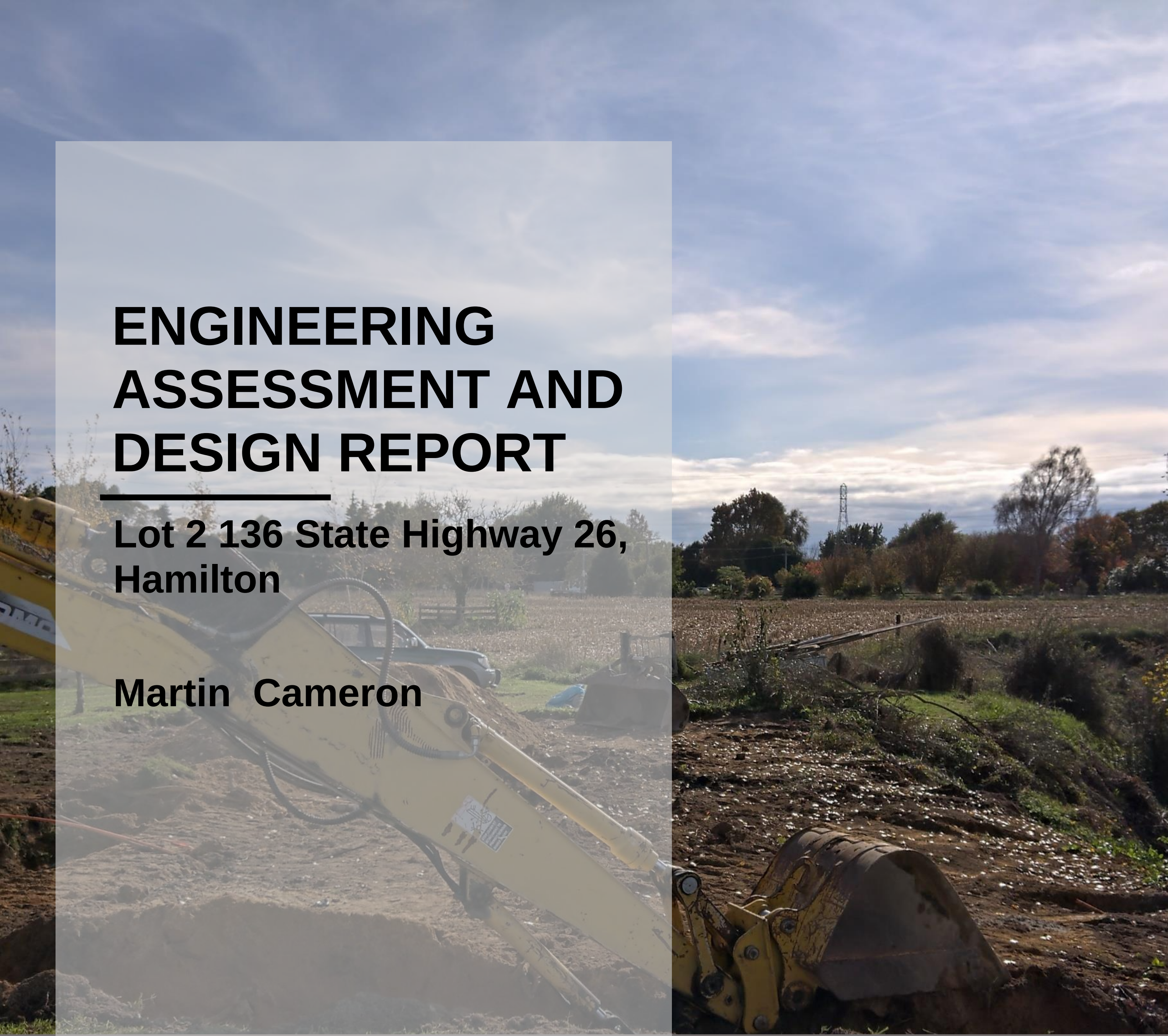


ENGINEERING ASSESSMENT AND DESIGN REPORT

Lot 2 136 State Highway 26, Hamilton

Martin Cameron

29 JANUARY 2021

PROJECT NO. 11122

TITUS CONSULTING ENGINEERS

Approved for issue by:

X Tony Richardson

Digitally signed by Tony Richardson
DN: cn=Tony Richardson, c=NZ, o=Titus Civil Ltd, email=tonyr@tituscivil.co.nz
Date: 2021.01.29 15:14:04 +13'00'

Anthony Richardson CPEng 1026340
Principal Project Engineer

DOCUMENT HISTORY AND STATUS

Rev.	Issued To	Date	Prepared	Reviewed	Approved
A	Martin Cameron	20/05/2020	RM	MH/JV	TR
B	Martin Cameron	27/05/2020	RM	MH/JV	TR
C	Martin Cameron	19/06/2020	RM	TR	TR
D	Martin Cameron	29/01/2021	RM	TR	TR

RECORD OF REVISION CHANGES

Revision B – Revised slope stability recommendations.

Revision C – Model revised to reduce height of slope by 2m through onsite earthworks.

Revision D – Section 5: Slope Stability Assessment updated with new design of basement. WW Design updated

TITUS Consulting Engineers

Hamilton Office: Level 4, Door 2, 169 London St

Ph: 07 242 0017

Email: office@tituscivil.co.nz

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Overview

TITUS CIVIL Consulting Engineers has been engaged by Martin Cameron to perform an engineering assessment and design report for a new single storey timber-framed building at Lot 2 136 State Highway 26.

The report includes the following.

- Section 2: Site and Soils Assessment.
- Section 3: Stormwater Assessment and Design.
- Section 4: Wastewater Assessment and Design.
- Section 5: Slope Stability Assessment.

The assessments and design meet the requirements of the local authority, Hamilton City Council, and the following technical documents.

- The building code,
- NZS3604:2011,
- District Plan,
- Any current ICMP,
- Waikato Regional Council Plan, and
- AS/NZS 1547/2012

1.2 Site Details

The site is currently a newly subdivided lifestyle block with a large gully at the back of the section. The site is bordered by a gully system to the east, a field to the north (used for cultivation), and a residential house and garage to the south / south west. The area near the proposed foundation is gently sloping to the north. The location of the house is close to the top of a slope joining the gully system to the east.

The large gully system is approximately 3km upstream from where it enters the Waikato River.

Figure 1 shows a photo of the proposed dwelling location.

Figure 1: Site Photo

1.3 Planning Requirements

The following requirements based on the Regional Council Plan, Consent Notices and Subdivisional Reports are noted, and have been duly considered in the proposed recommendations.

The following is taken from the resource consent from HCC:

(2)(7) *Any contaminated soil is to be removed under controlled conditions to a licensed waste facility or landfill for disposal in accordance with the RAP, and with the requirements of the disposal site and the relevant authority. Receipts of transport and disposal are required to be provided in the Site Validation Report.*

- An area of lead contaminated ground from near the previously existing cow shed has been removed and disposed of on the day of the site investigation.

The following is taken from the Geotechnical report for lot 4 of the same subdivision and gives a setback of 7.5m for a dwelling along the same gully slope that lot 2 is on:

Slope Stability Assessment

- The conducted slope stability assessment indicates a development building setback of at least 7.5m from the crest of the slope. Building within the setback zone is feasible but specifically designed foundations (such as piles) will be required.

2 SITE AND SOILS ASSESSMENT

2.1 Assessment Parameters

This section details findings of a site and soils assessment in accordance with NZS3604:2011 cl. 3.1.3.1 Determination of 'Good Ground'. The investigation is in relation to the construction of a new single storey timber-framed building.

In particular the investigation focussed on assessing:

- The bearing capacity of the soil in accordance with NZBC – B1 (New Zealand Building Code),
- Checking for organic and peat soils,
- Checking for soft and very soft clays containing gravel or other hard material and,
- Checking for uncontrolled fill.

NZBC requires 5 blows per 100mm down to a depth of twice the footing width or 3 blows per 100mm at greater depths to establish good ground in terms of bearing capacity of soils.

Foundations outside of the scope of NZBC or proprietary specifications require *specific engineering design* (SED).

The proposed building has a floor area of approx. 250m^2 and various foundation options are being considered.

2.2 Soil Investigation

The site assessment conducted on 12th of May 2020 included the following:

- General site walkover
- Hand Auger Tests: 4
- Scala Penetrometer Tests: 4
- Shear Vane Tests: 7
- Soakage Test: 1

Test locations are shown in Appendix A.

Topsoil was found at a depth of 200mm on site in borehole 5 but not in boreholes 1 to 4 as they were located beneath the removed cowshed foundations. Underlying soils consist predominantly of sand. Overall, the boreholes showed interbedded layers of sand and silt with little correlation between boreholes.

No soft clays were found on the site (kPa < 25).

Organic material was found in borehole 2 under the propsed dwelling location. The material is suspected to be a dump site associated with the previously existing cow shed. This material was only found in an isolated area and was removed on the day of inspection.

Soakage testing yielded a raw soakage rate of 900mm/hr. An appropriate factor of safety shall be applied before use in design calculations.

The water table was not found in any borehole to a depth of 2.0m.

2.3 Preliminary Liquefaction Assessment

2.3.1 Geological Setting

According to GNS (GNS Science, 2019), the underlying geology of the site is classified as (Late Pleistocene) river deposits (Hinuera Formation), as shown in Appendix D. This is described as cross-bedded pumice sand, silt, and gravel with interbedded peat. The Late Pleistocene sediments are approximately up to 27,000 years old. The site sits on a geological boundary between Hinuera Formation and Holocene sediments. This boundary will sit somewhere on the slope where eroded sediments have been deposited. Given the nearby gully and the free draining nature of the Hinuera Formation it is assumed that the long-term water table is located near the base of the gully.

2.3.2 Seismic Parameters

Table 1 below summarises the seismic parameters adopted for the site:

Table 1: Seismic parameters (NZTA Bridge Manual, Third Edition)

Ground Acceleration (SLS)	
Hamilton	
Class D	
1/25	
f	1.00
R_u	0.25
$C_{0,1000}$	0.28
M_{eff}	-
PGA, a_{max} (g)	**0.05**

Ground Acceleration (ULS)	
Hamilton	
Class D	
1/500	
f	1.00
R_u	1
$C_{0,1000}$	0.28
M_{eff}	5.9
PGA, a_{max} (g)	**0.22**

The site is located within the Waikato Basin which is generally known for deep sedimentary soils and deep basement rock. Development of a preliminary model of the fundamental site period (T0) across the Waikato Basin has shown that most places within the Waikato Basin have fundamental periods longer than 0.6s and hence should be categorised as Site Class D. (Jeong & Wotherspoon, 2019)

Therefore, Subsoil Class D – Deep or Soft Soil (NZS 1170.5:2004) may be adopted for this site.

2.3.3 Liquefaction Susceptibility

A comparison between the ideal conditions for liquefaction occurrence and conditions found for each proposed lot assessed is shown in Table 2 below;

Table 2: Conditions for liquefaction occurrence

Soil conditions considered susceptible to liquefaction occurrence	Site
Holocene to Late Pleistocene sediments	Yes
Cohesionless	Yes
Non-cohesive silt to medium to fine sand	Yes*
Loosely packed	Yes*
Shallow water table (<4m)	No
Thick non-liquefiable crust at the ground surface	Unlikely

**Limited layers*

Due to underlying geology and according to Hamilton City Liquefaction Report prepared by Tonkin & Taylor it is indicated that liquefaction damage is possible. Due to the depth to water table and the free draining nature of the gully systems around Hamilton, liquefaction damage at the site is considered unlikely and no mitigation measures are recommended.

2.4 Recommendations

The following foundations options are suitable given the soil conditions on site, however, are subject to confirmation of the specific requirements of the recommended foundation, the slope on site and any filling proposed for the site.

2.4.1 SED Piled Foundation

An SED Piled Foundation shall be designed as summarised below and as per the slope stability assessment (in Section 5).

Table 3: Foundation Parameters

SED Piled Raft for Garage	
Minimum depth of excavation for sand pad to good ground	1200mm below proposed ground level
Minimum Pile Depth	5.0m
Maximum Out-of-Plane Spacing	2.0m
Backfill material	Sand (Granular fill (brown rock) below 500mm)
Compaction standard	8 blows/300mm (Scala penetrometer) 270kPa
Inspections required	1 - Sub grade prior to back fill 2 - Compacted and finished sand pad

Foundation type	SED Piled raft
Comments	The foundation designer shall ensure the foundation is appropriate as per Section 5.
Piles for Wooden floor dwelling	
Minimum Pile Depth	5.0m
Maximum Out-of-Plane Spacing	2.0m
Inspections required	Pile driving / base of bored pile holes as applicable
Foundation type	SED pile foundation
Comments	The foundation designer shall ensure the foundation is appropriate as per Section 5

3 STORMWATER ASSESSMENT AND DESIGN

3.1 Design Parameters

- Lot Size: 1413m^2
- Proposed roof area: approx. 250m^2
- Design storms:
  - Primary: 10yr ARI
  - Secondary: 100yr ARI
- Rainfall data: Ruakura Rainfall data
- Climate change: 2.1 degrees warming
- Soakage rate: 900mm/hr (tested 12th of May 2020) – adopted 225mm/hr. Refer to Appendix C for results.
- Water table was determined to be 13.0m below the ground surface in the CPT logs from the neighbouring lot 4.

Figure 2 below summarises the catchment characteristics that have been adopted.

SOAKAGE DESIGN CALCULATIONS AND OUTPUTS

Rainfall Location	Event	ARI
Hamilton	Primary	10
	Secondary	100

Catchment	Area (m2)		C
	Existing	Proposed	
Grass	410		0.30
Roof		250	0.95
Concrete		160	0.90
Gravel			0.70
Other			-
TOTAL	**410**	**410**	
Composite C	0.3	0.93	
Adopted C	**0.30**	**0.93**	

Existing	Input / Select
Proposed	Answer

Existing Catchment Characteristics, Time of Concentration (Tc)	
Average grassed surface	0.045
Length of flow path (m)	20.00
Slope (%)	1.00
Tc (min)	13.07
Existing Q(max) (l/s) (interpolated wrt Tc)	2.90
Adopted Soakage rate (mm/hr)	225

Figure 2: Stormwater Design Parameters

3.1.1 Soakage Trench

It is proposed that a soakage trench is constructed to enable disposal of water from all the impermeable areas to ground during the design storm. Catchpits should be installed in the sealed areas with catchpit filters and be piped to the soakage trench.

All roof water should be routed to the soakage trench. The overflow from the soakage trench will flow in a pipe down to the bottom of the gully and discharge through a level spreader. The level spreader shall discharge onto an erosion control blanket or rock to prevent erosion at the base of the slope.

The soakage trench can either be constructed with 40-60mm clean rock or proprietary stormwater crates as follows[i]:

- A rock filled trench shall be **1.0**m deep and a minimum of **28.2**m^2 in plan area.
- A proprietary crate system shall be **0.86**m deep (2 layers) and a minimum of **16.4**m^2 in plan area.

The location of the **rock filled trench** underneath paved trafficable areas (for domestic residential driveways only) is acceptable given that an adequate pavement as described below is constructed in areas where vehicle loads are expected over the soakage trench, extending a minimum of 1.5m wider than the trench extents:

- Base Material: (Fill over top of soakage trench) - 200mm GAP 40 compacted to 102% RDD
- Surface - 125mm Concrete 25Mpa with SE62 Steel reinforcing Mesh - on 50mm chairs
- Sawcuts at a maximum 6m spacing, as per NZS 3604 Cl. 7.5.8.6.4 are to be provided

Subsurface water drains shall be sized in accordance with Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 Surface Water (E1/AS1) Section 3.

3.1.2 Alternative Option: Soak Holes

Disposal of water from impermeable surfaces during the design storm is possible through the use of a number of soakage holes. The depth and number of soak holes is shown in the table below. Note that 1 or 2 pits are not applicable as they are below the water table level.

Table 4: Soakage Hole Counts and Depth.

No Pits:	Depth:
3	8.7m
4	6.5m
5	5.2m
6	4.3m
7	3.6m

3.1.3 Secondary flow path

The stormwater runoff from impermeable surfaces has been designed to be routed via the soakage trench. The overflow from these devices shall discharge to the bottom of the nearby gully as far as possible from the slope beneath the proposed dwelling.

[i] These depths do not include the cover material that will need to be replaced once the trench is emplaced.

3.2 Operation and maintenance

It is recommended that first flush devices are installed upstream of the soakage trench and that these devices are regularly checked and cleaned along with the catchpit filters and overflow pipes.

3.3 Construction Monitoring

TITUS CIVIL Consulting Engineers have been engaged to perform inspections of the storm water system during construction.

4 WASTEWATER ASSESSMENT AND DESIGN

4.1 Design Parameters

The following design parameters have been adopted to design the system to meet the requirements:

- Water supply to the property will be reticulated community supply
- 5-bedroom home
- 8 people occupancy
- 165L/day/person
- Peak daily flow 1,320L/day
- The soil at the site is classified as a soil category 2 - Sandy loams (AS/NZS 1547:2012).
- Council planning maps show no flooding risk for the site.

4.1.1 Water Use Requirements

The following water use requirements are noted:

- Design information of 165L/day/person is based of AS/NZS 1547:2012. This requires the proposed building to have standard water reduction fixtures.
- standard water reduction fixtures include dual flush water closets, shower flow restrictors, aerator faucets, and water-conserving automatic washing machines

4.2 Treatment Design

4.2.1 Primary Treatment System

Primary treatment will be achieved through the use of a septic tank. This system can treat up to a maximum of 1,300l/day (averaged over a one-month period) under the Waikato Regional Council conditions for rule 3.5.7.5 of the Waikato Regional Plan.

Limitations of the primary system include:

- Average Daily Flow shall be <1,300l/day
- Water table shall have a 0.6m offset,
- Slope of disposal field shall be <15%,
- Size of property shall be ≥2,500m^2,
- Difficult in category 5 soils and,
- Not acceptable in category 6 soils.

The proposed primary system has been designed as per the Table below.

Table 5: System Specifications

Min Septic Tank (L)	24hr settling volume (L)	Scum and sludge capacity (L)	Max Pump out frequency (Yrs)
5000	1320	3200	5
DLR recommended (mm/d)	DLR adopted (mm/d)	Daily Flow (L/day)	Basal area (m^2)
15-30	20	1320	66

4.2.2 Wastewater Disposal

Primary treatment will be achieved through the use of a septic tank with disposal through conventional beds. The design is outlined in Table 6.

Table 6: Disposal Method Specifications

Disposal Method / Specification	Beds
Number of beds	2
Length (m)	20
Width (m)	1.7
Spacing (m)	1
Basal area (m^2)	66
Total area (m^2)	85 + 85 Reserve Area

Appendix E provides an indicative layout of the proposed wastewater system. Additional drawings provided separately reflect typical details for the proposed field.

It is required that the flows are distributed evenly to each trench. This can be achieved with an open splitter box (Dart developments or similar) that provides even distribution to all outlet pipes. Conventional Y or T-junctions with or without flow baffles should not to be used. The levels of the pipes installed in each trench are to be closely monitored to ensure even distribution of flows across the length of each disposal trench.

4.3 Maintenance, Operation and Planting

Maintenance and Operation of the system shall be as per the manufacturers specifications, AS/NZS 1547:2012 and the recommendations contained in the appendices.

Planting shall be as per AS/NZS 1547:2012 and the recommendations contained in the appendices.

4.4 Inspections

TITUS CIVIL Consulting Engineers should be engaged to inspect the installation of the Septic Treatment and Land Disposal Systems prior to any excavations and pipe installations being buried.

5 SLOPE STABILITY ASSESSMENT

5.1 Assessment parameters

This slope stability assessment will consider the stability of the existing slope as well as the proposed plans with the basement cut into the edge of the slope. The assessment also consider strength loss in liquefiable layers following a ULS event.

The slope has been modelled using SLIDE 2018 software under several loading and ground water conditions. The report details the results of the assessment under the following loading conditions:

- Gravity (drained)
- Gravity (drained, elevated water table)
- SLS (Serviceability Limit State) – (drained)
- ULS (Ultimate Limit State) – (drained)

The slope has been modelled in the three following scenarios:

- Existing conditions (prior to any earthworks undertaken on site)
- Proposed cutdown and dwelling
- Proposed cutdown and dwelling with strength loss layers due to liquefaction caused by a ULS earthquake.

Proposed slope cutting and dwelling foundation has been modelled to the specifications outlined in the latest engineering plans by Don Crowie Draughting & Design Services. Foundation Pile depths have been modelled to required depths to be founded below predicted failure arcs.

5.2 Historic Land Use

The site has previously been used as a milking shed that existed from pre-1938 until recent removal following subdivision of the land.

5.3 New Zealand Geotechnical Database

The New Zealand Geotechnical database has no entries close to the site. CPT logs from lot 4 of the subdivision have been used to determine the geological parameters in the slope model. The locations of the CPT logs are shown in Appendix A.

5.4 Geological Setting

Refer to section 2.3.1 *Geological Setting.*

5.5 Site Observations

The slope runs across the site from north to south. The slope separates flat (<5%) land above it to the west from the vegetated gully below it. Vegetation on the slope itself has been cleared in preparation for specialised planting. There were no outcrops of rock found on site.

This is consistent with the geology of the Hamilton basin which has deep soils and deep bedrock.

The slope ranges in steepness from 7 degrees to a maximum of 40 degrees with an average slope of 27 degrees or 51% incline. Two large poplar trees are present at the top of the slope. Figure 3 below shows the slope below the proposed dwelling location. The loose material seen on the slope in Figure 3 is sand from the removal of the milking shed foundation. No evidence of slope instability was seen during the site inspection.

Figure 3: Photo of slope from below proposed dwelling location.

5.6 General

Slope stability modelling has been undertaken using Slide 2018 by RocScience using the Morgenstern-Price method to analyse the slope. The cross section of the slope was based on contour data taken from HCC 3 waters online mapping service. Location of the slope modelled is attached in Appendix A and Slope models are attached in Appendix H.

The factors of safety (FOS) as summarised in Table 7 has been adopted as appropriate for the loading conditions:

Table 7: FOS Standard Requirements

Modelled Loading Condition	FOS Required
Gravity Conditions	1.5
Gravity Conditions (elevated water table)	1.3
Seismic SLS (Serviceability Limit State)	1.5
Seismic ULS (Ultimate Limit State)	1.1

5.7 Adopted Subsurface Conditions

The stratigraphy as determined by TITUS CIVIL Consulting Engineers with reference to CPT logs for lot 4 undertaken by OPUS, has been separated into the different materials displayed in the Table below.

Table 8: Material characteristics

Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu	Ru
Topsoil		17	19.7	Mohr-Coulomb	2	28		Water Surface	Automatically Calculated		
Coarse Dense Sands		18	20.7	Mohr-Coulomb	2	40		Water Surface	Automatically Calculated		
Coarse Sands		18	20.7	Mohr-Coulomb	2	38		Water Surface	Automatically Calculated		
Medium to Coarse Sands		18	20.7	Mohr-Coulomb	2	37		Water Surface	Automatically Calculated		
Medium Sands		18	20.7	Mohr-Coulomb	2	36		Water Surface	Automatically Calculated		
Medium to Fine Sands		19	21	Mohr-Coulomb	2	35		Water Surface	Automatically Calculated		
Fine Silts		17	19.7	Mohr-Coulomb	3	32		Water Surface	Automatically Calculated		
Holocene Sediments		13	14	Mohr-Coulomb	0	32		Water Surface	Automatically Calculated		
Free Draining hardfill		18	20.7	Mohr-Coulomb	2	37		Water Surface	Automatically Calculated		
Concrete Retaining Wall		25		Undrained	650		Constant	None			0
Concrete Floor		24		Mohr-Coulomb	30	40		None			0
Liquefied Layer		18		Undrained	2		Constant	Water Surface	Custom	0	

5.8 Groundwater Model

The water table has been modelled at 12.0m below the ground surface at the top of the slope and 0.3m below the surface at the bottom except in the elevated water table conditions.

The elevated water table has been modelled at 0.9m below the ground surface at the top of the slope and 0.9m above the ground surface at the bottom of the slope as the gully is expected to flood during a large storm event.

5.9 Loading

Loadings applied to each model are shown in the Table below. The location of loadings may be found in Appendix H.

Table 9: Surcharges to be present in slope profile.

Surcharge	Load	Load Type
Proposed Dwelling	25 kN/m^2	Uniformly Distributed
Deck and Roof Supports	6 kN/m^2	Uniformly Distributed

5.10 Supports

The properties of supports modelled are displayed in the Table below.

Table 10: Support properties

Type	Out of plane Spacing	Shear Strength - Static	Shear Strength - Transient	Depth
200 mm SED High Density Timber Pile	2.0 m	36 kN	59 kN	5.0m

5.11 Slope Stability Results

Under existing conditions, the model shows failure arcs below the required FOS up to 11.8m back from the crest of the slope during ULS and SLS conditions. The gravity condition had failure arcs below the required FOS up to 1.4m back from the crest of the slope.

Under the proposed slope cutting and dwelling foundation scenario the gravity and elevated water scenarios meet the required FOS required. The FOS reached for the dwelling under the SLS condition was 1.55 and the FOS reached under ULS conditions was 1.11. Both of these meet the required FOS for their conditions.

The strength loss scenario gave a FOS of 1.002 under ULS conditions.

Table 11 below shows the minimum FOS achieved for the modelled foundation under various seismic loading conditions as specified in Section 5.6 of this report.

Table 11: Worst Case failure plane FOS

Modelled Loading Condition	Minimum Global FOS (Existing)	FOS Reached (Proposed)	FOS Reached (Strength Loss)
Gravity Conditions	1.42	1.57	n/a
Gravity Conditions (elevated water table)	1.42	1.36	n/a
Seismic SLS (Serviceability Limit State)	1.28	1.58	n/a
Seismic ULS (Ultimate Limit State)	0.93	1.14	1.002

5.12 Recommendations

It is proposed the site is cut down by 2.0m reducing the overall slope height.

The top of the slope will be cut down a further 3.0m for the basement level of the house.

To improve stability of the slope the following recommendations have been made:

- The dwelling should be setback at least 6.0m from the new top of the slope after cutting down.
- The modelled foundation is based on 200mm diameter piles as per the Engineering Plans with a minimum embedment depth of 5.0m.
- The rest of the foundation piles will be designed by a suitably qualified engineer to be in accordance with suitable depths as outlined in section 2.4.1 of this report.
- Appropriate vegetation should be planted on the slope as to improve stability and avoid erosion.
- The soakage device should be positioned as far from the top of slope as reasonably possible.
- No overland flow paths should be directed onto or towards the slope.
- No undercutting of the slope should be undertaken without due consideration to slope stability.
- No additional surcharges should be placed at the top of the slope without further slope stability analyses.

6 LIMITATIONS

This report does not assess risk of contamination of soils. This report does not provide a foundation design.

Testing portrays a limited percentage of ground conditions at Lot 2 136 State Highway 26 and may not be representative of all soils present on site.

Assessment of the water table depth and moisture content is subject to seasonal variation.

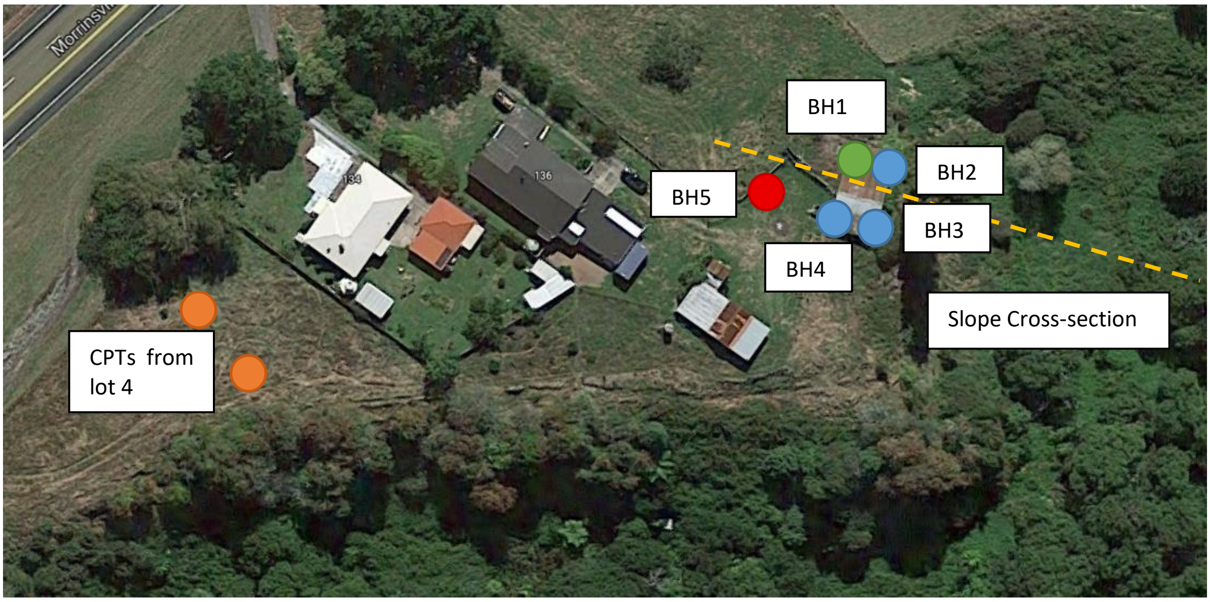
During excavation and construction, the site should be examined by a suitably qualified engineer in order to assess whether the exposed subsoils are compatible with the inferred soil conditions on which the recommendations have been based and potentially further investigation and design rationalisation may be required. Flooding and FFL requirements has not been assessed as part of this stormwater design.

This report has been prepared solely for Martin Cameron, its professional advisors, and local authorities in relation to Lot 2 136 State Highway 26. No liability is accepted for its use for any other purpose or by any other entity. Reliance by other parties or future owners of the property on the information or opinions contained in the report shall be verified with TITUS CIVIL Consulting Engineers.

Should you be in any doubt as to the recommendations of this report it is essential that you discuss these issues with TITUS CIVIL Consulting Engineers prior to proceeding with any work based on this report.

APPENDICES

APPENDIX A - Proposed Site Layout Plan



APPENDIX B - Soil Investigation Bore Logs

TITUS CONSULTING ENGINEERS

Log: BH1

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Material Description:	Blows /100mm:	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	0–100	Hinuera Formation	Medium SAND, yellowish orange and brown, poorly graded, moist, very loose	0			
	100–200			0			
	200–300			0			
	300–400		SILT with some sand, yellowish grey, low plasticity, moist, stiff	3	91	53	1.7
	400–500			2			
	500–600			3			
	600–700			2			
	700–800		SILT with some sand, light yellowish brown, low plasticity, moist, stiff	3	91	30	3
	800–900			2			
	900–1000			2			
	1000–1100			4			
	1100–1200			6	91	61	1.5
	1200–1300			4			
	1300–1400			4			
	1400–1500		*End of Borehole @1400mm*	5			
	1500–1600			4			
	1600–1700			6			
	1700–1800			6			
	1800–1900			5			
	1900–2000						
	2000–2100						

TITUS CONSULTING ENGINEERS

Log: BH2

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM
Project №: 11122

Water Table: Not Found
Geology: Hinuera Formation

Depth (mm)	Material Description	Blows /100mm	Undrained (kPa)	Remoulded (kPa)	Sensitivity
0–100	Medium SAND, yellowish brown, poorly graded, moist, very loose	0			
100–200		0			
200–300	Black, organics	0			
300–400		0			
400–500		0			
500–600		0			
600–700		0			
700–800		1			
800–900	Medium SAND, yellowish brown, poorly graded, moist, very loose to loose	2			
900–1000		1			
1000–1100	SILT, grey, low plasticity, moist, stiff	3	91	61	1.5
1100–1200		2			
1200–1300		2			
1300–1400		3			
1400–1500	Medium to coarse SAND with some silt, brown, well graded, moist, medium dense	5			
1500–1600		5			
1600–1700		5			
1700–1800		4			
1800–1900		5			
1900–2000					
2000–2100	*End of Borehole @2000mm*				

TITUS CONSULTING ENGINEERS

Log: **BH3**

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Material Description:	Blows /100mm:	Undrained:	Remoulded:	Sensitivity:
Not Found	0–100	Hinuera Formation	Fine SAND with minor silt, brown, well graded, moist, very loose	0			
	100–200			0			
	200–300			0			
	300–400		SILT, brownish grey, low plasticity, moist, stiff	2	91	38	2.4
	400–500			1			
	500–600			3			
	600–700		Medium SAND, yellowish brown, poorly graded, moist, loose to medium dense	2			
	700–800			3			
	800–900			2			
	900–1000			5			
	1000–1100			3			
	1100–1200		Silty fine SAND, light brown, well graded, moist, loose	3			
	1200–1300			5			
	1300–1400			5			
	1400–1500		SILT with some sand, light yellowish brown, low plasticity, moist, very stiff	8	206	53	3.9
	1500–1600			5			
	1600–1700		Medium to coarse SAND, brownish orange, well graded, moist, medium dense	5			
	1700–1800			6			
	1800–1900						
	1900–2000						
	2000–2100		*End of Borehole @2000mm*				

Shear Strength (kPa): Undrained / Remoulded / Sensitivity

TITUS CONSULTING ENGINEERS

Log:

BH4

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM

Project №: 11122

Water Table:	Depth (mm):	Geology:	Material Description:	Blows /100mm:	Shear Strength (kPa): Undrained:	Remoulded:	Sensitivity:
Not Found	0–100	Hinuera Formation	Medium SAND, brownish orange, poorly graded, moist, very loose	0			
	100–200			0			
	200–300			0			
	300–400			1			
	400–500		Sandy SILT, yellowish brown, low plasticity, moist, stiff	2	84	38	2.2
	500–600			1			
	600–700			2			
	700–800			3	99	69	1.4
	800–900		Silty medium to coarse SAND, dark brownish orange, well graded, moist, very loose to medium dense	3			
	900–1000			2			
	1000–1100			1			
	1100–1200		Silty SAND, greyish brown, well graded, moist, loose	3			
	1200–1300			4			
	1300–1400			5			
	1400–1500			4			
	1500–1600		Coarse SAND, yellowish brown, poorly graded, moist, medium dense to dense	4			
	1600–1700			5			
	1700–1800			5			
	1800–1900			8			
	1900–2000						
	2000–2100		*End of Borehole @2000mm*				

TITUS CONSULTING ENGINEERS

Log: BH5

Address: Lot 2 State Highway 26
Date: 12/05/2020
Testers: RM
Project №: 11122

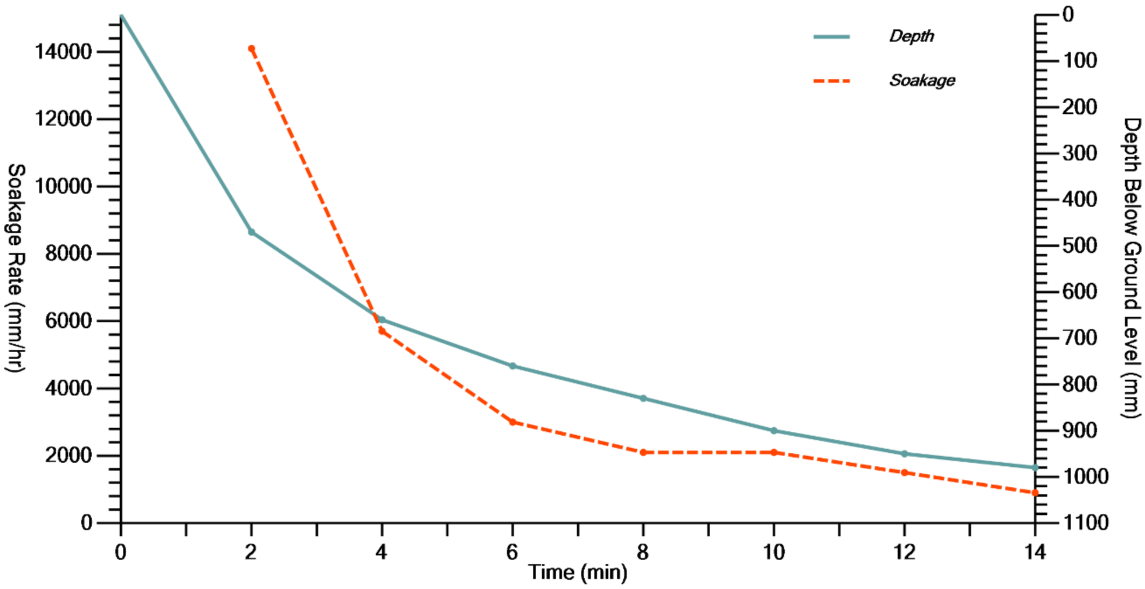
Water Table:	Depth (mm):	Geology:	Material Description:	Blows /100mm:	Shear Strength (kPa): Undrained	Remoulded	Sensitivity
Not Found	0–200	Undefined	Topsoil				
	200–500	Hinuera Formation	Medium SAND, yellowish brown, poorly graded, moist				
	500–900	Hinuera Formation	SILT, light brown, low plasticity, moist				
	900–1300	Hinuera Formation	Fine to medium SAND, brownish orange, well graded, moist				
	1300–2000	Hinuera Formation	Medium to coarse SAND, brown, well graded, moist				
	2000		*End of Borehole @2000mm*				

APPENDIX C - Percolation Test

TITUS CONSULTING ENGINEERS

Percolation Test Sheet

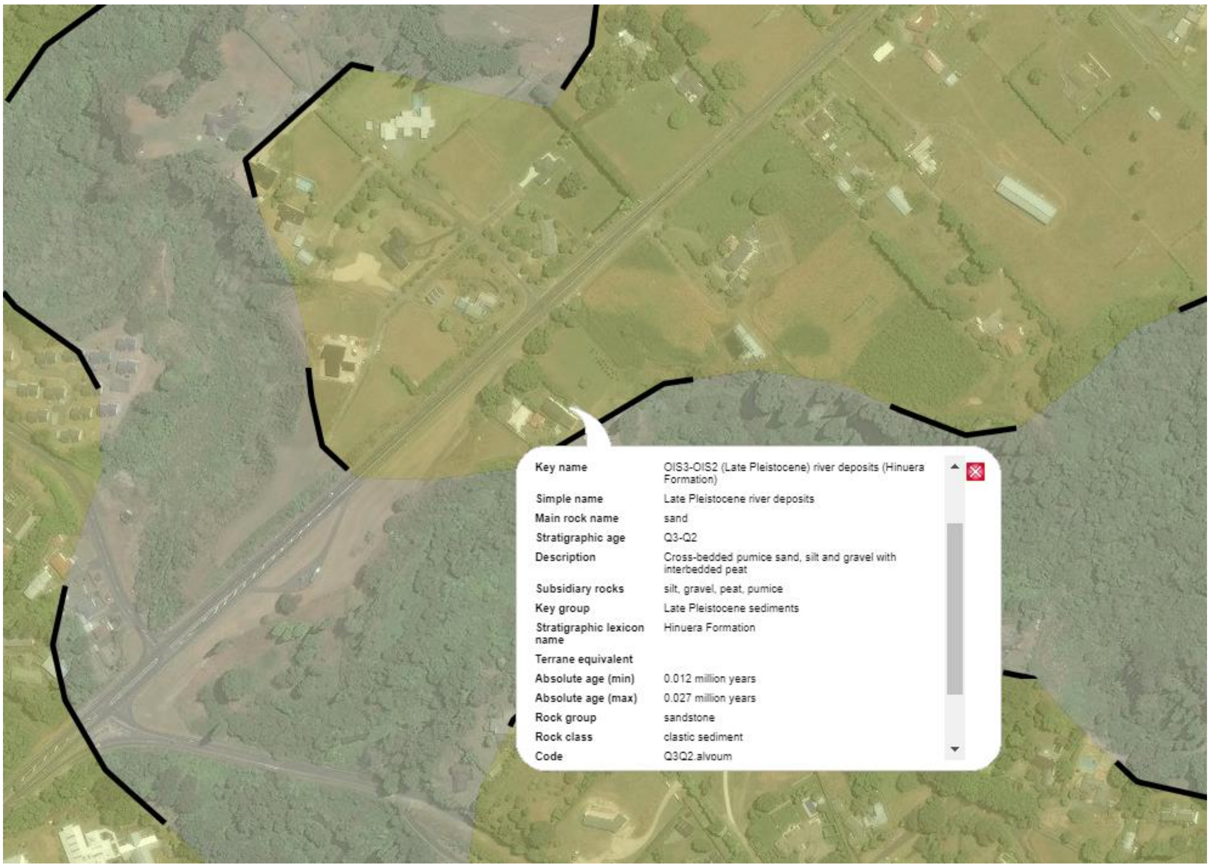
Project ID 11122
Address Lot 2 State Highway 26



Reading	Time Elapsed (min)	Drop (mm)	Soakage Rate (mm/hr)	Refill
1	2	470	14100	
2	4	190	5700	
3	6	100	3000	
4	8	70	2100	
5	10	70	2100	
6	12	50	1500	
7	14	30	900	

Log	BH1
Date	12/05/2020
Staff	RM
BH Depth	1400 mm
Ground Water	Not Encountered
Main Soil Type	SILT
Seasonal Variation	Conservative
Raw Soakage	900 mm/hr

APPENDIX D - Underlying Geology



APPENDIX E - Proposed Stormwater & Wastewater Layout Plan

Attached separately

APPENDIX F - Calculation Sheets

SOAKAGE DESIGN CALCULATIONS AND OUTPUTS

Legend	
Existing	Input / Select
Proposed	Answer

Rainfall Location	Event	ARI
Hamilton	Primary	10
	Secondary	100

Catchment	Area (m2) Existing	Area (m2) Proposed	C	
Grass	410		0.30	
Roof		250	0.95	0.6063158
Concrete		160	0.90	
Gravel			0.70	
Other			-	
TOTAL	**410**	**410**		
Composite C	0.3	0.93		
Adopted C	**0.30**	**0.93**		

Existing Catchment Characteristics, Time of Concentration (Tc)	
Average grassed surface	0.045
Length of flow path (m)	20.00
Slope (%)	1.00
Tc (min)	13.07

Existing Q(max) (l/s) (interpolated wrt Tc)	2.90
Adopted Soakage rate (mm/hr)	225

ARI	10								
Duration(min)	10	20	30	60	120	360	720	1440	2880	4320
Delta t (min)	10	10	30	60	240	360	720	1440	1440	
Delta Q (l/s)	-0.8	-0.4	-0.6	-0.5	-0.4	-0.1	-0.1	-0.1	0.0	
Intensity	91.9	69.1	57.1	38.7	23.6	10.6	6.7	4.1	2.5	1.8
Intensity CC	107.2	80.3	66.1	44.7	27.1	12.1	7.6	4.7	2.8	2.0
Existing Q (l/s)	3.1	2.4	2.0	1.3	0.8	0.4	0.2	0.1	0.1	0.1
Proposed Q (l/s)	11.4	8.5	7.0	4.7	2.9	1.3	0.8	0.5	0.3	0.2

ARI	10									
Duration	10m	20m	30m	60m	2h	6h	12h	24h	48h	72h
Depth EX	16.2	24.5	29.6	36.4	42.7	57.3	77.5	93.3	113.4	121.1
Depth CC	17.9	26.8	33.1	44.7	54.3	72.3	91.3	112.1	135.2	142.3
Existing Vol m3	2.0	3.0	3.6	4.5	5.3	7.0	9.5	11.5	13.9	14.9
Proposed Vol m3	6.8	10.2	12.6	17.1	20.7	27.6	34.8	42.8	51.6	54.3

Soakage - Clean Rock										
Depth	1	Voids	0.38							
Duration	10m	20m	30m	60m	2h	6h	12h	24h	48h	72h
Vsoak /m2	0.04	0.08	0.11	0.23	0.45	1.35	2.70	5.40	10.80	16.20
Vstore /m2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Vtotal /m2	0.4	0.5	0.5	0.6	0.8	1.7	3.1	5.8	11.2	16.6
Trench size m2	16.4	22.5	25.6	**28.2**	25.0	15.9	11.3	7.4	4.6	3.3

Soakage - SW Crates										
Depth	0.86	Voids	0.95	No. layers	2					
Duration	10m	20m	30m	60m	2h	6h	12h	24h	48h	72h
Vsoak /m2	0.04	0.08	0.11	0.23	0.45	1.35	2.70	5.40	10.80	16.20
Vstore /m2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Vtotal /m2	0.9	0.9	0.9	1.0	1.3	2.2	3.5	6.2	11.6	17.0
Trench size m2	8.0	11.5	13.6	**16.4**	16.4	12.7	9.9	6.9	4.4	3.2

BUILD MAGAZINE SOAK PITS:		SP Depth:
Vstore (m^3/hr)	16.91	3.6
Rc (m^3 / hr)	17.1	**No Pits:**
C	0.93	7
I (mm/hr)	44.7	
A(m^2)	410	
Vsoak (m^3/hr)	0.14	
Soak A(m^2)	0.64	
Sr (mm/hr)	225	

No Pits:	Depth:
1	26.58m
2	13.18m
3	8.71m
4	6.48m
5	5.14m
6	4.24m
7	3.60m

APPENDIX G - Key Do's & Don'ts for the Householder

DO

- Minimise your water use.
- Minimise the length of showers.
- Use showers in preference to baths.
- Use bio-degradable soaps and cleaners
- Check all your cleaning products to see if they are suitable for septic tanks.
- Minimise use of strong toilet cleaners.
- Scrape all plates and dishes to remove as much fat and grease as possible. Clean with paper towels and place in the rubbish.
- Report/fix all leaking taps as soon as possible.
- Use phosphate free/low phosphorus based laundry detergents.

DO NOT

- Don't pour any toxic/strong chemicals (paint, oil, grease, paint thinners, pesticides down any drains).
- Don't flush any products down the toilet, other than standard toilet paper.
- Don't discard any drugs down the sink or toilet.
- Don't use strong cleaners.
- Don't tip chlorine cleaners or disinfectant based products into the system.
- Don't use huge amounts of cleaners.
- Don't use chemical drain cleaning products.
- Don't do all your laundry on one day.
- Don't install in-sink garbage grinders. If a grinder exists, don't discharge high volumes of scraps, especially carbohydrates or fats/oils down it.
- Don't put coffee grounds down the sink.

APPENDIX H - Maintenance, Operation and Planting Recommendations

Attached separately

APPENDIX I - Typical Details

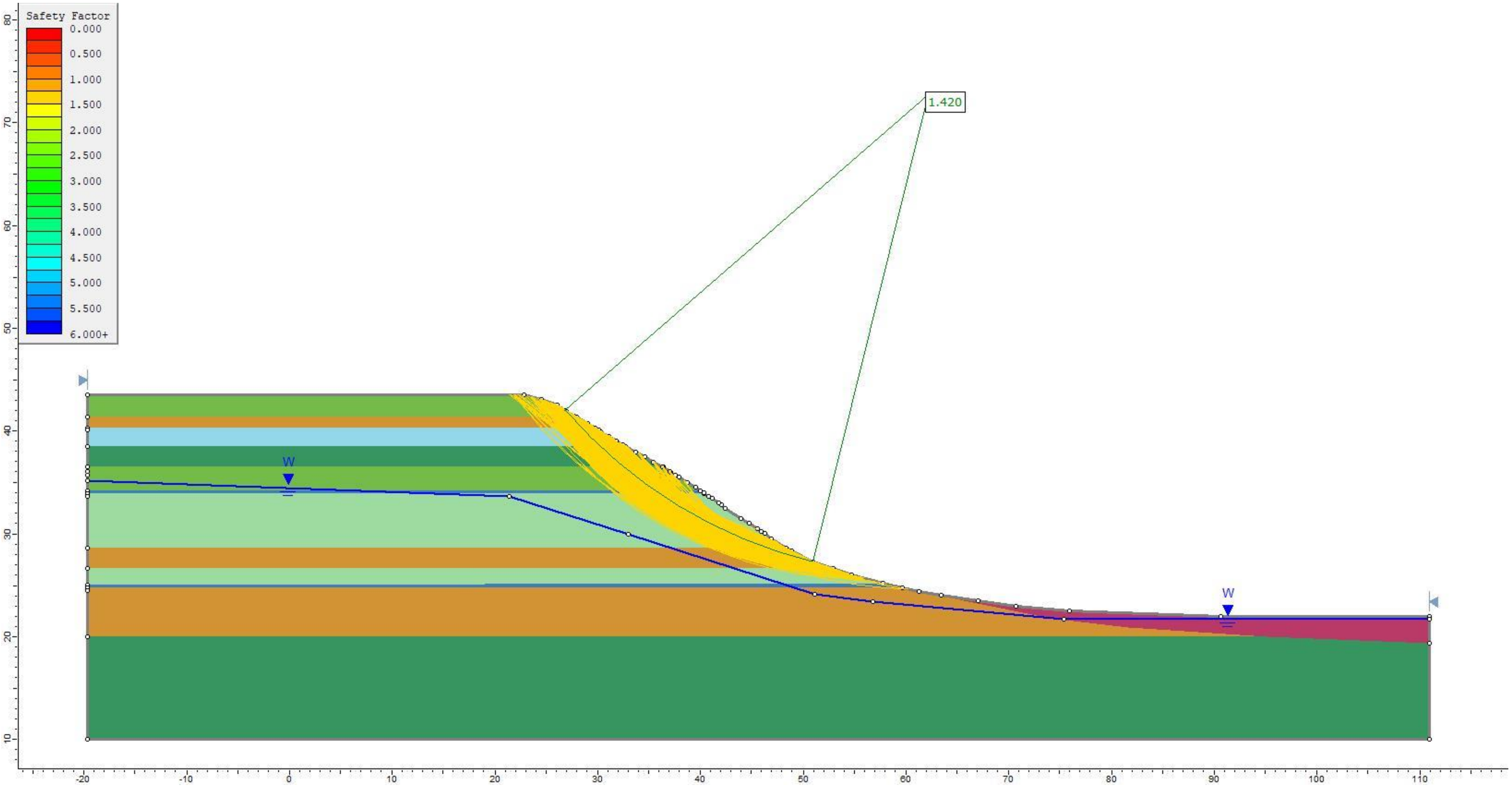
Attached separately

APPENDIX J – Slope Stability Models

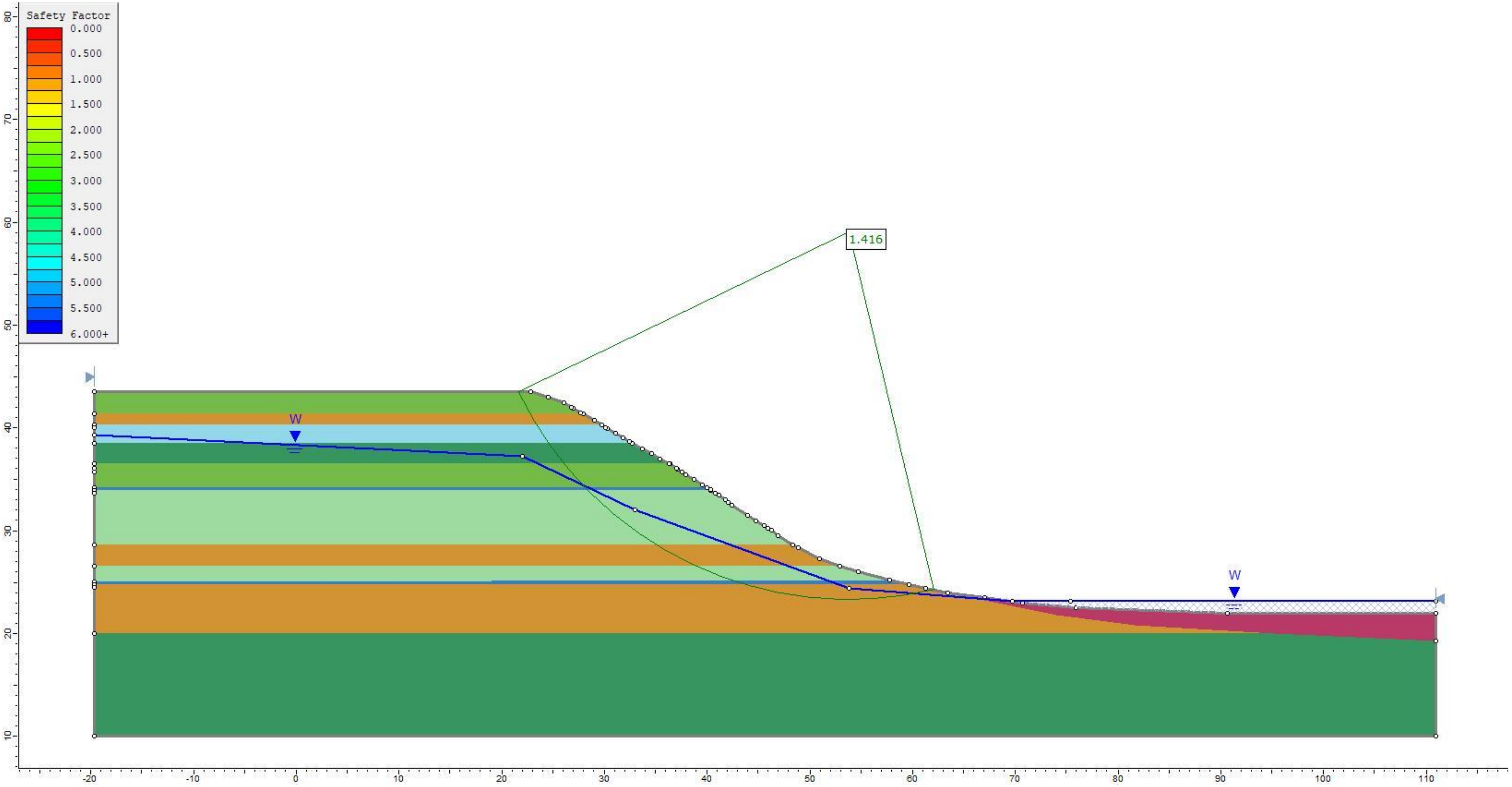
Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Ru
Topsoil		17	19.7	Mohr-Coulomb	2	28		Water Surface	Automatically Calculated	
Coarse Dense Sands		18	20.7	Mohr-Coulomb	2	40		Water Surface	Automatically Calculated	
Coarse Sands		18	20.7	Mohr-Coulomb	2	38		Water Surface	Automatically Calculated	
Medium to Coarse Sands		18	20.7	Mohr-Coulomb	2	37		Water Surface	Automatically Calculated	
Medium Sands		18	20.7	Mohr-Coulomb	2	36		Water Surface	Automatically Calculated	
Medium to Fine Sands		19	21	Mohr-Coulomb	2	35		Water Surface	Automatically Calculated	
Fine Silts		17	19.7	Mohr-Coulomb	3	32		Water Surface	Automatically Calculated	
Holocene Sediments		13	14	Mohr-Coulomb	0	32		Water Surface	Automatically Calculated	
Free Draining hardfill		18	20.7	Mohr-Coulomb	2	37		Water Surface	Automatically Calculated	
Concrete Retaining Wall		25		Undrained	650		Constant	None		0
Concrete Floor		24		Mohr-Coulomb	30	40		None		0
Liquefied Layer		18	20.7	Undrained	5		Constant	Water Surface	Automatically Calculated	

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (m)	Failure Mode	Pile Shear Strength (kN)	Force Direction
200 mm SED Piles High Str Static		Pile/Micro Pile	Passive (Method B)	2	Shear	36	Perpendicular to pile
200 mm SED Piles High Str Transient		Pile/Micro Pile	Passive (Method B)	2	Shear	59	Perpendicular to pile

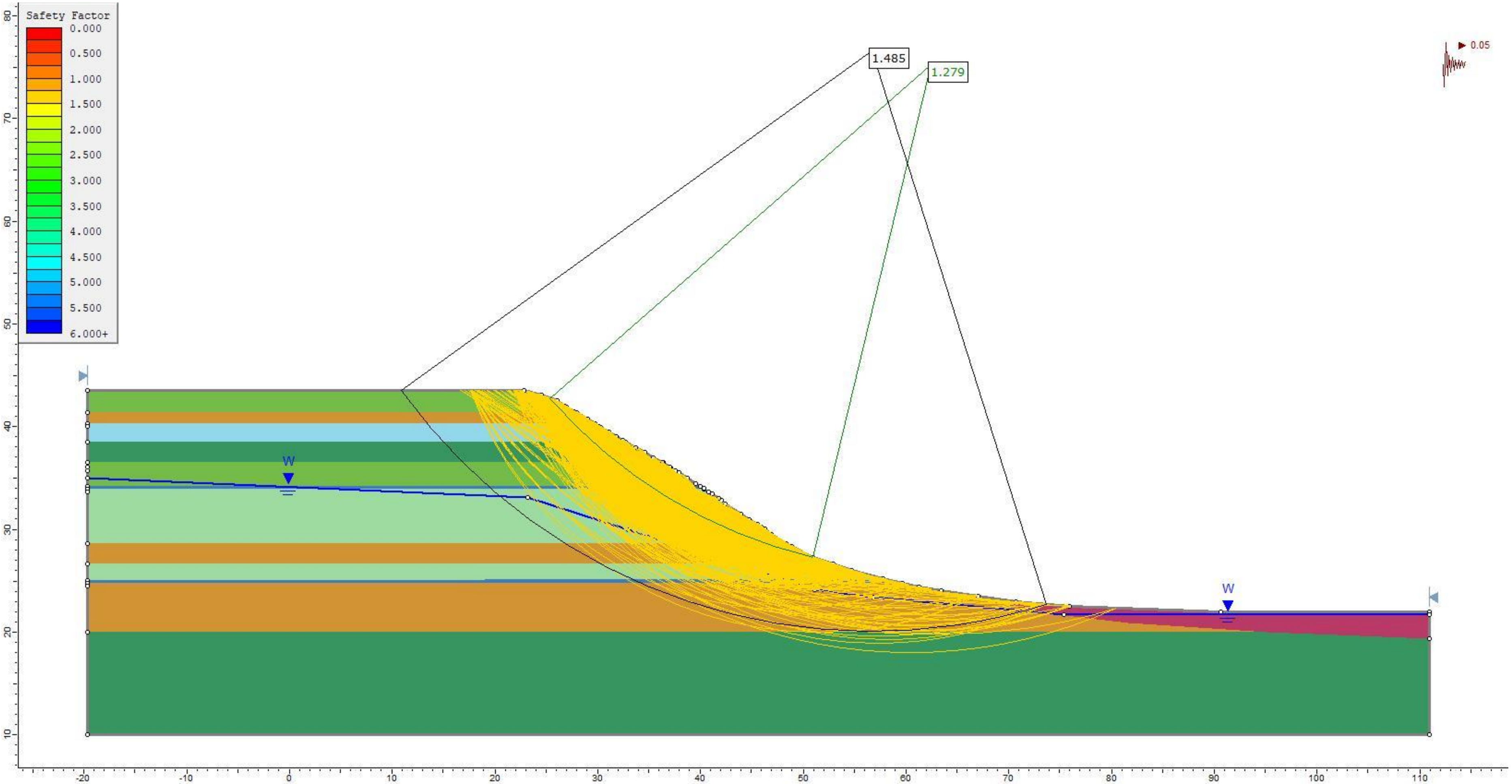
EXISTING SLOPE



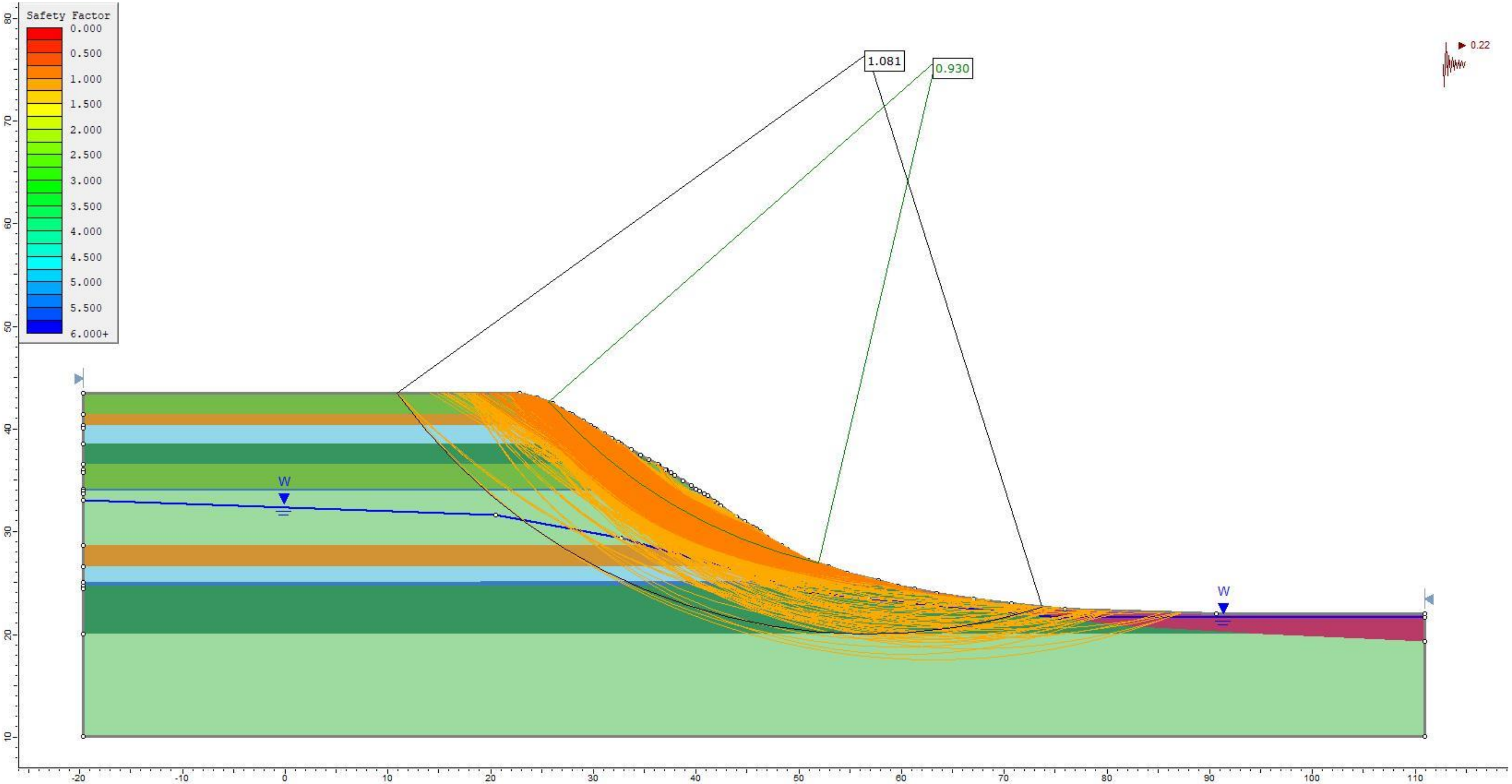
SLIDE 2018 model – Existing Site – Gravity Conditions – FOS required: 1.5



SLIDE 2018 model – Existing Site – Gravity Conditions –Elevated water table - FOS required: 1.3

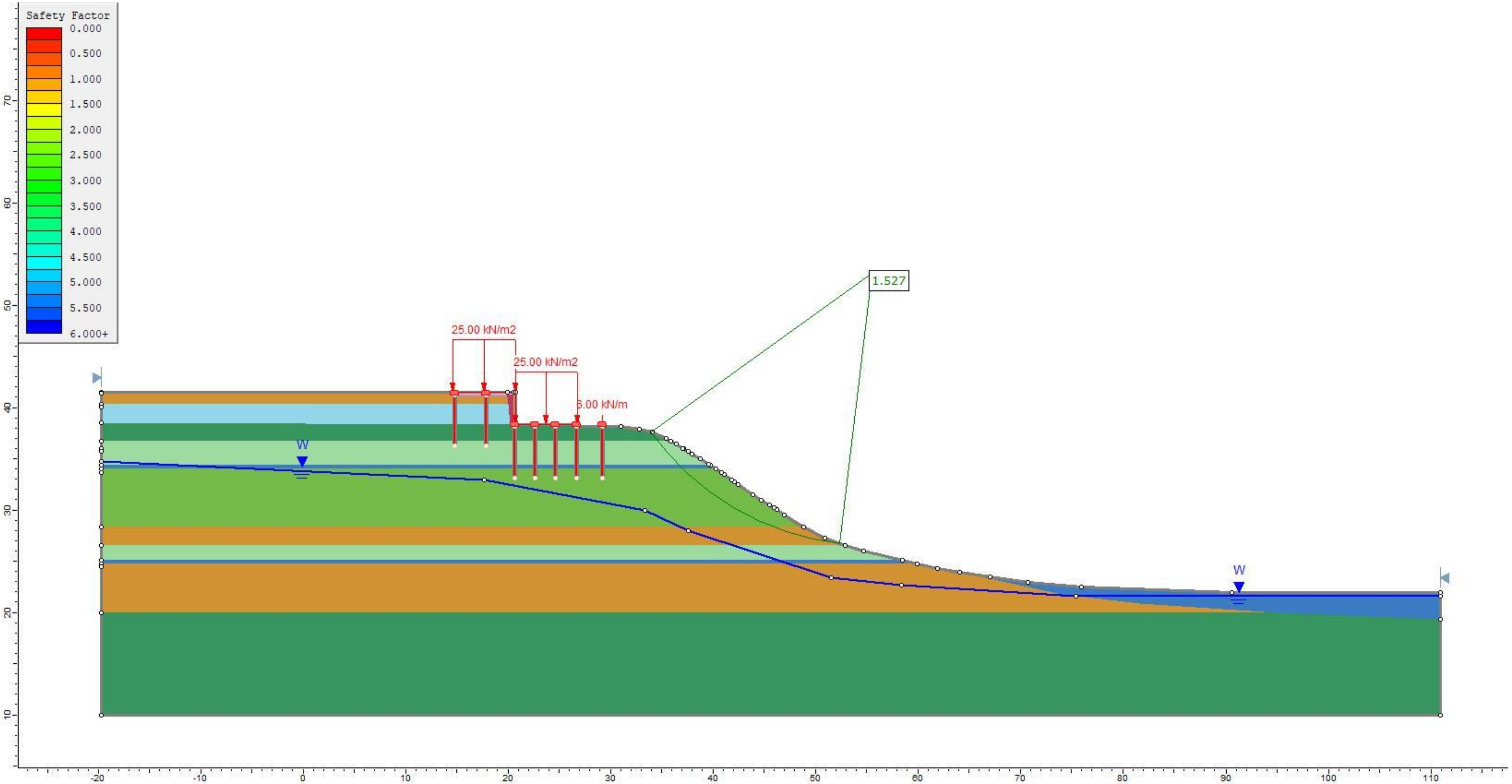


SLIDE 2018 model – Existing Site - SLS (Serviceability Limit State) – FOS required: 1.5

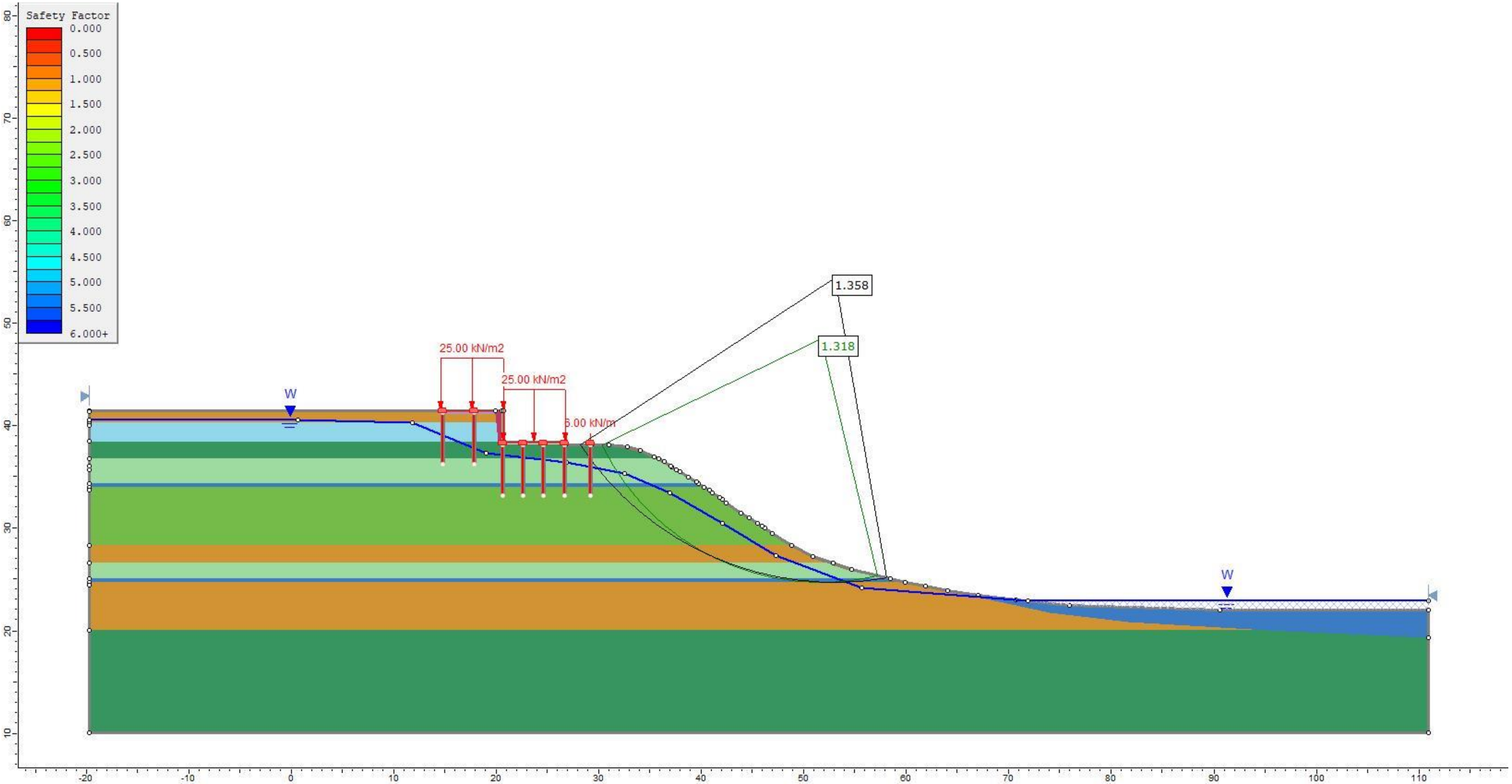


SLIDE 2018 model – Existing Site - ULS (Ultimate Limit State) – FOS required: 1.1

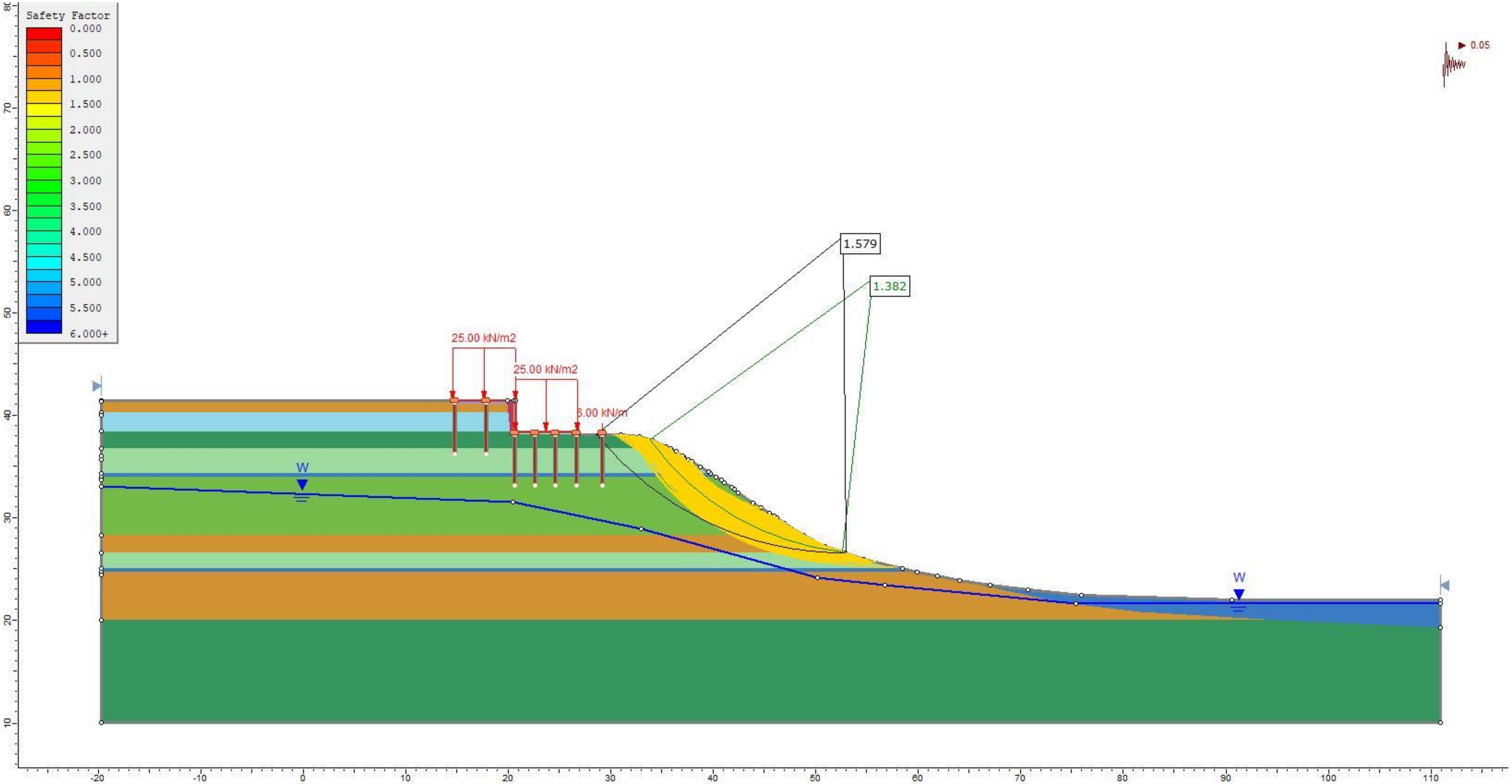
PROPOSED DWELLING



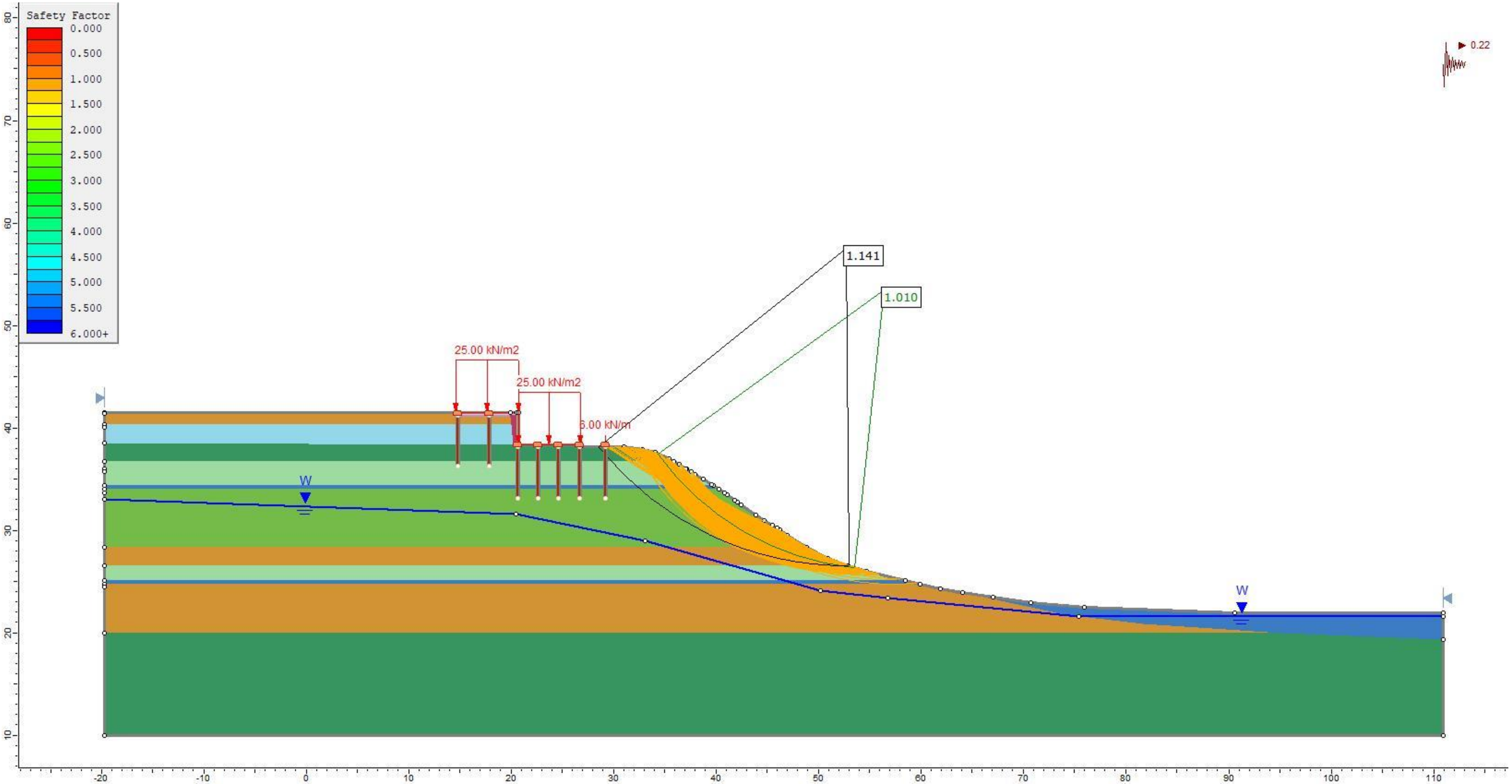
SLIDE 2018 model – Proposed Dwelling – Gravity Conditions – FOS required: 1.5



SLIDE 2018 model – Proposed Dwelling – Gravity Conditions –Elevated water table - FOS required: 1.3

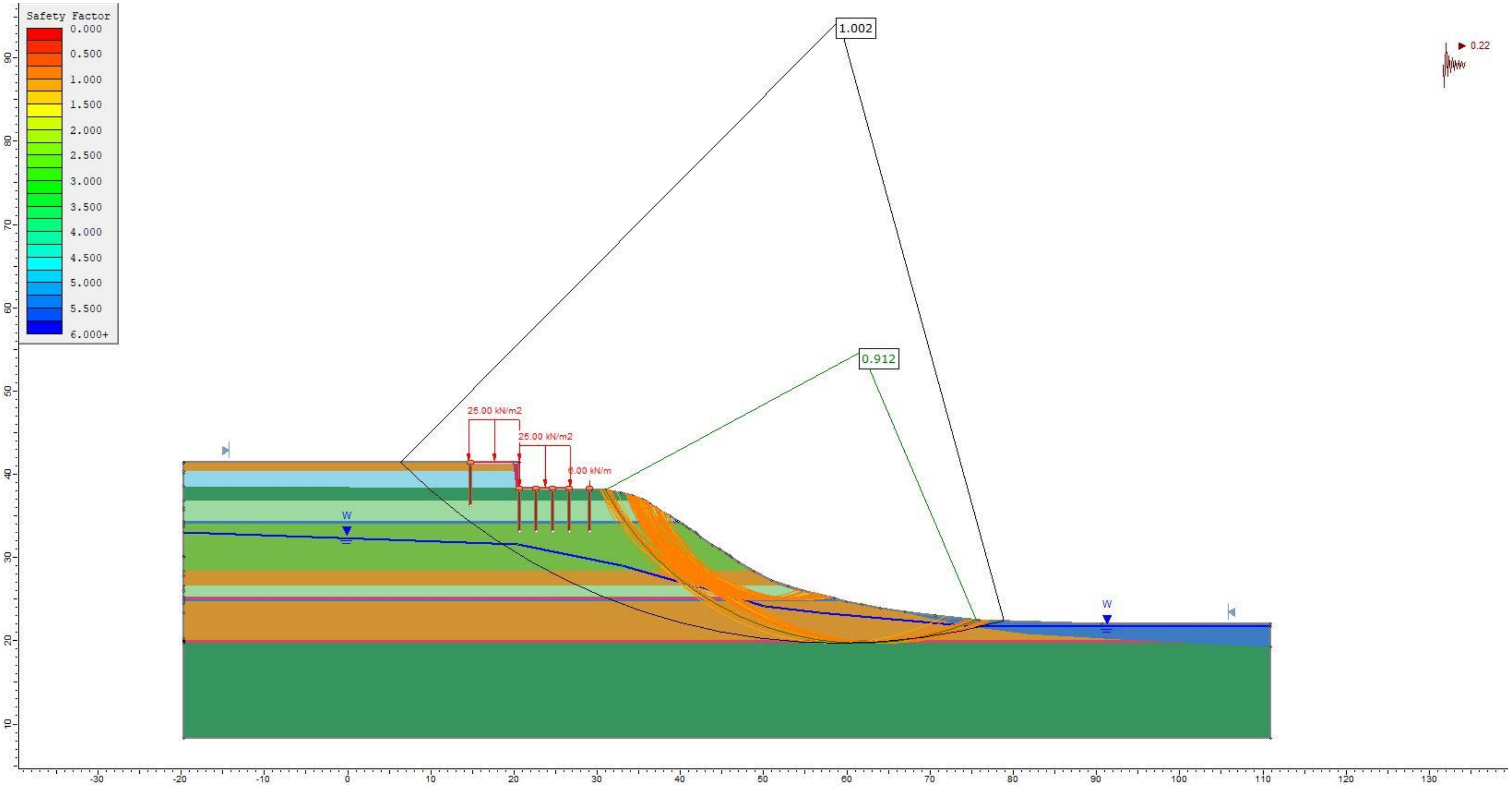


SLIDE 2018 model – Proposed Dwelling - SLS (Serviceability Limit State) – FOS required: 1.5



SLIDE 2018 model – Proposed Dwelling - ULS (Ultimate Limit State) – FOS required: 1.1

STRENGTH LOSS



SLIDE 2018 model – Proposed Dwelling – Strength Loss- ULS (Ultimate Limit State)