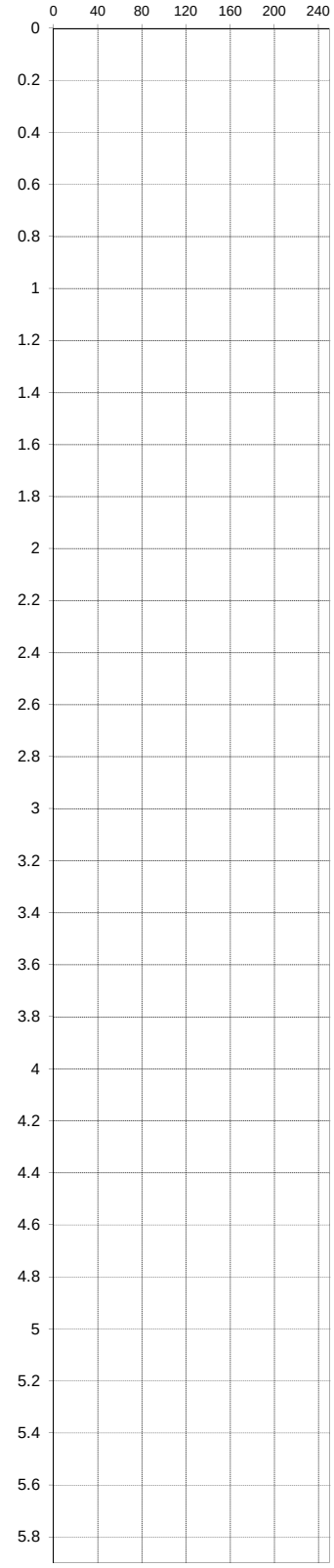
| 5.3 | | | | | |
| 5.4 | | | | | |
| 5.5 | | | | | |
| 5.6 | | | | | |
| 5.7 | | | | | |
| 5.8 | | | | | |
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

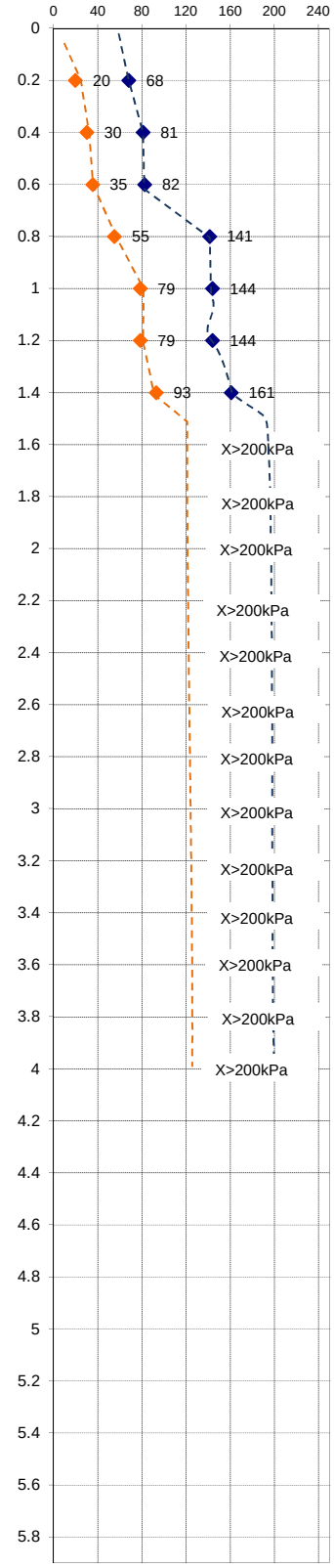
# BOREHOLE LOG

**BOREHOLE No:** HA7

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | D-M | St | SILT and clay, mixed black and light brown, stiff, dry to moist | Non-engineered Fill/Disturbed Topsoil |
| 0.5 | | D-M | St | CLAY, rare silt and fine pumiceous sand, plastic, stiff, dry to moist | Pleistocene Age Mangatuna Formation |
| 0.8 | | | VSt | very stiff | |
| 1.5 | | | | fine white pumiceous sand patch | |
| 1.6 | | M | H | moist, hard | |
| 3.4 | | | | fine very weak shell fragment | |
| 4.0 | | | | End of borehole @ 4m depth<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

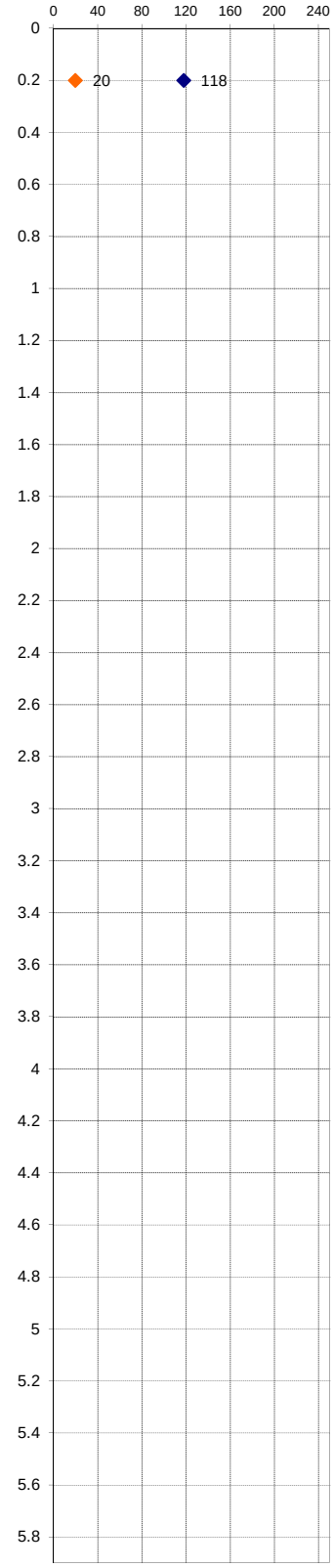
# BOREHOLE LOG

**BOREHOLE No:** HA8

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | VL-D | SILT some clay, light brown with black patches, very stiff, dry to moist | Non-engineered fill |
| 0.2 | | M | VSt | CLAY, rare to some silt, light brown to greenish brown, plastic, very stiff, moist | Pleistocene Age Mangatuna Formation |
| 0.5 | | | | End of borehole @ 0.5m<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

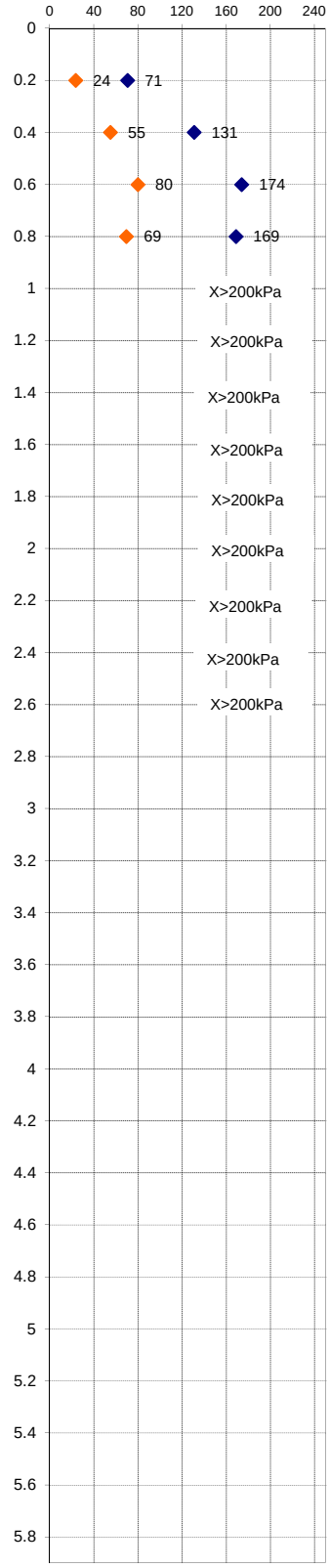
# BOREHOLE LOG

**BOREHOLE No:** HA9

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | VL-D | SILT, some clay, black, very stiff, dry to moist | Topsoil |
| 0.2 | | M | VSt | CLAY, rare to some silt, light brown to greenish brown, plastic, very stiff, moist | Pleistocene Age Mangatuna Formation |
| 1.0 | | | H | dry to moist, crumbly, hard | |
| 1.6 | | | | pocket of fine white pumiceous sand | |
| 2.5 | | | | End of borehole @ 2.5m<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** HA10

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 27/04/2017<br>**Hole completed:** 27/04/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** AHM<br>**Logged by:** AHM |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | St | SILT, trace fine-medium angular gravel, dark brownish black, moderately organic, moist | Topsoil Fill |
| 0.1 | | | | | |
| 0.2 | | M | St | SILT, clayey, light yellowish brown with dark brownish black and slight orange mottling, plastic, moist | Non-Engineered Fill |
| 0.3 | | | | | |
| 0.4 | | | | | |
| 0.5 | | | | orange mottling more frequent | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | VSt | very stiff | |
| 1.1 | | | | | |
| 1.2 | | | | slight dark brownish black mottling | |
| 1.3 | | | | | |
| 1.4 | | | | | |
| 1.5 | | | | | |
| 1.6 | | | | slight orange mottling | |
| 1.7 | | | | | |
| 1.8 | | | | | |
| 1.9 | | | | | |
| 2.0 | | | | | |
| 2.1 | | | | | |
| 2.2 | | | | | |
| 2.3 | | | | | |
| 2.4 | | | | | |
| 2.5 | | | | | |
| 2.6 | | | | | |
| 2.7 | | M | VSt | SILT, clayey, light yellowish brown with slight orange mottling, plastic moist | Pleistocene Age Mangatuna Formation |
| 2.8 | | | | | |
| 2.9 | | | | | |
| 3.0 | | M-W | | moist to wet | |
| 3.1 | | | | End of borehole at 3.1m due to borehole closure | |
| 3.2 | | | | Borehole dry on completion | |
| 3.3 | | | | Penetrometer test P1 put down in base of hole | |
| 3.4 | | | | | |
| 3.5 | | | | | |
| 3.6 | | | | | |
| 3.7 | | | | | |
| 3.8 | | | | | |
| 3.9 | | | | | |
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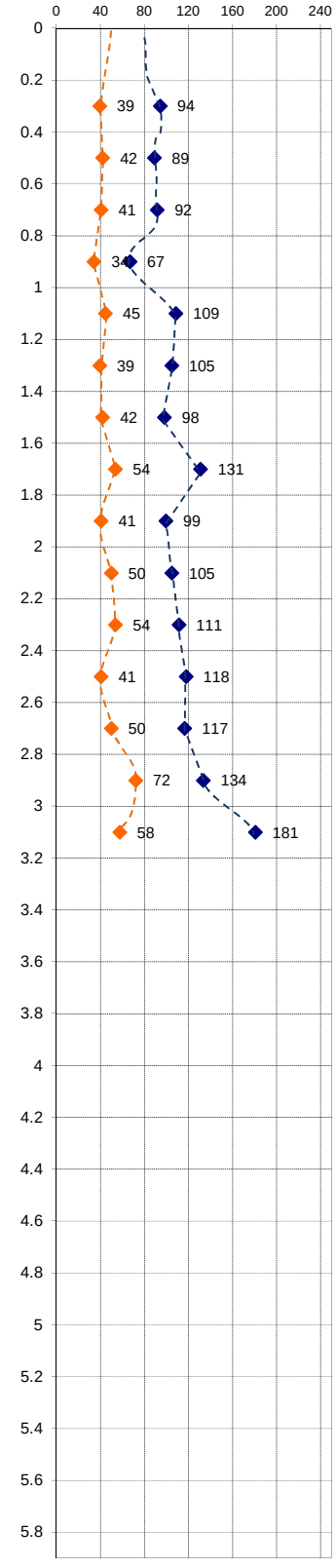
| 5.8 | | | | | |
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** **HA11**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 18/05/2017<br>**Hole completed:** 18/05/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** AHM<br>**Logged by:** AHM |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | | SILT, dark brownish black, moderately organic, moist | Topsoil Fill |
| 0.1 | | M | | GRAVEL, yellowish white, well graded, sub-angular, moist | Limestone Gravel Fill |
| 0.2 | | M | | CLAY, silty, light yellowish brown with dark brownish black patches and slight orange mottling, plastic, moist | Non-Engineered Fill |
| 0.3 | | | | | |
| 0.4 | | | | | |
| 0.5 | | | | orange mottling more frequent | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | | |
| 1.1 | | | | | |
| 1.2 | | M | | SILT, dark brownish black with light brown patches and slight orange mottling, plastic, moist | Buried Original Topsoil |
| 1.3 | | | | | |
| 1.4 | | M | | CLAY, silty, light yellowish brown with orange mottling, plastic, moist | Pleistocene Age Mangatuna Formation |
| 1.5 | | | | End of borehole at 1.5m, target depth reached | |
| 1.6 | | | | Borehole dry on completion | |
| 1.7 | | | | | |
| 1.8 | | | | | |
| 1.9 | | | | | |
| 2.0 | | | | | |
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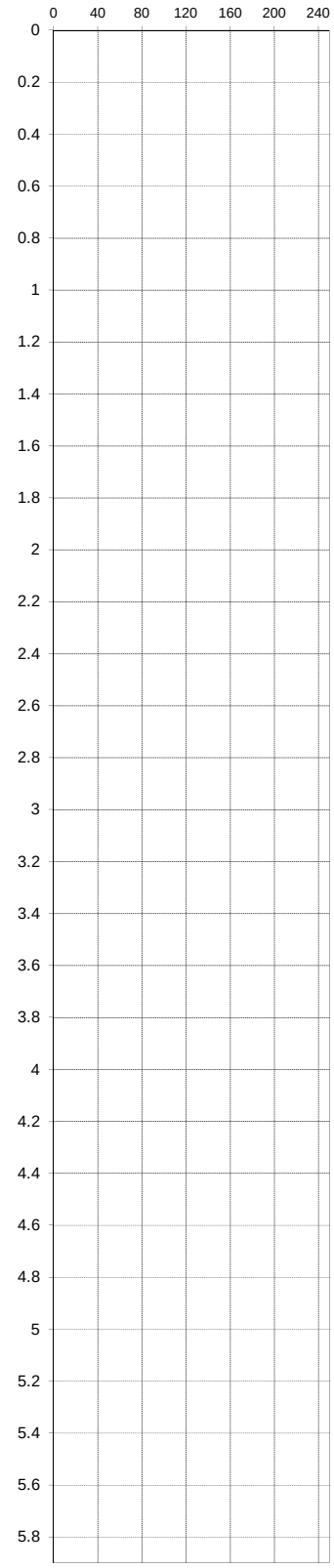
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** **HA12**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 18/05/2017<br>**Hole completed:** 18/05/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** AHM<br>**Logged by:** AHM |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | | SILT, dark brownish black, moderately organic, moist | Topsoil Fill |
| 0.1 | | M | | GRAVEL to COBBLES, yellowish white, well graded, sub-angular, moist | Limestone gravel fill |
| 0.2 | | | | | |
| 0.3 | | M | | CLAY, silty, light yellowish brown with orange mottling, plastic, moist | Pleistocene Age Mangatuna Formation |
| 0.4 | | | | | |
| 0.5 | | | | | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | | |
| 1.1 | | | | | |
| 1.2 | | | | | |
| 1.3 | | | | | |
| 1.4 | | | | | |
| 1.5 | | | | End of borehole at 1.5m, target depth reached | |
| 1.6 | | | | Borehole dry on completion | |
| 1.7 | | | | | |
| 1.8 | | | | | |
| 1.9 | | | | | |
| 2.0 | | | | | |
| 2.1 | | | | | |
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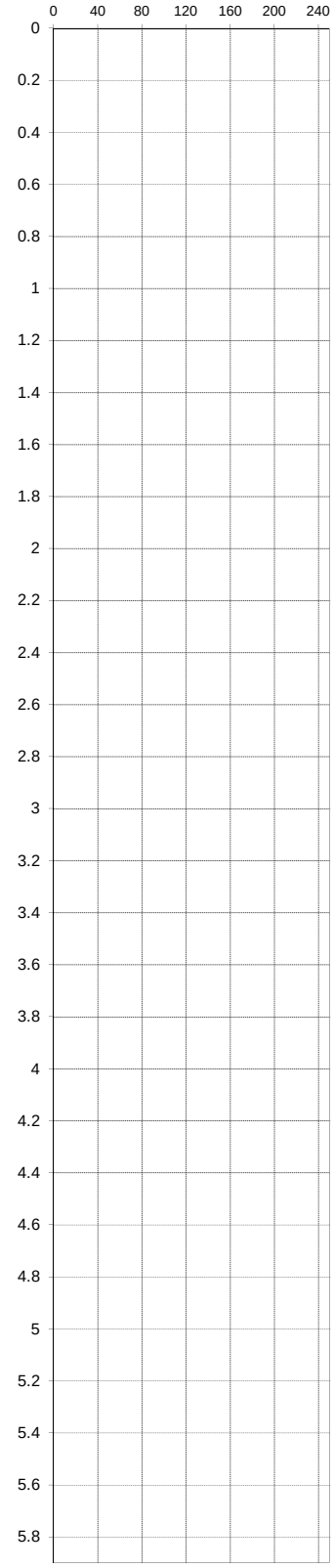
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

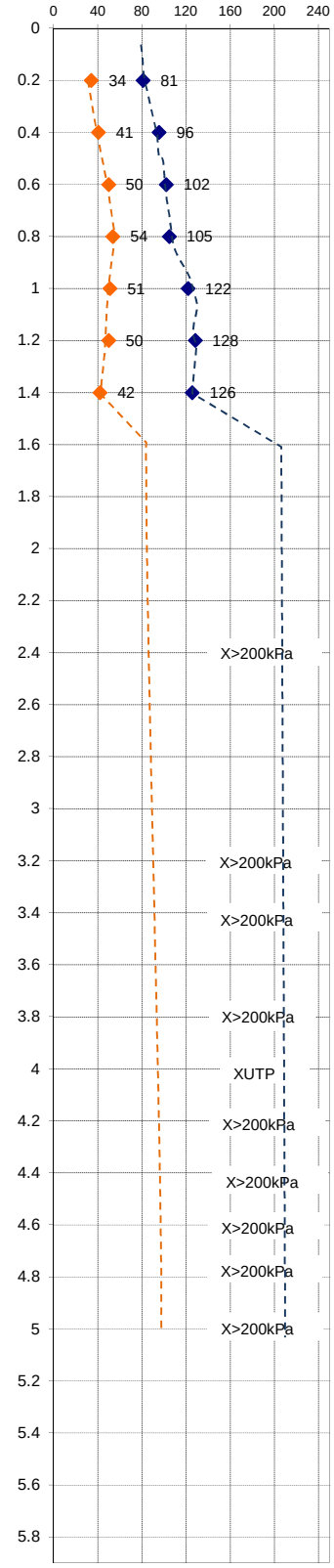
# BOREHOLE LOG

**BOREHOLE No:** HA13

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | St | SILT, some clay, dark grey with light brown streaks, stiff, dry to moist | Topsoil Fill |
| 0.2 | | M | St | CLAY, silty, light brown to greyish brown with rare black pockets, plastic, very stiff, moist | Non-Engineered Fill |
| 0.6 | | M | VSt | CLAY, silty, light brown, very stiff, moist | Pleistocene Age Mangatuna Formation |
| 1.3 | | D-M | MD | SAND, some silt, orange brown stained, fine to medium, well sorted, dry to moist | |
| 1.5 | | | | pocket of fine well rounded gravel | |
| 2.3 | | | | lense of light brown hard silty clay | |
| 2.5 | | | | pocket of well sorted very fine dense white pumiceous sand | |
| 2.9 | | D-M | D | GRAVEL, silty, fine well rounded, stained orange brown, dense, dry to moist | |
| 3.2 | | D-M | H | SILT, rare clay, rare coarse pumiceous sand, light grey and brown with orange brown patches, hard, dry to moist | |
| 3.8 | | | | 3.8m to 3.9m: some fine to medium angular hard light grey pumice gravel within silt matrix | |
| 4.0 | | D-M | H | CLAY, some silt, light grey and light brown with rare orange brown patches, hard, dry to moist | |
| 4.7 | | | | rare coarse pumiceous sand | |
| 5.0 | | | | End of borehole @ 5m depth | |
| 5.1 | | | | Hole dry on completion | |
| 5.2 | | | | Target depth reached | |
| 5.3 | | | | Penetrometer Test P2 put down adjacent | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

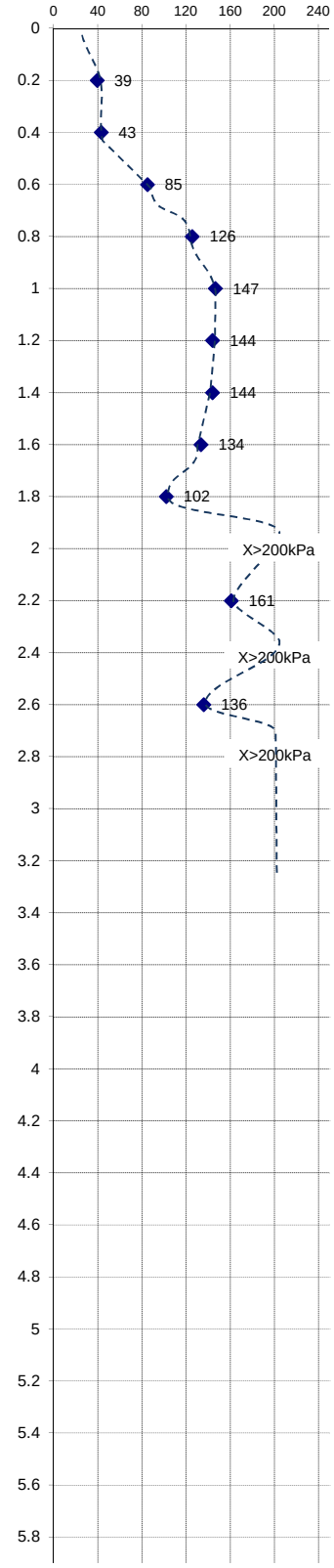
# BOREHOLE LOG

**BOREHOLE No:** HA14

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 30/05/2018<br>**Hole completed:** 30/05/2018 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M | F | CLAY, some silt, mottled dark grey and light brown, firm, moist | Fill |
| 0.2 | | M-W | F | CLAY, rare silt, fat, light brown, firm, sticky, moist to wet | Pleistocene Age Mangatuna Formation |
| 0.5 | | | St | stiff | |
| 0.6 | | | | rare fine decomposed roots | |
| 0.8 | | M | VSt | very stiff, moist | |
| 1.3 | | D-M | | greyish brown, dry to moist | |
| 1.8 | | | | some silt and very fine pumiceous sand | |
| 1.9 | | | | some orange brown staining | |
| 2.0 | | | H | hard | |
| 2.2 | | | VSt | very stiff | |
| 2.4 | | D-M | VSt-H | SILT, light brown, homogenous, very stiff to hard, dry to moist | |
| 3.0 | | | | End of borehole @ 3m depth<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

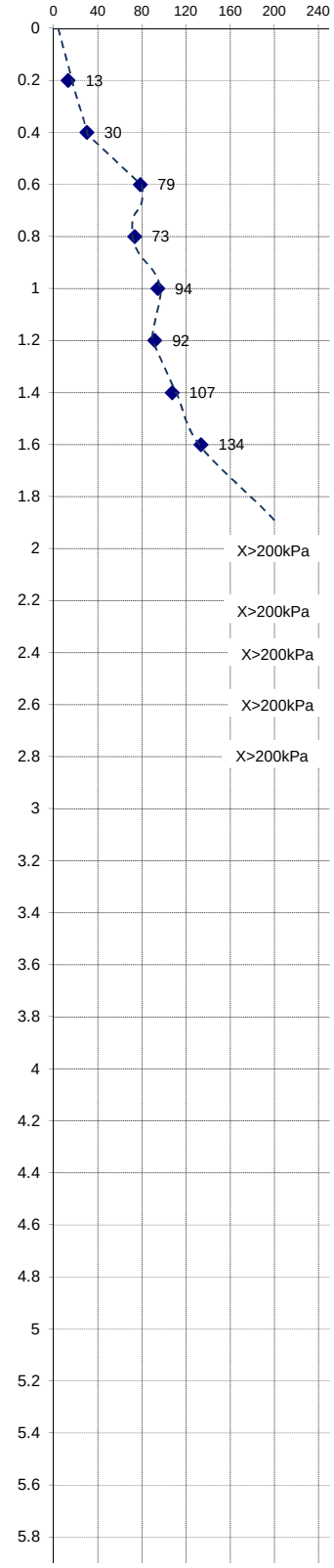
# BOREHOLE LOG

**BOREHOLE No:** **HA15**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 30/05/2018<br>**Hole completed:** 30/05/2018 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0–0.3 | | W | S | CLAY, some silt and decomposed wood, soft, dark brown to light brown, wet | Non-engineered Fill |
| 0.4–0.5 | | M | F | firm, moist | |
| 0.6–0.9 | | | St | stiff | |
| 1.0–1.1 | | | VSt | very stiff | |
| 1.2–1.5 | | D-M | | dry to moist, no decomposed wood | |
| 1.6–1.9 | | D | MD | SILT/very fine SAND, light orange brown, crumbly, medium dense, dry | |
| 2.0–2.1 | | D | H | SILT, black, hard, dry | Original Topsoil (buried) |
| 2.2–2.9 | | D-M | H | SILT, rare fine sand, light orange brown, homogenous, hard, dry to moist<br>rare clay | Pleistocene Age Mangatuna Formation |
| 3.0 | | | | End of borehole @ 3m depth<br>Hole dry on completion<br>Target depth reached | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** **HA16**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 30/05/2018<br>**Hole completed:** 30/05/2018 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | W | S | CLAY, some silt and decomposed wood, soft, dark brown to light brown, wet | Non-engineered Fill |
| 0.1 | | | | | |
| 0.2 | | | | | |
| 0.3 | | | | No Wood | |
| 0.4 | | D | St | dark grey with some light brown mottles, stiff, dry | |
| 0.5 | | | | | |
| 0.6 | | | St | stiff | |
| 0.7 | | | | | |
| 0.8 | | | F | firm | |
| 0.9 | | | | | |
| 1.0 | | | VSt | very stiff | |
| 1.1 | | | | | |
| 1.2 | | D-M | | dry to moist, no decomposed wood | |
| 1.3 | | | | | |
| 1.4 | | | | | |
| 1.5 | | | | | |
| 1.6 | | | H | hard | |
| 1.7 | | | | | |
| 1.8 | | | | some decomposed wood | |
| 1.9 | | | | | |
| 2.0 | | D | H | SILT, black, hard, dry | Original Topsoil (buried) |
| 2.1 | | | | | |
| 2.2 | | D-M | H | CLAY, some silt, light brown to light bluish brown, hard, dry to moist | Pleistocene Age Mangatuna Formation |
| 2.3 | | | | | |
| 2.4 | | | | | |
| 2.5 | | | | End of borehole @ 2.5m depth | |
| 2.6 | | | | Hole dry on completion | |
| 2.7 | | | | Target depth reached | |
| 2.8 | | | | | |
| 2.9 | | | | | |
| 3.0 | | | | | |
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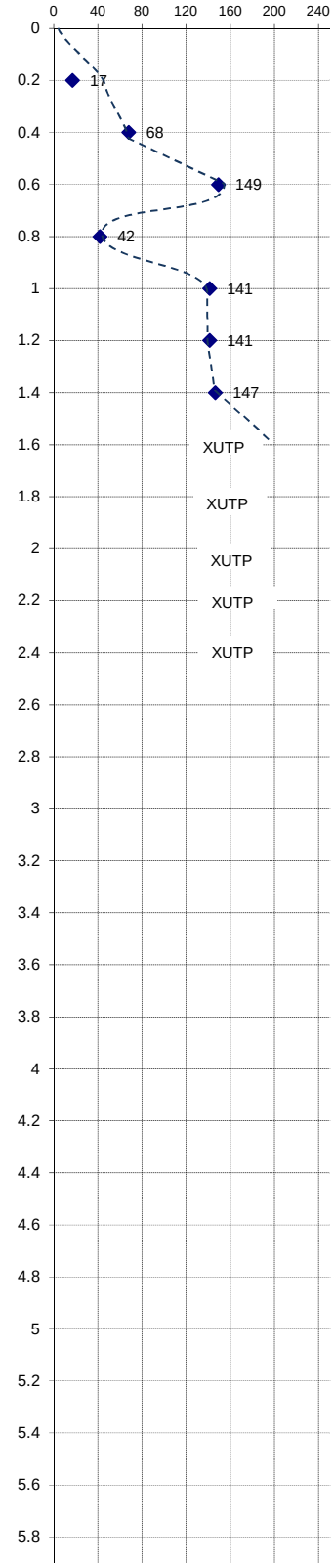
**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**BOREHOLE No:** **HA17**

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Borehole Location:** Refer to Site Investigation Plan | **Hole started:** 30/05/2018<br>**Hole completed:** 30/05/2018 |
| **Co-ordinates:** mN<br>mE | **Drill method:** 50mm handauger | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | W | S | CLAY, some silt and decomposed wood, soft, dark brown to light brown, wet | Non-engineered Fill |
| 0.1 | | | | | |
| 0.2 | | | F | firm | |
| 0.3 | | | | No Wood | |
| 0.4 | | D | VSt | CLAY, some silt, light brown, very stiff, dry to moist | Pleistocene Age Mangatuna Formation |
| 0.5 | | | | | |
| 0.6 | | | H | hard | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | End of borehole @ 1.0m depth | |
| 1.1 | | | | Hole dry on completion | |
| 1.2 | | | | Target depth reached | |
| 1.3 | | | | | |
| 1.4 | | | | | |
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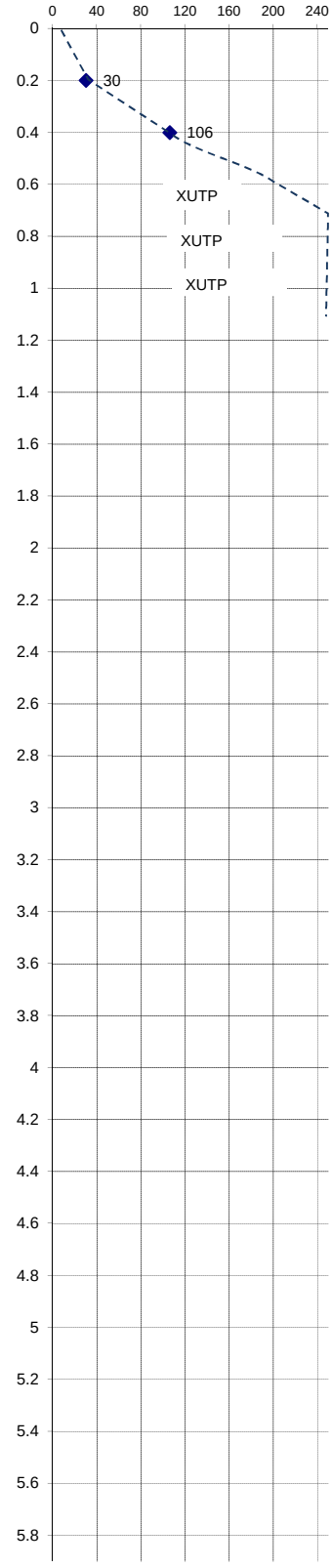
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**



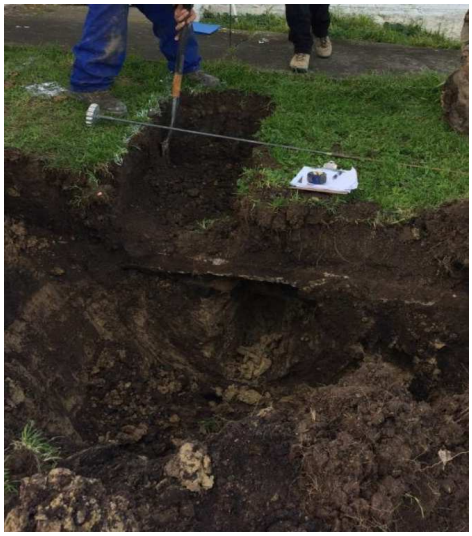

Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

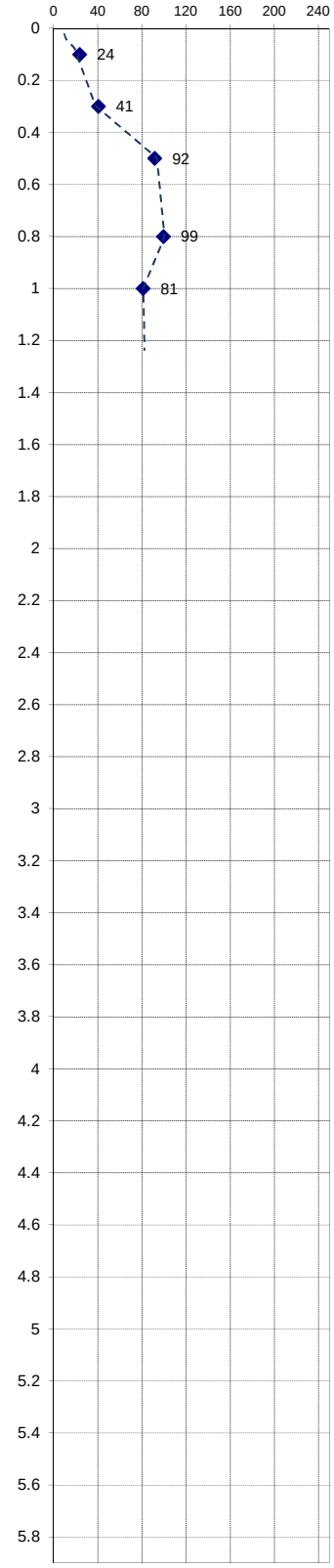
**Test Pit No:** TP1

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Test Pit Location:** At front door of Observatory | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN<br>mE | **Excavator method: 3 Tonne Excavator** | **Drilled by:** Pete Burgess Ltd<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0–1.3 | | M-W | F-St | SILT, some clay and sand, mixed light brown and black, moist to wet (Non-engineered Fill) | Non-Engineered Fill |
| 0.4–0.5 | | | | Concrete slab, 80mm thick, has 200mm deep strip foundation 300mm in from egde of slab on underside, dense | Concret Slab |
| 0.5–1.3 | | M | St | CLAY, silty, light brown to grey, firm to stiff, moist | Pleistocene Age Mangatuna Formation |
| 1.4 | | | | Base of test pit @ 1.4m<br>Test pit dry on completion | |



**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**Test Pit No:** TP2

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Test Pit Location:** Southeastern Corner of Observatory | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN<br>mE | **Excavator method: 3 Tonne Excavator** | **Drilled by:** Pete Burgess Ltd<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | M-W | F-St | Concrete footing 150mm thick | Foundation |
| 0.1 | | M-W | L | SILT, sandy, mixed light brown and black, loose, moist to wet (Non-engineered Fill) | Non-engineered Fill |
| 0.2 | | | | | |
| 0.3 | | M | St | CLAY, silty, light brown to grey, very stiff, moist | Pleistocene Age Mangatuna Formation |
| 0.4 | | | | | |
| 0.5 | | | | Base of test pit @ 0.5m<br>Pit dry on completion | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | | |
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| 1.9 | | | | | |
| 2.0 | | | | | |
| 2.1 | | | | | |
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| 4.9 | | | | | |
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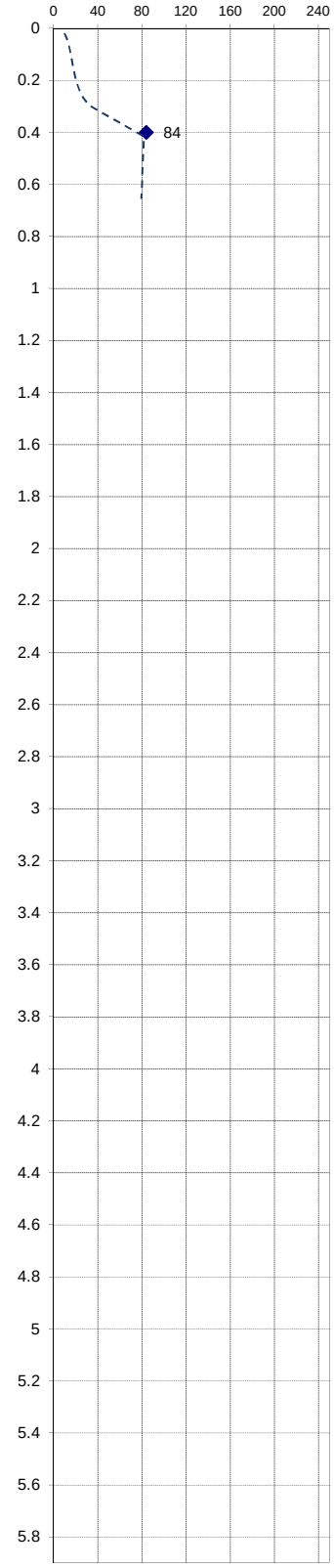
| 5.8 | | | | | |
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

**Test Pit No:** TP3

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Test Pit Location:** Northeastern Corner of Observatory | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN<br>mE | **Excavator method: 3 Tonne Excavator** | **Drilled by:** Pete Burgess Ltd<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 | | D | F-St | Concrete footing 80mm thick | Foundation |
| 0.1 | | D | L | SAND, silty, mixed light brown and black, loose, dry (Non-engineered Fill) | Non-engineered Fill |
| 0.2 | | | | | |
| 0.3 | | D-M | VSt | CLAY, silty, light brown to grey, very stiff, dry to moist | Pleistocene Age Mangatuna Formation |
| 0.4 | | | | | |
| 0.5 | | | | Base of test pit @ 0.5m<br>Pit dry on completion | |
| 0.6 | | | | | |
| 0.7 | | | | | |
| 0.8 | | | | | |
| 0.9 | | | | | |
| 1.0 | | | | | |
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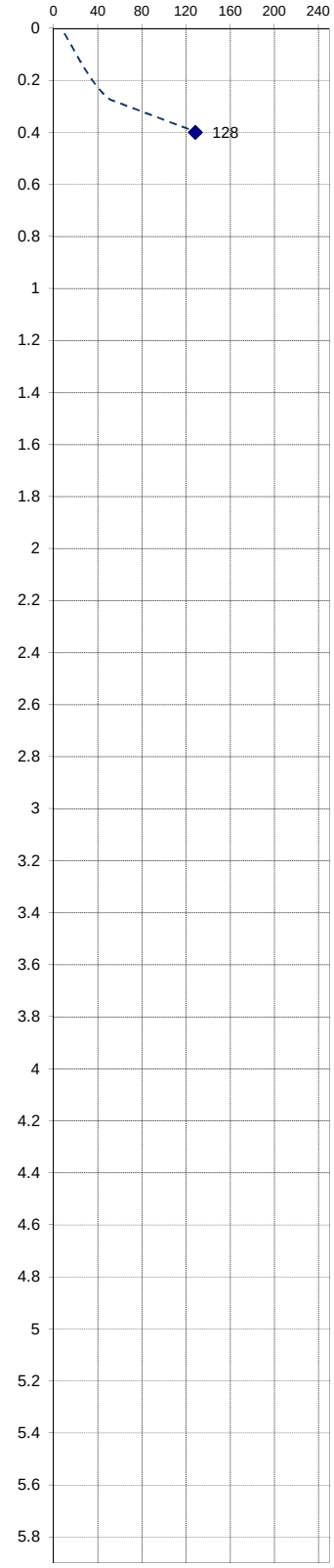
| 5.8 | | | | | |
| 5.9 | | | | | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

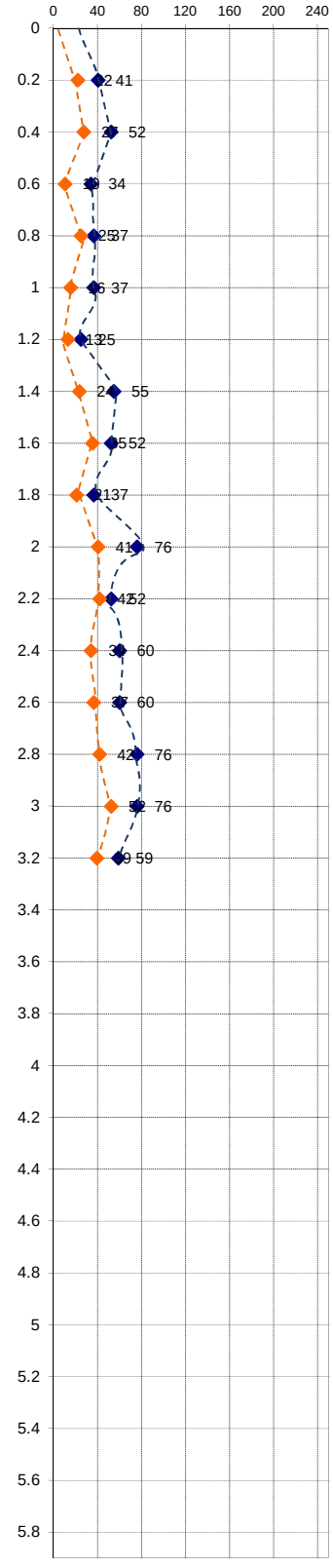
# BOREHOLE LOG

**BOREHOLE No:** EXP1

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Exposure Location:**6m East of Gun Emplacement/Refer to Site Investigation Plan | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN mE | **Drill method:** N/A | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 – 1.3 | | M-W | F-St | CLAY, silty, light brown with black patches,firm to stiff, moist to wet<br>Base of fill sloping towards emplacement @ 25˚ to 30˚ | Non-Engineered Fill |
| 1.4 – 2.0 | | M | F-St | CLAY, silty, light brown to grey, firm to stiff, moist | Pleistocene Age Mangatuna Formation |
| 2.0 – 3.1 | | | St | stiff | |
| 3.2 | | | | Base of Exposure @ 3.2m<br>Undrained shear strengths low due to increase moisture from rainfall event on face of cut | |

**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

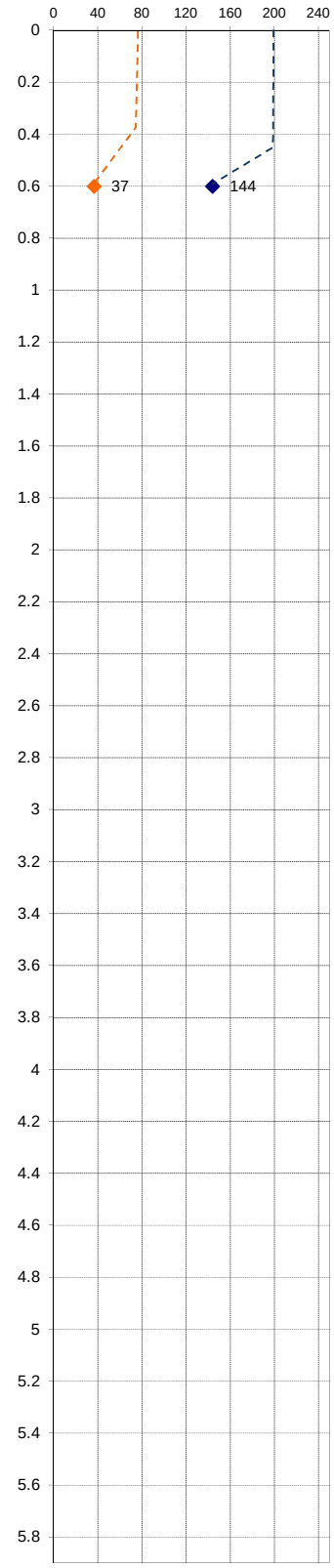
# BOREHOLE LOG

**BOREHOLE No:** EXP2

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Exposure Location:** East of Observatorye/Refer to Site Investigation Plan | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN mE | **Drill method:** N/A | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 – 0.7 | | D-M<br>M | H<br>VSt | CLAY, silty, light brown, desiccated, hard, dry | Pleistocene Age Mangatuna Formation |
| 0.8 – 1.2 | | M-W | MD | SAND, some silt, fine to menium, well sorted, light grey to light brown, medium dense, moist to wet | |
| 1.3 – 1.6 | | M | MD-D | GRAVEL, silty, fine to medium, well rounded, brown with some orange brown staining, medium dense to dense, moist | |
| 1.7 – 5.9 | | | | Base of Exposure @ 1.7m<br>High undraineed shear strengths due to dry nature of clay | |

**Undrained Shear Strength (kPa)**



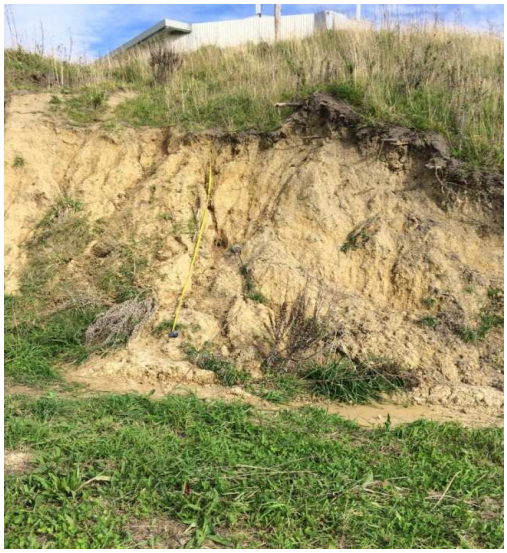

Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# BOREHOLE LOG

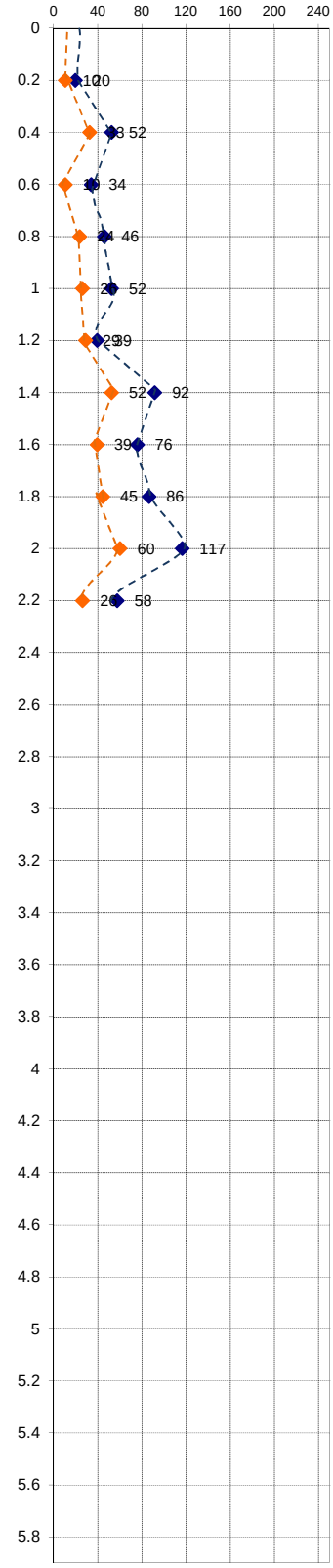
**BOREHOLE No:** EXP3

| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No:** 13364 |
| **Project Location:** Part Lot 3 DP5159, Titirangi Summit, Gisborne | **Exposure Location:** NE of Onbservatory/Refer to Site Investigation Plan | **Hole started:** 19/05/2017<br>**Hole completed:** 19/05/2017 |
| **Co-ordinates:** mN<br>mE | **Drill method:** N/A | **Drilled by:** RGC<br>**Logged by:** RGC |

| Depth (m) | Graphic | Moisture | Strength | Soil Description | Geology |
|---|---|---|---|---|---|
| 0.0 – 1.3 | | M-W | F-St | CLAY, silty, light brown to greyish brown,firm, moist to wet | Pleistocene Age Mangatuna Formation |
| 1.4 – 1.5 | | | St-VSt | stiff to very stiff | |
| 1.6 – 2.1 | | M-W | MD | SAND, silty, tracee of clay, light brown to greyish brown, medium dense, moist to wet | |
| 2.2 – 3.1 | | M-W | MD-D | GRAVEL, sandy, fine to medium, well rounded, stained brown to orange brown, medium dense to dense, moist to wet | |
| 3.2 | | | | Base of Exposure @ 3.2m<br>Undrained shear strengths low due to increase moisture from rainfall event | |



**Undrained Shear Strength (kPa)**




Notes: Shear strength lines are indicative only.
Shear strength calibrated and adjusted for plasticity
UTP: Unable to penetrate

# DRILLHOLE LOG

LAND DEVELOPMENT & EXPLORATION LTD.

**BOREHOLE No:** MBH1



**Client:** Gisborne District Council

**Project:** Geotechnical Investigation

**LDE Project No.:** 13364

**Project Location:** Gisborne Observatory, Titirangi Drive, Gisborne

**Borehole Location:** Refer to site plan

**Hole started:** 27/05/2017
**Hole completed:** 27/05/2017
**Drilled by:** LDE Drilling
**Logged by:** RGC

**Co-ordinates:**

**R.L.** m

**Drill method:** Direct Push

| Tests | Depth (m) | Core Rec' | Graphic | Moisture | Strength | Engineering Description | Defects | Geology |
|---|---|---|---|---|---|---|---|---|
| | 0.0 | | | | | No Core (Compression) | | Non-Engineered Fill |
| | 0.1 | | | M | S | SILT, sandy (pumiceous), rare clay, dark brown to black, soft, moist | | |
| 10 | 0.2 | | | | | | | |
| | 0.3 | | | M | F | SILT, some pumiceous sand, trace rootlets, dark grey to black, friable, firm, moist | | Original Topsoil |
| 35 | 0.4 | | | | | | | |
| | 0.5 | 90 | | M | L | SAND (pumiceous), rare to some fines, brown, loose, moist | | Rhyolitic Tephra (Air fall) |
| 45 | 0.6 | | | | | | | |
| | 0.7 | | | M | F | CLAY, rare pumiceous sand, light brown to light orange brown, firm, moist | | Pleistocene Age Mangatuna Formation |
| 25 | 0.8 | | | | | | | |
| | 0.9 | | | | | | | |
| 40 | 1.0 | | | | | | | |
| | 1.1 | | | | | | | |
| 90 | 1.2 | | | | St | some pumiceous sand, stiff | | |
| | 1.3 | | | | | thin (4mm) clean white pumiceous sand layer (30°dip) | | |
| 80 | 1.4 | | | | | | | |
| | 1.5 | 100 | | | | some dry orange brown patches | | |
| 130 | 1.6 | | | | VSt | rare decomposed rootlets (typical Mangatuna Formation), very stiff | | |
| | 1.7 | | | | | | | |
| 120 | 1.8 | | | | | | | |
| | 1.9 | | | | | | | |
| 100 | 2.0 | | | D-M | | rare completely weathered very weak fine mudstone gravel and shell fragments, dry to moist, crumbly | | |
| | 2.1 | | | | | | | |
| 110 | 2.2 | | | | | | | |
| | 2.3 | | | | | | | |
| 140 | 2.4 | | | M | | moist | | |
| | 2.5 | 100 | | | | Thin (4mm) silt horizons | | |
| 180 | 2.6 | | | | | | 2.6m & 2.8m: Set of slip surfaces, 30° dip, slightly polished, wavy, dry faces-appears relict, grey surfaces on both | |
| | 2.7 | | | | | | | |
| 180 | 2.8 | | | | | | | |
| | 2.9 | | | | | | | |
| 110 | 3.0 | | | D-M | | dry to moist | | |
| | 3.1 | | | | | | | |
| 105 | 3.2 | | | | | | | |
| | 3.3 | | | D-M | VSt | SILT, clayey, light brown to orange brown, very stiff, dry to moist | | |
| 120 | 3.4 | | | | | | | |
| | 3.5 | 100 | | | | | | |
| 120 | 3.6 | | | | | | | |
| | 3.7 | | | | | | | |
| 105 | 3.8 | | | | | | | |
| | 3.9 | | | | | | | |
| 110 | 4.0 | | | | | | | |
| | 4.1 | | | | | | | |
| 125 | 4.2 | | | | | crumbly | | |
| | 4.3 | | | | | | | |
| 100 | 4.4 | | | | | | | |
| | 4.5 | 100 | | | | | | |
| 130 | 4.6 | | | | | 4.6m to 4.8m: Rare shell fragments, sand, and fine well rounded gravel | | |
| | 4.7 | | | | | | | |
| 135 | 4.8 | | | | | | | |
| | 4.9 | | | | | | | |
| 135 | 5.0 | | | | | 5.0m to 5.2m: core loss | | |
| | 5.1 | | | | | | | |
| | 5.2 | | | D | MD | SAND, fine to medium, light brown to orange brown, contains pockets of light brown clay, medium dense, dry | | |
| | 5.3 | | | | | | | |
| | 5.4 | | | | | | | |
| | 5.5 | 80 | | | | | | |
| | 5.6 | | | | | rare fine well rounded gravel and shell fragments | | |
| | 5.7 | | | | | | | |
| | 5.8 | | | | | pocket/lense of light brown clay | | |
| | 5.9 | | | | | | | |

LAND DEVELOPMENT & EXPLORATION LTD.

# DRILLHOLE LOG

**BOREHOLE No:** MBH1



| | | |
|---|---|---|
| **Client:** Gisborne District Council | **Project:** Geotechnical Investigation | **LDE Project No.:** 13364 |
| **Project Location:** Gisborne Observatory, Titirangi Drive, Gisborne | **Borehole Location:** Refer to site plan | **Hole started:** 27/05/2017<br>**Hole completed:** 27/05/2017 |
| **Co-ordinates:** | **R.L.** m<br>**Drill method:** Ditrect Push | **Drilled by:** LDE Drilling<br>**Logged by:** RGC |

| Tests | Depth (m) | Core Rec' | Graphic | Moisture | Strength | Engineering Description | Defects | Geology |
|---|---|---|---|---|---|---|---|---|
| 145 | 6.0 | | | D | MD | SAND, fine to medium, light brown to orange brown, contains pockets of light brown clay, medium dense, dry | | Pleistocene Age Mangatuna Formation |
| | 6.1 | | | | | | | |
| | 6.2 | | | | | | | |
| | 6.3 | | | | | | | |
| | 6.4 | 100 | | D | MD | GRAVEL, sandy, well rounded, fine to medium, medium dense, dry | | |
| | 6.5 | | | | | | | |
| 100 | 6.6 | | | | | SILT, rare clay and pumiceous sand, light greenish brown with orange brown veins, medium dense, dry to moist | | |
| | 6.7 | | | | | | | |
| 100 | 6.8 | | | | | | | |
| | 6.9 | | | | | | | |
| 100 | 7.0 | | | | | End of Borehole @ 7.0m | | |
| | 7.1 | | | | | Borehole Dry on Completion | | |
| | 7.2 | | | | | | | |
| | 7.3 | | | | | | | |
| | 7.4 | | | | | | | |
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| | 11.9 | | | | | | | |



LAND DEVELOPMENT & EXPLORATION LTD.

Titirangi Observatory, Titirangi Drive, Gisborne

Machine Borehole One Core Photographs

| | |
|---|---|
| DRAWN | RGC |
| CHECKED | GEW |
| DATE | 14-Jun-18 |
| PROJECT | 13364 |


| | | | |
|---|---|---|---|
| LDE LAND DEVELOPMENT & EXPLORATION LTD. | Titirangi Observatory, Titirangi Drive, Gisborne<br>Machine Borehole One Core Photographs | DRAWN | RGC |
| | | CHECKED | GEW |
| | | DATE | 14-Jun-18 |
| | | PROJECT | 13364 |

# Numeric Slope Stability Analyses Summary Information Sheet & Models

Numeric Slope Stability Analyses Strength Parameter Table

Table 1: Soil Strength Parameters

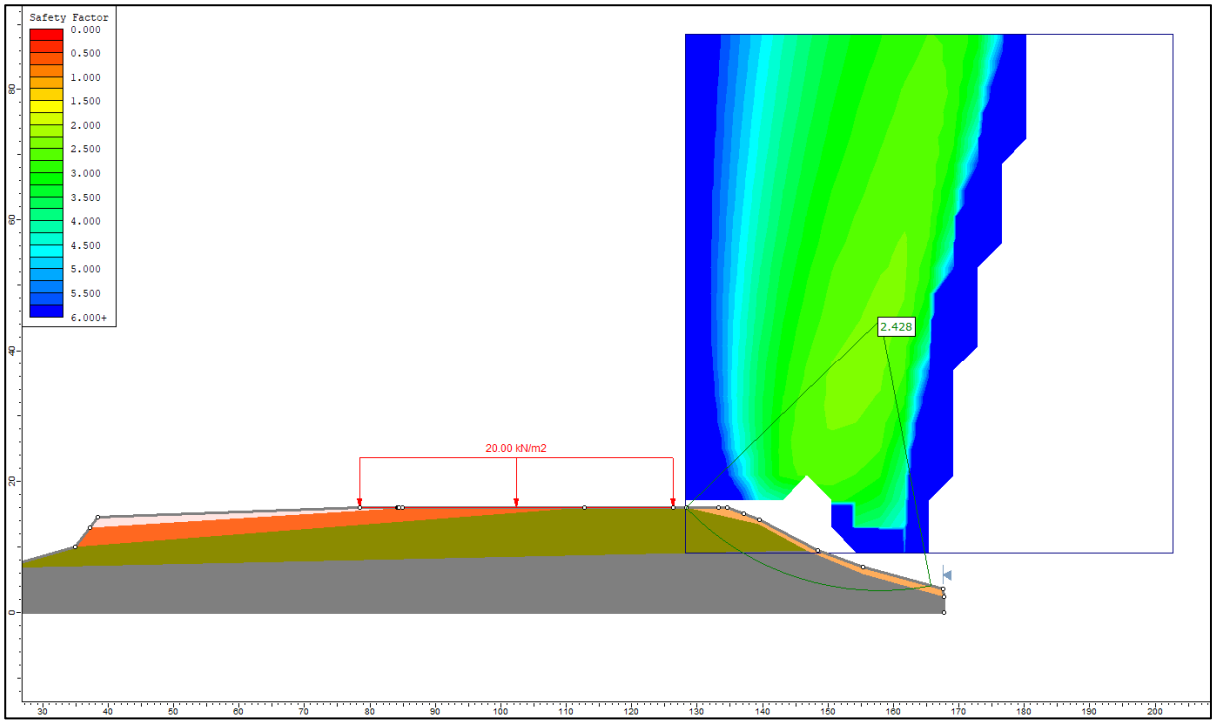
| Material | γ (kN/m³) | C' (kPa) | Ø' (°) | Su (kPa) |
|---|---|---|---|---|
| Non-engineered Fill | 18 | 2 | 25 | - |
| Firm Clay | 19 | 3 | 24 | 25 |
| Stiff To Very Stiff Clay | 19 | 4 | 26 | 75 |
| Very Stiff To Hard Clay | 19 | 7 | 30 | 150 |
| Medium Dense To Dense Sand & Gravel | 20 | 1 | 35 | - |
| High Density Cemented Tephra/Very Weak Sandstone | UCS = 1MPa | GSI = 60, IRC = 7 | | |

Numeric Slope Stability Analyses Material Colour Key

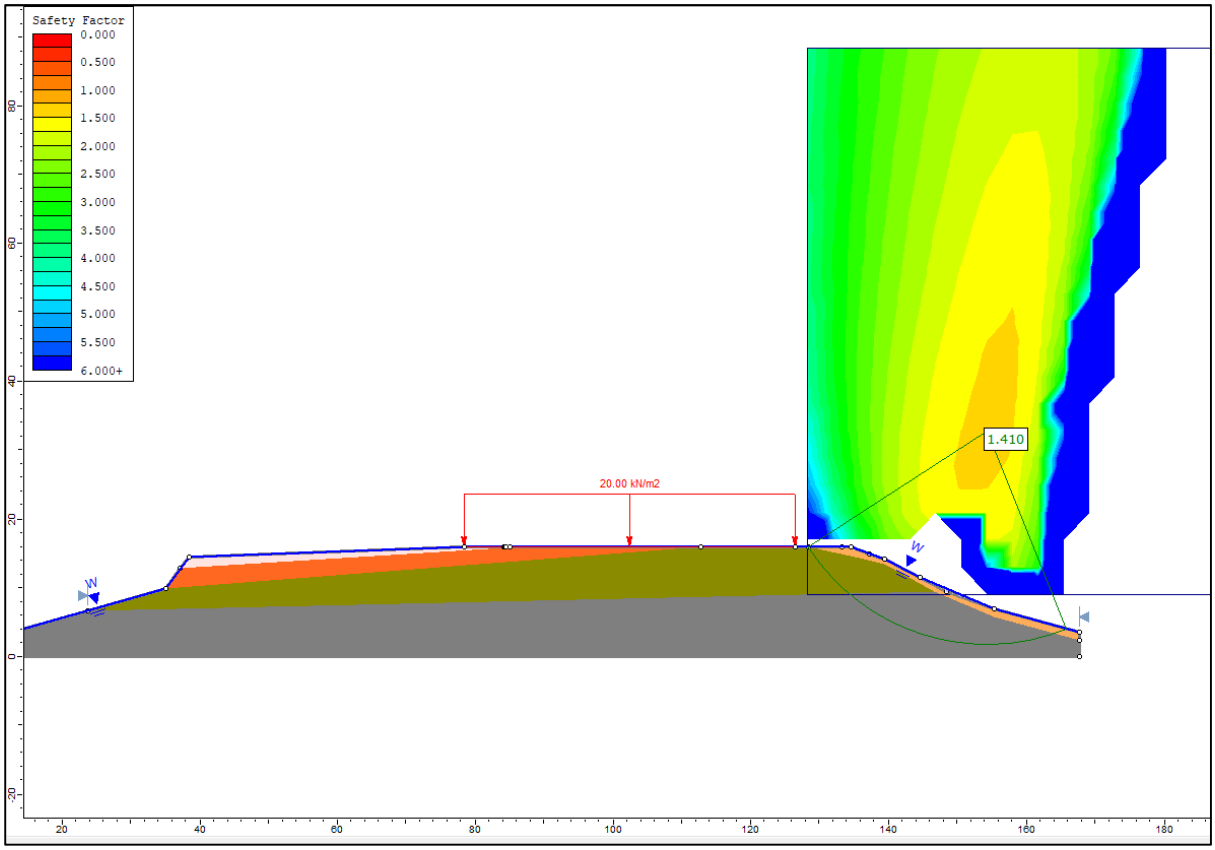
| Material Name | Color |
|---|---|
| Non-Engineered Fill | |
| Firm Clay | |
| Stiff To Very Stiff Clay | |
| Very Stiff To Hard Clay | |
| Medium Dense To Dense Sand & Gravel | |
| High Density Cemented Tephra/very Weak Sandstone | |

Notes:

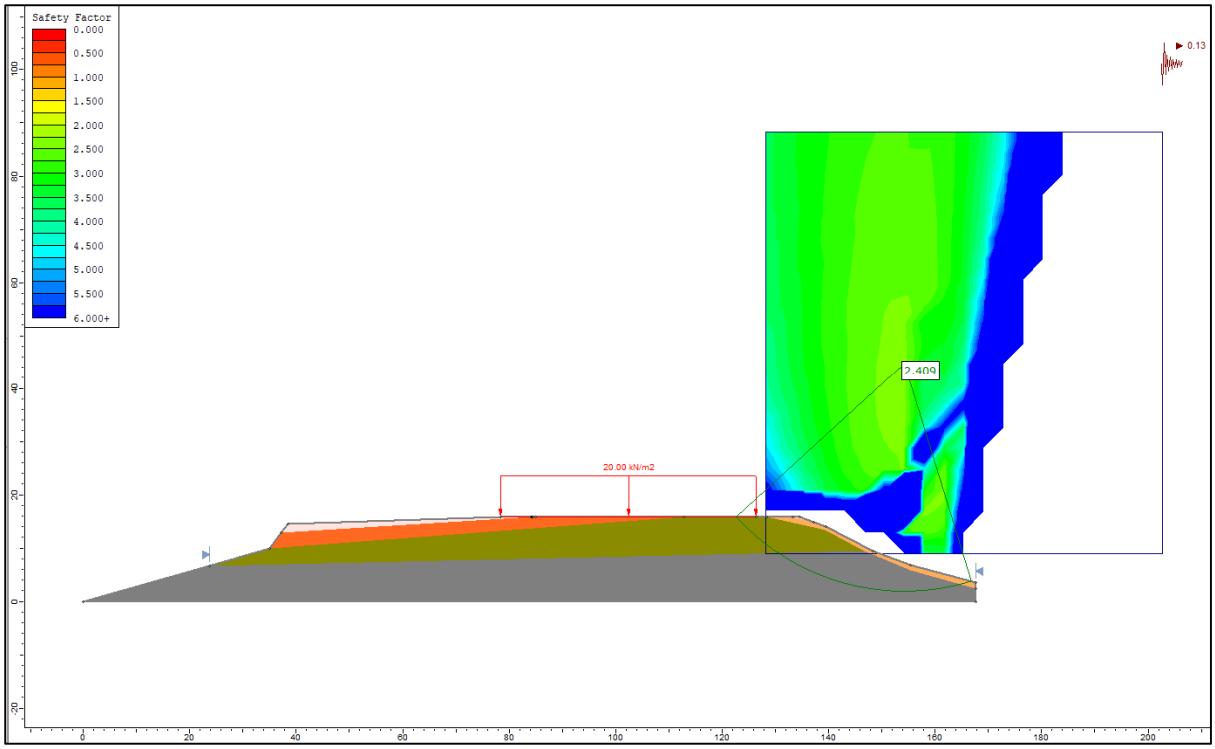
A distiributed load of 20kN/m² representing the likley load of the future building has been applies to each model on top of the new platfrom proposed to be created.



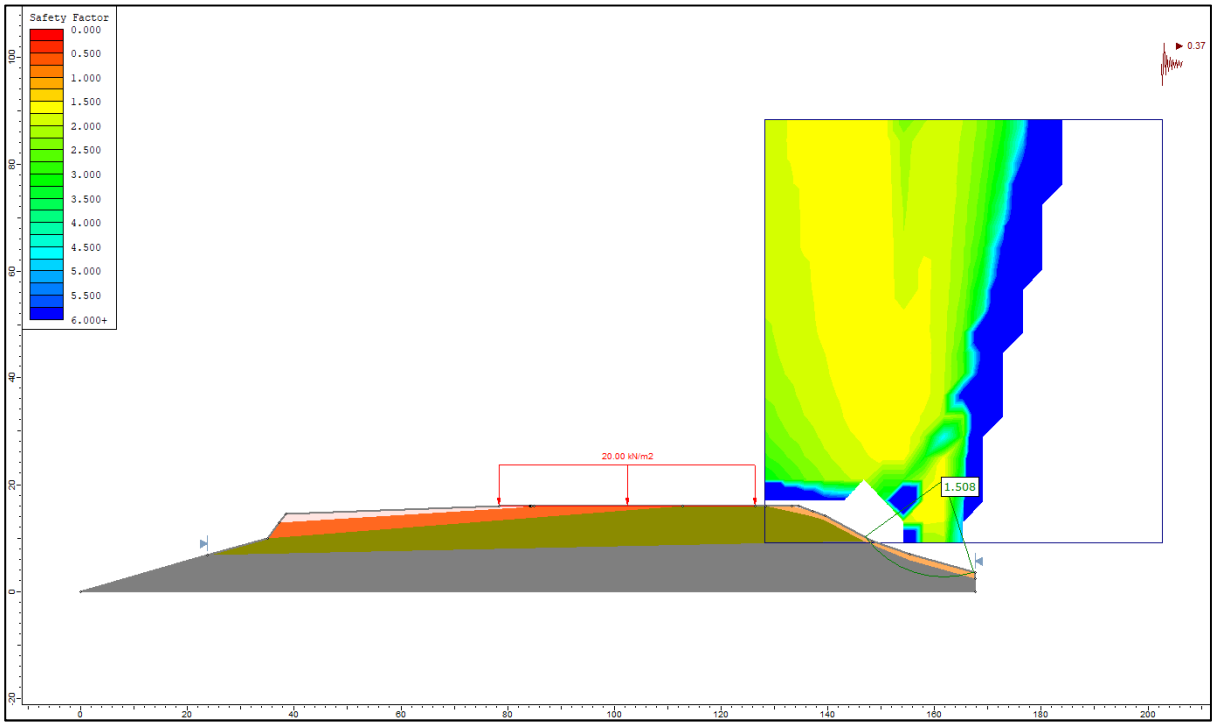

Rotational model north slope – Design/Prevailing groundwater condition showing FoS values exceed 1.5.



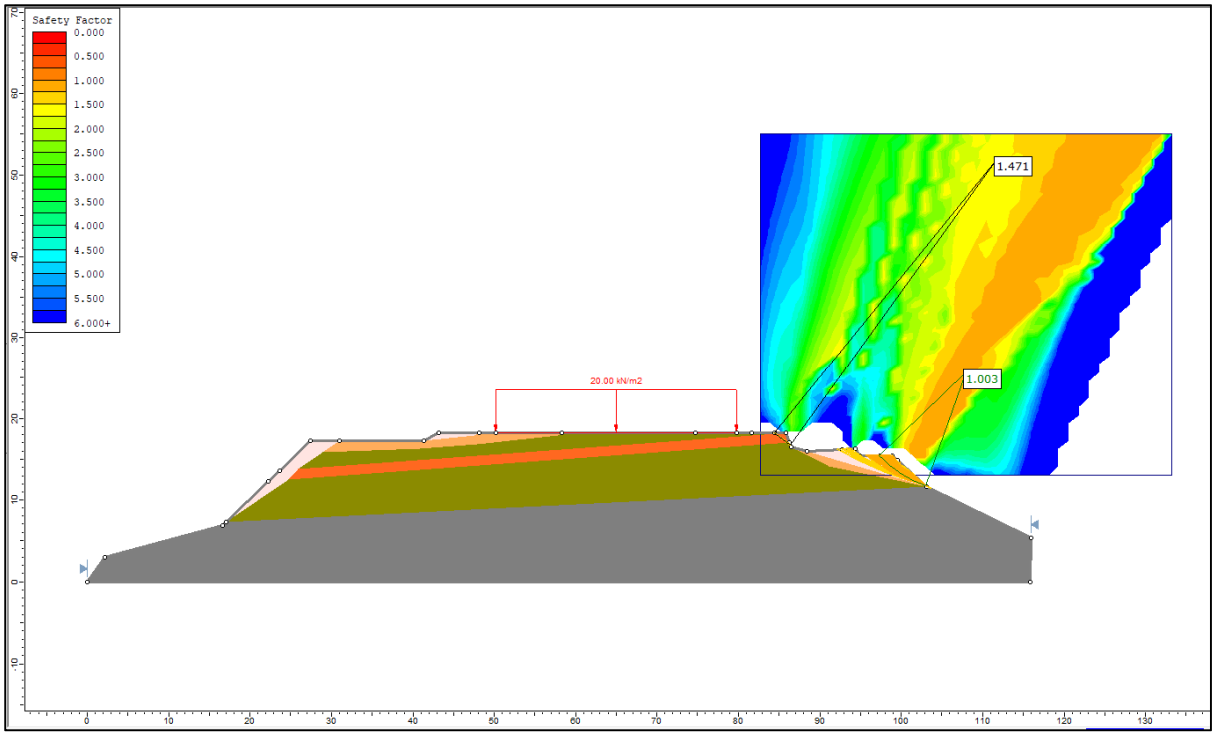

Rotational model north slope – Extreme groundwater condition showing FoS values exceed 1.2.



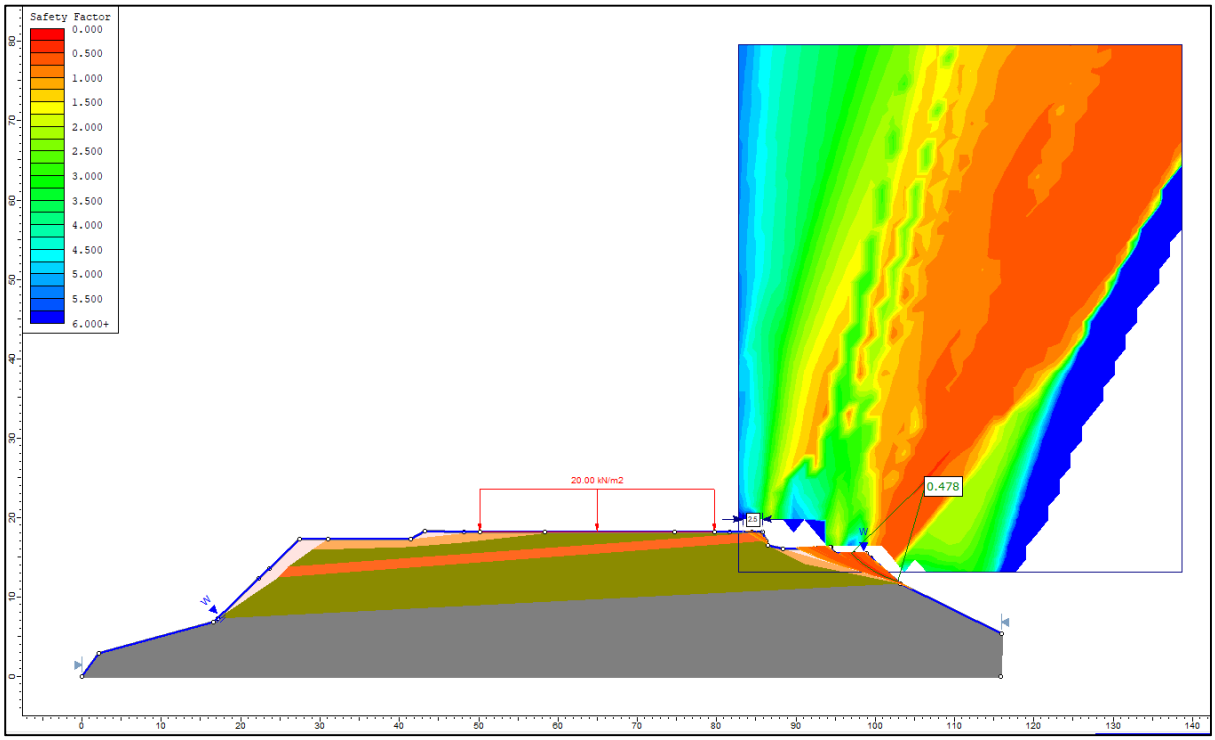

Rotational model north slope – SLS seismic condition showing FoS values exceed 1.0.



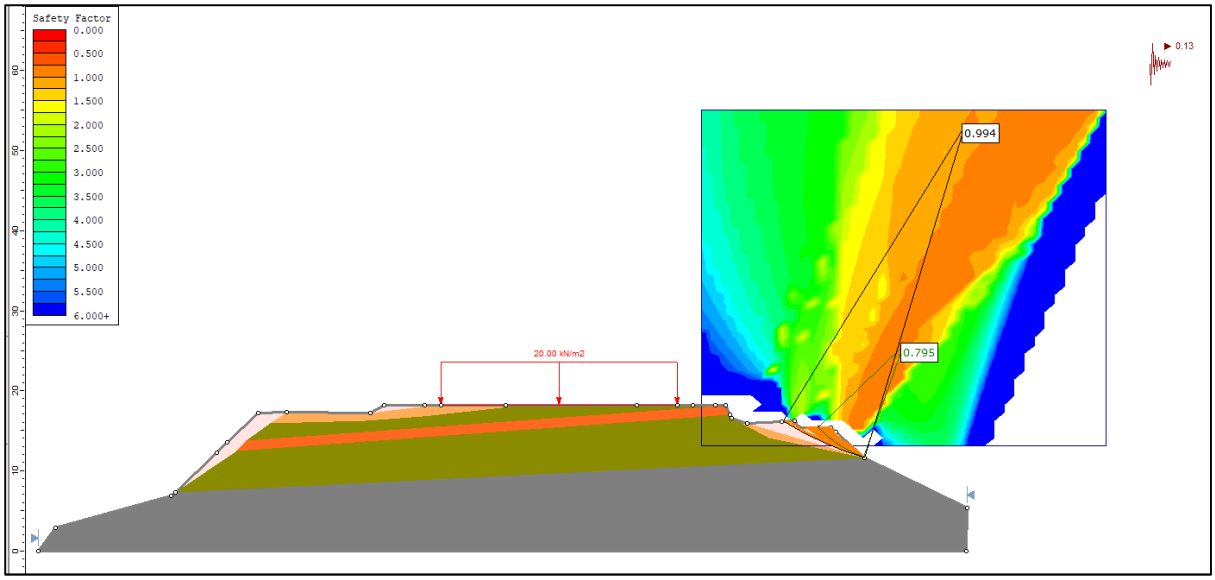

Rotational model north slope – ULS seismic condition showing FoS values exceed 1.0.



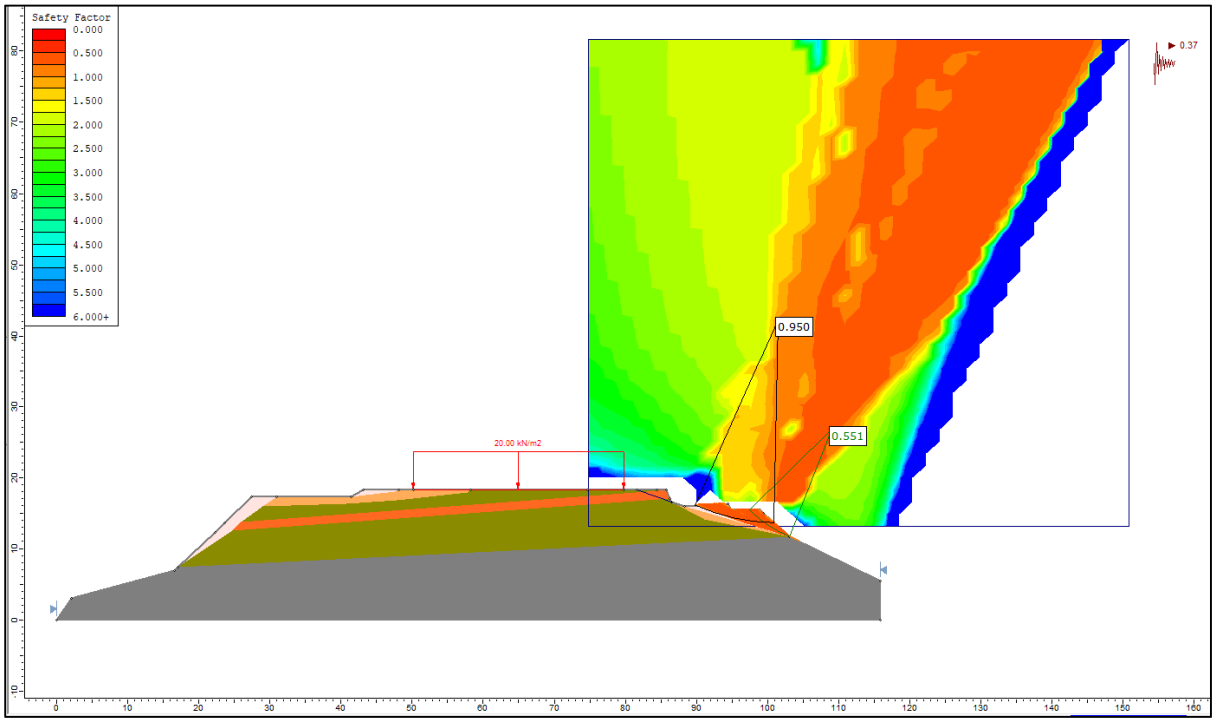

Rotational model east slope – Design/Prevailing groundwater condition showing FoS values <1.5



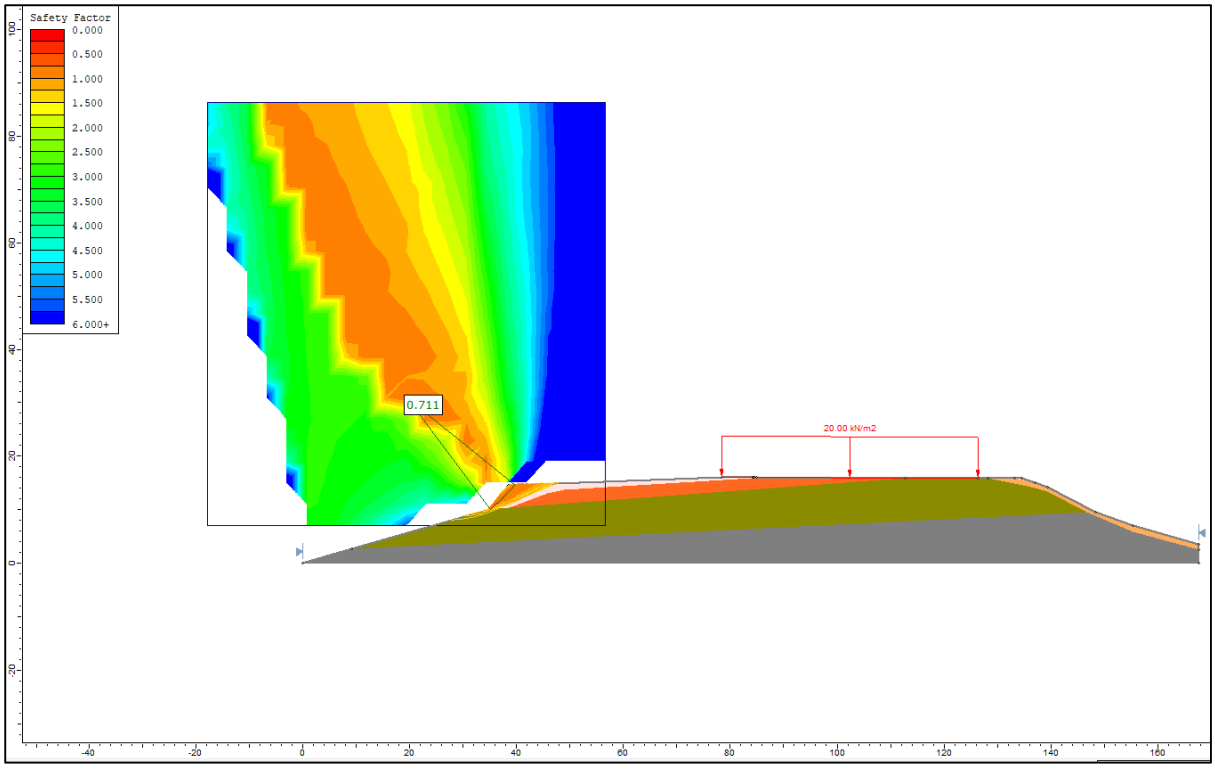

Rotational model east slope – Extreme groundwater condition showing FoS values <1.2



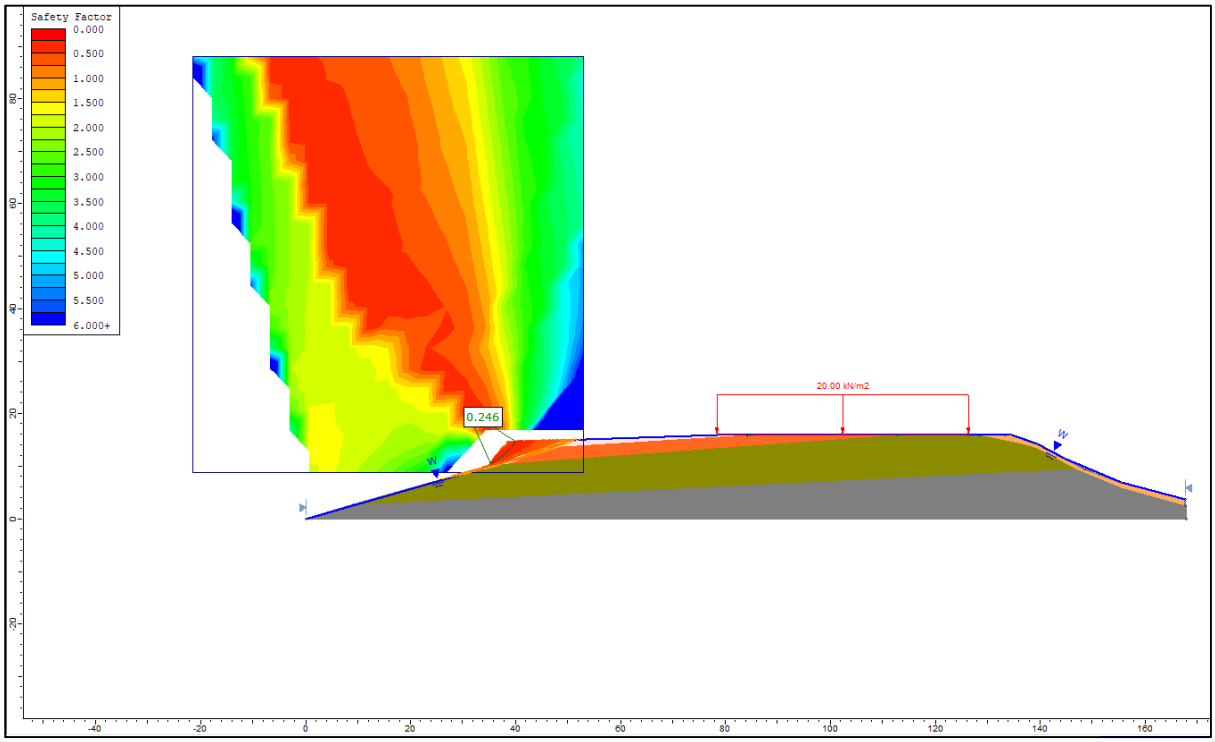

Rotational model east slope – SLS seismic condition showing FoS values <1.0



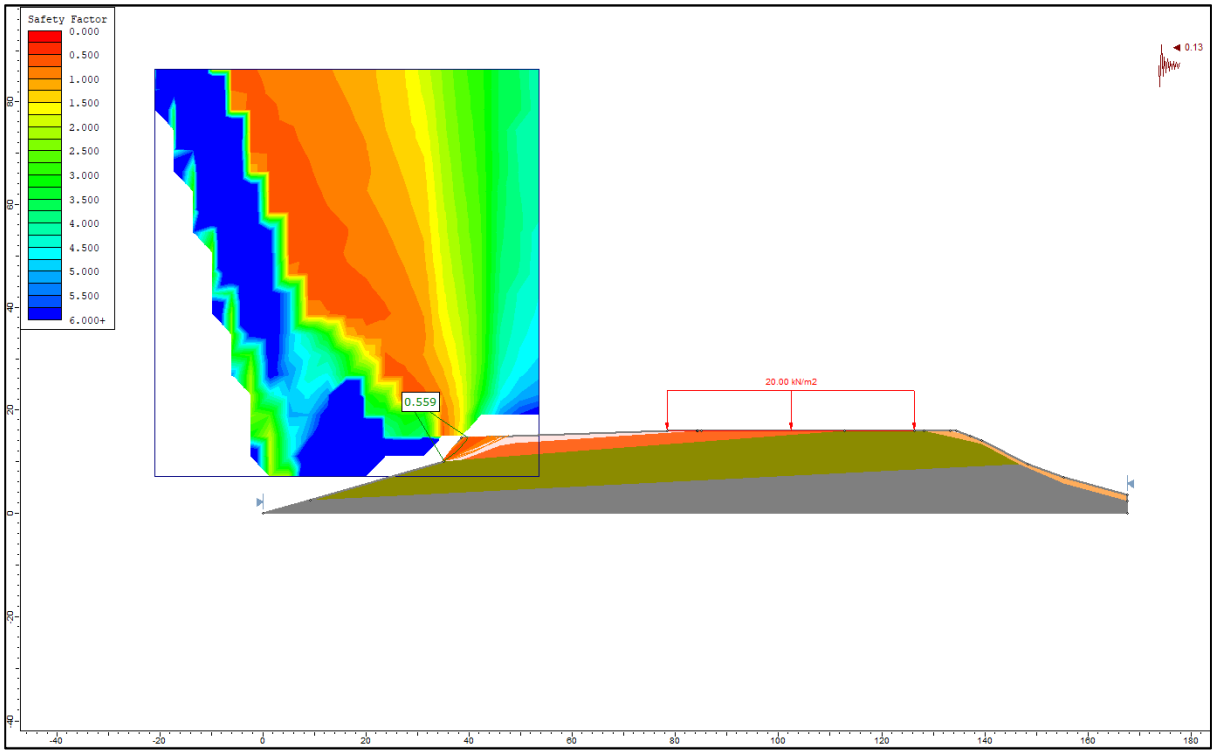

Rotational model east slope – ULS seismic condition showing FoS values <1.0



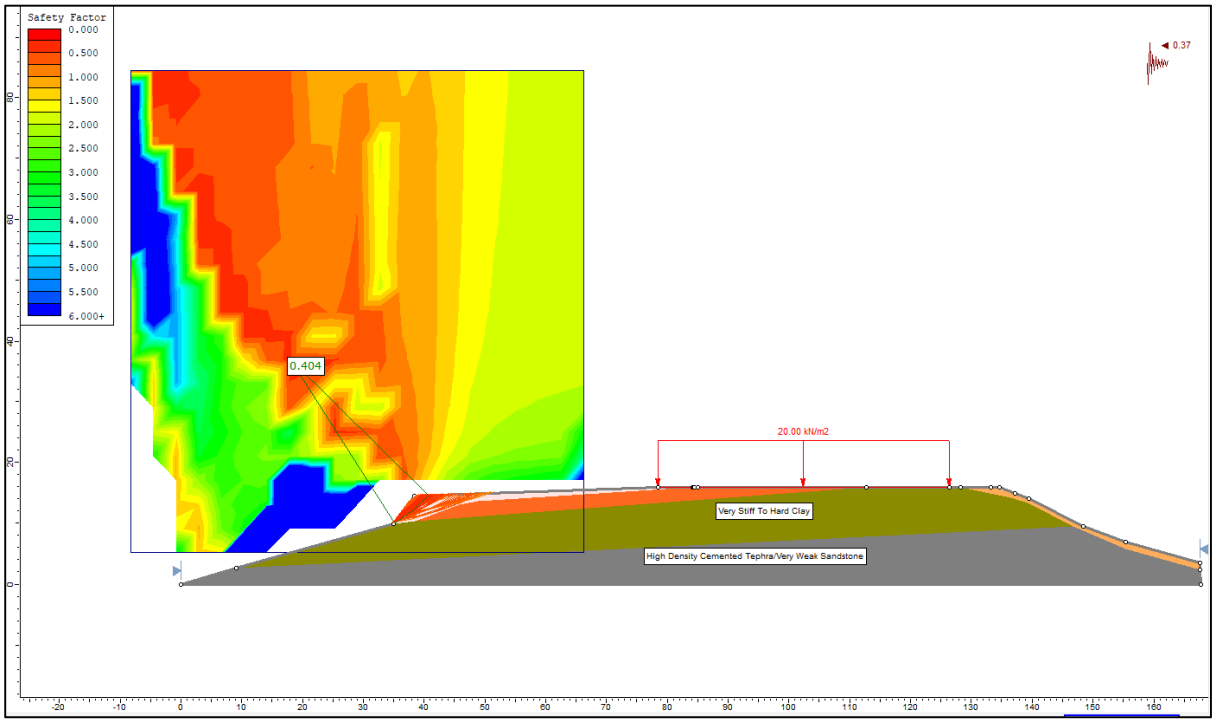

Rotational model south slope – Design/Prevailing groundwater condition showing FoS values <1.5.



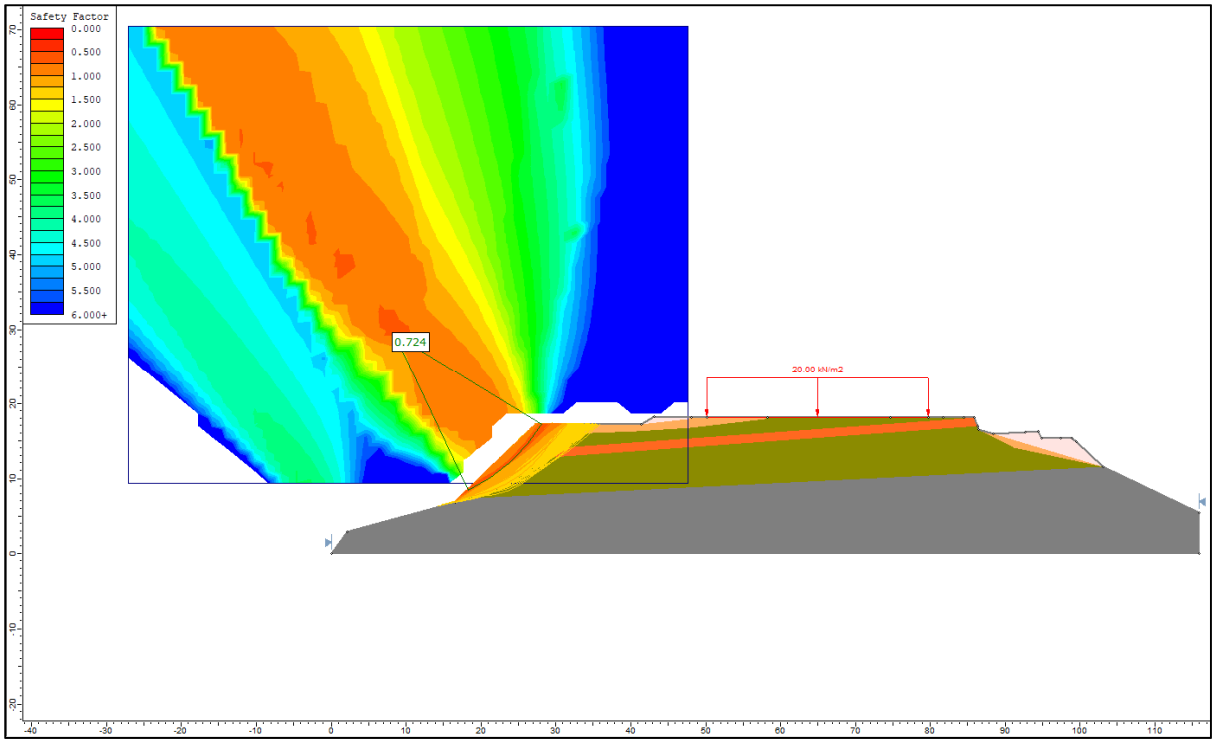

Rotational model south slope – Extreme groundwater condition showing FoS values <1.2.



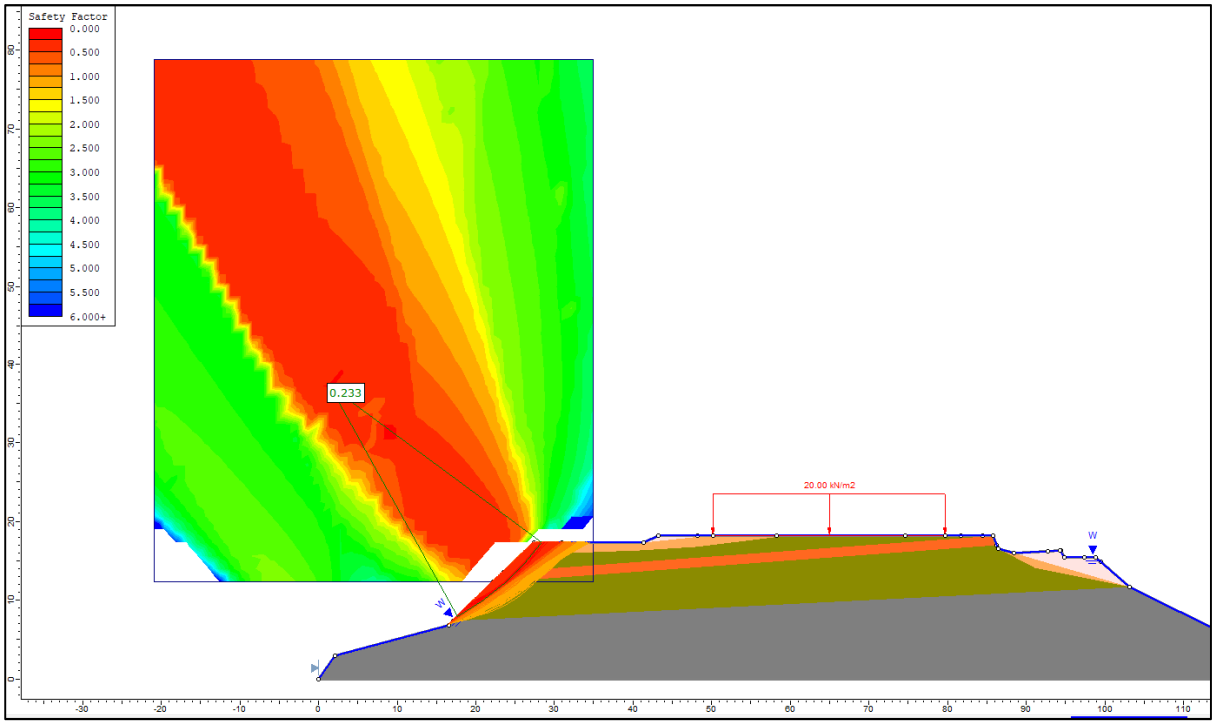

Rotational model south slope – SLS seismic condition showing FoS values <1.0.



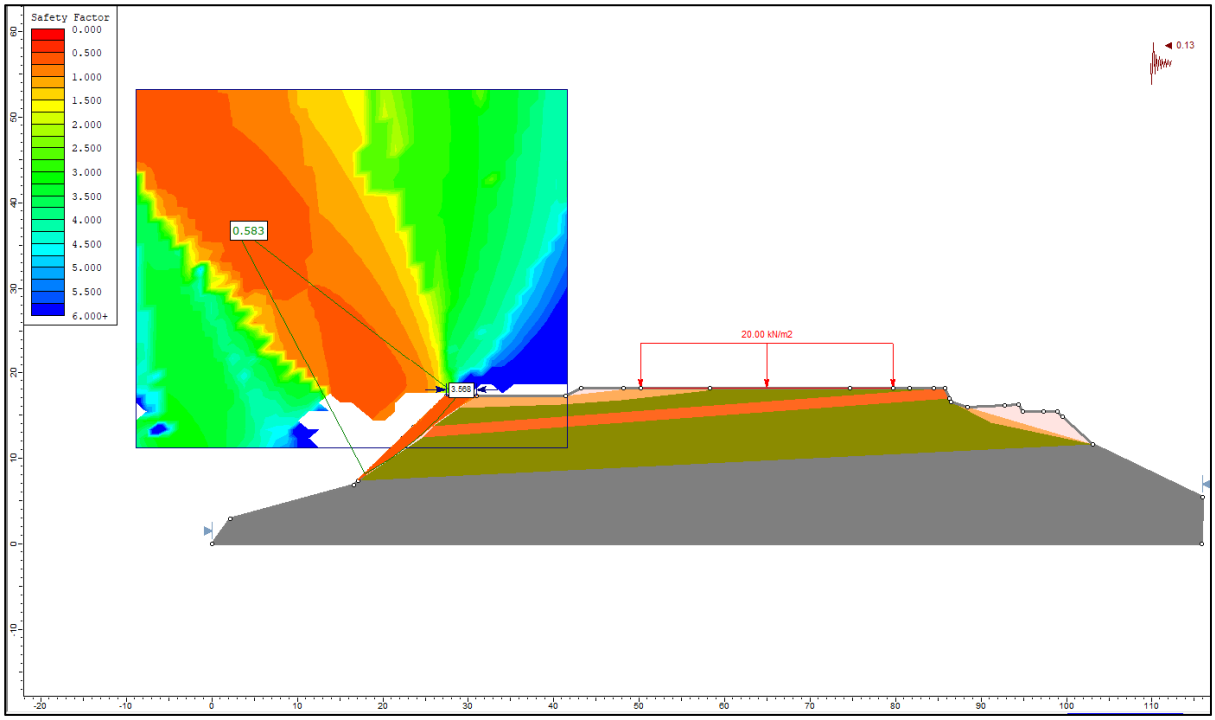

Rotational model south slope – ULS seismic condition showing FoS values <1.0.



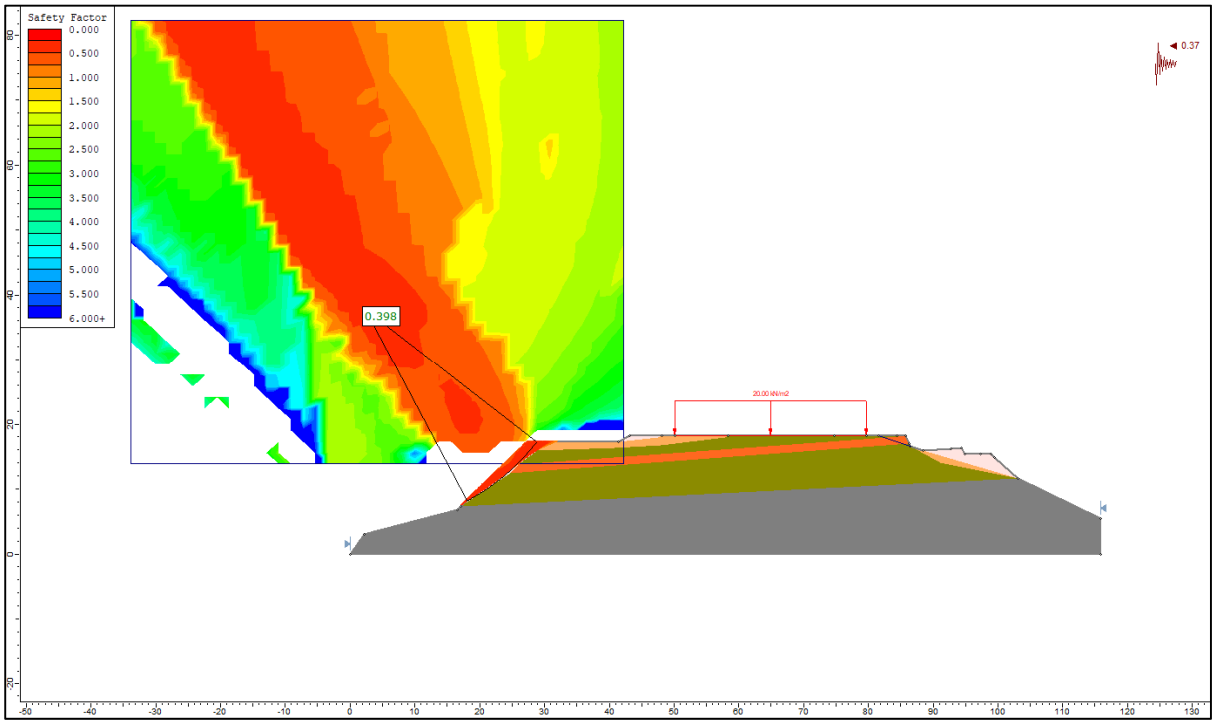

Rotational model southwest slope -Design/Prevailing groundwater condition showing FoS values <1.5.



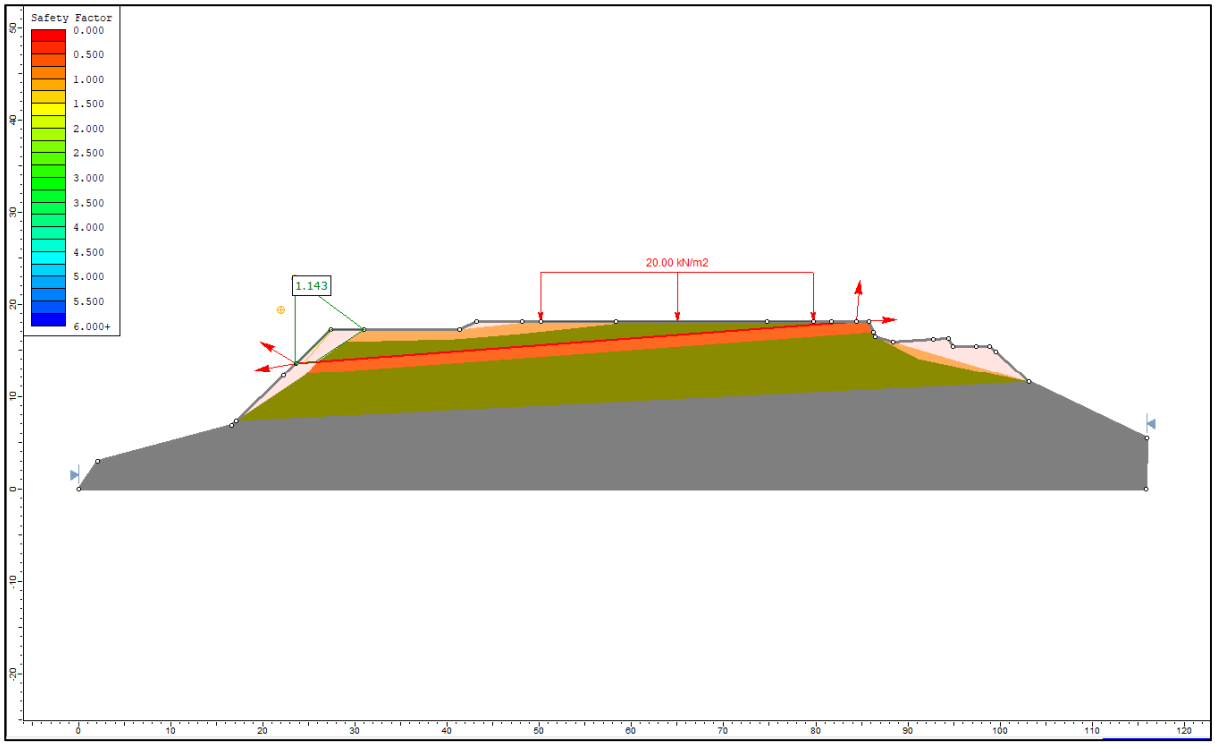

Rotational model southwest slope -Extreme groundwater condition showing FoS values <1.2



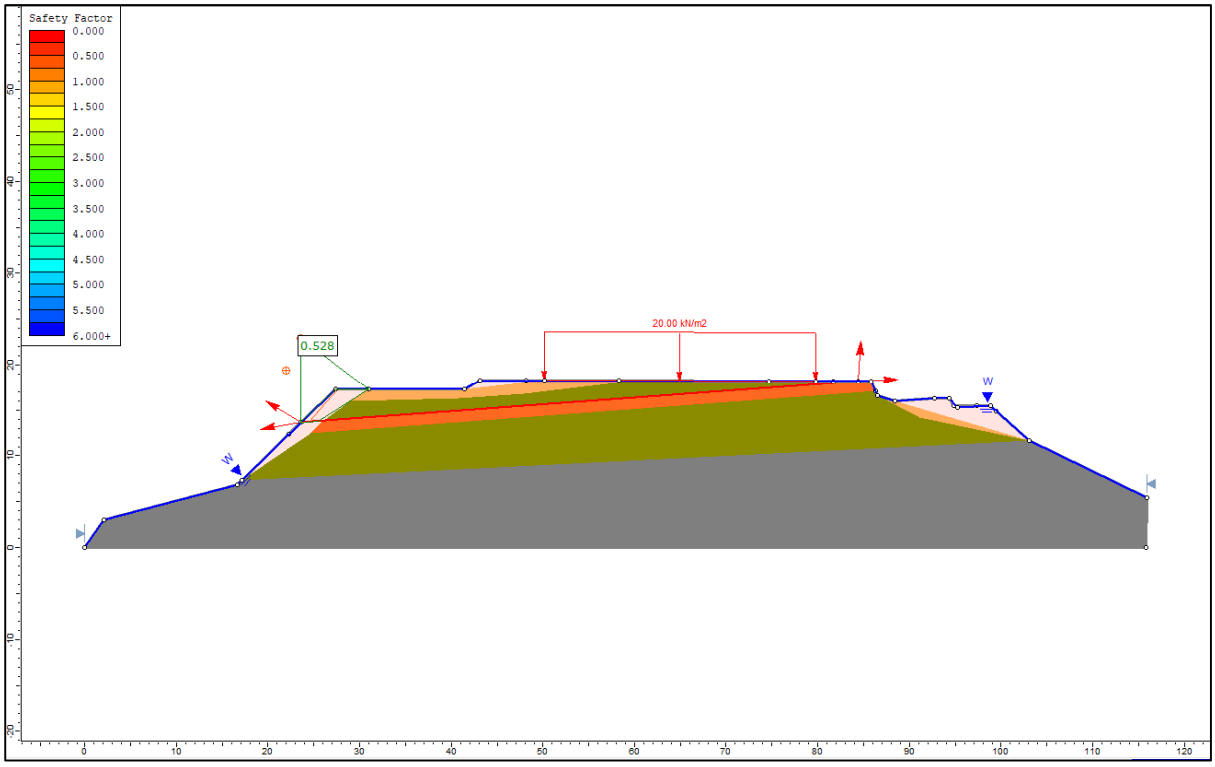

Rotational model southwest slope –SLS seismic condition showing FoS values <1.0



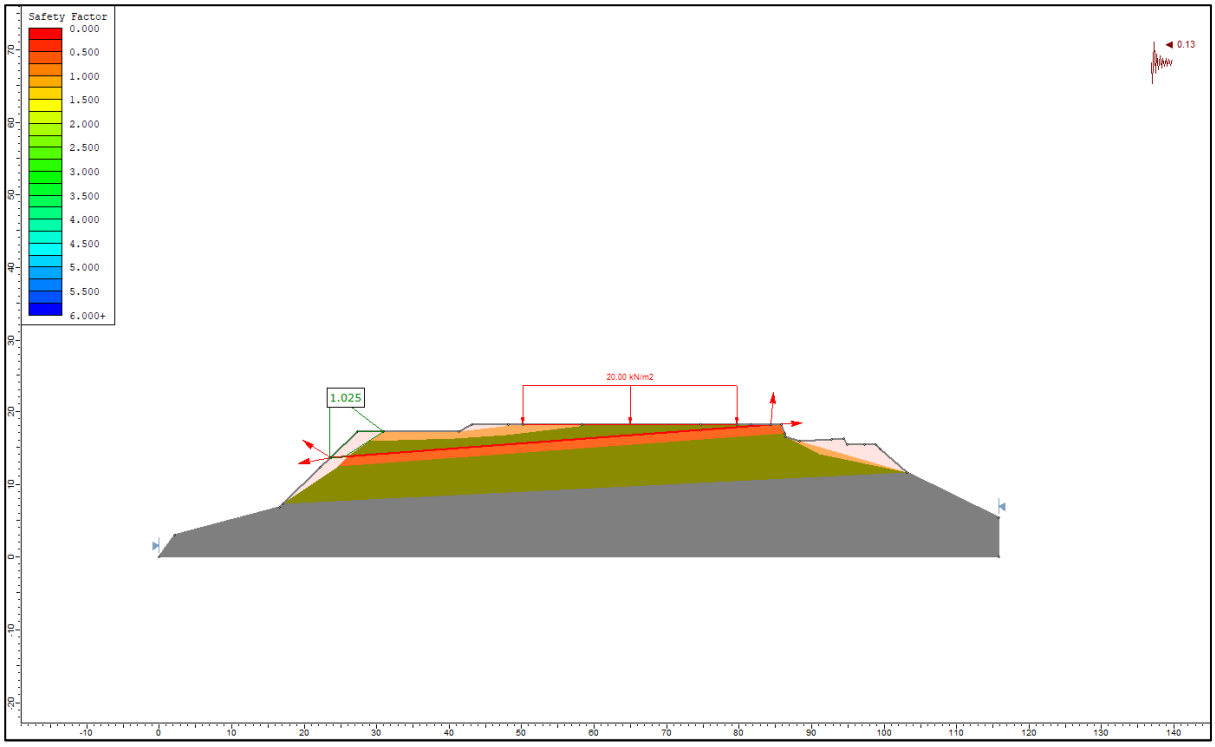

Rotational model southwest slope –ULS seismic condition showing FoS values <1.0.



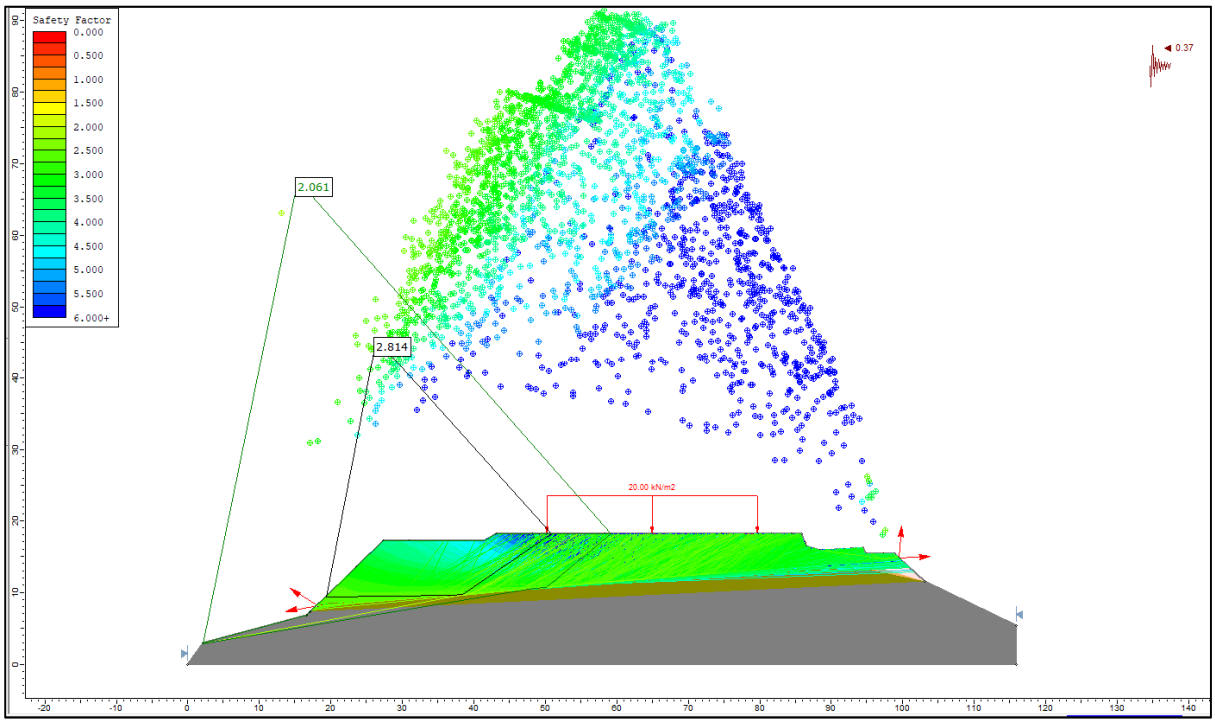

Translational model southwest slope -Design/Prevailing groundwater condition showing FoS values <1.5.




Translational model southwest slope– Extreme groundwater condition showing FoS values <1.2.




Translational model southwest slope – SLS seismic condition showing FoS values exceed 1.0.




Translational model southwest – ULS seismic condition showing FoS values exceed 1.0.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