Hastings District Council

Civic Administration Building
Lyndon Road East, Hastings
Phone: (06) 871 5000
Fax: (06) 871 5100
WWW.hastingsdc.govt.nz

OPEN

A G E N D A

COUNCIL MEETING

Meeting Date:	**Tuesday, 5 March 2019**
Time:	**9.00am**
Venue:	**Council Chamber** **Ground Floor** **Civic Administration Building** **Lyndon Road East** **Hastings**

Council Members	Chair: Mayor Hazlehurst Councillors Barber, Dixon, Harvey, Heaps, Kerr, Lawson, Lyons, Nixon, O'Keefe, Poulain, Redstone, Schollum, Travers and Watkins
Officer Responsible	Chief Executive – Mr N Bickle
Council Secretary	Mrs C Hunt (Extn 5634)

HASTINGS DISTRICT COUNCIL

COUNCIL MEETING

TUESDAY, 5 MARCH 2019

VENUE:	Council Chamber Ground Floor Civic Administration Building Lyndon Road East Hastings
TIME:	**9.00am (Cape Kidnappers)**

A G E N D A

1. Prayer

2. Apologies & Leave of Absence

At the close of the agenda no apologies had been received.

Leave of Absence had previously been granted to Councillor Lyons

3. Seal Register

4. Conflict of Interest

Members need to be vigilant to stand aside from decision-making when a conflict arises between their role as a Member of the Council and any private or other external interest they might have. This note is provided as a reminder to Members to scan the agenda and assess their own private interests and identify where they may have a pecuniary or other conflict of interest, or where there may be perceptions of conflict of interest.

If a Member feels they do have a conflict of interest, they should publicly declare that at the start of the relevant item of business and withdraw from participating in the meeting. If a Member thinks they may have a conflict of interest, they can seek advice from the General Counsel or the Democratic Support Manager (preferably before the meeting).

It is noted that while Members can seek advice and discuss these matters, the final decision as to whether a conflict exists rests with the member.

5. Confirmation of Minutes

Minutes of the Council Meeting held Thursday 21 February 2019.
(Previously circulated)

REPORT TO: COUNCIL

MEETING DATE: TUESDAY 5 MARCH 2019

FROM: GROUP MANAGER: ASSET MANAGEMENT
CRAIG THEW
GENERAL COUNSEL
SCOTT SMITH
RISK AND CORPORATE SERVICES MANAGER
REGAN SMITH
PROJECT MANAGER
DAVID BISHOP

SUBJECT: CAPE KIDNAPPERS HAZARD MANAGEMENT

1.0 SUMMARY

1.1 The purpose of this report is to obtain a decision from the Council on managing access to Cape Kidnappers Beach to protect public safety.

1.2 This issue arises from the serious injury to two Korean tourists on 23 January 2019 due to a large unexpected landslide.

The Council is required to give effect to the purpose of local government as prescribed by Section 10 of the Local Government Act 2002. That purpose is to meet the current and future needs of communities for good quality local infrastructure, local public services, and performance of regulatory functions in a way that is most cost–effective for households and businesses. Good quality means infrastructure, services and performance that are efficient and effective and appropriate to present and anticipated future circumstances.

1.3 The objective of this decision relevant to the purpose of Local Government is to minimise the threat to public safety by managing risk within the tolerance of the local community to serious injury or fatality to people.

1.4 This report concludes by recommending that a Quantitative Risk Analysis (QRA) is completed to inform long term decision-making on access to the beach and that the temporary road closure for the Clifton beach remains in place until the risk analysis is completed and understood.

2.0 BACKGROUND

2.1 Historical Access

2.2 Historically access to Clifton beach along the base of the cliffs to the Cape Kidnappers Gannet colonies has been open to anyone wishing access the area subject to the tides and condition of the beach.

2.3 In around 1933 a 13 hectare reserve, including the Saddle and Black Reef Gannet colonies, was created to provide protection for the breeding ground. This reserve is now administered by the Department of Conservation (DOC). Note; The reserve does not include the Gannet colony on the Cape Kidnappers plateau.

2.4

2.5 Early Māori occupation of Te Matau-a-Māui utilised the coastline for access to offshore and shoreline reefs, inshore fishing grounds, estuaries and wetlands – providing food sources, materials for housing, security, clothing, tools and all requirements for daily life.

2.6 The Clifton area has a long history of use by the local community and tourists as a fishery, beach walk, and for gannet visit. Commercial operations have been undertaken since 1952 by Gannet Beach Adventures.

2.7 **Recent Tourist Activity**

2.8 Tourist activity in the area has been growing as a result of ongoing promotion of the Hawke's Bay region by various agencies including Hawke's Bay Tourism, and greater promotion of the Clifton to Cape Kidnappers excursion primarily by DOC.

2.9 Indicative Cape Kidnappers reserve counter data captured by DOC show that there has been an increase in activity over the last 3 years. However, exact visitor numbers cannot be confirmed.

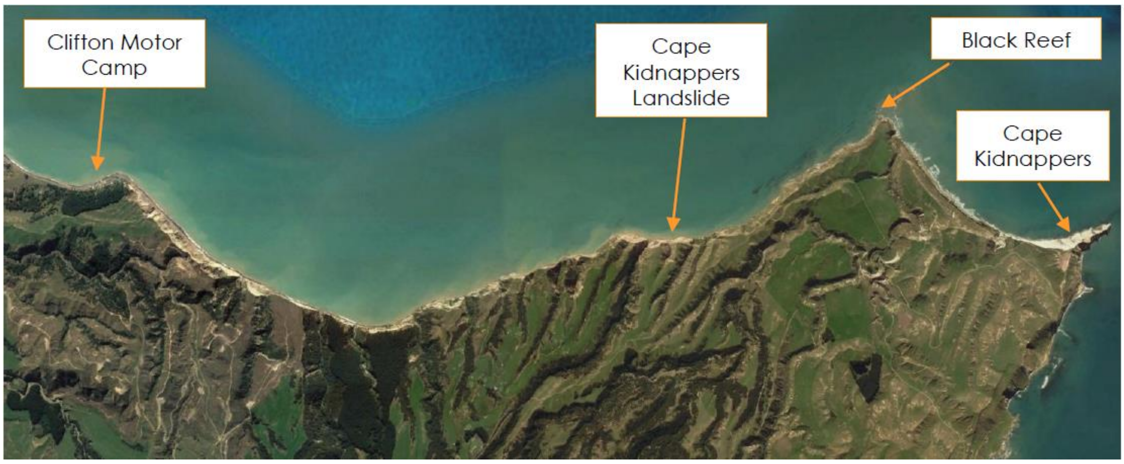
2.10 Based on passenger numbers provided by Gannet Beach Adventures annual visitor numbers may be in the region of 15,000 to 25,000, with an elevated level of activity in the last season.

2.11 **Landslide Events**

2.12 Anecdotal information indicates that landslides along this stretch of cliffs are a well-known phenomenon that occur frequently. It is also understood that landslides regularly block the beach, with consequential disruption to beach activities. This is supported by existing imagery of the cliffs which shows the remains of relatively large debris mounds on the beach (refer Stantec Report, page 19).

2.13 On the 23rd January 2019 a major landslide occurred approximately 5km along Clifton beach seriously injuring two Korean tourists. In response to this event DOC closed the Cape Kidnappers Reserve at request of the Police and placed warnings on their website to discourage tourists from attempting to visit the colony due to uncertainty over the level of risk.

2.14



2.15 Council's response to the event was to implement a road closure notice under s342(1)(b) and the tenth schedule of the Local Government Act 1974 to close the beach to avoid any further injuries or fatalities and due to concerns that subsequent landslides might occur. In addition, Officers immediately requested support from Stantec through the current alliance agreement to provide expert geotechnical advice on the situation.

3.0 CURRENT SITUATION

3.1 Status of Beach Access

3.2 The road closure notice, on-site signage and media briefings/public information regarding the need to stay off the beach remain in place. The Cape Kidnappers Reserve remains closed by DOC (refer images below).

3.3

3.4 Legal Position

3.5 All non-authorised access along the beach toward the Cape from Clifton has been temporarily prohibited by the Council. That temporary prohibition applies to both vehicles and pedestrians. The temporary prohibition stems from the common law status of the beach as road, and relies on the powers given to the Council by s342(1)(b) and the tenth schedule of the Local Government Act 1974 (LGA74).

3.6 The temporary prohibition may be enforced by the Police, but the Police have indicated that they intend to use persuasive methods of enforcing the prohibition rather than issuing tickets, undertaking prosecutions, or attempting to physically stop those intent on breaching the temporary prohibition.

3.7 The temporary prohibition is the most appropriate legal mechanism that the Council has to seek to prevent people from accessing the beach. That said, the topic is legally complex and uncertainty exists as to whether the temporary prohibition would he held (if tested in court) to be a proper exercise of the LGA74 power. That uncertainty primarily stems from the non-statutory nature of the beach's status as road, and the untested question of whether that type of road can be the subject of the LGA74 powers in this context. Uncertainties will remain unless a court were to consider the matter.

3.8 One aspect of the temporary prohibition that is clear is that it can only be temporary. While the LGA74 and case law provide no guidance on what "temporary" means in this context, the current prohibition plainly cannot be a permanent solution. It is the view of the Council's General Counsel that where there is a threshold in immediate sight, such as a 3 - 6 month period while further study of the cliff is undertaken, then that time could be viewed as "temporary".

3.9 Should we not exercise prudent controls that we have the power to implement, and that causes loss to another, that may open the Council to a claim in tort. Whether prudent controls in the circumstances extends to the imposition of a temporary road closure is a question to which the answer is somewhat circular – it depends on what one views the risks to be and without the QRA we could only base that view on past experience.

3.10 In terms of our obligations under the Health and Safety at Work Act (HSWA), if the beach is a place over which we can exercise a relevant control, and for some it is also a workplace, then it is highly likely that we owe an obligation under s36 and 37 of that HSWA. Any such obligation would extend to taking "reasonably practicable" steps to manage safety risks that other people are exposed to on a workplace over which we exercise (some) control. What step are reasonably practicable in the circumstances will, as with tortious risks, depend on the nature of the risk and without the QRA we could only base that view on past experience.

3.11 Any legal testing of the temporary power being exercised could occur in two contexts:

- As a part of a prosecution of the Council by Worksafe, or a civil claim against the Council arising from an incident on the beach; or
- A challenge to the exercise of the power by way of judicial review or as a part of any civil claim made against the Council connected to the impacts of the restriction.

3.12 Put plainly, the testing of the power would remain similar when it is exercised and when it is not, but the Council has the choice over the context and forum within which that testing might take place.

3.13 If a QRA was to indicate that permanent controls over vehicles are necessary, that power is available via the making of bylaws. Any permanent control of pedestrians would require further consideration, but may also be a subject that a bylaw should seek to address relying on the bylaw making powers in s145 of the LGA02. Any bylaws made would need a proper decision making process under the Local Government Act 2002.

3.14 It is highly unlikely that the Council would be held to be under a positive duty to create a bylaw. That would be a duty to create a power, rather than a duty to exercise a power already held. With that in mind, it is the General Counsel's advice that in terms of the prohibition, any potential duty ends at the completion of the QRA and implementation of any longer term measures. This will be the outlying reach of the temporary powers.

3.15 **Geotechnical Assessment**

3.16 Geotechnical monitoring of the landslide area has been undertaken since the 23rd January event. The monitoring activities include visual observation and, drone and ground based surveying.

3.17 Council has engaged one of the Directors of Gannet Beach Adventures to support the geotechnical analysis. This has contributed valuable local knowledge regarding the nature of rockfall events that have assisted Stantec in developing their report.

3.18 As a result, Stantec have provided the attached Interim Report on Cape Kidnappers Landslide (the Stantec Report) presenting their expert opinion for Council to consider. The key points from this report are:

3.19 General Situation:

- There is no baseline risk information available to which the current landslide event can be compared.
- Landslide hazards exist along most of the beach from Clifton to Cape Kidnappers, and the risk is not constant and will be continually changing.
- Due to an increasing number of visitors using the beach the overall risk exposure is increasing. For this reason, precedence over the last 50 years or so is not a reliable argument for the injury event risk being acceptable.
- As the beach is accessed by a significant number of visitors and there is the potential for multiple injuries/fatalities in the event of landsliding, societal risk is a key consideration.

3.20 Considerations for the 23rd January Landslide event site:

- Historically, relative to other areas along the cliffs, the event site appears to have had a higher landslide hazard compared to other parts of the beach prior to the 23rd January 2019 landslide occurring. Previous landsliding had occurred in the days, weeks and years prior including a sizable landslide in 2015.
- The velocity of landslide would be described as 'extremely rapid' (velocity exceeding 5m/sec), as demonstrated by the injured tourists' inability to escape and the generated impulse wave from the rockfall deposit displacing the sea.

- The immediate risk at the location of the 23rd January landslide is higher than it was as a result of the current landslide activity.
- Making an accurate assessment of future landslide behaviour is constrained by the available information on how the cliffs respond to different environmental conditions, in particular rainfall, earthquake shaking and storms with associated wave action.

3.21 Key Expert Recommendations:

- Beach access should remain closed to all beach users until a Quantitative Risk Assessment (QRA) is completed to assess the risk associated with landslide hazard for both the immediate event area and the remainder of Clifton Beach between Clifton and Cape Kidnappers.
- The QRA will need to consider; Individual risk of loss of life (person most at risk), Societal risk (potential for multiple fatalities) and taking an As Low As Reasonably Practicable (ALARP) approach.

3.22 Initial estimates for completing a robust QRA is 6 months, including time for peer review.

3.23 **Risk Considerations**

3.24 The following sets out key risk management considerations in accordance with the HDC Enterprise Risk Management Policy and Framework V3.4 (the HDC Risk Policy).

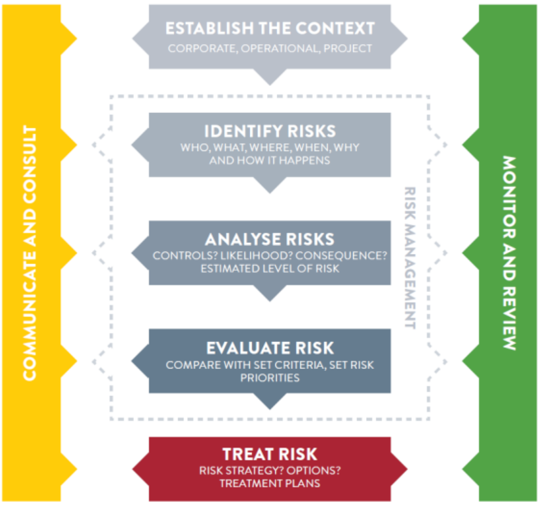
3.25 Risk Management Objective:

3.26 The current HDC Risk Policy sets the following objectives which are particularly relevant to the current situation:

- HDC seeks to protect personal safety in all undertakings.
- All sources of risk are assessed before undertaking any activity.
- Risks are managed within the risk criteria established for the activity.

3.27 Based on these objectives, the implementation of a road closure notice to protect safety of the public is aligned with the policy objectives, as is the expert geotechnical recommendation to undertake a QRA.

3.28 The following diagram taken from the HDC Risk Policy outlines the risk process as guidance for considering the current situation.



3.29 Risk Context: Before considering the risk associated with the use of the beach it is necessary to establish the context of the situation for decision making.

3.30 As previously stated one of the purposes of Local Government is to minimise the threat to public safety.

3.31 The advice in the Stantec Report states that the "key elements at risk from landslide hazard at the CKL [previous landslide] location are (assuming the beach is open):"

- "People – injury or loss of life, with the potential for multiple injuries/fatalities:
    - General public:
        - Locals.
        - Tourists – Cape Kidnappers Walking Track, administered by the Department of Conservation (DOC). Numbers not reliably known, around 15,000 people per annum (lower bound) and increasing.
    - Guided public – eg Gannet Beach Adventures. Around 10,000 people per annum.
    - Workers – employees of Gannet Beach Adventures.
- Infrastructure / property:
    - Public – none when on foot but vehicles used to access the beach.
    - Private:
        - Property – loss of land via cliff retreat. The cliff top is owned by Cape Kidnappers Station.
        - Gannet Beach Adventures – such as tractors.
- Environment – the beach and foreshore from inundation."

3.32 In addition to these elements at risk Council should also consider relevant stakeholders including:

- Cultural considerations relating to access the offshore and shoreline reefs and inshore fishing grounds.
- The general societal view of the level of safety in public spaces, which is becoming increasingly focused on the protection of individuals from harm.

- Tourists/visitors to the district. Most will be day visitors looking for a unique experience while in Hawke's Bay. Generally, they are likely to have a low awareness of the risk and would generally expect easy to access and low difficulty excursions to present minimal hazards.
- The role other agencies may be able to play, including; DOC, Hawke's Bay Tourism, Hawke's Bay Regional Council and Worksafe.
- It should be noted that DOC are currently undertaking an internal review that needs to be completed before initiating a detailed risk analysis. DOC have also indicated that a detailed risk analysis would be required before a final decision could be made on the future use of the Black Reef reserve.

3.33 In terms of the physical environment it can be summarised from the Stantec Report that landslide events are part of an ongoing natural process of significant scale, and that falls are unpredictable and tend to occur with little or no warning.

3.34 Council's mandate to act must also be considered in setting the context for a decision relating to use of the beach for access to Cape Kidnappers. The drivers for Council to be involved include; a legal obligation to act and an implied obligation to act based on community expectation for agencies to help ensure public safety. The legal position is covered in section 3.46.

3.35 When considering whether there is an implied obligation to take action, it is worth noting that there is no clear mandate for any agency (e.g. DOC, Hawke's Bay Regional Council, WorkSafe, NZTA) to take action regarding pedestrian access to the beach, and similarly the obligations on agencies to act with regard to commercial operations are also uncertain. As a result, a gap may exist that could mean no agency takes action to address the public safety concerns. Considering the area is a significant tourist attraction, leaving the situation unmanaged is unlikely to meet the expectations of the public and tourists for the level of safety expected while visiting the area. Therefore, it may be considered that the responsible position for Council is to take some form of action to protect the safety of beach users.

3.36 <u>Risk Criteria</u>: Risk criteria represent those tests or benchmarks for significance that are used to evaluate whether a risk can be tolerated or requires further treatment. These tests represent the organisation risk tolerance. This concept is closely related to the idea of risk appetite, which is the amount of risk an organisation wishes to seek or retain.

3.37 In this situation, as the cape landscape and the trip to the Gannet colonies can be considered an iconic natural feature and attraction, there is an appetite to resume tourist operations. However, this should only be permitted if the possibility of serious injury or fatality is within personal, societal and Council tolerance for serious injury or fatality.

3.38 In relation to rock fall Council does not have an existing criteria that could be applied. As a result, it is necessary to rely upon other industry standards. In this case the Australian Geomechanics Society Landslide Risk Management Guidelines (AGS, 2007d) suggest the upper limit for tolerable loss of life risk for the Person Most At Risk (PMAR) is better than 1 death every 10,000 years (or 1 x 10-4 per annum).

3.39 It should be noted that the amount of time people spend on the beach will affect their level of exposure to the hazards, and in turn affects the level of risk. In this case, exposure will be affected by the time taken to traverse the beach, the proximity to the foot of the cliff, and the accessibility of the beach (e.g. due to tides etc). In addition, the overall volume of people making the journey will affect the wider Societal risk.

3.40 Once a tolerable level of risk has been determined, an “As Low As Reasonably Practicable” approach should be applied to follow best practice for managing the risk as reinforced in the Stantec Report (refer page iii). This means all practical measures to lower the risk should be implemented unless the cost of the measure is disproportionate to the benefit gain.

3.41 Risk Identification: The primary risk faced is that a landslide occurs when people are present in the landing zone causing serious injury or fatality. Due to the nature of tourist operations this could potentially involve multiple people.

3.42 Should this risk materialise, there are consequential impacts for Council that include; possible legal challenge and potential reputation impact due loss of confidence amongst community/public.

3.43 However, should Council take action to protect public safety the consequential risks need to be considered. Implementing actions to protect safety will make Council responsible for the adequacy and effectiveness of those measures. As a consequence, additional liability risk may be created that Council must manage and these will require adequate resources.

3.44 Risk Assessment: As recommended in the Stantec Report a QRA is required to define the risk level with any degree of confidence. The decision to undertake a QRA is a key decision in this report.

3.45 Until a QRA is available the level of risk is unquantified. As a result it is not possible to determine whether or not the level of risk is tolerable or whether additional mitigations could be effective in reducing the risk exposure. Therefore, until the situation can be assessed it is pragmatic to take a conservative view of the risk faced by beach users.

3.46 General Legal Risks: In terms of the legal risks the Council faces, the position is clouded. If the temporary prohibition is lifted (alongside measures to warn people of the risks involved in access along the beach) and a landslide occurred causing damage to property / injury / fatalities, then the Council is unlikely to face civil liability resulting from such an incident, but it could be the subject of a prosecution by Worksafe. The lifting of the temporary prohibition without any ALARP style controls would cause the risks to be higher, but the Council would still be unlikely to face a civil liability resulting from an incident. The General Counsel would like to emphasise that this advice relates to legal liability only.

3.47 The inverse of that position is leaving the temporary prohibition in place until a QRA is completed. Under those circumstances any legal risk would stem from that position being successfully challenged as a part of or followed by a claim for damages. Such a claim would face considerable difficulties, including the need to prove that the temporary prohibition was outside the Council powers, and to prove loss caused by the temporary prohibition, as opposed to other factors such as DOC closing access to its land or the need for the claimant party to comply with any HSE obligation they themselves might have. In this scenario and HSE risks the Council might face would be fully mitigated.

4.0 OPTIONS

4.1 In considering the options that could be taken the following actions are not considered prudent or reasonable responses to the current situation.

4.2 The options not considered further are:

- Removing the road closure notice and returning to pre-event activities without taking additional steps to make the nature of the hazards clear to beach users. This is due to the change in risk profile caused by the increasing visitor numbers, the elevated rockfall risk at the 23rd January site and the current understanding regarding the severity of injury that could result.
- Undertaking a QRA but removing the road closure notice, whether or not additional control measures are taken. This approach is not considered prudent because undertaking the QRA acknowledges that there is uncertainty whether the risks to beach users is acceptable, but removing the road closure notice implies Council is comfortable to allow the public to be exposed to unknown level of risk.
- Not undertaking a QRA and leaving the road closure notice in place. This is not possible as the s342(1)(b) road closure power only allows a temporary closure to be applied, so this cannot be a permanent solution.
- Taking action to permanently close the beach access (e.g. through a Council Bylaw), on the basis that there is insufficient information to justify this course of action.

4.3 As a result, the following two options are considered to represent the most credible responses considering the uncertainty of the situation.

4.4 **Option 1**: Not undertake a QRA and remove the temporary road closure notice after implementation of reasonable control measures.

4.5 **Option 2**: Undertake the QRA and leave the road closure notice in place until the results of the risk analysis are available.

5.0 SIGNIFICANCE AND ENGAGEMENT

5.1 Permanent restriction of access to the Clifton beach and Cape Kidnappers is likely to be of significance to the community. Therefore, any decision that involves ongoing restriction of access would require the opportunity for appropriate consultation before a decision is made.

5.2 However, as the decisions considered in this report relate to a temporary restriction, or for removing the existing restriction, the current decisions are not considered sufficient to trigger Council Significance and Engagement Policy.

5.3 It should be noted that Officers have been in regular contact with key members of the local community and operators to keep them informed of the situation and to understand their needs.

6.0 ASSESSMENT OF OPTIONS (INCLUDING FINANCIAL IMPLICATIONS)

6.1 **Option 1**: Not undertake a QRA and remove the temporary road closure notice after implementation of reasonable control measures.

6.2 This option puts aside the recommendation to undertake a detailed risk analysis to inform future decision making. As a result, due to the temporary nature of the road closure notice, this notice must be lifted allowing access to the beach to resume. However, this should not be done until suitable steps are taken to ensure that visitors to the area understand the hazards and can make informed decisions.

6.3 Legal: This option presents a minor civil risk, but carries a risk of criminal prosecution by Worksafe should an incident occur.

6.4 Risks: Unless a QRA is completed it is not possible to determine whether the risk to beach users is within any of the risk criteria for tolerable levels of harm to individuals or from a societal perspective.

6.5 Considering the known ongoing nature of landslide events and the nature of possible injury, allowing use of the beach does raise the prospect that visitors will be exposed to an unreasonable risk of injury for the nature of the activity.

6.6 Therefore, this option cannot be considered consistent with Council's responsibility to minimise threat to public safety, nor is it consistent with the adopted appetite to avoid harm to people in the HDC risk policy.

6.7 This option is not supported by expert geological advice provided in the Stantec report. Therefore, exposes Council to greater consequential risks should a harm event occur in the future.

6.8 In addition, DOC intends to leave the reserve closure in place until their internal review and a risk analysis can be completed. Therefore, removing the road closure notice may create confusion over the use of the beach, and similarly leave Council exposed to greater consequential risks should a harm event occur in the future.

6.9 Financial: The financial commitment in this option relates to the cost of installation and maintenance of additional signage and managing publication information. These costs are considered relatively minor and it is envisioned that they can be absorbed within existing operational budgets.

6.10 Conclusion: Without further information there is potentially high risk of further injuries to visitors should use of the beach access to the cape resume. Therefore, this option is considered the least conservative approach and as a result is not preferred.

6.11 **Option 2**: Undertake the QRA and leave the road closure notice in place until the results of the risk analysis are available.

6.12 This option implements the expert geological advice by initiating a detailed risk analysis to allow informed decisions on future use of the beach. In light of the fact that undertaking the QRA acknowledges that there is an uncertain level of risk involved, it is prudent assume that this risk is not tolerable until proven otherwise. Therefore, the road closure notice should remain in place as it is Council's most appropriate legal mechanism to manage use of the beach.

6.13 Legal: This option presents minor civil legal risk to the Council associated with challenge to the temporary prohibition and/or a claim for damages, but mitigates the criminal risk.

6.14 Risk: This option represents a prudent approach considering the level of uncertainty over the possibility for loss of life and the complex legal environment.

6.15 Therefore, this option best aligns with Council's responsibility to minimise threat to public safety, and is consistent with the adopted appetite to avoid harm to people in the HDC risk policy.

6.16 The main risk associated with this option is the length of time required to complete a QRA (estimate at 6 months), which impacts both the cost of the work and the consequences for a timely decision on beach use before the next summer season. To mitigate the timeliness issue providing clear direction on Council's involvement is necessary.

6.17 Financial: The cost of temporary signage and public communications to implement the road closure notice is not considered material, and can be met by existing operational budgets.

6.18 The cost of undertaking a QRA is difficult to determine with certainty, as it is dependent on the amount of research required to build a robust model and the effort required by a peer review organisation to satisfy themselves that the developed model is sound.

6.19 Best estimates indicate that the cost for the Clifton to Cape Kidnappers QRA is likely to be in the region of $200,000 to $250,000. However, similar QRA exercises undertaken by DOC have cost in the region of $400,000 to $600,000. So Officers suggest it would be prudent to assume a final total cost of up to $300,000.

6.20 There are no current funding provisions in place to meet the QRA cost, this would need to be treated as unbudgeted expenditure.

6.21 To reduce the burden on Council, Officers are pursuing a cost sharing arrangement with other parties, primarily DOC, and propose that Council should aim to achieve the most reasonable balance of costs between parties.

6.22 Conclusion: While this option may commit Council to a reasonable direct cost, it does meet the Council's overarching drivers for public safety and takes a conservative approach to meeting those legal obligations that could be argued to apply in this instance.

7.0 PREFERRED OPTION/S AND REASONS

7.1 **Option 2**: Undertake the QRA and leave the road closure notice in place until the results of the risk analysis are available.

7.2 This option is preferred because:

7.2.1 It aligns with expert advice on the geological hazard,

7.2.2 It represents a prudent approach to ensuring any legal duties Council might have are met.

7.2.3 It aligns with the overall purpose for Local Government to minimise the threat to public safety,

7.2.4 Is consistent with Council's approach embodied in the HDC Enterprise Risk Management Policy and Framework.

8.0 RECOMMENDATIONS AND REASONS

A) That the report of the Group Manager: Asset Management titled "Cape Kidnappers Hazard Management" dated 5/03/2019 be received.

B) That the Chief Executive be delegated authority to negotiate and enter into a contract with Stantec and GNS Science to undertake a Quantitative Risk Analysis of the landslide hazard posed by the cliffs from Clifton beach to Cape Kidnappers, acknowledging that this will be unbudgeted expenditure.

C) That the Chief Executive be delegated authority to negotiate and enter into cost sharing arrangements for the Quantitative Risk Analysis with other relevant stakeholders to achieve the most reasonable balance in costs for Council.

D) That the existing road closure notice under s342 and the tenth schedule of the Local Government Act 1974 is to remain in place until the results of the risk analysis are available to inform future decisions.

With the reasons for this decision being that the objective of the decision will contribute to meeting the current and future needs of communities for good quality local infrastructure in a way that is most cost-effective for households and business by:

i) Minimising the threat to public safety.

Attachments:

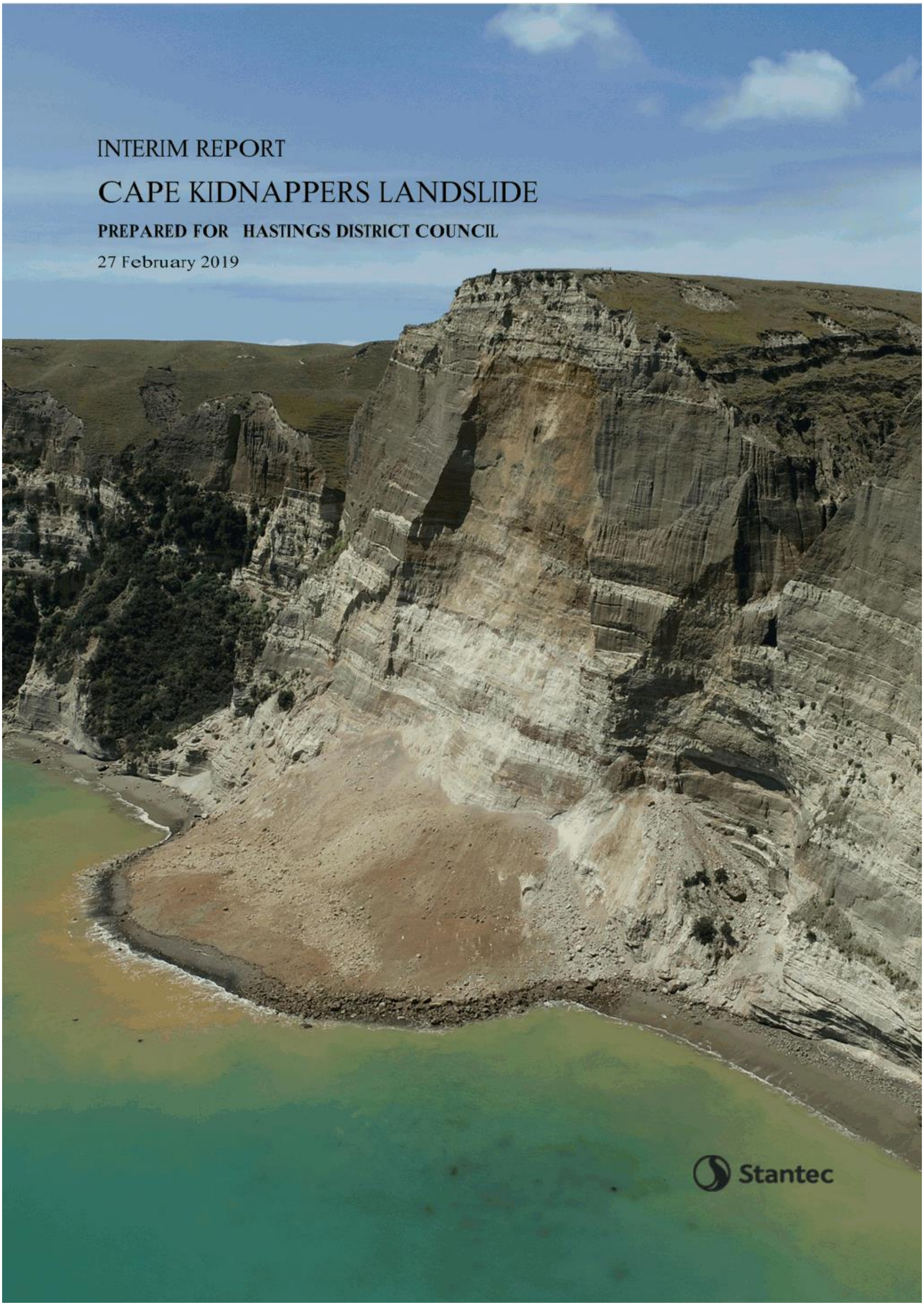
1 Cape Kidnappers Landslide Interim Report FINAL Stantec 27 February 2019 PRJ19-002-0172

INTERIM REPORT

CAPE KIDNAPPERS LANDSLIDE

PREPARED FOR HASTINGS DISTRICT COUNCIL

27 February 2019



Stantec

QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Joanna Davenport	Matt Shore

PREPARED BY		
Matt Shore	[signature]	27/02/19
CHECKED BY		
Hannah Bryce	[signature]	27/02/19
REVIEWED BY		
Charlie Price	[signature]	27/02/19
APPROVED FOR ISSUE BY		
Joanna Davenport	[signature]	27/02/19

HAWKE'S BAY
1st Floor, 100 Warren Street South, Hastings 4122
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 6 873 8900, FAX +64 6 873 8901

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
A	15/02/19	Draft for comment	MS	HB	CP	JD
B	27/02/19	Final	MS			JD

Executive Summary

Introduction

Stantec New Zealand (Stantec) have been commissioned by Hastings District Council (HDC) to act as their geotechnical advisor for their response to the Cape Kidnappers Landslide (CKL). The landslide occurred on the 23 January 2019 injuring two tourists who were present on Clifton Beach at the time of the landslide. Following the landslide, HDC closed beach access east of Clifton through to Cape Kidnappers to all users. Beach access has remained closed since that time.

The key objectives of this interim report are to inform HDC decision-making with regards to:

- Can the beach be re-opened?
- Is there currently an increased risk at the immediate landslide location due to landslide hazard? Is this an acceptable level of risk?
- What are the unknowns?

The focus of this report is on the risk posed by landslide hazard at the immediate location of the 23 January 2019 CKL only. General comments with regards to landslide hazard at Clifton Beach between Clifton and Cape Kidnappers are also provided in the interests of public safety. This report is current at 15 February 2019.

Risk Context

The key elements at risk from landslide hazard at the CKL location are (assuming the beach is open):

- People – injury or loss of life, with the potential for multiple injuries/fatalities:
  - General public:
    - Locals.
    - Tourists – Cape Kidnappers Walking Track, administered by the Department of Conservation (DOC). Numbers not reliably known, around 15,000 people per annum (lower bound) and increasing.
  - Guided public – Gannet Beach Adventures. Around 10,000 people per annum.
  - Workers – employees of Gannet Beach Adventures.
- Infrastructure / property:
  - Public – none when on foot but vehicles if used to access the beach.
  - Private:
    - Property – loss of land via cliff retreat. The cliff top is owned by Cape Kidnappers Station.
    - Gannet Beach Adventures – such as tractors.
- Environment – the beach and foreshore from inundation.

The landslide hazard to the above key elements at risk is on the backshore (the 'beach') and the foreshore (the area between the low and high tide marks) is by 'inundation'. Generally, beach access occurs 2 hours either side of low tide. Most visitors would visit the site between October and March, but the beach is accessed year-round by the public.

The risk to each of the above key elements is not the same. This is due to several factors, such as visitor's awareness of the hazard, the locations visited, the amount of time spent in the hazard area, when and how visitors access the beach etc.

As the beach is accessed by a significant number of visitors and there is the potential for multiple injuries/fatalities in the event of landsliding, societal risk is a key consideration.

Other elements at risk exist, such as reputational risk to various stakeholders, and these will need to be considered in the wider risk context.

Landslide Characteristics

The key characteristics of the 23 January 2019 CKL are:

- The cliff is 130 m high, with an overall slope angle of 70°. It strikes east-west and has a northerly aspect. The beach width is 10 m from above the high tide mark to the base of the cliff or 25 m from the low tide mark to the base of the cliff.
- The cliff forming materials are interbedded sandstone, tuff and conglomerate, which are less than 2 million years old (geologically 'young'). They are bedded, which dips obliquely out the slope towards the northwest at 12°. They are 'massive' in structure, being largely free from rock defects such as joints.
- The landslide mechanism comprises a rockfall, with some evidence for localised toppling failure. The failure mechanism is sometimes referred to as a 'cliff collapse' or 'rock avalanche'.
- The CKL had a source area volume of approximately 25,000 m^3. The source area was largely the mid to upper two thirds of the cliff and primarily occurred in conglomerate interbedded with some tuff. Failure appears to have been through the 'intact' rock material and does not appear to be significantly controlled by rock mass defects, such as joints. Locally however, some joints may have acted as the release surface for the rockfall.
- The rockfall deposit volume was around 30,000 m^3 (i.e. on the beach). The deposit was 125 m wide (beach length) and extended 75 m out from the base of the cliff, beyond the low tide mark. Some fly rock appears to have extended out further from the base of the cliff than this.
- The characteristics of the CKL deposit appear to have been strongly influenced by the presence of the 2015 landslide debris at the base of the cliff, which appears to have acted as a 'ramp' and projected it out further from the base of the cliff than otherwise may have been the case.
- The velocity of the landslide would be described as 'extremely rapid', as demonstrated by the injured tourists' inability to escape and the generated impulse wave from the rockfall deposit displacing the sea.
- There was no definitive 'trigger' for the landslide, which occurred under 'sunny sky' conditions. A number of apparent landslide 'causes' have been identified by this assessment. A key one of which is erosion of the base of the cliff resulting in the over steepening of the slope and the associated retrogressive landsliding as the cliff tries to find a stable angle. The earlier 2015 landslide at the same location was a critical part of this process. This occurred directly below the 23 January 2019 CKL.
- The CKL location appears to have had a higher landslide hazard than other parts of the beach prior to the 23 January 2019 landslide occurring. Landsliding had occurred in the days, weeks and years prior.
- Subsequent to 23 January 2019, landsliding has continued to occur at the immediate CKL location.
- It can be expected that the occurrence of landsliding at the location will decrease with time, back to a 'baseline' level of landsliding. What that 'baseline' level is, is not currently known. However, it is expected that the level observed since 23 January is above that baseline level. Each time a more significant landslide occurs, an increased likelihood of landsliding will exist for a period.

Based upon the findings of this assessment completed 15 February 2019, it is concluded:

- Risk at the immediate CKL location was not quantified prior to the 23 January 2019 landslide occurring (nor along the remainder of the beach from Clifton to Cape Kidnappers). This report has not attempted to quantify what the risk is currently. We are not stating an opinion that we believe it to be unacceptably high but only that it is not quantified.
- The risk at the immediate CKL location is currently higher than it was prior to the landslide as:
    - There is an increased likelihood of landsliding.
    - As the rockfall deposit on the beach is eroded, the probability of a beach user being struck by a landslide will likely increase. This is as beach users will be closer to the base of the cliff in the location any future landslides are most likely to impact. Analysis would be required to reliably confirm this however.

- Although the risk before the CKL occurred was unquantified, and the risk is currently still unquantified, the overall risk trend is likely one of increasing risk. This is largely due to the significantly increasing number of beach users.
- For this reason, reliance on precedence over the last 50 years or so is not a sound argument for the pre-CKL risk being acceptable (or the current risk). There have been several incidents and many near misses reported previously and this makes no consideration of the significantly increasing visitor numbers.
- The current short to medium-term is also the period of the year with the highest visitor numbers and therefore when the risk is likely to be at its annual highest.
- A key uncertainty in the short to medium-term is that the completed surveillance of the CKL since it occurred has essentially been under 'sunny sky' conditions. The likely performance of the CKL under different environmental conditions which are judged important for its stability, such as rainfall, earthquake shaking and storms with associated wave action, is therefore not reliably known.
- Other key factors to consider are:
    - Rockfalls can be more difficult to inspect and monitor compared to some other landslide mechanisms. Especially when the site characteristics are considered.
    - Rockfalls do not always occur with pre-failure warning signs, like some other landslide mechanisms. Additionally, any warning signs that do occur may not be seen, for various reasons. Pre-failure instability which occurred before the 23 January CKL cannot be relied upon as always occurring before landsliding.
    - Rockfalls are typically 'extremely rapid' and escape is often not possible. For other landslide mechanisms which are of slower velocity, evacuation can be possible.
    - When people are struck by rockfall, published information shows the probability of death is high. Although it is acknowledged that four instances of people surviving rockfall impact have now occurred on Clifton Beach.
    - Large volume rockfalls are not a necessity to cause injury or a fatality. Even a small rockfall, of less than 1 m^3, could cause an injury or a fatality, considering the site characteristics (i.e. high steep cliffs and the potential for people to be at the base of the cliff considering the beach width).
- Landslide hazard is not restricted to the immediate CKL location. Landslide hazard exists along most of the beach from Clifton to Cape Kidnappers. The risk has not been previously quantified nor is it quantified by this study. This hazard is evident from the number of near-misses which have been reported.

Recommendations

It is recommended as of the 15 February 2019:

- Beach access should remain closed to all beach users until a Quantitative Risk Assessment (QRA) is completed to assess the risk associated with landslide hazard for both the immediate CKL area and the remainder of Clifton Beach between Clifton and Cape Kidnappers.
- This QRA should be completed in accordance with the recommended methodology of the Australian Geomechanics Society Practice Note Guidelines for Landslide Risk Management (2007). A QRA is judged standard practice for assessing the PLOL.
- As part of the QRA, tolerable risk acceptance criteria will need to be established for the purposes of decision making. Guidance on this can be obtained from a variety of sources.
- The QRA will need to consider the following:
    - Individual risk of loss of life (person most at risk).
    - Societal risk – with lower tolerable risk criteria applicable when there is the potential for multiple fatalities.
    - As Low As Reasonably Practicable (ALARP) approach is met.

- Monitoring of the CKL should continue as the QRA is completed, to inform the risk assessment. The current monitoring program should be continued but should be reviewed as results are obtained and reviewed (including the methods used and their frequency).
- Should the beach access be re-opened before the QRA is completed, the risk to beach users will not be reliably quantified and this needs to be acknowledged by HDC. Should this decision be made, then an ALARP approach should be adopted in the interim while the QRA is completed.

Abbreviations

ANCOLD	Australian National Committee on Large Dams
AGS	Australian Geomechanics Society
ALARP	As Low As Reasonably Practicable
CKL	Cape Kidnappers Landslide
DEM	Digital Elevation Model
DOC	Department of Conservation
HBRC	Hawke's Bay Regional Council
HDC	Hastings District Council
GNS	GNS Science
MLWS	Mean low water spring
MHWS	Mean high water spring
PLOL	Loss of Life
PGA	Peak ground acceleration
QRA	Quantitative Risk Assessment
UAV	Unmanned Aerial Vehicle

Hastings District Council

Cape Kidnappers Landslide

CONTENTS

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APPENDICES

1. Introduction

1.1 Project Background

Stantec New Zealand (Stantec) have been commissioned by Hastings District Council (HDC) to act as their geotechnical advisor for the Cape Kidnappers Landslide (CKL). The landslide occurred on the 23 January 2019 injuring two tourists who were present on Clifton Beach at the time of the landslide. Following the landslide, HDC has closed all beach access east of Clifton through to Cape Kidnappers. Beach access has remained closed since that time.

1.2 Report Objectives

The key objectives of this interim report are to inform HDC decision-making with regards to:

- Can the beach be re-opened?
- Is there currently an increased risk at the immediate landslide location due to landslide hazard? Is this an acceptable level of risk?
- What are the unknowns?

This report is written as a 'white paper' with a variety of readers in mind. A subsequent technical report will be prepared for the CKL providing more detail with regards to the characteristics of the landslide and what these mean for future landslide hazard risk management.

When reading this report, the following terms are defined as follows:

- 'The landslide' – refers to the landslide of the 23 January 2019. Information and monitoring have shown this was not a single event however, with landsliding occurring both prior to and post 23 January 2019.
- 'The site' – refers to the immediate landslide location only.

The focus of this report is the risk posed by landslide hazard at the immediate location of the 23 January 2019 landslide only.

General comments with regards to landslide hazard at Clifton Beach away from the immediate location of the 23 January 2019 landslide are provided in the interests of public safety.

This report is current as of 15 February 2019.

1.3 Risk Context

The key elements at risk from landslide hazard at the CKL location are (assuming the beach is open):

- People – injury or loss of life, with the potential for multiple injuries/fatalities:
  - General public:
    - Locals.
    - Tourists – Cape Kidnappers Walking Track, administered by the Department of Conservation (DOC). Numbers not reliably known, around 15,000 people per annum (lower bound) and increasing.
  - Guided public – Gannet Beach Adventures. Around 10,000 people per annum.
  - Workers – employees of Gannet Beach Adventures.
- Infrastructure / property:
  - Public – none when on foot but vehicles if used to access the beach.
  - Private:

  - Property – loss of land via cliff retreat. The cliff top is owned by Cape Kidnappers Station.
  - Gannet Beach Adventures – such as tractors.
- Environment – the beach and foreshore from inundation.

The landslide hazard to the above key elements at risk on the backshore (the 'beach') and the foreshore (the area between the low and high tide marks) is by 'inundation'. Generally, beach access occurs 2 hours either side of low tide. Most visitors would visit the site between October and March, but the beach is accessed year-round by the public.

The risk to each of the above key elements is not the same. This is due to several factors, such as visitor's awareness of the hazard, the locations visited, the amount of time spent in the landslide hazard area, when and how visitors access the beach.

As the beach is accessed by a significant number of visitors and there is the potential for multiple injuries/fatalities in the event of landsliding, societal risk is a key consideration.

Other elements at risk exist, such as reputational risk to various stakeholders, and these will need to be considered in the wider risk context.

1.4 Report Layout

This report is structured as follows:

- Section 2 – the characteristics of the site of relevance to this assessment, such as geological and physiographic.
- Section 3 – landslide terminology used in this report.
- Section 4 - the characteristics of the landslide, including the interpreted failure mechanism and the reasons it likely occurred.
- Section 5 – a summary of the monitoring established for the landslide and the results obtained to date.
- Section 6 - a qualitative assessment of likely future performance of the immediate landslide area.
- Section 7 – comments around landslide hazard along Clifton Beach away from the immediate landslide area.
- Section 8 - conclusions and recommendations.
- Section 9 – references.
- Section 10 - limitations.

2. Site Setting

The following subsections briefly summarise the setting of the site, relevant to this assessment.

2.1 Location Map

The location of the CKL is shown on Figure 2-1, together with other key locations referenced in this report. The location is 4.5 km east of Clifton in a straight line or approximately 5.0 km beach length. At the site, the beach and foreshore are considered a legal road and is within the district of the HDC (which extends to Mean Low Water Spring (MLWS)).

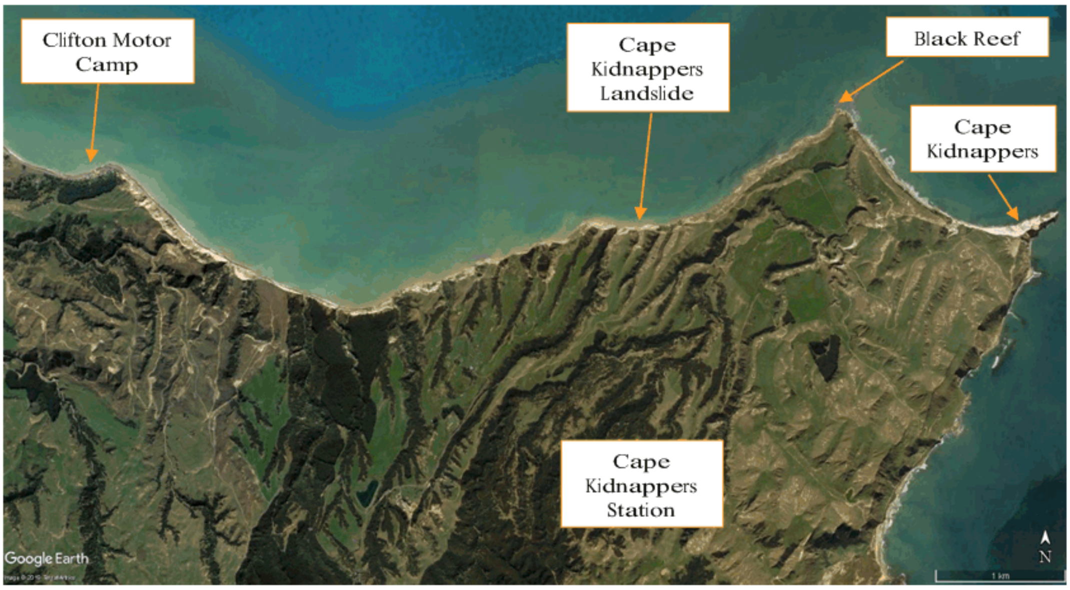


Figure 2-1: Cape Kidnappers Landslide location plan

2.2 Physiographic

An orthoplane (elevation) of the CKL is presented as Figure 2-2 and an orthophoto (plan) as Figure 2-3.

The cliff on which the landslide occurred broadly strikes east-west and has a northerly (facing) aspect. The cliff is roughly 130 m high. Prior to the landslide, the cliff had an overall slope angle of around 75°. The cliff section did not appear to have been a uniform slope angle however (refer Figure 2-4). The section is judged as primarily controlled by geotechnical properties of the cliff forming materials (refer subsequent section), with secondary influences of coast and slope forming processes. Below mid-height, below the rockfall source area, the cliff sloped typically at 70°. Above this, within most of the landslide source area, the cliff appeared to slope more steeply at 85°. The top 20 m or so of the cliff, which includes the upper part of the landslide source area and the area above it, slopes at 70°. The cliff face is free of vegetation. The cliff top is grassed.

The ridge crest of the cliff is 30 m wide and near-level ('flat topped'). The sides of the ridge crest slope at around 45° down into West Hanging Gully and East Hanging Gully. These side slopes display evidence for inferred active shallow instability.

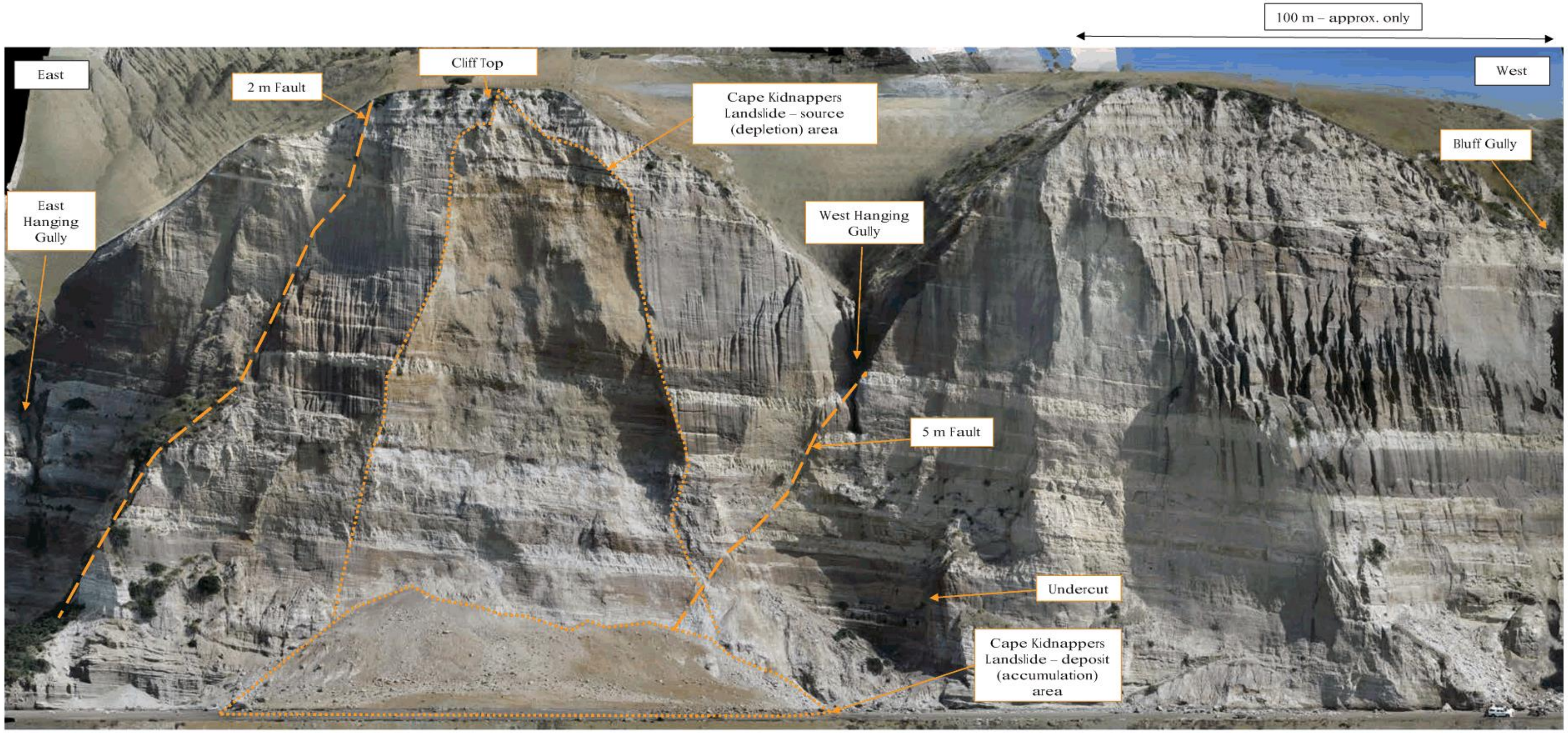


Figure 2-2: Cape Kidnappers Landslide orthoplane (taken at low tide, 25 January 2019)

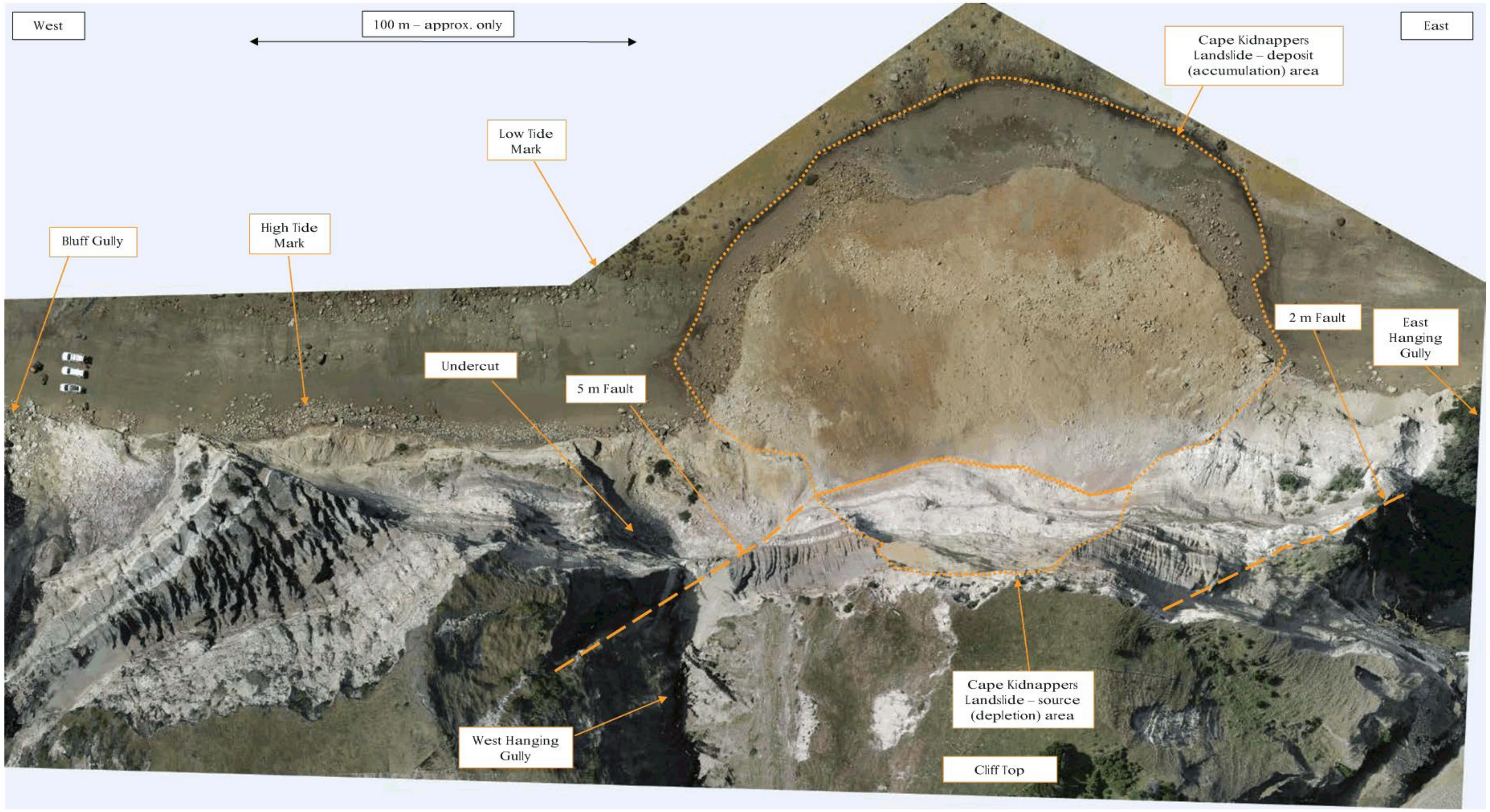


Figure 2-3: Cape Kidnappers Landslide orthophoto (taken at low tide, 25 January 2019)

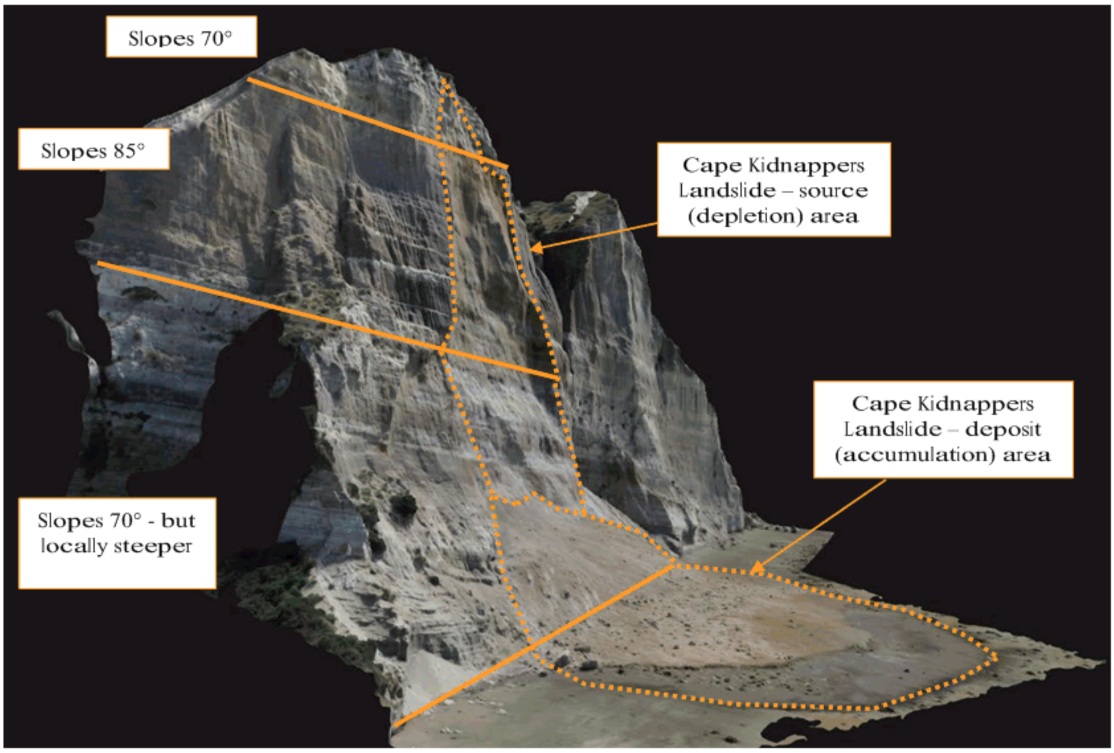


Figure 2-4: Schematic cliff section at the landslide location (25 January 2019)

Anecdotally, no seepage has been observed from the cliff face itself. Following rainfall, it is understood that both East Hanging Gully and West Hanging Gully flow (ephemeral), resulting in waterfalls down the cliff face. Surface water flow down the cliff face is evidenced by the sheet and rill erosion which has taken place in the upper two thirds of the face. This erosion is useful for determining the relative ages of the cliff faces.

The beach width is 10 m from above the high tide mark to the base of the cliffs (Figure 2-5). The beach width is 25 m from the low tide mark to the base of the cliffs. The beach is generally gently sloping, covered with sand with some gravel, cobbles and boulders. Localised exposure of in-situ rock is present within the beach, at the base of the cliff, generally exposed following some beach erosion. This appears to be a wave cut platform. Unlike some other sections of Clifton Beach, there is no significant rock exposure below the low tide mark (locally referred to as 'reefs'). This is likely important for understanding landslide triggers and causes.

Rockfall deposits of various ages are present on the beach, at the base of the cliffs.

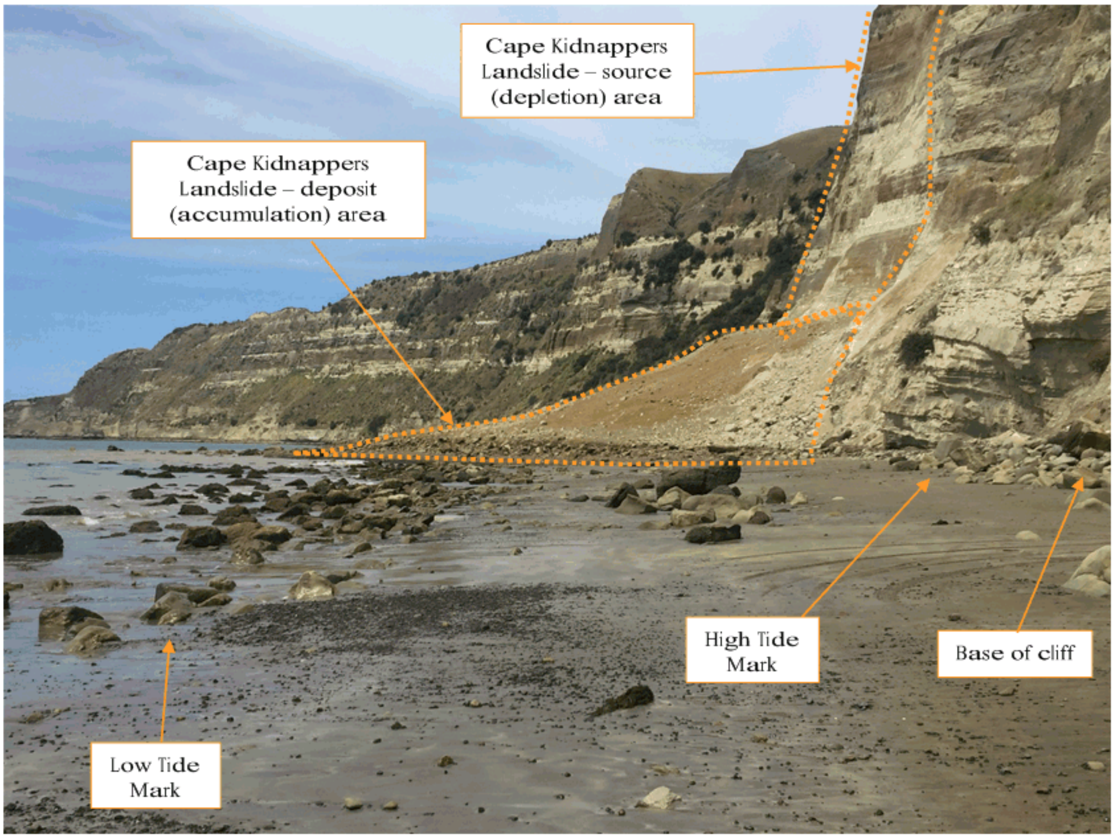


Figure 2-5: A view looking east along the beach at the landslide location (taken at low tide, 25 January 2019)

2.3 Geological

The published geological map for the site is shown as Figure 2-6. The key geological units shown at the immediate landslide area are (youngest to oldest):

- Q5b – these deposits are mapped on top of the cliffs and represent old marine benches. They are described as 'beach deposits of sand, silt, mud, gravel; commonly containing loess, palaeosols and tephra' and are shown to be between 128,000 and 71,000 years old.
- eQp – Kidnappers Group – is shown to form the cliffs at the landslide location. These deposits are described as 'basal fossiliferous sandstone overlain by conglomerate, sandstone, carbonaceous mudstone, tephra and ignimbrite'. These deposits are assessed to be between 1.8 million and 425,00 years old.
- Pmz – shown to outcrop at black reef, Cape Kidnappers and south of Cape Kidnappers. These deposits are described as 'Early Pliocene massive calcareous and fossiliferous mudstone with minor interbedded sandstone at Cape Kidnappers'. Their age is shown as between 5.32 and 3.6 million years old.

The bedding within the cliffs is shown on the published geological map to dip towards the northwest at 8° at the landslide location. Due to the east-west strike of the cliff, this equates to obliquely out of slope. Two un-named active faults are present 500 m west of the landslide location. The New Zealand Active Fault Database (https://data.gns.cri.nz/af/) does not contain any information for these active faults (such as sense of movement, Recurrence Interval, age of last rupture etc.). The map indicates the mapped fault locations vary from 'accurate' to 'approximate', with the eastern most fault showing the eastern side is downthrown. These faults are not discussed further in this report.

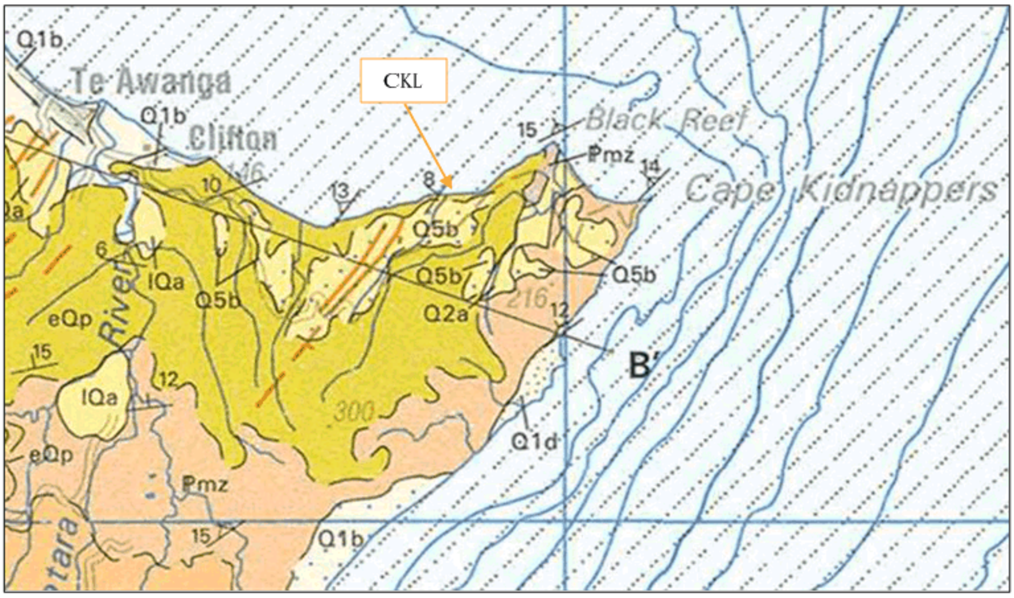


Figure 2-6: Published geological map (Lee et al. 2011)

Further detail on the geology of the CKL area is provided in Beu & Grant-Taylor (1975). They show the area to comprise 'beds of gravel, pumice and sandstone, about 1 million to 300,000 years old', consistent with that documented above. The cliff forming materials are noted to get geologically older from Clifton to Black Reef. An elevation of the cliffs is also presented in Figure 2-7, which shows the cliff on which the landslide occurred is bound by two geological faults, the '2 foot fault' to the east (referred to as '2 m Fault' in this report) and the '15 foot fault' to the west (referred to as '5 m Fault' in this report). The cliff is shown to comprise in its lower two thirds interbedded pumice and conglomerate with the upper third comprising conglomerate. A capping of silt and pumice is shown at its very top. Sandstone is shown at the very base of the cliff, mainly on the eastern side, due to the dip of the bedding.

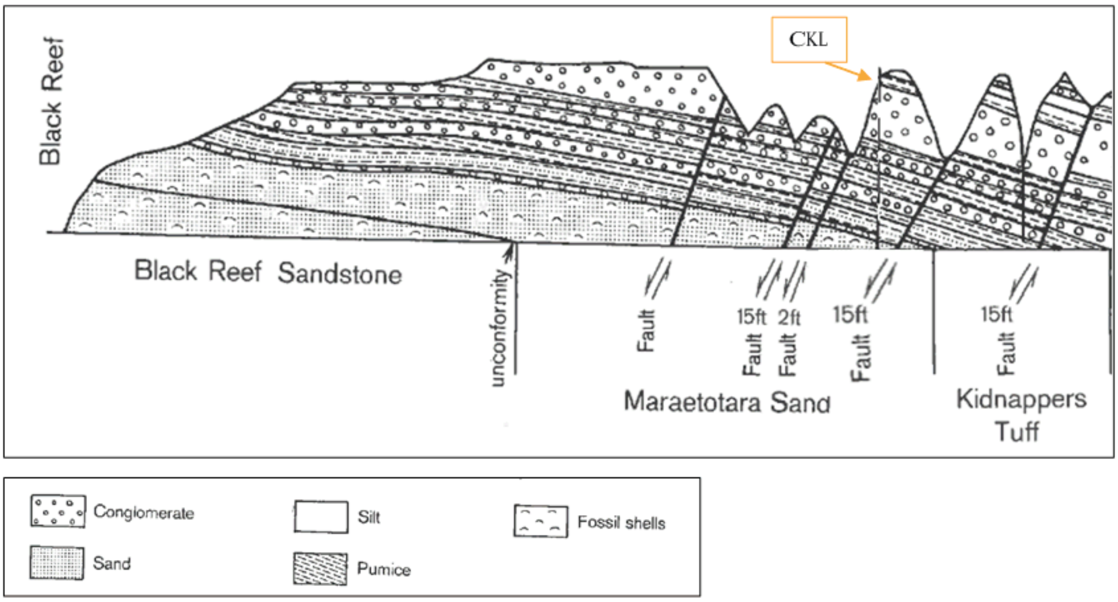


Figure 2-7: Cliff geological elevation (from Beu & Grant-Taylor (1975))

2.4 Geotechnical

For geotechnical purposes, it is common to define units based on similar engineering characteristics (such as strength). Limited work has currently been undertaken to geotechnically characterise the cliff from materials.

Based upon visual inspection, four main geotechnical units are observed within the cliff (from oldest to youngest, refer Figure 2-8):

- Unit 1 – Tuff (80%) with some interbedded conglomerate (20%) - the materials forming the upper part of the source area and the area immediately above it. The tuff appears to be slightly weathered and of very weak intact strength. The upper part of this unit may have soil-like properties due to near-surface effects, such as weathering.
- Unit 2 - Conglomerate (90%) with some interbedded tuff (10%) – the materials which form most of the rockfall source area. The conglomerate appears to be the highest strength cliff forming materials, forming the steepest part of the cliff. It appears as being weak to moderately strong intact strength. Locally, the strength of the conglomerate is higher (i.e. 'hard rock'). The tuff is of very weak intact strength.
- Unit 3 – Interbedded conglomerate (50%) and tuff (50%) – the materials which form the lower part of the rockfall source area and most of the lower part of the cliff. The conglomerate, being higher strength, forms localised steeper sections in this section of cliff face. Their strengths are as described above.
- Unit 4 – Sandstone – present within the very base of the cliff only. Variable, being a siltstone locally. These materials are slightly weathered and of very weak intact strength.

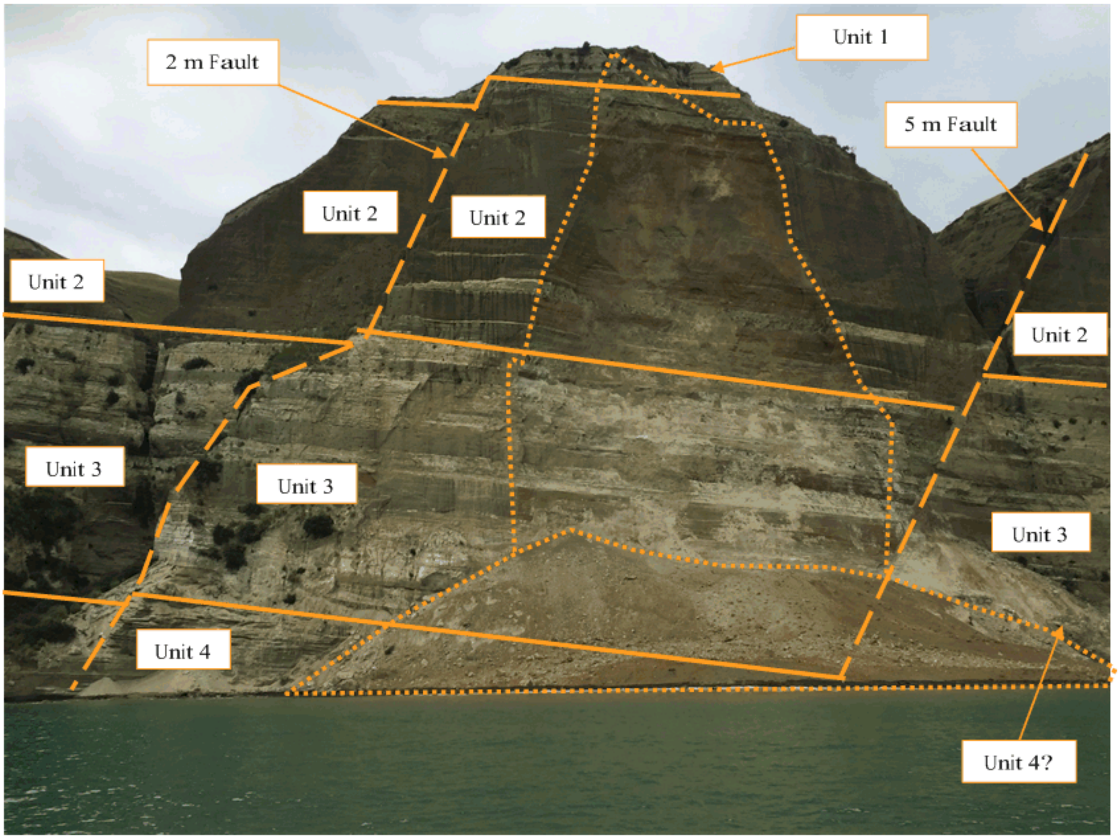


Figure 2-8: Geotechnical units within the cliff (25 January 2019)

Bedding was measured to dip at 12° towards the northwest (slightly higher than the published map value of 8°). This is obliquely (indirectly) out of slope (Figure 2-9). Bedding is flatter towards the east (Black Reef).

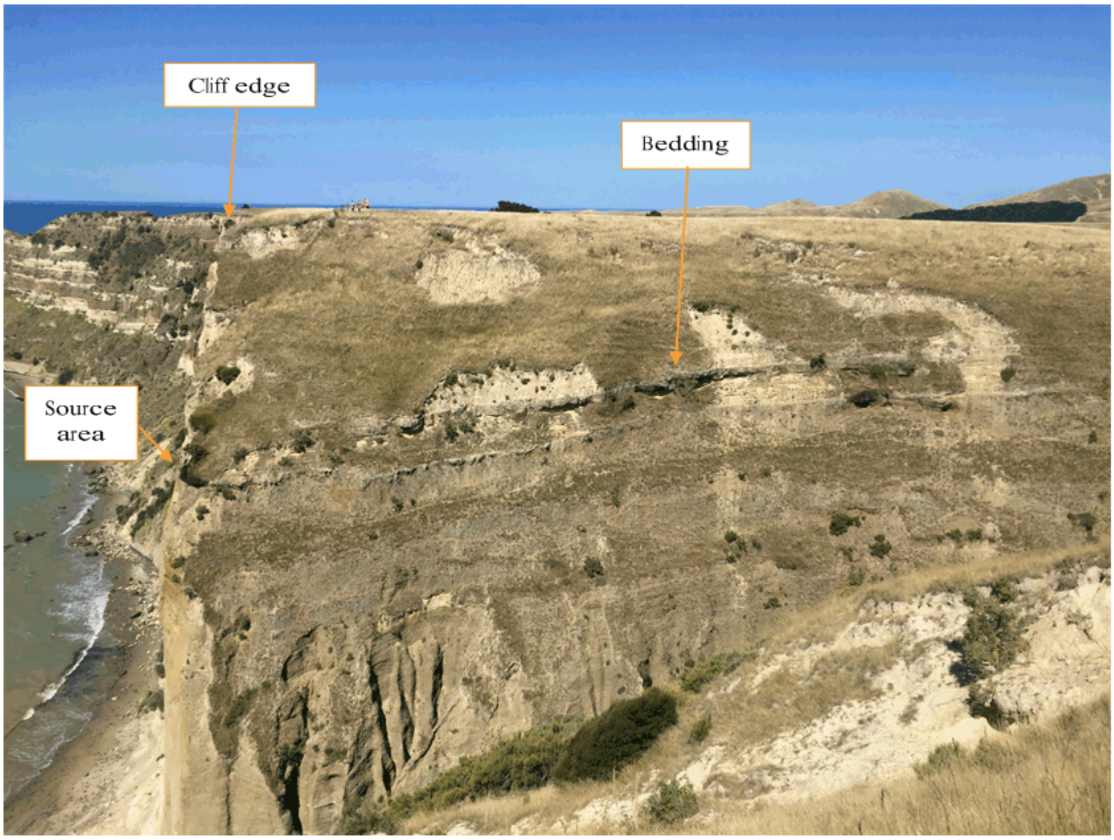


Figure 2-9: Bedding within the CKL cliff, viewed from the west, dipping obliquely out of slope (5 February 2019)

The two mapped faults are also shown in Figure 2-8, which have been upthrown on their western side (normal sense). The faults are similar in characteristics and dip at 60°, with a dip direction of approximately 135° (towards the southeast). This means the faults dip obliquely into the slope. These faults are important, due to their influence on the geotechnical characteristics of the cliff forming materials. The displacement across the fault is largely across a single surface, but locally the faults do split with displacement on two or more surfaces. Joints do appear to be associated with the faults also and are again an important consideration. The faulting may have localised influence on the dip and dip direction of the bedding.

Although the cliff forming materials are typically 'massive', some jointing can be seen. One joint set is obvious at beach level to the right of the landslide location near the undercut. This set strikes roughly north-south and is subvertical. A second joint set appears to strike northwest-southeast and is again subvertical. It appears to control the face of the cliff and those adjoining it locally.

In summary, the cliff forming materials can be summarised as being interbedded 'soft rocks' and except for bedding, relatively 'massive' and free from rock defects such as joints. This means that their behaviour will be controlled largely by the intact strength of the material, as opposed to the strength of joints etc. in the rock, which typically controls the behaviour of 'hard rocks'. Locally however, there is evidence that rock mass defects are important.

2.5 Other

The following subsections briefly discuss the setting of the site, relative to other factors likely important for stability of the CKL.

2.5.1 Seismic

Relative to most other parts of New Zealand, the site would be described as of being of higher relative seismic hazard. Calculated horizontal Peak Ground Accelerations' (PGA's) for various return period are shown in Table 2-1, assuming Site Class B (rock), in accordance with the NZTA Bridge Manual (2018, magnitude unweighted). Topographic amplification will be significant, considering the height and slope angle of the cliff and therefore likely higher than those values stated. GNS (2014) observed amplification factors of 2.5 for horizontal motions and 3 for vertical motions in the Port Hills, Christchurch. Significant landsliding would be expected under higher return periods.

Table 2-1: Unweighted peak ground accelerations for various return periods

	Unweighted PGA's – Site Class B				
	Return period (years)				
Site	25	100	500	1,000	2,500
Hastings	0.08	0.15	0.31	0.40	0.55
Associated Mw	6.0	6.75	6.5	6.75	7.0

The cliff forming materials are not judged susceptible to liquefaction and associated effects.

No active faults are mapped within the immediate CKL landslide location (i.e. no known surface rupture hazard). The closest mapped active faults are those 500 m to the west, as shown on the published geological map.

2.5.2 Climate

Relative to most other parts of New Zealand, the site would be described as of being of lower relative rainfall. Figure 2-10 shows median annual total rainfall of between 700 and 800 mm for the site.

Median annual average wind speeds for the site are between 3 to 4 m/s (approximately 11 to 14 km/hr).

Temperature changes on the cliff face may be important, with the cliff aspect being northerly and therefore receiving all day sun. The cliff forming materials may be subject to loss of strength upon warming/cooling, with similar effects due to wetting/drying. Freeze-thaw is unlikely to be important.

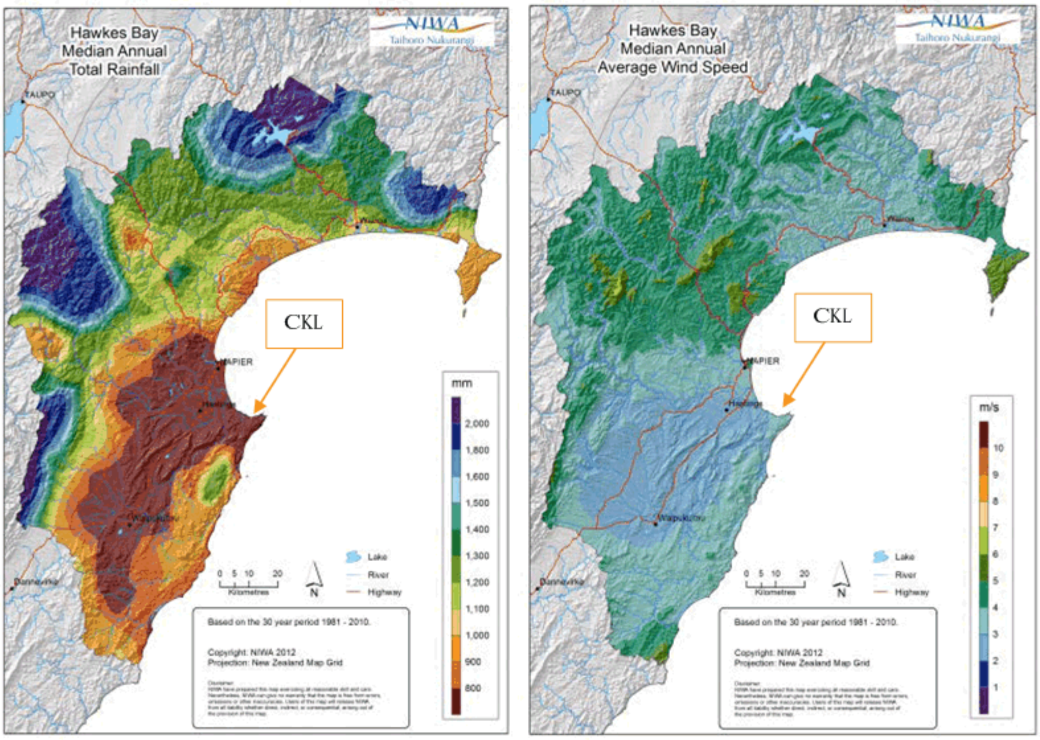


Figure 2-10: Key climate information (from https://www.niwa.co.nz/climate/national-and-regional-climate-maps/hawkes-bay)

2.5.3 Coastal Processes

Understanding coastal erosion is likely critical for stability of the cliffs. Key tide levels for Napier are shown in Figure 2-11 but are expected to vary at the CKL location.

	Chart datum (m)	Napier vertical datum 1962 (m)	HBRC datum (m)
Highest Astronomic Tide (HAT)	1.97	1.05	11.05
Mean High Water Spring (MHWS)	1.84	0.92	10.92
Mean High Water Neap (MHWN)	1.46	0.54	10.54
Mean Sea Level (MSL)	0.92	0	10
Mean Low Water Neap (MLWN)	0.40	-0.52	9.48
Mean Low Water Spring (MLWS)	0.06	-0.86	9.14
Chart Datum (CD)	0	-0.92	9.08

Source: LINZ (2012)

Figure 2-11: Key tide levels at Napier (from T&T 2016)

It is understood there has been no previous study at the immediate CKL location assessing coastal processes and specifically, rates of coastal erosion. Reference is made to T&T (2016) for general discussion about coastal process relevant to the CKL. Although the location of the CKL is not specially included in the study, it provides useful context with regards to beach profiles, sediments, water levels and waves.

The direction of sediment transport (littoral or longshore drift) at the CKL is to the west and then north. Sediment size decreases with the littoral drift. Erosion from 'Cape Kidnappers' has been calculated by others previously to provide an estimated sediment volume of 18,000m^3/year (T&T 2016) to the sediment budget. This is presumably an averaged value for the entire stretch of coastline from Cape Kidnappers to Clifton.

The fetch length, the distance over which the wind can blow over the surface of the sea, from northerly and north easterly winds is 50 km and 65 km respectively. Wave refraction due to Black Reef will be important for wave characteristics.

Brief review of aerial imagery shows active retrogression of the cliffs. The location of the CKL seems to be an area of relative higher rates of erosion, compared to other sections of the cliffs. As mentioned previously, this is inferred as a result of the cliff forming materials and the absence of any reefs in the nearshore and foreshore.

Increasing sea level and intensity of storms (and associated wave heights) will be important considerations in the future for coastal erosion.

3. Landslide Terminology and Classification

A basic introduction to landslides is provided below, as it is critical for understanding landslide hazard and the associated risk. Reference is made to Appendix B for further information.

Landslide definitions used in this report are as presented by Cruden & Varnes (1996). This is the most widely-used landslide classification in general practice. A 'landslide' is defined as 'the movement of a mass of rock soil down a slope under the effects of gravity'.

Landslides are classified as per the movement type (failure mechanism) and the characteristics of the pre-failure material, as shown in the simplified figure below (Figure 3-1). Their rate of movement is also described as part of their classification, as shown in Figure 3-2 and Figure 3-3.

CKL

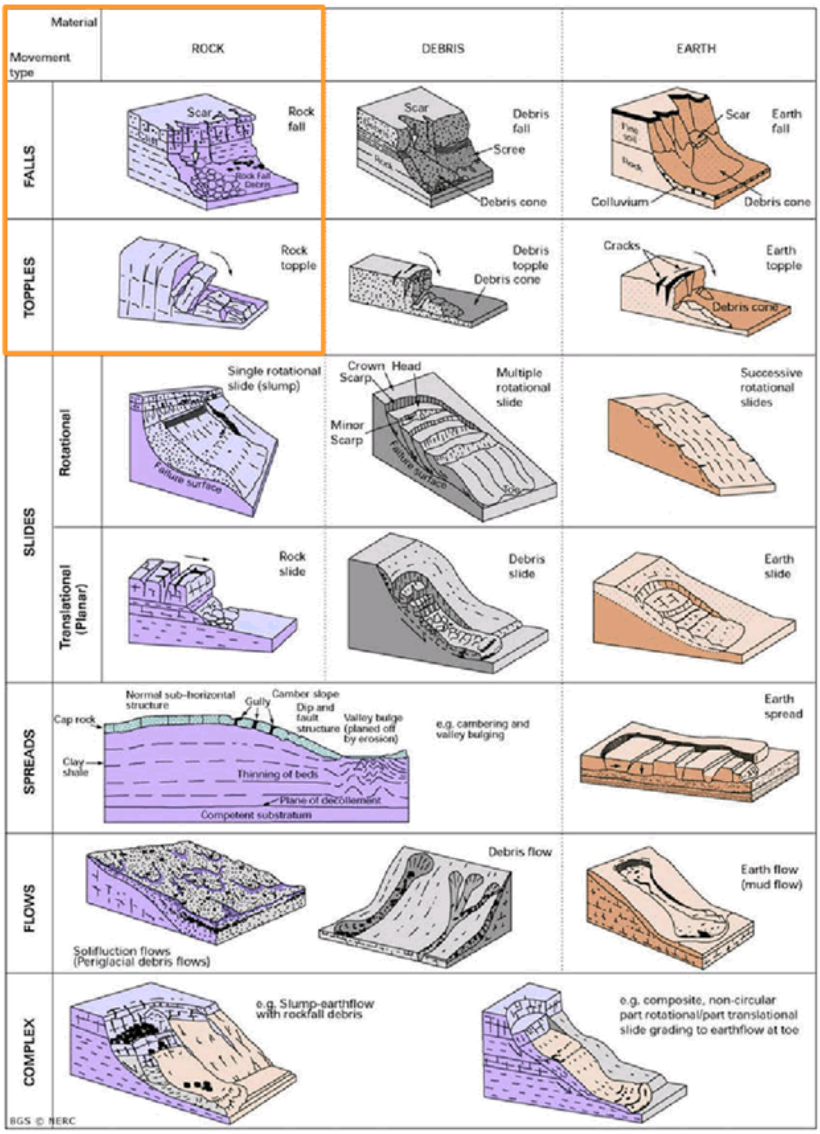


Figure 3-1: Landslide classification (from Cruden & Varnes 1996)

Velocity Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	Extremely Rapid			Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
		5×10^3	5 m/sec	
6	Very Rapid			Some lives lost; velocity too great to permit all persons to escape
		5×10^1	3 m/min	
5	Rapid			Escape evacuation possible; structures; possessions, and equipment destroyed
		5×10^{-1}	1.8 m/hr	
4	Moderate			Some temporary and insensitive structures can be temporarily maintained
		5×10^{-3}	13 m/month	
3	Slow			Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
		5×10^{-5}	1.6 m/year	
2	Very Slow			Some permanent structures undamaged by movement
		5×10^{-7}	15 mm/year	
1	Extremely SLOW			Imperceptible without instruments; construction POSSIBLE WITH PRECAUTIONS

CKL

Figure 3-2: Landslide velocities (from Cruden & Varnes 1996)

Activity

State	Distribution	Style
Active	Advancing	Complex
Reactivated	Retrogressive	Composite
Suspended	Widening	Multiple
Inactive	Enlarging	Successive
Dormant	Confined	Single
Abandoned	Diminishing	
Stabilised	Moving	
Relict		

Figure 3-3: Other landslide descriptive terms (from Cruden & Varnes 1996)

To avoid ambiguity:

- 'Rock' is defined as 'a hard or firm mass that was intact in its natural place before the initiation of movement'.
- 'Soil' is defined as 'an aggregate of solid particles, generally of minerals or rocks, that either was transported or was formed by the weathering of rock in place. Gases or liquids filling the pores of the soil form part of the soil'. 'Soil' can be divided into:
  - 'Earth', where '80% or more of the soil particles are less than 2 mm, the upper limit of sand-sized particles'.
  - 'Debris', where '20% to 80% of the particles are larger than 2 mm, and the remainder are less than 2 mm'.
- A 'fall' is defined as 'the detachment of soil and/or rock from a steep face, which moves down the slope by freefall, bouncing, rolling or sliding, or a combination thereof. May occur singularly or in clusters'. Falls are typically very rapid to extremely rapid.
- A 'topple' is defined as above for a 'fall', but where 'forward rotation or overturning occurs around an axis'. A difference from falls may be that movement may start slowly and then accelerate significantly, due to the rotation involved.
- A landslide 'trigger' is commonly defined as a single event that initiated the movement, typically an external stimulus, which causes an immediate or near-immediate response. Common landslide triggers in New Zealand are rainfall, earthquakes, volcanic activity, erosion and anthropogenic (human modification of slopes).

- Landslide 'causes' are considered as factors which make a slope vulnerable to failure (i.e. predispose). There can be one or several causes. The causes can either be internal to the landslide or external factors. They are typically divided into four key categories:
  - Geological – such as low strength materials, presence of weaker layers, kinematically feasible failure mechanisms due to unfavourable geological structures, materials which lose strength on exposure etc.
  - Hydrogeological – such as groundwater levels and pressures.
  - Geomorphological – such as erosion and weathering.
  - Anthropogenic (i.e. human activities) – such as slope modification or deforestation.

4. Landslide Characteristics

The following subsections provide a summary of the 23 January 2019 CKL characteristics. A subsequent technical report will provide greater detail.

4.1 Provisional Landslide Timeline

A timeline for the CKL is still being developed. What is clear, is that the immediate landslide location has been subject to previous landsliding. Landsliding has continued post the 23 January 2019 (refer subsequent Section).

The provisional timeline of key events based upon brief assessment is shown in Figure 4-1.

Date		
Pre-2015	•Description	Various sized rockfalls
	•Evidence	Anecdotal information, freely available imagery
2015	•Description	'Large' rockfall
	•Evdience	Anecdotal information, visual inspection, freely available imagery
	•Other	Impeded beach access
Dec 2018	•Description	'Moderate' rockfall
	•Evdience	Anecdotal information, visual inspection, freely available imagery
21 Jan 2019	•Description	'Small' rockfall
	•Evdience	Anecdotal information, visual inspection, freely available imagery
21/22 Jan 2019	•Description	'Moderate' rockfall
	•Evdience	Anecdotal information, visual inspection, freely available imagery
	•Other	Impedeed beach access
23 Jan 2019	•Description	'Large' rockfall (main landslide)
	•Evdience	Eyewitnesses, anecdotal information, imagery
	•Other	Two toursits injured, beach closed subsequently
23 Jan to 2 Feb 2019	•Description	'Small' rockfall
	•Evdience	Eyewitnesses, anecdotal information, visual inspection, monitoring data
	•Other	Beach closed
2 Feb 2019	•Description	'Large' rockfall
	•Evdience	Eyewitnesses, anecdotal information, visual inspection, monitoring data
	•Other	Near miss, two tourists, beach closed at the time
3 Feb to 15 Feb 2019	•Description	'Small' to 'moderate' rockfalls
	•Evdience	Eyewitnesses, anecdotal information, visual inspection, monitoring data
	•Other	Beach closed

Figure 4-1: Provisional timeline for the Cape Kidnappers Landslide

4.2 Pre-Landslide

An image of the cliff from March 2015 is shown below as Figure 4-2. This image is taken before the 2015 landslide occurred.

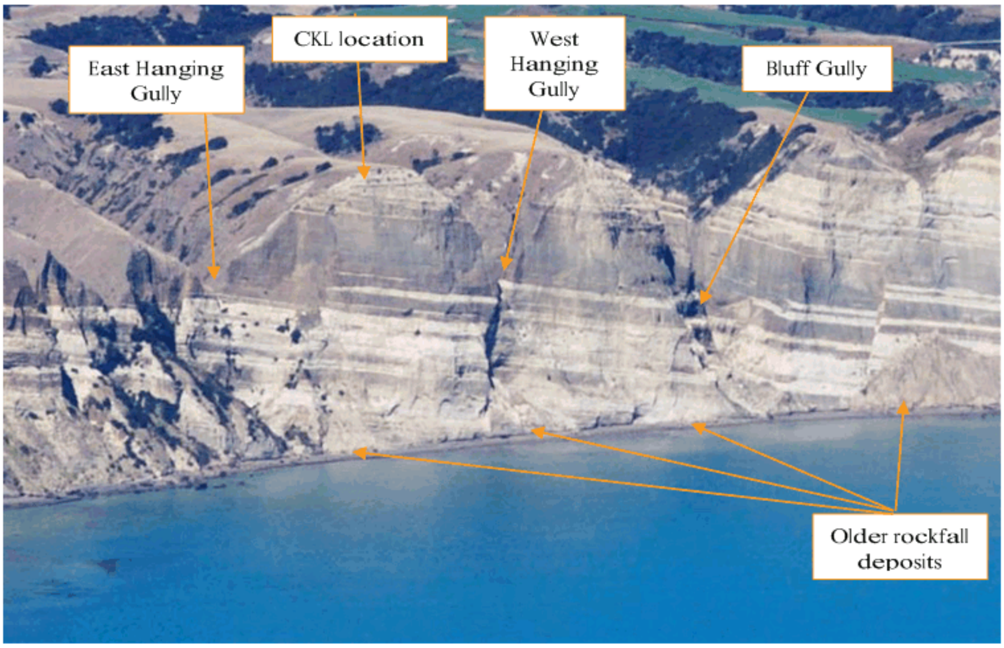


Figure 4-2: The CKL location in March 2015

The latest available image of the cliff prior to the CKL was taken in October 2018 and is shown below as Figure 4-3. This image provides the best information with regards to the 2015 rockfall and the pre-CKL cliff form.

Key observations from a review of the image are:

- 2015 rockfall[1]:
  - The 2015 failure was significant in size.
  - The source area was within the lower half of the cliff, largely within the interbedded tuff and conglomerate. The landslide left the upper half of the cliff significantly overhanging.
  - Detachment within the source area does not obviously appear to be controlled by defects such as joints within the rock. Detachment appears to have occurred through intact material, although the central part of the source area may have detached along a joint (planar in form).
  - The rockfall deposit mantles the lower part of the cliff and is steep in form. It is very steep, at 45°. The rockfall deposit will likely have been changed significantly by erosion prior to the image being taken (in the 2 years or so following the rockfall occurring).
- General:
  - No obvious loose material appears to be present in the CKL source area.
  - The cliff form in the CKL source area is comparable to the areas immediately either side. It is not obviously concave or convex in appearance. It appears to have a uniform slope angle.
  - The areas either side of the CKL source area looks geologically older, suggestive of previous failure of the CKL source area more recently than the areas either side.
  - No significant seepage is evident from the face.
  - The face is bare and free from vegetation.

[1] This was previously reported as 2014 based upon anecdotal information. Photographic information shows it occurred in 2015 (likely winter).

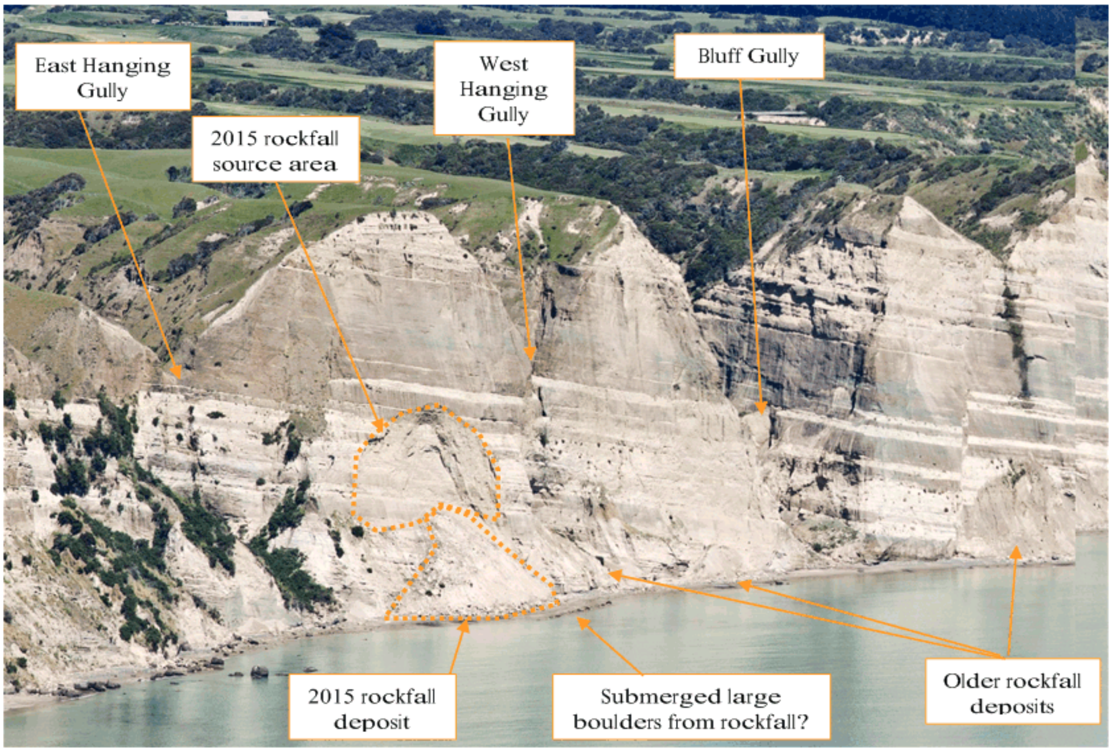


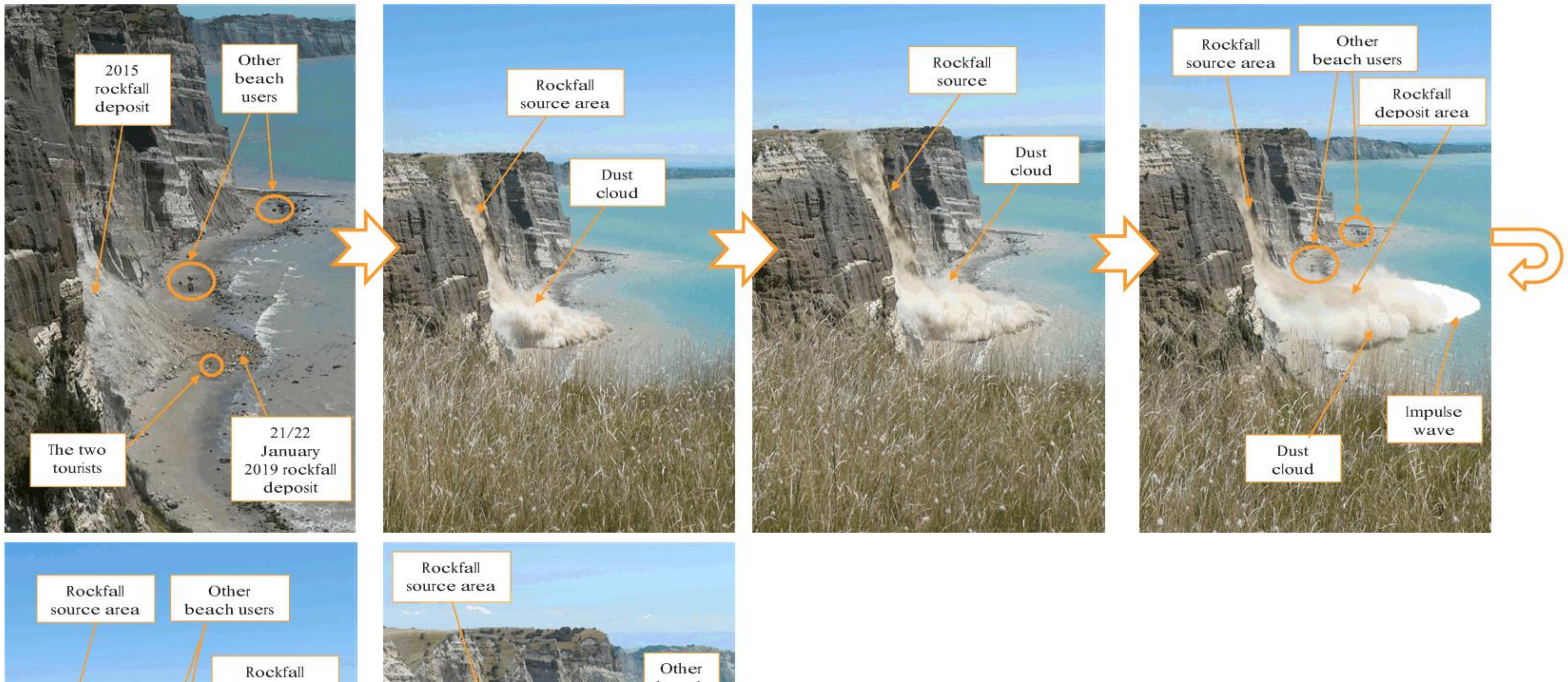
Figure 4-3: The location of the CKL viewed in October 2018, showing the earlier 2015 rockfall source area and deposit

More general comments with regards to the location prior to the CKL are:

- A reliable pre-landslide cliff survey is not available. The only data available is from 2011/2012 LiDAR.
- The location of the 2015 source area and associated deposit are well defined by available imagery.
- The locations of the rockfalls in December 2018 and in the few days before the 23 January 2019 CKL are not reliably known.

4.3 Failure Images

Third party images of the 23 January 2019 landslide are shown below in Figure 4-4. Key features are marked on the images. A video of the latter parts of the CKL can be found at https://twitter.com/AnushaBradley/status/1087917915779878912/video/1.


2015 rockfall deposit
Other beach users
The two tourists
21/22 January 2019 rockfall deposit
Rockfall source area
Dust cloud
Rockfall source
Dust cloud
Rockfall source area
Other beach users
Rockfall deposit area
Impulse wave
Dust cloud
Rockfall source area
Other beach users
Rockfall
Rockfall source area
Other

4.4 Mechanism

Based upon the work completed to date, the CKL of 23 January 2019 would be described as a 'rock fall'. Anecdotal information suggests toppling may have occurred locally. The rockfall deposit suggests the material was dry to moist. The velocity of the landslide would have been very rapid to extremely rapid based upon site characteristics and observations (such as the impulse wave generated).

Similar failures as a result of the 2011 Christchurch Earthquake were commonly referred to as 'cliff collapse' and termed 'rock avalanches' elsewhere from steep slopes in New Zealand.

There is no definitive evidence that the landslide was primarily controlled by rock mass defects ('structurally controlled'), such as by joints or the 5 m Fault. The detachment in the source area appears to have occurred largely through intact rock, being only locally released by pre-existing surfaces (joints). Although bedding dips obliquely out of slope, there is no obvious sliding surface in the imagery. Wedge and toppling also do not appear to be the primary failure mechanism based upon the absence of required rock defects.

4.5 Source Area Characteristics

Annotated oblique views of the rockfall source area is provided as Figure 4-5 and Figure 4-6.

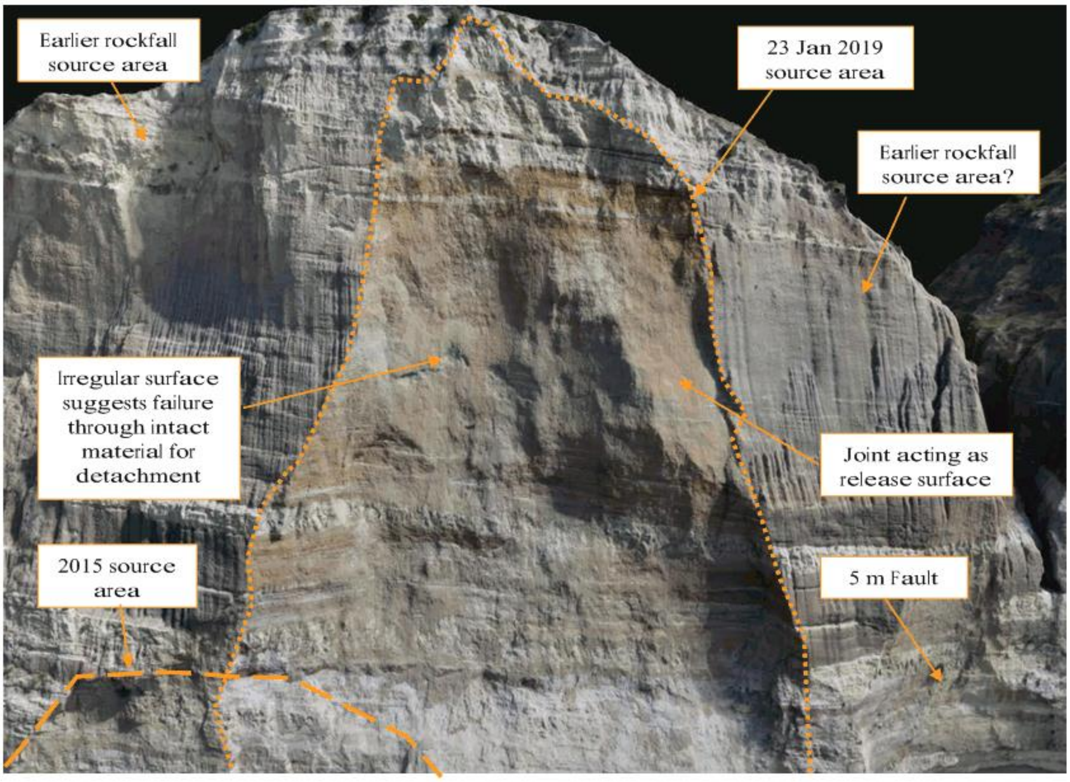


Figure 4-5: Oblique view of the rockfall source area, looking south (25 January 2019)

Key comments with regards to the rockfall source area are as follows:

- The source area was approximately 1,200 m².
- The source area volume was around 25,000 m³.

- The maximum width of the source area was 70 m.
- The elevation difference (height) of the source area was 110 m.
- The maximum thickness of the source area appears to have been around 15 m.
- Detachment at the source area appears to have occurred largely through intact material. Locally, there is evidence that some joints may have acted as the detachment/release surface (Figure 4-6).

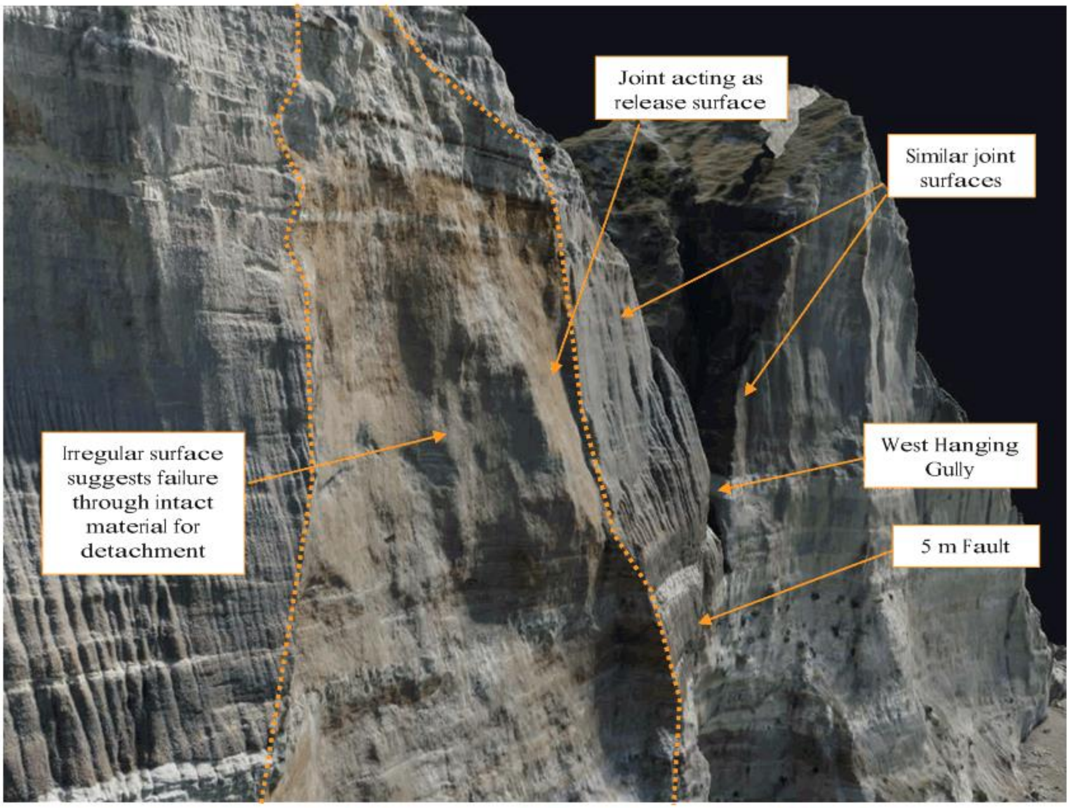


Figure 4-6: Oblique view of the rockfall source area, showing pre-existing rock defects that acted as release surfaces (25 January 2019)

4.6 Rockfall Deposit Characteristics

An annotated oblique view of the rockfall deposit is provided as Figure 4-7. A view looking east along the beach of the rockfall deposit is presented as Figure 4-8. The eroded 'toe' of the rockfall deposit is shown as Figure 4-9 to illustrate its composition.

Key comments with regards to the rockfall deposit are as follows:

- The rockfall deposit is 125 m wide (beach length) and extended about 75 m out from the base of the cliff below the low tide mark.
- Some fly rock appears to have extended out further from the base of the cliff than this, to almost 100 m. This is based upon the fresh appearance of the rock, compared to those which were pre-existing, typically covered with seaweed.
- The maximum thickness of the deposit is around 15 m.

- The morphology of the deposit supports a retrogressive failure, with evidence for several rockfalls.
- There is no evidence for flow-like behaviour in the deposit, in the form of ridges, cracking etc.
- The 2015 landslide debris at the base of the cliff is likely to have acted as a 'ramp', making the rockfall deposit travel out further from the base of the cliff than it otherwise may have done.
- The rockfall occurred at low tide, this is judged important for the characteristics of the rockfall deposit.
- The deposit can be described as a sandy gravel, with some silt, cobbles and boulders. A maximum boulder size of approximately 5 m³ was observed. It is apparent that the conglomerate largely broke down during failure to produce a soil-like material. Some isolated cobbles and boulders of conglomerate remain, which are those of higher intact strength.
- The rockfall deposit volume from the CKL is around 30,000 m³.
- Based upon the calculated source area volume and the rockfall deposit volume, a bulking factor of around 1.2 is estimated.
- There is no information available for the impulse wave generated as the rockfall deposit displaced the sea.
- The source area material was dry to moist at the time of failure, based upon the significant dust cloud generated.

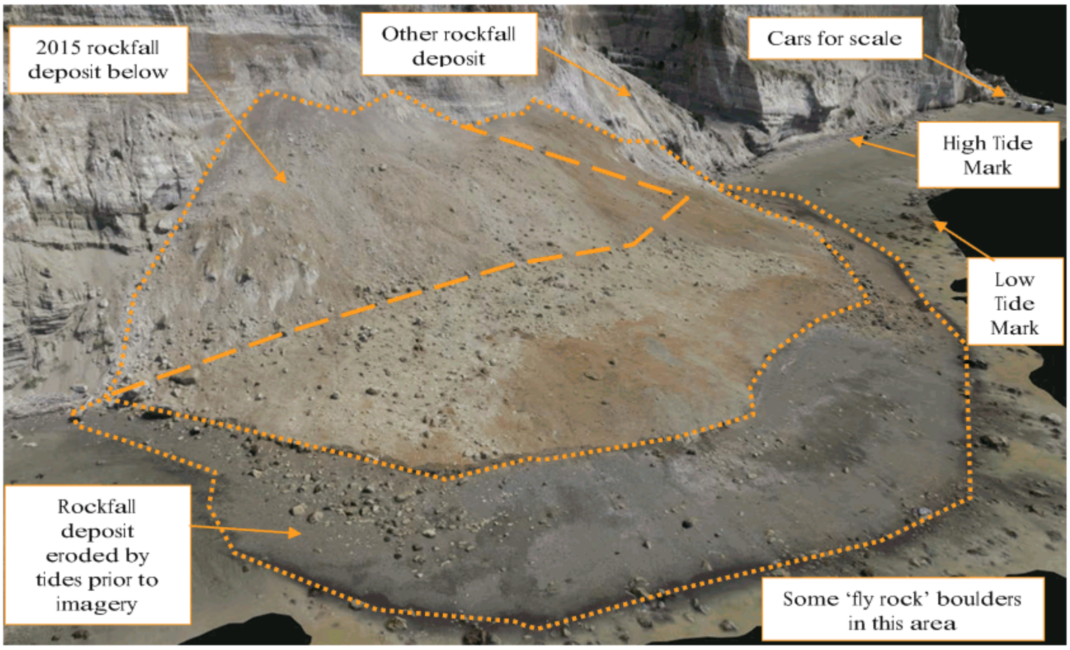


Figure 4-7: Oblique view of the rockfall deposit, looking southwest (25 January 2019)

Figure 4-8: Rockfall deposit viewed on the 28 January 2019 from the west

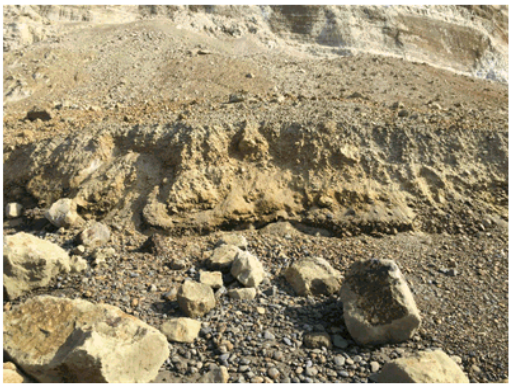


Figure 4-9: Example of the rockfall deposit following erosion, viewed on the 28 January 2019

4.7 Trigger

No definitive 'trigger' seems to have caused the 23 January 2019 CKL, based upon review of freely available data for typically landslide triggers in New Zealand. Although it is worth noting 50 mm of rain fell on the 16 and 17 January 2019, one week before the landslide.

4.8 Causes

Causes contributing to the 23 January 2019 CKL will be discussed in more detail in the technical report. For the CKL, causative factors appear to be largely geological and geomorphological. Anthropogenic causative factors can largely be excluded, other than the change in vegetation type at the cliff top. Hydrogeological factors do not seem critical at this stage of the assessment, as no seepage has been observed from the face previously and no significant rain had occurred in the immediately preceding days (24 to 48 hrs say) or was occurring at the time of failure.

Erosion at the base of the cliff is a key causative factor (see Figure 4-10) for the retrogressive failure of the cliff (i.e. from the base of the cliff upwards). Erosion seems to be higher at the CKL location compared to some other sections of the neighbouring coast, due to its strike and the absence of any significant 'reefs' in the foreshore or nearshore.

Another cause which should be investigated would be the effects of the overall climatic trends leading up to the landslide (i.e. hot and dry, potential desiccation or loss of strength of materials).

Figure 4-10: An example of recent landsliding triggered by erosion at the toe of the slope, location around 500 m east of the CKL (5 February 2019)

5. Monitoring and Performance

This section of the report details the performance of the CKL since its occurrence on the 23 January 2019.

5.1 Monitoring Methods

Three key methods of monitoring the CKL have been used, as detailed below.

5.1.1 Visual Inspection

Periodic inspections have been completed by Stantec to assess visual evidence for changes in the landslide source area and deposit. Inspections were completed as follows:

- Boat – 25 January.
- Beach – 25 January, 28 January, 31 January, 5 February and 8 February.
- Cliff top – 25 January, 29 January, 30 January and 5 February.

5.1.2 UAV

Periodic Unmanned Aerial Vehicle (UAV, drone) surveys have been completed to quantify changes in the landslide source area and deposit. Comparisons between surveys have been used to identify the locations and volumes of ongoing rockfalls. In addition, the drone surveys have been used to assess how the rockfall deposit is changing with time due to coastal processes.

- Equipment used:
  - Leica rover (GS16/GS18) and Leica base station (GS16/GS14).
  - DJI Matrice M200 UAV with X4S camera and Klau PPK GPS system.
- Coordinate control:
  - Origin of coordinates is IT XX SO 7407 (BCRN).
  - 801731.456mN, 426390.813mE (HB2000).
- Height control:
  - Origin of height is IT XX SO 7407 (BCRN).
  - RL 2.994 (NZVD 2016).
- Methodology:
  - Three control points were placed on top of the slip and, before each flight, 5-6 temporary control points were placed at the base of the slip. These points were all measured with RTK GPS with 30 second observation on each. These points were used as a mixture of control and check points.
  - A grid flight at altitude RL 70 m was flown first in autonomous mode to cover the base of the slip, followed by two flights in manual mode.
  - When possible PPK GPS was used to position each image to +-/30mm, however due to the height of the cliff and satellite geometry, PPK was not always the most suitable means of positioning the data. In the absence of good PPK observations, the data was coordinated solely with the ground control points.
  - Pix4D was used to process the UAV imagery and generate a point cloud, 3D textured mesh, orthoplane image, and nadir orthophoto.
  - Accuracies of check points were between 10-22mm horizontally and 12-20mm in height when comparing all processing reports.

- The average GSD has been ~1.73cm/px.

UAV (drone) surveys were completed on the 25 January, 28 January, 31 January, 5 February and 8 February.

In addition, two manual flights were completed from the cliff top on the 25 January and 4 February to collect general landslide images.

5.1.3 Cliff Top Ground Survey

To assess evidence for global instability of the cliff, survey monitoring points (23 No.) were established on the cliff top on 30 January (1 week after the CKL). The survey points were installed to provide greater accuracy of potential deformation at the cliff top location, than that which was being achieved by UAV survey. Subsequent survey of the installed monitoring points was completed on 31 January, 1 February, 4 February, 5 February, 11 February and 14 February. Surveying has been completed by Zorn Surveying Limited.

Key comments with regards to the ground-based survey are:

- Equipment used:
  - Total station theodolite.
  - SOKKIA Set 330R3 #D22823.
- Accuracy:
  - Reflectorless (White)
  - Fine measurement setting:
    - ±(3 + 2 ppm X D) mm (0.3 to 100 m).
    - ±(5 + 10 ppm X D) mm (over 100 to 150 m).
- Methodology:
  - 2 survey marks have been placed on site (‘control points’).
  - IS A approx. 1 m on landward side of fence line and this is the primary location from which the monitoring points are surveyed.
  - IS B is approx. 169.5 m inland on small rise. This is used to confirm the stability of IS A.
  - Observation by direct measurement to IS B and observations to 2 points approx. 45° to the left and right of ISB are used to confirm orientation and any movement at IS A.
  - Measurement is completed by line of sight, to avoid the need for accessing near the immediate cliff top.
  - The 23 monitoring points have been established. These are surveyed from IS A (2 sets recorded) then the data is downloaded into 12d survey software, where an XYZ output is produced.

The locations of the monitoring points are shown in Figure 5-1. Three rows of survey points were installed at approximately 5, 10 and 15 m distance from the cliff edge.

Figure 5-1: Locations of the survey monitoring points located at the cliff top, above the CKL location (5 February 2019)

5.2 Monitoring Results

The following sections detail the key changes in the CKL as observed by monitoring since 23 January 2019, relevant for short-term decisions with regards to risk.

Specifically:

- The frequency and characteristics of further rockfalls.
- Changes in the rockfall deposit on the beach – which is important for the areas beach users may access should the beach be re-opened (i.e. as the deposit is eroded, people will naturally go closer to the base of the cliff, in the location rockfalls are most likely to spatially impact (land)).

Reference is made to Appendix A for figures showing the change in the rockfall source area and deposit, as identified by the periodic UAV surveys.

Figure 5-2 shows elevation changes in the CKL source area between 25 January 2019 (the first UAV survey) and 8 February 2019 (the latest UAV survey). Figure 5-3 shows plan changes in the CKL rockfall deposit between 25 January 2019 (the first UAV survey) and 8 February 2019 (the latest UAV survey).

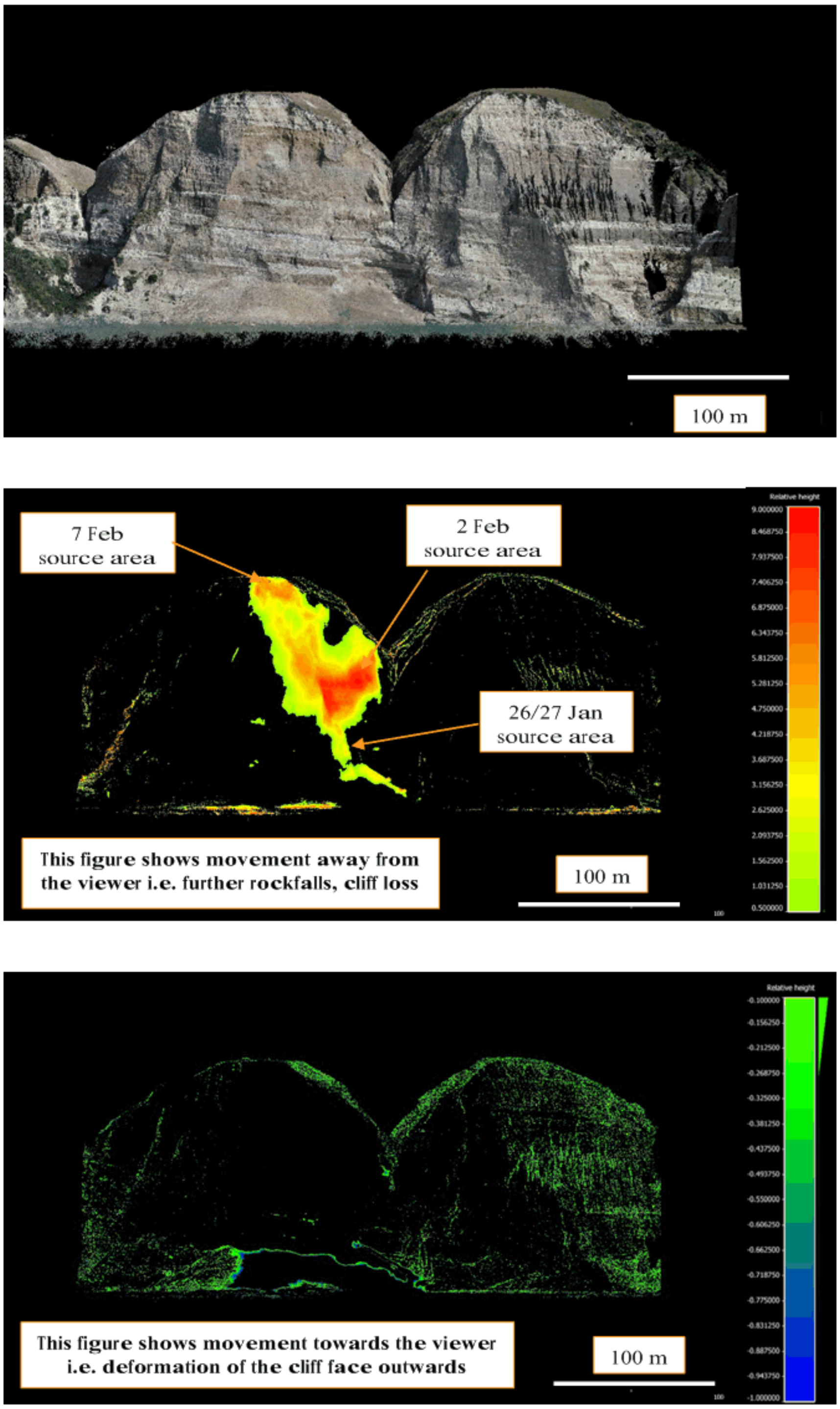


Figure 5-2: Elevation changes in the CKL between the 25 January 2019 and 8 February 2019 (scale m)

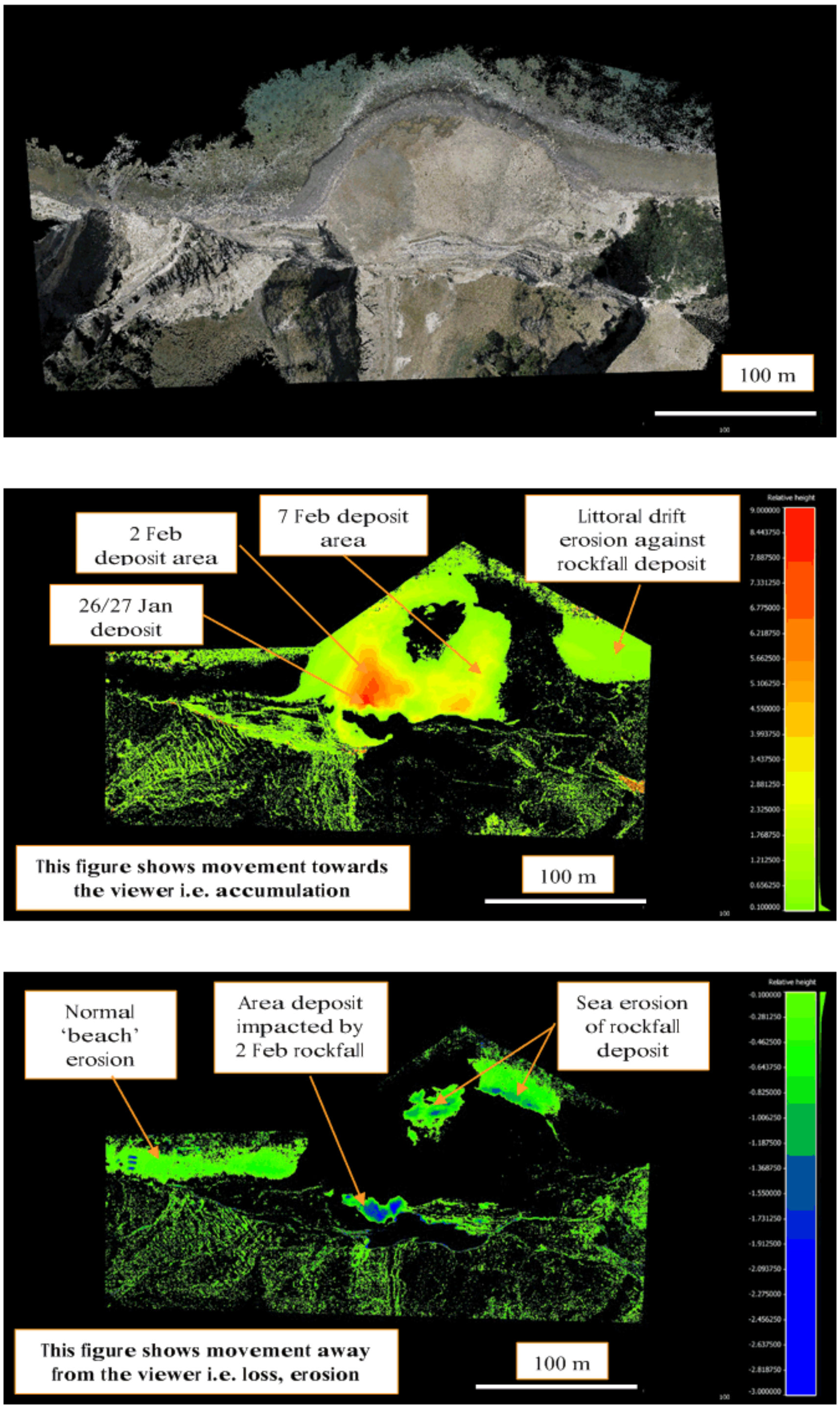


Figure 5-3: Plan changes in the CKL between the 25 January 2019 and 8 February 2019 (scale m)

The key observations from these figures can be summarised as follows (which does not include the 23 January landslide):

- 26 or 27 January 2019 landslide:
  - Location - lower left side scarp (or right side as you look at the cliff from the beach), in the vicinity of 5m Fault.
  - Source area volume 330 m³. The cliff face retrogressed 4 m locally. The rockfall occurred from Unit 3, which comprises interbedded conglomerate and tuff. The source area was 30 to 40 m above beach level.
  - Rockfall deposit volume 380 m³. A bulking factor of 1.15 was calculated. The rockfall deposit largely landed on the existing rockfall deposit, although some material did locally make it onto the beach. The overall rockfall deposit locally increased vertically 2 m.
  - The beach was closed at the time. The landslide was not observed and therefore no additional records are available. No obvious trigger.
- 2 February 2019 landslide:
  - Location - most of the cliff face immediately to the left of the left side scarp of the 23 January landslide (or right side as you look at the cliff from the beach). The landslide occurred above the 26/27 January landslide and likely destabilised the section of cliff face above it.
  - Source area volume 10,000 m³. The cliff face retrogressed up to 9 m locally. The rockfall occurred from Unit 2, which comprises conglomerate interbedded with some tuff. The source area was from 40 m above beach level to the cliff top (130 m above beach level).
  - Rockfall deposit volume 12,500 m³. A bulking factor of 1.25 is calculated. The rockfall deposit significantly increased the existing rockfall deposit on the beach in both plan and volume (i.e. in part it landed on the beach). The overall rockfall deposit locally increased vertically 8 m.
  - The beach was closed at the time. Two tourists were almost struck by the rockfall deposit (i.e. they were struck by the dust cloud generated by the landslide). No additional records are available. No obvious trigger.
- 7 February 2019 landslide:
  - Location - from the cliff top, largely above the source area from the 23 January landslide. The 23 January landslide appears to have destabilised this area.
  - Source volume 2,500 m³. The cliff face locally retrogressed up to 7 m. The cliff top also retrogressed several metres locally. The source area was 110 to 130 m above beach level. The landslide occurred in Unit 1, which comprises tuff with some interbedded conglomerate and likely some soil-like materials.
  - Rockfall deposit volume was 2,900 m³. A bulking factor of 1.15 was calculated. The rockfall deposit largely landed on the existing rockfall deposit, extending from the base of the cliff by 50 m. Evidence suggests the rockfall hit the upper part of the face following detachment. The overall rockfall deposit locally increased vertically by 5 m.
  - The beach was closed at the time. The landslide was not observed and therefore no additional records are available. No obvious trigger.

In addition to the above significant failures, the UAV data and direction visual inspection, indicates smaller rockfalls have also occurred. These have largely accumulated at the very base of the cliff on the existing rockfall deposit.

UAV data and visual inspection indicates no deformation of the cliff face, within the level of survey accuracy, outwards (i.e. deformation that may be expected with toppling for example).

The UAV data and visual inspection show that sea erosion of the rockfall deposit has been occurring between 25 January and 8 February. Several thousand cubic metres has already been eroded. Larger waves experienced between 10 and 13 February are likely to have resulted in significant further erosion of the rockfall deposit.

In summary, the survey monitoring points installed at the cliff top above the CKL have shown limited movement since their installation, a period of two weeks (31 January 2019 to 14 February 2019). As mentioned previously, a survey error of around 3 mm exists for this method of surveying. Should movement be occurring at the cliff top, suggestive of further cliff retrogression, it would be expected points would show movement towards the north and down in RL. Results which now lies outside the survey error are highlighted in bold.

Table 5-1: Changes in the survey monitoring points on the cliff top above the CKL (31 January 2019 to 14 February 2019)

Monitoring Point	Difference N (m)	Difference E (m)	Difference RL (m)
CKL01	0.004	**-0.005**	**-0.006**
CKL02	0.002	0.002	**-0.005**
CKL03	-0.001	-0.001	-0.003
CKL04		Lost with 7 February 2019 landslide	
CKL05	0.003	**-0.005**	-0.004
CKL06	0.002	**-0.005**	-0.003
CKL07	-0.001	-0.001	**-0.005**
CKL08	0.001	-0.001	-0.003
CKL09	-0.002	0	-0.003
CKL10	0.003	-0.002	-0.004
CKL11	0.001	-0.001	-0.004
CKL12	-0.002	**0.045**	0.003
CKL13	-0.001	0.001	-0.003
CKL14	-0.003	-0.001	-0.003
CKL15	**0.015**	**0.008**	**-0.006**
CKL16	-0.001	-0.002	-0.002
CKL17	0.003	0.001	-0.001
CKL18	0.006	0.003	-0.002
CKL19	0.002	0	-0.001
CKL20	0.003	-0.002	-0.002
CKL21	0.001	-0.004	-0.002
CKL22	-0.002	-0.004	-0.002
CKL23	-0.001	-0.004	-0.002

Key observations from the survey data:

- Nearly all survey points have reduced in level. Those which are at or above the survey confidence, are nearly all those located in closest proximity to the cliff edge.
- Survey point CKL04 was lost in the 7 February 2019 landslide but had shown no movement outside survey confidence before that time.
- The surveyor believes the differences in N and E observed at CKL12 and CKL15 are survey error, although readings were taken twice and showed the same results.

As part of the completed visual inspections at the cliff top, several 'sinkhole' type features have been observed. These are assessed to pre-date the CKL, based upon their appearance. It is currently interpreted that these features are more likely related to near-surface shallow slope instability than global instability of the cliff. Similar landforms are evident on the gully side slopes. Continued monitoring of the survey points will help confirm this assumption.

5.3 Factors Influencing Landslide Performance

When the above performance data is considered, the following factors influencing landslide performance should be considered:

- There has been no significant rainfall since 23 January 2019 (less than 10 mm).
- There have been no significant storm events with associated larger waves, since 23 January 2019.[2]
- There has been no felt earthquakes, since 23 January 2019.

All monitoring of the CKL to date has been essentially completed under 'sunny sky' conditions. The likely performance of the CKL under other environmental conditions (such as rainfall, earthquakes and storms with significant waves) is therefore not reliably known. This is a key uncertainty for short to medium-term risk management.

5.4 Remedial Works

Due to site and landslide characteristics, there is relatively limited remedial works which could be practically completed. Helicopter sluicing would be one option to remove apparent loose material on the face of the cliff, but we understand that has been shown to be of variable effectiveness following the 2016 Kaikoura Earthquake.

It is assumed the rockfall deposit will be left for the sea to progressively erode. Should the landslide deposit need to be moved for some reason, then remotely controlled earthmoving equipment can be used to improve worker safety.

5.5 Likely Future Performance

Based upon existing monitoring and judgement, key changes expected are:

- Rockfall source area (refer Figure 5-4):
  - 1. Cliff face to the right (or left as viewed from beach). Large volume. Deposit will impact beach. Significantly overhanging. Oldest geological surface.
  - 2. The undercut area near 5 m Fault. Moderate volume. Subject to sea erosion and surface water erosion from West Hanging Gully. Significantly overhanging. Deposit will land on existing deposit but may locally impact the beach.
  - 3. Top of cliff, some loose and/or overhanging material. Small volume. Likely to land on existing deposit.
  - 4. Left side scarp of the 2 February landslide (or right side as viewed from the beach). Some loose and/or overhanging material. Small to moderate volume. Likely to land on existing deposit but may locally impact the beach.
  - 5. Small volume failures from face, locally overhanging. Will likely land on existing rockfall deposit.

[2] Large waves have been experienced between the 10 and 15 Feb 2019, but their effects on the rockfall deposit are not currently known.

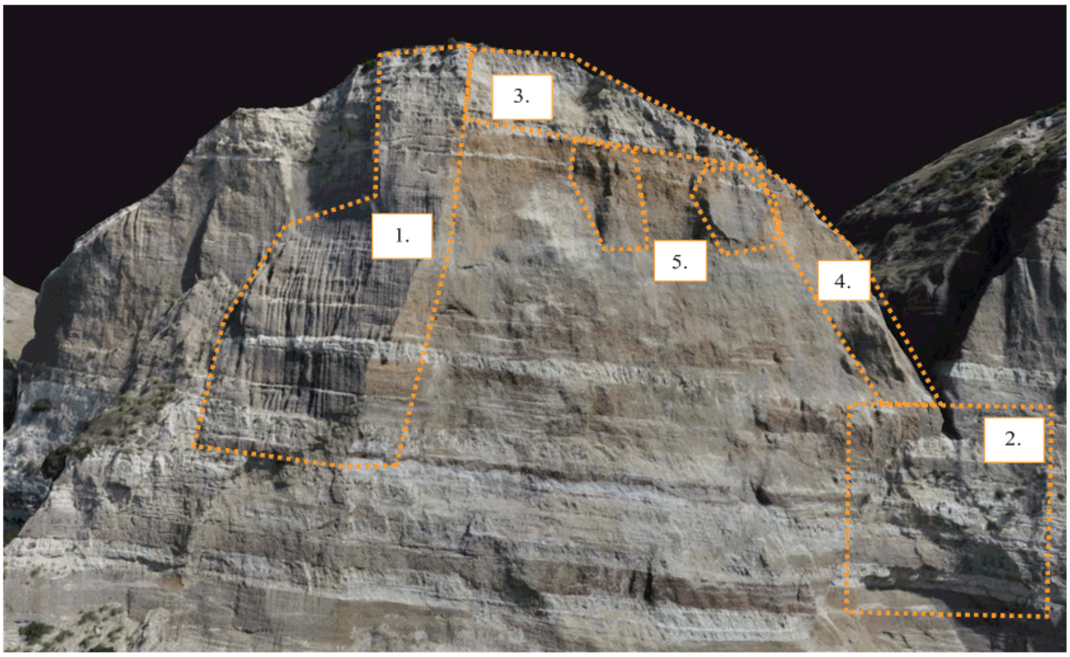


Figure 5-4: Key areas of likely future changes in the CKL source area (image 8 February 2019)

- Rockfall deposit area (Figure 5-5):
  - It is expected that the rockfall deposit will be eroded progressively over time, with the original beach 're-developed'.
  - This is important, as beach users will be passing more into areas future rockfalls may spatially impact (i.e. land) closer to the base of the cliff.

It can be expected that the occurrence of landsliding at the location will eventually decrease with time, back to a 'baseline' level of landsliding. What that 'baseline' level is, is not currently known. However, it is expected that the level observed since the 23 January exceeds that baseline level. Each time a more significant landslide occurs an increased likelihood of landsliding will exist for a period. This concept is shown below in Figure 5-6. This is simplified, as it takes no consideration for changes in environmental factors, for example which, may locally impact this trend (such as storms with waves, rainfall, earthquakes etc.).

With the above concept in mind, two key uncertainties exist which are important for understanding the landslide hazard risk:

- What is the 'baseline' level of landsliding?
- What is the time to reach this 'baseline'?

Likelihood cannot be substituted for risk in Figure 5-6. Risk will not necessarily reduce as the likelihood of landsliding reduces. This is discussed in the following section.

The current rate of landsliding will reflect current climatic and marine conditions. This may change in the future, as a result of climate change (sea level rise and increased storminess). The current 'baseline' may not therefore be the future 'baseline'.

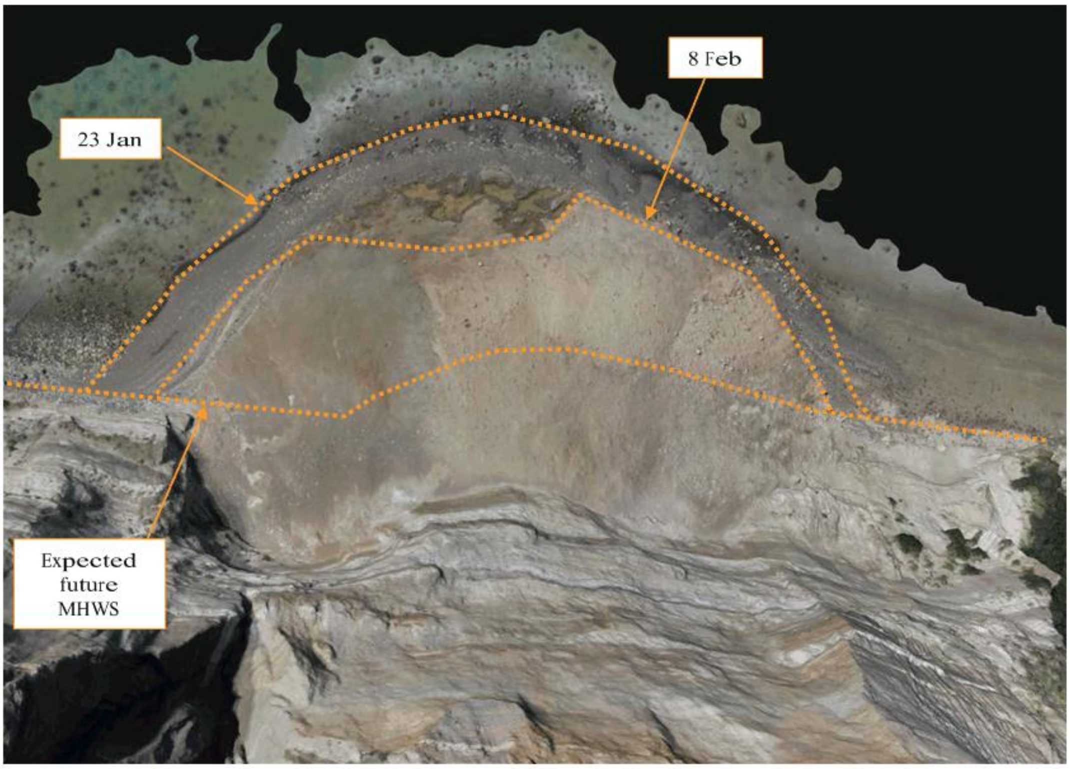


Figure 5-5: Key areas of likely future changes in the CKL deposit area (image 8 February 2019)

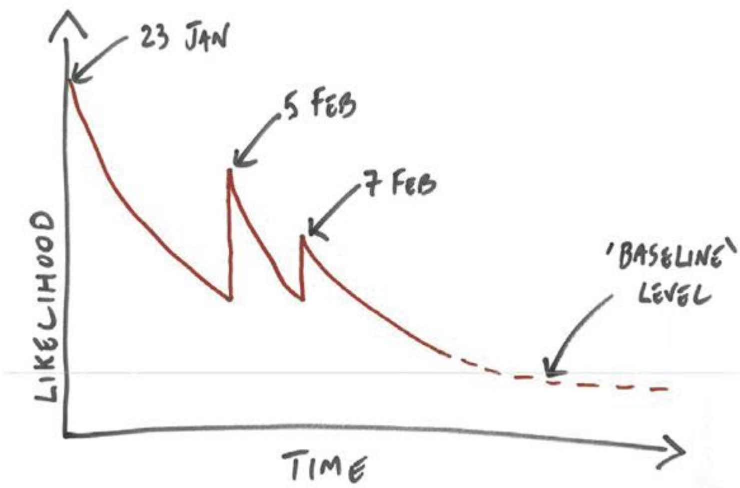


Figure 5-6: Simplified expected trend of the likelihood of further landsliding

5.6 Future Monitoring

Monitoring of the CKL should continue until a council decision is made with regards to beach re-opening. This is so an understanding of the performance of the landslide under more variable environmental conditions is obtained and an understanding of what may be a 'baseline' level of landsliding is developed. The current monitoring program should be continued but should be reviewed as results are obtained and analysed (including the methods used and their frequency).

Other monitoring methods typically used to develop an understanding of landslide behaviour includes instruments installed to detected changes in movement rates or groundwater levels and pressures for example in the landslide. Due to site and landsliding characteristics, these are not judged applicable in this instance.

Sentinel satellite data has not been acquired and used for monitoring of the CKL. This could be of value for future studies and ongoing risk management. The Sentinel data can be used to understand changes in the cliffs and beach which are occurring over time, by comparing periodic images obtained via satellite.

Subsurface investigations and testing are not judged to be a requirement to inform short-term decision-making. This is as there is good exposure of the site which allows development of a ground model and to qualitatively understand the geotechnical characteristics of the site materials. It is noted that materials of the same geological formation of the cliff can be inspected at beach level to the west, due to the inclination of bedding.

6. Risk Discussion

6.1 Introduction

The following subsections provide a discussion with regards to landslide risk at the immediate CKL location. The risk posed by future landsliding has not been quantified by this study. The risk posed by landslide hazard has also not been quantified previously.

The key elements at risk are discussed in Section 1.3. As one of the key elements at risk is people, with the potential for injury or loss of life (PLOL), this is judged critical for decision-making (i.e. public safety).

Key definitions relevant for this Section of the report are:

- Acceptable risk – 'a risk which everyone is prepared to accept. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort'.
- Tolerable risk – 'a risk within a range that society can live with to secure certain net benefits. It is a range of risk that we do not regard as negligible or as something we might ignore, but rather something we need to keep under review and reduce further if and as we can'.
- Societal risk – the risk of a given hazard occurring, the consequences of which would affect more than an individual. As the site receives a high number of visitors, there is the potential for multiple injury/fatalities and on this basis, societal risk is a key consideration.

Further definitions of risk terminology are presented as Appendix C.

Acceptable risk criteria are typically one or two orders of magnitude lower than tolerable risk criteria. Tolerable risks are those used for landslide hazard scenarios such as this. Societal tolerable risks are lower than individual tolerable risks. This is as society is less prepared to accept risks that affect many people, as opposed to an individual.

It is important to note than many beach users likely do not know there is a landslide hazard (and therefore associated risk).

6.2 Risk Discussion

It is assessed:

- Risk at the immediate CKL location was not quantified prior to the 23 January 2019 landslide occurring (nor along the remainder of the beach from Clifton to Cape Kidnappers). This report has not attempted to quantify what the risk is currently. We are not stating an opinion that we believe it to be unacceptably high but only that it is not quantified.
- The risk is not constant and will be changing continually.
- Relatively speaking, the risk at the immediate CKL location is currently higher than it was prior to the landslide as:
    - There is currently an increased likelihood of landsliding. Further landslides have and continue to occur at the site.
    - As the rockfall deposit on the beach is eroded, the probability of a beach user being struck by a landslide will likely increase. This is as beach users will be closer to the base of the cliff in the location any future landslides are most likely to impact. Analysis would be required to reliably confirm this, however. See Figure 6-1.
- Although the risk before the CKL occurred was unquantified, and the risk is currently still unquantified, the overall risk trend is likely one of increasing risk. This is largely due to the significantly increasing number of beach users.
- For this reason, reliance on precedence over the last 50 years or so is not a sound argument for the pre-CKL risk being acceptable. There have been several incidents and many near misses reported previously and this makes no consideration of the significantly increasing visitor numbers.

- The current short to medium-term is also the period of the year with the highest visitor numbers and therefore when the risk is likely to be at its annual highest.
- A key uncertainty in the short to medium-term is that the completed surveillance of the CKL since it occurred has essentially been under 'sunny sky' conditions. The likely performance of the CKL under different environmental conditions which are judged important for its stability, such as rainfall, earthquake shaking and storms with associated wave action, is therefore not reliably known.
- Other key factors to consider are:
  - Rockfalls can be more difficult to inspect and monitor compared to some other landslide mechanisms. Especially when the site characteristics are considered.
  - Rockfalls do not always occur with pre-failure warning signs, like some other landslide mechanisms. Additionally, any warning signs that do occur may not be seen, for various reasons. Pre-failure instability which occurred before the 23 January CKL cannot be relied upon as always occurring before landsliding.
  - Rockfalls are typically 'extremely rapid' and escape is often not possible. For other landslide mechanisms which are of slower velocity, evacuation can be possible.
  - When people are struck by rockfall, published information shows the probability of death is high. Although it is acknowledged that four instances of people surviving rockfall impact have now occurred on Clifton Beach.
  - Large volume rockfalls are not a necessity to cause injury or a fatality. Even a small rockfall, of less than 1 m^3, could cause an injury or a fatality, considering the site characteristics (i.e. high steep cliffs and the potential for people to be at the base of the cliff considering the beach width).

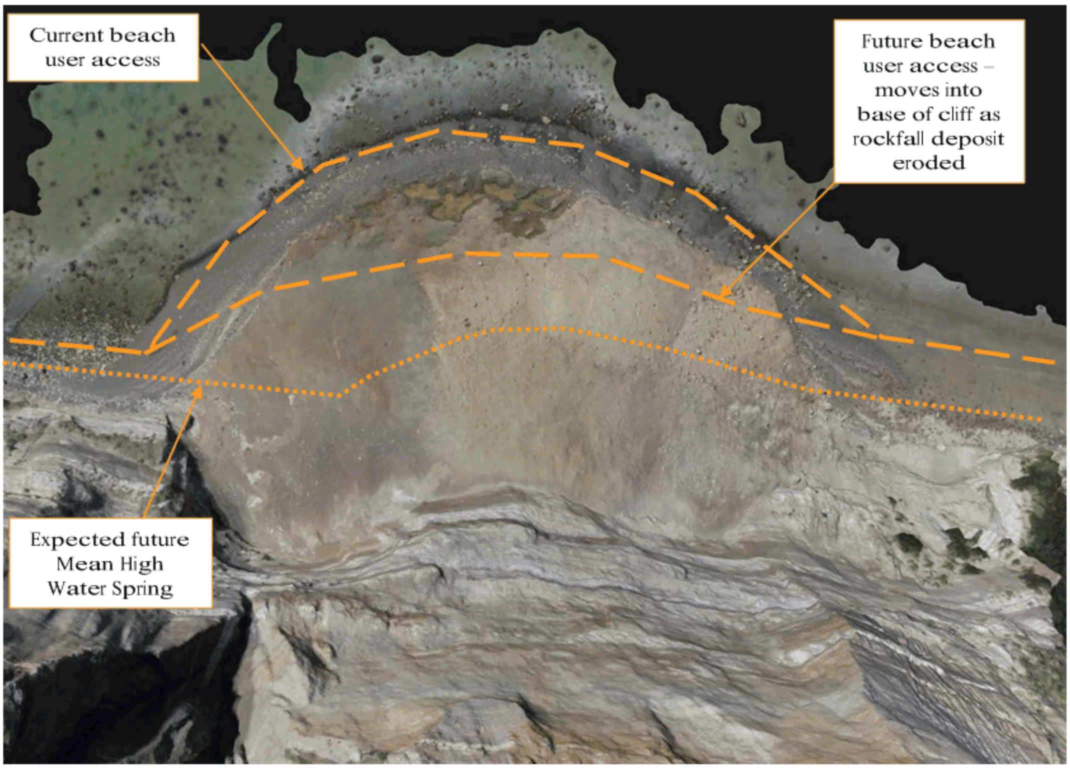


Figure 6-1: How changes to the rockfall deposit impacts beach user risk

6.3 Quantitative Risk Assessment (QRA)

A QRA has not been completed as part of this assessment. A QRA is recommended to be completed for the CKL location. QRA's are considered required when assessing PLOL so the risk can be compared to established criteria for tolerable risk. This QRA should be completed in accordance with the recommended methodology of the Australian Geomechanics Society Practice Note Guidelines for Landslide Risk Management (2007). This is the most -widely used methodology for assessing PLOL in New Zealand. Examples of its recent application include:

- Department of Conservation (DOC) – several examples to assess the probability of PLOL at their assets which experience large visitor numbers, such as Fox Glacier and Franz Joseph Glacier.
- Christchurch City Council (CCC) – following the 2011 Christchurch Earthquake to assess the risk associated with rockfall and cliff collapse hazard in the Port Hills, together with the associated land zonation.

The risk calculation from AGS (2007) is summarised in Figure 6-2.

For loss of life, the individual risk can be calculated from:

$$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)} \quad (2)$$

Where

- $R_{(LoL)}$ is the risk (annual probability of loss of life (death) of an individual).
- $P_{(H)}$ is the annual probability of the landslide.
- $P_{(S:H)}$ is the probability of spatial impact of the landslide impacting a building (location) taking into account the travel distance and travel direction given the event.
- $P_{(T:S)}$ is the temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
- $V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

A full risk analysis involves consideration of all landslide hazards for the site (e.g. large, deep seated landsliding, smaller slides, boulder falls, debris flows) and all the elements at risk.

Figure 6-2: QRA calculation for the probability of loss of life from AGS (2007)

Key components of any future QRA will be:

- A coordinated approach with other relevant stakeholders – such as the DOC and Gannet Beach Adventures.
- Investigations to define the input parameters for the risk calculation.
- Sensitivity analysis for varying input parameters for the risk calculation.
- Landslide hazard maps – will need to be developed along the entire beach, so the differing risk can be determined. This will also be important for working out the risk to visitors per trip.
- Assigning the individual PLOL for different beach users and assessing this against risk acceptance criteria. Examples may include:
  - The individual most at risk will need to be identified. Most likely an employee of Gannet Beach Adventures or a local, who regularly accesses the beach.
  - A risk per trip for visitors:
    - General public, on foot.
    - Gannet Beach Adventures trip.
- Assessing the societal risk and assessing this against risk acceptance criteria.
- Peer review.
- Defining acceptance criteria (see below).

For planning purposes, a QRA would likely take approximately six months to complete. But this timeframe will be very much dependent on the completion of investigations required to inform the QRA, stakeholder involvement in the QRA and its peer review. The output of the QRA needs to be sound, as the key element at risk is people (i.e. public safety) and there is the potential for high consequences (i.e. multiple fatalities).

6.4 Tolerable Risk Acceptance Criteria

Three scenarios will need to be considered and satisfied when the risk is assessed as part of a QRA:

- Individual tolerable risk criteria (PLOL).
- Societal tolerable risk criteria.
- As Low As Reasonably Practicable (ALARP) is met.

These are discussed in more details in the subsections below.

6.4.1 Individual Risk

Risk acceptance criteria would need to be established as part of the QRA. Guidance on tolerable risk acceptance criteria are provided in AGS (2007), as shown below in Figure 6-3 (individual most at risk). This guidance is based upon AGS review of tolerable risk criteria from a variety of other similar hazards both nationally and internationally.

Situation	Suggested Tolerable Loss of Life Risk for the person most at risk
Existing Slope (1) / Existing Development (2)	10^{-4} / annum
New Constructed Slope (3) / New Development (4) / Existing Landslide (5)	10^{-5} / annum

Figure 6-3: Individual tolerable risk acceptance criteria from AGS (2007)

As context for the above risk acceptance criteria, Figure 6-4 shows these criteria against known New Zealand natural hazard risks and other everyday risks that have been quantified. This shows that the individual tolerable risk criteria are comparable to road accidents and drowning for example.

We understand that CCC adopted these tolerable risk acceptance criteria as part of land zoning following the 2011 Christchurch Earthquake.

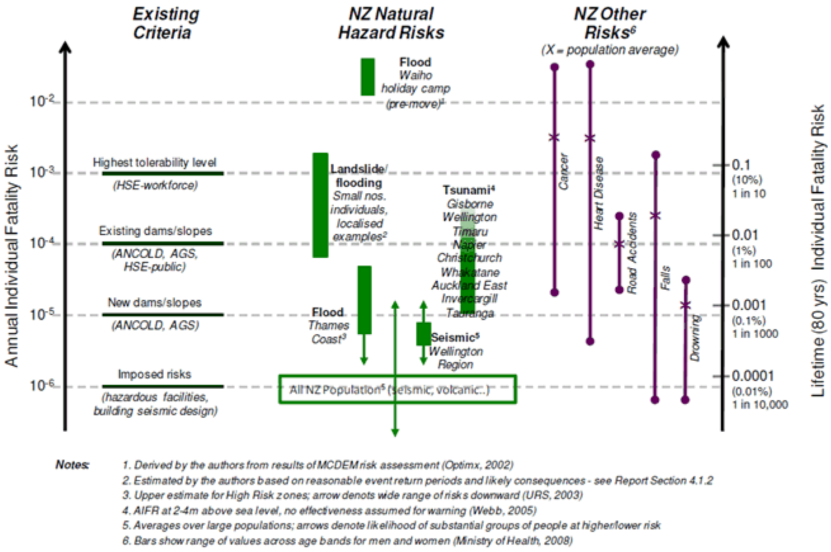


Figure 6-4: Comparison of known New Zealand risks and tolerable risk criteria (from GNS 2012)

6.4.2 Societal Risk

A key component of any future QRA will be the assessment of 'societal risk'. This accounts for society's intolerance to incidents that that cause many simultaneous casualties. Society will generally expect that the probability that the incident may occur be low. Societal risk is typically expressed by f-n plots. Figure 6-5 shows the tolerable risk acceptance criteria for societal risk from ANCOLD (2003) as an example. This shows with an increasing number of fatalities, how the acceptable tolerable risk criteria become lower (10 fatalities, the tolerable risk criteria is 10 times lower than the individual tolerable risk).

ANCOLD specify that risks which lie above the appropriate limit of tolerability are unacceptable, except in exceptional circumstances. ANCOLD also state that to be acceptable, risks are to be lower than the limits of tolerability 'to an extent determined in accordance with ALARP'.

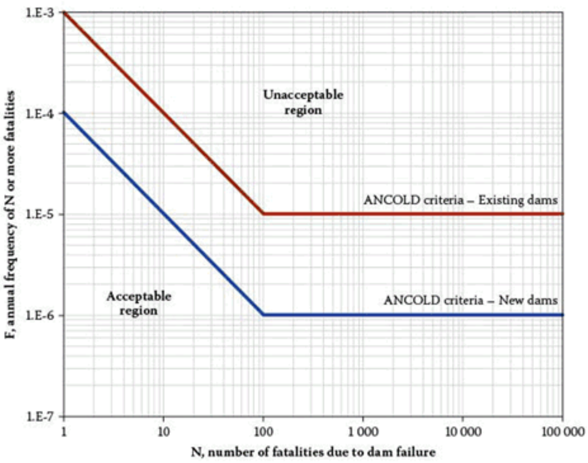


Figure 6-5: Societal tolerable risk acceptance criteria - F-N plot from ANCOLD (2003)

6.4.3 ALARP

A further important principle for tolerable risk is that of As Low As Reasonably Practicable (ALARP). ALARP can be further defined as (from ANCOLD 2003):

- 'Risk is tolerable only if the risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained'.
- 'Residual risk is tolerable only if further risk reduction is impracticable or requires action that is grossly disproportionate in time, trouble and effort to the risk reduction achieved'.

6.5 Other

A further item to be considered as part of any future QRA, will be the applicability of any other design standards/criteria. For example, if the beach is considered a legal road, the applicability of the NZTA Bridge Manual (2018) and if exemptions can be made from this.

7. General Landslide Hazard

The section of beach between Clifton and Cape Kidnappers is approximately 10 km long. Most beach users visiting this area will access this section of beach (20 km return trip).

Brief review of freely available information for the section of beach between Clifton and Cape Kidnappers shows that landslide hazard exists elsewhere and not just at the immediate CKL location. This evidence includes previous incidents/near misses, anecdotal information and review of aerial imagery confirming previous landsliding.

The risk posed by landslide hazard along the beach will vary, due to the differing site characteristics along the beach. Differing characteristics include cliff height and form, cliff forming materials, the width of beach and varying numbers and behaviours of beach users. The current rates of landsliding will reflect the current climatic and marine conditions. These current rates may be different in the future, due to changes as a result of climate change (higher sea levels, increased storminess).

It is understood that the risk posed by landslide hazard is currently unquantified. A QRA is recommended for the section of beach between Clifton and Cape Kidnappers to assess the risk posed by landslide hazard to the different elements at risk (as detailed in the previous Section for the CKL location). Although the landslide hazard risk is unquantified, it is clear the overall risk trend is one of increasing risk, largely due to increasing visitor numbers.

The risk posed by landslide hazard away from the immediate CKL location has not changed as a result of the CKL.

8. Conclusions and Recommendations

8.1 Conclusions

The key characteristics of the 23 January 2019 CKL are:

- The cliff is 130 m high, with an overall slope angle of 70°. It strikes east-west and has a northerly aspect. The beach width is 10 m from above the high tide mark to the base of the cliff or 25 m from the low tide mark to the base of the cliff.
- The cliff forming materials are interbedded sandstone, tuff and conglomerate, which are less than 2 million years old (geologically 'young'). They are bedded, which dips obliquely out the slope towards the northwest at 12°. They are 'massive' in structure, being largely free from rock defects such as joints.
- The landslide mechanism comprises a rockfall, with some evidence for localised toppling failure. The failure mechanism is sometimes referred to as a 'cliff collapse' or 'rock avalanche'.
- The CKL had a source area volume of approximately 25,000 m^3. The source area was largely the mid to upper two thirds of the cliff and primarily occurred in conglomerate interbedded with some tuff. Failure appears to have been through the 'intact' rock material and does not appear to be significantly controlled by rock mass defects, such as joints. Locally however, some joints may have acted as the release surface for the rockfall.
- The rockfall deposit volume was around 30,000 m^3 (i.e. on the beach). The deposit was 125 m wide (beach length) and extended 75 m out from the base of the cliff, beyond the low tide mark. Some fly rock appears to have extended out further from the base of the cliff than this.
- The characteristics of the CKL deposit appear to have been strongly influenced by the presence of the 2015 landslide debris at the base of the cliff, which appears to have acted as a 'ramp' and projected it out further from the base of the cliff than otherwise may have been the case.
- The velocity of the landslide would be described as 'extremely rapid', as demonstrated by the injured tourists' inability to escape and the generated impulse wave from the rockfall deposit displacing the sea.
- There was no definitive 'trigger' for the landslide, which occurred under 'sunny sky' conditions. A number of apparent landslide 'causes' have been identified by this assessment. A key one of which is erosion of the base of the cliff resulting in the over steepening of the slope and the associated retrogressive landsliding as the cliff tries to find a stable angle. The earlier 2015 landslide at the same location was a critical part of this process. This occurred directly below the 23 January 2019 CKL.
- The CKL location appears to have had a higher landslide hazard than other parts of the beach prior to the 23 January 2019 landslide occurring. Landsliding had occurred in the days, weeks and years prior.
- Subsequent to 23 January 2019, landsliding has continued to occur at the immediate CKL location.
- It can be expected that the occurrence of landsliding at the location will eventually decrease with time, back to a 'baseline' level of landsliding. What that 'baseline' level is, is not currently known. However, it is expected that the level observed since 23 January exceeds that baseline level. Each time a more significant landslide occurs an increased likelihood of landsliding will exist for a period.

Based upon the findings of this assessment completed 15 February 2019, it is concluded:

- Risk at the immediate CKL location was not quantified prior to the 23 January 2019 landslide occurring (nor along the remainder of the beach from Clifton to Cape Kidnappers). This report has not attempted to quantify what the risk is currently. We are not stating an opinion that we believe it to be unacceptably high but only that it is not quantified.
- The risk at the immediate CKL location is currently higher than it was prior to the landslide as:
  - There is an increased likelihood of landsliding.
  - As the rockfall deposit on the beach is eroded, the probability of a beach user being struck by a landslide will likely increase. This is as beach users will be closer to the base of the cliff in the location any future landslides are most likely to impact. Analysis would be required to reliably confirm this however.

- Although the risk before the CKL occurred was unquantified, and the risk is currently still unquantified, the overall risk trend is likely one of increasing risk. This is largely due the significantly increasing number of beach users.
- For this reason, reliance on precedence over the last 50 years or so is not a sound argument for the pre-CKL risk being acceptable (or the current risk). There have been several incidents and many near misses reported previously and this makes no consideration of the significantly increasing visitor numbers.
- The current short to medium-term is also the period of the year with the highest visitor numbers and therefore when the risk is likely to be at its annual highest.
- A key uncertainty in the short to medium-term is that the completed surveillance of the CKL since it occurred has essentially been under 'sunny sky' conditions. The likely performance of the CKL under different environmental conditions which are judged important for its stability, such as rainfall, earthquake shaking and storms with associated wave action, is therefore not reliably known.
- Other key factors to consider are:
    - Rockfalls can be more difficult to inspect and monitor compared to some other landslide mechanisms. Especially when the site characteristics are considered.
    - Rockfalls do not always occur with pre-failure warning signs, like some other landslide mechanisms. Additionally, any warning signs that do occur may not be seen, for various reasons. Pre-failure instability which occurred before the 23 January CKL cannot be relied upon as always occurring before landsliding.
    - Rockfalls are typically 'extremely rapid' and escape is often not possible. For other landslide mechanisms which are of slower velocity, evacuation can be possible.
    - When people are struck by rockfall, published information shows the probability of death is high. Although it is acknowledged that four instances of people surviving rockfall impact have now occurred on Clifton Beach.
    - Large volume rockfalls are not a necessity to cause injury or a fatality. Even a small rockfall, of less than 1 m^3, could cause an injury or a fatality, considering the site characteristics (i.e. high steep cliffs and the potential for people to be at the base of the cliff considering the beach width).

Landslide hazard is not restricted to the immediate CKL location. Landslide hazard exists along most of the beach from Clifton to Cape Kidnappers. The risk has not been previously quantified nor is it quantified by this study. This hazard is evident from the number of near-misses which have been reported.

8.2 Recommendations

It is recommended as of the 15 February 2019:

- Beach access should remain closed to all beach users until a Quantitative Risk Assessment (QRA) is completed to assess the risk associated with landslide hazard for both the immediate CKL area and the remainder of Clifton Beach between Clifton and Cape Kidnappers.
- This QRA should be completed in accordance with the recommended methodology of the Australian Geomechanics Society Practice Note Guidelines for Landslide Risk Management (2007). A QRA is judged standard practice for assessing the PLOL.
- As part of the QRA, tolerable risk acceptance criteria will need to be established for the purposes of decision making. Guidance on this can be obtained from a variety of sources.
- The QRA will need to consider the following:
    - Individual risk of loss of life (person most at risk).
    - Societal risk – with lower tolerable risk criteria applicable when there is the potential for multiple fatalities.
    - As Low As Reasonably Practicable (ALARP) approach is met.

- Monitoring of the CKL should continue as the QRA is completed, to inform the risk assessment. The current monitoring program should be continued but should be reviewed as results are obtained and reviewed (including the methods used and their frequency).
- Should the beach access be re-opened before the QRA is completed, the risk to beach users will not be reliably quantified and this needs to be acknowledged by HDC. Should this decision be made, then an ALARP approach should be adopted in the interim while the QRA is completed.

9. References

AGS 2007 (C and D). Practice Note Guidelines for Risk Management

ANCOLD 2003. Guidelines on Risk Assessments, Australian National Committee on Large Dams Inc.

Beu & Grant-Taylor 1975. Geology and fossils of the Cape Kidnappers Area, New Zealand Geological Survey, DSIR. Published by Department of Lands and Survey Wellington, P63/5000.Res. SERIES 1975/2.

Cruden & Varnes 1996. Landslide types and processes, Special report. Transportation Research Board, National Academy of Sciences, 247:36-75.

GNS 2017. Assessment of the liquefaction risk in the Hawkes Bay. GNS Report 2015/186, Oct 2017.

GNS 2014. Site amplification, polarity and topographic effects in the Port Hills during the Canterbury earthquake sequence.

GNS 2012. Canterbury Earthquakes 2010/11 Port Hills Slope Stability; Principles and Criteria for the Assessment of Risk from Slope Instability in the Port Hills, Christchurch.

Lee, J.M.; Townsend, D.; Bland, K.; Kamp, P.J.J. (compilers) 2011: Geology of the Hawke's Bay area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences 1:250,000 geological map 8. 86 p. + 1 folded map.

NZTA 2018. Bridge Manual, SP/M/022, Third Edition, NZ Transport Agency.

T&T 2016. Clifton to Tangoio Coastal Hazards Strategy 2120, Coastal Hazard Assessment.

10. Limitations

This report has been prepared for Hastings District Council in accordance with the generally accepted practices and standards in use at the time it was prepared. Stantec accepts no liability to any third party who relies on this report.

The information contained in this report is accurate to the best of our knowledge at the time of issue. Stantec has made no independent verification of this information beyond the agreed scope set out in the report.

The interpretations as to the likely subsurface conditions contained in this report are based on the site observations and field investigations made at discrete locations as described in this report. The type, spacing and frequency of the investigations, sampling, and testing of materials were selected to meet the technical, financial and time requirements agreed by the client. Stantec accepts no liability for any unknown or adverse ground conditions that would have been identified had further investigations, sampling, and testing been undertaken.

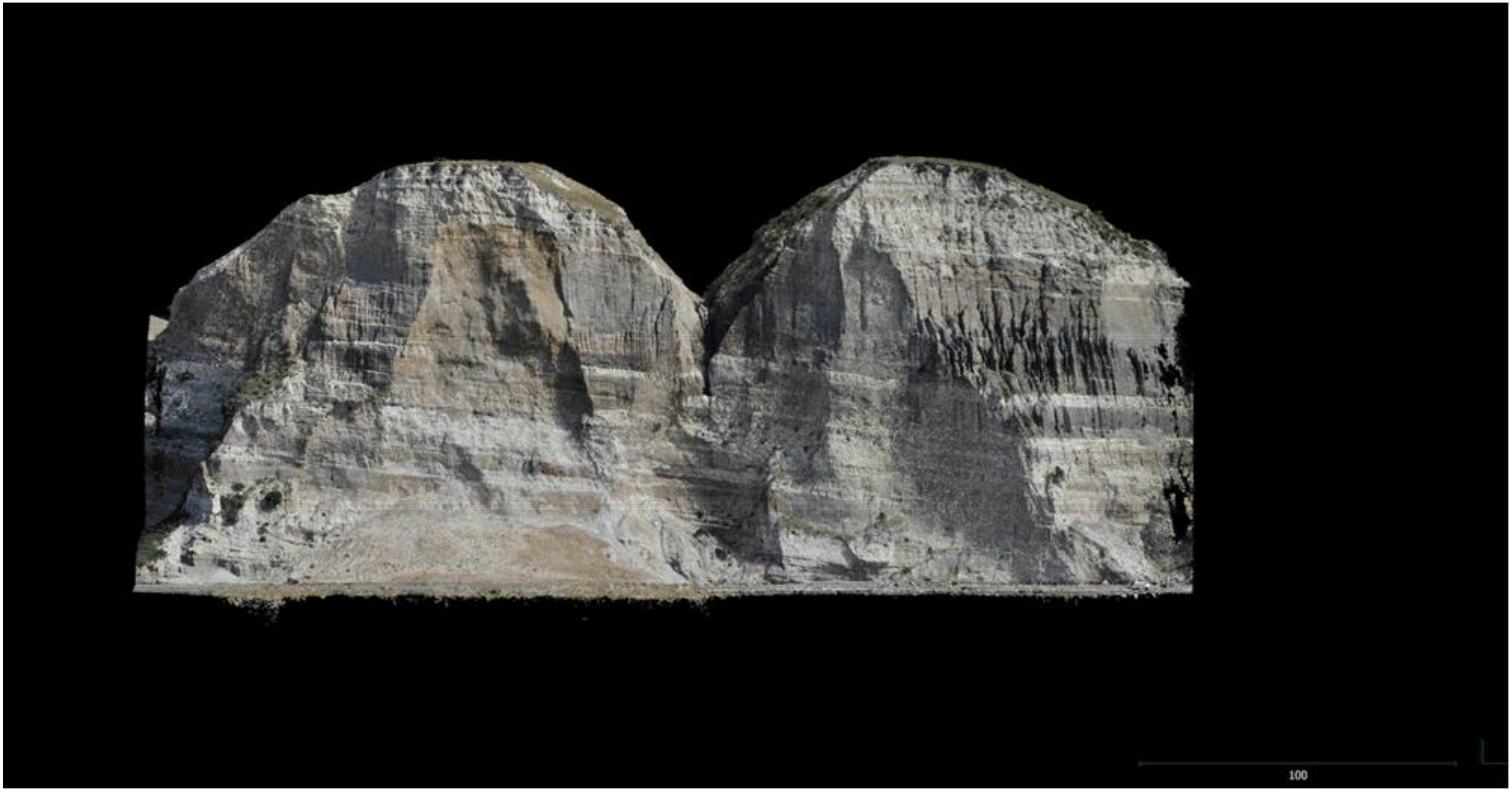
Actual ground conditions encountered may vary from the predicted subsurface conditions. For example, subsurface groundwater conditions often change seasonally and over time. No warranty is expressed or implied that the actual conditions encountered will conform exactly to the conditions described herein.

Where conditions encountered at the site differ from those inferred in this report Stantec should be notified of such changes and should be given an opportunity to review the recommendations made in this report in light of any further information.

This report does not purport to describe all the site characteristics and properties. Subsurface conditions and testing relevant to construction works must be undertaken and assessed by any contractors as necessary for their own purposes.


Appendices

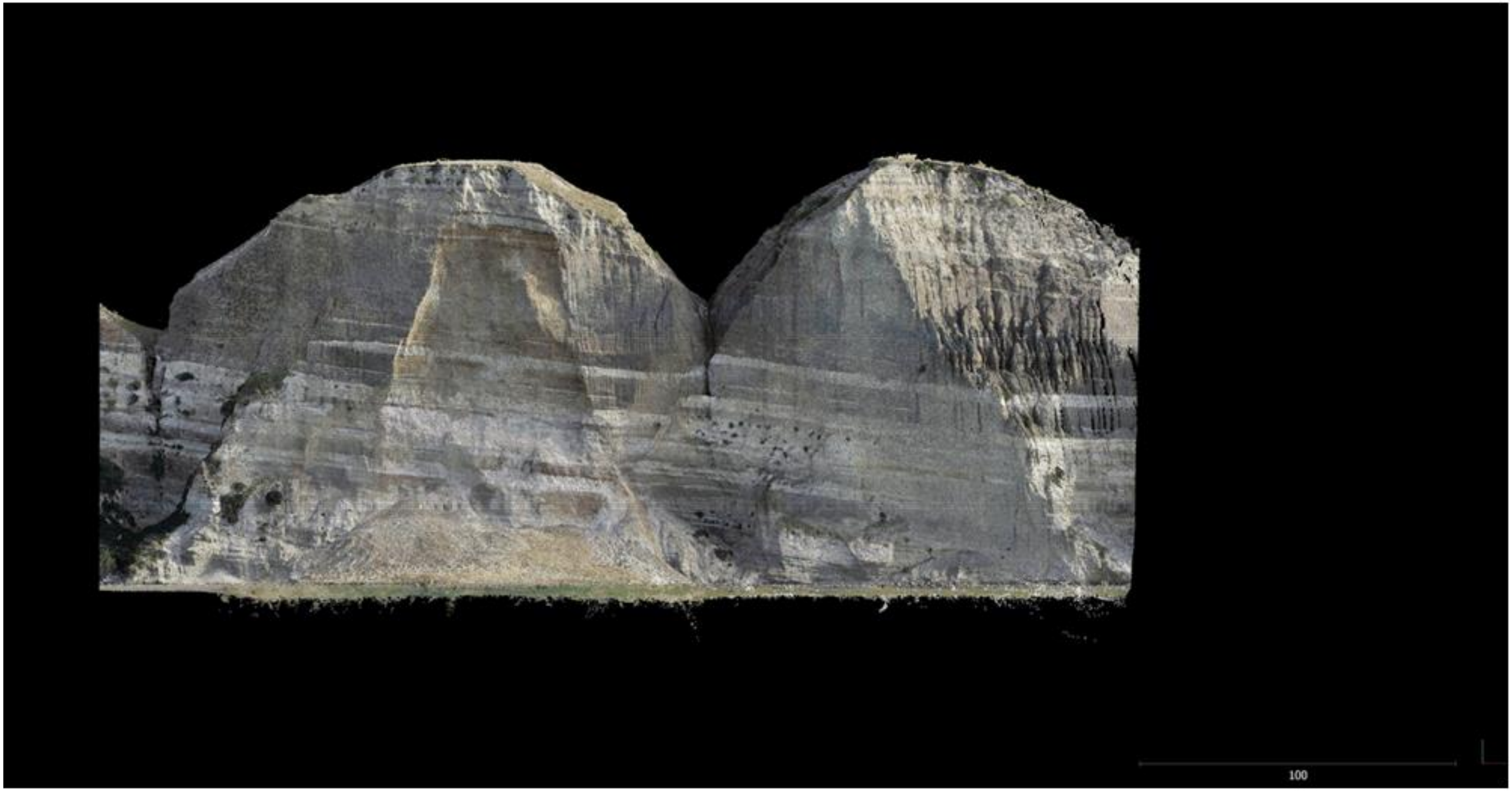
Appendix A Drawings



Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation 25 January 2019

Stantec



Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation 28 January 2019

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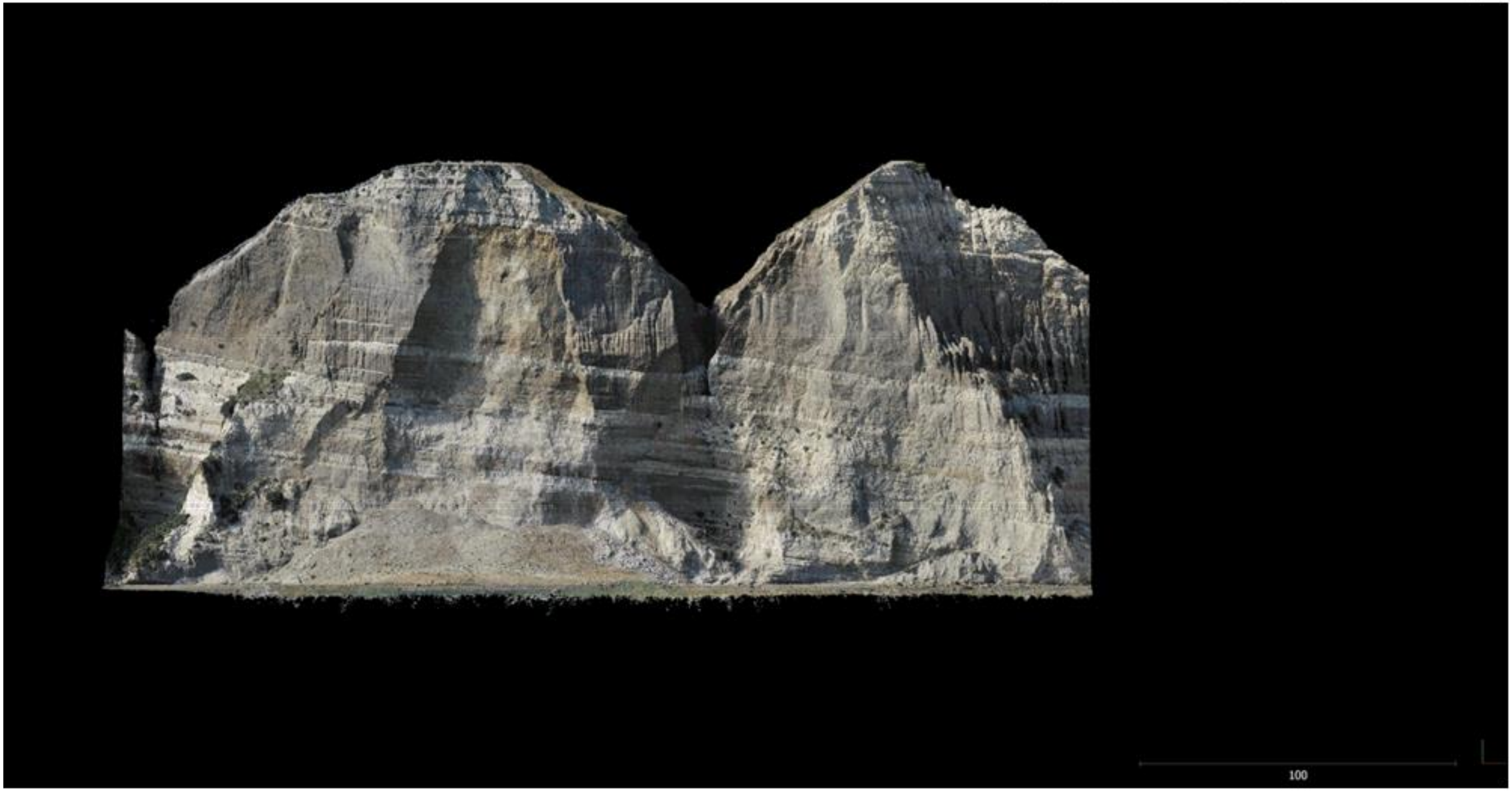

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation 31 January 2019

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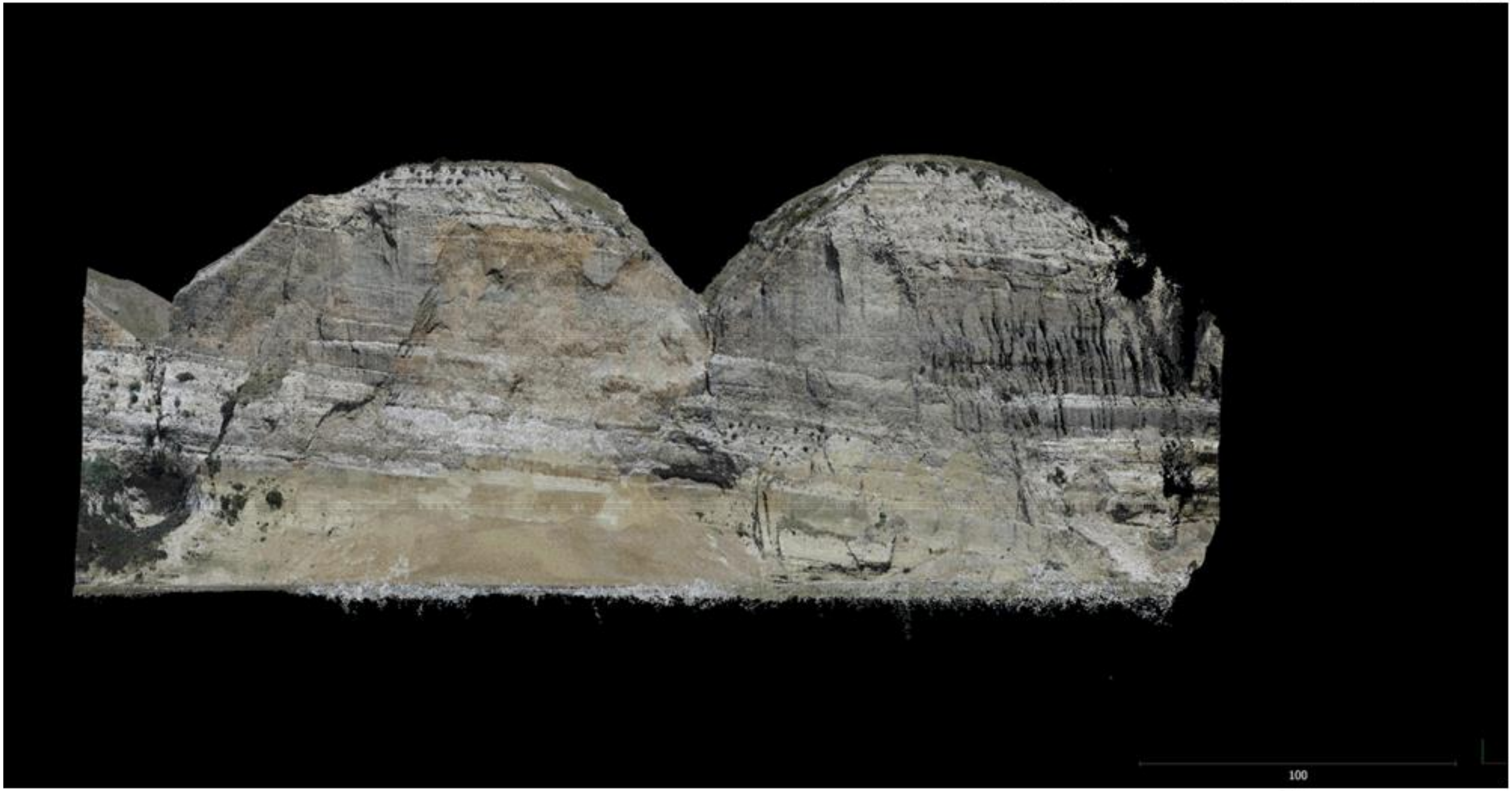
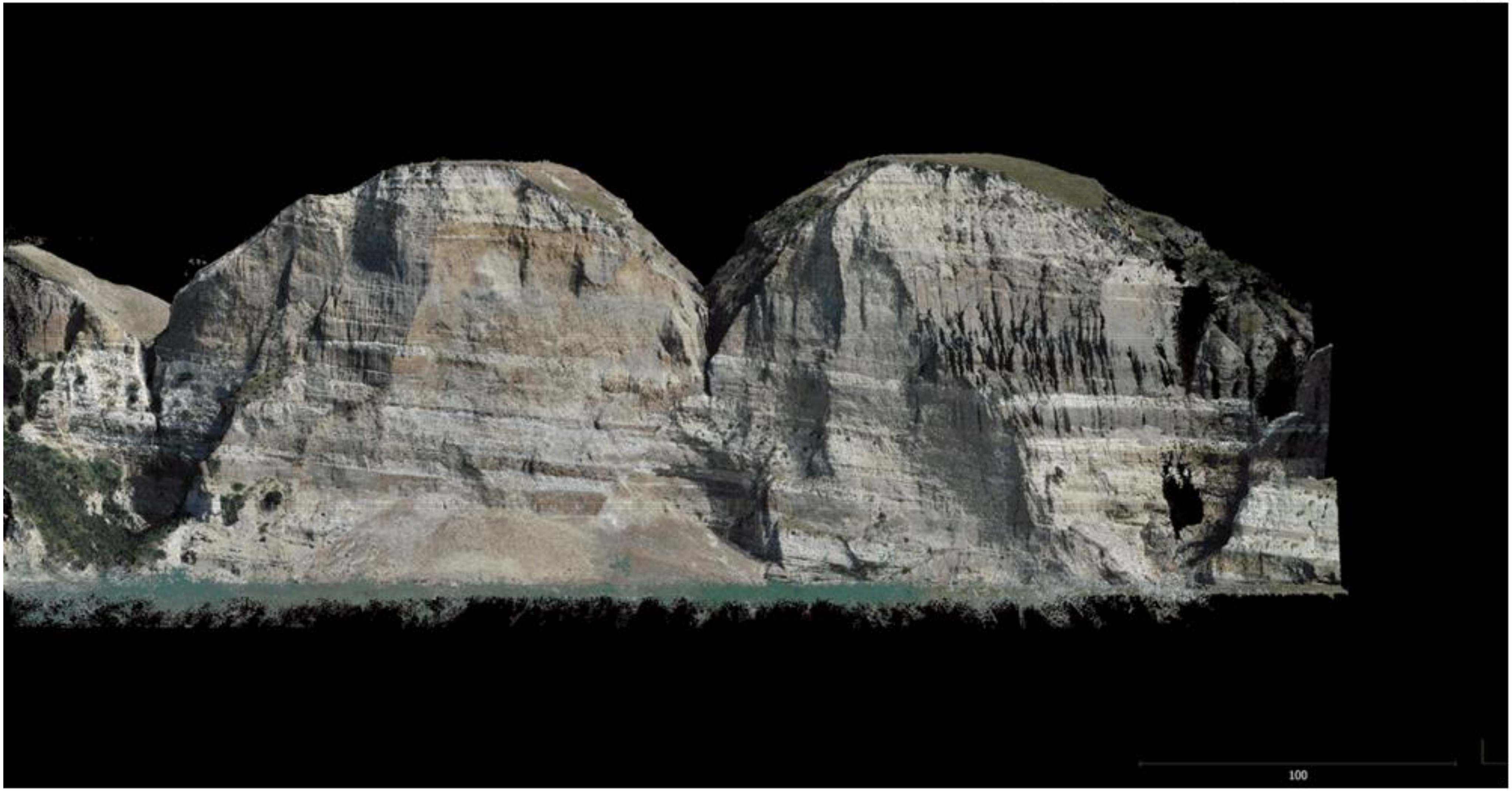


Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation 5 February 2019

Stantec



Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation 8 February 2019

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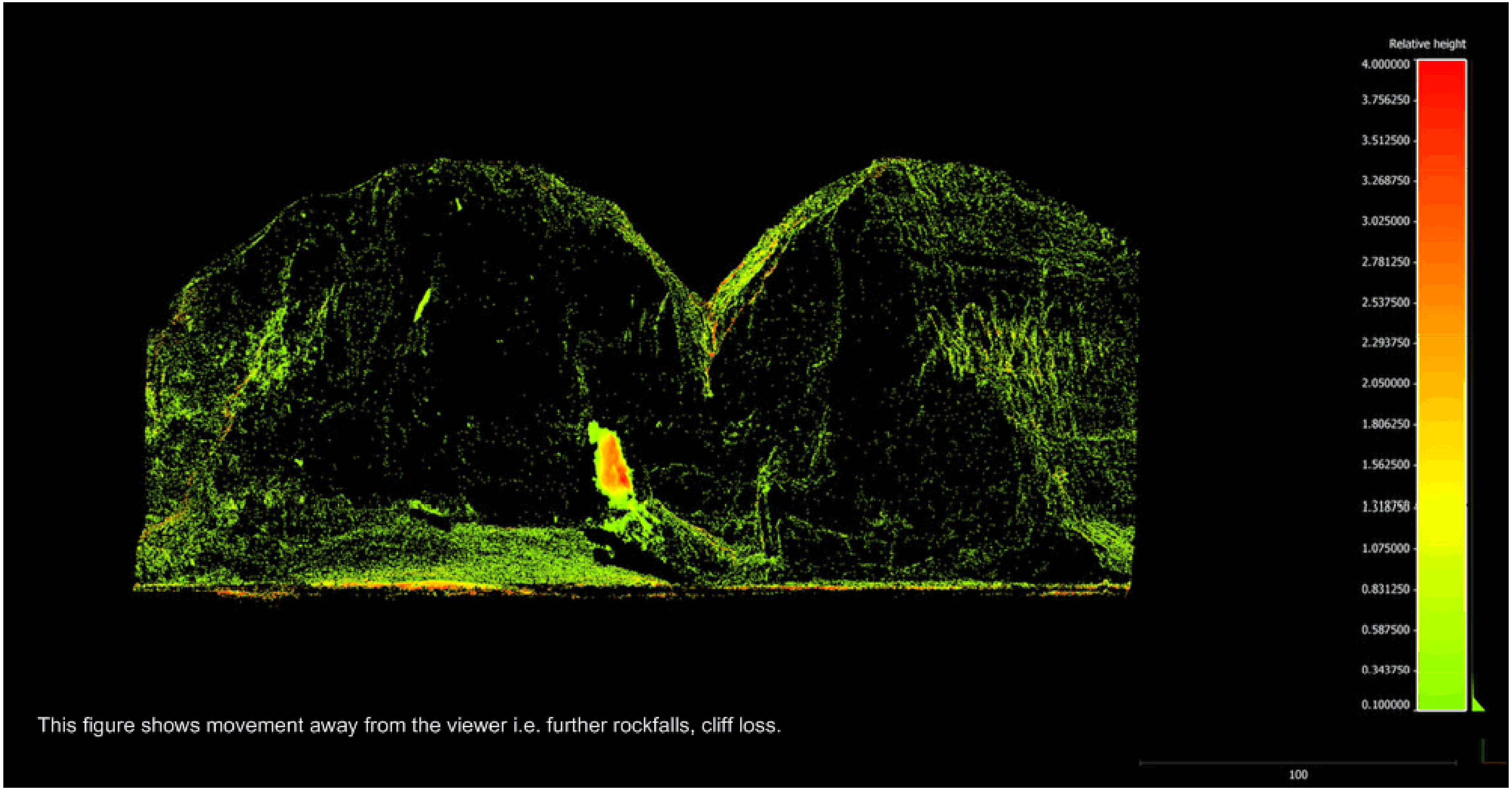

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
25 January 2019 to 28 January 2019

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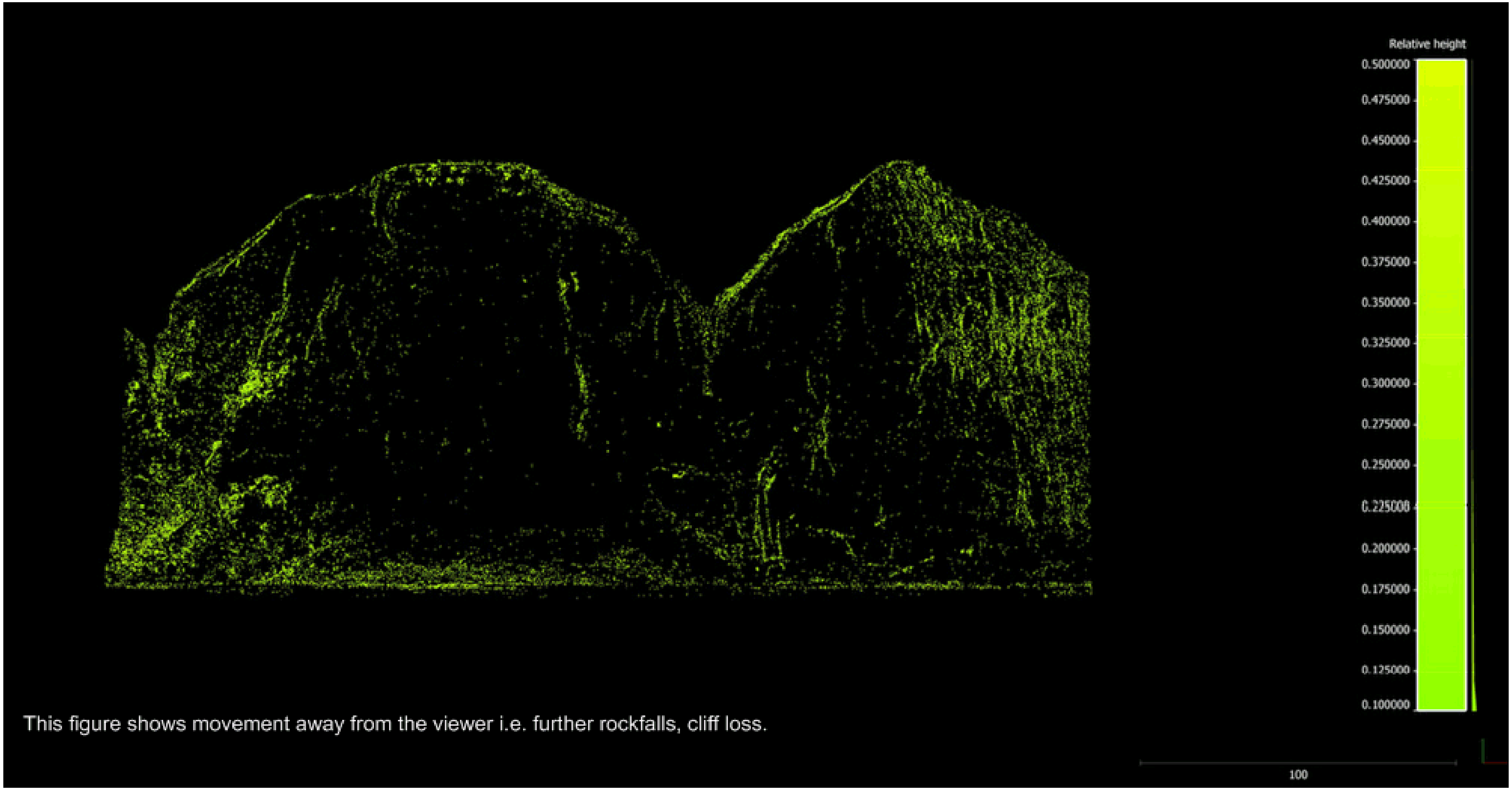

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
28 January 2019 to 31 January 2019

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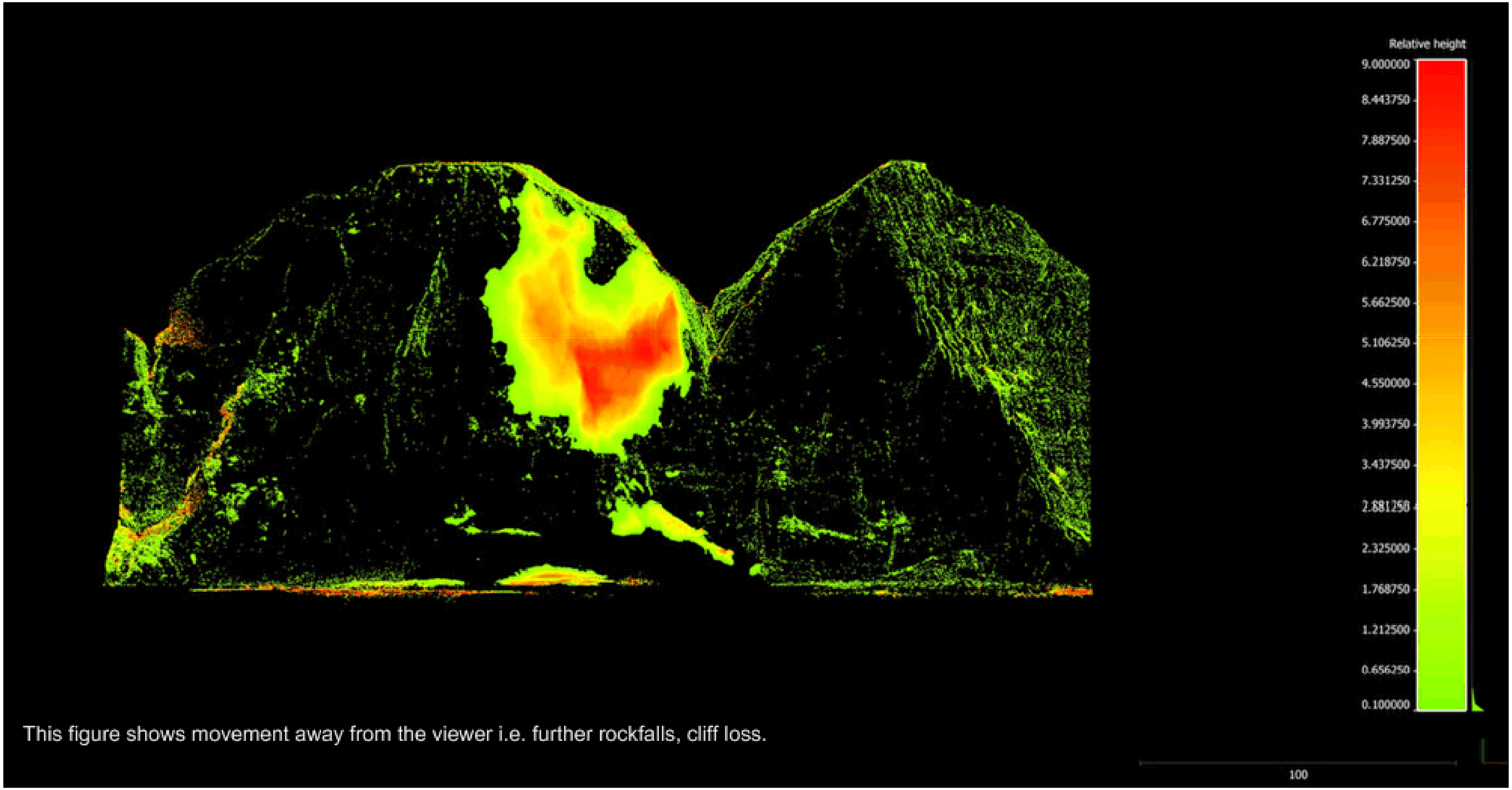

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
31 January 2019 to 5 February 2019

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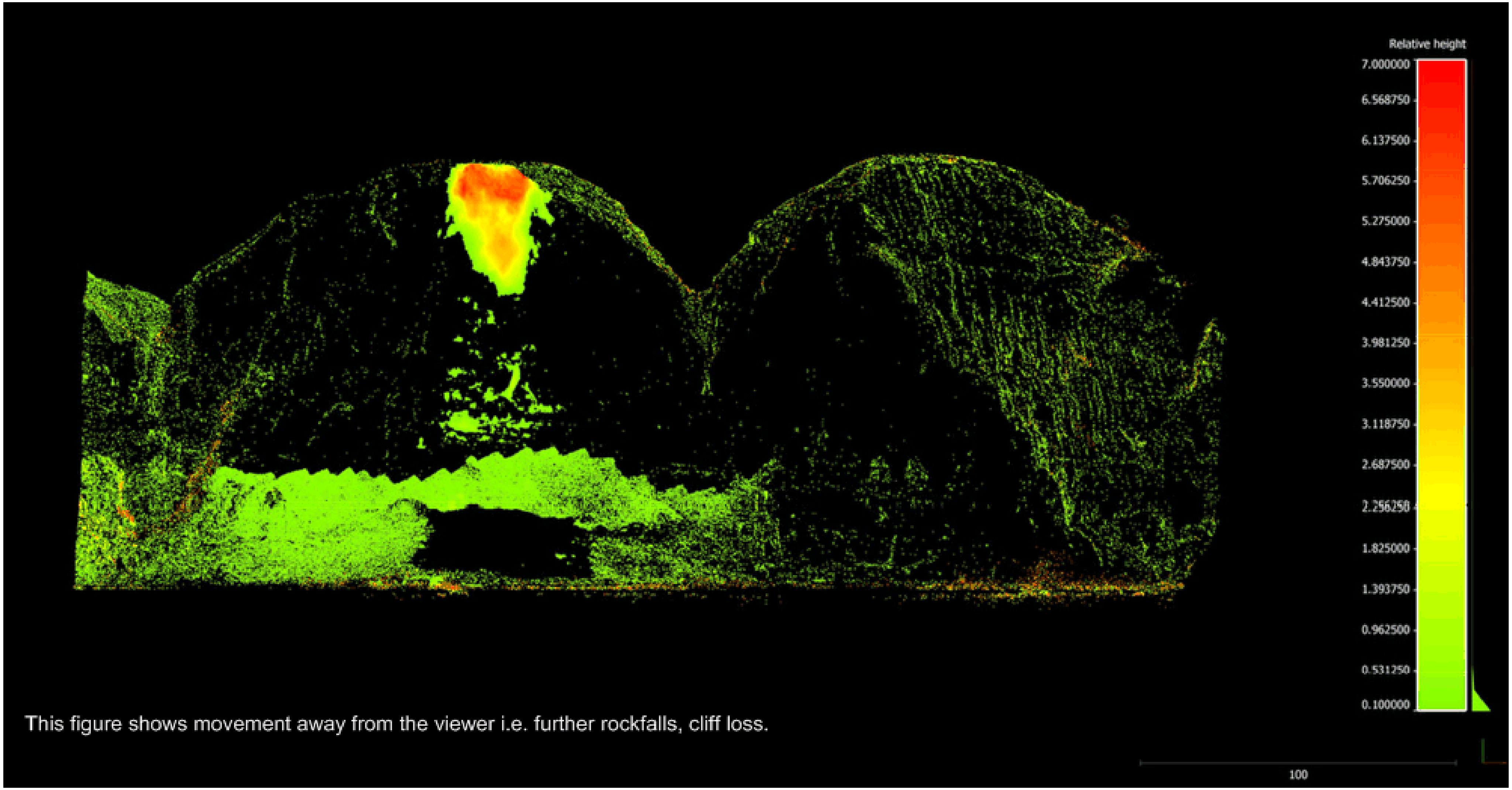

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
5 February 2019 to 8 February 2019

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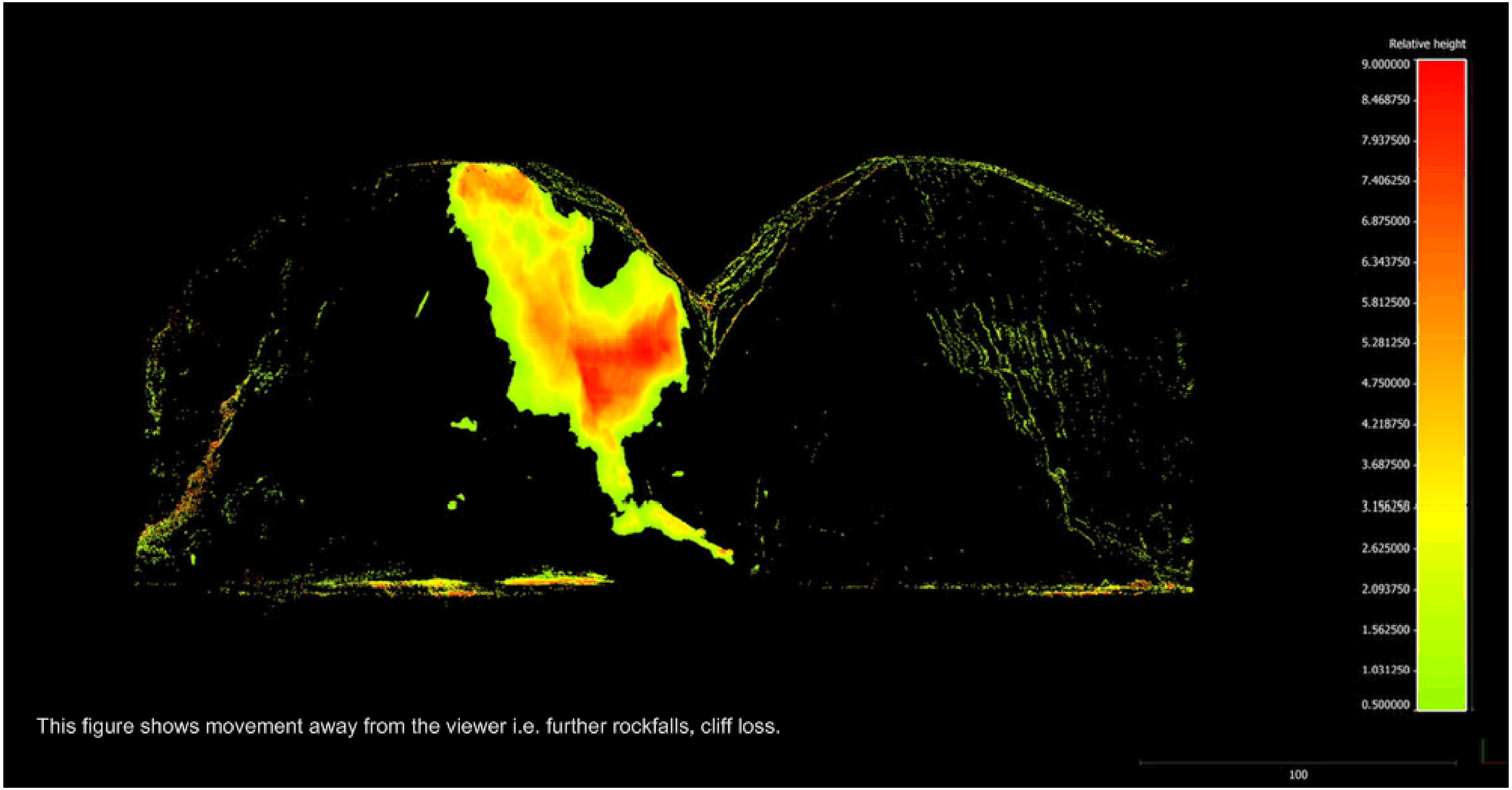

This figure shows movement away from the viewer i.e. further rockfalls, cliff loss.

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
25 January 2019 to 8 February 2019

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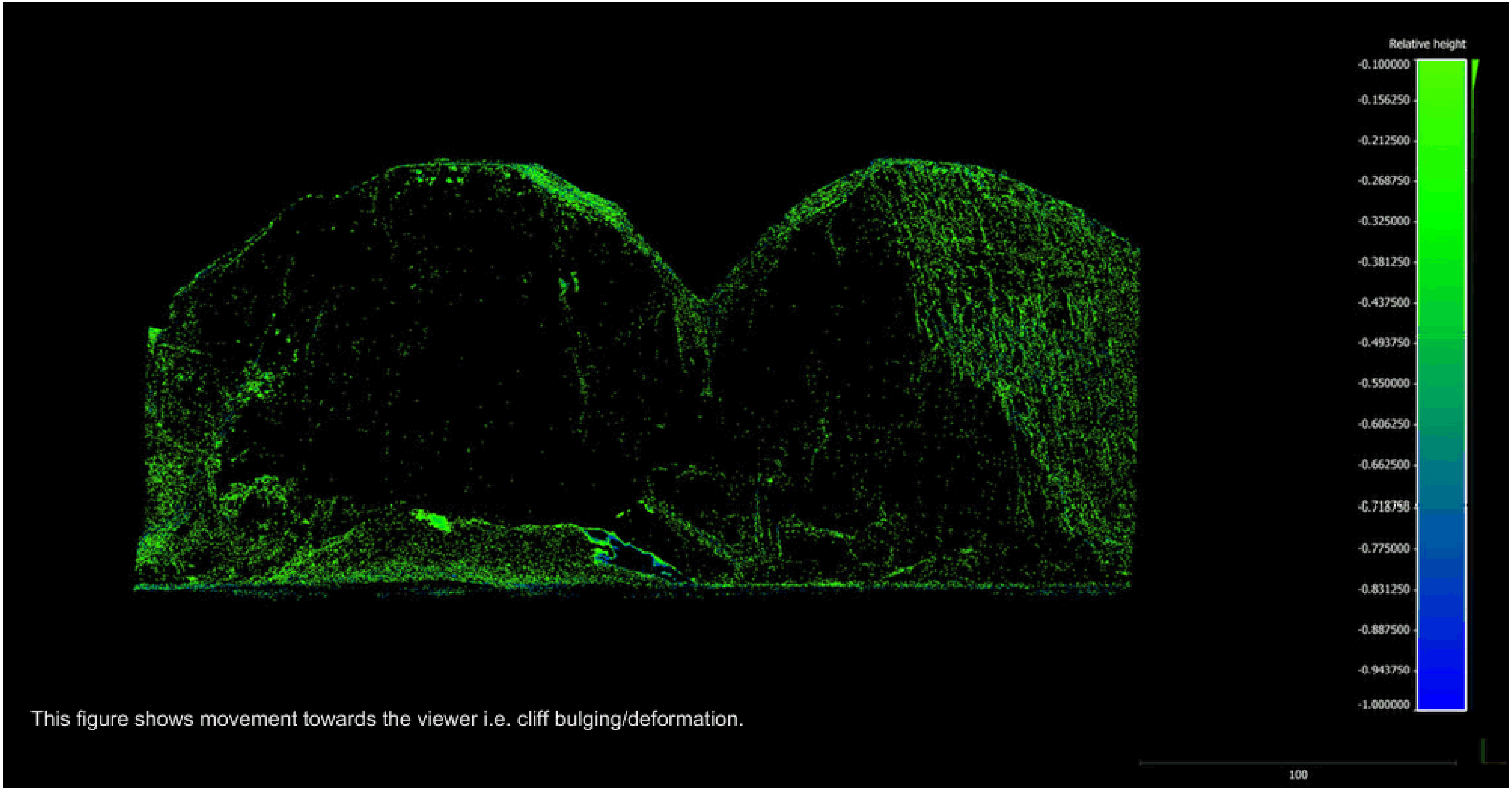

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
25 January 2019 to 28 January 2019

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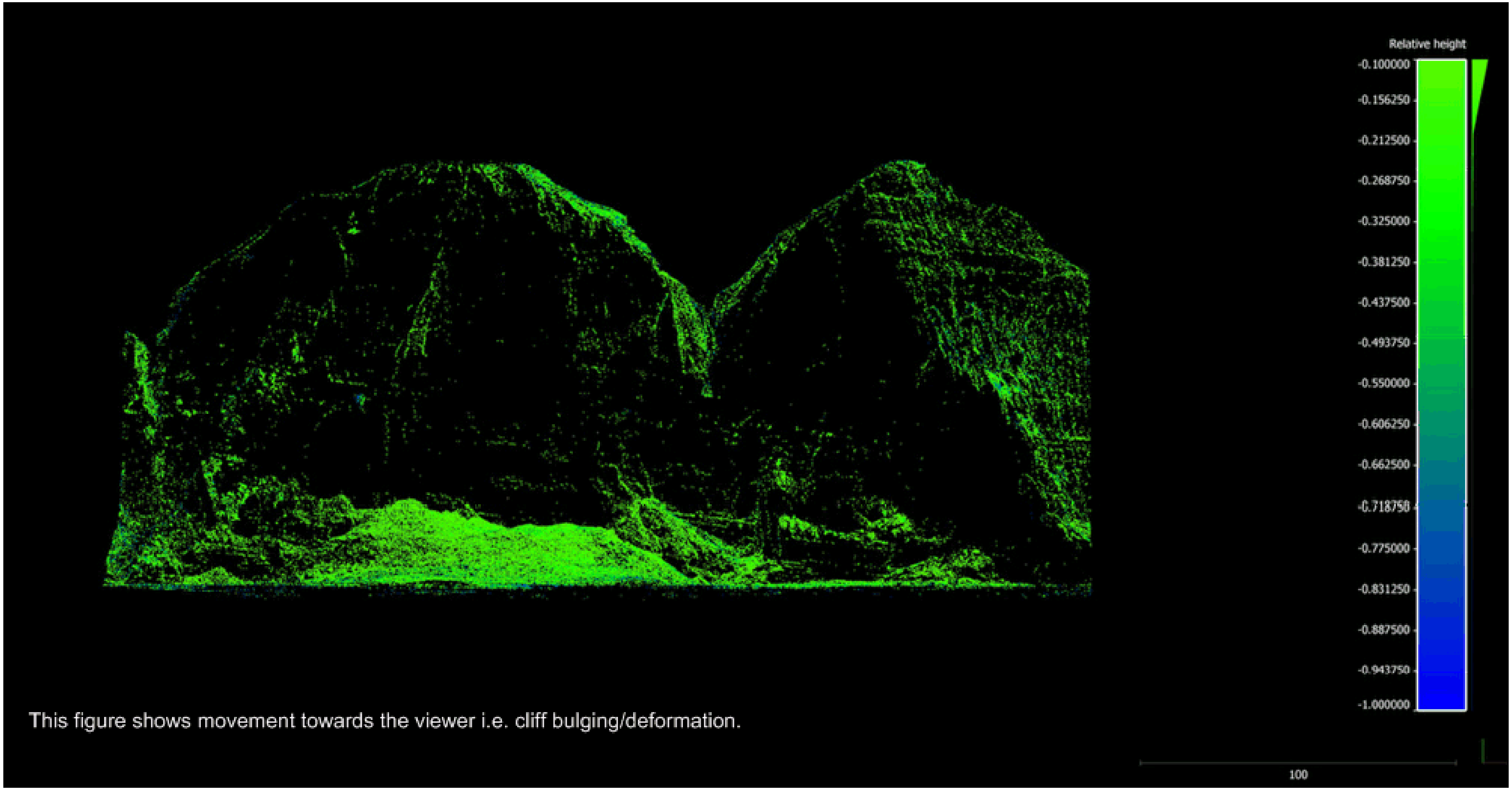

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
28 January 2019 to 31 January 2019

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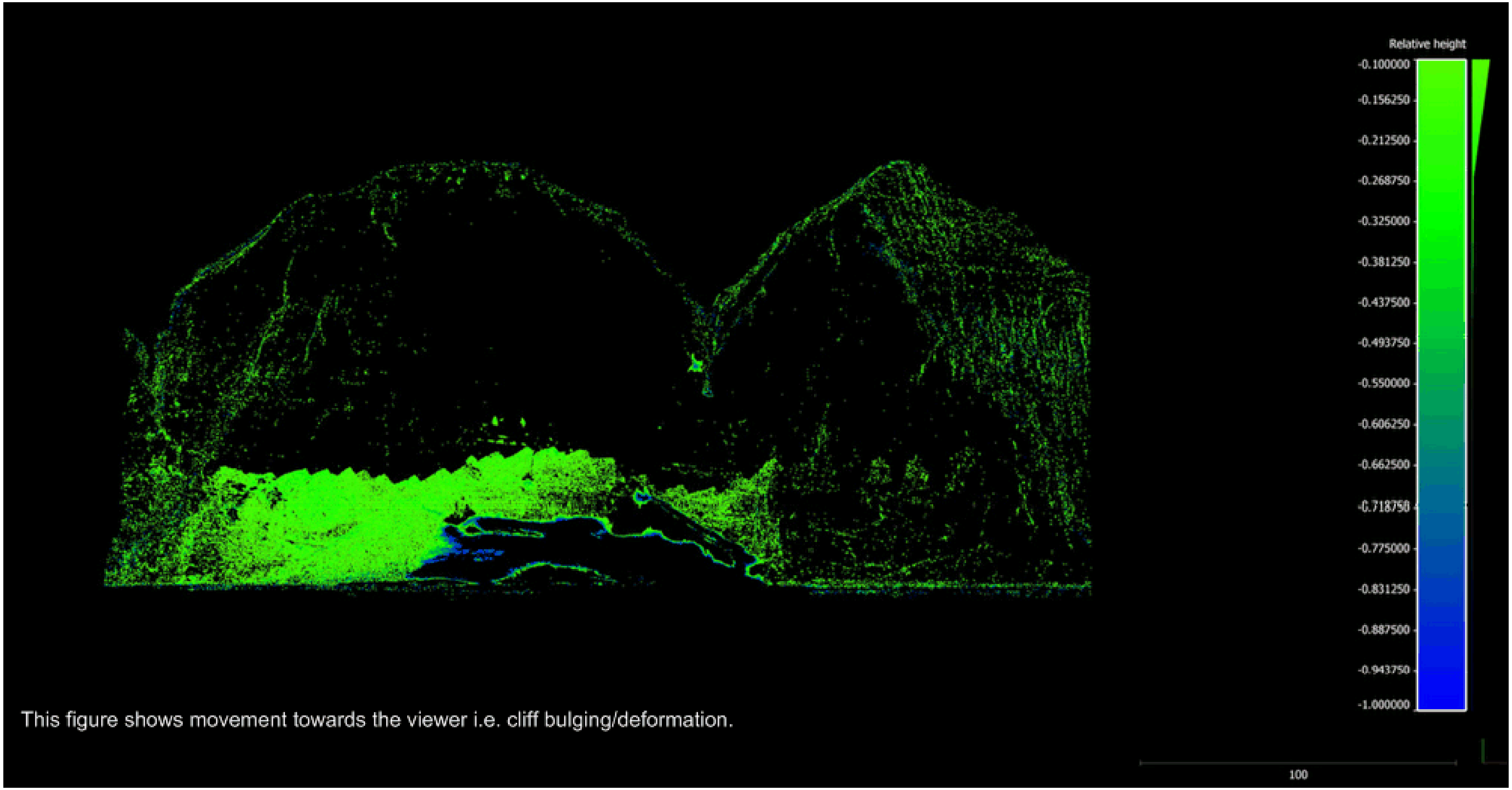

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
31 January 2019 to 5 February 2019

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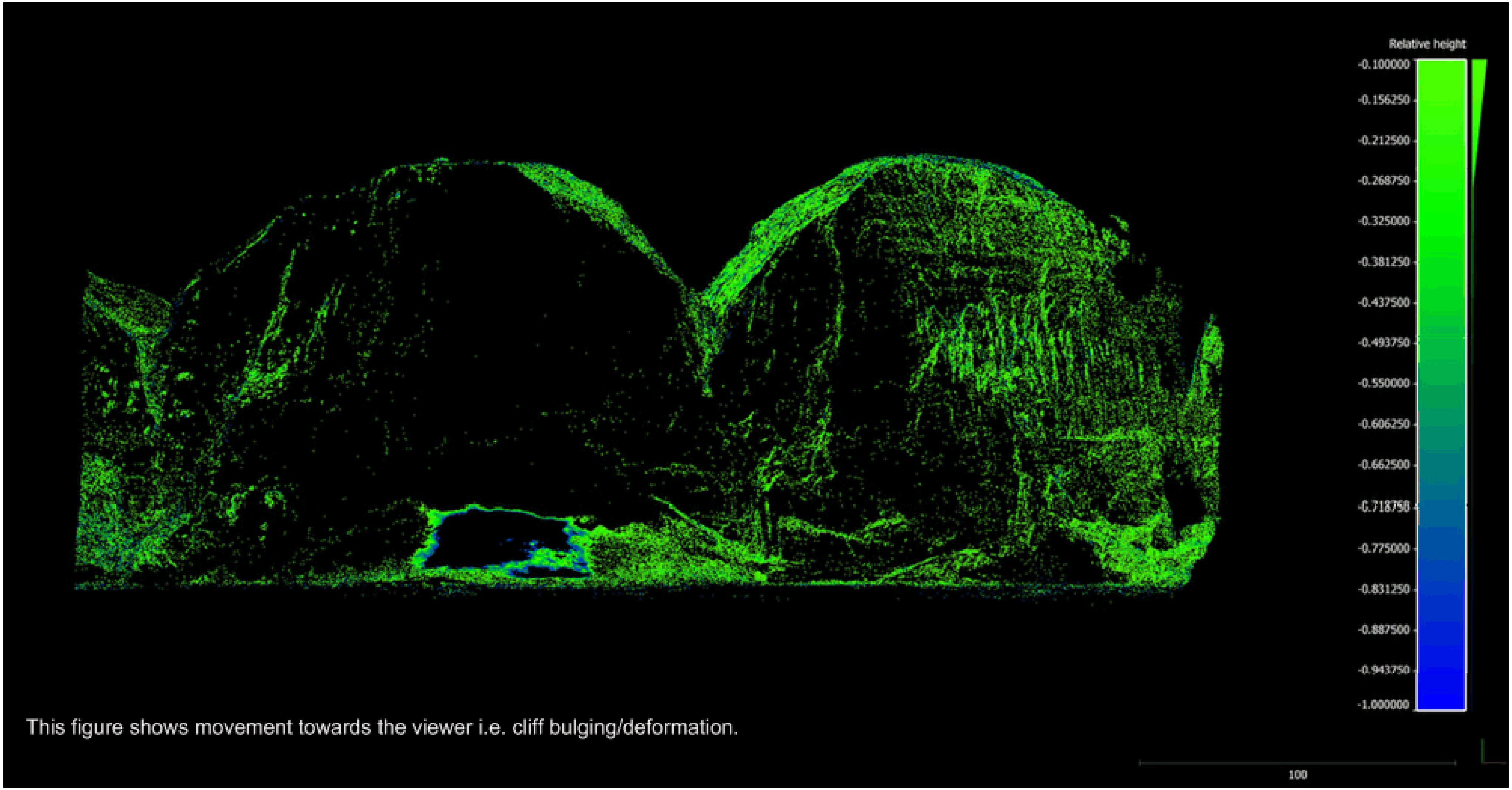

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
5 February 2019 to 8 February 2019

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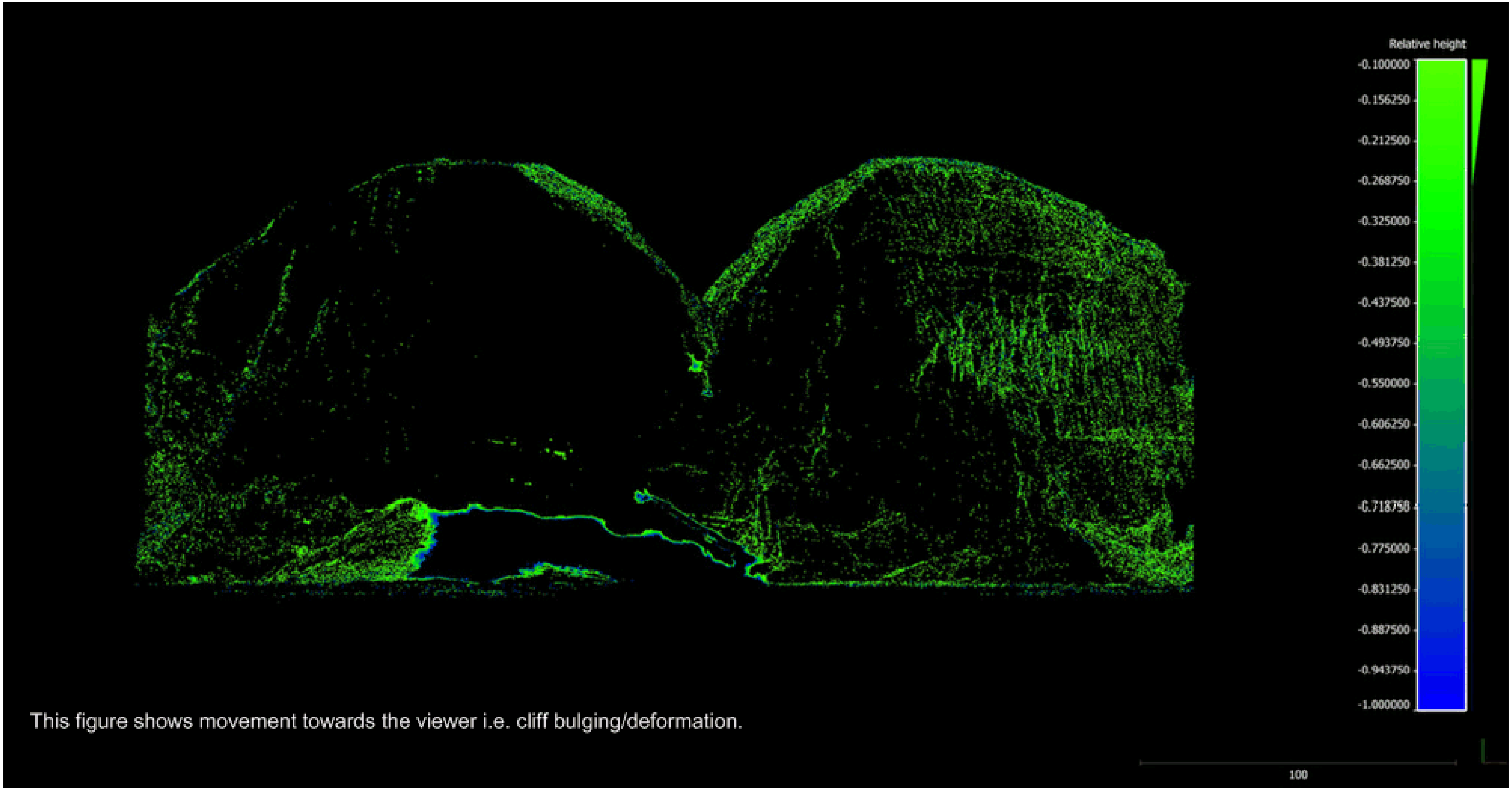

Cape Kidnappers Landslide
Hastings District Council

Cliff Elevation Changes
25 January 2019 to 8 February 2019

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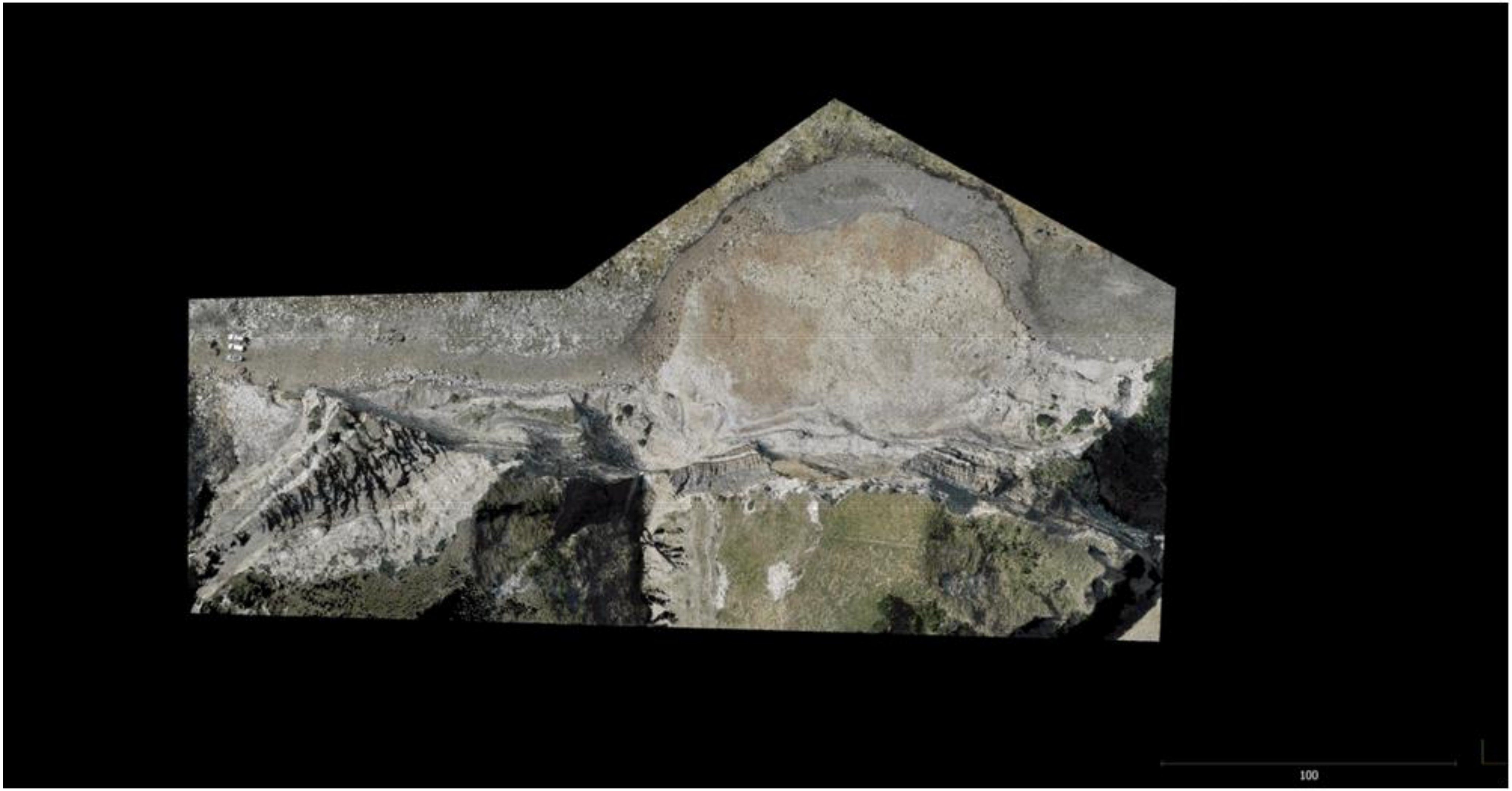

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan 25 January 2019

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Cape Kidnappers Landslide
Hastings District Council

Cliff Plan 28 January 2019

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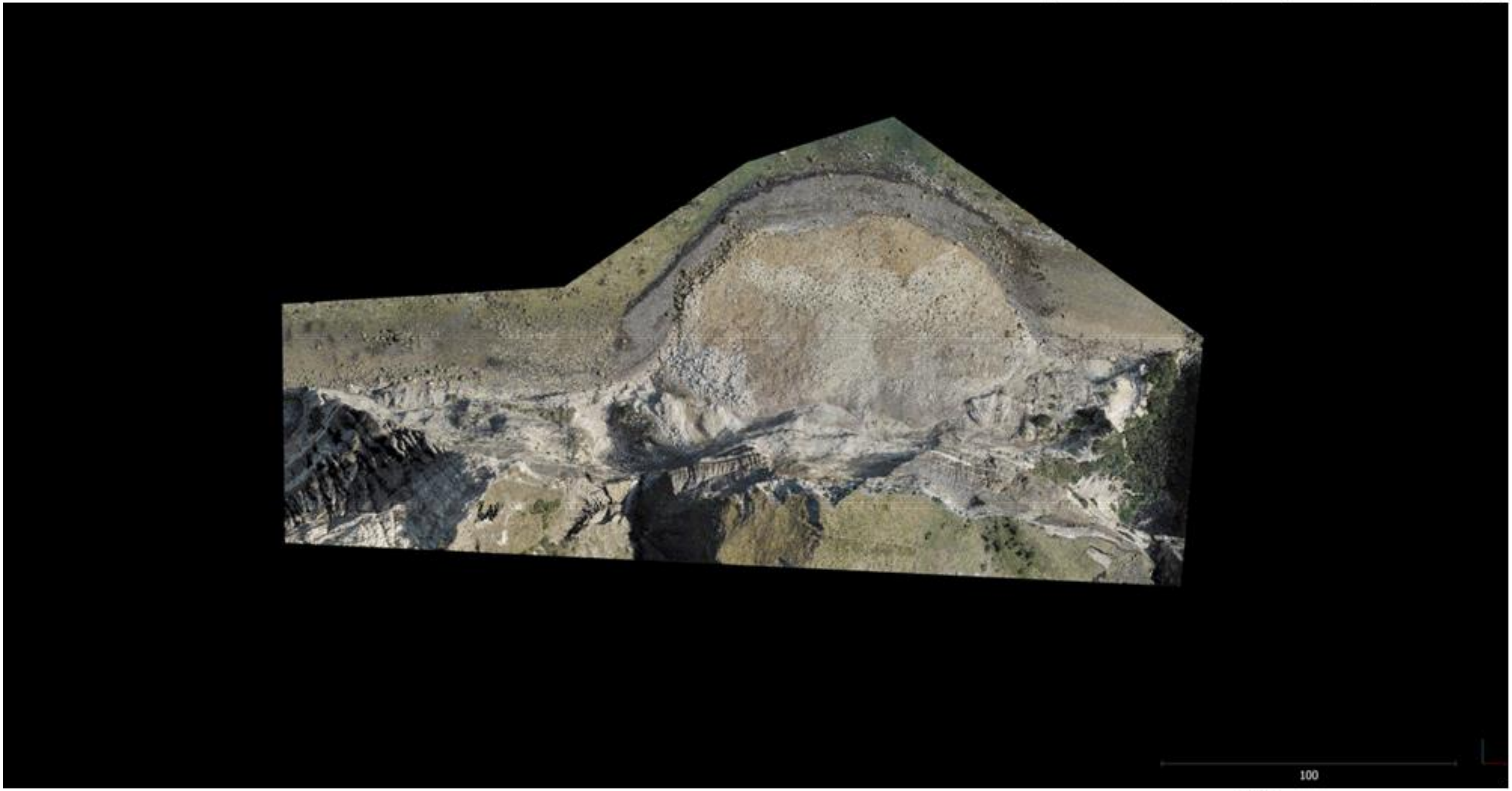

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan 31 January 2019

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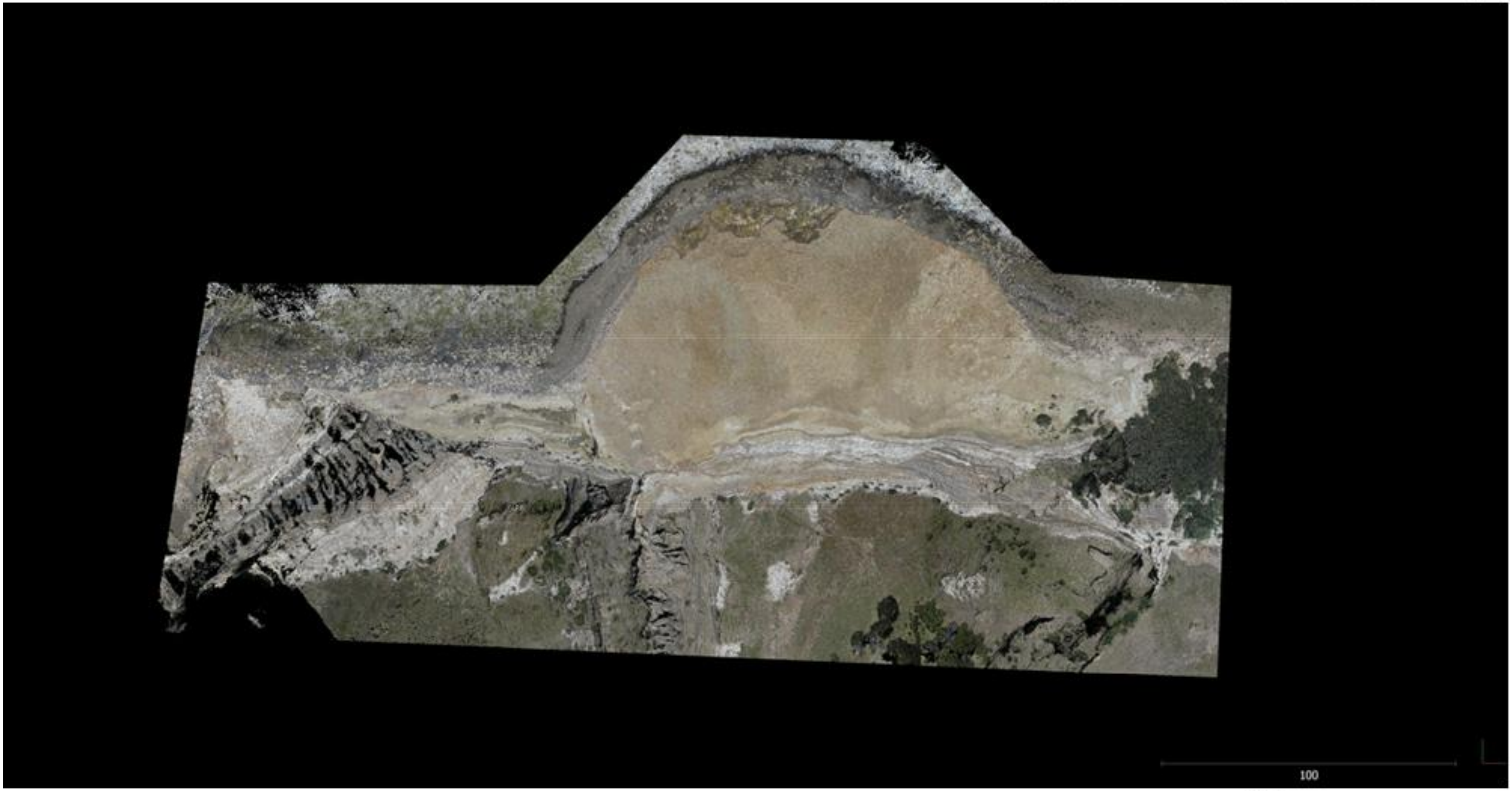

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan 5 February 2019

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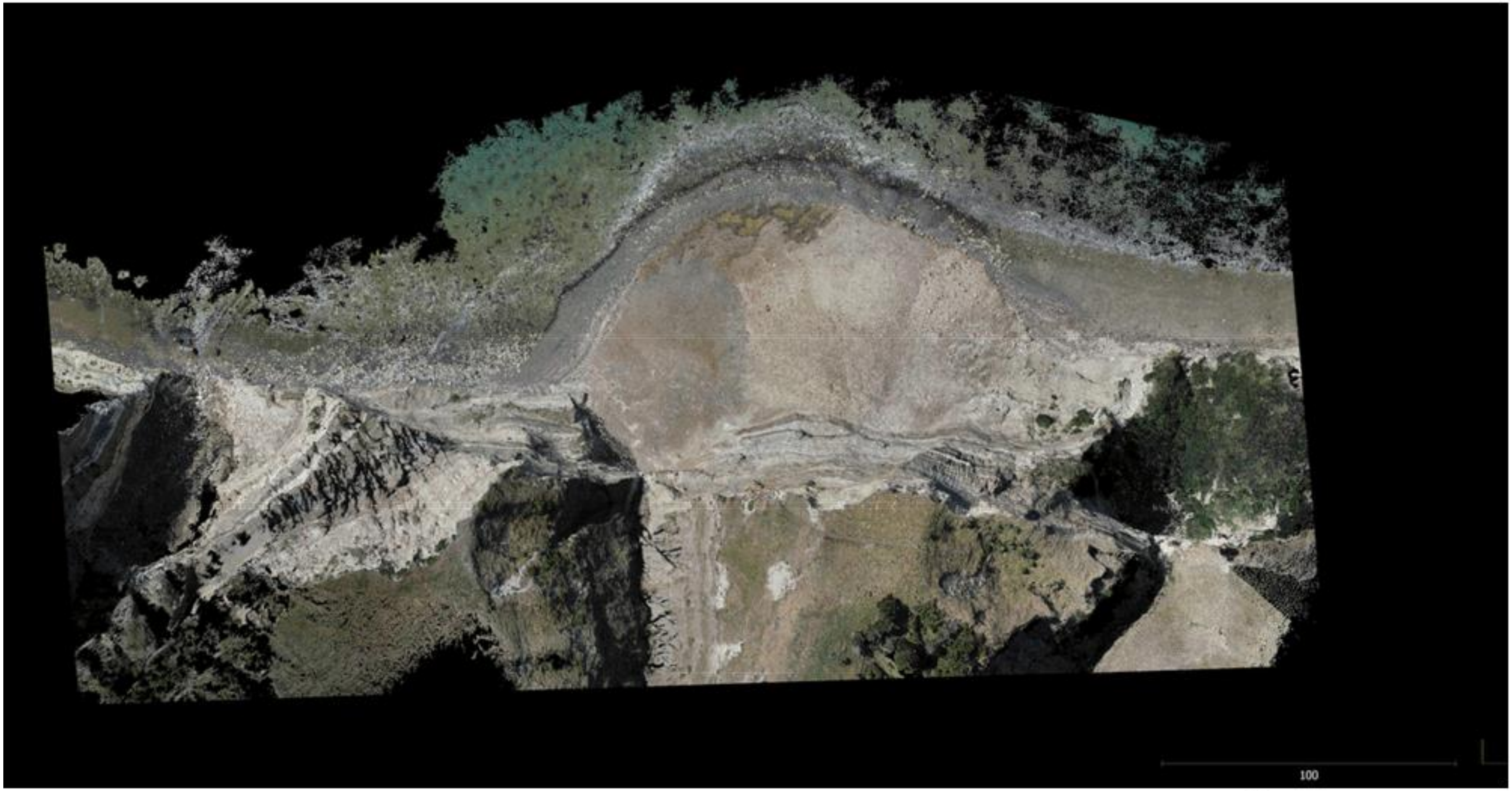

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan 8 February 2019

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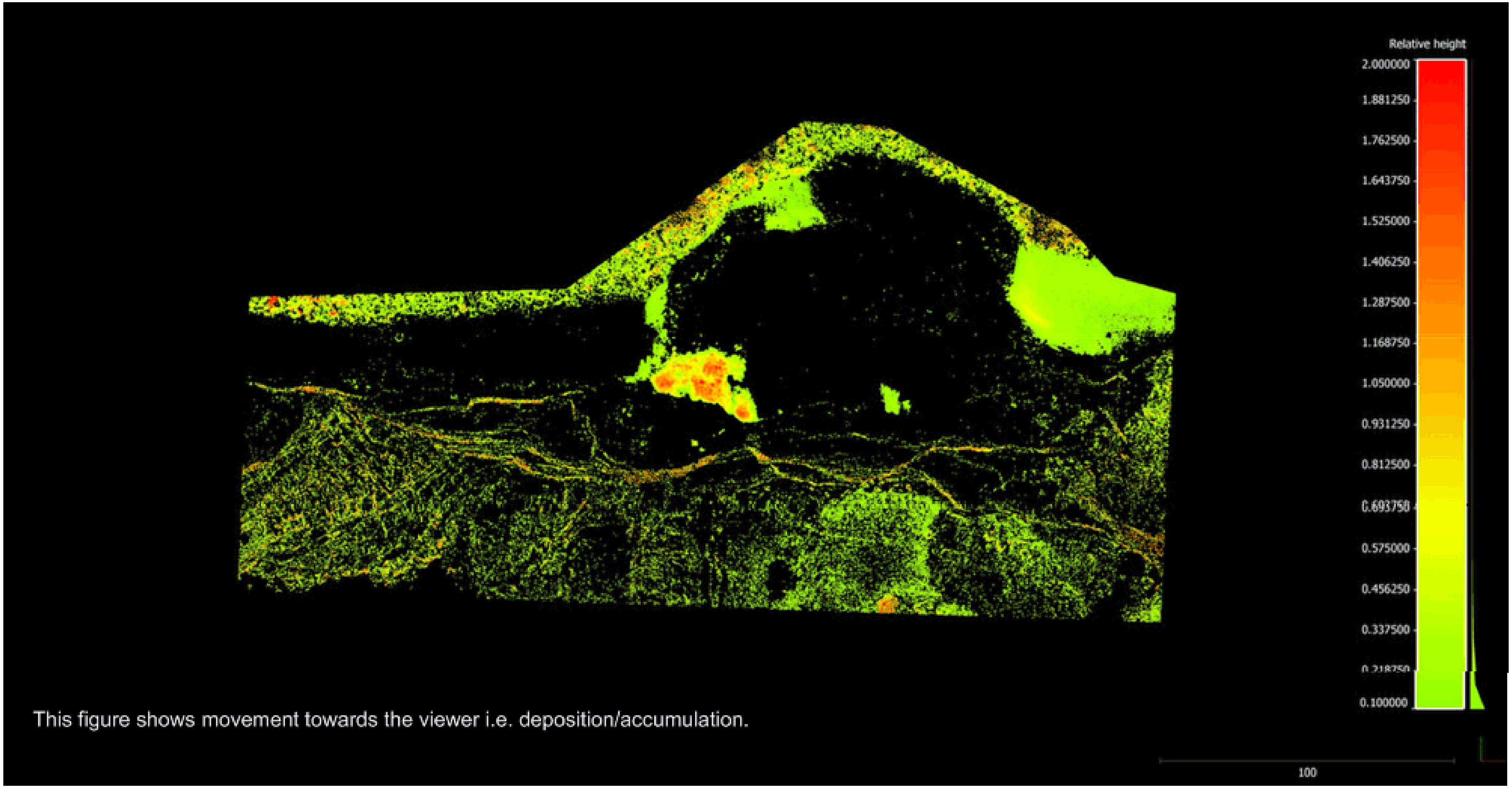

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
25 January 2019 to 28 January 2019

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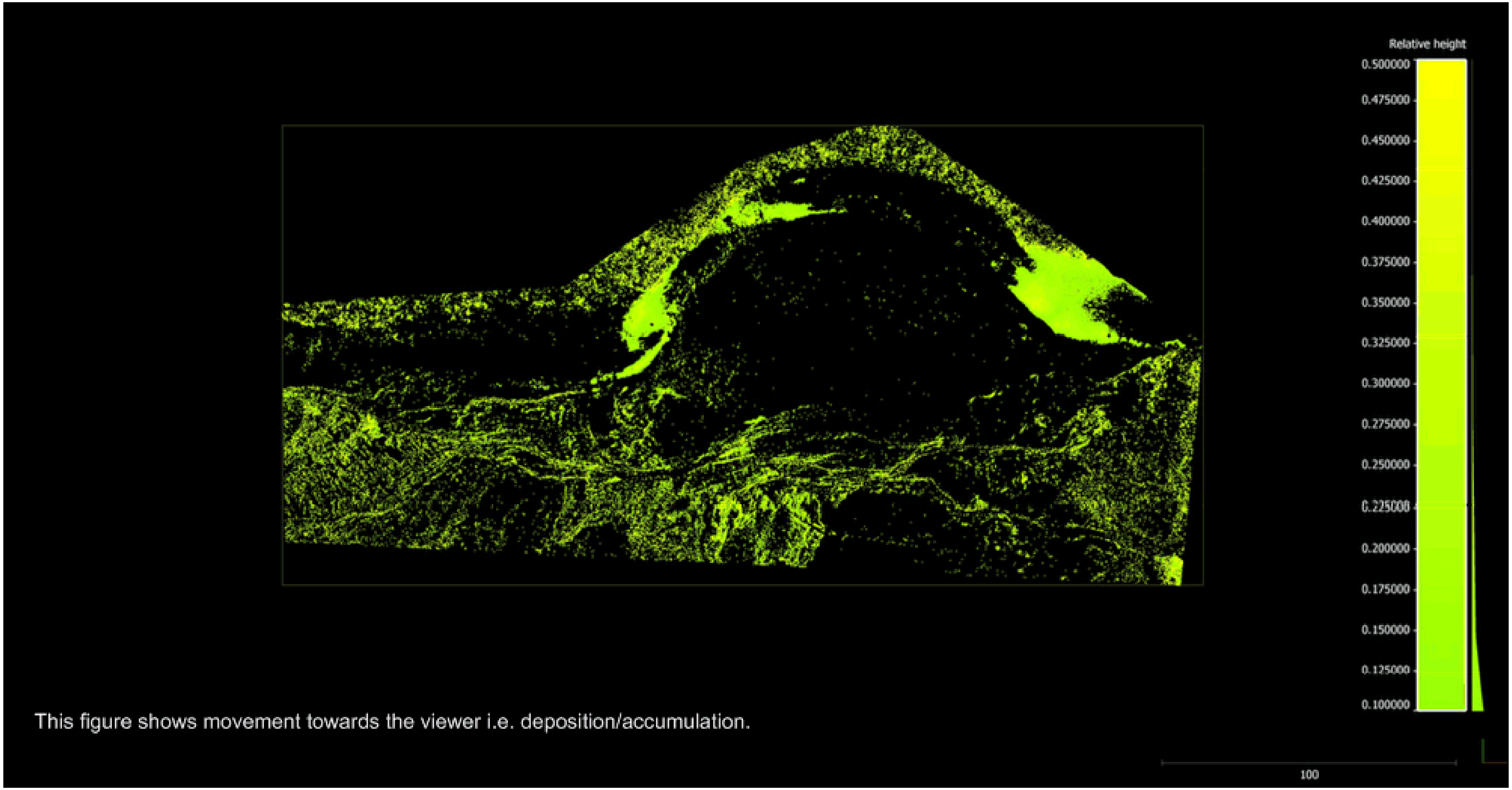

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
28 January 2019 to 31 January 2019

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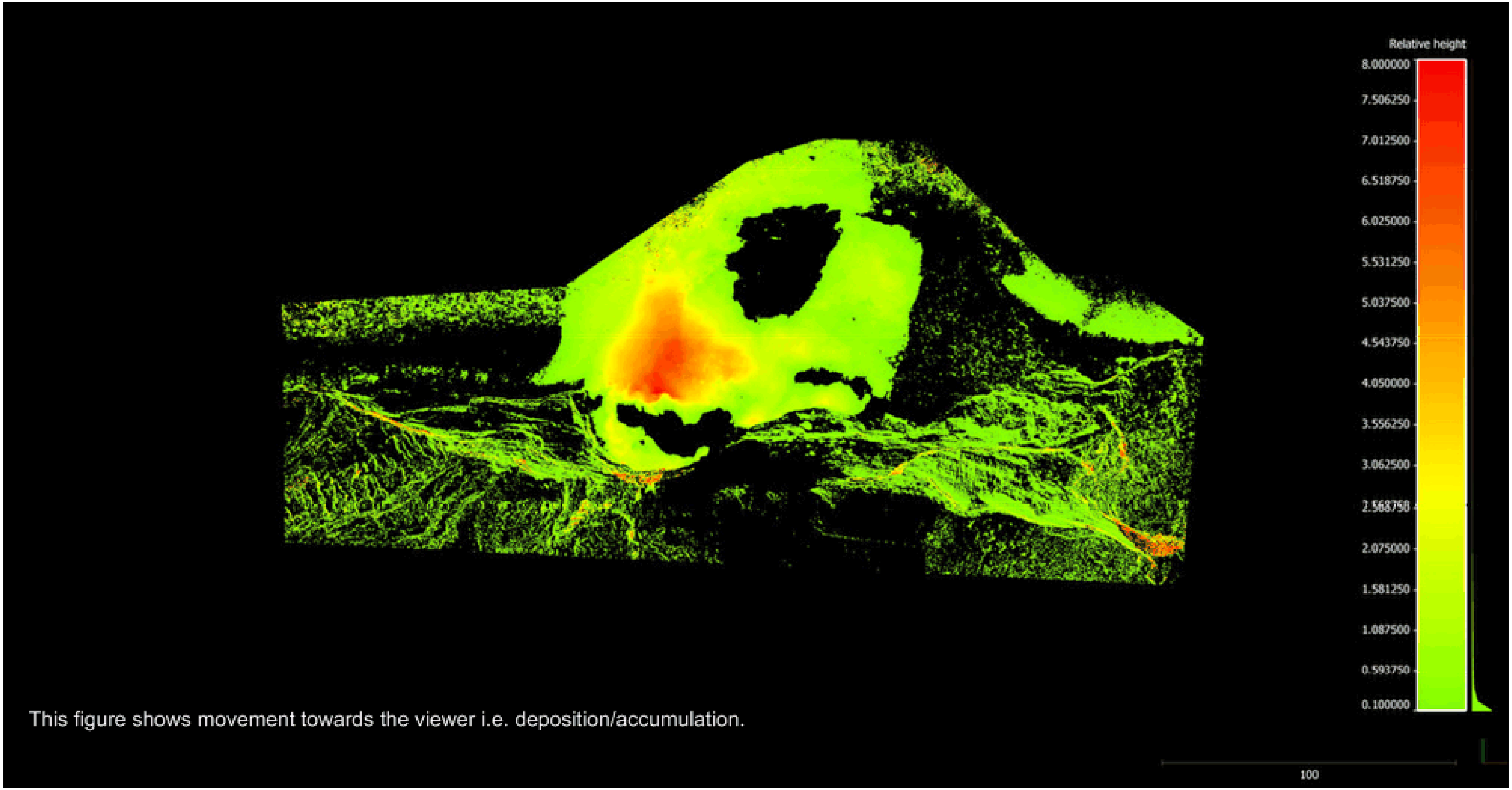

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
31 January 2019 to 5 February 2019

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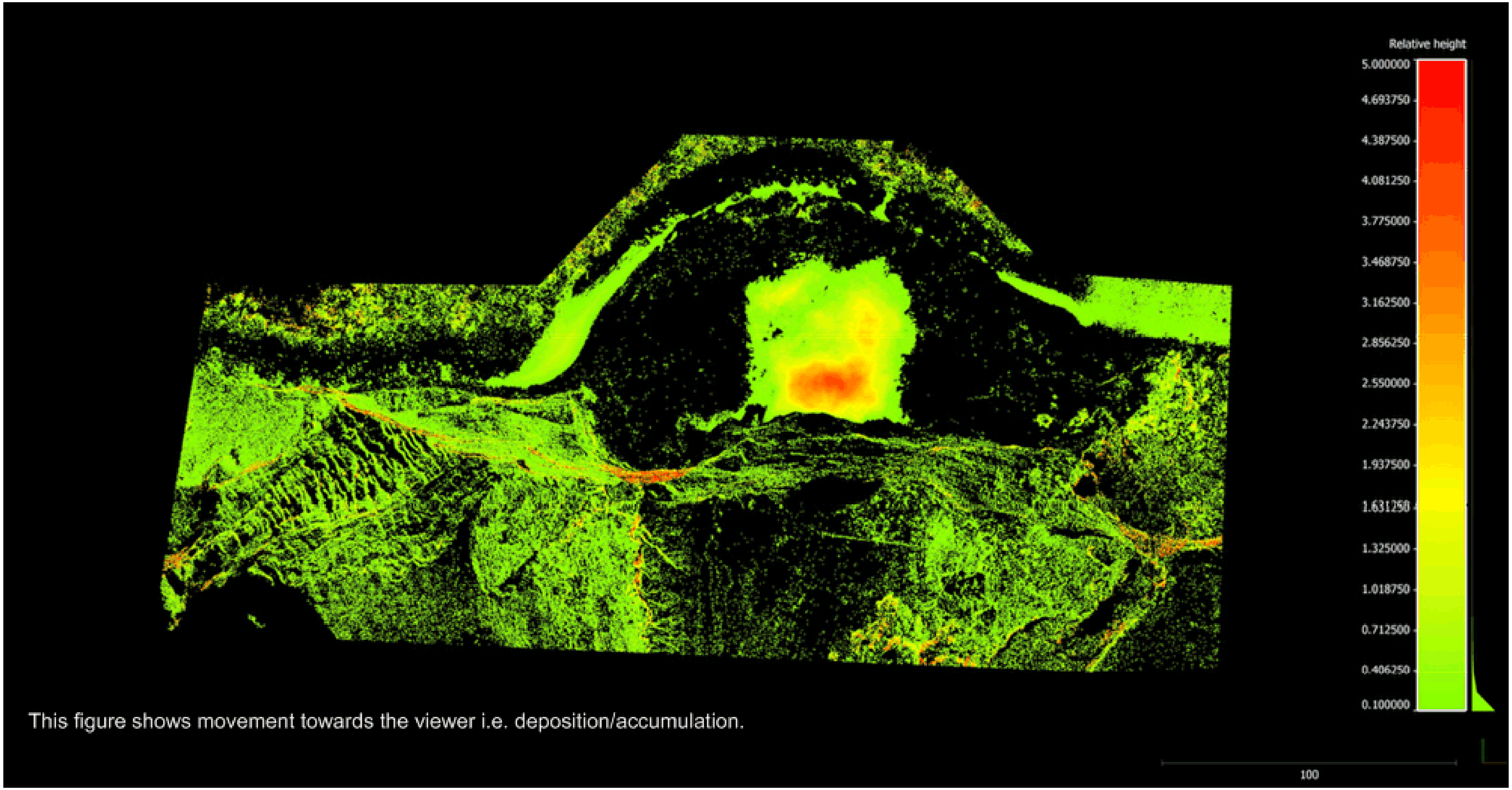
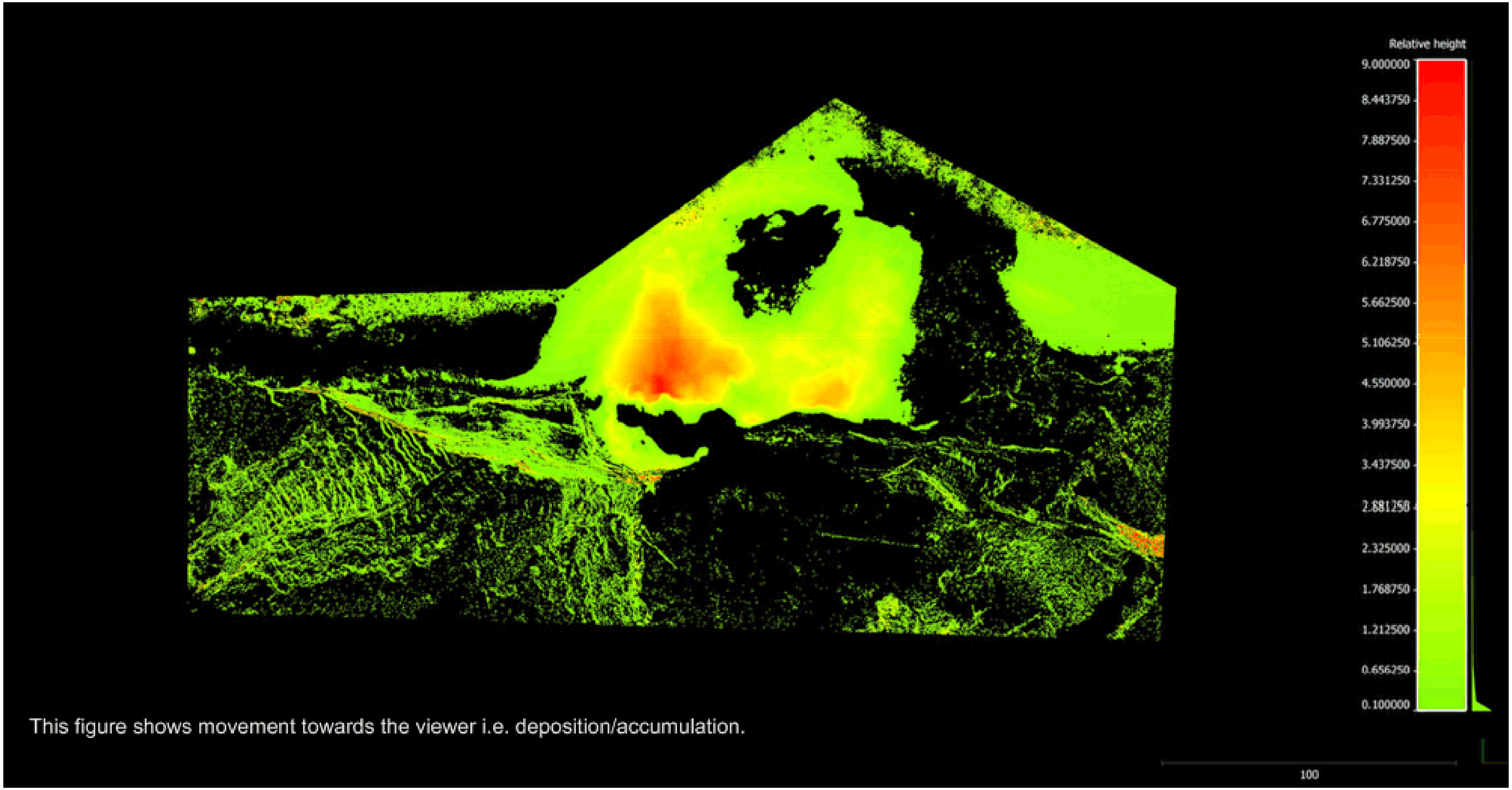


This figure shows movement towards the viewer i.e. deposition/accumulation.

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
5 February 2019 to 8 February 2019

Stantec



Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
25 January 2019 to 8 February 2019

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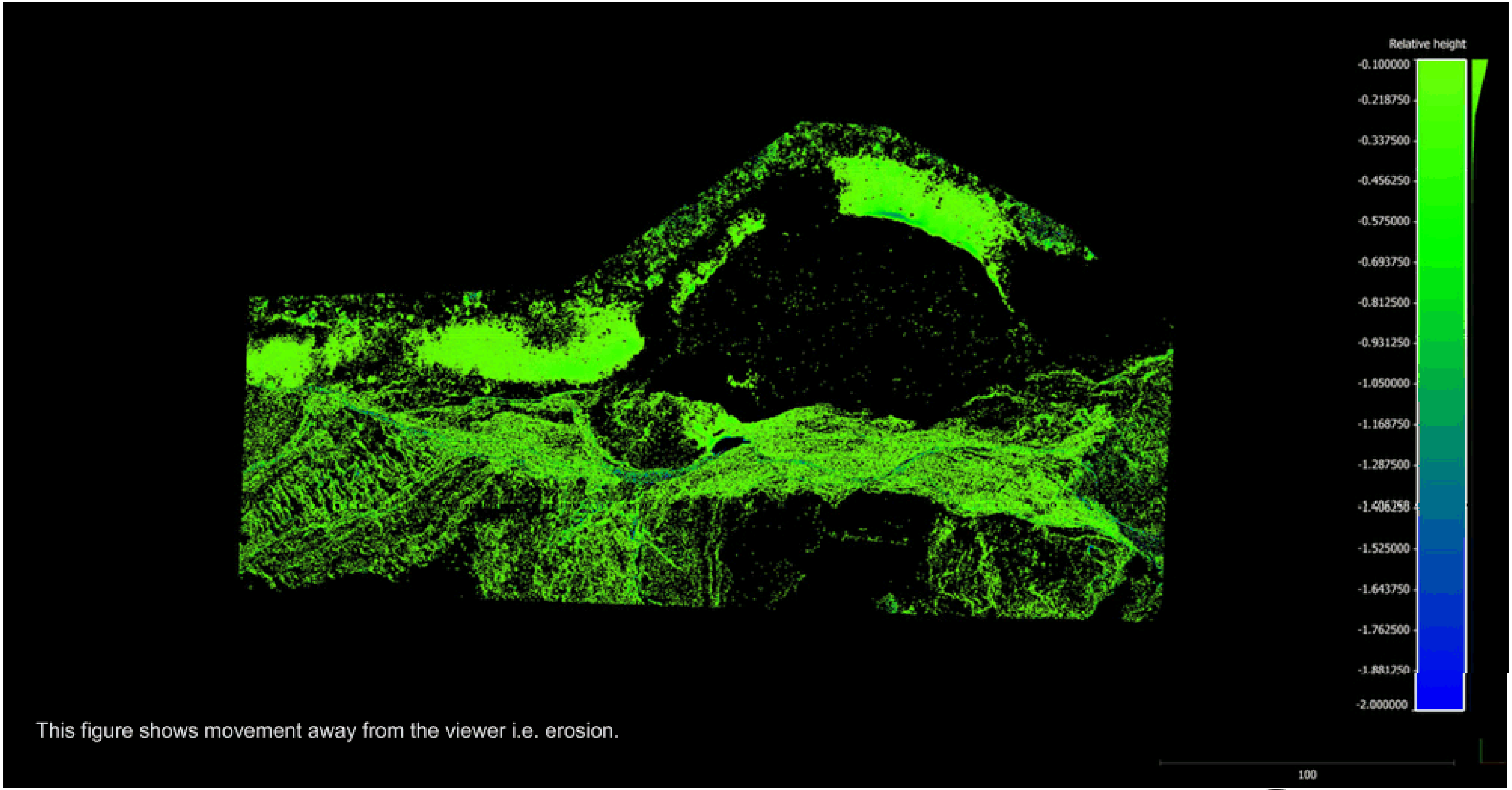
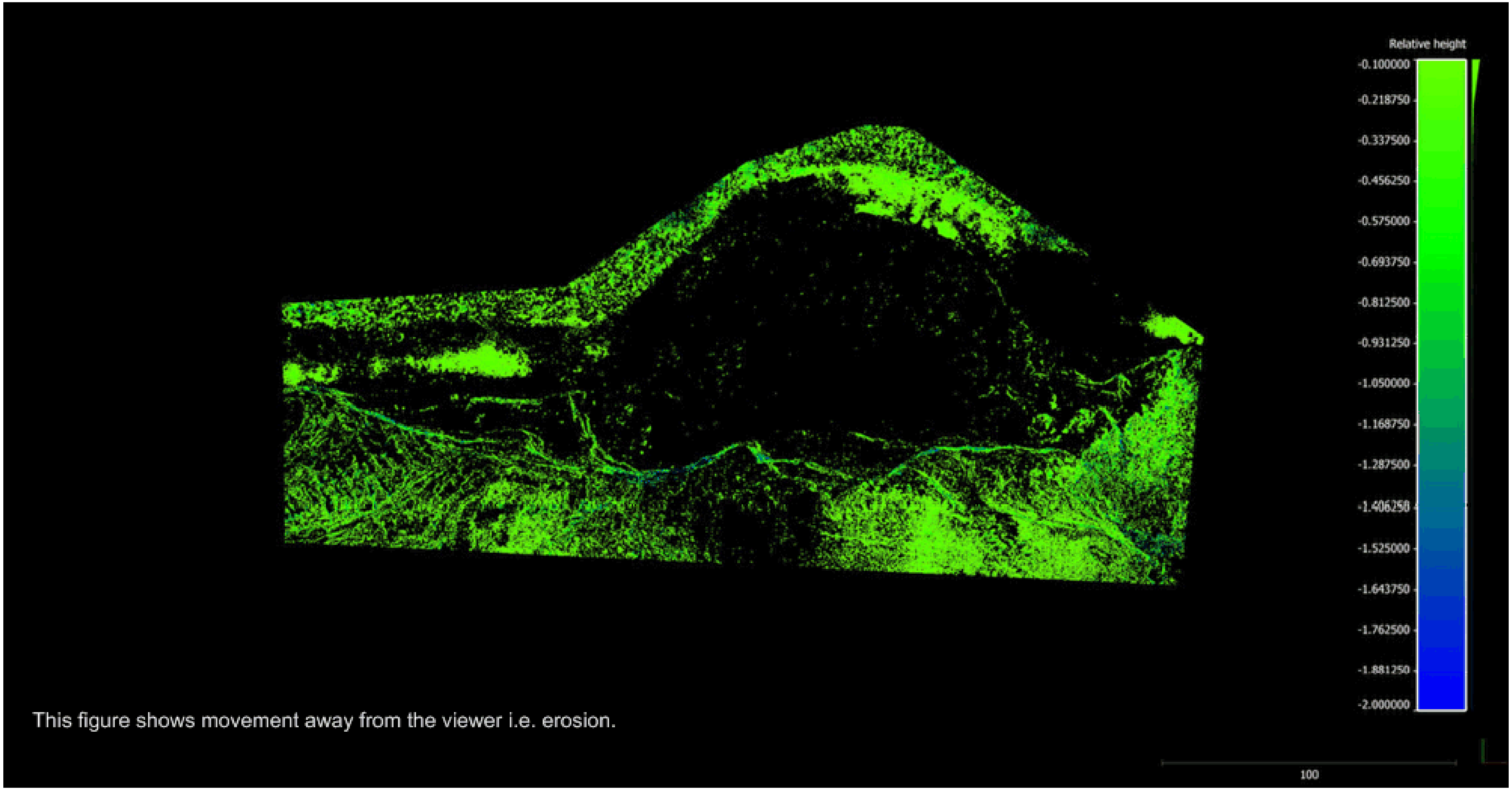


Cape Kidnappers Landslide
Hastings District Council

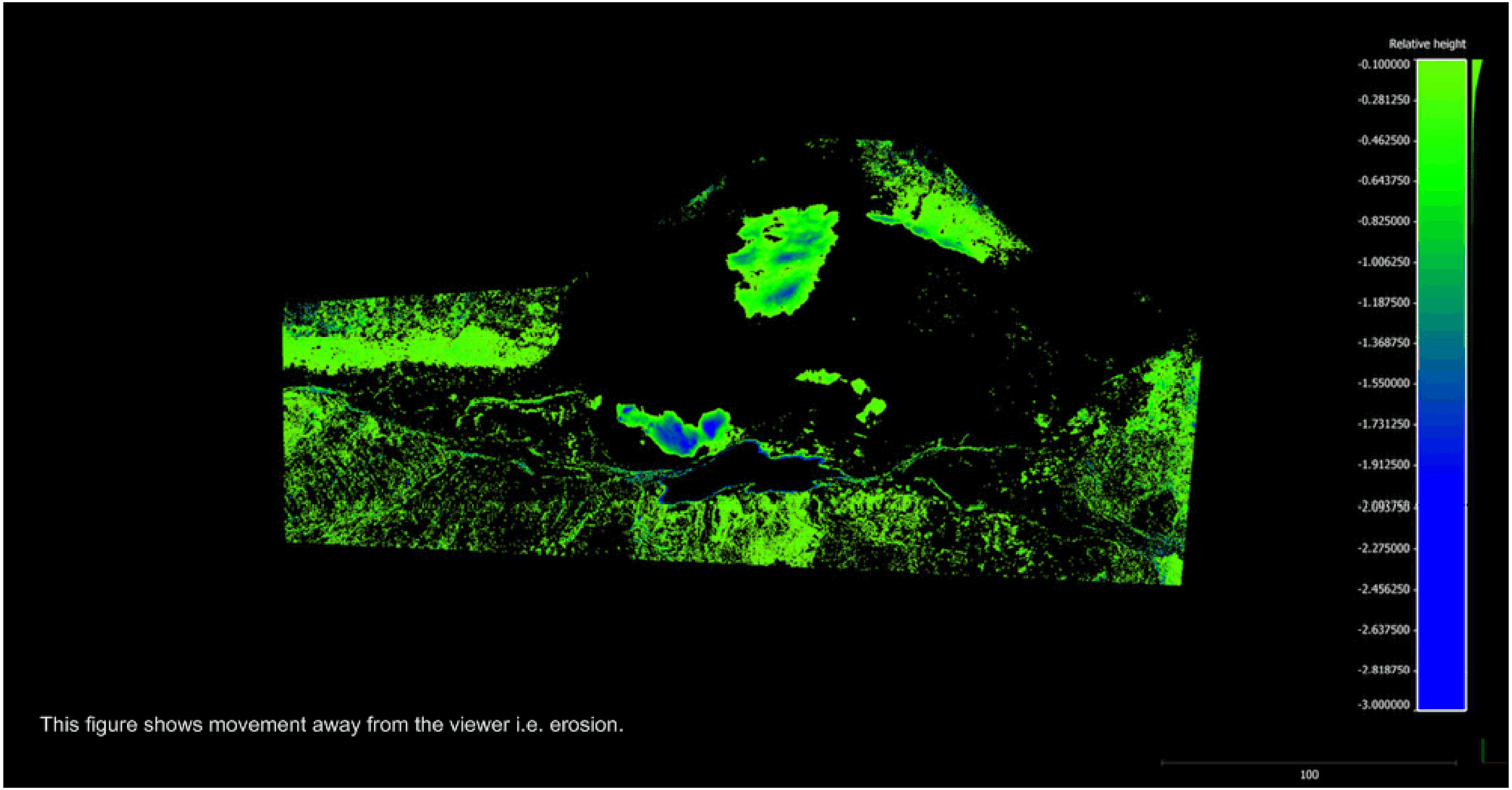
Cliff Plan Changes
25 January 2019 to 28 January 2019

Stantec



Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
28 January 2019 to 31 January 2019

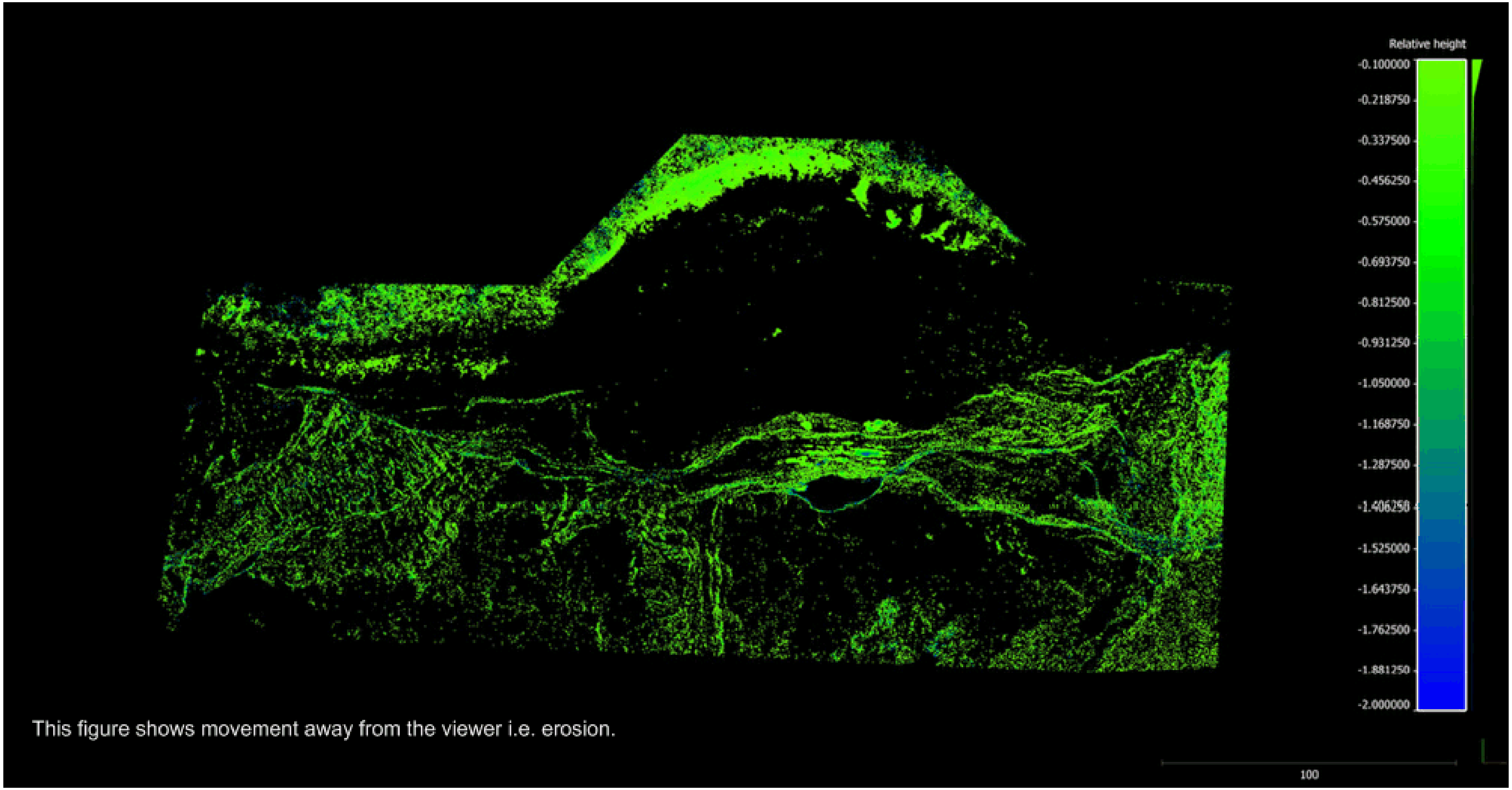


This figure shows movement away from the viewer i.e. erosion.

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
31 January 2019 to 5 February 2019

Stantec



This figure shows movement away from the viewer i.e. erosion.

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
5 February 2019 to 8 February 2019

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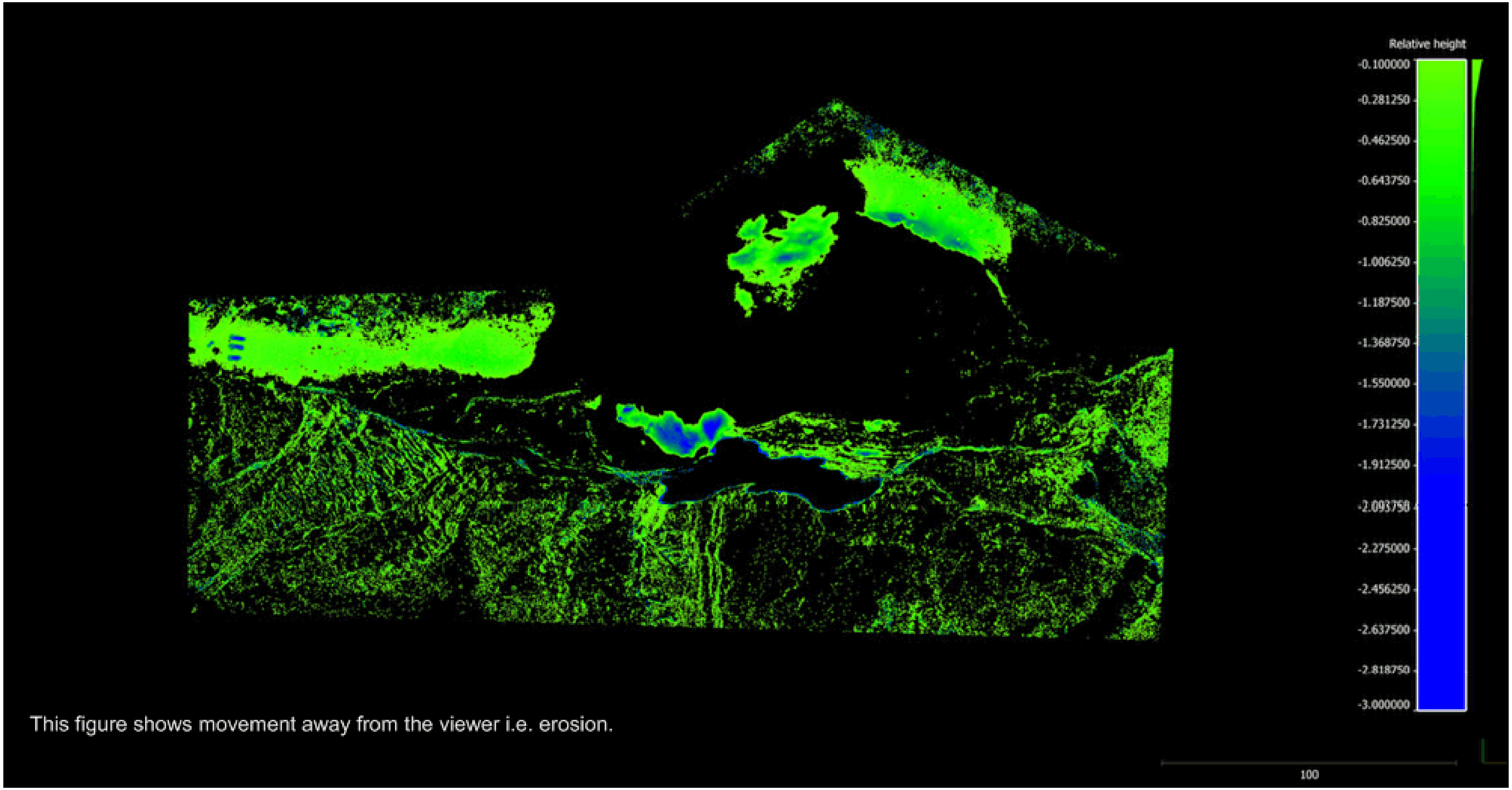

This figure shows movement away from the viewer i.e. erosion.

Cape Kidnappers Landslide
Hastings District Council

Cliff Plan Changes
25 January 2019 to 8 February 2019

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Appendix B Landslide Terminology and Classification (from AGS 2007)

APPENDIX B - LANDSLIDE TERMINOLOGY

The following provides a summary of landslide terminology which should (for uniformity of practice) be adopted when classifying and describing a landslide. It has been based on Cruden & Varnes (1996) and the reader is recommended to refer to the original documents for a more detailed discussion, other terminology and further examples of landslide types and processes.

Landslide

The term ***landslide*** denotes "the movement of a mass of rock, debris or earth down a slope". The phenomena described as landslides are not limited to either the "land" or to "sliding", and usage of the word has implied a much more extensive meaning than its component parts suggest. Ground subsidence and collapse are excluded.

Classification of Landslides

Landslide classification is based on Varnes (1978) system which has two terms: the first term describes the material type and the second term describes the type of movement.

The material types are ***Rock***, ***Earth*** and ***Debris***, being classified as follows:-

The material is either rock or soil.

Rock: is "a hard or firm mass that was intact and in its natural place before the initiation of movement."

Soil: is "an aggregate of solid particles, generally of minerals and rocks, that either was transported or was formed by the weathering of rock in place. Gases or liquids filling the pores of the soil form part of the soil."

Earth: "describes material in which 80% or more of the particles are smaller than 2 mm, the upper limit of sand sized particles."

Debris: "contains a significant proportion of coarse material; 20% to 80% of the particles are larger than 2 mm and the remainder are less than 2 mm."

The terms used should describe the displaced material in the landslide before it was displaced.

The types of movement describe how the landslide movement is distributed through the displaced mass. The five kinematically distinct types of movement are described in the sequence ***fall***, ***topple***, ***slide***, ***spread*** and ***flow***.

The following table shows how the two terms are combined to give the landslide type:

Table B1: Major types of landslides. Abbreviated version of Varnes' classification of slope movements (Varnes, 1978).

TYPE OF MOVEMENT		TYPE OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly Coarse	Predominantly Fine
FALLS		Rock fall	Debris fall	Earth fall
TOPPLES		Rock topple	Debris topple	Earth topple
SLIDES	ROTATIONAL	Rock slide	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		Rock spread	Debris spread	Earth spread
FLOWS		Rock flow (Deep creep)	Debris flow (Soil creep)	Earth flow
COMPLEX	Combination of two or more principle types of movement			

Figure B1 gives schematics to illustrate the major types of landslide movement. Further information and photographs of landslides are available on the USGS website at http://landslides.usgs.gov.

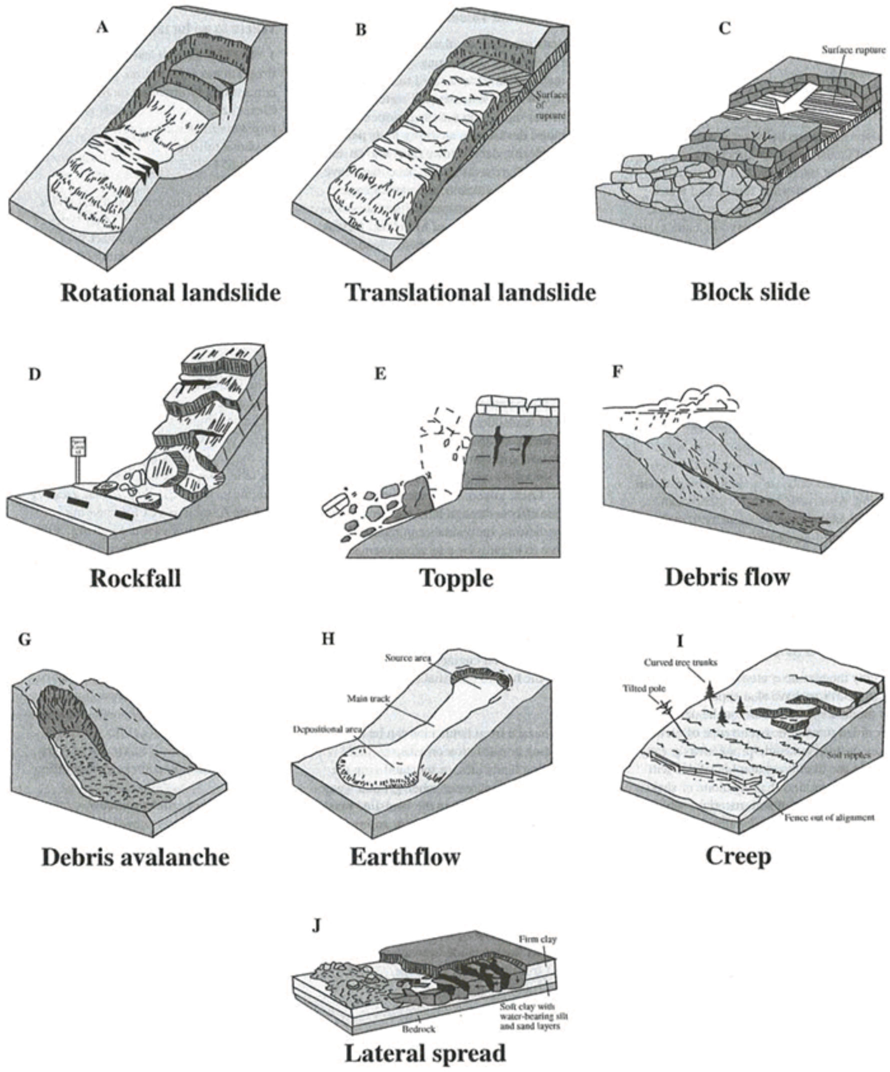

Figure B1: These schematics illustrate the major types of landslide movement.
(From US Geological Survey Fact Sheet 2004-3072, July 2004, with kind permission for reproduction.)

The nomenclature of a landslide can become more elaborate as more information about the movement becomes available. To build up the complete identification of the movement, descriptors are added in front of the two-term classification using a preferred sequence of terms. The suggested sequence provides a progressive narrowing of the focus of the descriptors, first by time and then by spatial location, beginning with a view of the whole landslide, continuing with parts of the movement and finally defining the materials involved. The recommended sequence, as shown in Table B2, describes activity (including state, distribution and style) followed by descriptions of all movements (including rate, water content, material and type). Definitions of the terms in Table B2 are given in Cruden & Varnes (1996).

Second or subsequent movements in complex or composite landslides can be described by repeating, as many times as necessary, the descriptors used in Table B2. Descriptors that are the same as those for the first movement may then be dropped from the name.

For example, the very large and rapid slope movement that occurred near the town of Frank, Alberta, Canada, in 1903 was a *complex, extremely rapid, dry rock fall – debris flow*. From the full name of this landslide at Frank, one would know that both the debris flow and the rock fall were extremely rapid and dry because no other descriptors are used for the debris flow.

The full name of the landslide need only be given once; subsequent references should then be to the initial material and type of movement; for the above example, "the rock fall" or "the Frank rock fall" for the landslide at Frank, Alberta.

Table B2: Glossary for forming names of landslides.

Activity

State	Distribution	Style
Active	Advancing	Complex
Reactivated	Retrogressive	Composite
Suspended	Widening	Multiple
Inactive	Enlarging	Successive
Dormant	Confined	Single
Abandoned	Diminishing	
Stabilised	Moving	
Relict		

Description of First Movement

Rate	Water Content	Material	Type
Extremely rapid	Dry	Rock	Fall
Very rapid	Moist	Earth	Topple
Rapid	Wet	Debris	Slide
Moderate	Very Wet		Spread
Slow			Flow
Very slow			
Extremely slow			

Note: Subsequent movements may be described by repeating the above descriptors as many times as necessary. These terms are described in more detail in Cruden & Varnes (1996) and examples are given.

Landslide Features

Varnes (1978, Figure 2.1t) provided an idealised diagram showing the features for a *complex earth slide – earth flow*, which has been reproduced here as Figure B2. Definitions of landslide dimensions are given in Cruden & Varnes (1996).

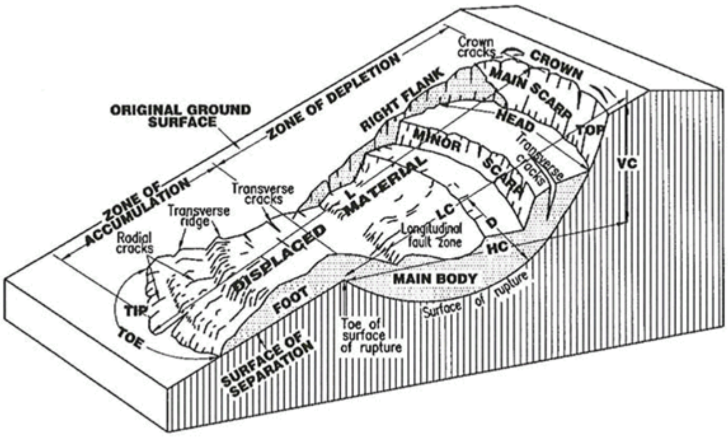

Figure B2: Block of Idealised Complex Earth Slide – Earth Flow

(*Varnes, D J (1978,)Slope Movement Types and Processes. In Special Report 176: Landslides: Analysis and Control(R L Schuster & R J Krizek, eds.), TRB, National Research Council, Washington, DC, pp.11-33).*

Rate of Movement

Figure B3 shows the velocity scale proposed by Cruden & Varnes (1996) which rationalises previous scales. The term "creep" has been omitted due to the many definitions and interpretations in the literature.

Velocity Class	Description	Velocity (mm/sec)	Typical Velocity	Probable Destructive Significance
7	Extremely Rapid			Catastrophe of major violence; buildings destroyed by impact of displaced material; many deaths; escape unlikely
		5×10^3	5 m/sec	
6	Very Rapid			Some lives lost; velocity too great to permit all persons to escape
		5×10^1	3 m/min	
5	Rapid			Escape evaluation possible; structures; possessions, and equipment destroyed
		5×10^{-1}	1.8 m/hr	
4	Moderate			Some temporary and insensitive structures can be temporarily maintained
		5×10^{-3}	13 m/month	
3	Slow			Remedial construction can be undertaken during movement; insensitive structures can be maintained with frequent maintenance work if total movement is not large during a particular acceleration phase
		5×10^{-5}	1.6 m/year	
2	Very Slow			Some permanent structures undamaged by movement
		5×10^{-7}	15 mm/year	
	Extremely SLOW			Imperceptible without instruments; construction **POSSIBLE WITH PRECAUTIONS**

Figure B3: Proposed Landslide Velocity Scale and Probable Destructive Significance.

REFERENCES AND ACKNOWLEDGEMENT

Cruden, D.M., & Varnes, D.J. (1996), "Landslide Types and Processes", Ch.3 in "Landslides. Investigation and Mitigation", Eds Turner, A.K. and Schuster, R.L. Special Report 247, Transport Research Board, National Research Council, Washington D.C. Extracts reprinted above by kind permission of the authors and publishers. Copies of the publication can be obtained from "Transport Research Board, National Research Council, 2101 Constitution Avenue, N.W., Washington D.C. 20418, USA.

IAEG (International Association of Engineering Geology) Commission on Landslides, (1990). Suggested nomenclature for landslides, Bulletin IAEG, No. 41, pp.13-16.

Varnes, D.J. (1978). Slope Movement Types and Processes. In *Special Report 176: Landslides: Analysis and Control* (R.L. Schuster and R.J. Krizek, eds.), TRB, National Research Council, Washington, D.C., pp.11-33.

WP/WLI (International Geotechnical Societies' UNESCO Working Party on World Landslide Inventory) (1990). A suggested method for reporting a landslide. Bulletin IAEG, 41, pp.5-12

WP/WLI (International Geotechnical Societies' UNESCO Working Party on World Landslide Inventory) (1993). A suggested method for describing the activity of a landslide. Bulletin International Association of Engineering Geology, 47: 53-57.

WP/WLI (International Geotechnical Societies' UENSCO Working Party on World Landslide Inventory) (1994). Multilingual Glossary for Landslides, Bitech Press, Vancouver, in press.

Appendix C Risk Terminology (from AGS 2007)

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Annual Exceedance Probability (AEP) – The estimated probability that an event of specified magnitude will be exceeded in any year.

Consequence – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

Elements at Risk – The population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.

Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

Hazard – A condition with the potential for causing an undesirable consequence (the landslide). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.

Individual Risk to Life – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.

Landslide Activity – The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (e.g. seasonal) or continuous (in which case the slide is "active").

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.

Landslide Risk - The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.

Landslide Susceptibility – The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.

Likelihood – Used as a qualitative description of probability or frequency.

Probability – A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

There are two main interpretations:

(i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It

includes also the idea of population variability. Such a number is called an "objective" or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.

Qualitative Risk Analysis – An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.

Quantitative Risk Analysis – An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.

Risk Analysis – The use of available information to estimate the risk to individual, population, property, or the environment, from hazards. Risk analyses generally contain the following steps: Scope definition, hazard identification and risk estimation.

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Control or Risk Treatment – The process of decision making for managing risk and the implementation or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.

Risk Estimation – The process used to produce a measure of the level of health, property or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis and their integration.

Risk Evaluation – The stage at which values and judgments enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk Management – The complete process of risk assessment and risk control (or risk treatment).

Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental and other losses.

Susceptibility – see Landslide Susceptibility

Temporal Spatial Probability – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.

Tolerable Risk – A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

Hawke's Bay
1st Floor, 100 Warren Street South
Hastings 4122
PO Box 13-052, Armagh
Christchurch 8141
Tel +64 6 873 8900
Fax +64 6 873 8901

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HASTINGS DISTRICT COUNCIL

COUNCIL MEETING

TUESDAY, 5 MARCH 2019

RECOMMENDATION TO EXCLUDE THE PUBLIC

SECTION 48, LOCAL GOVERNMENT OFFICIAL INFORMATION AND MEETINGS ACT 1987

THAT the public now be excluded from the following part of the meeting, namely:

10 Opera House Plaza Redevelopment

The general subject of the matter to be considered while the public is excluded, the reason for passing this Resolution in relation to the matter and the specific grounds under Section 48 (1) of the Local Government Official Information and Meetings Act 1987 for the passing of this Resolution is as follows:

GENERAL SUBJECT OF EACH MATTER TO BE CONSIDERED	***REASON FOR PASSING THIS RESOLUTION IN RELATION TO EACH MATTER, AND PARTICULAR INTERESTS PROTECTED***	***GROUND(S) UNDER SECTION 48(1) FOR THE PASSING OF EACH RESOLUTION***
10 Opera House Plaza Redevelopment	**Section 7 (2) (i)** The withholding of the information is necessary to enable the local authority to carry on, without prejudice or disadvantage, negotiations (including commercial and industrial negotiations). The information in this report is commercially sensitive..	**Section 48(1)(a)(i)** Where the Local Authority is named or specified in the First Schedule to this Act under Section 6 or 7 (except Section 7(2)(f)(i)) of this Act.