# Geotechnical Report for a subdivision at Cowan Bay Road, Pohuehue

Prepared for Cowan Bay Farm Limited

Project 46953 - GEO/1 - 28/06/2017

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Our opinions and recommendations are based on our comprehension of the current regulatory standards and must not be considered legal opinions. For legal advice, please consult your solicitor. This opinion is not intended to be advice that is covered by the Financial Advisors Act 2010.

The recommendations and opinions contained in this report are based on our visual reconnaissance of the site, information from geological maps and upon data from the field investigation as well as the results of in situ testing of soil. Inferences are made about the nature and continuity of subsoils away from and beyond the exploratory holes which cannot be guaranteed. The descriptions detailed on the exploratory hole logs are based on the field descriptions of the soils encountered.

This report includes the following Appendices:

Appendix A –Subdivision Scheme Plan

Appendix B – Individual Lot Survey Plans

Appendix C – Exploratory Hole Logs

Appendix D – Hand Augered Exploratory Hole Core Photos

Appendix E – Slope Stability Models

These Appendices should be read in conjunction with the main part of the report and this report should not be considered complete without them.

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# 1.0 INTRODUCTION

Engineering Design Consultants Ltd (EDC) has been contracted to provide a geotechnical investigation and report on land at Cowan Bay Farm, Cowan Bay Road, Pohuehue, Auckland for a proposed subdivision.

This geotechnical investigation has been conducted to determine whether the land on which the development work has been proposed is likely to be subject to erosion, subsidence, or slippage; or whether the proposed development work itself is likely to accelerate, worsen, or result in instability of the land or any other property; and to recommend adequate provisions to protect the land or the proposed development or other property from instability in accordance with the provisions of the Building Act 2004. The report also contains recommendations for foundations.

## 2.0 SITE DESCRIPTION

The legal description of the site is Lot 2 DP 501845 and Lot 11 DP 476990. The site has an area of 884,837m$^2$. The site is located on the northern side of Cowan Bay Road, which roughly follows a main west to east trending ridgeline and the site boundary forms an irregular shape. The site contains one existing dwelling and shed on the southern side of Cowan Bay Road. The site has a number of sidling ridge and valley features across it, the slopes of the individual ridges relevant to the proposed lots will be outlined in later sections.

According to the Auckland Council GIS Viewer, a stream runs along the northern boundary of the site, before opening into an estuary where it meets Cowan Bay. There are also a number of overland flow paths and streams that run down the valley features on the site. These features are shown on Figure 1.

According to the Auckland Council GIS Viewer there are no wastewater or stormwater services on the site.

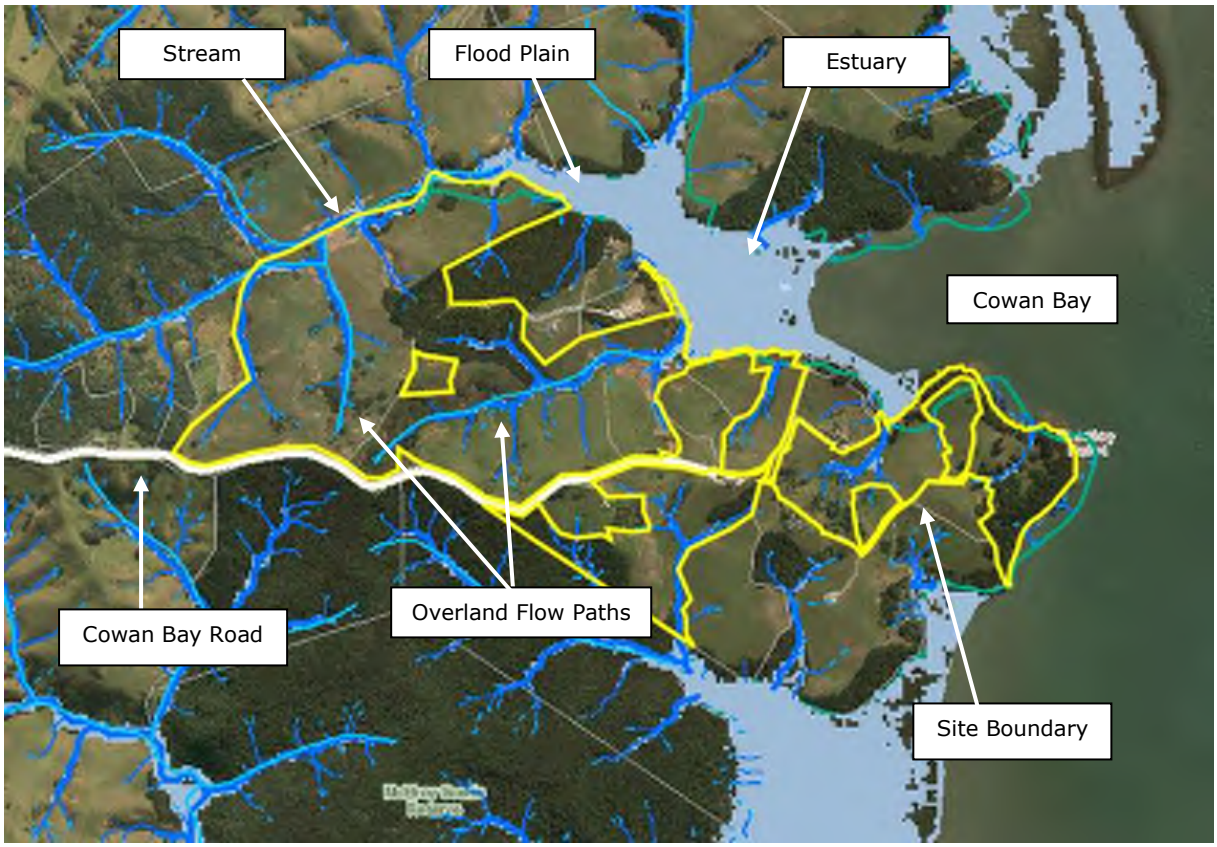


**Figure 1: Site boundary and features (aerial photo from Auckland Council GIS Viewer)**

## 3.0 PROPOSED DEVELOPMENT

Lot 2 DP 501845 is to remain as a working farm. It is proposed to subdivide Lot 11 DP 476990 into 6 Lots. Lots 1 – 5 will have a suitable building platform identified and will be developed for residential occupation. Lot 6 will be the balance of the subdivision. A large area of Lot 6 is proposed to be planted. Figure 2 illustrates the approximate locations of the proposed Building Platforms (BP). The building platform number corresponds with the proposed Lot number. The Subdivision scheme plan is attached in Appendix A

Building Platform 1 is being investigated by RPH Consultants Ltd. Building platforms 2, 3 and 5 are located at the top of slopes, while building platform 4 is located midway down a slope approximately below building platform 3. The survey plans drafted by Parallax Consultants Ltd, for each individual lot are attached in Appendix B.


**Figure 2: Approximate building platform locations (aerial photo from Auckland Council GIS Viewer)**

# 4.0 DESKTOP STUDY

## 4.1 Published Geology

In assessing the geology of the site, we have referred to the following geological maps and records:

1. **Edbrooke S. W. (Compiler) "Geology of The Auckland Area" QMAP 1: 250 000 Sheet 3 Geological Map; IGNS Wellington.**
2. **New Zealand Geotechnical Database**

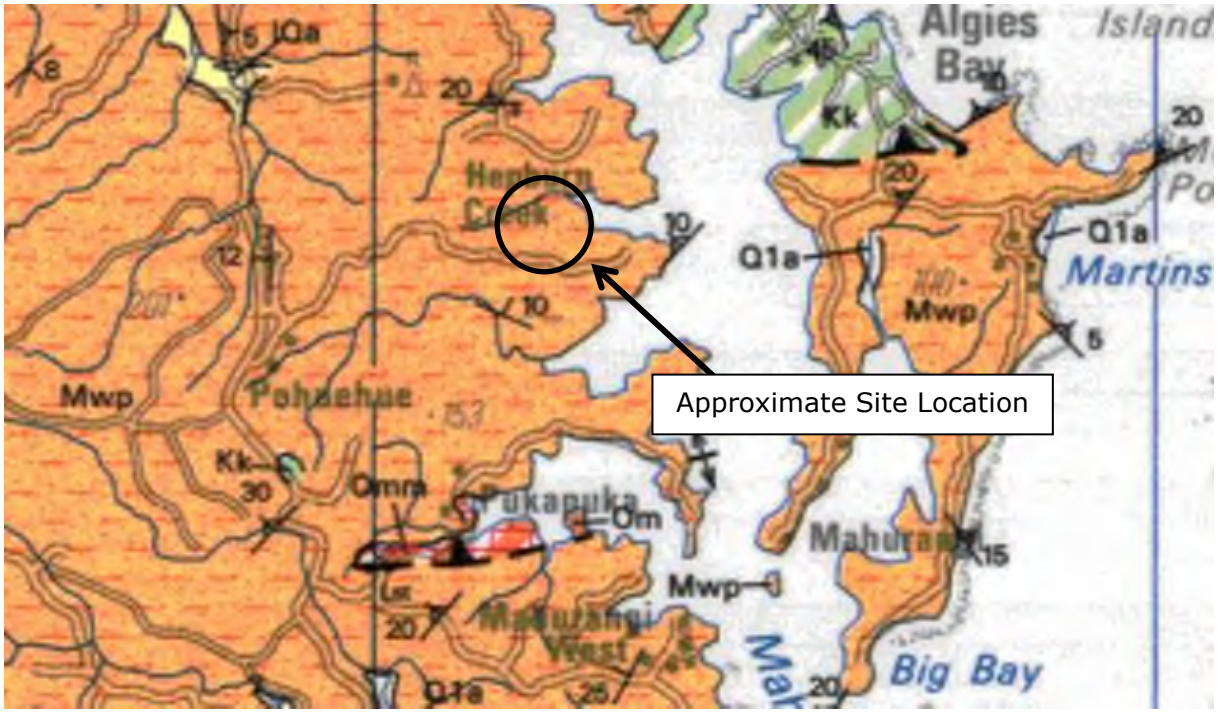


**Figure 3: Extract of the Geological QMap (courtesy of GNS Science)**

| | |
|---|---|
| **Q1a** | **Alluvium / colluvium** |
| **Mwp** | **Pakiri Formation** |
| **Omm** | **Mahurangi Limestone** |
| **Kk** | **Mangakahia Complex** |

The 1:250,000 QMap indicates that the site is underlain by The Pakiri Formation. This is a northwards extension of the East Coast Bays Formation and is formed from thick-bedded turbidites, mainly of volcanic rich sediments. These are typically graded medium to coarse grained sandstones, interbedded with thinner siltstones and fine grained sandstones.

The Pakiri Formation weathers to form a mantle of silts and clays with variable sand content which can extend to depths of 10m. In some places, the soils can be clayey or silty sands. The shear strength of the silts and clays can range from very stiff to soft,

often depending on the moisture content. The clay rich and cohesive silt soils are prone to shrinking and swelling following changes in natural moisture content.

Instability may occur where there is a conjunction of steep slopes (about or steeper than the angle of internal friction), high groundwater levels and a distinct boundary between the weathered and unweathered rock. This instability may take the form of translational rather than rotational failures where slopes are steep. Deep-seated instability within the unweathered siltstones and sandstones is relatively rare, unless related to defects within the rock mass.

## 4.2 Past Geotechnical Reports

The following geotechnical reports that had previously been written for the site were referred to:

- Colin Ashby Consulting, Geotechnical Report of Lot 1, DP 177006 Cowan Bay Road – Warkworth, dated December 2001, Ref 3347.
- RPH Consulting Ltd, Geotechnical Report in respect Building Platform (Puriri) Inc Scope of Earthworks for Cowan Bay Farm Limited Lot 2 DP 550085, dated August 2011.
- RPH Consulting Ltd, Geotechnical Report in respect Building Platform East for Cowan Bay Farm Limited Lot 2 DP 45728, dated March 2015.

The Colin Ashby Consulting report undertook an investigation including a single augered exploratory hole and multiple exploratory test pits. The exploratory holes encountered weathered Waitemata Group sediments. The augered exploratory hole generally encountered weathered silt with thin layers of limonitic gravelly silt throughout the hole. No water table was encountered in the hole. Three test pits were dug as part of the investigation. The test pits encountered weathered silts to a depth between 1.5m and 2.5m below ground level (bgl). Underlying the silt was weathered siltstone dipping west at approximately 5° - 6°. Two faults were identified in the test pits, these faults had minor offsets and showed no signs of recent movement. It was determined that the faults were historic relating to slumping of soft material during deposition.

Both RPH Consulting reports undertook an investigation including augered exploratory holes and Scala Penetrometer testing. The augered exploratory holes encountered weathered silts and clays, the water table was not encountered. One exploratory hole undertaken on the East Building Platform was drilled in a gully, this hole encountered colluvial soils and a high-water table. Both investigations identified layers of soft material within the profile and soil creep was considered.

## 4.3 Aerial Photo Interpretation

The earliest aerial photo available on the Auckland Council GIS Viewer was from 1999. This photo illustrates that the site looked as it does today and there was no previous development on the site.

# 5.0 SITE INVESTIGATION

## 5.1 Hand Augered Exploratory Holes

A shallow geotechnical investigation was undertaken on 13 and 14 February, 2017. The investigation included ten hand augered exploratory holes (HA's 1 to 10 inclusive). In situ shear vane testing was undertaken in the hand augered holes, generally at 0.5m intervals. Scala penetrometer tests were carried out at the bottom of each of the hand augered holes. An additional ten Scala Penetrometer tests were undertaken as part of the investigation to a depth of 1.8 meters below ground level (bgl). The termination depths of the hand augers are shown in Table 1 below. The detailed exploratory hole logs and Scala Penetrometer summary are attached in Appendix C, photos of the hand augered exploratory holes core samples are attached in Appendix D.

| Exploratory Hole | Proposed Lot | Hand Auger Termination Depth (m) | Scala Penetrometer Termination Depth (m) |
|---|---|---|---|
| HA01 | 5 | 4.95 | 6.75 |
| HA02 | 5 | 4.25 | 4.6 |
| HA03 | 4 | 2.9 | 3.0 |
| HA04 | * | 2.4 | 2.8 |
| HA05 | * | 2.4 | 3.4 |
| HA06 | 3 | 5.0 | 6.85 |
| HA07 | 3 | 4.1 | 4.35 |
| HA08 | 2 | 4.4 | 5.0 |
| HA09 | 2 | 3.4 | 3.5 |
| HA10 | 2 | 5.0 | 6.8 |
| HA11 | 4 | 4.0 | 4.1 |

**Table 1: Hand Auger and Scala Penetrometer from base of auger hole, termination depths**

*Lot position altered, holes are no longer associated with any proposed lot.

The layout of the exploratory holes was designed to determine the likely nature and distribution of subsoils and provide information for construction of the proposed new dwellings and assessment of the proposed building platforms geotechnical suitability. The approximate location of the testing is shown on Figure 4 below.

Refusal of a Scala Penetrometer test is taken as being three consecutive blow counts of 7 or more for 50 mm of penetration increment, or a blow count of 10 or more for a single 50 mm increment. This is usually taken as indicating very dense or hard material that could indicate a rock deposit. In some cases, the weathering of rock to residual soil can lead to alternating dense bands that cause refusal, without the material actually being solid rock.

The Scala Penetrometer testing was mainly used to determine where any softer layers of soil were encountered and to extend the depth of the exploratory holes. In some cases, the blow counts have been correlated to provide an estimate of bearing capacity but these are considered conservative in the cohesive soil found on this site. These estimates are only used where no shear vane results are available or from granular soils.

Any groundwater ingress was recorded and is shown on the logs in Appendix C.

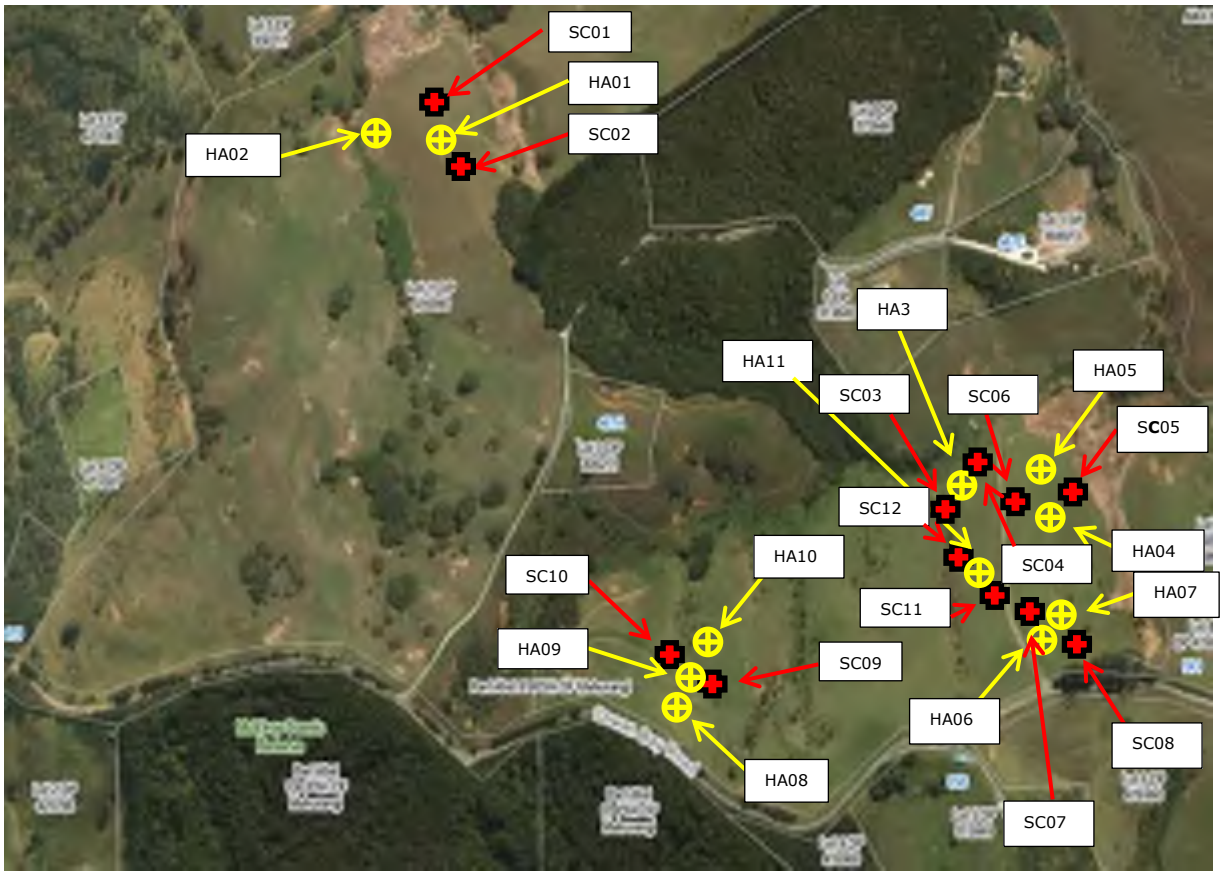


**Figure 4: Approximate exploratory hole and Scala Penetrometer testing locations (courtesy of Auckland Council GIS)**

## 5.2 Soils Encountered

### 5.2.1 Topsoil

Topsoil was encountered in all the exploratory holes. Topsoil was encountered from the ground surface to between 0.05m and 0.6m bgl.

### 5.2.2 Fill

No fill was encountered in any of the hand augered exploratory holes. There is the possibility that fill has been placed elsewhere on the site. Given the topography and the past land use this is unlikely. If there is any fill that has been placed on the site it is unlikely to affect the building platforms.

### 5.2.3 Colluvium

Possible colluvial material was encountered in the top 1m of HA2. This very stiff silt appeared to be Pakiri Formation, however it was overlying alluvial soils. For this reason, it is inferred that the stiff material has fallen from above. There are no obvious signs of slips on the slope above where HA2 was drilled.

### 5.2.4 Alluvium

Alluvial material was encountered in HA2. HA2 was drilled at the base of the slope on Lot 2. The alluvial soil encountered is inferred to have been deposited by water flowing through the adjacent gully feature. The alluvial material was encountered from 1.0m bgl to 3.5m bgl. The alluvial soil was generally firm to stiff, pale grey clayey silt. A layer of loose sand was also encountered within the alluvium. Decaying organic material, mainly wood was encountered throughout the alluvial material. The shear strength of the alluvial material was between 40kPa and 75kPa with an average strength of 55kPa.

### 5.2.5 Residual Soil

Residual soil thought to be derived from weathered Pakiri Formation rock was encountered in all the augered exploratory holes. With the exception of HA2, Pakiri Formation was encountered from below the topsoil to the termination of the auger in every hole. In HA2 Pakiri Formation residual soil was encountered at 3.5m bgl underlying alluvial soils. The residual soil was generally stiff to very stiff silt and sandy silt with occasional layers of medium dense sand. Limonite sand and gravel layers as well as black volcanic ash layers, were encountered throughout the residual soil.

The shear strength of the residual soil was between 50kPa and 200kPa, with an average strength of 150kPa.

HA's 2 – 5 and 7 – 9 were all terminated early due to refusal on a competent layer.

Scala Penetrometer testing at the base of the exploratory holes generally graded from loose to dense soils. In some of the exploratory holes refusal of Scala Penetrometer testing was encountered.

### 5.2.6 Rock

Refusal of some hand augered exploratory holes and Scala Penetrometer testing, indicates either very dense soil or rock at depth. Test pits dug in a previous geotechnical investigation by Colin Ashby Consulting encountered weathered siltstone at depth. It is likely that refusal of the hand augered exploratory holes and Scala Penetrometer is on this weathered siltstone or similar weathered sandstone associated with the Pakiri Formation.

### 5.2.7 Groundwater

Groundwater was encountered in HA2 at 2.0m bgl. Groundwater was not encountered in any other exploratory hole.

### 5.2.8 Sensitivity

Sensitivity is defined as the ratio of the undisturbed shear strength of a cohesive soil to the remoulded shear strength at the same moisture content, which is an indication of the materials sensitivity to disturbance. The higher the sensitivity of the soil the more difficult it is to re-use for engineered fill. The sensitivity of the natural soil tested during the investigation was generally found to be moderately sensitive to sensitive. Occasional tests indicated extra sensitive soil, this could be a false reading due to the high granular content of the soil.

### 5.2.9 Soil Expansivity

Based on exploratory hole findings and the old Rodney District Council Database (RDC), we assess the soil underlying the entire site to be moderately expansive confirming the soils category to be Class 'M' per AS 2870:2011 "Residential Slabs and Footings – Construction".

An allowance for extra depth should be given to cater for the seasonal shrink-swell effects of the soil, in accordance with AS 2870:2011.

# 6.0 SLOPE STABILITY ANALYSIS

Slope stability analysis was undertaken for all the lots due to the steep slopes adjacent to the proposed building platforms.

The slope stability analyses was undertaken using Rocscience's *SLIDE* (version 7.009) stability software based on topographic survey data both from Parallax Consultants Ltd and from Auckland Council's GIS contour data. Soil creep is not included in the analysis and should be taken into account when designing foundations. It should be noted that the control of stormwater runoff was not taken into consideration by the computerised analysis, but will have a beneficial effect on the Factor of Safety.

| Factor of Safety | Likelihood of Instability | Comments |
|---|---|---|
| 1.5 and greater | Very Unlikely | A stable slope. In most cases, such a slope will survive moderately severe ground shaking during an earthquake and will accommodate construction on its surface without affecting the state of stability. |
| 1.25 to 1.5 | Unlikely | No signs of instability. Surface building loads reduce factors of safety. At the lower end of this category, slopes are sensitive to groundwater rise and earthquake loads. About 50% of slopes in this category are expected to survive moderately severe earthquake loading, the remainder would yield, deform or fail under earthquake loading. |
| 1.1 to 1.25 | Likely | Signs of general stability with some indications of instability by tension and creep. Normal small variations in soil strength characteristics have a big effect on the state of stability. This category is sensitive to changing groundwater conditions, external loading and earthquake loading as they all reduce safety and promote instability. Moderately severe shaking is expected to produce an unstable condition. Imposed building loads reduce the state of stability. |
| 1.0 to 1.1 | Very Likely | Generally, failure or near failure by landslipping. Small changes in ground and water conditions could precipitate ground rupture. Slopes have no tolerance to earthquake loads. Moderately severe shaking would produce instability. Signs of creep movements are likely to be evident. |
| Less than 1.0 | Almost certain | Slope is theoretically unstable and likely to fail. Slopes have no tolerance to earthquake loadings. Signs of creep movements are likely to be evident. |

**Table 2: Factor of Safety Classification**

It is normal to accept a minimum calculated factor of safety of 1.5 or higher, as indicating long-term stability. For factors of safety of less than 1.0, slopes are usually considered to be unstable.

Where under normal conditions factors of safety are above 1.5, it is considered that for transient short term conditions, (i.e. those conditions where the soil is saturated following a period of intense rainfall), a factor of safety of 1.3 is acceptable.

Specific results of the slope stability assessment are given in the lot specific sections of this report.

Table 3 below illustrates the general soil parameters used in the slope stability assessment. These parameters are based on the subsoil data from our investigation, other relevant investigations plus the published geotechnical data from the Auckland Council "Code of Practice for Land Development and Subdivision Section 2 – Earthworks and Geotechnical Requirements – v1.6 24 September 2013".

| Material | Cohesion (c') in kPa | Angle of friction (Ø') In degrees | Unit weight kN/m³ |
|---|---|---|---|
| Topsoil | 1 | 28 | 15 |
| Firm silt | 1 | 28 | 18 |
| Stiff silt | 3 | 30 | 18 |
| Stiff sandy silt | 3 | 30 | 18 |
| Very stiff silt | 5 | 32 | 18 |
| Very stiff sandy silt | 4 | 32 | 18 |
| Loose sand | 0 | 28 | 18 |
| Medium dense silty sand | 1 | 34 | 18 |
| Competent material | Infinite strength | | 18 |

**Table 3: General material properties used for slope stability analysis**

The silt encountered in the exploratory holes contained a relatively high amount of sand and fine gravel consistently through the holes. For this reason, the cohesion parameter of all the silt was decreased for slope stability modelling. The granular nature of sand and gravel decreases the ability of the silt particles to 'bond' to one another and hence decreases the cohesion of the soil mass.

The slope stability models for each of the lots are attached in Appendix E

## 7.0 SITE ACCESS

The access for all lots is proposed to be from Cowan Bay Road. The access will in some cases involve upgrading existing farm tracks, or may involve constructing new driveways. Lot specific access options will be available in the individual lot sections.

## 8.0 LOT 1

Lot 1 has previously been investigated by RPH Consultants Ltd and therefore EDC conducted no further geotechnical investigation or analysis for Lot 1.

# 9.0 LOT 2

The proposed building platform on Lot 2 is to be located on the northern side of Cowan Bay Road. (Figure 2). From the road, the site is very steep, sloping at approximately 26° to the north east. Further north east the gradient decreases, this is where the building platform will be located. The building platform is sloping at approximately 12° to the north east (away from Cowan Bay Road). Below the proposed building platform (further north east) the slope gradient increases to approximately 18°. There is some evidence of shallow soil creep in the area of the proposed building platform. There was no visible evidence of deep seated instability on or below the building platform. Immediately above the building platform a slip scarp and some movement of the soils is visible. This slip has most likely been mobilised by the removal of toe support through the cutting of the farm track below it. We recommend that the toe of the slide is retained to prevent further movement towards the building platform.

There is a gully feature to the east of the proposed building platform. This feature was likely carved by flowing water. From the building platform to the base of the gully the gradient is approximately 27°.

It is likely that earthworks will be required to cut the building platform flat.

## 9.1 Site Investigation

Exploratory holes HA's 8 - 10 and SC's 9 - 10 were undertaken on Lot 2. HA8 was drilled on the slip area above the proposed building platform. The approximate location of the exploratory holes is shown on Figure 5 below.

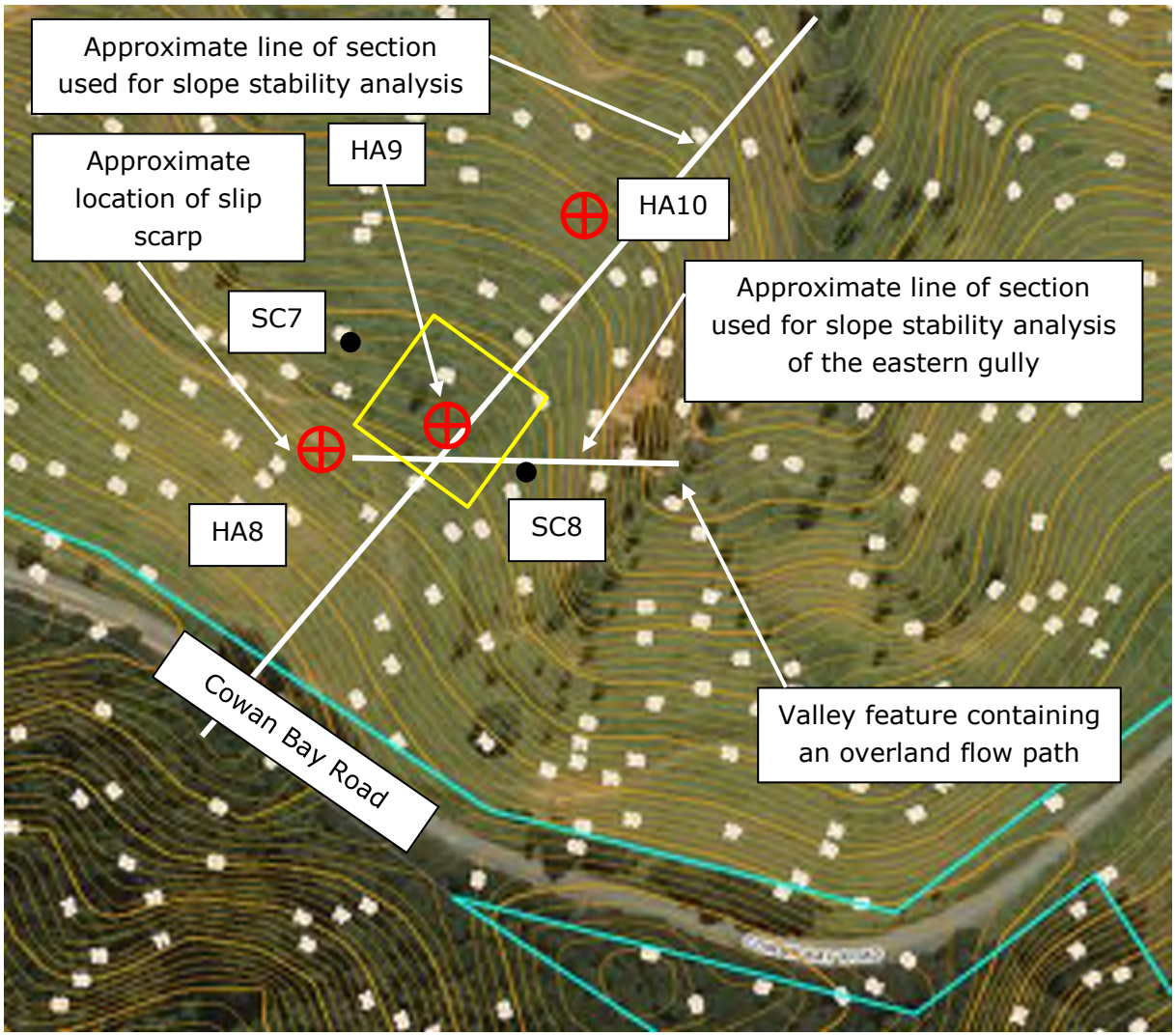


**Figure 5: Approximate exploratory hole locations undertaken on Lot 2 (courtesy of Auckland Council GIS Viewer)**

### 9.1.1 Subsoil Conditions

Lot 2 is generally underlain by very stiff silt with variable clay content. Occasional small pockets of sand and gravels were also encountered within the residual soil. The shear strength of the residual soil is approximately 150kPa. HA8 was drilled through the slip materials observed above the proposed building platform. A layer of firm material was encountered between 2.1m bgl and 2.8m bgl. Another layer of firm material was encountered from 3.9m bgl to 4.1m bgl. It is interpreted that the slip is moving on those two firm layers. Underlying the lower firm layer very stiff silt was encountered before the hole reached refusal at 5.0m bgl.

HA9 was terminated early at 3.5m due to refusal of both the hand augered exploratory hole and Scala Penetrometer testing. It is inferred that refusal occurred on weathered rock. HA10 was terminated at the target depth of 5m bgl. Scala Penetrometer testing at the base of the hole indicates medium dense soil grading to very dense soil at the termination of the testing (6.8m bgl).

Scala Penetrometer testing (SC's 5 and 6) encountered generally loose to medium dense soil between the ground surface and 1.8m bgl (termination of the testing).

## 9.2 Slope Stability Analysis

The cross-section lines for the slope stability analysis are shown on Figure 5 above. These line is based on the Auckland Council GIS Viewer LiDAR contours and the Parallax Consultants Ltd topographic survey. The lines were taken through the steepest part of the slope both downslope to the north west and into the gully feature on the eastern side of the building platform, while allowing for the most information possible to be utilised from the exploratory holes.

The soil parameters used in the slope stability analysis are shown in Table 3 of this report.

The model was assessed for existing slope conditions, normal and transient conditions (raised groundwater level). The results of the three models for the northern slope are shown in Table 4 below, the results of the three models for the eastern gully are shown in Table 5 below.

| File Name | Description | Minimum Calculated Factor of Safety | Required Factor of Safety |
|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 1.6 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 1.6 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.3 | 1.3 |

**Table 4: Slope stability analysis results for Lot 2 – Northern slope**

| File Name | Description | Minimum Calculated Factor of Safety | Minimum Calculated Factor of Safety above 63m contour | Required Factor of Safety |
|---|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 1.4 | 1.5 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 1.4 | 1.5 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.2 | 1.3 | 1.3 |

**Table 5: Slope stability analysis results for Lot 2 – Eastern gully slope**

The results indicate that the risk of a global failure of the north eastern slope is unlikely. The north-eastern models indicate a Factor of Safety of 1.6 under normal conditions and 1.3 under transient conditions. The worst case slip circle was above the building platform in all the models.

The results indicate that the risk of global failure of the eastern gully slope is possible. The lowest calculated Factor of Safety is below the required in all three models (1.4 for normal conditions and 1.2 for transient conditions). The models indicate that the required Factor of Safety can be achieved if the building platform is setback above the 63m contour (based on the Parallax Surveyors and Planners topographic survey).

These analyses do not assess for soil creep, which should be allowed for in the top 0.5m of the soil profile during design of the proposed new foundations. Alternatively, to alleviate the need to design for soil creep a flat building platform should be cut and the foundations set back a minimum of 1.5m from the edge of the cut platform.

## 9.3 Site Access

Site access is proposed to be from Cowan Bay Road, and is proposed to have a maximum grade of 1V in 4H and will be concreted. The proposed site access is shown on the lot plan attached in Appendix B.

## 9.4 Recommendations and Conclusions

### 9.4.1 Slope Stability

Based on the slope stability models for the eastern gully section we recommend setting the building platform back above the 63m contour (based on the Parallax Surveyors and Planners topographic survey). This setback only needs to be above the very steep slopes to the east and does not need to follow the contour around the ridge to the west. The approximate building limitation line is set back 16m above the 57.5m contour (Parallax Surveyors) denoted on the lot plan in Appendix B by the edge of the building platform. This building limitation line is extrapolated from one slope stability section, the limitation line may be able to be moved if further stability modelling is undertaken.

If a flat building platform is cut, we recommend that EDC is provided the details of the cut plan to determine the required setback from the eastern edge of the cut platform.

We also recommend that the toe of the slip above (south west) the building platform is retained (approximately 0.5m – 1.0m). This will decrease the possibility of continued movement of the slip due to removal of toe support. We recommend that the retaining wall also acts as a barrier pile wall below ground to retain the entire slip depth. Based on the soils encountered in HA8 the slip material is encountered until 4.5m bgl. It is however likely that at the location of the required retaining wall the slip surface will be shallower or no longer present. EDC should be contacted when the wall location is determined for further advice. Depending on the proposed wall location, further investigation may be required.

### 9.4.2 Foundation Design

Based on the exploratory hole results for HA's 9 and 10 we consider the following foundation options to be viable:

- Waffle-Slab type foundations with piles on the leading edge (if a flat platform is cut)
- Slab-on-grade with deepened edge beams and piles on the leading edge(if a flat platform is cut)
- Piled foundations
- Traditional strips and pads with piles on the leading edge (spread foundations)
- Edge ringbeam with piles on the leading edge, with suspended floor

Due to the steep slopes across the site we recommend that all shallow foundation types utilise piles on the leading (downhill) edge of the foundation.

We recommend that all foundations are designed to accommodate 0.5m of soil creep and the anticipated Class 'M' expansivity. If a flat platform is cut and the foundations are set back a minimum of 1.5m from the edge of the cut it will not be required to make allowances for soil creep, subject to confirmation by a CPEng (geotechnical) at the time of construction of the building platform.

All topsoil and any unanticipated fill encountered should be removed from the building platform prior to foundation construction. If engineered fill is required to form a building platform, further slope stability analysis will be required to confirm the stability of such fill.

We recommend that EDC be provided with a copy of the foundation plans before Building Consent submission, to allow EDC to confirm that the foundation options chosen are in accordance with the recommendations of this report.

### 9.4.3 Soil Bearing Capacity

The natural Pakiri Formation soils have shear strengths generally above 70kPa. It is therefore anticipated that a geotechnical ultimate bearing capacity of greater than 300kPa will be available for foundations founded below topsoil. After applying a static strength reduction factor (Φ) of 0.5, this indicates a dependable bearing capacity of at least 150kPa.

### 9.4.4 Settlement

The natural very stiff and stiff silt will in our opinion exhibit only low compressibility under the anticipated foundation loads, associated with the proposed development. Settlement of foundations in this material should most likely be within accepted limits, provided that the inspection and design of foundations are carried out in accordance with the requirements of NZS3604:2011 and the recommendations made in this report.

### 9.4.5 Expansive Soils

The natural soils must be treated as Class "M" soils in terms of AS2870: 2011. Any foundations that penetrate into the natural materials must be designed for Class "M", we recommend a minimum depth of 600mm for any edgebeams, strips, or pads (if a flat platform is cut and the required setbacks adhered too) and a minimum depth of 900mm for any piles.

### 9.4.6 Earthworks

It is considered that earthworks may be required to cut the building platform down and provide more useable space. The surplus topsoil and any unsuitable soil (including soft or organic material), should be removed. This can be used for landscaping away from building platform, driveway and slopes, or removed completely from site. If it is to be placed on sloping areas further geotechnical advice will be required if the proposed thickness exceeds 600mm.

Any engineered fill, should be placed in layers of not more than 150mm thickness, suitably compacted at the optimum moisture content using an appropriate compaction method, to achieve, not less than 95% of the maximum dry density. The fill compaction could be checked by employing suitable site testing methods such as Scala Penetrometer testing, hand held shear vane (shear strength >120kPa), Clegg Hammer testing or other methods as described under NZS 4402:1986.

Any fill that is placed on a slope will require benching into the natural ground to assist with stability of the fill. If fill is wished to be placed on a slope EDC should be contacted to confirm the stability of such fill and provide advice in relation to benching of the underlying natural materials.

Cut and fill batters should be constructed no steeper than 1V in 4H unless approved by a Professional Chartered Engineer (Geotechnical). We recommend that all batter surfaces at a minimum are covered with erosion matting and vegetation.

Any fill over 600mm thick must be certified by a Professional Chartered Engineer (Geotechnical) who has experience working with slope stability.

Any earthworks on the site must include controls to limit stormwater from overtopping the slopes as this could induce shallow instability on the edges of the cut and fill.

### 9.4.7 Stormwater

There is no reticulated potable water in the area; therefore rainwater will be being collected in tanks for use in the homes. The tanks will require a suitable overflow discharge outlet to be designed at the Building Consent stage. We recommend that no stormwater is discharged on the steep slopes below the building platform and that pipes carry the water to an overland flow path or other suitable discharge location to be discharged through a designed outlet.

### 9.4.8 Wastewater

A wastewater system and disposal areas will need to be developed following the design of the proposed dwelling being confirmed. Although EDC have not been provided with any details of the proposed dwelling, it is considered that a TP58 compliant system is likely to be able to be constructed dependent on the size of the proposed dwelling. It is recommended that the wastewater field is not located on the steep slopes below the building platform, due to the saturation of the slopes and potential for instability that would occur.

# 10.0 LOT 3

## 10.1 Site description

The proposed building platform on Lot 3 is to be located on the northern side of Cowan Bay Road, at the top of a slope (Figure 2). Where the building platform is proposed to be located the site slopes to the north at approximately 17°. The site also slopes to the north east at approximately 27° before decreasing to approximately 20°. There is some evidence of shallow soil creep in the area of the proposed building platform. It is considered from aerial photographs and site observation that the 27° slope to the north east of the building platform is likely to be a historical landslide scarp.

It is likely that earthworks will be required to cut the building platform flat.

## 10.2 Site Investigation

Exploratory holes HA's 6 - 7 and SC's 7 - 8 were undertaken on Lot 3. The approximate location of the exploratory holes are shown on Figure 6 below.

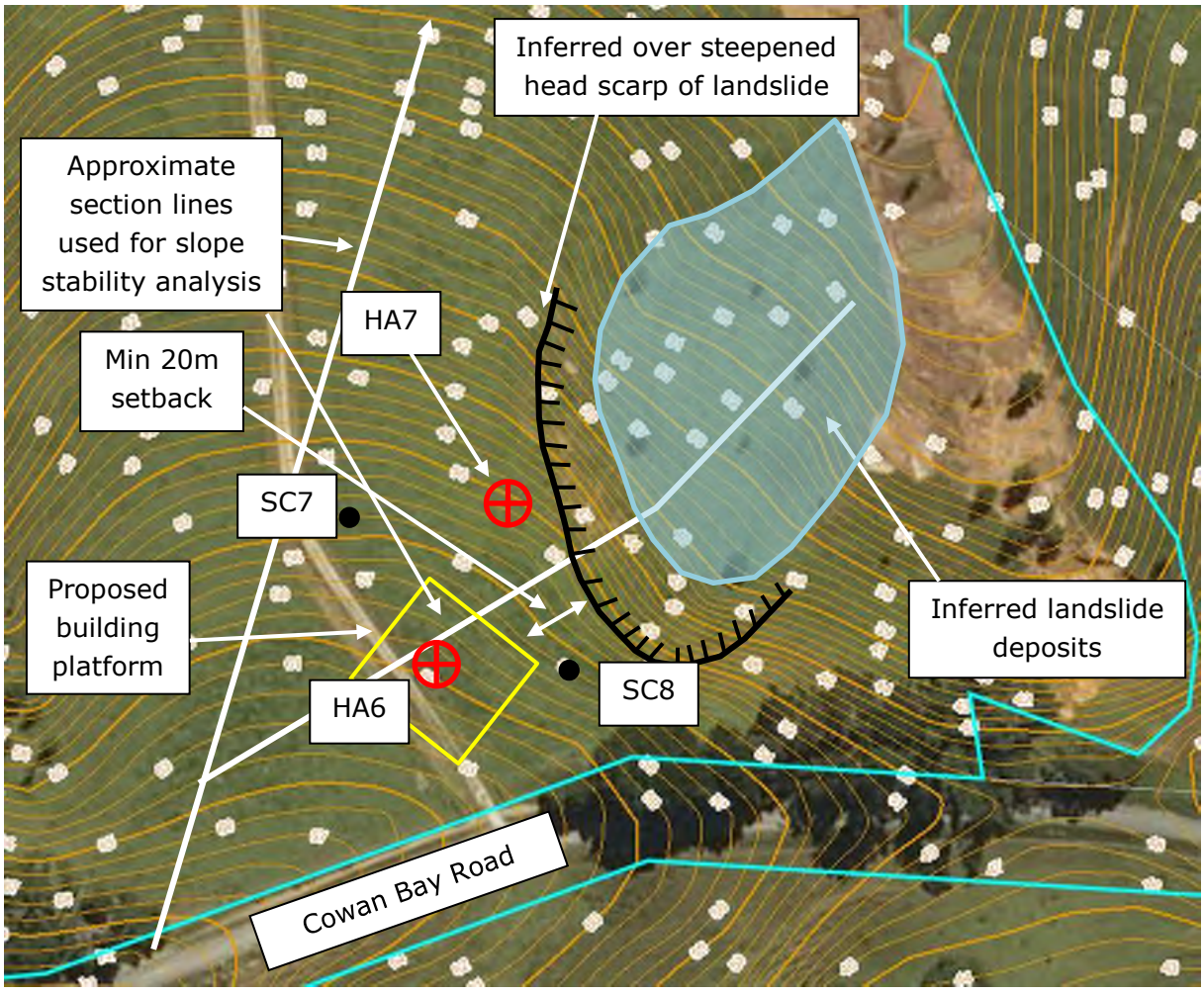


**Figure 6: Approximate exploratory hole locations undertaken on Lot 3 (courtesy of Auckland Council GIS Viewer)**

### 10.2.1 Subsoil Conditions

Lot 3 is generally underlain by very stiff silt. Occasional small pockets of sand and gravels were also encountered within the residual soil. The shear strength of the residual soil is approximately 135kPa. In HA7 between 1.1m bgl and 2.9m bgl a weaker layer of stiff silt containing clay and pumice sand was encountered. This layer has an average shear strength of 70kPa and could be linked to the cause of the adjacent slip. No groundwater was encountered in either of the exploratory holes.

HA6 was terminated at its target depth of 5.0m, Scala Penetrometer testing at the base of the auger indicated loose to medium dense soil to the termination of the hole at 6.85m bgl. HA7 was terminated 4.1m bgl due to difficulty drilling. Scala Penetrometer testing at the base of the hole was terminated at 4.35m bgl due to refusal of testing. This is inferred to be the top of the Pakiri Formation rock.

Scala Penetrometer testing SC7 encountered generally loose to medium dense soil between the ground surface and 1.8m bgl (termination of the testing). SC8 encountered medium dense soil from the ground surface to approximately 0.9m bgl. Below the medium dense soil, loose soil was encountered until the termination of testing at 1.8m bgl.

## 10.3 Slope Stability Analysis

Two stability sections were analysed for Lot 3, one section was drawn through the historical slip to the east of the building platform. The second section was drwan down the slope to the north east of Lot 3.

The cross-section lines for the slope stability analysis are shown on Figure 6 above. These lines are based on the Parallax Consultants Ltd topographic survey. They were taken through the steepest part of the slope to the east and north east of the proposed building platform, while allowing for the most information possible to be utilised from the exploratory holes.

The soil parameters used in the slope stability analysis are shown in Table 3 (Section 6) of this report.

The model was assessed for existing slope conditions, normal and transient conditions (raised groundwater level). The results of the three models for the east slope are shown in Table 6 below, the results of the three models for the north eastern slope are shown in Table 7 below.

| File Name | Description | Minimum Calculated Factor of Safety | Minimum Calculated Factor of Safety 20m setback from slip | Required Factor of Safety |
|---|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 1.4 | 1.5 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 1.4 | 1.5 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.1 | 1.3 | 1.3 |

**Table 6: Slope stability analysis results for Lot 3 – East Slope (historical slip)**

| File Name | Description | Minimum Calculated Factor of Safety | Required Factor of Safety |
|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 2.0 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 1.9 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.7 | 1.3 |

**Table 7: Slope stability analysis results for Lot 3 – North east slope**

The results indicate that there is a risk of global failure of the slope to the east of the proposed building platform. The models indicate a Factor of Safety of 1.4 under normal conditions and 1.1 under transient conditions. To achieve the required Factor of Safeties, the model indicates that the building platform will need to be set back 20m from any part of the crest of the historical slip.

These analyses do not assess for soil creep, which should be allowed for in the top 0.5m of the soil profile during design of the proposed new foundations. Alternatively, to alleviate the need to design for soil creep a flat building platform should be cut and the foundations set back a minimum of 1.5m from the edge of the cut platform.

### 10.4 Site Access

Site access is proposed to be from Cowan Bay Road, and is proposed to have a maximum grade of 1V in 7H and will be metalled. The proposed site access is shown on the lot plan attached in Appendix B.

## 10.5 Recommendations and Conclusions

### 10.5.1 Slope Stability

We recommend the building platform is setback a minimum of 20m from the crest of the historical landslide to the east of the proposed building platform.

Alternatively, we recommend that due to the potential for future reactivation of the historical slip the building platform is shifted to the west on the other side of the existing farm track. The soil profile for this western site is based on HA6 and Scala Penetrometers previously completed by RPH Consulting Ltd.

### 10.5.2 Foundation Design

Based on the exploratory hole results for HA's 6 and 7 we consider the following foundation options to be viable:

- Waffle-Slab type foundations with piles on the leading edge (if a flat platform is cut)
- Slab-on-grade with deepened edge beams and piles on the leading edge(if a flat platform is cut)
- Piled foundations
- Traditional strips and pads with piles on the leading edge (spread foundations)
- Edge ringbeam with piles on the leading edge, with suspended floor

Due to the steep slopes across the site we recommend that all shallow foundation types utilise piles on the leading (downhill) edge of the foundation.

If the building platform is to be moved to the western side of the existing farm track, we recommend that a waffle-slab type foundation designed for a Geotechnical Ultimate Bearing Capacity of 200kPa (Dependable Bearing Capacity of 100kPa). Or piled foundations to a minimum depth of 2m bgl are adopted.

We recommend that all foundations are designed to accommodate 0.5m of soil creep. If a flat platform is cut and the foundations are set back a minimum of 1.5m from the edge of the cut it will not be required to make allowances for soil creep, subject to confirmation by a CPEng (geotechnical) at the time of construction of the building platform.

All topsoil and any unanticipated fill encountered should be removed from the building platform prior to foundation construction. If engineered fill is required to form a building platform, further slope stability analysis will be required to confirm the stability of such fill.

We recommend that EDC be provided with a copy of the foundation plans before Building Consent submission, to allow EDC to confirm that the foundation options chosen are in accordance with the recommendations of this report.

### 10.5.3 Soil Bearing Capacity

The natural Pakiri Formation soils have shear strengths generally above 65kPa. It is therefore anticipated that a geotechnical ultimate bearing capacity of greater than 300kPa will be available for foundations founded below topsoil. After applying a static strength reduction factor (Φ) of 0.5, this indicates a dependable bearing capacity of at least 150kPa.

Scala Penetrometer testing was used to determine the Bearing Capacity for the possible building platform west of the existing farm track. Testing indicates a Geotechnical Ultimate Bearing Capacity of 200kPa above 2m bgl and a Geotechnical Ultimate Bearing Capacity of 300kPa below 2m bgl. These figures are probably conservative and we recommend designing for a geotechnical Ultimate Bearing Capacity of 300kPa (dependable of 150kPa), to be confirmed at the time of construction.

### 10.5.4 Settlement

The natural very stiff and stiff silt will in our opinion exhibit only low compressibility under the anticipated foundation loads, associated with the proposed development. Settlement of foundations in this material should most likely be within accepted limits, provided that the inspection and design of foundations are carried out in accordance with the requirements of NZS3604:2011 and the recommendations made in this report.

### 10.5.5 Expansive Soils

The natural soils must be treated as Class "M" soils in terms of AS2870: 2011. Any foundations that penetrate into the natural materials must be designed for Class "M", we recommend a minimum depth of 600mm for any edgebeams, strips, or pads (if the ridge is cut down to allow shallow foundations) and a minimum depth of 900mm for piles on the eastern side of the existing farm track. Or a minimum depth of 2.0m for piles on the western side of the existing farm track.

### 10.5.6 Earthworks

It is considered that earthworks may be required to cut the building platform down and provide more useable space. The surplus topsoil and any unsuitable soil (including soft or organic material), should be removed. This can be used for landscaping away from building platform, driveway and slopes, or removed completely from site. If it is to be placed on sloping areas further geotechnical advice will be required if the proposed thickness exceeds 600mm.

Any engineered fill, should be placed in layers of not more than 150mm thickness, suitably compacted at the optimum moisture content using an appropriate compaction method, to achieve, not less than 95% of the maximum dry density. The fill compaction could be checked by employing suitable site testing methods such as Scala Penetrometer testing, hand held shear vane (shear strength >120kPa), Clegg Hammer testing or other methods as described under NZS 4402:1986.

Any fill that is placed on a slope will require benching into the natural ground to assist with stability of the fill. If fill is to be placed on a slope EDC should be contacted to

confirm the stability of such fill and provide advice in relation to benching of the underlying natural materials.

Cut and fill batters should be constructed no steeper than 1V in 4H unless approved by a Professional Chartered Engineer (Geotechnical). We recommend that all batter surfaces are covered with erosion matting to prevent sediment runoff into the driveway drains or the surrounding bush.

Any fill over 600mm thick must be certified by a Professional Chartered Engineer (Geotechnical) who has experience working with slope stability.

Any earthworks on the site must include controls to limit stormwater from sheet flowing down slopes as this could induce shallow instability on the edges of the cut and fill.

### 10.5.7 Stormwater

There is no reticulated potable water in the area; therefore rainwater will be being collected in tanks for use in the homes. The tanks will require a suitable overflow discharge outlet to be designed at the Building Consent stage. We recommend that no stormwater is discharged on the steep slopes below the building platform and that pipes carry the water to an overland flow path or other suitable discharge location to be discharged through a designed outlet.

### 10.5.8 Wastewater

A wastewater system and disposal areas will need to be developed following the design of the proposed dwelling being confirmed. Although EDC have not been provided with any details of the proposed dwelling, it is considered that a TP58 compliant system is likely to be able to be constructed dependent on the size of the proposed dwelling. It is recommended that the wastewater field is not located on the steep slopes below the building platform, due to the saturation of the slopes and potential for instability that would occur.

# 11.0 LOT 4

## 11.1 Site description

The proposed building platform on Lot 4 is to be located half way down a slope to the north of Cowan Bay Road (Figure 2) on the western side of an existing farm track. Where the building platform is proposed to be located the site slopes to the north at approximately 16°. North west of the proposed building platform the site slopes into a gully at approximately 20° There is some evidence of shallow soil creep in the area of the proposed building platform. The Lot area extends to the eastern side of the farm track where there is some existing hummocky ground thought to be linked to slope instability. We recommend that the building platform is set back a minimum of 20m to the west from any of the hummocky ground.

It is likely that some retaining or a fill batter may be required on the downhill side of the building platform. Retaining will also likely be required on the uphill side of the building platform to support the platform cut. This would enable a cut and fill platform to be constructed.

## 11.2 Site Investigation

Exploratory holes HA 11 and SC's 11 - 12 were undertaken on Lot 4. HA's 3 – 7 were drilled in the vicinity of Lot 4 and results can be used for correlation. The approximate location of the exploratory holes is shown on Figure 7 below.

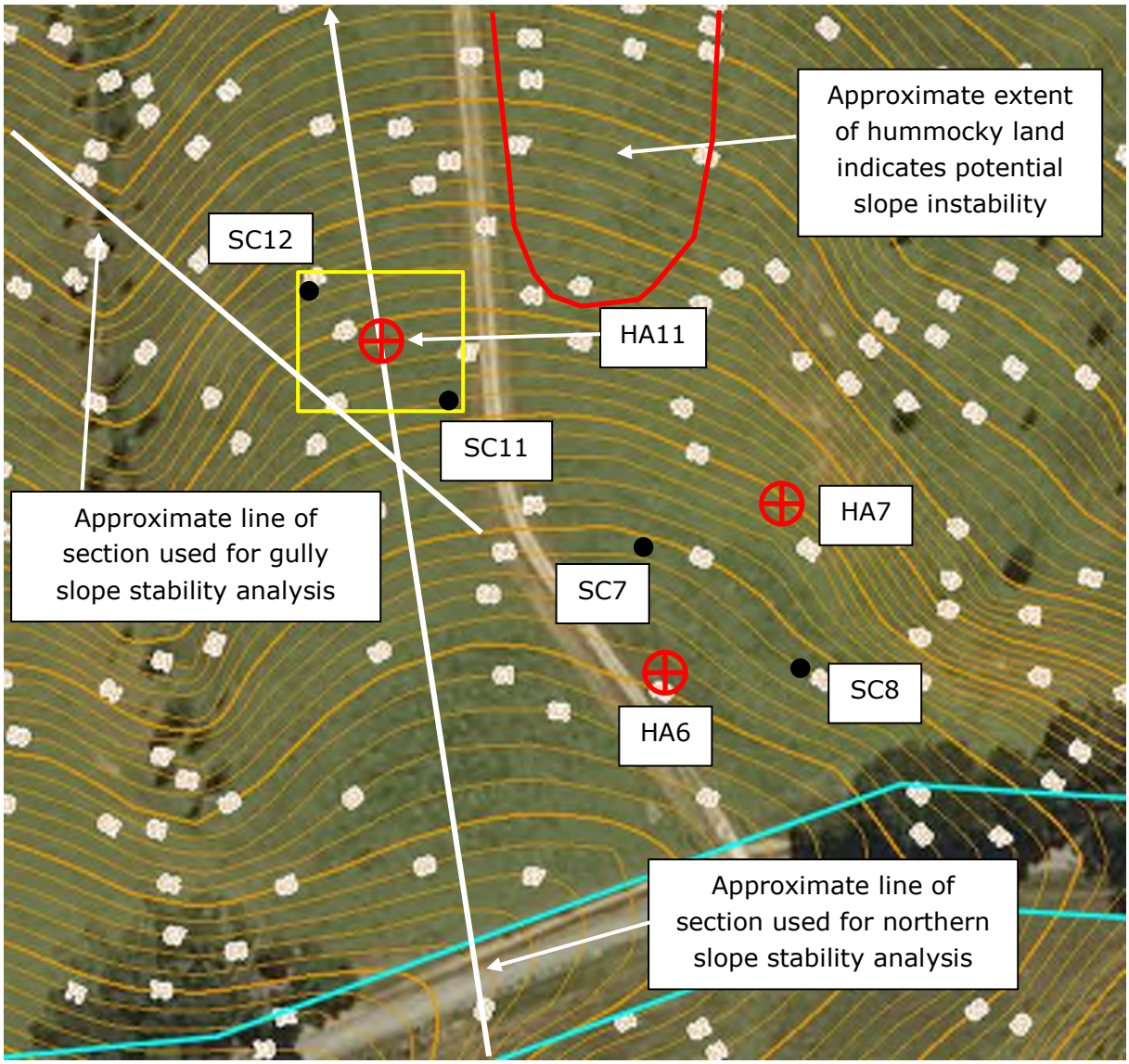


**Figure 7: Approximate exploratory hole locations undertaken on Lot 4 (courtesy of Auckland Council GIS Viewer)**

### 11.2.1 Subsoil Conditions

Lot 4 is generally underlain by very stiff silt becoming sandy silt below 2.6m bgl. A layer of medium dense silty sand was encountered between 2.8m and 3.8m bgl. Trace fine white angular gravels and black volcanic ash were also encountered within the residual soil. The shear strength of the residual soil is approximately 150kPa in HA11. This is consistent with the soil behaviour and strength encountered in the exploratory holes in the vicinity of Lot 4. The soil encountered between 1.5m and 2.8m bgl was generally soft to firm on the auger despite testing as very stiff on the shear vane. This indicates that the soil is sensitive, likely due to pumice within the soil. No groundwater was encountered in HA11. HA11 was terminated early (4.0m bgl) due to refusal on a competent layer.

Scala Penetrometer testing (SC's 11 and 12) encountered generally loose soil between the ground surface and 1.1m bgl. Generally medium dense soil was encountered from 1.1m to 1.8m bgl (termination of the testing).

### 11.3 Slope Stability Analysis

The cross-section lines for the slope stability analyses is shown on Figure 7 above. These lines are based on the Auckland Council GIS Viewer LiDAR contour lines. The lines were taken through the worst case section of the general slope to the north and the steeper slope into the gully on the west of the proposed building platform, while allowing for the most information possible to be utilised from the exploratory holes.

The soil parameters used in the slope stability analysis are shown in Table 3 (Section 6.0) of this report.

The model was assessed for existing slope conditions, normal and transient conditions (raised groundwater level). The results of the northern section slope stability analysis are shown in Table 8 below. The results of the gully section slope stability analysis are shown in Table 9 below.

| File Name | Description | Minimum Calculated Factor of Safety | Required Factor of Safety |
|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 2.1 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 2.1 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.9 | 1.3 |

**Table 8: Slope stability analysis results for Lot 4 northern slope**

| File Name | Description | Minimum Calculated Factor of Safety | Required Factor of Safety |
|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 2.0 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 1.8 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.5 | 1.3 |

**Table 9: Slope stability analysis results for Lot 4 Gully Slope**

The results indicate that the risk of a global failure of the slope is unlikely. The models indicate Factors of Safety between 1.8 and 2.1 under normal conditions and between 1.5 and 1.9 under transient conditions.

These analyses do not assess for soil creep, which should be allowed for in the top 0.5m of the soil profile during design of the proposed new foundations.

## 11.4 Site Access

Site access is proposed to be from Cowan Bay Road, and is proposed to have a maximum grade of 1V in 6H and will be metalled. The proposed site access is shown on the lot plan attached in Appendix B.

## 11.5 Recommendations and Conclusions

### 11.5.1 Slope Stability

The slope stability analysis undertaken on the worst-case scenario slope indicate that the slopes surrounding the proposed building platform are unlikely to fail. We recommend that the building platform is setback a minimum of 20m to the west of the hummocky ground seen on the eastern side of the existing farm track.

### 11.5.2 Foundation Design

Based on the exploratory hole results for HA11 we consider the following foundation options to be viable:

- Waffle-Slab type foundations with piles on the leading edge (if a flat platform is cut)
- Slab-on-grade with deepened edge beams and piles on the leading edge(if a flat platform is cut)
- Piled foundations
- Traditional strips and pads with piles on the leading edge (spread foundations)
- Edge ringbeam with piles on the leading edge, with suspended floor

Due to the steep slopes across the site we recommend that all shallow foundation types utilise piles on the leading (downhill) edge of the foundation.

We recommend that all foundations are designed to accommodate 0.5m of soil creep. If a flat platform is cut and the foundations are set back a minimum of 1.5m from the edge of the cut it will not be required to make allowances for soil creep, subject to confirmation by a CPEng (geotechnical) at the time of construction of the building platform.

All topsoil and any unanticipated fill encountered should be removed from the building platform prior to foundation construction. If engineered fill is required to form a building platform, further slope stability analysis will be required to confirm the stability of such fill.

We recommend that EDC be provided with a copy of the foundation plans before Building Consent submission, to allow EDC to confirm that the foundation options chosen are in accordance with the recommendations of this report.

### 11.5.3 Soil Bearing Capacity

The natural Pakiri Formation soils encountered in HA11 have shear strengths generally above 100kPa. It is therefore anticipated that a geotechnical ultimate bearing capacity of greater than 300kPa will be available for foundations founded below topsoil. After applying a static strength reduction factor (Φ) of 0.5, this indicates a dependable bearing capacity of at least 150kPa. It should be noted that soils encountered below 1.5m bgl were sensitive. These soils will not be suitable to use as fill and care should be taken during earthworks with earthworks only taking place in good weather.

### 11.5.4 Settlement

The upper natural very stiff and stiff silt will in our opinion exhibit only low compressibility under the anticipated foundation loads, associated with the proposed development. Settlement of foundations in this material should most likely be within accepted limits, provided that the inspection and design of foundations are carried out in accordance with the requirements of NZS3604:2011 and the recommendations made in this report.

### 11.5.5 Expansive Soils

The natural soils must be treated as Class "M" soils in terms of AS2870: 2011. Any foundations that penetrate into the natural materials must be designed for Class "M", we recommend a minimum depth of 600mm for any edgebeams, strips, or pads (if the ridge is cut down to allow shallow foundations) and a minimum depth of 1000mm (plus 3 x pile diameters) for any piles.

### 11.5.6 Earthworks

It is considered that earthworks will be required to cut the building platform down and provide more useable space. The surplus topsoil and any unsuitable soil (including soft, organic or sensitive material), should be removed. This can be used for landscaping away from building platform, driveway and slopes, or removed completely from site. If it is to be placed on sloping areas further geotechnical advice will be required if the proposed thickness exceeds 600mm.

It is likely that fill is to be compacted on the downhill side of the building platform behind a retaining structure to create a flat building platform.

Any engineered fill, should be placed in layers of not more than 150mm thickness, suitably compacted at the optimum moisture content using an appropriate compaction method, to achieve, not less than 95% of the maximum dry density. The fill compaction could be checked by employing suitable site testing methods such as Scala Penetrometer testing, hand held shear vane (shear strength >120kPa), Clegg Hammer testing or other methods as described under NZS 4402:1986.

Any fill that is placed on a slope will require benching into the natural ground to assist with stability of the fill. If fill is wished to be placed on a slope EDC should be contacted to confirm the stability of such fill and provide advice in relation to benching of the underlying natural materials.

Cut and fill batters should be constructed no steeper than 1V in 4H unless approved by a Professional Chartered Engineer (Geotechnical). We recommend that all batter surfaces are covered with erosion matting to prevent sediment runoff into the driveway drains or the surrounding bush.

Any fill over 600mm thick must be certified by a Professional Chartered Engineer (Geotechnical) who has experience working with slope stability.

Any earthworks on the site must include controls to limit stormwater from overtopping the slopes as this could induce shallow instability on the edges of the cut and fill.

### 11.5.7 Stormwater

There is no reticulated potable water in the area; therefore rainwater will be being collected in tanks for use in the homes. The tanks will require a suitable overflow discharge outlet to be designed at the Building Consent stage. We recommend that no stormwater is discharged on the steep slopes below the building platform and that pipes carry the water to an overland flow path or other suitable discharge location to be discharged through a designed outlet.

### 11.5.8 Wastewater

A wastewater system and disposal areas will need to be developed following the design of the proposed dwelling being confirmed. Although EDC have not been provided with any details of the proposed dwelling, it is considered that a TP58 compliant system is likely to be able to be constructed dependent on the size of the proposed dwelling. It is recommended that the wastewater field is not located on the steep slopes below the building platform, due to the saturation of the slopes and potential for instability that would occur.

# 12.0 LOT 5

## 12.1 Site description

The proposed building platform on Lot 5 is to be located on the top of a ridge, near the northern boundary of the site (Figure 2). The ridge rises to south east of the building platform at approximately 9°. On all other sides of the building platform the slopes fall away. The slopes below the building platform range from approximately 20° to 25°. Evidence of soil creep was observed in the vicinity of the building platform. There was no obvious evidence of historical deep seated instability.

## 12.2 Site Investigation

Exploratory holes HA's 1 – 2 and SC's 1 - 2 were undertaken on Lot 5. The approximate location of the exploratory holes is shown on Figure 8 below.

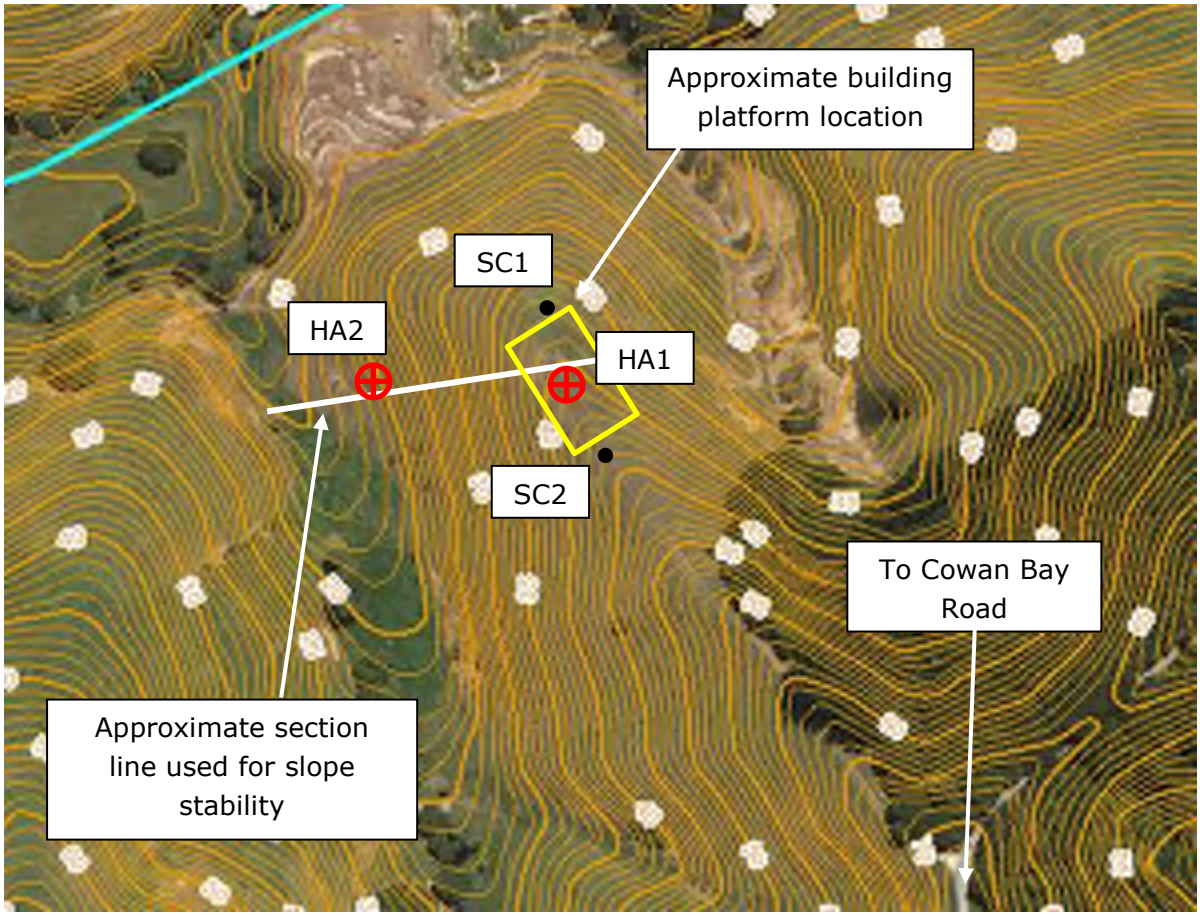


**Figure 8: Approximate exploratory hole locations undertaken on Lot 5 (courtesy of Auckland Council GIS Viewer)**

### 12.2.1 Subsoil Conditions

The building platform on Lot 5 is generally underlain by very stiff Pakiri Formation silt, with variable clay and sand content as was encountered in HA1. Trace quantities of fine gravel and black volcanic ash were also encountered. The residual soil encountered had an average shear strength of 150kPa. No groundwater was observed underlying the

building platform. HA2 was drilled at the base of the slope adjacent to the gully. Firm to stiff alluvial soils were encountered to 3.5m bgl, before very stiff silt and medium dense sand of the Pakiri Formation were encountered. Groundwater was encountered at 2.0m bgl in HA2.

Scala Penetrometer testing at the base of HA1 indicated medium dense soil grading to dense soil. HA2 encountered refusal at 4.6m bgl. Scala Penetrometer testing SC1 and SC2 encountered generally medium dense soil from ground level to 1.8m bgl at termination of the testing.

### 12.3 Slope Stability Analysis

The cross-section line for the slope stability analysis is shown on Figure 8 above. This line is based on the Auckland Council GIS Viewer topographic contours. It was taken through the steepest part of the slope to the west of the proposed building platform, while allowing for the most information possible to be utilised from the exploratory holes.

The soil parameters used in the slope stability analysis are shown in Table 3 (Section 6.0) of this report.

The model was assessed for existing slope conditions, normal and transient conditions (raised groundwater level). The results of the three models are shown in Table 10 below.

| File Name | Description | Minimum Calculated Factor of Safety | Required Factor of Safety |
|---|---|---|---|
| Slope Stability Existing | Existing site layout with normal groundwater levels | 1.5 | 1.5 |
| Slope Stability Proposed | Proposed site layout with normal groundwater conditions | 1.5 | 1.5 |
| Slope Stability Saturated | Proposed site layout with transient (extreme) groundwater conditions | 1.3 | 1.3 |

**Table 10: Slope stability analysis results for Lot 5**

The results indicate that the risk of a global failure of the slope is unlikely. The models indicate a Factor of Safety of 1.5 under normal conditions and 1.3 under transient conditions.

These analyses do not assess for soil creep, which should be allowed for in the top 0.5m of the soil profile during design of the proposed new foundations. Alternatively, to alleviate the need to design for soil creep, a flat building platform should be cut and the foundations set back a minimum of 1.5m from the edge of the cut platform.

### 12.4 Site Access

Site Access will be from Cowan Bay Road, and will utilise the existing Right of Way for 487, 487A, 487B and 487C Cowan Bay Road. The access for this proposed lot will turn off

the Right of Way just beyond 487A Cowan Bay Road and follow the ridge down to the building platform. The access is proposed to have a maximum grade of 1V in 5H and will be metalled. The proposed site access is shown on the lot plan attached in Appendix B.

## 12.5 Recommendations and Conclusions

### 12.5.1 Slope Stability

The slope stability analysis undertaken on the worst-case scenario slope indicate that the slopes surrounding the proposed building platform are unlikely to fail.

### 12.5.2 Foundation Design

Based on the exploratory hole results for HA's 1 and 2 we consider the following foundation options to be viable:

- Waffle-Slab type foundations with piles on the leading edge (if a flat platform is cut)
- Slab-on-grade with deepened edge beams and piles on the leading edge(if a flat platform is cut)
- Piled foundations
- Traditional strips and pads with piles on the leading edge (spread foundations)
- Edge ringbeam with piles on the leading edge, with suspended floor

Due to the steep slopes across the site we recommend that all shallow foundation types utilise piles on the leading (downhill) edge of the foundation.

We recommend that all foundations are designed to accommodate 0.5m of soil creep. If a flat platform is cut and the foundations are set back a minimum of 1.5m from the edge of the cut it will not be required to make allowances for soil creep, subject to confirmation by a CPEng (geotechnical) at the time of construction of the building platform.

All topsoil and any unanticipated fill encountered should be removed from the building platform prior to foundation construction. If engineered fill is required to form a building platform, further slope stability analysis will be required to confirm the stability of such fill.

We recommend that EDC be provided with a copy of the foundation plans before Building Consent submission, to allow EDC to confirm that the foundation options chosen are in accordance with the recommendations of this report.

### 12.5.3 Soil Bearing Capacity

The natural Pakiri Formation soils have shear strengths generally above 90kPa (on top of the ridge). It is therefore anticipated that a geotechnical ultimate bearing capacity of greater than 300kPa will be available for foundations founded below topsoil. After applying a static strength reduction factor (Φ) of 0.5, this indicates a dependable bearing capacity of at least 150kPa.

### 12.5.4 Settlement

The upper natural very stiff and stiff silt will in our opinion exhibit only low compressibility under the anticipated foundation loads, associated with the proposed development. Settlement of foundations in this material should most likely be within accepted limits, provided that the inspection and design of foundations are carried out in accordance with the requirements of NZS3604:2011 and the recommendations made in this report.

No foundations will be founded in the alluvial material encountered in HA2.

### 12.5.5 Expansive Soils

The natural soils must be treated as Class "M" soils in terms of AS2870: 2011. Any foundations that penetrate into the natural materials must be designed for Class "M", we recommend a minimum depth of 600mm for any edgebeams, strips, or pads (if a flat platform is cut) and a minimum depth of 900mm for any piles.

### 12.5.6 Earthworks

It is considered that earthworks will be required to cut the building platform down and provide more useable space. The surplus topsoil and any unsuitable soil (including soft or organic material), should be removed. This can be used for landscaping away from building platform, driveway and slopes, or removed completely from site. If it is to be placed on sloping areas further geotechnical advice will be required if the proposed thickness exceeds 600mm.

If it is proposed to place fill on the steep slopes EDC should first be contacted to examine the stability of the fill.

Any engineered fill, should be placed in layers of not more than 150mm thickness, suitably compacted at the optimum moisture content using an appropriate compaction method, to achieve, not less than 95% of the maximum dry density. The fill compaction could be checked by employing suitable site testing methods such as Scala Penetrometer testing, hand held shear vane (shear strength >120kPa), Clegg Hammer testing or other methods as described under NZS 4402:1986.

Any fill that is placed on a slope will require benching into the natural ground to assist with stability of the fill.

Cut and fill batters should be constructed no steeper than 1V in 4H unless approved by a Professional Chartered Engineer (Geotechnical). We recommend that all batter surfaces are covered with erosion matting to prevent sediment runoff into the driveway drains or the surrounding bush.

Any fill over 600mm thick must be certified by a Professional Chartered Engineer (Geotechnical) who has experience working with slope stability.

Any earthworks on the site must include controls to limit stormwater from overtopping the slopes as this could induce shallow instability on the edges of the cut and fill.

### 12.5.7 Stormwater

There is no reticulated potable water in the area; therefore rainwater will be being collected in tanks for use in the homes. The tanks will require a suitable overflow discharge outlet to be designed at the Building Consent stage. We recommend that no stormwater is discharged on the steep slopes below the building platform and that pipes carry the water to an overland flow path or other suitable discharge location to be discharged through a designed outlet.

### 12.5.8 Wastewater

A wastewater system and disposal areas will need to be developed following the design of the proposed dwelling being confirmed. Although EDC have not been provided with any details of the proposed dwelling, it is considered that a TP58 compliant system is likely to be able to be constructed dependent on the size of the proposed dwelling. It is recommended that the wastewater field is not located on the steep slopes below the building platform, due to the saturation of the slopes and potential for instability that would occur.

## 13.0 LOT 6

Lot 6 is proposed to contain the balance of farm; therefore, no further investigation was undertaken across Lot 6.

# 14.0 GEOTECHNICAL HAZARD ASSESSMENT

| Hazard | Potential Susceptibility | |
|---|---|---|
| | Current (a) | Post Development (b) |
| Erosion | No erosion was observed within the proposed building platform areas. | There is potential for erosion on building platforms and the surrounding slopes when earthworks are undertaken. Drainage should be implemented to prevent this, drainage should direct water away from the slopes below the PBP's. All earthworks should be undertaken in summer conditions. |
| Falling Debris | There is a small slip above the proposed building platform on Lot 2. | It is anticipated that if the slip reactivates it may runout across the proposed building platform. The slip should be retained. |
| Slippage | Evidence of soil creep and probable slumping was observed on the slopes surrounding all building platforms. Slip Scarps were also seen on Lot's 2 and 3. | All foundations will need to be designed for soil creep unless flat platforms are cut with a minimum foundation setback of 1.5m from the edge of the platform<br>Slope stability analysis was undertaken on all lots. Where required setbacks have been recommended. |
| Subsidence | No evidence of subsidence was observed on-site. | Provided that the foundations are located on a suitable natural bearing stratum and designed as per the recommendations in this report, the risk of subsidence is considered low. |
| Inundation - Liquefaction | The encountered soil types at this site are not anticipated to be at risk of liquefaction. As such the liquefaction inundation risk is considered low. | There is no anticipated change to the inundation risk as a result of the development. |
| Inundation - Flooding | No streams or overland flows paths flow through the proposed building platforms. | According to the Auckland Council GIS Viewer there are no flood plains on any of the proposed building platforms. The building platform on Lot 4 will be closest to the |

**Table 11: Geotechnical Hazard Assessment**

# 15.0 CONCLUSIONS AND RECOMMENDATIONS

## 15.1 General

Any earthworks must conform to NZS 4431: 1989.

Silt control in accordance with Auckland Council Guideline Document 2016/005 – "Erosion & Sediment Control Guide for Land Disturbing Activities in the Auckland Region" will be required.

## 15.1 Slope Stability

Slope stability assessments were undertaken on Lot's 2, 3, 4 and 5 of the proposed subdivision. Lot 1 is not being investigated by EDC, Lot 6 is the balance of the site and at this stage no building platforms are proposed on Lot 6.

The slope stability analysis of Lots 2 and 3 indicate that setbacks will be required from the slope crests. Analysis of Lots 4 and 5 indicate that the risk of global instability is unlikely.

## 15.2 Foundations

Specific foundation requirements are applicable for each of the three proposed building platforms. See Sections 9.4.2, 10.4.2, 11.4.2 and 12.4.2 of this report for further details.

## 15.3 Bearing Capacity

It is anticipated that a general geotechnical ultimate bearing capacity of 300kPa will be available for foundations founded at 600mm below cleared ground level and for waffle-slab foundations founded above 600mm depth across the site. (After applying a static strength reduction factor (Φ) of 0.5. This indicates a dependable bearing capacity of 150kPa).

It is anticipated that a general geotechnical ultimate bearing capacity of 500kPa will be available for piled foundations founded below 1000mm depth. (After applying a static strength reduction factor (Φ) of 0.5. This indicates a dependable bearing capacity of 250kPa).

## 15.4 Settlement

All the lots investigated were generally underlain by natural very stiff and stiff silt. These soils will in our opinion exhibit only low compressibility under the anticipated foundation loads, associated with the proposed development. Settlement of foundations in this material should most likely be within accepted limits, provided that the inspection and design of foundations are carried out in accordance with the requirements of NZS3604:2011 and the recommendations made in this report.

## 15.5 Soil Expansivity

The natural soils encountered on Lot's 2 - 5 must be treated as Class "M" soils in terms of AS2870: 2011. Any foundations that penetrate into the natural materials must be designed for Class "M", we recommend a minimum depth of 600mm for any edgebeams, strips, or pads (if a flat platform is cut) and a minimum depth of 900mm for any piles.

### 15.6 Site Access

It is proposed that all sites will be accessed from Cowan Bay Road, utilising several existing and proposed tracks/driveways. All the proposed access ways will require specific design including retaining walls and batters.

### 15.7 Retaining Walls

Retaining walls are likely to be needed during development of these sites for building platforms and access ways. In particular, a large retaining structure on Lot 4 will likely be required to support a cut and fill building platform. When retaining structures are proposed, EDC should be contacted to provide additional specific advice in relation to the design of these walls.

We recommend the following parameters to be used for the design of any new retaining walls:

| | | |
|---|---|---|
| Soil Bulk Unit Weight | $\gamma$ | = 18kN/m$^3$ |
| Soil in situ Shear Strength | $c_u$ | = 60kPa |
| Internal Angle of Friction | $\phi$ | = 28° |
| Active Earth Pressure Co-Efficient | $k_a$ | = 0.33 |
| Passive Earth Pressure Co-Efficient* | $k_0$ | = 0.5 |

Surcharge (if wall is on a boundary or supporting infrastructure) = 12kPa

*Passive earth pressure co-efficient used when the wall is supporting infrastructure or a boundary and must remain rigid.

Please note: any visible retained height in excess of 1m will require an approved hand rail designed to code to be fitted to the top of the retaining wall.

### 15.8 Earthworks

Earthworks may be required to form level ground for the building platforms and to construct the driveways to the new building sites. The surplus soil and any uncertified fill (if encountered at later date), soft or otherwise unsuitable material, should be removed from below the building platform. This can be used for landscaping away from building platforms and slopes – subject to geotechnical approval.

Any engineered fill, should be placed in layers of not more than 150mm thickness, on a level surface (slopes may require benching to achieve a level surface), suitably compacted at the optimum moisture content using an appropriate compaction method, to achieve, not less than 95% of the maximum dry density. The fill compaction could be checked by employing suitable site testing methods such as Scala Penetrometer testing, hand held shear vane (shear strength >120kPa) or other methods as described under NZS 4402:1986.

If it is proposed to place any fill on slopes, EDC should be contacted to verify the stability of placing such fill.

Where a Scala Penetrometer is used, readings of 4 blows or more per 100mm of penetration is generally considered as an acceptable degree of compaction.

Granular hard fill should be compacted at optimum moisture content to achieve 95% of the maximum dry density. When checked with a Clegg Hammer, the compaction should such achieve a Clegg Impact Value (CIV) greater than 25.

Where previously unrecorded fill is encountered, this material must be completely removed from below the proposed building pad. Suitability of such material, for driveway construction, should be confirmed by the Chartered Geotechnical Engineer.

Cut and fill batters should be constructed no steeper than 1V in 4H (14°) unless approved by a Chartered Engineer (Geotechnical).

Any fill over 600mm total depth on sloping ground is of potential concern as it adds additional surcharge. Building foundations constructed over such fill will also have a potential for differential settlement.

EDC should be consulted if fills >600mm thick are proposed. Any fill over 600mm thickness within the building platforms must be certified by a Chartered Engineer (Geotechnical) who has experience working with expansive soils.

It should be anticipated that earthworks plant and inclement weather could lead to the creation of significant quantities of unsuitable material, unless the earthworks programme, site activities and the plant used are chosen accordingly. For Lot 3 in particular we recommend no earthworks between the start of May and the end of August (i.e. winter) and earthworks should only be undertaken if a prolonged dry period is forecast.

### 15.9 Stormwater

Stormwater collected from roofs should be used for domestic purposes. Stormwater from impermeable surfaces and overflow from domestic tanks shall be collected and disposed of to appropriate points in accordance with Council requirements and not on the steep slopes. These points shall be protected from erosion due to the concentrated discharge of water, usually by the use of spreader bars. It is considered likely that there is sufficient space on each lot to provide adequate stormwater disposal, although further calculations will be required to confirm this following finalisation of the house plans for each lot.

Cut off drains may be required up slope of the building platforms on Lots 2 and 4 depending on the amount of water anticipated to flow down the slopes above. We recommend a civil engineer is consulted for this work.

### 15.10 On-Site Wastewater Disposal

It is proposed that each individual dwelling utilises on-site disposal for the generated wastewater. When designing lot sizes sufficient space for both main and reserve on-site wastewater disposal fields should be considered around the proposed building platforms

in accordance with Auckland Council's TP58. Further calculations will need to be undertaken to confirm this following finalisation of the house plans for each lot. Due to the slopes of the site an extra allowance in field area will be required (refer to AS/NZS 1547:2012), if the disposal fields are proposed to be located on the slope. We recommend that no wastewater disposal fields are located on slopes directly below the proposed building platforms. If the wastewater fields are required in these areas, we recommend that EDC be contacted to confirm the stability under saturated conditions and that strong rooted and high water use vegetation is planted within the wastewater field areas.

There are a number of aspects of both the treatment process and the disposal system that must be given appropriate consideration in the context of this development. Of key significance is the potential for contamination of any nearby overland flow paths. This will need to be addressed during detailed design of the individual disposal system.

# 16.0 SUPERVISION CONSIDERATIONS

## 16.1 Earthworks and Foundation Inspections

The geotechnical engineer should generally inspect earthworks and foundation construction at the following stages, and pursuant to any Building Consent Conditions:

i) Once topsoil and existing fill is stripped

ii) During any bulk cut and fill required to form a platform

iii) Once foundations are excavated

## 16.2 Pile Inspections - Timber Pole Piles

The geotechnical engineer should generally inspect timber poles piles at the following stages, and pursuant to any Building Consent Conditions:

i) Following excavation of the pile holes

ii) Once the poles are installed and before concrete pour

## 16.3 Retaining Wall Inspections (if any Retaining Walls are required)

A Pre-construction Meeting will be required with the engineer and contractor that is constructing the retaining walls

The geotechnical engineer should generally inspect any retaining wall construction (if required), at the following stages, and pursuant to any Building Consent Conditions:

For timber pole walls:

i) Following excavation of the pile holes

ii) Once the poles are installed and before concrete pour

iii) Once the first row of rails are in place and drain coil installed

iv) Once all rails are in place and the drainage media installed

For gravity walls (e.g. block) and including segmental ("Keystone" type):

i) Following excavation for footing

ii) Once footing reinforcing steel in place

iii) During backfilling and placement of any geogrids

iv) When first section of blocks are laid

v) When draincoil in place and prior to backfill

### 16.4 General

All inspections will require a minimum of 24 hours notice and it should be noted that unless we are given the chance to undertake all appropriate inspections for the items specified in the Building Consent, we would not be able to issue a Producer Statement (PS4).

## 17.0 HEALTH AND SAFETY

We recommend that 'Safety in Design' principles are included during the design of the new dwellings and any associated structures. Specifically, for this site consideration needs to be made with respect to excavations, working on steep slopes and working around potentially unstable land (particularly on Lot's 2 and 3). Care should be taken during planning and construction of temporary all weather construction access on steep slopes and construction methodology for earthworks and retaining structures. Temporary works may be required during these phases. EDC would be happy to provide geotechnical advice in relation to these issues at any workshops or design meetings for this project.

# APPENDIX A

# SUBDIVISION SCHEME PLAN


Territorial Authority: Auckland Council
Operative Auckland Council District Plan (Rodney Section) 2011:
Zone: East Coast Rural
Auckland Unitary Plan Operative in part:
Zone: Rural - Rural Coastal Zone, Whangateau - Waiwera Coastal Area
Natural Resources: SEA Overlay
Natural Heritage: ONL & HNC Overlay

## Memorandum of Easements

| Purpose | Shown | Servient Tenement | Dominant Tenement |
|---|---|---|---|
| Right of Way & Utility Services | F V QF | Lot 6 | Lot 5 |
| Telecomm-unications | QD | Lot 4 | Lot 3 DP313489<br>Lot 1 DP375848<br>Lot 1 DP398973 |

Existing Telecommunications Easement over Area QA (created by EI 5547255.6) on Lot 3 is to be cancelled.

## Land Rehabilitation Planting Areas

| | | | |
|---|---|---|---|
| **PA** | 9.66 ha | **PG** | 0.32 ha |
| **PB** | 0.17 ha | **PH** | 3.78 ha |
| **PC** | 0.24 ha | **PI** | 0.34 ha |
| **PD** | 5.71 ha | **PJ** | 0.75 ha |
| **PE** | 5.88 ha | **PK** | 0.96 ha |
| **PF** | 2.19 ha | Total | 30.00 ha |

Areas shown as **PA** to **PK** are to be subject to land covenants for the protection of land rehabilitation planting areas.

## Amalgamation Condition

That Lot 6 hereon and Lot 2 DP 501845 are held together in one computer register.

## Existing Covenants

The following areas are subject to existing land covenants for the protection of wetlands, native bush or planting:
FH, ZH, ZI, G, H, I, J, N, P, Q, AE, K, AA, AB, AC, AD, AG, AI, AJ, M, CA, CB, DA, DB, DC, DD, DI, DJ, DK, EA, EB, EC, ZA, ZB, ZC, ZD, ZE, ZF, & ZG
For consent notice numbers see DP 476990 & CT 750686.

## Existing Easements

Existing ROW & Services: F, V, QF, QG
Pedestrian ROW: X, ES, ET, FG
Telecomm: QA, QB, QC, AB, K
Electricity in gross: K, AA, AH, DD, DJ, FG, FH, ZB, ZD, ZF

| | |
|---|---|
| Land District: | North Auckland |
| Total Area: | 88.4837 ha |
| CT: | 750686 |

NOTES:
1. This plan has been prepared for consent purposes only and is not to be used for any other purpose.
2. All metric measurements and areas are subject to final survey.

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PO Box 266 Warkworth 0941, Ph 09 425 8700
www.parallaxsurveyors.co.nz

Project:
Cowan Bay Farm Limited
Cowan Bay Road
Pohuehue

Plan Title:
Lots 1 to 6 being a proposed subdivision of Lot 11 DP 476990 & Covenant over Lot 2 DP 501845

| Original Scale: | Original Size: |
|---|---|
| 1:5000 | A3 |
| Date: | Job Number: |
| June 2017 | 11028-46b |

# APPENDIX B

# INDIVIDUAL LOT SURVEY PLANS


Territorial Authority: Auckland Council
Operative Auckland Council District Plan (Rodney Section) 2011:
Zone: East Coast Rural
Auckland Unitary Plan Operative in part:
Zone: Rural - Rural Coastal Zone,
Whangateau - Waiwera Coastal Area
Natural Resources: SEA Overlay
Natural Heritage: ONL & HNC Overlay

## Memorandum of Easements

| Purpose | Shown | Servient Tenement | Dominant Tenement |
|---|---|---|---|
| Right of Way & Utility Services | F V QF | Lot 6 | Lot 5 |
| Telecomm-unications | QD | Lot 4 | Lot 3 DP313489<br>Lot 1 DP375848<br>Lot 1 DP398973 |

Existing Telecommunications Easement over Area QA (created by EI 5547255.6) on Lot 3 is to be cancelled.

## Land Rehabilitation Planting Areas

| | | | |
|---|---|---|---|
| **PA** | 9.66 ha | **PG** | 0.32 ha |
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| **PE** | 5.88 ha | **PK** | 0.96 ha |
| **PF** | 2.19 ha | Total | 30.00 ha |

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## Amalgamation Condition

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## Existing Covenants

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FH, ZH, ZI, G, H, I, J, N, P, Q, AE, K, AA, AB, AC, AD, AG, AI, AJ, M, CA, CB, DA, DB, DC, DD, DI, DJ, DK, EA, EB, EC, ZA, ZB, ZC, ZD, ZE, ZF, & ZG
For consent notice numbers see DP 476990 & CT 750686.

## Existing Easements

Existing ROW & Services: F, V, QF, QG
Pedestrian ROW: X, ES, ET, FG
Telecomm: QA, QB, QC, AB, K
Electricity in gross: K, AA, AH, DD, DJ, FG, FH, ZB, ZD, ZF

| | |
|---|---|
| Land District: | North Auckland |
| Total Area: | 88.4837 ha |
| CT: | 750686 |

NOTES:
1. This plan has been prepared for consent purposes only and is not to be used for any other purpose.
2. All metric measurements and areas are subject to final survey.

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www.parallaxsurveyors.co.nz

Project:
Cowan Bay Farm Limited
Cowan Bay Road
Pohuehue

Plan Title:
Lot 2
Building Platform Plan

| | |
|---|---|
| Original Scale: 1:1000 | Original Size: A3 |
| Date: June 2017 | Job Number: 11028-47b Version 3 |


Territorial Authority: Auckland Council
Operative Auckland Council District Plan (Rodney Section) 2011:
Zone: East Coast Rural
Auckland Unitary Plan Operative in part:
Zone: Rural - Rural Coastal Zone,
Whangateau - Waiwera Coastal Area
Natural Resources: SEA Overlay
Natural Heritage: ONL & HNC Overlay

## Memorandum of Easements

| Purpose | Shown | Servient Tenement | Dominant Tenement |
|---|---|---|---|
| Right of Way & Utility Services | F V QF | Lot 6 | Lot 5 |
| Telecomm-unications | QD | Lot 4 | Lot 3 DP313489<br>Lot 1 DP375848<br>Lot 1 DP398973 |

Existing Telecommunications Easement over Area QA (created by EI 5547255.6) on Lot 3 is to be cancelled.

## Land Rehabilitation Planting Areas

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|---|---|---|---|
| **PA** | 9.66 ha | **PG** | 0.32 ha |
| **PB** | 0.17 ha | **PH** | 3.78 ha |
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| **PE** | 5.88 ha | **PK** | 0.96 ha |
| **PF** | 2.19 ha | Total | 30.00 ha |

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## Amalgamation Condition

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FH, ZH, ZI, G, H, I, J, N, P, Q, AE, K, AA, AB, AC, AD, AG, AI, AJ, M, CA, CB, DA, DB, DC, DD, DI, DJ, DK, EA, EB, EC, ZA, ZB, ZC, ZD, ZE, ZF, & ZG
For consent notice numbers see DP 476990 & CT 750686.

## Existing Easements

Existing ROW & Services: F, V, QF, QG
Pedestrian ROW: X, ES, ET, FG
Telecomm: QA, QB, QC, AB, K
Electricity in gross: K, AA, AH, DD, DJ, FG, FH, ZB, ZD, ZF

| | |
|---|---|
| Land District: | North Auckland |
| Total Area: | 88.4837 ha |
| CT: | 750686 |

NOTES:
1. This plan has been prepared for consent purposes only and is not to be used for any other purpose.
2. All metric measurements and areas are subject to final survey.

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Project:
Cowan Bay Farm Limited
Cowan Bay Road
Pohuehue

Plan Title:
Lots 3 & 4
Building Platform Plan

| Original Scale: | Original Size: |
|---|---|
| 1:1000 | A3 |
| Date: June 2017 | Job Number: 11028-47c Version 3 |


Territorial Authority: Auckland Council
Operative Auckland Council District Plan (Rodney Section) 2011:
Zone: East Coast Rural
Auckland Unitary Plan Operative in part:
Zone: Rural - Rural Coastal Zone,
Whangateau - Waiwera Coastal Area
Natural Resources: SEA Overlay
Natural Heritage: ONL & HNC Overlay

## Memorandum of Easements

| Purpose | Shown | Servient Tenement | Dominant Tenement |
|---|---|---|---|
| Right of Way & Utility Services | F V QF | Lot 6 | Lot 5 |
| Telecomm-unications | QD | Lot 4 | Lot 3 DP313489<br>Lot 1 DP375848<br>Lot 1 DP398973 |

Existing Telecommunications Easement over Area QA (created by EI 5547255.6) on Lot 3 is to be cancelled.

## Land Rehabilitation Planting Areas

| | | | |
|---|---|---|---|
| **PA** | 9.66 ha | **PG** | 0.32 ha |
| **PB** | 0.17 ha | **PH** | 3.78 ha |
| **PC** | 0.24 ha | **PI** | 0.34 ha |
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| **PE** | 5.88 ha | **PK** | 0.96 ha |
| **PF** | 2.19 ha | Total | 30.00 ha |

Areas shown as **PA** to **PK** are to be subject to land covenants for the protection of land rehabilitation planting areas.

## Amalgamation Condition

That Lot 6 hereon and Lot 2 DP 501845 are held together in one computer register.

## Existing Covenants

The following areas are subject to existing land covenants for the protection of wetlands, native bush or planting:
FH, ZH, ZI, G, H, I, J, N, P, Q, AE, K, AA, AB, AC, AD, AG, AI, AJ, M, CA, CB, DA, DB, DC, DD, DI, DJ, DK, EA, EB, EC, ZA, ZB, ZC, ZD, ZE, ZF, & ZG
For consent notice numbers see DP 476990 & CT 750686.

## Existing Easements

Existing ROW & Services: F, V, QF, QG
Pedestrian ROW: X, ES, ET, FG
Telecomm: QA, QB, QC, AB, K
Electricity in gross: K, AA, AH, DD, DJ, FG, FH, ZB, ZD, ZF

| | |
|---|---|
| Land District: | North Auckland |
| Total Area: | 88.4837 ha |
| CT: | 750686 |

NOTES:
1. This plan has been prepared for consent purposes only and is not to be used for any other purpose.
2. All metric measurements and areas are subject to final survey.

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Project:
Cowan Bay Farm Limited
Cowan Bay Road
Pohuehue

Plan Title:
Lot 5
Building Platform Plan

| | |
|---|---|
| Original Scale: 1:1000 | Original Size: A3 |
| Date: June 2017 | Job Number: 11028-47d Version 3 |

# APPENDIX C

# EXPLORATORY HOLE LOGS

**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA01

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | CT | GBW |

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: 266

| DEPTH (m) GL | SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments) | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|
| | TOPSOIL | TS | | | | |
| | Very stiff, brownish orange, SILT, dry, friable, trace rootlets (1-2mm diameter) (PAKIRI FORMATION) | | | | | |
| | trace fine sand | | | | 8.4 | |
| | trace speckles of brown and red | | | | | |
| 1 | Very stiff, pinkish orangish red, SILT, trace fine sand, moist, friable (PAKIRI FORMATION) | | | Peak Exceeded | - | |
| | speckled white, trace white fine angular gravels | | | | 4.9 | |
| | trace to minor clay, streaks of pale grey, pale grey has low plasticity | | | | | |
| 2 | | | | | 3.2 | |
| | streaks of brown and light pink | | | | 5.3 | |
| | streaks of brownish black volcanic ash | | | | | |
| 3 | | | | | 5.9 | |
| | streaks of pale grey, trace fine gravel | | | | 6.1 | |
| | speckles of pale grey, no streaks | | | | | |
| 4 | | | | | 6.3 | |
| | speckles and streaks of black | | | Peak Exceeded | - | |
| 5 | End of Hand Auger (Target Depth Achieved) | | | Peak Exceeded | - | |
| 6 | | | | | | |

EOH @ 6.75 m

**NOTES:**
No groundwater encountered during drilling


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FAX (09) 415 1280

1st FLOOR, UNIT 1, 100 BUSH ROAD, ALBANY, AUCKLAND

PH (09) 451 9044




Printed: 4/05/2017 5:27:48 PM

**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA02

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| SG | CT | GBW |

BH LOCATION: COORDS: 1751424mE, 5964999mN RL GROUND:

SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION | Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak 40 80 120 160 | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) 5 10 15 |
|---|---|---|---|---|---|---|---|
| | TOPSOIL | | | | | | |
| | Very stiff, brown grey trace orange, SILT, dry, friable (ALLUVIUM) | | | | | | |
| | pale grey streaked orange, slightly friable, slightly moist | | | | | 4.5 | |
| 1 | Stiff, pale grey brown, clayey SILT, moist (ALLUVIUM) | | | | | 1.9 | |
| | moderately plastic | | | | | | |
| | grey trace orange, trace decayed organic material | | | | | 2.0 | |
| | decaying organic material | | | | | | |
| 2 | | | | SWL | | 2.1 | |
| | poor sample recovery | | | | | | |
| | saturated, light bluish grey | | | | | 2.1 | |
| | 'Loose' blueish grey, SAND, wet (ALLUVIUM) | | | | | | |
| | poor sample recovery | | | | | | |
| 3 | | | | | | 7.0 | |
| | Stiff, greenish grey, SILT, friable, wet (ALLUVIUM) | | | | | | |
| | some sand and fine gravel | | | | | | |
| | Very stiff, orange, CLAY, wet, friable (PAKIRI FORMATION) | | | | Peak Exceeded | - | |
| | light greenish grey | | | | | | |
| | much sand and fine and occasional medium gravel | | | | | | |
| 4 | pale grey streaked orange, occasional pockets of limonite sand and fine gravel | | | | Unable To Penetrate | - | |
| | 'Medium dense', yellowish orange, silty SAND, wet (PAKIRI FORMATION) | | | | | | |
| | End of Hand Auger (Difficult to Drill) | | | | | | |

EOH @ 4.60 m

**NOTES:**

groundwater encountered at 2.0m bgl

Scala bouncing at 4.6m bgl


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**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA03

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | CT | GBW |

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: 266

| DEPTH (m) GL | SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments) | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|
| | TOPSOIL | TS | | | | |
| | trace orange streaks | TS | | | 14.5 | |
| | Very stiff, pale brown mixed orange, SILT, trace sand, dry, friable (PAKIRI FORMATION) | | | | | |
| | orange mixed dark grey | | | | | |
| 1 | minor to some sand, streaks of black | | | Peak Exceeded | - | |
| | 'Dense', pale brown, silty fine SAND, dry, friable (PAKIRI FORMATION) | | | | | |
| | streaks of pale grey clay | | | | | |
| | Unable to drill with hand auger switching to Scala Penetrometer for guide hole | | | | | |
| | Very stiff, orangish brown, sandy SILT, dry, friable, trace fine gravel (PAKIRI FORMATION) | | | | | |
| 2 | | | | Unable To Penetrate | - | |
| | Very stiff, brown, streaked dark grey, orange, brown, black, clayey SILT, moist, moderately plastic (PAKIRI FORMATION) | | | | 12.5 | |
| | streaks of limonite and black fine angular gravels | | | | | |
| | Pale grey, intermixed reddish black limonite gravel, difficult to drill, sandy SILT, minor clay (PAKIRI FORMATION) | | | Unable To Penetrate | - | |
| 3 | Very stiff, pale grey speckled white, SILT, minor clay, some sand and fine gravel, moist, friable (PAKIRI FORMATION) | EOH @ 3.00 m | | Unable To Penetrate | - | |
| | wet, pockets/streaks of limonite fine gravel and sand | | | | | |
| | End of Hand Auger (Unable to Drill) | | | | | |

**NOTES:**
No groundwater encountered during drilling
Scala bouncing at 2.95m bgl


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**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA04

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| SG | CT | GBW |

BH LOCATION: COORDS: 1752144mE, 5964703mN RL GROUND:

SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments) | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|
| | TOPSOIL | TS | | | | |
| | Very stiff, pale grey mottled orange, SILT, dry, friable (PAKIRI FORMATION) | | | | | |
| | pale grey streaked orange, friable in places, slightly moist | | | Peak Exceeded | - | |
| | non friable, small pockets of orange sand and fine gravels | | | | | |
| 1 | friable, moist | | | | 4.0 | |
| | pale grey trace orange, patches of grey | | | | 4.9 | |
| 2 | trace sand | | | | 5.4 | |
| | pale grey | | | | | |
| | 'Medium dense', pale grey/orange, silty SAND (PAKIRI FORMATION) | | | Unable To Penetrate | - | |
| | End of Hand Auger (Difficult to Drill) | | | | | |

EOH @ 2.80 m

**NOTES:**
No groundwater encountered during drilling
Scala bouncing at 2.8m bgl


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**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA05

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| SG | CT | GBW |

BH LOCATION: COORDS: 1752142mE, 5964721mN RL GROUND:

SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments) | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|
| | TOPSOIL | TS | | | | |
| | Stiff, pale grey brown mottled orange, SILT, slightly moist, friable (PAKIRI FORMATION) | | | | 4.8 | |
| | non friable, moist | | | | | |
| 1 | pale grey mottled orange, friable in places, occasional small pockets of sand and fine gravel | | | | 2.8 | |
| | | | | | 5.3 | |
| | moist to very moist, pale grey trace orange | | | | | |
| 2 | 'Medium dense', pale grey trace orange, silty SAND (PAKIRI FORMATION) | | | Unable To Penetrate | - | |
| | some fine gravel, pale grey/orange | | | | | |
| | some white | | | Unable To Penetrate | - | |
| | End of Hand Auger (Difficult to Drill) | | | | | |
| 3 | | | | | | |

EOH @ 3.40 m

**NOTES:**
No groundwater encountered during drilling
Scala bouncing at 3.4m bgl


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**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA06

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| SG | CT | GBW |

BH LOCATION: COORDS: 1752146mE, 5964570mN RL GROUND:

SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION | Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|---|
| | TOPSOIL | | TS | | | | |
| | Very stiff, brown trace orange, SILT, dry, friable, some topsoil intrusion (PAKIRI FORMATION) | | | | Unable To Penetrate | - | |
| | slightly moist, friable in places | | | | | | |
| | pale grey brown streaked orange, non friable | | | | Unable To Penetrate | - | |
| 1 | occasional very small pockets of sand and fine gravel | | | | | | |
| | pale grey white streaked orange, slightly friable | | | | | 3.7 | |
| | friable | | | | | | |
| | yellowish pale grey mottled orange | | | | | 3.3 | |
| 2 | trace sand | | | | | 3.3 | |
| | pale grey trace orange, moist | | | | | | |
| 3 | small pockets of sand and fine gravel | | | | | 3.5 | |
| | much sand and fine gravel | | | | | 2.7 | |
| 4 | Very stiff, pale grey brown, sandy SILT, moist, friable, some fine gravel (PAKIRI FORMATION) | | | | | 2.7 | |
| | 'Medium dense', pale grey brown, SAND, moist (PAKIRI FORMATION) | | | | | 2.9 | |
| | orange/light brown grey | | | | | | |
| 5 | End of hand Auger (Target Depth Achieved) | | | | Unable To Penetrate | - | |
| 6 | | | | | | | |

EOH @ 6.85 m

**NOTES:**
No groundwater encountered during drilling


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**DRILLED:** 13/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA07

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | CT | GBW |

BH LOCATION: COORDS: 1752161mE, 5964590mN RL GROUND: SHEAR VANE ID#: 266

| DEPTH (m) GL | SOIL DESCRIPTION | Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak 40 80 120 160 | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) 5 10 15 |
|---|---|---|---|---|---|---|---|
| | TOPSOIL | | TS | | | | |
| | trace orange streaks | | | | | | |
| | Very stiff, brownish orange, SILT, trace sand, moist, low plasticity (PAKIRI FORMATION) | | | | | | |
| | streaks of grey | | | | | 6.5 | |
| 1 | | | | | | | |
| | grey, streaks of orange, stiff, very moist | | | | | 4.3 | |
| | | | | | | 3.1 | |
| | trace clay | | | | | | |
| | orange streaked pale grey | | | | | | |
| 2 | | | | | | 3.6 | |
| | pale grey streaked orange | | | | | | |
| | minor clay, minor pumice sand | | | | | 3.5 | |
| | very moist | | | | | | |
| | pockets and streaks of limonite | | | | | | |
| 3 | very stiff | | | | | 3.6 | |
| | dark grey, streaks of orange limonite | | | | | | |
| | saturated, orange, trace fine gravel, streaks of pale grey | | | | | | |
| | stiff, some sand | | | | | 10.2 | |
| | Very stiff, dark grey, SILT, moist, low plasticity (PAKIRI FORMATION) | | | | | | |
| | some sand, friable | | | | | | |
| 4 | streaks of limonite, very friable | | | | Unable To Penetrate | - | |
| | End of Hand Auger (Unable to Drill) | | | | | | |

EOH @ 4.35 m

**NOTES:**

No groundwater encountered during drilling but soils very moist between 1.1m and 2.9m bgl
Scala bouncing at 4.3m bgl


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**DRILLED:** 14/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA08

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | CT | GBW |

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION | Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|---|
| | TOPSOIL | | | | | | |
| | Very stiff, orange streaked dark grey, SILT, trace sand, dry, friable (PAKIRI FORMATION) | | | | | | |
| | moist, low plasticity, stiff | | | | | 4.2 | |
| 1 | orange streaked brown | | | | | 3.2 | |
| | orange streaked pale grey | | | | | 2.3 | |
| | streaks of coarse orange sand | | | | | | |
| | Stiff, grey streaked reddish orange, sandy SILT, moist, friable (PAKIRI FORMATION) | | | | | | |
| 2 | 'Medium dense', brownish orange streaked grey, silty SAND, moist, friable (PAKIRI FORMATION) | | | | | 3.3 | |
| | Stiff, brownish orange, SILT, some clay, trace fine gravel, moist to very moist, low plasticity (PAKIRI FORMATION) | | | | | 2.7 | |
| | Stiff, pale grey trace orange streaks, clayey SILT, trace fine gravel, moist, moderately plastic (PAKIRI FORMATION) | | | | | | |
| 3 | firm | | | | | 4.6 | |
| | Firm, pale grey streaked orange, SILT, minor pumice sand, moist, friable, trace fine gravel (PAKIRI FORMATION) | | | | | | |
| | pale brownish orange | | | | | | |
| | Very stiff, pale grey trace orange, SILT, some clay, moist, moderate plasticity, trace streaks of orange sand (PAKIRI FORMATION) | | | | | 4.9 | |
| | stiff | | | | | | |
| 4 | pockets of wet sand | | | | | 2.5 | |
| | very stiff | | | | | | |
| | Firm, grey, CLAY, moist/wet, high plasticity (PAKIRI FORMATION) | | | | Unable To Penetrate | - | |
| | minor gravel | | | | | | |
| | Very stiff, pale grey, SILT, moist, slightly friable (PAKIRI FORMATION) | | | | | | |
| | orange streaks, very friable, difficult to drill | | | | | | |
| 5 | End of Hand Auger (Difficult to Drill) | | EOH @ 5.00 m | | | | |

**NOTES:**

No groundwater encountered during drilling but soils moist between 0.4m and end of hole, becoming moist to wet in places with depth
Scala bouncing at 5.0m bgl


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**DRILLED:** 14/02/2017 **FILE:** 46953

**HAND AUGER NO.:** **HA09**

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | CT | GBW |

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION | Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak 40 80 120 160 | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) 5 10 15 |
|---|---|---|---|---|---|---|---|
| | TOPSOIL | | | | | | |
| | Stiff, grey streaked red, sandy SILT, dry, friable (PAKIRI FORMATION) | | | | | | |
| | Very stiff, grey streaked orange/red, SILT, some sand, dry, friable (PAKIRI FORMATION) | | | | | 10.4 | |
| | trace sand, slightly friable, moist | | | | | | |
| 1 | no red streaks, dark grey streaked orange, low plasticity | | | | | 4.8 | |
| | trace orange streaks | | | | | 3.2 | |
| | some orange, stiff, minor clay, low plasticity | | | | | | |
| 2 | streaks of orange fine angular gravel of limonite, pale grey | | | | | 2.3 | |
| | pockets of limonite orange sand and gravel | | | | | 2.6 | |
| | Stiff, grey streaked orange, speckled white, silty CLAY, minor gravel, moist, moderate plasticity (PAKIRI FORMATION) | | | | | | |
| 3 | Stiff, reddish orange streaked red, moist, friable, trace clay, sandy SILT, trace black speckles of fine angular gravel (PAKIRI FORMATION) | | | | | 2.7 | |
| | Stiff, pale grey trace black speckles, SILT, minor clay, moist, low plasticity (PAKIRI FORMATION) | | EOH @ 3.50 m | | Unable To Penetrate | - | |
| | black streaks of volcanic ash | | | | | | |
| | orange intermixed pale grey and brown, black speckles, trace fine gravels, some clay | | | | | | |
| | pale grey, black speckles | | | | | | |
| | End of Hand Auger (Unable to Penetrate) | | | | | | |

**NOTES:**

No groundwater encountered during drilling but soils moist from 0.5m bgl to base of hole
Scala bouncing at 3.5m bgl


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**DRILLED:** 14/02/2017 **FILE:** 46953

**HAND AUGER NO.:** HA10

SHEET 1 OF 1

**PROJECT:** Proposed Subdivision **CLIENT:** Cowan Bay Farm Ltd

**ADDRESS:** Cowan Bay Farm

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | CT | GBW |

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments) | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|
| | TOPSOIL | | | | | |
| | Stiff, brownish orange, streaked brown, SILT, trace sand, dry, friable, (200mm- very stiff) (PAKIRI FORMATION) | | | | 19.6 | |
| | no brown streaks, trace white speckles | | | | | |
| 1 | streaks of brownish red | | | Peak Exceeded | - | |
| | very friable | | | | | |
| | trace black streaks | | | Peak Exceeded | - | |
| | streaks of black volcanic ash | | | | | |
| 2 | trace pockets of pink, brownish orange | | | | 3.3 | |
| | pale orange | | | | | |
| | trace rootlets (1-2mm diameter) | | | | 3.6 | |
| | trace streaks of red and black | | | | | |
| 3 | trace fine white angular gravels, orangish brown | | | | | |
| | very friable, stiff | | | | 3.5 | |
| | | | | | 3.4 | |
| | streaks of limonite grave and sand around volcanic ash | | | | | |
| | very friable, stiff | | | | | |
| 4 | wet, trace clay | | | | 2.7 | |
| | streaks of white and orange | | | | | |
| | | | | Peak Exceeded | - | |
| | Very stiff, pale grey, SILT, trace clay, moist, slightly friable (PAKIRI FORMATION) | | | | | |
| | wet, orangish brown, some clay, low plasticity | | | | | |
| 5 | 'Medium dense', brownish orange streaked black volcanic ash, silty SAND, wet, friable (PAKIRI FORMATION) | | | Peak Exceeded | - | |
| | End of Hand Auger (Target Depth Achieved) | | | | | |
| 6 | | | | | | |

EOH @ 6.80 m

**NOTES:**
No groundwater encountered during drilling but soils wet at base of hole


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**DRILLED: 24/04/2017** **FILE: 46953**

**HAND AUGER NO.:** **HA11**

SHEET 1 OF 1

**PROJECT: Proposed Subdivision** **CLIENT: Cowan Bay Farm Ltd**

**ADDRESS: Cowan Bay Farm**

| LOGGED | PROCESSED | CHECKED |
|---|---|---|
| DM | DM | GBW |

BH LOCATION: COORDS: RL GROUND: SHEAR VANE ID#: 4469

| DEPTH (m) GL | SOIL DESCRIPTION (Strength/density, colour, structure, minor, MAJOR, plasticity, moisture content, other comments) | LEGEND | GROUND WATER | SHEAR STRENGTH (kPa) ○Residual ●Peak | SOIL SENSITIVITY | SCALA BLOWS (PER 50 mm) |
|---|---|---|---|---|---|---|
| | TOPSOIL | | | | | |
| | streaks of orange silt | | | | | |
| | Very stiff, brownish orange, SILT, moist, low plasticity (PAKIRI FORMATION) | | | | 2.2 | |
| 1 | streaks of pale grey, streaks of bright orange | | | | 2.1 | |
| | trace rootlets | | | | | |
| | streaks of bright red, trace white fine angular gravels | | | | 2.7 | |
| | Very stiff (firm on auger), brownish red, streaks pale orange, SILT, minor clay, trace fine gravel (white), moist, friable (PAKIRI FORMATION) | | | | | |
| 2 | streaks and pockets of black volcanic ash, wet | | | | 7.3 | |
| | occasional pockets of white silt | | | | 6.1 | |
| | Very stiff, brownish red, sandy SILT, minor clay, occasional streaks of black volcanic ash, wet, friable (PAKIRI FORMATION) | | | | | |
| 3 | 'Medium dense', brownish red, streaked cream, silty SAND, wet, friable (PAKIRI FORMATION) | | | | 5.2 | |
| | brownish grey | | | Unable To Penetrate | - | |
| | 50mm layer of low plasticity, creamy red, silty clay | | | | | |
| | Very stiff, dark brownish grey, streaks of red, sandy SILT, minor clay, saturated, friable, trace pumice, trace fine gravel (PAKIRI FORMATION) | | | | | |
| 4 | some pumice 'crushes in fingers', orange, occasional creamy brown | | | Unable To Penetrate | - | |
| | End of Hand Auger - Too Difficult to Drill | | | | | |

EOH @ 4.10 m

**NOTES:**

No groundwater encountered during drilling but soils wet from 1.6m to 3.8m bgl and saturated from 3.8m to base of holes


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# APPENDIX D

# HAND AUGERED EXPLORATORY HOLE CORE PHOTOS

HA1 – Lot 5

HA2 – Lot 5

HA3

HA4

HA5

HA6 – Lot 3

HA7 – Lot 3

HA8 – Lot 2

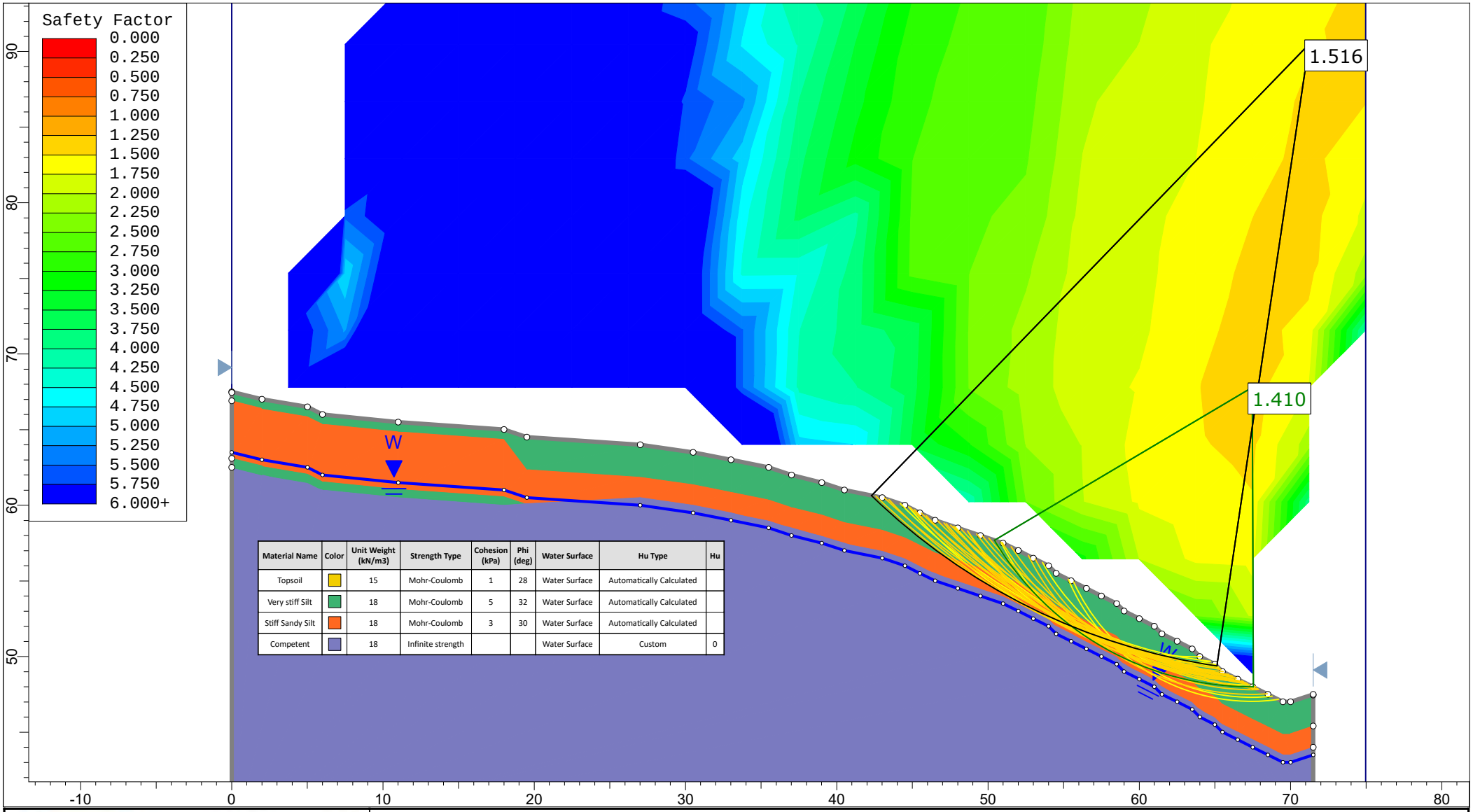
HA9 – Lot 2

HA10 – Lot 2

HA11 – Lot 4

# APPENDIX E

# SLOPE STABILITY MODELS

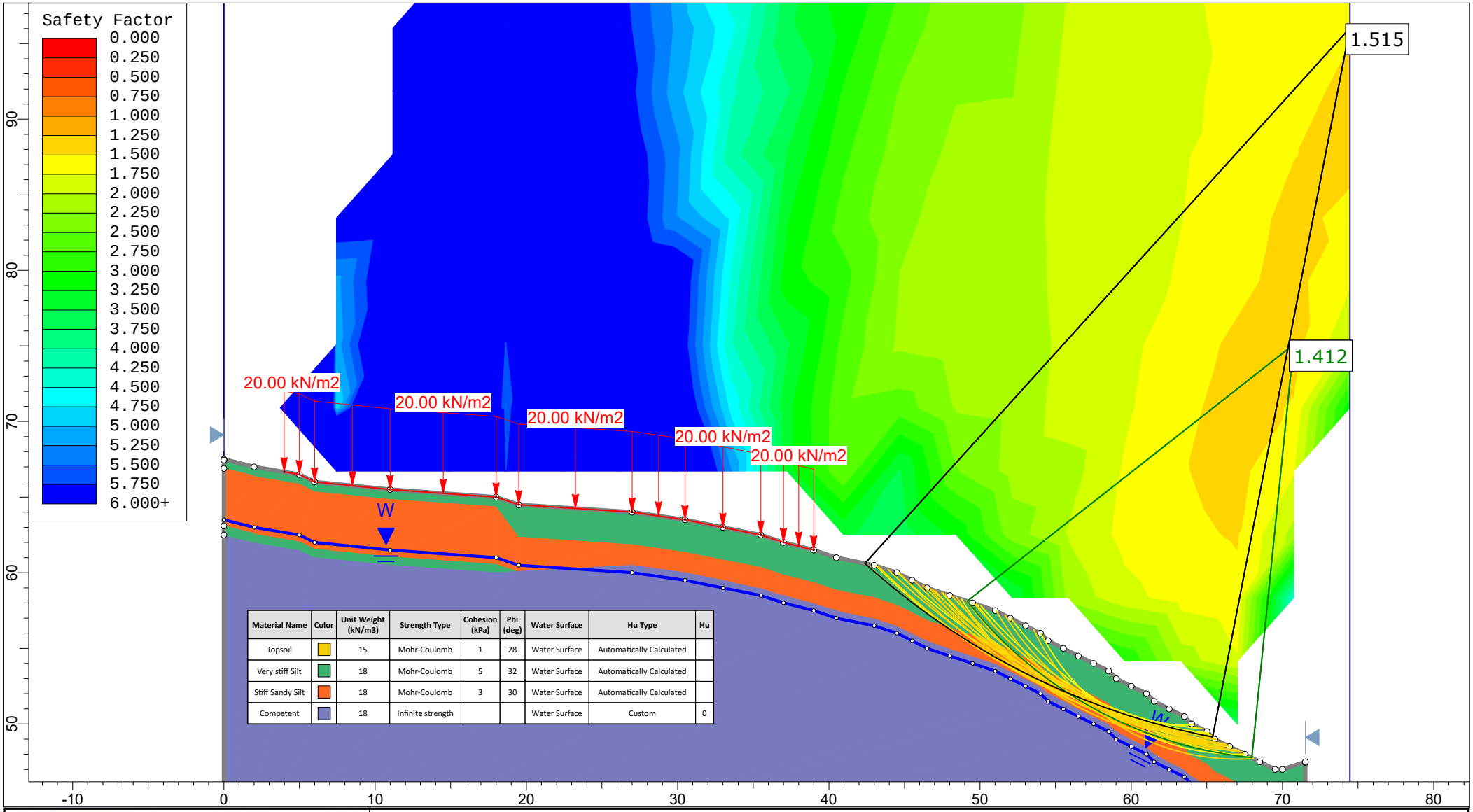



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Sandy Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 2 - Eastern Gully | | |
| *Analysis Description* | Slope Stability - Existing | | |
| *Drawn By* | DM | *Scale* 1:350 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 232931653.sli |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Sandy Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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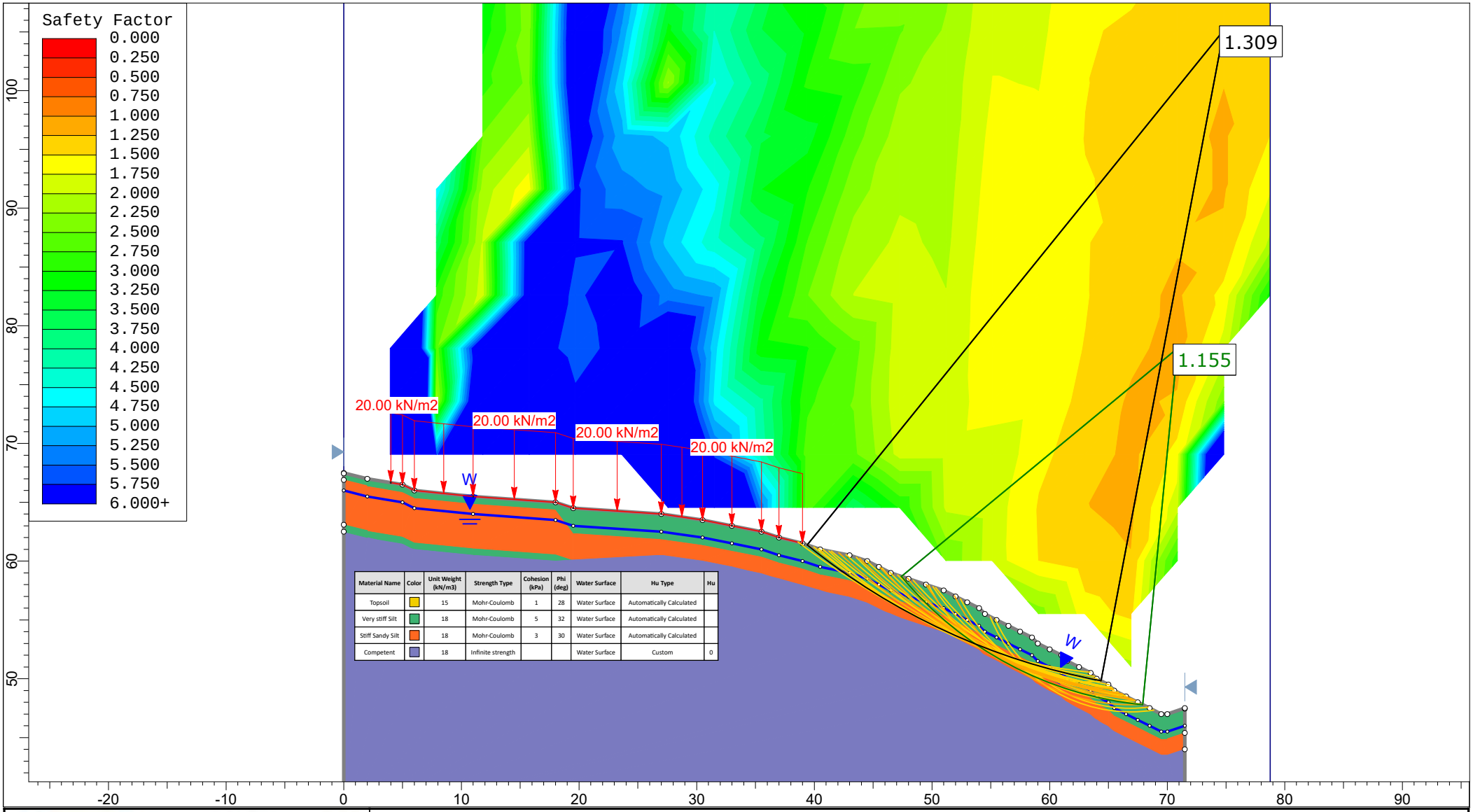
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 2 - Eastern Gully | | |
| *Analysis Description* | Slope Stability - Proposed | | |
| *Drawn By* | DM | *Scale* 1:350 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 232932211.sli |

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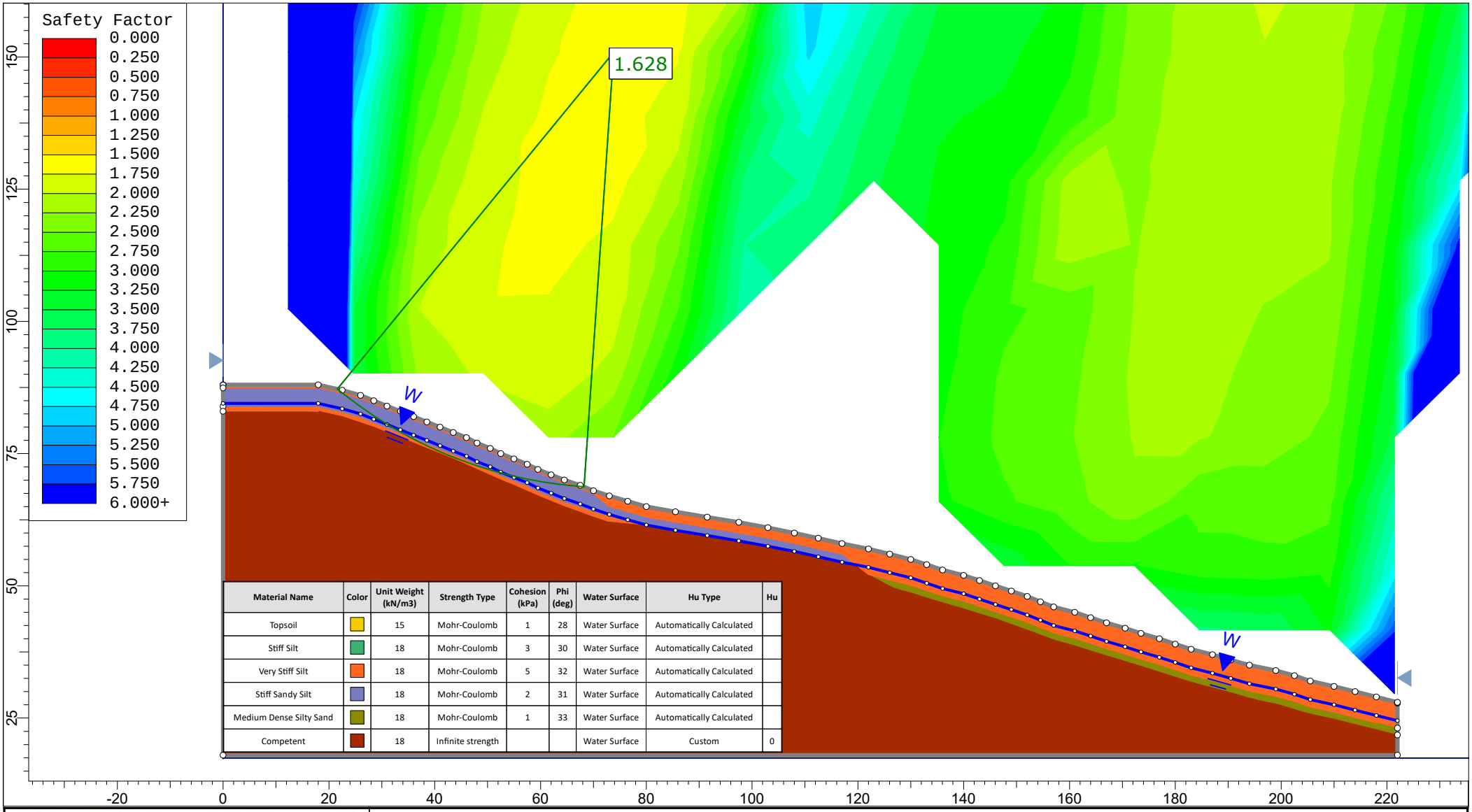
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 2 Eastern Gully | | |
| *Analysis Description* | Slope Stability - High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:450 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 232932675.sli |

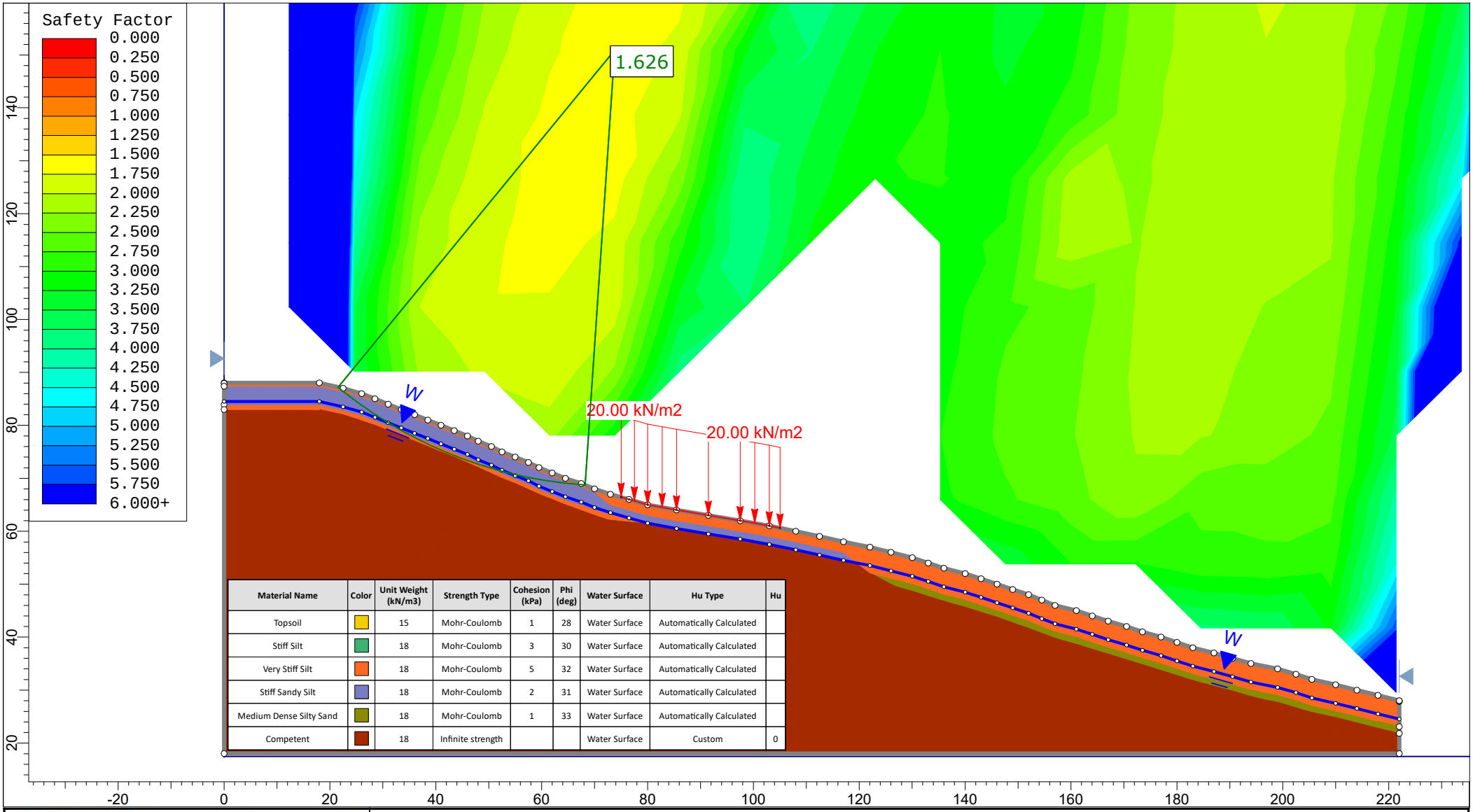



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Sandy Silt | | 18 | Mohr-Coulomb | 2 | 31 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 33 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 2 | | |
| *Analysis Description* | Slope Stability Analysis - Existing | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 2017-03-22-Cowan Bay Farm - Lot 2 - GEO-Slope stability existing.slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Sandy Silt | | 18 | Mohr-Coulomb | 2 | 31 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 33 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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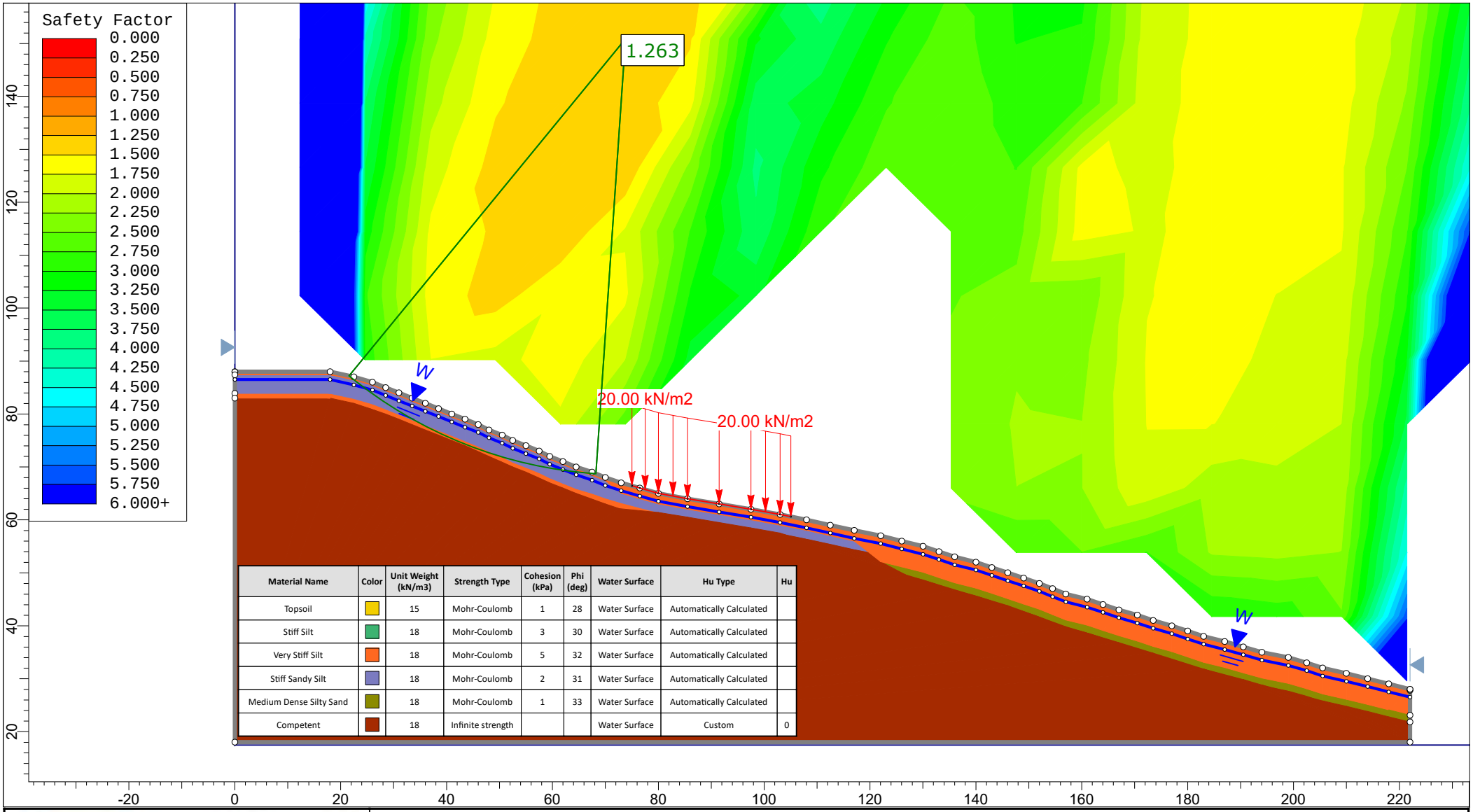
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 2 | | |
| *Analysis Description* | Slope Stability Analysis - Proposed | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 2017-03-22-Cowan Bay Farm - Lot 2 - GEO-Slope stability Proposed.slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Sandy Silt | | 18 | Mohr-Coulomb | 2 | 31 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 33 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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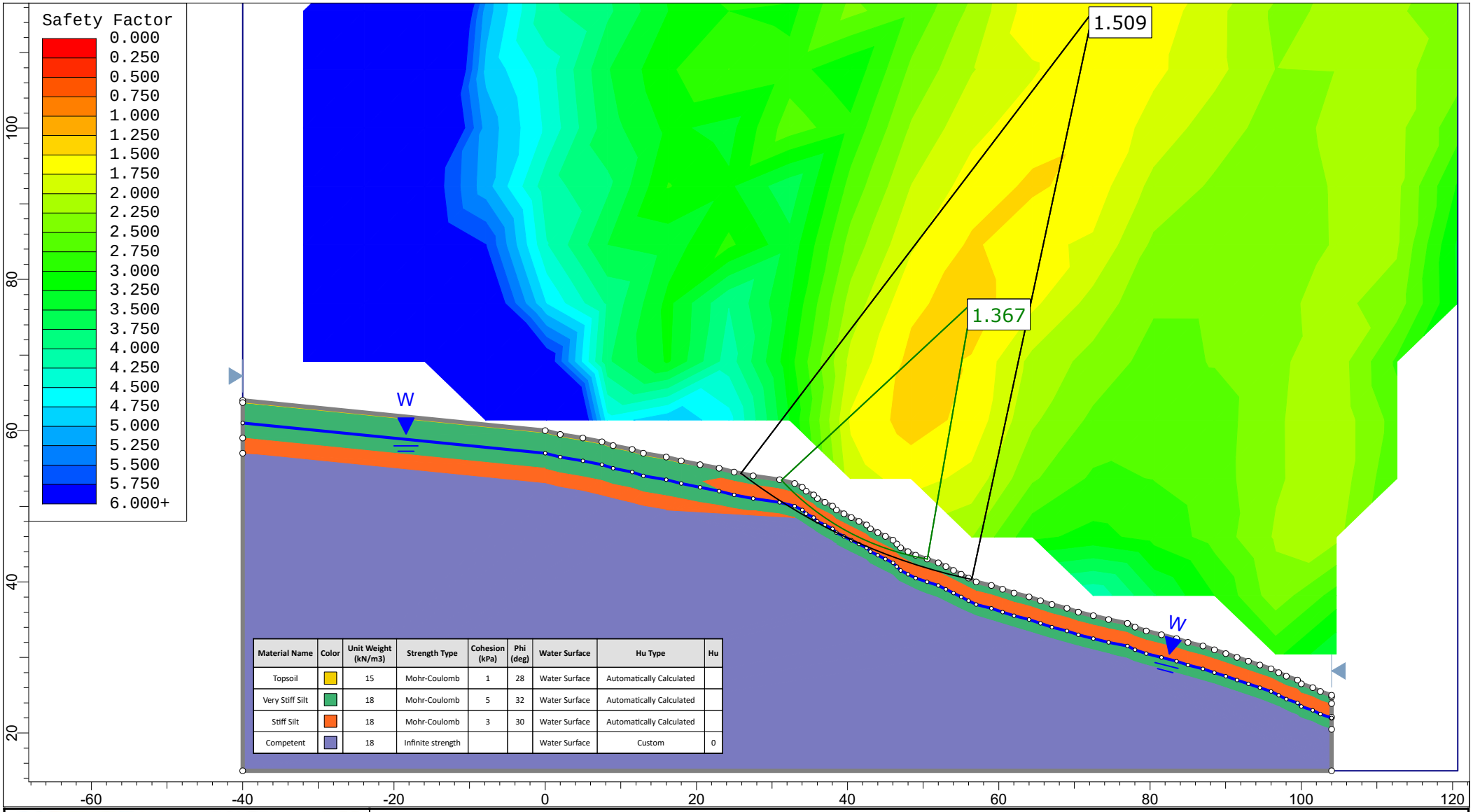
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 2 | | |
| *Analysis Description* | Slope Stability Analysis - High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 2017-03-22-Cowan Bay Farm - Lot 2 - GEO-Slope stability High Groundwater slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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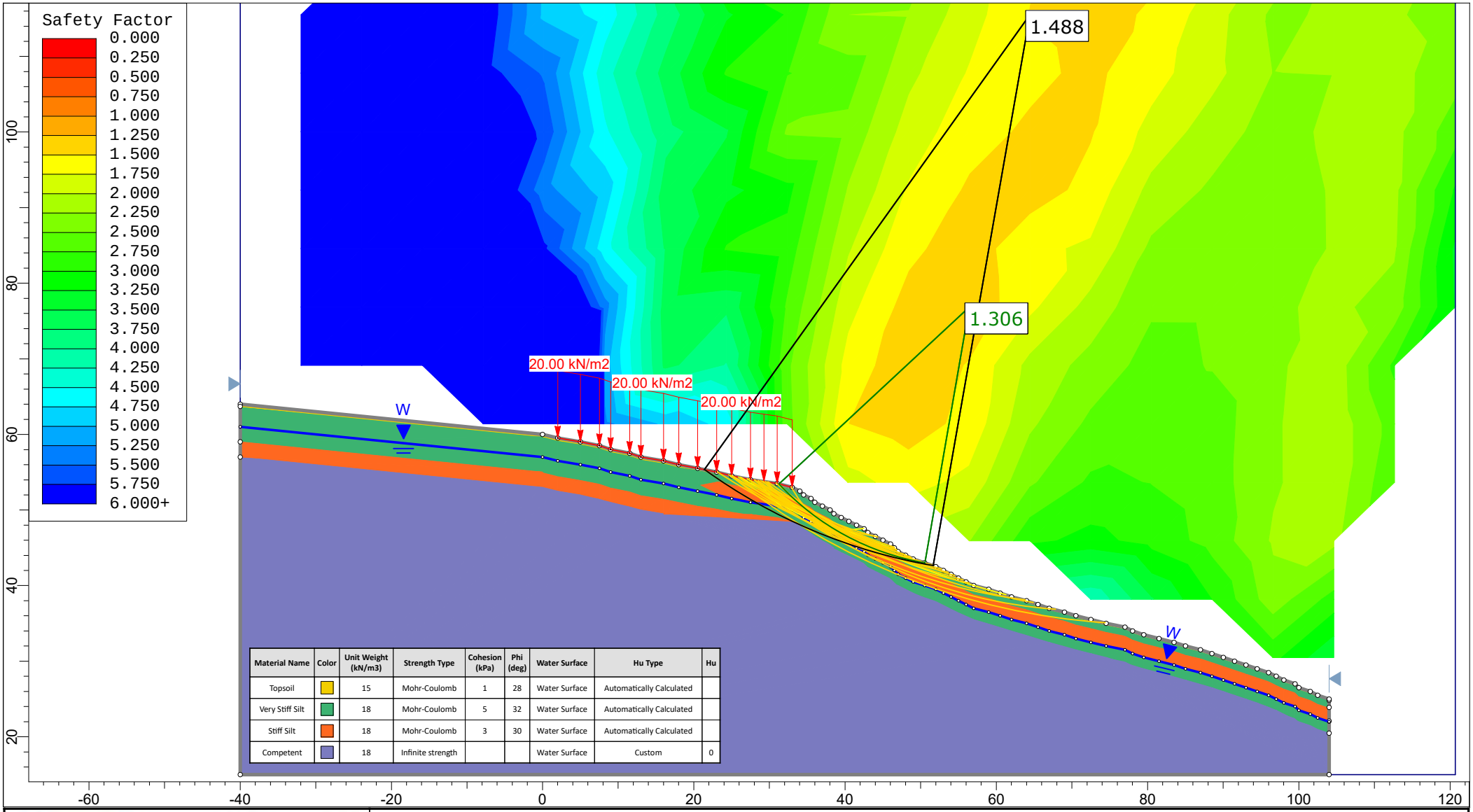
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Road - Lot 3 - Historical Slip Section | | |
| *Analysis Description* | Slope Stability Existing | | |
| *Drawn By* | DM | *Scale* 1:700 | *Company* EDC |
| *Date* | March 2017 | *FileName* | 4017-03-29_Cowan Bay Farm- Lot 3 - Historical Slip -GEO-Slope Stability - Existing sli |

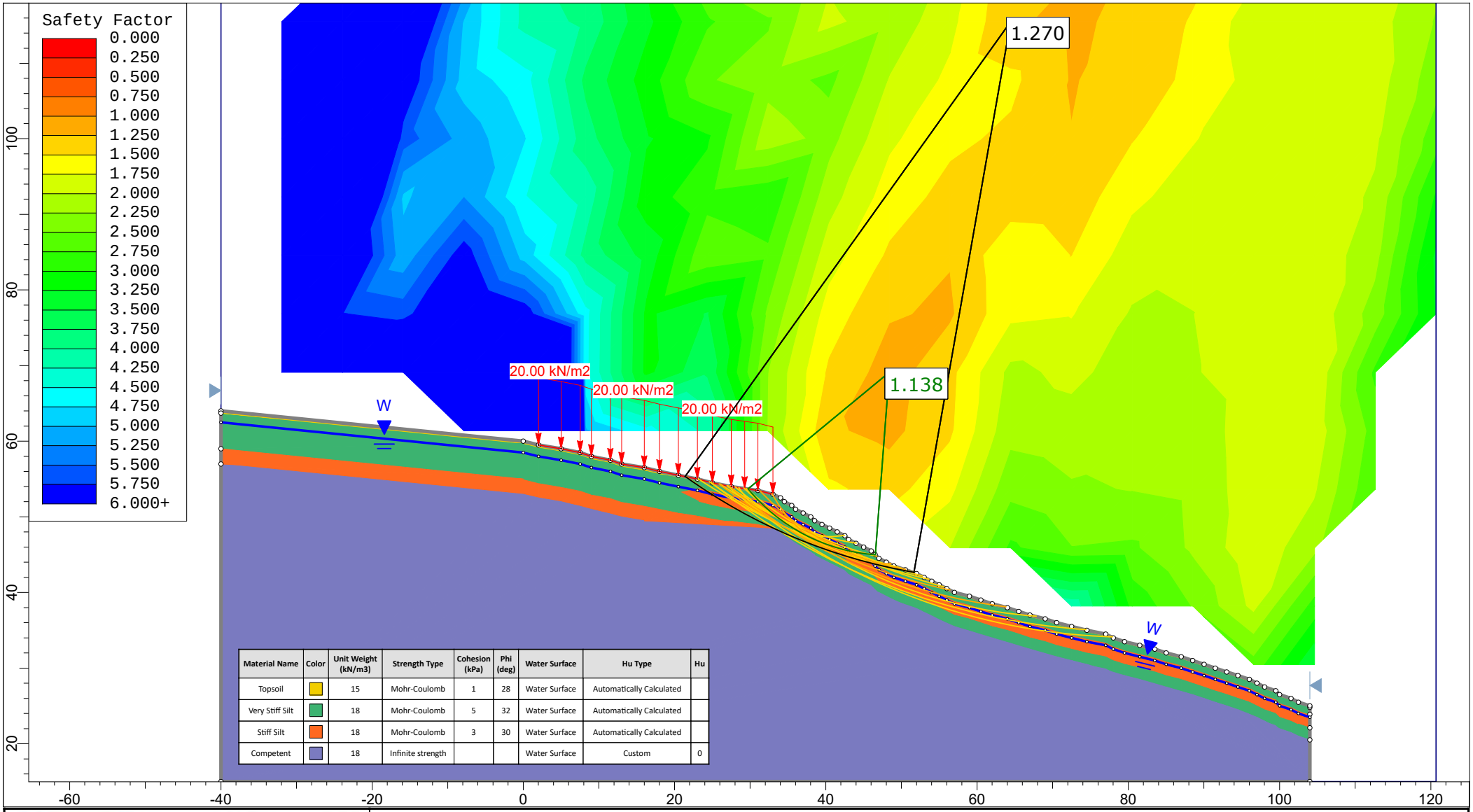



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Road - Lot 3 - Historical Slip Section | | |
| *Analysis Description* | Slope Stability Proposed | | |
| *Drawn By* | DM | *Scale* 1:700 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 1703-29_Cowan Bay Farm- Lot 3 - Historical Slip -GEO-Slope Stability - Proposed.slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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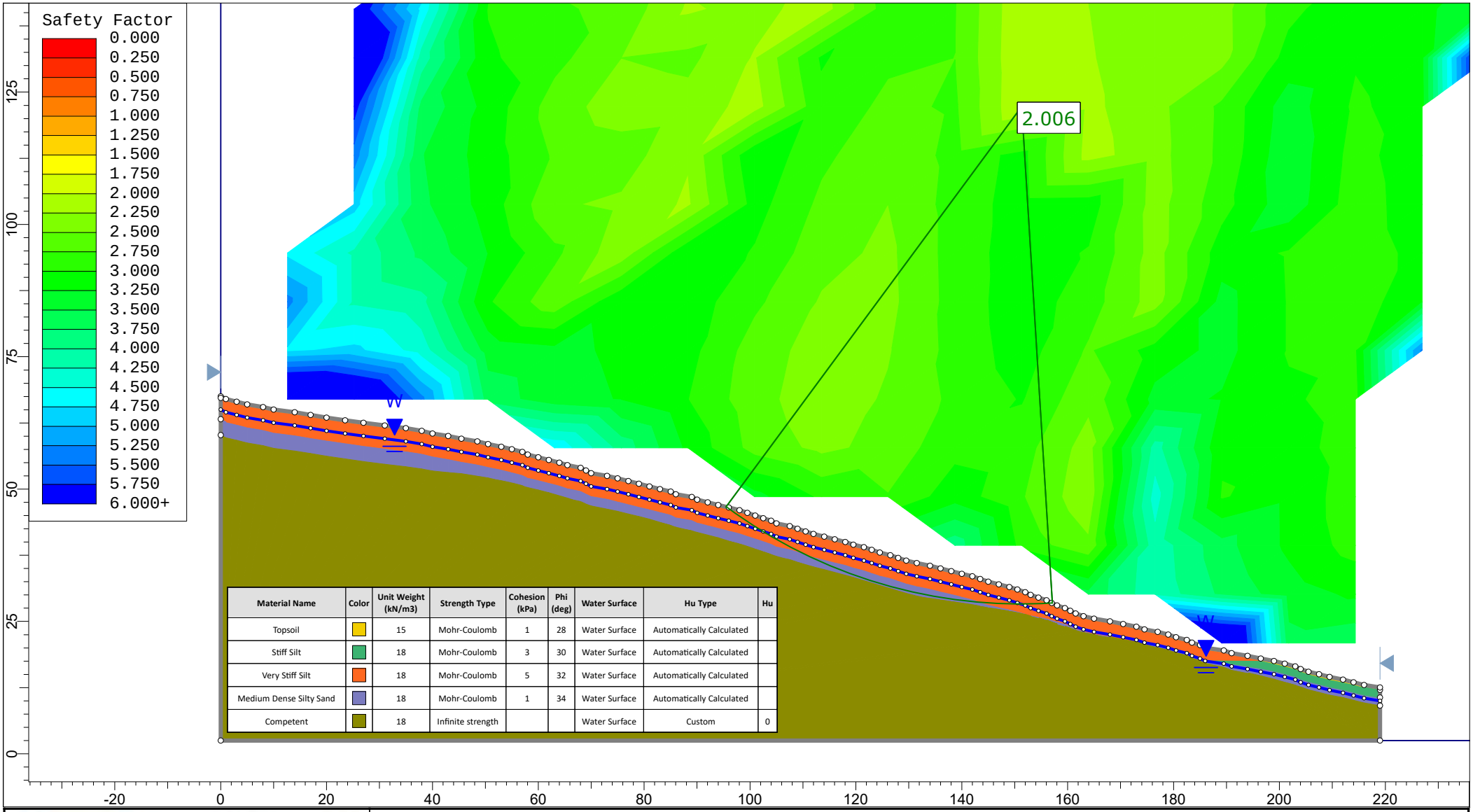
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Road - Lot 3 - Historical Slip Section | | |
| *Analysis Description* | Slope Stability High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:700 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 1703-29_Cowan Bay Farm- Lot 3 - Historical Slip -GEO-Slope Stability - High Groundwater.slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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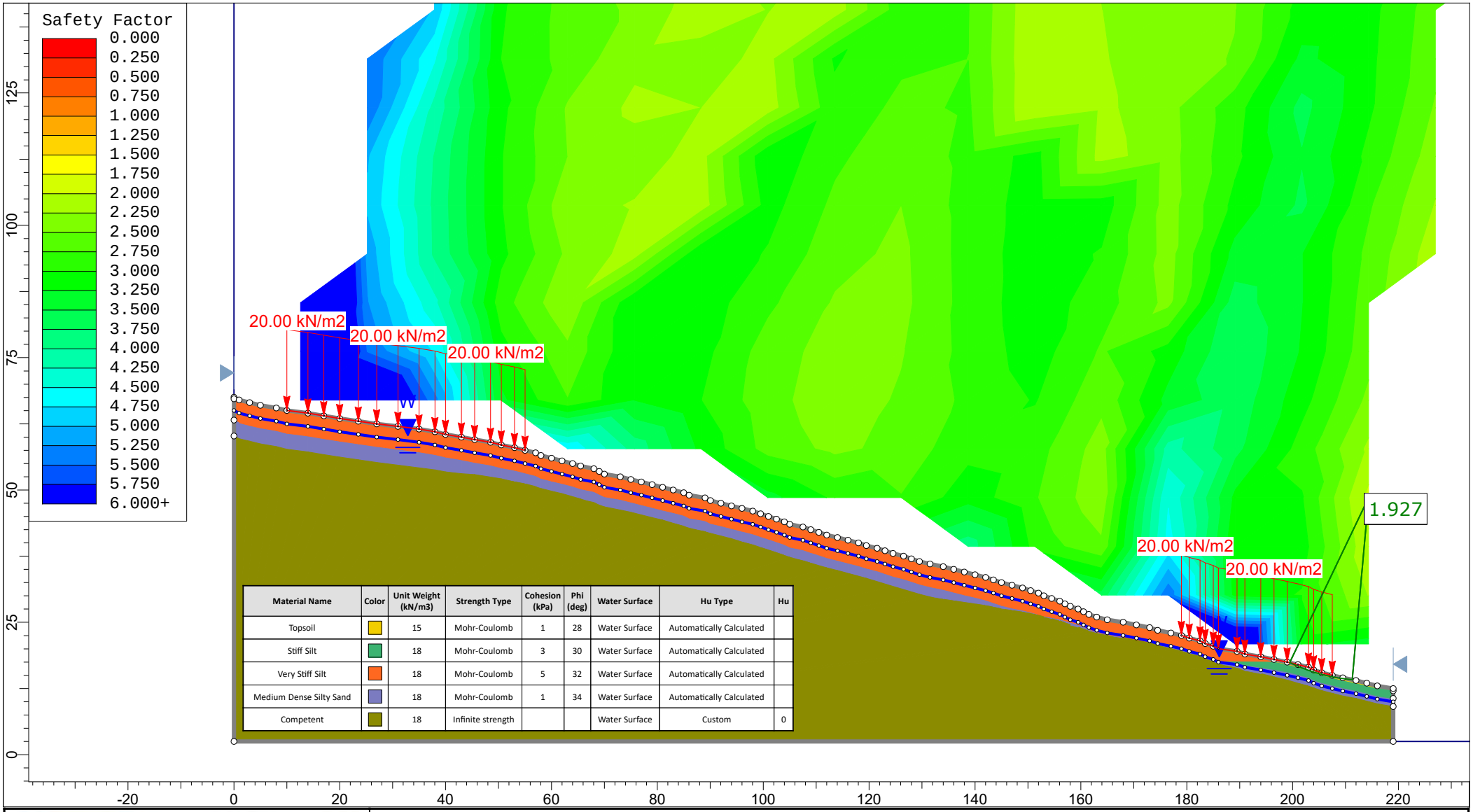
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 3 | | |
| *Analysis Description* | Slope Stability - Existing | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 1017-03-29-Cowan Bay Farm - Lot 4 & Possiable Lot 3 - GEO - Slope stability existing slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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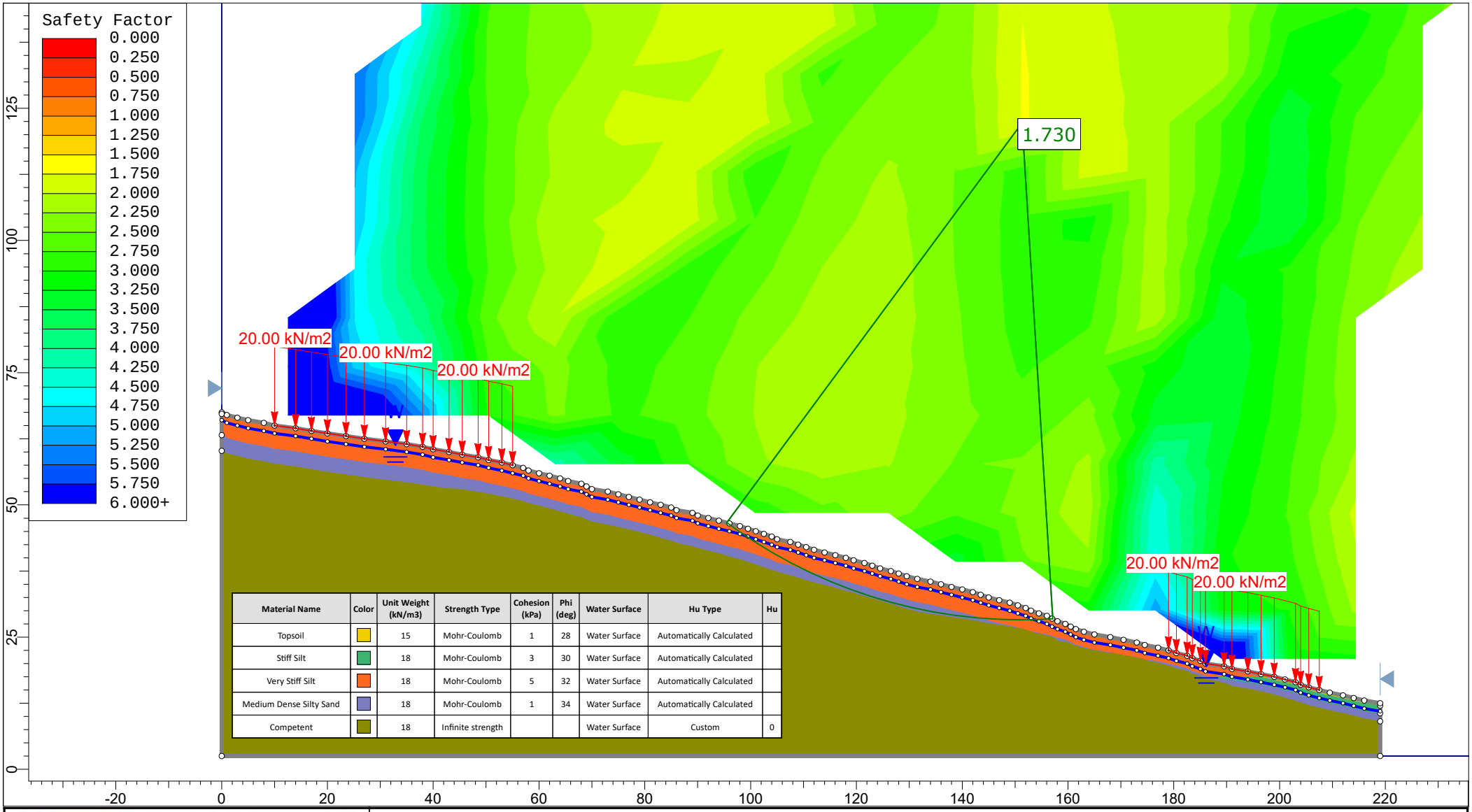
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 3 | | |
| *Analysis Description* | Slope Stability - Proposed | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-03-29-Cowan Bay Farm - Lot 4 & Possiable Lot 3 - GEO - Slope stability Proposed.slim |

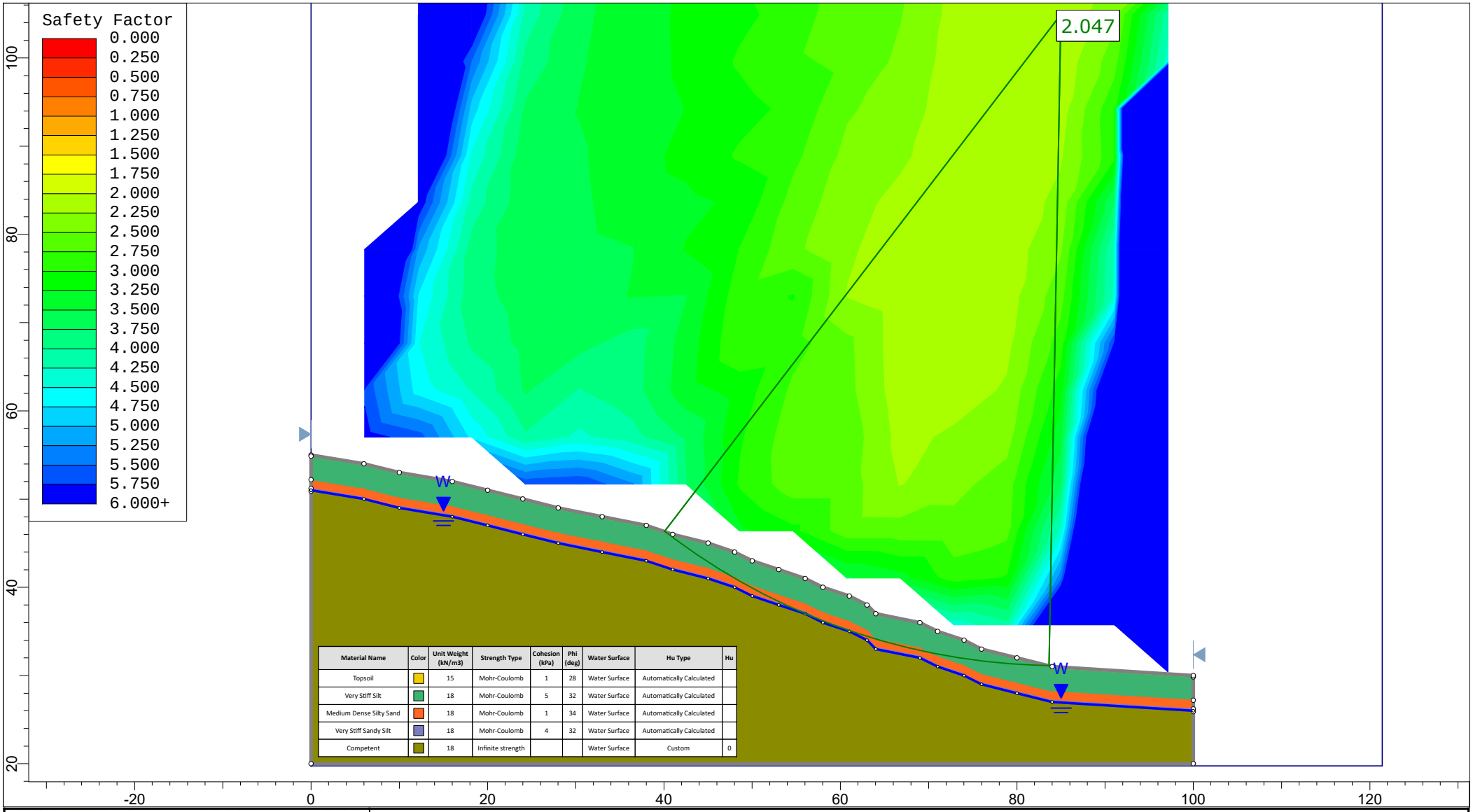



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Stiff Silt | | 18 | Mohr-Coulomb | 3 | 30 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 3 | | |
| *Analysis Description* | Slope Stability - High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 1117-03-29-Cowan Bay Farm - Lot 4 & Possiable Lot 3 - GEO - Slope stability High Groundwater slim |




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Very Stiff Sandy Silt | | 18 | Mohr-Coulomb | 4 | 32 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

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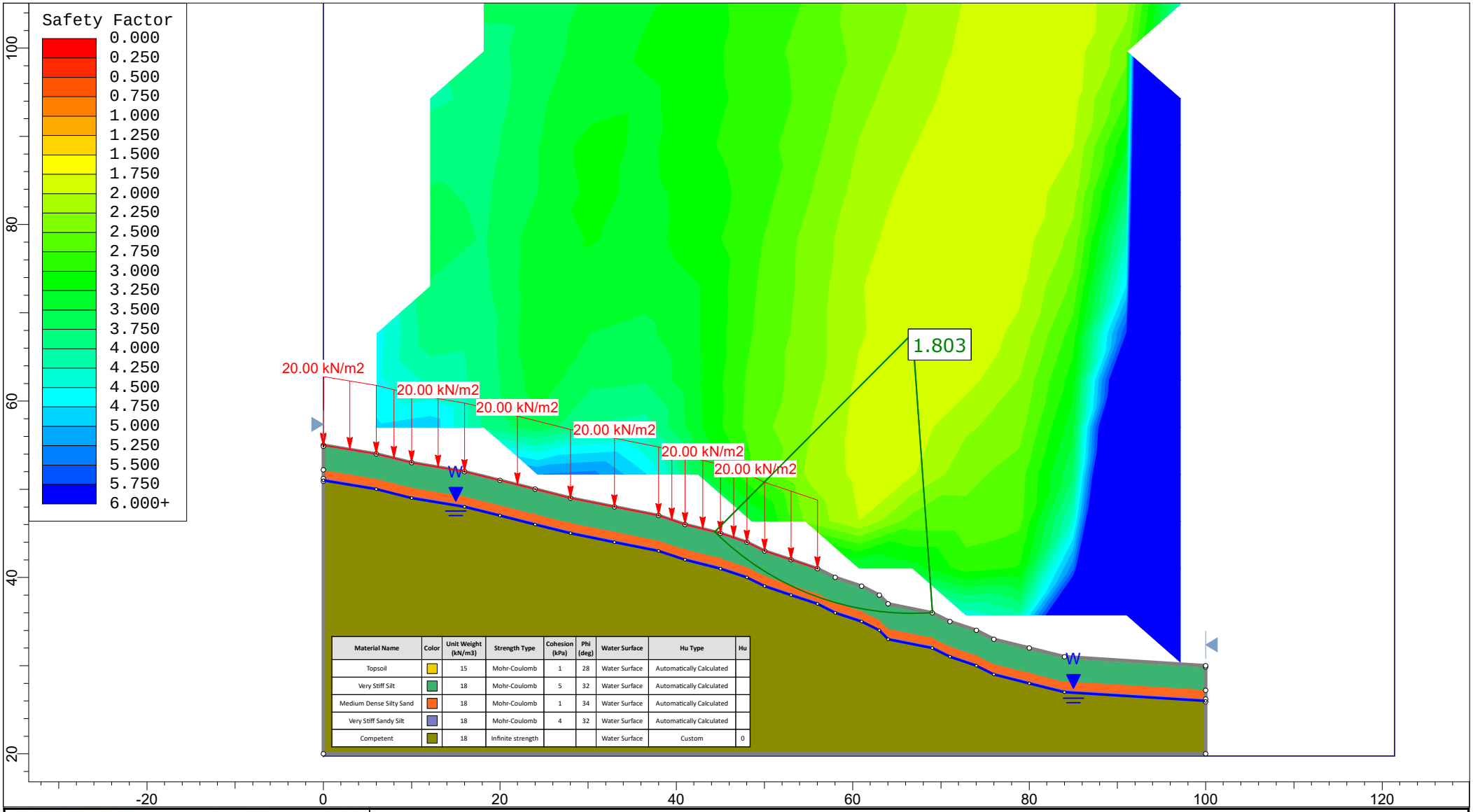
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 4: Gully Slope | | |
| *Analysis Description* | Slope Stability - Existing | | |
| *Drawn By* | DM | *Scale* 1:600 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-04-27_Cowan Bay Farm_Lot 4_Gully Slope_Existing.slim |

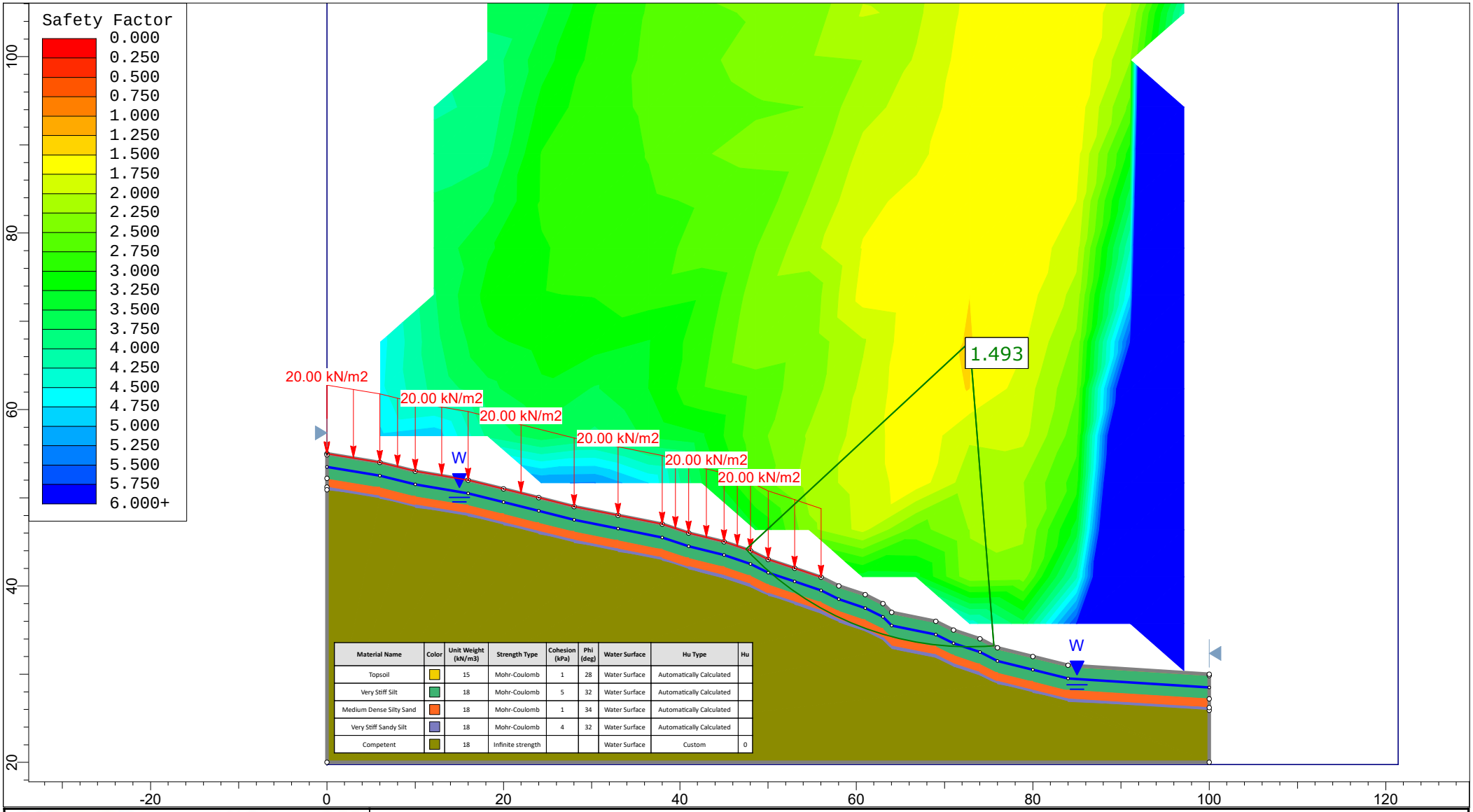



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Very Stiff Sandy Silt | | 18 | Mohr-Coulomb | 4 | 32 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

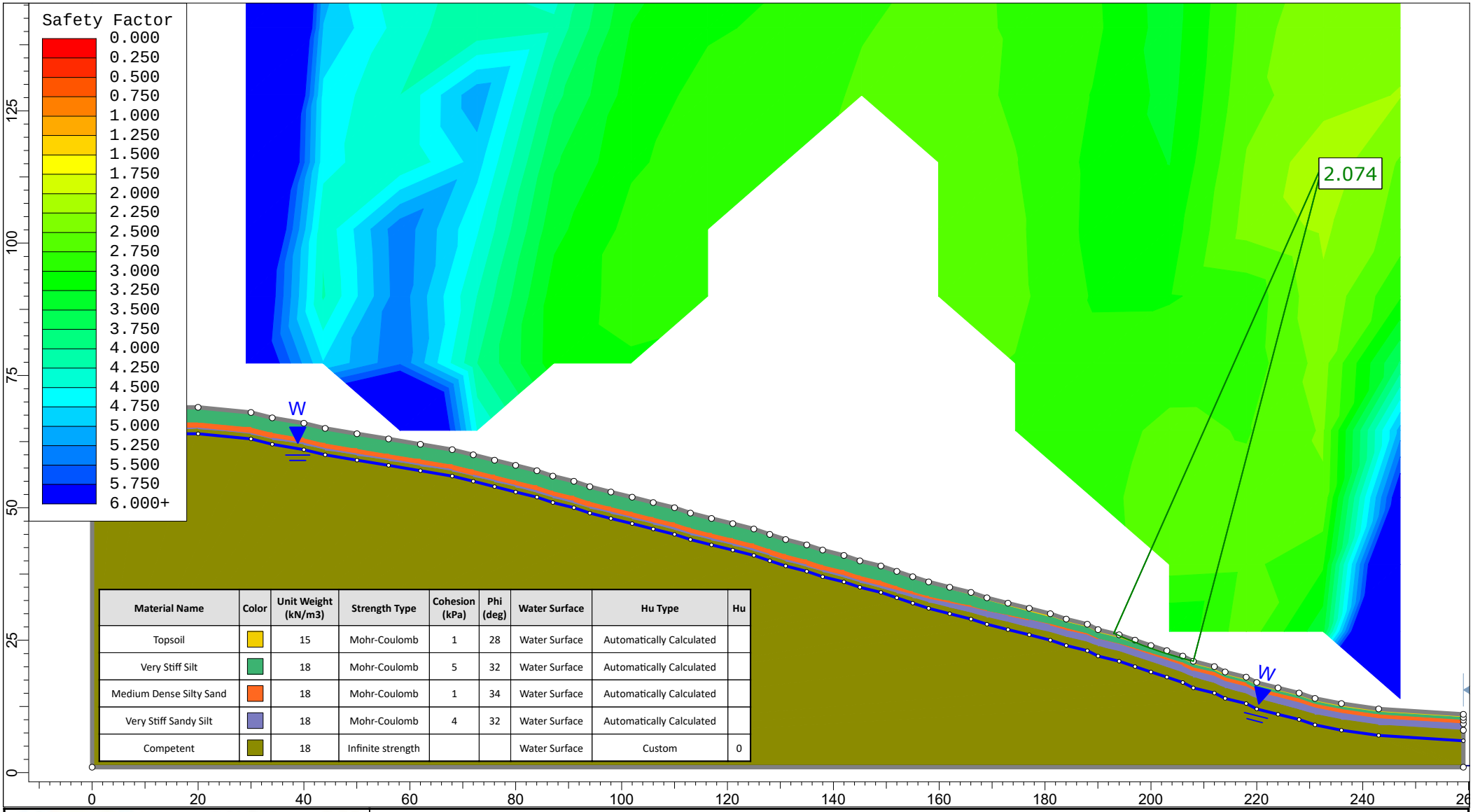
| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 4: Gully Slope | | |
| *Analysis Description* | Slope Stability - Proposed | | |
| *Drawn By* | DM | *Scale* 1:600 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-04-27_Cowan Bay Farm_Lot 4_Gully Slope_Proposed.slim |




ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 4: Gully Slope | | |
| *Analysis Description* | Slope Stability - High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:600 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-04-27_Cowan Bay Farm_Lot 4_Gully Slope_High GRoundwater.slim |

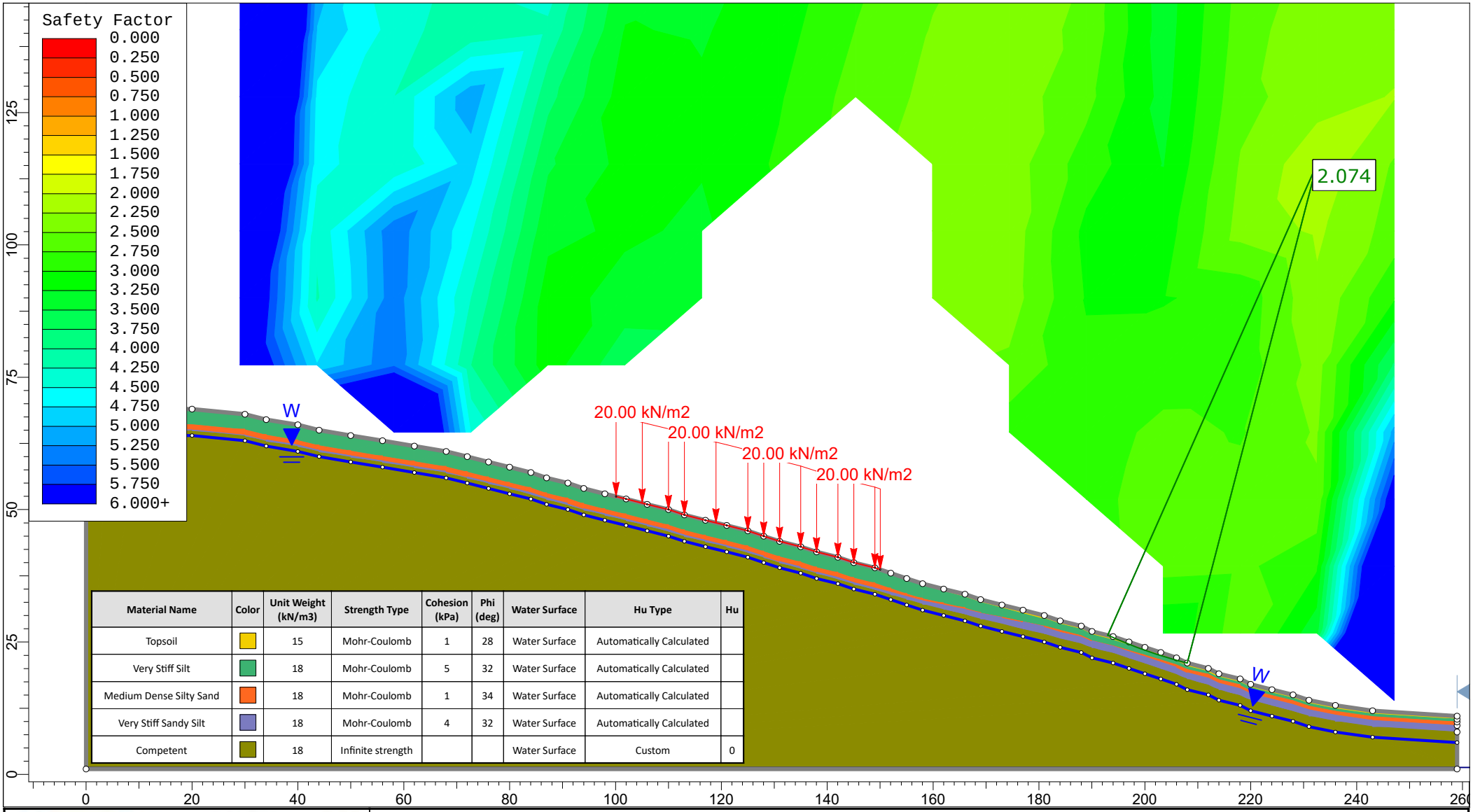



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Very Stiff Sandy Silt | | 18 | Mohr-Coulomb | 4 | 32 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 4: Northern Slope | | |
| *Analysis Description* | Slope Stability - Existing | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-04-27_Cowan Bay Farm - Lot 4_Existing.slim |

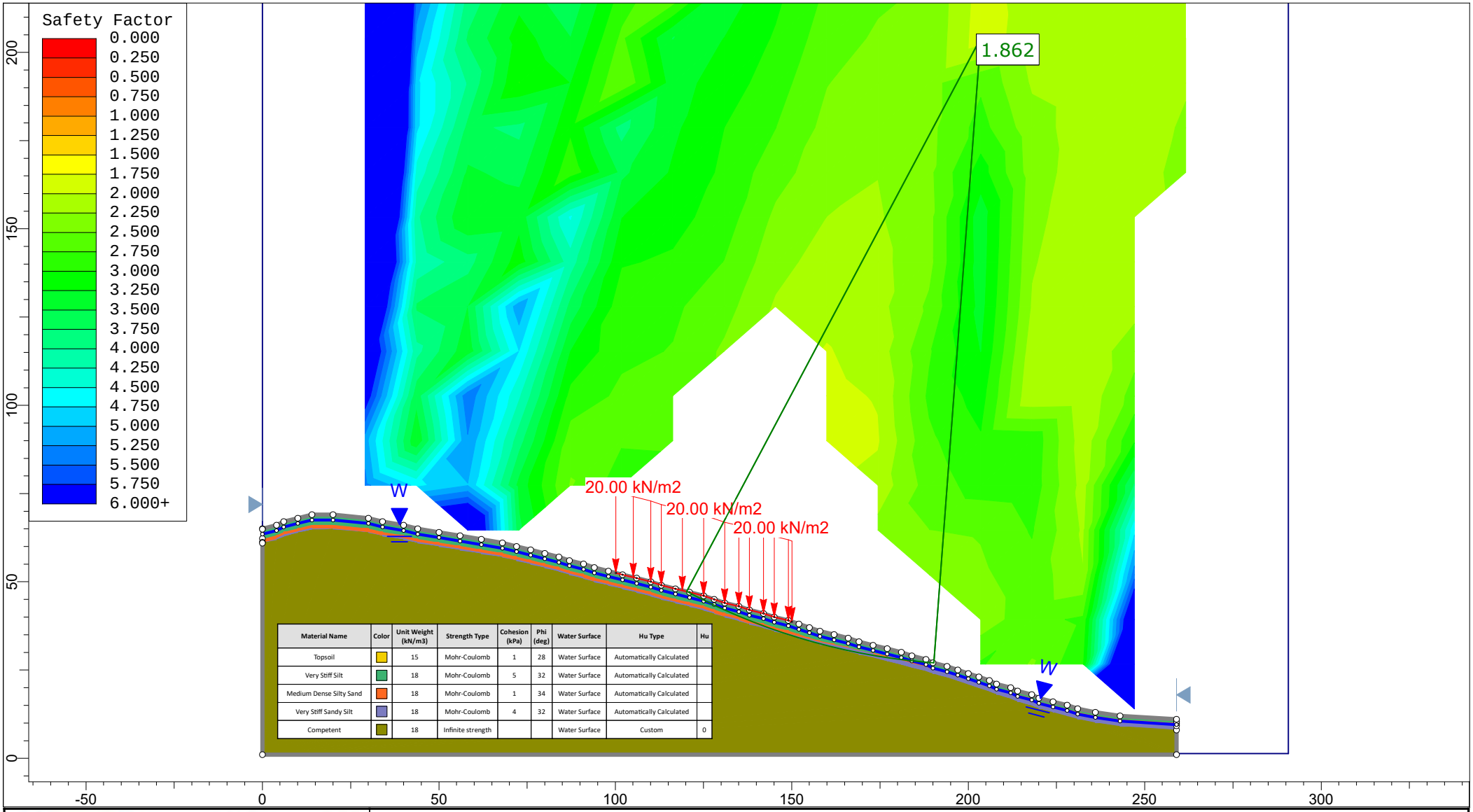



| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Topsoil | | 15 | Mohr-Coulomb | 1 | 28 | Water Surface | Automatically Calculated | |
| Very Stiff Silt | | 18 | Mohr-Coulomb | 5 | 32 | Water Surface | Automatically Calculated | |
| Medium Dense Silty Sand | | 18 | Mohr-Coulomb | 1 | 34 | Water Surface | Automatically Calculated | |
| Very Stiff Sandy Silt | | 18 | Mohr-Coulomb | 4 | 32 | Water Surface | Automatically Calculated | |
| Competent | | 18 | Infinite strength | | | Water Surface | Custom | 0 |

ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

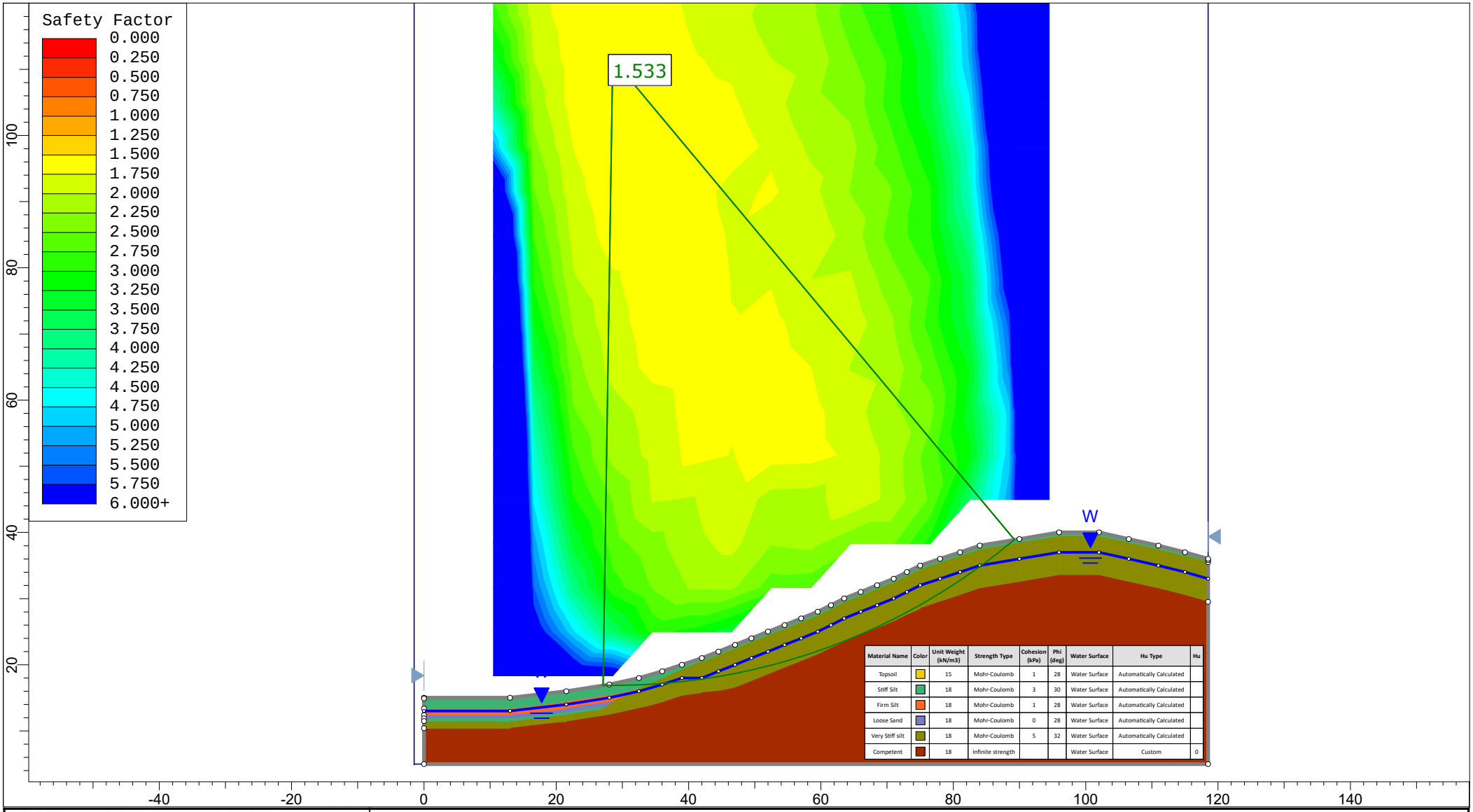
| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 4: Northern Slope | | |
| *Analysis Description* | Slope Stability - Proposed | | |
| *Drawn By* | DM | *Scale* 1:1000 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-04-27_Cowan Bay Farm - Lot 4_Proposed.slim |




ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

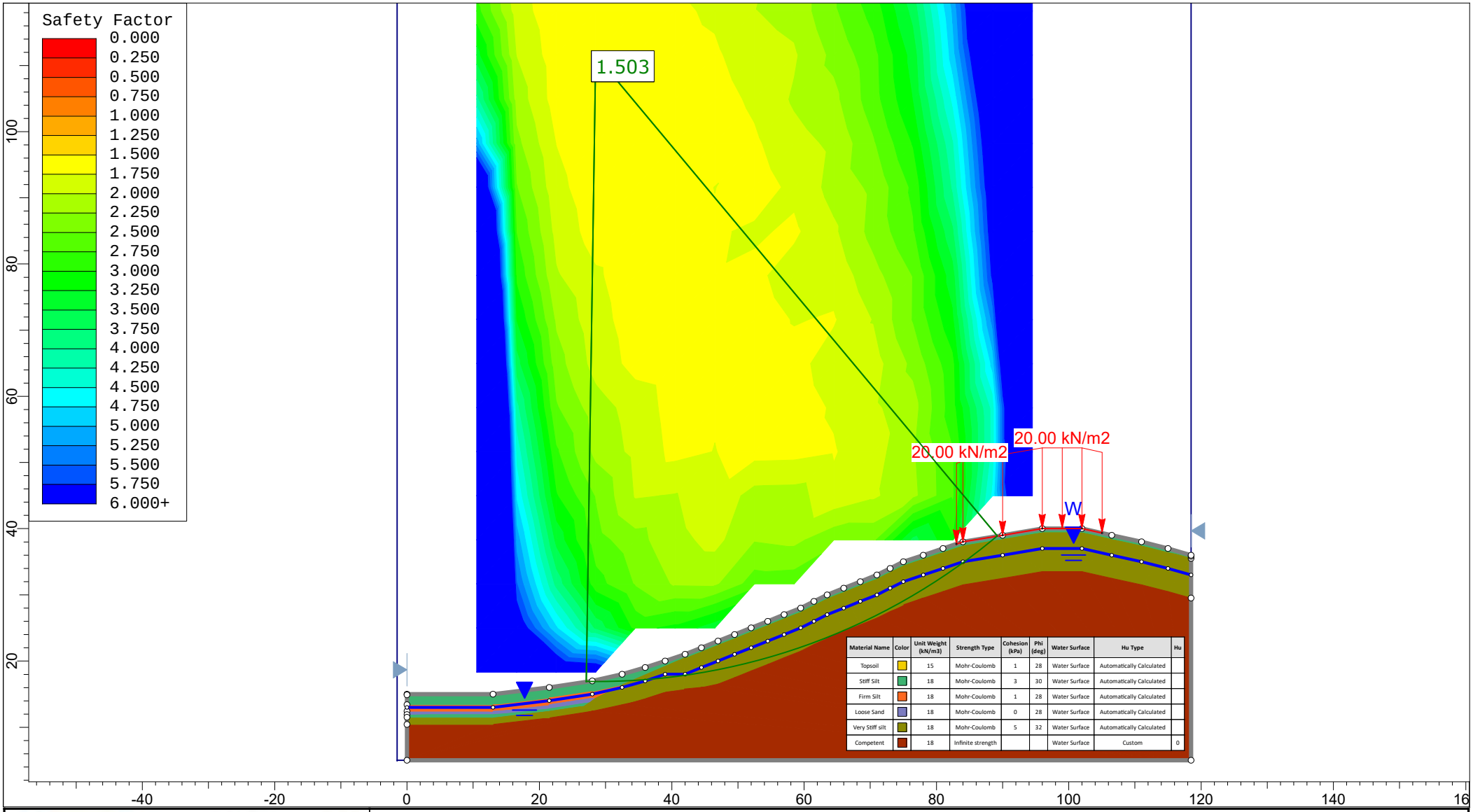
| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 4: Northern Slope | | |
| *Analysis Description* | Slope Stability - High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:1500 | *Company* EDC |
| *Date* | April 2017 | *File Name* | 2017-04-27_Cowan Bay Farm - Lot 4_High Groundwater.slim |




ENGINEERING DESIGN CONSULTANTS

SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 5 | | |
| *Analysis Description* | Slope Stability - Existing | | |
| *Drawn By* | DM | *Scale* 1:800 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 2017-03-21_Cowan Bay Farm Lot 5-GEO-Slope Stability Existing.slim |

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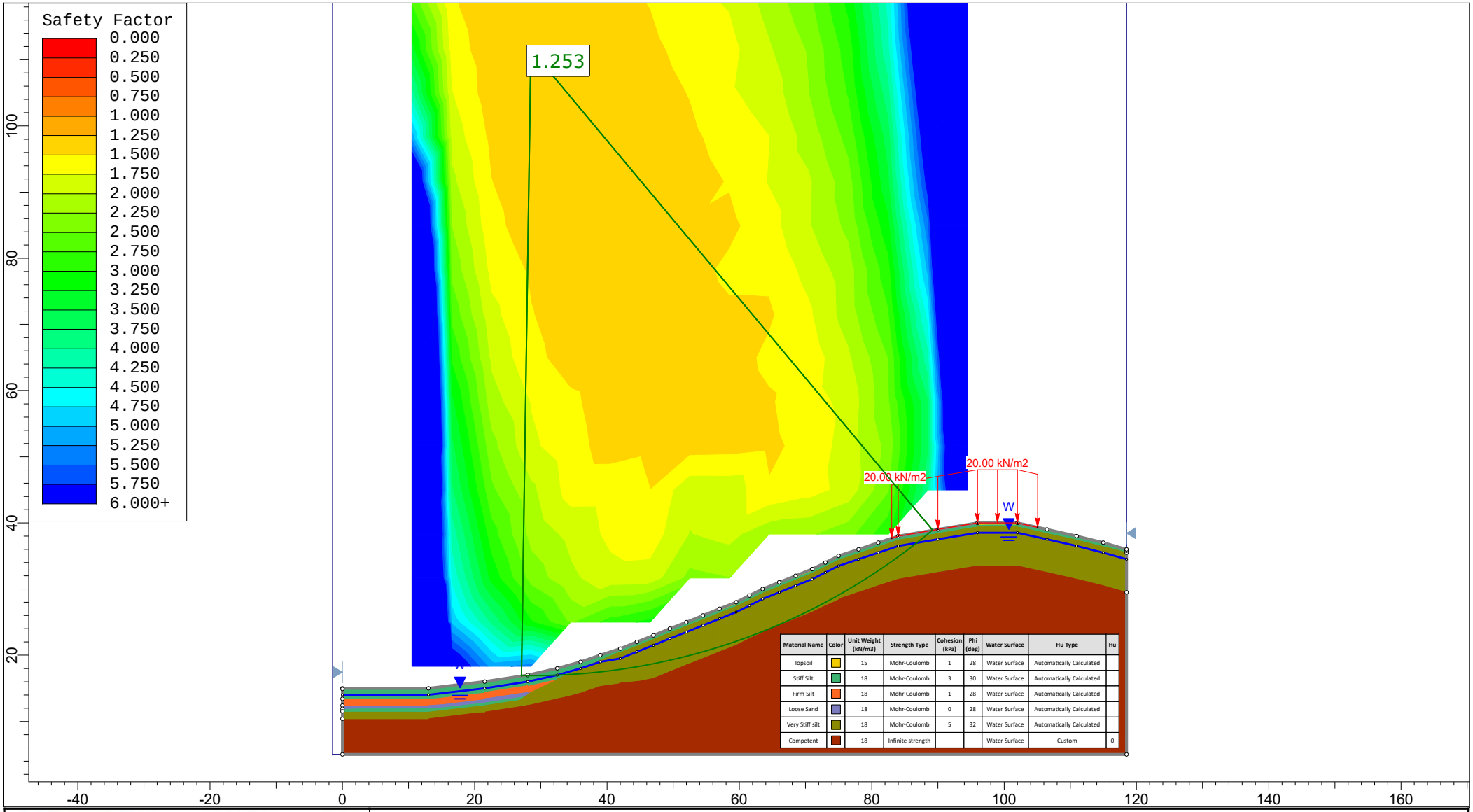
SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 5 | | |
| *Analysis Description* | Slope Stability - Proposed | | |
| *Drawn By* | DM | *Scale* 1:800 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 2017-03-21_Cowan Bay Farm Lot 5-GEO-Slope Stability Proposed.slim |

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SLIDEINTERPRET 7.009

| | | | |
|---|---|---|---|
| *Project* | Cowan Bay Farm - Lot 5 | | |
| *Analysis Description* | Slope Stability - High Groundwater | | |
| *Drawn By* | DM | *Scale* 1:800 | *Company* EDC |
| *Date* | March 2017 | *File Name* | 2017-03-21_Cowan Bay Farm Lot 5-GEO-Slope Stability High Groundwater slim |