15 August 2024

Email:

Dear

Thank you for your email concerning the ongoing repairs across the district roading network as a result of the cyclone and storm events of 2022/23. I respond to your official information request, as set out below;

a) A copy of the geotechnical report relevant to the area in question.
b) The timeline for when the necessary work on the embankment is scheduled to commence.
c) Assurance that the carriageway will be reinstated to facilitate two-lane traffic and that the footpath will be preserved upon completion of the work.

The Councils web page gives an insight into the current repairs that we are addressing as well as the proposed programme for the forthcoming year, and are updated regularly as part of our policy in keeping interested parties informed.

https://www.tcdc.govt.nz/Our-Services/Transport-Roads-and-Road-Safety/Road-and-Highway-Conditions

In addition, responses to many frequently asked questions can be found at:

https://www.tcdc.govt.nz/Our-Services/Transport-Roads-and-Road-Safety/Road-Repairs-after-Storms-FAQs

Our roading manager comments;
"With regard to the specific sites that you have enquired about at Purangi Road, Flaxmill Bay, this is a low to medium priority site when judged against the remaining sites across the district that require repair. We currently aim to have full design (including consenting for coastal works agreed with Waikato Regional Council) completed by the end of November, tendering and procurement to be completed between December and February with a construction start in March 2025 or April 2025. The design is for the full reinstatement of two vehicle lanes and footpath."

Please also find attached the options report HD Geo completed and well as the Coastal Report.

A small amount of information has been redacted from the report under section 7(2)(a) to withhold and protect the privacy of people. In making the decision to withhold the information under section 7 I do not consider there to be a countervailing interest warranting its release.

You have the right to seek an investigation and review by the Ombudsman of this decision. Information about how to make a complaint is available at www.ombudsman.parliament.nz or freephone 0800 802 602.

Kind Regards,

Legal Technical Specialist (LGOIMA)

18 JANUARY 2023

26 London Street
Hamilton 3204
PO Box 9266
Hamilton 3240
New Zealand
64 (0)7 957 2727

Pinnacles Civil Ltd

HD2740 – Purangi Road RP 11.1 – Inspection of underslip

Following your request, we have conducted a high-level site assessment on 08 January 2023 for the under slip on Purangi Road at RP 10.8. We returned to site on the 16.01.2023 following the complete failure of the shoulder.

The walkover revealed that the true right-hand side (TRHS) shoulder has been undercut by coastal erosion during high sea levels and storm surges. This has caused the large Pohutukawa trees to lose support and fail downslope with their root ball pulling the soil from below the concrete footpath.

We have qualitatively assessed the risk to the footpath and pedestrians as **high**. The risk to the road is assessed as **medium**. The risk will increase with time and following rainfall as the scarp is expected to regress to the TRHS lane.

We recommend that the concrete foot path is closed until the slip is repaired. We recommend that the practitioner's rock buttress and gabion wall is constructed to re-form the road shoulder and to mitigate further costal erosion.

Site note attached.

Kind regards,

HUNTER JENKINSON

Engineering Geologist
Hunter@hdgeo.co.nz
7(2)(a) [redacted]

ANDREW HOLLAND, CPENG

Technical Director, Principal Engineer
Andrew@hdgeo.co.nz

Inspection Details:

Job reference: HD2740 Inspection date/time: 08/01/2023 @ 10:00 am & 16.01.2023
Event date/time: November 2022 & January 2023
Road: Purangi Road RP: 10.870 to 10.884 Side: TRHS
Site location derived by: Mobile roads online ADT: 1316 (est) 02/07/2020 0% heavy
Road surface: Chip seal Personnel onsite: Hunter Jenkinson (HD Geo)
Client interactions and/or comments on site visit: N/A

Site observations:

A 10 m long under slip has occurred on the True Right-Hand Side (TRHS) of the Purangi Road at RP 10.870. The shoulder has completely failed creating a 3 m high vertical scarp slope directly adjacent to the concrete foot path. The debris including a large Pohutukawa Trees is located on the foreshore and will slowly be removed during high tides. The path and road have not been damaged however it is expected to crack as the outside edge settles. This could result in the foot path suddenly dropping away. The shoulder either side of the slip are expected to fail in a similar way in the near future.

The TRHS slope either side of the slip is about 5 - 7 m high and sloping between 60 – 70 degrees down to the foreshore. Large Pohutukawa trees on the outside edge of the shoulder are sitting on what appears to be side-cast fill or colluvium that is comprised of small to large boulders (<0.5 m to 2m dia) in a fine-grained matrix. The Minden Rhyolite Subgroup is exposed at the toe of the slope on the foreshore. There are obvious signs of coastal erosion at the toe of the slope which is over-steepening the base and allowing the large boulders to fall out, removing support to the trees above. The road is 6.7 m wide and a 45-degree slope is located on the TLHS of the road which is heavily vegetated.

A culvert is located on the low chainage side of the site and does not currently appear to be related to the under slip.

Event description and failure mechanism:

Underslip

We have assessed the recent failure was triggered by high sea levels and storm surges during storm events which have eroded the toe of the slope below the Pohutukawa trees. This has removed the fine-grained material causing the boulders to fall out onto the foreshore, removing support to the large Pohutukawa trees above. This has allowed the Pohutukawa trees to fail down-slope pulling the shoulder soils with their root ball, resulting in the path being undercut. Further parts of the shoulder are expected to fail in the short term or during storms which result in large sea swells and surges.

Qualitative risk assessment

We have qualitatively assessed the risk to footpath and pedestrians as **high** because the failure has undercut the foot path. The risk to the road is assessed as **medium** as it is currently unaffected. The current scarp face is expected to slowly regress over time and during rainfall and high sea levels which will result in further damage to the foot path and eventually the road. If the risk is realised, the road surface maybe effected and the TRHS lane reduced in width. The concrete foot path should be closed. A temporary foot path could be installed along the TRHS lane away from the failure.

RISK RANK MATRIX		CONSEQUENCES				
		1 – S	2 – Mi	3 – Mo	4 – Ma	5 – C
LIKELIHOOD	5 – AC	High	High	Extreme	Extreme	Extreme
	4 – L	Medium	High	High	Extreme	Extreme
	3 – P	Low	Medium	High	High	Extreme
	2 – U	Low	Low	Medium	High	High
	1 - R	Low	Low	Medium	High	High

Qualitative risk (asset and road user) profile with time			
High	X	X X	X X
Medium	X		
Low			
	Short (Days)	**Medium** (Weeks - months)	**Long** (Months – years)

Blue = Road Black = Foot path and pedestrians.
Refer to risk assessment criteria for definitions of terms

Sketch and section of site:

Online link to Drone model: [Purangi Road RP 10.8 drone model]

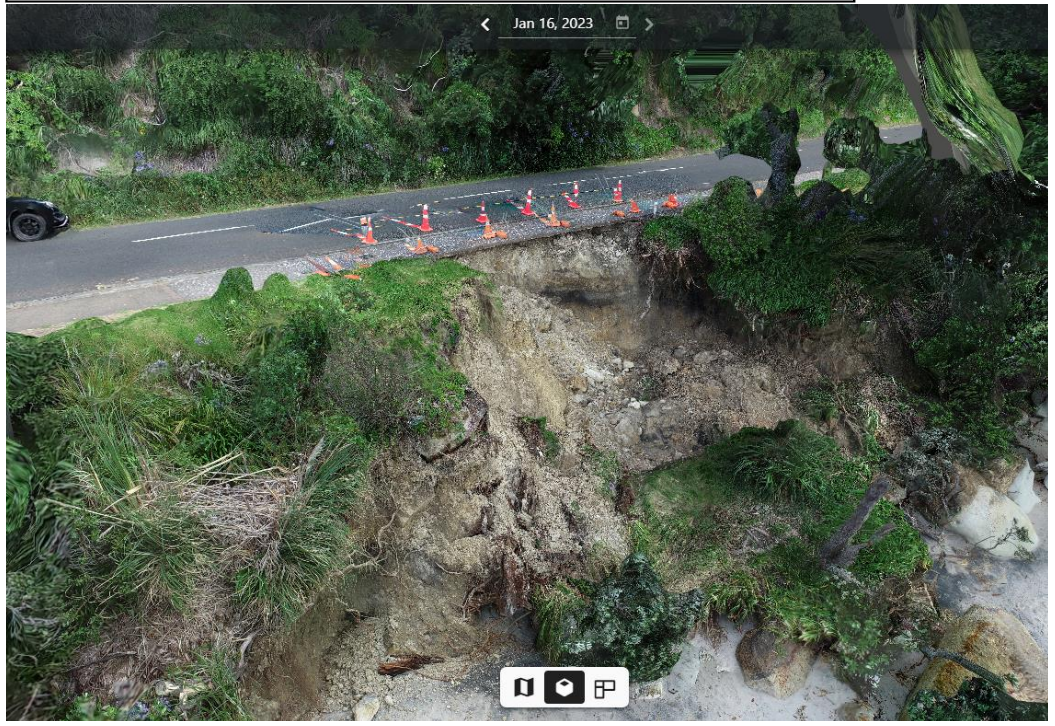


Figure 1: Drone image 16.01.2023.

Figure 2: Looking up chainage at the scarp. Not the very outside edge of the concrete is undermined.

Options:

Option description	Special considerations:	Residual risk	Cost
1: Do now (minimum) – until a permanent option is constructed (loss of asset, injury to public) • The road should be put on single lane give way priority to allow for a temporary foot path to be installed along the TRHS lane. (the concrete path should be closed). • Install warning signs and speed restrictions for traffic • Frequent monitoring should occur. Especially during and following rainfall and high sea levels/storms.	• Prepare for reduction in road width, road disruption or lane closure in the short to medium term if the scarp regresses further.	• Medium to high risk increasing to high over time.	• Low cost – ongoing until permanent fix • ROC Est - Pinnacles
2: Practitioner's solution – Road retreat & erosion controls The road could be realigned to move the corridor away from the slope. This would require cuts into the TLHS batter slope. • Batter slopes can be cut at the same angles to those existing. • Install coir matting down the failed slope below the road and re-plant with suited shrubs and trees to help mitigate erosion. • Rip rap rock could be placed at the toe of the slope to mitigate erosion.	• Minor slumping and failure could occur in the new cut batter • Land ownership issues may be present • Temporary road closure maybe required for construction • Road geometrics will be affected • Expect the slope below to continue to erode which may affect the new road alignment in the medium to long term.	• Low risk for the medium to long term • Expected design life/performance can be refined/confirmed by further geotechnical investigation and design	• Medium cost – ongoing until permanent fix • ROC Est - Pinnacles
3: Practitioner's solution – Rock buttress + gabions The failed material will be cut to waste, and a bench formed on suitable ground or bedrock. A rock buttress can be constructed from the foreshore up to the road shoulder. A 2 m high gabion wall can be located on top of the buttress to help limit the footprint on the foreshore. • The rock buttress will be constructed using suitable sized boulders founded on suitable ground. • Maximum 45-degree buttress angle. • 2m high maximum gabion wall on top of the buttress • Reinstate the footpath.	• Resource consent will be required for construction on the foreshore. • Temporary road closure maybe required for construction.	• Low risk for the medium to long term. • Expected design life/performance can be refined/confirmed by further geotechnical investigation and design	• Medium to high cost – ongoing until permanent fix • ROC Est - Pinnacles
4: Engineered option – Designed gravity block wall or MSE wall Detailed assessment and design of a gravity block wall or MSE wall (Gabion, MagnumStone, RediRock, Duramesh wall). • 7 m high wall. • Block extenders or geotextile anchors maybe required to achieve the required factor of safety for a block wall. • founded on competent ground (stiff to very stiff residual soils or bedrock). • riprap rock or similar to be placed at the toe for scour.	• Temporary road closure or stop/stop traffic control will be required during physical works. • Further geotechnical investigation and assessment will be required. • Inspections must be completed by HD Geo during construction. • Installation of a 'hard' structure in this environment can lead to end/edge effects, causing/speeding failure adjacent to the structure	• Risk will remain low for both asset and user for the design life of the structure (up to 50 years).	• High cost • ROC Est - Pinnacles

Recommendation:

We recommend that **Option 3**, rock buttress and gabion wall is considered for this site. This option will mitigate the erosion from future storm surges and allow the footpath to be reinstated. Option 2 may be cost effective but will not treat the failure mechanism or trigger. Option 4 will have little effect on the foreshore but maybe unfeasible due to high cost.

The do now option should be considered as an immediate fix until a more permanent solution is built.

Notes and comments in using site report:

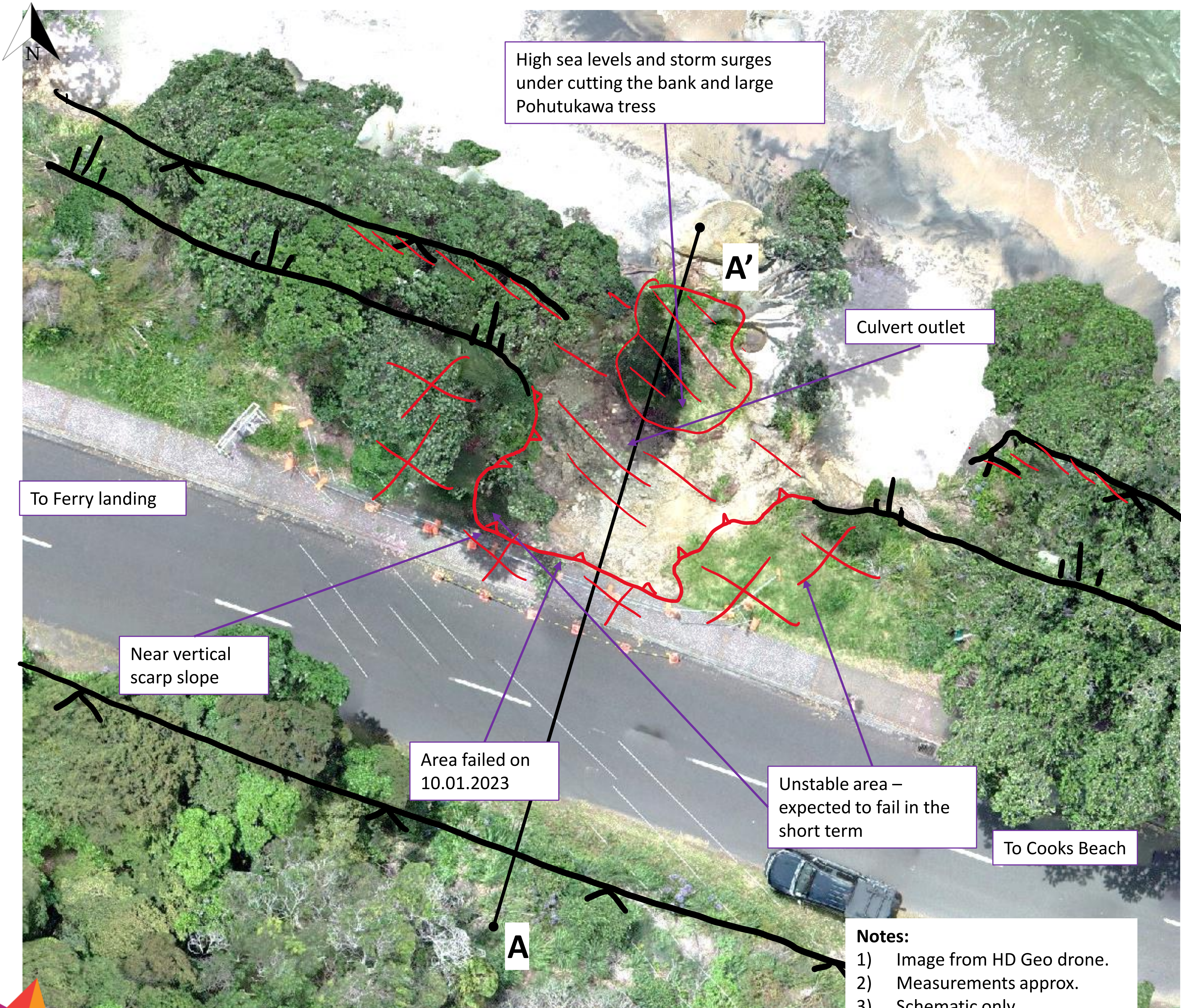
LIKELIHOOD – The possibility of the hazard occurring.			CONSEQUENCES- The most likely consequence should the hazard occur.		
Category	**Definition**	**Example timeframes**	**Category**	**Definition**	**Example consequence**
5 – AC	**Almost Certain** e.g. Often occurs –	days to weeks	5 – C	**Catastrophic** e.g. A fatality may reasonably be expected	Significant risk to road users / long term road closure to facilitate repairs with no alternative access- ADT > 100
4 – L	**Likely** e.g. Could easily happen –	weeks to months	4 – Ma	**Major** e.g. A fatality is possible	Significant risk to road users / long term road closure to facilitate repairs with no alternative access- ADT < 100
3 – P	**Possible** e.g. Could happen or known to happen –	months to years	3 – Mo	**Moderate** e.g. Hospitalisation and either short or long-term disability	An injury requiring hospitalisation may reasonably be expected / practitioner solutions are possible
2 – U	**Unlikely** e.g. Hasn't happened but could happen -	could happen in several years	2 – Mi	**Minor** e.g. Medical treatment or first aid or both	Inconvenience to road users while repairs are made
1 - R	**Rare** e.g. Conceivable but only in extreme circumstances	not expected in several years	1 - S	**Superficial**	No significant change to risk to road users – a second event will be required to occur before treatment is required.

Considerations in assessing likelihood:

- Failure methodology – this leads to expected next occurrence of event

Considerations in assessing consequence:

- What is the risk to the road user either from the event itself or until the event is identified to council site management is in place?
- What impact will avoidance have on the traffic? Avoidance: reduce the road to single lane/give way priority if sight lines are appropriate.
- Consider approach visibility (sight distance) to hazard



hd GEO

LEGEND

Top of slope

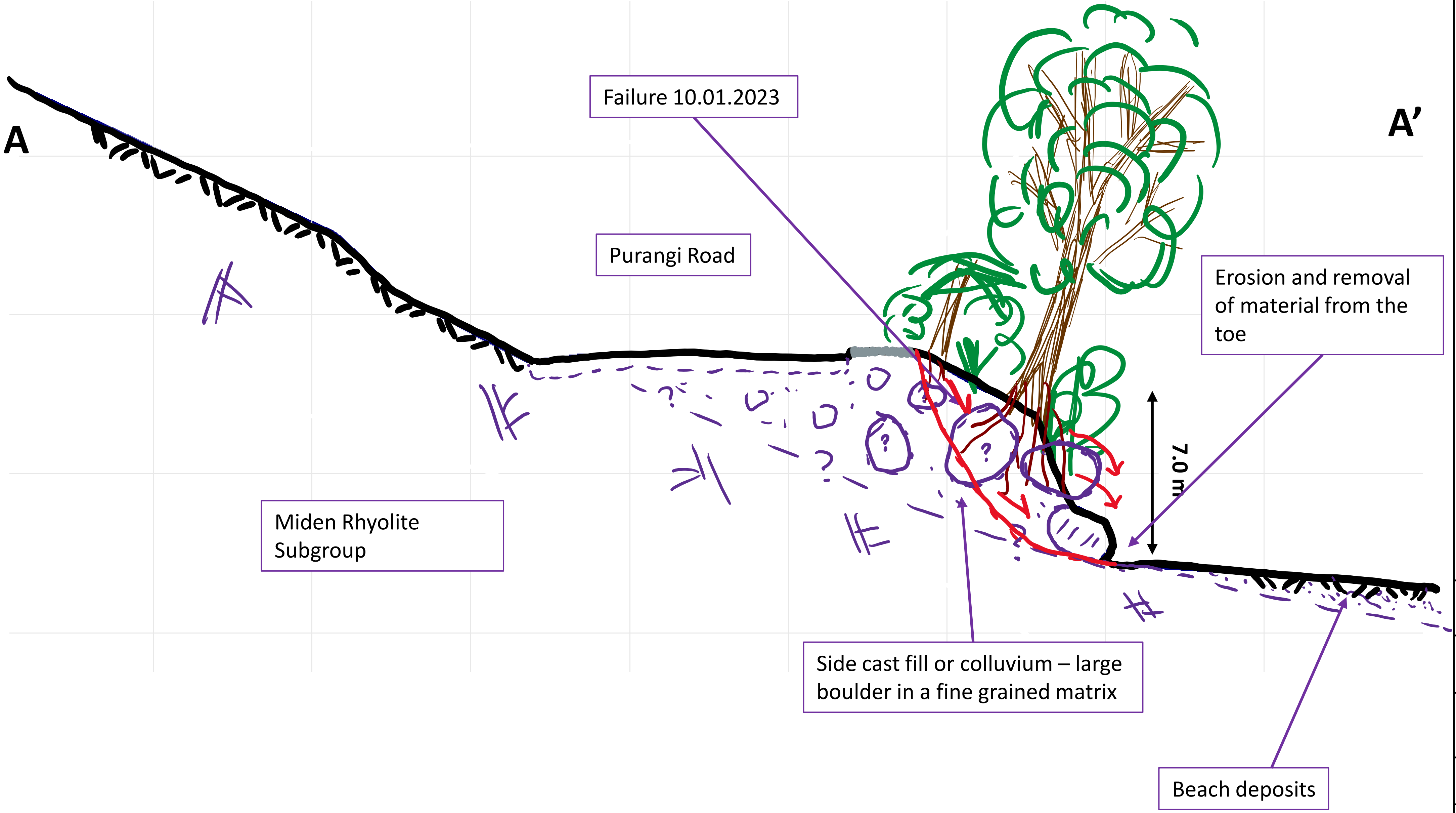
Bottom of slope

Surface water flow

Scarp

Debris

PROJECT: Purangi Road RP 10.8	
PROJECT No: HD2740	
CLIENT: TCDC/ cc Pinnacles Civil Group Ltd	
TITLE: Site plan	
SCALE: N/A	
Drawing No: 01	
Drawing By: HJ	
Rev no:	
1	Initial – 11.01.2023
2	Post failure – 18.01.2023



Notes:

1) Image from HD Geo drone.
2) Measurements are approx.
3) Schematic only.

HD GEO

PROJECT: Purangi Road RP 10.8

PROJECT No: HD2740

CLIENT: TCDC/ cc Pinnacles Civil Group Ltd

TITLE: Schematic section

SCALE: N/A

Drawing No: 02

Drawing By: HJ

Rev no:

1	Initial – 11.01.2023
2	Post failure – 18.01.2023

Coastal Processes, Engineering and Ecological Assessment for Purangi Road Coastal Protection

Prepared for:

Pinnacles Civil
Design | Build | Asset Management

Coastal Processes, Engineering and Ecological Assessment for Purangi Road Coastal Protection

Report Status

Version	Date	Status	Approved by
V. 1	30 November 2023	Final Draft	

It is the responsibility of the reader to verify the version number of this report.

Authors

Shaw Mead *BSc, MSc (Hons), PhD*

Contents

Figures

Tables

1 Introduction

This report has been developed to provide advice on coastal erosion protection works for Purangi Road, Coromandel, which 1 of 9 sites being assessed (Figure 1-1). Site visits have been undertaken to consider local ecology, and additional data and information reviews have been used to further consider coastal processes and provide guidance on rock sizing for construction of a revetment to protect the road.

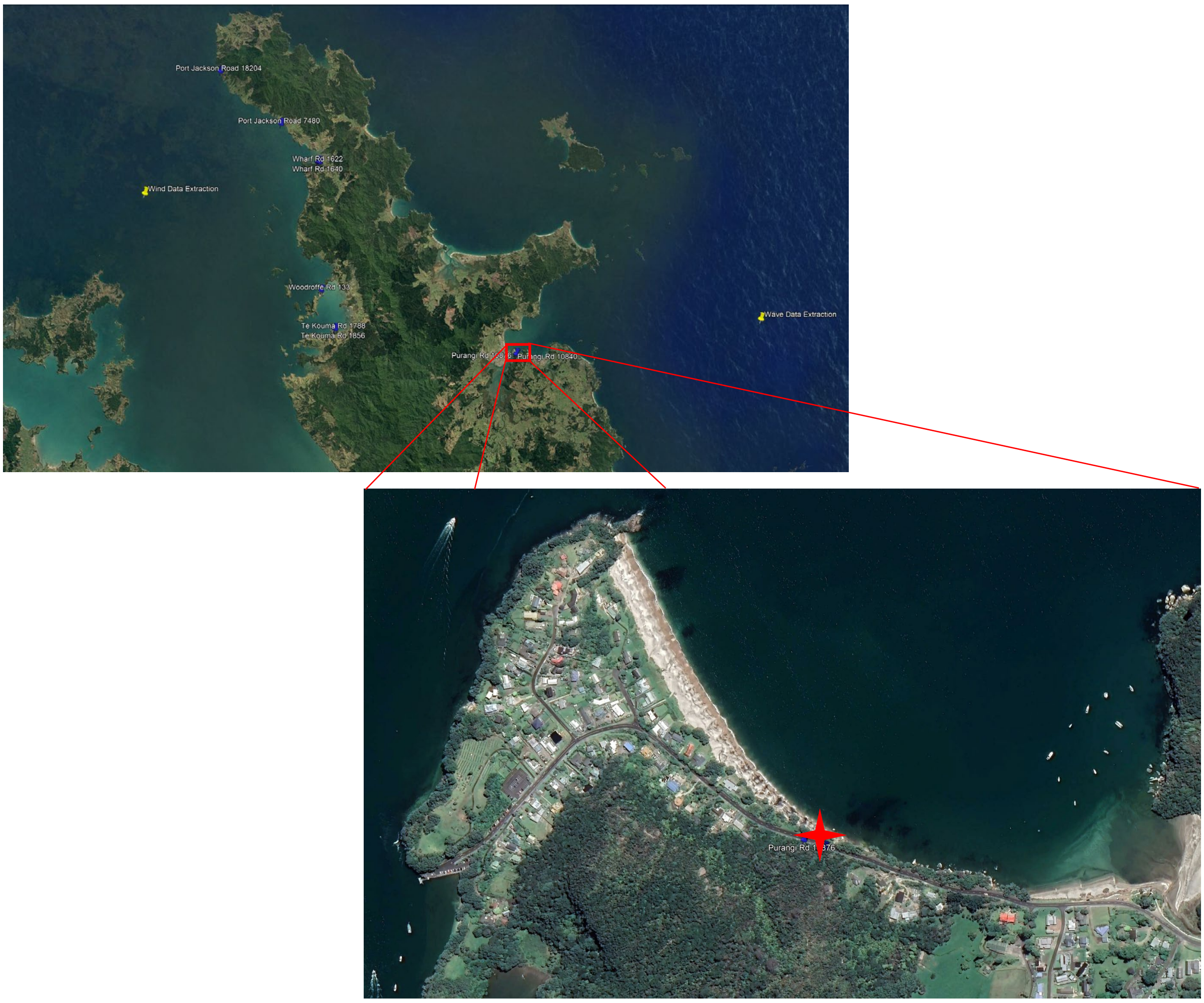


Figure 1-1. Locations of the Purangi Road site that require coastal protection measures.

2 Site Description

The Purangi Road site is located in Maramaratotara Bay/Flaxmill Bay inside Mercury Bay on the eastern side of the Coromandel Peninsula, and so exposed to long period ocean swells from the ENE (Figure 1-1). Although the site is protected by the headland of the Shakespeare Cliffs to the east (Figure 2-1) and has only an 18 km fetch to the Ohinmau Island (Figure 2-2) and usually a very benign site, the process of refraction of long period waves means that it is still vulnerable to extreme events from the north easterly quarter such as extra-tropical cyclones. The damaged road that requires protecting from extreme wave events is the perched above a sand beach with occasional large boulders (Figure 2-3 and Figure 2-4).

Flaxmill Bay has a yellow/white sand beach with a gradient of approximately 1:25 (V:H), with large boulders around the high tide mark, which is relatively close to the toe of the cliff at the site on Purangi Road (Figure 2-1). The top of the is mostly terrestrial grasses and weeds (e.g., kikuyu, agapanthus and pampas grass), with a mix of exotic/invasive and native species along the cliff, most notably Pohutukawa trees (Figure 2-4). Just to the east of the slip there is a concrete buttress protecting the cliff and road above it (Figure 2-5).

Figure 2-1. Looking northeast from the eroded site at Purangi Road, with Shakespeare Cliffs headland in the middle right of the image.

Figure 2-2. Although the site is protected by the headland to the east and has only an 18 km fetch to the Ohinmau Island, the process of refraction of long period waves means that it is still vulnerable to extreme events.

Figure 2-3. The dangerous footpath at Purangi Road.

Figure 2-4. The damaged road that requires protecting from extreme wave events is the perched above a sand beach with occasional large boulders.

Figure 2-5. A concrete buttress protecting the cliff and road above it to the east of the slip.

2.1 Coastal Processes

The geology at this site consists of the Coroglen Subgroup, typified by lithic and pumice-rich ignimbrite and local rhyolitic and obsidian rich pumice breccia deposits and tuff. (Figure 2-6). This mix of soils and rocks can be seen in the scoured slip area (Figure 2-4), above the beach comprised of medium grain sand at an approximate gradient of 1:25 (V:H). As noted above, the high tide mark is relatively close to the toe of the cliff; the high tide came to the base of the cliff/slip in the initial site visit and was ~5 m seaward of it during the second (Figure 2-4 and Figure 2-1, respectively). Maramaratotara Bay/Flax Mill Bay is a pocket beach bounded by headlands and orientated to be in equilibrium with the wave climate (i.e., there is very little alongshore sediment transport, as evidenced by the formation of beach cusps) (Figure 2-7).

The Whitianga has a maximum astronomical tidal range of 2.5 m, a spring tidal range of 1.7 m, and a neap tidal range of 1.1 m (Table 2-1).

Table 2-1. Tide table for Whitianga (LINZ).

Tidal Phase	MHWS	MHWN	MLWN	MLWS	MSL
Height (m)	2.1	1.8	0.7	0.4	1.3

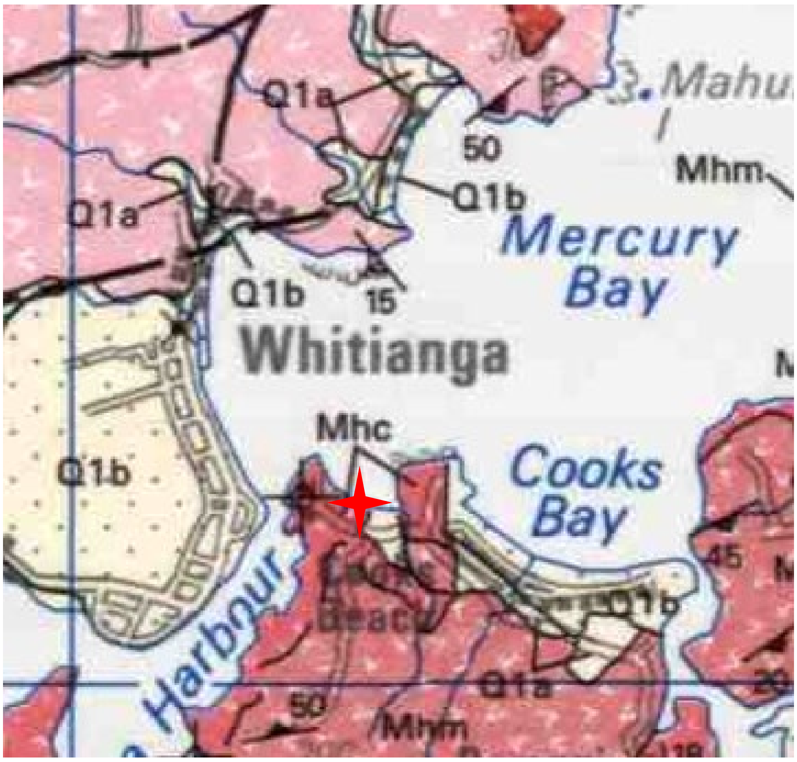


Figure 2-6. The geology at this site consists of the Coroglen Subgroup, typified by lithic and pumice-rich ignimbrite and local rhyolitic and obsidian rich pumice breccia deposits and tuff. (Geological Map of the Auckland Area, 1:250 000 geological Map 3 by Institute of Geological and Nuclear Sciences).

Figure 2-7. Maramaratotara Bay/Flax Mill Bay is a pocket beach bounded by headlands and orientated to be in equilibrium with the wave climate (i.e., there is very little alongshore sediment transport, as evidenced by the formation of beach cusps).

As noted above, this site is usually protected, and so benign and relatively stable for much of the time. The coastal processes at the sites are dominated by northeasterly quarter winds and wave, which can be extreme on occasion with significant wave heights of >4.0 m and wave periods over 16 seconds (see Section 3.1 below). Due to the pocket nature of the beach bounded by headlands, it is orientated to be in equilibrium with the wave climate, and therefore there is very little alongshore sediment transport (Figure 2-7). During locally generated short period waves (i.e., from strong onshore winds) sand is dragged off of the beach face (i.e., across shore sediment transport), which is returned to the upper beach during calmer periods (e.g., Dean, 1988). It is evident that the cliff face along the northern side of Purangi Road is exposed to wave attack during extreme events and prone to failure (Figure 2-4 and Figure 2-5). The mean wave height and period on the eastern side of the Coromandel Peninsula is 0.9 m at 9 seconds.

3 Extreme Wave Events and Rock-Sizing

At this site, the erosion threat is due to large waves generated both distantly (i.e., long period swells) and locally (i.e., short period wind-generated swells). To determine the extreme wave heights, 44 years of 3-hourly wave data was extracted on the eastern side of the Coromandel Peninsula, due east of Mercury Bay (Figure 1-1), and an extreme value analysis was undertaken. The 1 in 100-year return period wave event for the site was then used to determine appropriate rock-sizes for the revetment at the site. Sea level rise (SLR) and vertical land movement (VLM) have also been considered to determine the maximum depth-limited wave height at the shore.

3.1 Extreme Wave Event Analysis

An extreme value analysis was carried out on the 44 years of 3-hourly wave data (Figure 3-1) using the WAFO Group (2011) toolbox developed by faculty of Engineering, Mathematical Statistics, Lund University, Sweden, which is a commonly used statistical toolbox for carrying out univariate extreme value analysis. The routines in WAFO were used for fitting a statistical distribution to the occurrence of wave heights. The analysis was carried out using a Peaks over Threshold (PoT) method and fitting the resultant data to a generalised Pareto distribution. The results of the analysis are presented in Table 3-1.

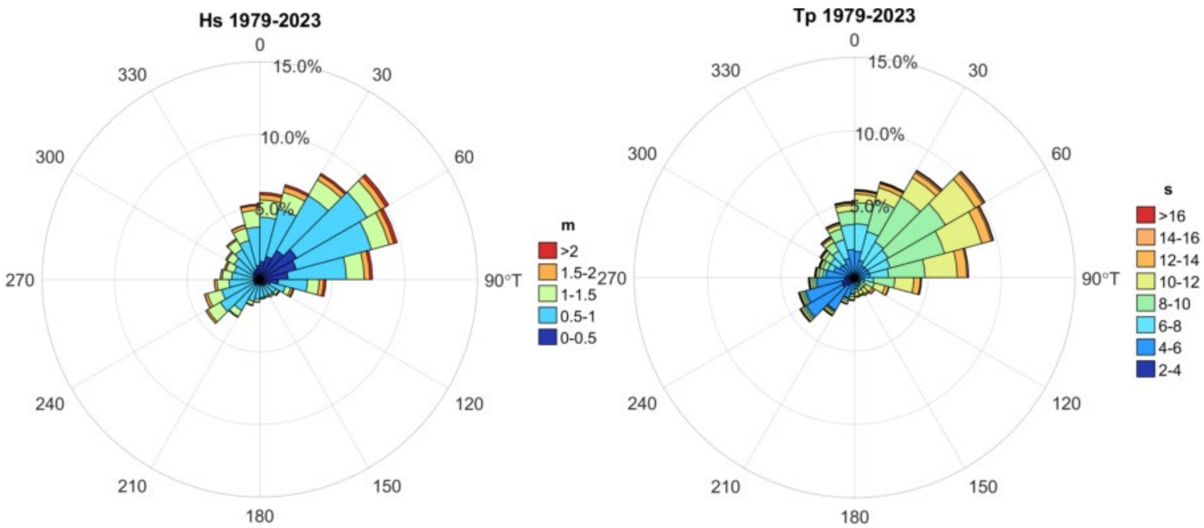


Figure 3-1. Wave roses (left wave height; right wave period) for the eastern side of the Coromandel Peninsula (Figure 1-1).

Table 3-1. Return period wave heights for the western Coromandel Peninsula (Figure 1-1).

Return period (yrs)	Hs (m)
1	4.186
5	5.067
10	5.352
30	5.715
50	5.853
100	6.015

The 1 in 100-year significant wave heights of 6.0 m at 12 seconds was adopted for revetment rock-sizing, noting that due to the location of the proposed revetment at approximately the high tide mark, wave heights will be depth-limited. During an extreme wave event, the waves reaching the revetment will be depth-limited, and it is the design still water level at the revetment that determines the maximum height of the waves able to impact on the revetments. This is then used to determine the design of the breakwater armour.

To consider potential depth in front of the structures using a 50-year planning horizon, a nearshore water depth has been calculated comprised of MHWS (2.1 m), 50 years of SLR including VLM (Figure 3-2; 0.56 m) and 0.5 m of storm surge (generally taken as the maximum that occurs in New Zealand). Note, wave set-up for short period waves is negligible. This results in a still water depth of approximately 1.06 m at the toe of the revetments, with wave breaking occurring in depths of 7.7 m during a 1 in 100 year event (using a depth-limited breaking ratio of 0.78); i.e., breaking over 550 m offshore of the beach

Given the gradient of the beach, 0.75 m has been added to the depth at the toe of the revetments as a factor of safety and to account for the beach slope; i.e., the shoaling and breaking waves have the potential to break onto the revetments from offshore of the revetment toes. This results in 1.81 m for the still water level, and with the application of a depth-limited breaking ratio of 0.78, a significant wave height of 1.41 m with a period of 12 seconds. This wave height has been applied to the rock sizing for the site.

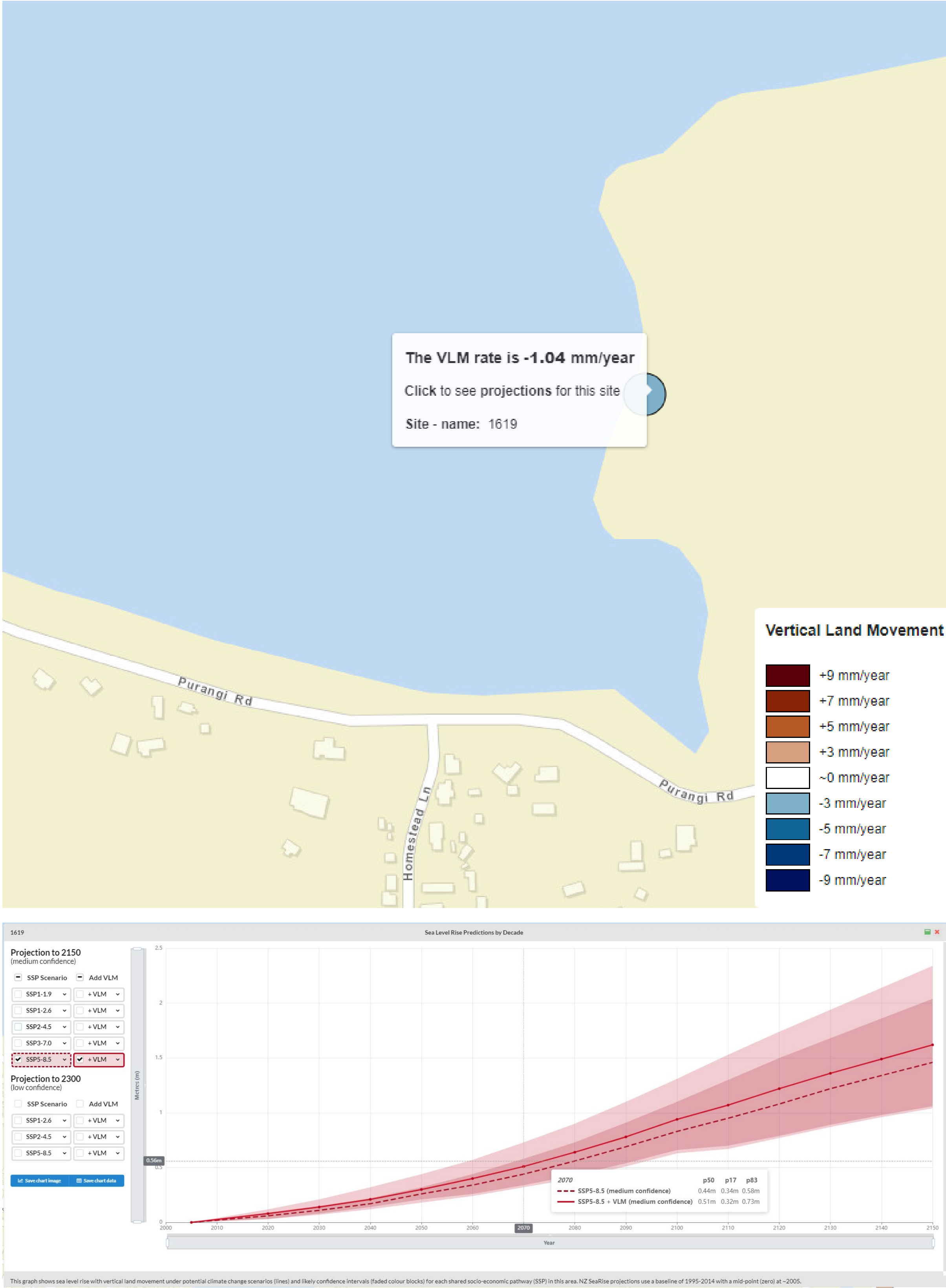


Figure 3-2. 50-years of SLR applying the most conservative projection (SSP5-8.5) is 0.48 m, however, VLM at this site (#1619) is downwards at -1.04 mm/yr, which increases the actual SLR to 0.56 m. https://searise.takiwa.co/map/6233f47872b8190018373db9/embed

3.2 Rock-Sizing

The size/weight of armour units for revetments are calculated to ensure that they are stable under design conditions (i.e., 100-year return period wave heights during an extreme water level event), with an acceptable failure of <5% of the structures. From the results of the extreme analysis to determine the 1:100-year wave event, a wave height of 1.41 m with a period of 12 seconds was used.

The US Army Corps of Engineers' (2006) method for determining stable stone size for given wave heights relies on the Hudson formula which is expressed as:

$$W = \gamma_r H^3 / K_D (\gamma_r/\gamma_w - 1)^3 \cot\theta$$

where,

W = weight of the outer layer armour unit

γ_r = unit weight of armour unit

H = design wave height

K_D = stability coefficient from armour size, shape, and material

γ_w = unit weight of water

θ = angle of structure slope

Where K_D is a stability coefficient taking onto account all the other variables. K_D values in the literature are for "no damage" conditions defined so that up to 5% of the armour rock may be displaced. H in the equation being taken as $H_{1/10}$ i.e., the highest 1/10th of all waves. Here "breaking" means wave breaking directly onto the armour rocks. K_D levels of 2 are recommended for angular rock armour under breaking waves, and 3-4 where waves are surging (e.g., in a marina).

For an extreme wave height of 1.41 m at 12 seconds (i.e., the longest fetch 100-year wind generated waves), a slope of 1:1 (V:H) given the steep nature of the cliff, basalt rock and a K_D value of 2 were applied. The recommended size of rock was found to have a nominal diameter (D_{50}) of 1.21 m (with a 10% safety factor). This rock size was also determined using the Van de Meer shallow water formula, which is considered to be more conservative for small wave climates; this resulted in nominal diameter (D_{50}) of 1.27 m. From these calculations, a mix of rocks with diameters[1] ranging from 1.0 to 1.4 m are suitable for the site (nominal diameter of 1.2 m), or rock weight of 1,410 to 3,880 kg. The armour layer should be 2.4 m thick (i.e., 2x

[1] Note, these calculations are for spherical rocks, for other shaped rocks the sizes should be based on the rock density to meet the required weight. Here a density of 2,700 kg/m^3 has been applied.

the nominal rock size), placed on 1,200 gsm non-woven filter cloth. A generic cross-section is shown in Figure 3-2.

Should additional material be required for gradient the soil under the revetment, clean back fill can be used prior to installation of the non-woven geofabric. The toe of the revetments should extend into the sand beach to the same depth as the thickness of the armour (i.e., 2.4 m; Figure 3-2), or onto the bedrock if this is struck before the depth is achieved.

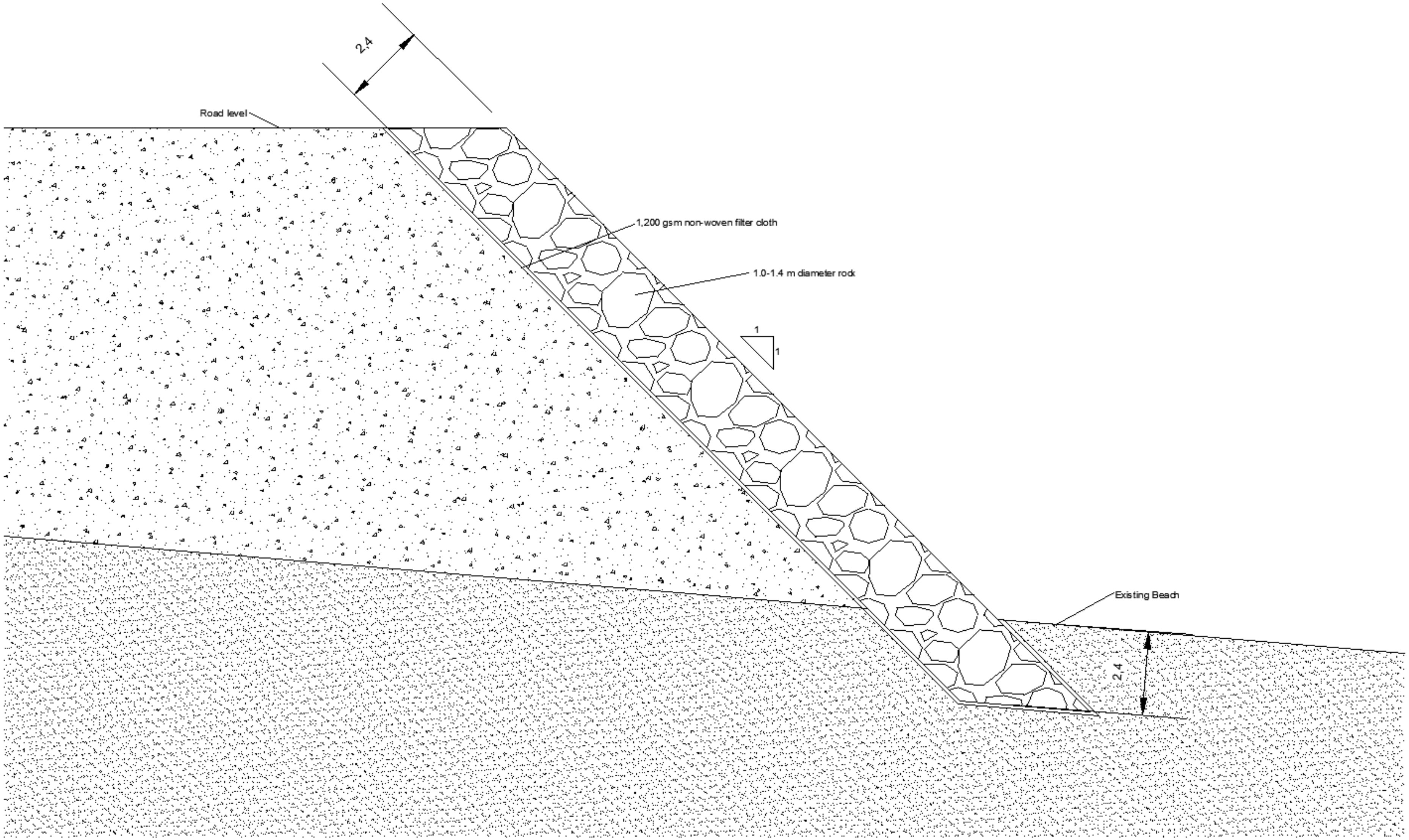


Figure 3-3. Generic cross-section for the revetment at Purangi Road.

4 Marine and Terrestrial Ecology

At all the sites visited and surveyed (9 sites around the Coromandel Peninsula), little to no marine life was found in the intertidal zone. At this site, at the toe of the slip/cliff there is a sand beach with a gradient of approximately 1:25 (V:H), with large boulders around the high tide mark (Figure 4-1). No living marine organisms were found along the toe of the slip, or further down the beach; mobile beach sand is an abrasive habitat for marine organisms, although it is expected that ephemeral sand hoppers (*Bellorchestia* spp.) would occasionally be found in flotsam at the top of the beach.

With respect to terrestrial ecology, the top of the is mostly terrestrial grasses and weeds such as kikuyu (*Cenchrus clandestinus*), agapanthus (*Agapanthus praecox*) buttercup (*Ranunculus repens*) and pampas grass (*Cortaderia* sp.) . Along the cliff adjacent to the slip is a mix of exotic/invasive and native species including Pohutukawa (*Metrosideros excelsa*), fivefinger (*Pseudopanax arboreus*), *Caprosma* sp., and golden wattle (*Acacia mearnsii*) (Figure 4-2 to Figure 4-4). Of note, there is a large Pohutakawa in the middle of the slip that is still living after slipping down the cliff when it failed (Figure 4-1). It is recommended that an arborist is consulted prior to construction of revetments to assess whether the central Pohutakawa is removed and what kind of measures should be included in the CEMP to ensure adjacent trees are not damaged.

Figure 4-1. The sand beach and large boulders around the high tide mark at the toe of the slip.

Figure 4-2. The top of the slip is mostly terrestrial grasses and weeds (e.g., kikuyu, agapanthus and pampas grass), with a mix of exotic/invasive and native species along the cliff.

Figure 4-3. The mix of terrestrial grasses and weeds and exotic/invasive and native species along the cliff.

Figure 4-4. The still living Pohutakawa that slipped down the cliff when it failed.

5 Summary and Recommendations

The site at Purangi Road that requires coastal protection is usually benign and relatively stable, however, exposed to long period ocean swells from the ENE as well as locally wind-generated waves. The coastal processes at the sites are dominated by northeasterly quarter winds and wave, which can be extreme on occasion with significant wave heights of >4.0 m and wave periods over 16 second. Due to the pocket nature of the beach bounded by headlands, it is orientated to be in equilibrium with the wave climate, and therefore there is very little alongshore sediment transport. During locally generated short period waves (i.e., from strong onshore winds) sand is dragged off of the beach face (i.e., across shore sediment transport), which is returned to the upper beach during calmer periods. It is evident that the cliff face along the northern side of Purangi Road is exposed to wave attack during extreme events and prone to failure.

To determine the extreme wave heights, 44 years of 3-hourly wave data was extracted in a location in the Hauraki Gulf on the eastern side of the Coromandel Peninsula, and an extreme value analysis was undertaken. The 1 in 100-year significant wave height was found to be 6.0 m at 12 seconds. However, during an extreme wave event, the waves reaching the revetment will be depth-limited, and it is the design still water level at the revetment determine the maximum height of the waves able to impact on the revetments. This is then used determine the design of the breakwater armour. A depth-limited significant wave height of 1.41 m with a period of 12 seconds was calculated with the application of 50 years of SLR and VLM, storm surge and a factor of safety. This wave height was then used to determine appropriate rock-sizes for the revetment. A generic cross-section for the revetment and specifications has been produced for the site.

With respect to impacts on coastal processes, due to the relatively small structural footprint, the location of the toe of the structures at approximately the high tide mark and the very little alongshore sediment transport, the impacts are considered less than minor; noting that the structure will remedy the erosion of Purangi Road. Given the mostly benign nature of the site and the location of the revetment at around the high tide mark, end-effects are not expected except during extreme events, and so visual monitoring should be regularly undertaken.

With respect to marine ecological impacts, these are considered less than minor; there were no living marine invertebrates at the site.

With respect to terrestrial ecological impacts, these are considered less than minor, although the large Pohutukawa trees require consideration. While there is a mix of native and exotic/invasive species adjacent to the site, it is mostly bare from the slip, which indicates impacts will be less than minor. However, of note are some large Pohutukawa trees adjacent to the site, including a still living tree that came down with the slip. It is recommended that an arborist is consulted prior to construction of revetments to assess whether the central Pohutakawa is removed and what kind of measures should be included in the CEMP to ensure adjacent trees are not damaged..

References

Dean, R., 1988. Prediction of Eroded Versus Accreted Beaches. Coastal Engineering Technical Note, U.S. Army Engineer Waterways Experiment Station, CETN-II-2 6/88.

WAFO Group, 2011. WAFO – a Matlab toolbox for analysis of random waves and loads, Version2.5, 07-Feb-2011 . Mathematical Statistics, Lund University.