ASSETS AND SERVICES COMMITTEE

1 SEPTEMBER 2021

AGENDA ITEM D1

HINEKURA ROAD EROSION AND LANDSLIDE REMEDIATION REPORT

Purpose of Report

To update members on risk mitigation proposals to the landslide erosion along Hinekura Road near Hikawera Road.

Recommendations

Officers recommend that the Committee:

1. *Receive the Hinekura Road Erosion and Landslide Remediation Report.*
2. *Note the Greater Wellington Regional Council (GWRC) Erosion and Landslide Remediation Plan and that all recommendations identified in this report will be carried out within existing Council budgets.*
3. *Note the WSP Consultants Hinekura Landslide July 2021 Assessment memo.*
4. *Note that Council officers will continue to work closely with GWRC and WSP Consultants to come up with a final risk mitigation strategy for 1673 Hinekura Road.*

1. Background

There is an active landslide at 1673 Hinekura Road of approximately 450m long and 100m wide. This landslide has likely been active for many years and is prone to movement and instability following heavy rain. Council officers regularly monitor the road for movement.

During the June 2021 weather event this section of road became unstable and was closed. It has since been reopened to light traffic.

Stabilising the landslide area is considered difficult, however proposals have been received from GWRC and WSP Consultants to mitigate the risk of further erosion and stabilise the landslide area and road.

2. Discussion

2.1 Immediate Works

GWRC's Council officers will continue to work with GWRC, WSP Consultants and the landowner to finalise a risk mitigation strategy. Initial works as proposed by GWRC (see Appendix 1) will be undertaken, and Council's share of the cost amounting to $30,000 will be completed within existing budgets. Works will be undertaken as weather allows.

2.2 Geotechnical Assessment

A geotechnical assessment of the Hinekura Road landslip area has been provided by WSP Consultants and is attached in Appendix 2.

2.3 Communications

Council's Communication's Team have setup an email group for Hinekura Road residents to enable immediate distribution of future road closures. The group will be kept up to date on current and future works proposals.

3. Conclusion

Council officers are working with key stakeholders to put immediate risk mitigation measures into place for the active landslide at 1673 Hinekura Road. A longer term risk mitigation plan will be developed to further stabilise the land and roading infrastructure.

4. Appendices

Appendix 1 – GWRC Erosion and Landslide Remediation Plan

Appendix 2 – WSP Consultants Hinekura Landslide July 2021 Assessment memo

Contact Officer: Tim Langley, Roading Manager

Reviewed By: Harry Wilson, Chief Executive Officer

Appendix 1 – GWRC Erosion and Landslide Remediation Plan

TO Harry Wilson
Chief Executive
South Wairarapa District Council

FROM David Boone
Manager, Land Management
Greater Wellington Regional Council

DATE 24 August 2021

HINAKURA HILL - RECOMMENDED EROSION AND LAND SLIDE REMEDIATION PLAN

This memo outlines GW's recommendation for risk mitigation works to the landslide erosion along Hinakura Road near Hikawera Road.

Background

A large, active landslide was observed at 1673 Hinakura Road in South Wairarapa in June, 2020. The landslide area, approximately 450m long and 100m wide, has likely been active for many years. The land movement and instability was exacerbated by a heavy rain event in March 2020. A geotechnical assessment was commissioned by South Wairarapa District Council and undertaken by WSP consultants on 19 June, 2020. The assessment found the following key issues as a result of the landslide occurring:

- The slope had experienced fresh tension cracks which were affecting an 80m section of Hinakura Road
- A linear fissure (split) had occurred on the western side of the landslide, and ran through a farm dam about 50m upslope of the road which supplies water to the farm. The dam, ~300m^2 in area (depth unknown), was observed to be leaking water as a result.
- Movement of the landslide continues to occur.
- Ongoing movement may result in the breaching of the farm dam, which would flood the slope below the dam as well as the road. This outcome would result in further severe damage to the road and impacted farmland, as well as pose safety risks to road users.

Current situation

In June, 2021, a landslide occurred in close proximity to 1673 Hinakura Road in South Wairarapa. As part of this, there were two shear planes (a plane or other surface along which rocks are ruptured by compressive stress) detected, and a sympathetic movement tied to them. The road dissected one of the shear planes, which has resulted in the road subsiding. These shear plane movements are shown in Appendix 1 below.

The June 2021 rain event caused significant damage to the road, and resulted in the road being impassable for local residents and large utility vehicles for approximately a week.

To date, remedial action has involved removal of trees and temporary repairs to improve drainage. As it stands, the road in this location only allows for light vehicle access following these repairs. The recommendations outlined in this memo highlights a sequence of remedial actions to reduce risk by minimising the likelihood of

the land sliding in the future to safeguard land, infrastructure and the community's reliance on the road in the short and long-term.

Recommendations

To maximise the effectiveness of these recommendations all actions need to be implemented.

GW has considered recommendations provided by WSP in their geotechnical assessment report (19 June, 2020). Where applicable, costs are estimated (GST exclusive), and do not include any council staff time required for the supervision of the works.

All paddocks and stages referred to in the below table are shown in Appendix 1.

Stage and description	Rationale	Construction notes	Estimated cost (GST exclusive)
Stage 1: New water supply dam Construction of a new dam as shown in Appendix 1	The current dam is instable. Although it is not the only cause of road risk, it is a contributing factor and should be relocated. Construction of the new dam site is critical to landowner approval of other works required.	The new dam site has telephone lines nearby so exact siting of the dam and associated angle drains will need to take this into consideration. The overflow outlet and associated drainage will need to be considered how best to drain past the road. The map shows a second alternative dam site in the paddock "Cabbage Trees 2". A third option is to alter the drainage to drain into the existing dam in Big Dam paddock and alter the reticulation setup.	$10,000
Stage 2: Tree removal Damaged and leaning trees on site to be removed and replaced. This includes: a) Trees on the shear plane (No Name paddock) b) Removal of old willows in toe accumulation area (Cabbage Tree 1 paddock) c) Old pines on top road edge d) Crack and golden willow on bottom road edge	These trees are a health & safety hazard. Their removal will allow for other land stabilising work to be undertaken.	Tasks (c) and (d): Removal of the trees along and above the road will be similar to tree removal already completed. Tasks (a) and (b): The old willows in the toe accumulation area and in No Name paddock will be removed by ground crew.	$5,000
Stage 3: Drainage construction Construction of approximately 850m of V drains in paddock labelled "Cabbage Tree 1 paddock." (See Appendix 3 for explanation of a V drain)	This will dewater the slope to minimise lubrication of the shear planes.	These will be constructed to allow for movement across the shear plane edges without cutting off the drains.	$10,000

Stage 4: Drainage across road Construction of approximately 150m of novacoil. This will be connected to the existing drain on the western side of the movement with a catching box, and drain to the base of the movement. (See Appendix 3 for explanation of a catching box)	Removal of the current drainage along the shear plane boundary, which will minimise the likelihood of the land to continue subsiding.	The western-most v drain near the dam to be decommissioned may be reconfigured once the dam has been infilled. The novacoil and catching box will need to be entered onto the SWDC asset register and programmed for routine monitoring and maintenance.	$5,000
Stage 5: Decommission old water storage dam Empty and infill redundant dam	Minimise the ability for excess water to accelerate the movement, and prevent breaching of the dam.	This will require a pump unit for a day, and a digger for a day. The water could be pumped into the new dam to provide water over the summer. **Seasonal constraints:** The earthworks described in stages 1-5 need to take place during the summer when the area is drier, both to allow the completed works to settle before any significant rainfall events occur and to minimise the pugging damage and risk of getting machinery stuck.	$2,000
Stage 6: Fencing stock exclusion for planting protection Existing fencing needs to be reinstated, and fencing of two proposed retirement areas (Stages 7).	The retirement areas act to stabilise the ground through preventing excess water build up. The fencing helps to ensure the area remains securely managed, and stock are excluded to protect the seedlings and maintain vegetation cover.	A gate and laneway for stock movement may also need to be added to retain access to the remaining part of No Name paddock after the retirement. **Seasonal constraints:** The fencing will need to take place during drier months, and for the reinstatement of the fences removed to date these cannot be reinstated until the rest of the trees are removed. The recommended planting cannot be put in until the earthworks are completed so will need to be put in next winter.	$15,000
Stage 7: Planting Retirement of land in “No Name” paddock of farm. This will remove LUC class 7 land (Erosion prone), and the bottom of the shear plane from grazing.	This will provide erosion control to minimise movement of the hill side.	“No Name” planting: About 2,500 seedlings, and 50 willows for stabilising small stream banks Road edge planting and “Cabbage Tree 1”: About 130 poles (Willow or poplar trees), and	$16,000

And Retirement of land above the road, replacement of road edge trees, and poplar and willow planting around v drains and infilled dam. See Appendix 2 for detailed retirement planting plan		500 seedlings **Seasonal constraints:** The recommended planting cannot be put in until the earthworks are completed so will need to be put in next winter. **Winter 2021 planting already completed:** This winter some willows have been planted below the road where one of the existing culverts drains to, and where additional water will drain to once the V drains are constructed. These willows will help tie up the soil and stabilise the receiving area.	

Estimated total cost of recommended works is **$63,000 (excluding GST)**.

Works implementation

GW accepts no responsibility to deliver the work involved in these recommendations, however we are agreeable to assisting SWDC's lead on implementing further remedial work.

GW staff have involved the landowner in the development of these recommendations and we understand that they are supportive of the works being undertaken. Confirmation and formal approval to enter upon private land to undertake any work is a matter for SWDC to manage.

GW will, in good faith, make every possible effort to assist SWDC to be successful in the delivery of works required to manage future landslide erosion risk at this site.

GW will provide the tree planting materials needed. GW staff will assist with site supervision and contractor management during works construction if so requested by SWDC.

GW is committed to co-funding 50% of the total cost of works described in this memo, up to a maximum of $30,000, conditional to the Manager, Land Management being satisfied that the full package of necessary erosion mitigation works described in this memo have been implemented to a satisfactory quality. GW considers that SWDC is responsible for confirming the source of the remaining 50% co-funding prior to beginning any work, i.e. SWDC and/or landowner contribution.

For further information, please contact:

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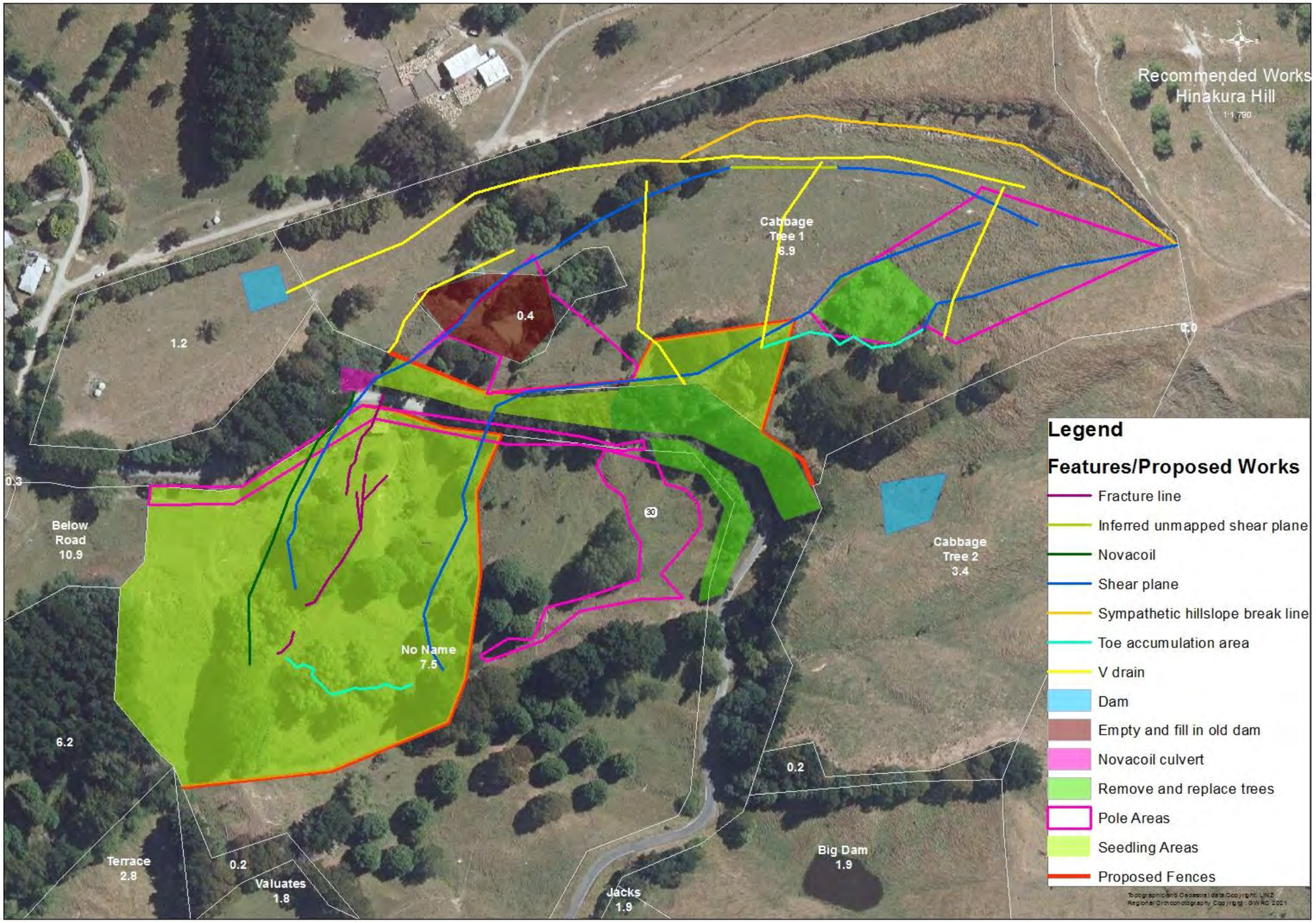
Appendix 1


Recommended Works
Hinakura Hill
1:1,790
Cabbage
Tree 1
6.9
0.4
1.2
0.0
0.3
Below
Road
10.9
30
Cabbage
Tree 2
3.4
No Name
7.5
6.2
0.2
Terrace
2.8
0.2
Valuates
1.8
Jacks
1.9
Big Dam
1.9
Legend
Features/Proposed Works
Fracture line
Inferred unmapped shear plane
Novacoil
Shear plane
Sympathetic hillslope break line
Toe accumulation area
V drain
Dam
Empty and fill in old dam
Novacoil culvert
Remove and replace trees
Pole Areas
Seedling Areas
Proposed Fences

Appendix 2


0.4
1.2
Cabbage
Tree 1
6.9
Recommended Works
Hinakura Hill
1:1,069
Below
Road
10.9
No Name
7.5
Cabbage
Tree 2
3.4
6.2
Terrace
2.8
0.2
1.9
Legend
Existing trees
Mixed Eucalyptus
Tree Lucerne/Poplar/Willow
Willow
Proposed Fences

Greater Wellington
Te Pane Matua Taiao

Appendix 3

Picture of a catching box, with inlet visible where water is running. An outlet is on the other side of the box.

Picture of a v drain, with the aerial view of this v-drain on the right, White Rock Road.

Appendix 2 – WSP Consultants Hinekura Landslide July 2021 Assessment memo

Memorandum

To	Ben Turner, Tim Langley (South Wairarapa District Council)
From	Giles Farquhar, David Stewart
Office	Wellington
Date	16 August 2021
File/Ref	5-C4072.01; GER Report 2021/46
Subject	Hinakura Road Landslide July 2021 Assessment

1 Introduction

WSP were engaged by South Wairarapa District Council (SWDC) to inspect and carry out an initial assessment of the reactivated landslide affecting Hinakura Road (RP: Hinakura RD/17.07 – 17.140) and the property of 1673 Hinakura Road, 15 km east of Martinborough in the Wairarapa.

The landslide moved significantly on 22 June 2021 following heavy rainfall (149mm fell on the 21st and 22nd June at the Pahaoa River rain gauge, Hinakura (Greater Wellington, 2021)).

The initial site visit was carried out with Ben Turner by WSP Principal Geotechnical Engineer, David Stewart on 29 June 2021 (Photo 1). A set of photos from that visit were supplied to SWDC on 29 June (copied in Appendix A). Engineering geologist Giles Farquhar and principal surveyor Caleb Baildon visited the site on 5 July 2021 to carry out a UAV survey and install and survey monitoring pegs around the landslide.

WSP were previously engaged to assess this landslide following movement a year before, in June 2020. An inspection and UAV survey of the landslide was carried out on the 10th June 2020 and a geotechnical memo supplied to SWDC included recommendations for mitigating the movement and monitoring the landslide. The 2020 survey data and availability of a 2013 LiDAR survey has allowed comparison with the 2021 survey to determine movement rates.

This current memo summarises observations from the 2021 site visits, summarises landslide displacement data especially from UAV surveys and provides some recommendations to assist SWDC in mitigating the risk at the site.

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Photo 1: Site on 29 June 2021, showing translation of the road downslope. Lateral scarp in foreground has been removed to allow arborists in to cut down tilting trees (arborist staff visible in background). White SWDC monitoring pegs visible at right and just to left of blue culvert marker.

2 Site Description

The section of Hinakura Road inspected is a tar sealed road providing access to farms in the Hinakura Valley, just east of Hikawera Road. Traffic volumes are relatively light but include a high proportion of logging truck traffic as well as school traffic. There is one alternative route to the north, which is one way, requires dry weather and adds a large amount of time to the trip.

The landslide is 500m long and ~80m wide in farm paddocks in a broad south facing gully, extending from the ridge top down a relatively planar gentle slope (average of 1V to 6H) with the landslide toe near the base of the slope below the road (Refer plan in Appendix B). A small farm dam is located in the gully, about 50m upslope of the road. The dam water surface is currently approx. 400m^2 in area and 9m higher in elevation than the road.

3 Investigations and Monitoring

3.1 WSP Geotechnical investigations

Initial observations were made on the walkover of the site on 29 June 2021 with more detailed engineering geological mapping undertaken on 5 July 2021 using the June 2020 UAV imagery as a base map. The main landslide features were transferred onto an updated aerial map obtained via UAV survey on the 5th July 2021.

Two hand auger investigation holes were carried out in an attempt to get information on ground characteristics and identify the failure depth. One hand auger was located on the dam crest and the second to the east of the dam, but reaching only 1.5m and 1.0m depth respectively. Both hand augers were terminated due to the stiff squeezing nature of the soils and the failure plane was not identified. Hand auger locations are displayed on the Appended Engineering Geology map (Appendix B).

3.2 WSP Survey activities

3.2.1 Waratah 'extensometer'

Installation of a pair of waratahs, one either side of the 'fissure' below the dam which marks the western lateral margin of the landslide (Photo 2). The initial measurement (using steel tape measure) between the two waratahs was 5.02m on 5 July 2021.

3.2.2 Survey pegs around landslide

Wooden survey pegs were installed at 12 locations across the landslide extent above the road on 5 July 2021 (as locations shown in Appendix B). This will allow future monitoring of vertical and horizontal displacements of different portions of the landslide and provide data to be able to better understand how the landslide behaves.

The pegs were installed to just above flush with ground level (Photo 3) and initial coordinates were surveyed by RTK GPS.

All pegs and waratahs have been GPS surveyed by a WSP surveyor with initial coordinates provided in Appendix E.

Photo 2: Waratah extensometer below dam (offset broken fence at left) and Photo 3: Survey peg

3.2.3 UAV survey

A WSP surveyor carried out a UAV survey (using a DJI Phantom P4 RTK drone) of the full extent of landslide on the 5th July 2021. Subsequently an accurate 3D model of the site has been produced which shows landslide features and locations of installed survey monitoring points. A copy of this model in reality mesh format was provided to SWDC via a cloud based data transfer; this model can be viewed using free Bentley Context Capture viewer software. The UAV model captured in June 2020 model has been reprocessed to a higher spatial accuracy which has enabled comparison of movement between the 2020 and 2021 drone surveys. In addition, the two UAV survey models have been compared to 2013 aerial LiDAR date to see the changes to the slope since 2013.

3.3 SWDC Monitoring pegs along the road

11No. pegs were installed at the landslide along the road by SWDC on the 30th April 2021. Distances between pegs have been measured and recorded by SWDC. The pegs identified up to 850mm of movement between 30Th April 202021 and 22nd June 2021. The vast bulk of

movements occurred between the 14th and 22nd of June, with only up to 100mm of movement in the prior 6 weeks. SWDC's results are presented in Appendix C.

These pegs were sighted on the 29 June 2021 visit (Photo 1). However, the majority of these pegs were destroyed during reinstatement of the road after the landslide movement in the week prior to the 5 July visit.

3.4 GWRC

A consultant to GWRC (Stan Braaksma) has separately provided assistance to SWDC regarding planting and drainage for the landslide.

4 Observations

4.1 Farm Dam Area

The dam crest has changed markedly since the June 2020 visit (compare Figures 1a and 1b).

Total horizontal offset of ~ 10m is indicated at the dam crest as the fissure marking the western extent of the landslide intersects the dam (Figure 1a). Horizontal movement of the fence below the dam crest between June 2020 and July 2021 is ~8.5 m (compare Figures 1a and 1b and Figures 2), with about 1.6m of vertical displacement over this 12 month period (refer Appendix D). Comparison with the 2013 LiDAR (Figure 2) shows that much more movement happened in the last 12 months than the period between 2013 and 2020.

With further movement of the landslide, the water from dam is expected to increase in flow onto the slope below and into the lower part of the landslide

Figure 1a: Farm Dam as at June 2020

Figure 1b: Offset of dam crest as at 5 July 2021

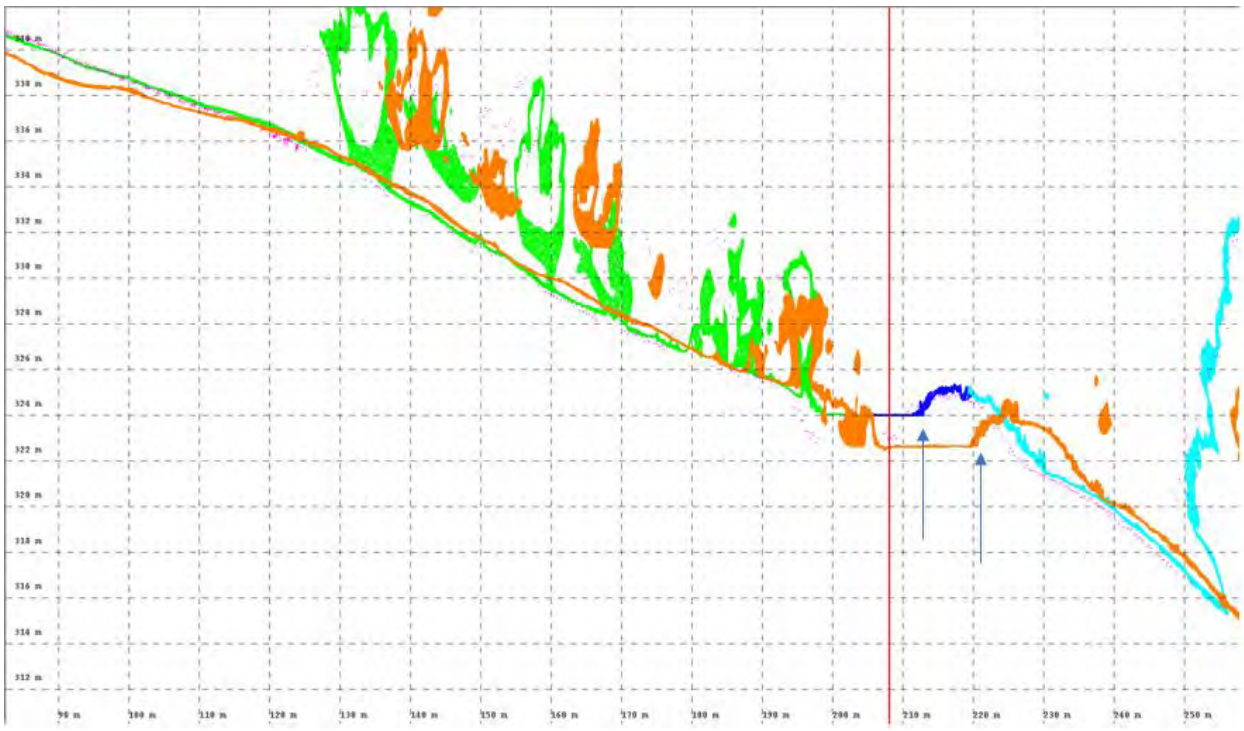


Figure 2: Movement at the dam displayed by blue arrows, 2020 (blues and green) and 2021 (orange). 2013 LiDAR is visible as pink dots

4.2 Road level observations

At road level the road had been reinstated. Trees above the road are tilting downslope with the movement. SWDC have undertaken removal of some of these tilting trees (Photo 1) because of the risk they posed to the road.

Movement of the road is of a similar order to the farm dam with ~8m horizontal and 1 – 2m vertical drop indicted from June 2020 to July 2021 (Figures 3 and 4).

The barn that was present in 2020 below the road has been removed by the farmer after a tension crack intersected the structure (Figure 3).

Figure 3: Movement of the road from June 2020 to July 2021. Red line remains in the same location showing the movement of the road from north to south.

Figure 4: Horizontal and vertical offset of the road edge between 2020 and 2021. Profile position is along red line at right, which is parallel to the direction of slope movement - oblique to the road alignment

4.3 Upper landslide area

The head scarp at the top of the slope is more obvious and appears to have become larger with a large amount of exposed in-situ mudstone in the upper northern lateral scarp (Photo 4).

Photo 4: UAV image from 5 July 2021 of the head area of the landslide

Comparison of the 3D survey models shown that the ground surface has dropped significantly (refer evacuated zone on Figure 5) just below the headscarp. The upper southern margin has a zone of buckled ground inferred to be a compression zone and has risen slightly suggesting that the movement direction here has been largely southward, before becoming more westward moving further downslope. The influence of this upper slope movement on the whole landslide is worthy of further consideration.

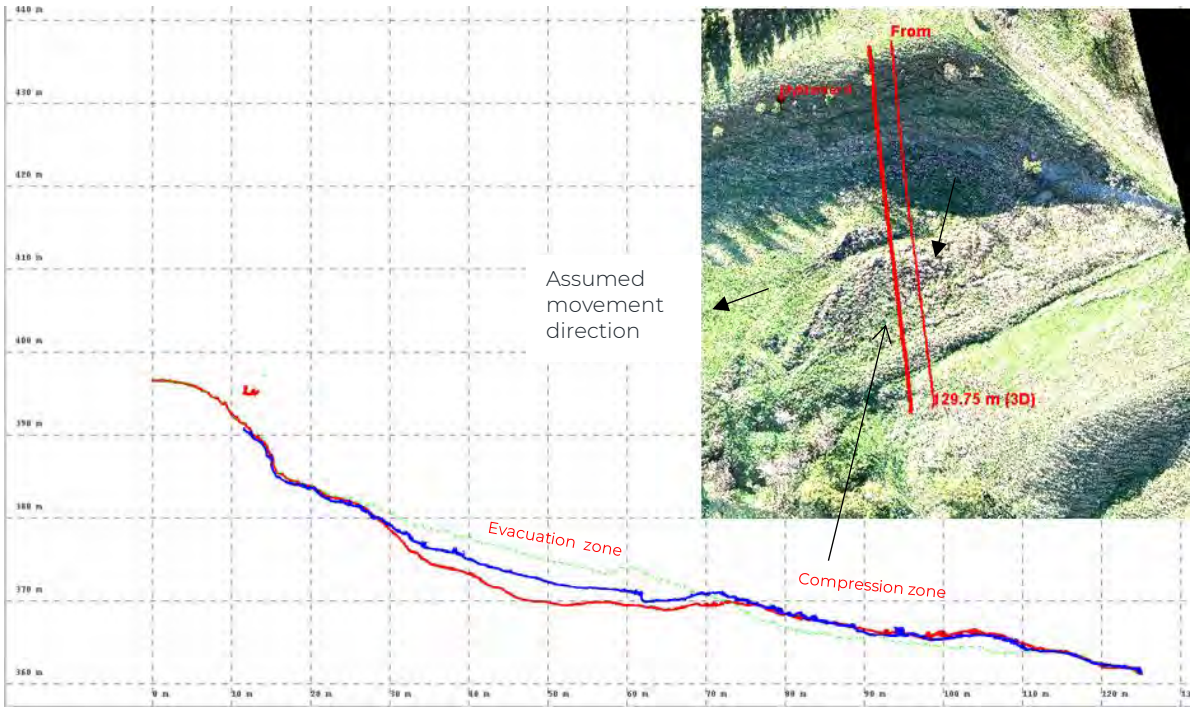


Figure 5: Comparison of ground surface in upper landslide area in 2013 (green), 2020 (blue-uncorrected) and 2021 (red). Profile along thicker red line.

Many of the features noted in the WSP 2020 report are still present, but many features have become more pronounced due to the most recent movement, such as more widespread tension cracking, tilting and bulging of the ground.

Ground springs were noted by the farmer in many areas around the slip area and are present for variable lengths of time and regularly appear in new locations.

Majority of the slope in the upper section and near the dam is saturated with pooling of water on the ground surface

5 Conclusions

- The large landslide at 1673 Hinakura Road moved significantly (>850mm) after a heavy (159mm) rain event on 22 June 2021, disrupting the road.
- An 80m long section of Hinakura Road currently significantly affected with temporary repairs undertaken by roading contractor to make it usable by light vehicles
- Comparison of UAV survey models captured in June 2020 and 5 July 2021 indicate about 8.5m horizontal and 1.5 m vertical movement of the landslide between these dates at both the farm dam and road level.
- Comparison of June 2020 and 2013 (LiDAR) surveys suggest a much smaller amount of movement (about 2 to 3 m of movement) between these 2013 and 2020, which is consistent with the landowners comment that slope movement has been noted for the past ~ two years.
- The farm dam is compromised by the pronounced fissure marking the edge of the landslide which extends through the dam. As at 5 July the water level appears similar to 2020. However, the dam is leaking and there is a high risk of the dam wall breaching soon and flooding the slope below. The likely consequence if there is a rapid dam breach is uncontrolled water flows inundating the road and associated more severe damage.to the road as well as safety risks to road users (as noted in our 2020 report).
- The assessed risk is High to Very High, hence risk mitigation actions are required.
- Stabilisation of such a large landslide will be difficult and requires a good understanding of the mechanisms controlling the movement. However, there are measures that can be carried out to mitigate risks from future movement. Dewatering of the farm dam followed by drainage management across the landslide area will assist. Targeted tree planting will remove water and provide root reinforcement in the medium to longer term.
- Drilling of investigation drillholes would enable determining the depth of the landslide, and ground and groundwater conditions at representative locations including at road level.
- Periodic surveying of the survey pegs will enable the behaviour of the overall landslide to be better understood. This information in addition to subsurface investigation results, will enable better targeting of the type and location of additional stabilisation measures.
- The rate of movement has accelerated, and in addition to manual measuring of the waratahs and the pegs at road level, Council may wish to consider real-time monitoring sensors to provide immediate notice of accelerating movement trends.

6 Recommendations

- Dewatering of the farm dam in a controlled manner as soon as possible, supervised by appropriate geotechnical and / or dam specialists.
- Continue engaging with GWRC and implement drainage and tree planting measures to assist stabilisation of the landslide.
- Periodic survey of monitoring points across the site after movement events are observed to establish the extent of the movement and movement trends.
- Reinstatement and regular measurement of the SWDC monitoring points on the road that were destroyed.
- Consideration of installation of real-time monitoring at keys locations such as the dam waratah extensometer and road level to provide alerts to Council/residents of developing movement.
- Undertake drilling investigations at road level and ideally other locations to better define the depth of failure and groundwater conditions.
- Carry out assessment of new survey and geotechnical investigation information, to update the landslide model; and carry out slope stability analysis, and assessment of movement patterns across the landslide to provide recommendations for long term risk mitigation of the landslide movement.

Appendix A: Photos from 29 June 2021 WSP Site visit

29 June 2021 Hinakura Road Landslide photos

Approx. 4-5m offset of original white edge line to right of cones

Sharp tension cracks in (I year old) drain

Landslide margin through/ below dam face

Water breaching dam along line of fissure (moderate flow) view downslope

Fissure (western landslide margin) going upslope of dam

View of edge of landslide from above dam, toward headscarp

Central section of western (right looking down) lateral margin scarp

Head scarp with compression bulge on eastern (left looking down) margin

Eastern margin mid section with compression zone in foreground and trees buttressing edge of movement

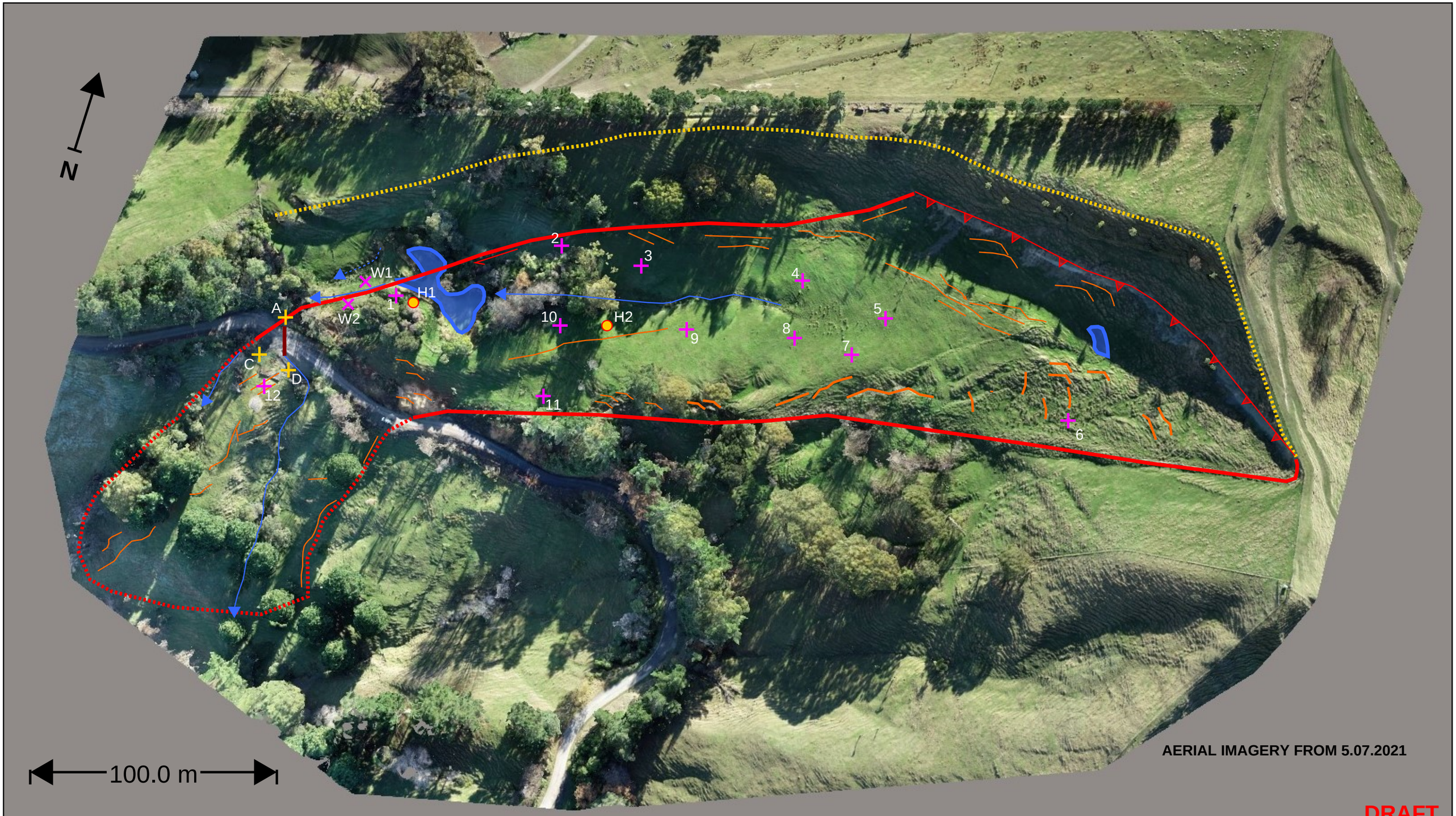
Eastern margin of landslide pushing steeper slopes below and causing secondary movement onto steeper slopes above road. Subhorizonal striae visible on both photos showing main movement is very low angle (near horizontal).

29 June 2021 Hinakura Road DS photos - WSP

Lower slope above road landslide has pushed and tilted pine trees at top of steep slope above road (which have been cut down this week to the right – photo below)

Bulging at eastern margin of landslide has just reached fence (and trees)

Appendix B – Engineering Geology Map



HINAKURA ROAD LANDSLIDE

ENGINEERING GEOLOGY MAP

5-C4072.01

G. FARQUHAR

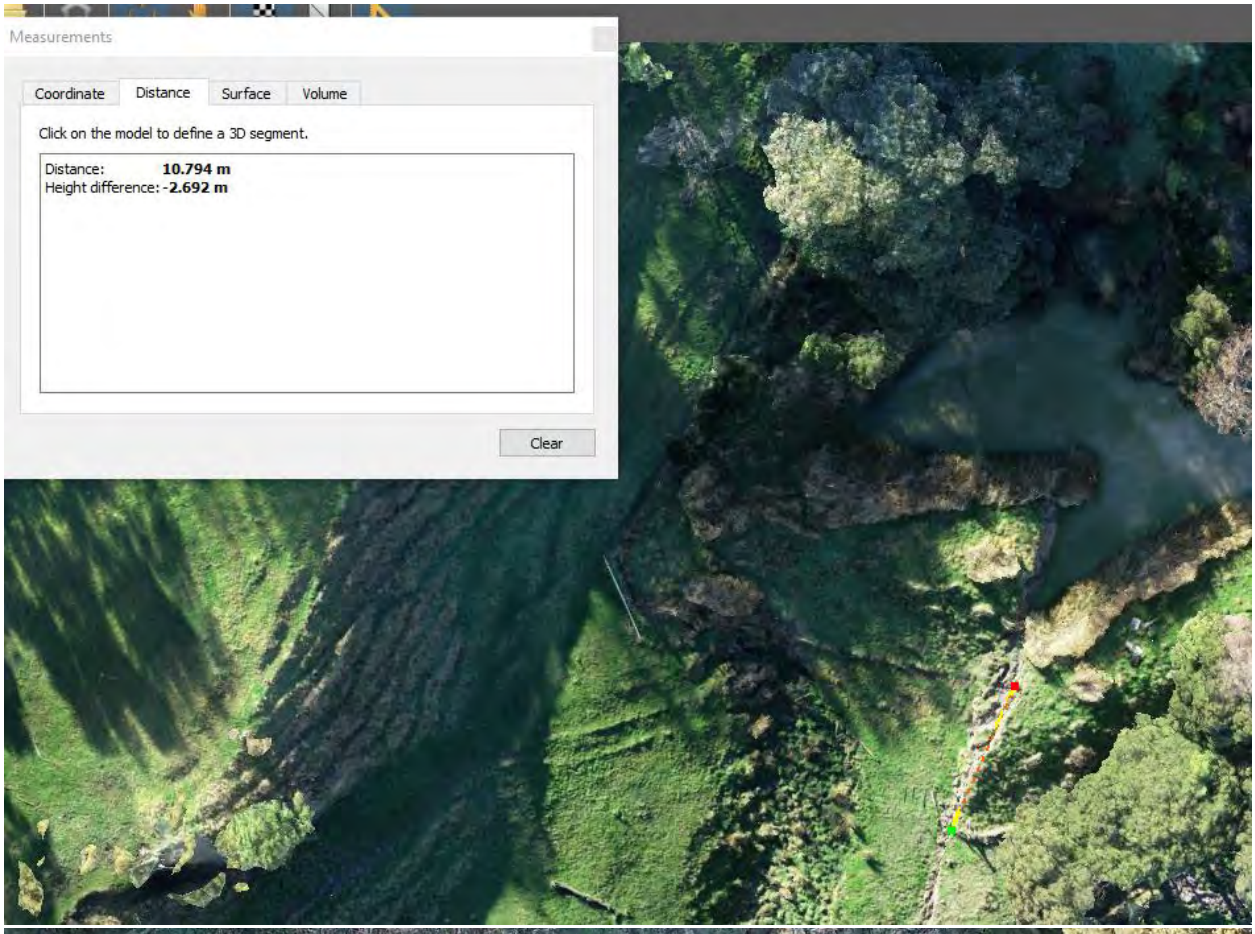
LEGEND

- ACTIVE LANDSLIP OUTLINE
- INFERRED LAND-SLIP OUTLINE
- HEAD SCARP
- TENSION CRACK
- WATER FLOW
- HISTORIC WATER FLOW
- HAND AUGER
- WSP SURVEY PEG
- SWDC SURVEY PEG
- WSP SURVEY WARATAH
- WATER BODY
- CULVERT
- HISTORIC LANDSLIP SCARP

Appendix C – SWDC Tape measurements between roadside pegs

Peg to peg	Displacement (m)							
	30/04/2021	3/05/2021	19/05/2021	27/05/2021	3/06/2021	14/06/2021	22/06/2021	Total Displacement
I to A	21.49	21.44	21.43	21.42	21.4	21.39	21.38	0.11
I to B	17.56	17.51	17.5	17.49	17.46	17.45	17.45	0.11
I to C	20.85	20.8	20.85	20.85	20.85	20.86	21.57	-0.72
I to D	21.66	21.85	21.66	21.65	21.66	21.69	22.26	-0.6
I to E	5.95	5.95	5.96	5.95	5.97	5.95	5.79	0.16
A to B	9.1	9.1	9.1	9.1	9.09	9.1	9.01	0.09
A to C	24.88	24.86	24.9	24.84	24.84	24.84	25.07	-0.19
B to C	15.76	15.76	15.76	15.76	15.75	15.75	15.94	-0.18
D to E	17.66	17.65	17.64	17.64	17.65	17.66	17.79	-0.13
D to F	20.87	20.87	20.87	20.86	20.86	20.85	20.62	0.25
D to G	15.63	15.56	15.56	15.56	15.55	15.55	15.39	0.24
E to F	18.2	18.2	18	18.2	18.2	18.2	18.2	0
E to G	21.68	21.68	21.68	21.68	21.68	21.69	21.7	-0.02
H to D	32.26	32.22	32.29	32.24		32.12	32.01	0.25
H to G	16.81	16.75	16.77	16.76		16.66	16.59	0.22
Z to Y	18.01	18	18.01	18.01		18.04	18.52	-0.51
Z to X	15.06	15.07	15.06	15.05		15.03	14.61	0.45
Z to W	24.25	24.27	24.25	24.25		24.22	23.73	0.52
Y to X	12.88	12.9	12.88	12.87		12.87	12.8	0.08
Y to W	12.9	12.89	12.87	12.87		12.84	12.05	0.85
X to W	10.28	10.29	10.3	10.24		10.27	10.14	0.14

Appendix D: Measurements of Fence Offset below Dam off 3D models July 2021 and June 2020



Appendix E: GPS Coordinates for marks installed on 5 July 2021 anb other existing marks

100	1819344.151	5427864.48	323.664	PEG	
102	1819383.079	5427899.281	328.245	PEG 2	
104	1819443.574	5427907.996	335.723	PEG 3	
106	1819506.185	5427929.379	346.074	PEG 4	
108	1819549.919	5427929.724	354.481	PEG 5	
111	1819613.553	5427900.659	362.598	PEG 6	
112	1819556.171	5427907.027	353.684	PEG 7	
114	1819525.669	5427899.264	347.312	PEG 8	
116	1819470.257	5427886.608	338.806	PEG 9	
118	1819417.192	5427877.224	330.967	PEG 10	
120	1819419.546	5427844.733	326.048	PEG 11	
122	1819293.476	5427814.959	309.162	PEG C	
124	1819298.786	5427806.744	308.45	PEG 12	
127	1820637.298	5428117.634	420.146	A1YA	
130	1819259.436	5427896.304	326.863	IS	
132	1819318.81	5427914.271	334.339	PEG	
134	1819676.597	5428005.607	405.11	TRIG FLAX	
138	1819303.19	5427815.521	309.221	PEG D	
140	1819295.958	5427838.005	311.878	PEG	
142	1819325.988	5427857.385	319.976	WARATAH	dam
144	1819327.144	5427862.258	319.996	WARATAH	dam
999	1819318.27	5427915.375	334.188	IT 1	