8 February 2024
Job No: 1092596.0000

Southland District Council
15 Forth Street
Invercargill 9810

Attention: Regan McNought

Dear Regan

Bluecliffs Beach Road Paptotara, Southland
Preliminary Hazard and Geotechnical Assessment - October 2023

1 Introduction

Tonkin & Taylor Ltd (T+T) has been engaged by Southland District Council (SDC) to conduct a preliminary assessment of erosion damage and provide concepts for short to medium term mitigation and/or management in front of 21 private properties on Bluecliffs Beach Road, Papatotara at the mouth of the Waiau River.

Landward erosion varying from approximately 5 to 30m has occurred along approximately 1,500m of the shore of the Waiau River estuarine lagoon because of a storm event on 21 September 2023. This included erosion in front of the private properties, which account for about 450m of the shore along Bluecliffs Beach Road. The properties are located on a river terrace about 10m above sea level. A coastal slope ('cliff') separates the properties and the lagoon. Figure 1 (Appendix A) presents a 2022 aerial image, with approximate property boundaries and an estimate of the landward limit of September 2023 storm event erosion relative to the lagoon shore position in November 2022.

A site visit was undertaken by T+T on 20 October 2023 which included a walkover of the shore in front of the properties, informal discussions with property owners and collection of aerial images using a UAV.

Historical aerial imagery has been sourced from Retrolens and Google Earth (see Figure 4, Appendix A for examples). A wider search and literature review has not been undertaken for this preliminary assessment.

This report has been finalised following review and commend of a draft provided to SDC in December 2023.

2 Observations

2.1 Historical Observations

Observations from the aerial images are summarised in Table 2.1 below with examples of the aerials presented in Figure 2 (Appendix A).

Tonkin & Taylor Ltd | Level 3, PwC Centre, 60 Cashel Street, West End, Christchurch 8013, New Zealand
PO Box 13055, Christchurch 8141 P +64-3-363 2440 F +64-9-307 0265 E chc@tonkintaylor.co.nz

The observations indicate decadal cycles caused by major floods and erosion at the river mouth that disturb the beach ridge, lagoon and 'normal flow' river mouth that become established between flood events.

The width of the shore between the coastal slope in front of the properties and the lagoon has reduced from greater than 50m to less than 10m over the period of observation (75 years).

The position of the seaward beach ridge appears similar (+/- 5 to 10%) over the period of observation (75 years), although a more rigorous comparison is required to assess this with more certainty.

The location and shape of the coastal slope in front of the properties has not changed significantly over the period of observations. Bluecliffs Beach Road west of the properties has been impassible for more than 20 years.

Table 2.1 Summary of aerial image observations

Timeframe	Observations	Comments
1940s to 1970s 20 years	Beach ridges built up in front of coastal slope, beach approximately 50m seaward of 1980s to 2020s position. Mouth at centre of river. Lagoon remnants west and east of properties, alluvial fans from local streams.	Landform appears consistent over this period. Presence of isolated lagoon/ponds suggest that cycles of flood erosion occurred in the decades preceding.
1970s to 1980s 10 years	Flood erosion, mouth moving to west, 40m wide shore between lagoon and coastal slope. Bluecliffs Beach Road is drivable from the properties to Hump Burn along the back beach and in front of sea cliffs.	Cycle of flood erosion and establishment of long lagoon.
1980s to 2010s 30 years	Long lagoon, mouth to west, 20m wide shore between lagoon and coastal slope. Bluecliffs Beach Road from the properties to Hump Burn is impassable from sometime in the 1990s due to erosion in front of sections of sea cliff and washout of the culvert at Waimotu Creek.	Large gap in images from 1984 to 2003, therefore uncertainty on consistency of landform – there could be another flood erosion cycle in this period.
2010s to 2020s 10 years	Flood, erosion, mouth moved in front of properties, 5 to 20m wide shore from east to west.	Cycle of flood erosion and establishment of long lagoon.
2020s	Long lagoon, mouth to west, 5 to 20m wide shore from east to west	Long lagoon.
September 2023 storm	Flood, erosion, mouth moved in front of properties, 5 to 15m wide shore from east to west.	Start of another cycle of flood erosion. Based on observation above a long lagoon is likely to re-establish in coming years/decade.

2.2 Site Observations

A summary of observations from our site visit on 20 October 2023 follow:

- SDC was excavating and removing a small landfill on the shore of the lagoon immediately west of the properties. The extent of erosion had not reached the main landfill, although some

sawdust deposits were noted exposed on the lagoon shore, likely to have been dumped, or buried more than 50 years ago when the sawmill was operating. Comment on or assessment of the landfill is not within the scope of this assessment.

- River mouth 'breakout' from the September storm event occurred as far west as Waimotu Creek, leading to erosion of cliffs, exposure of old retaining wall poles and rock armour at the creek mouth, and erosion of about 50m of the road that gave access to the creek mouth. Approximately 20m of shore erosion plus 5 to 10m of coastal slope and road fill erosion occurred in this area (see Figures 1, 3 and 4, Appendix A).
- The river mouth appears to have stepped east to in front of properties. The position on 20 October 2023 was at the western end of the properties (Figure 3, Appendix A).
- Property owners report that erosion occurred at the toe of coastal slope when the mouth was open and waves could wash onto the toe at high tide.
- The extent of erosion varies along the shore in front of the properties and west to Waimotu Creek as estimated on Figure 1 (approximately 5m to 30m) and illustrated on Figure 3, 4, 5 and 6 (Appendix A).
- The beach ridge is now re-establishing where river mouth breakouts had occurred. The shore between the lagoon and coastal slope is rebuilding by accumulation of gravel (Figure 3, 4, 5 and 6, Appendix A).
- Observed erosion into the toe of the coastal slope has occurred in sand and gravel that is interpreted as lagoon shore deposits built up since the last erosion cycle. This interpretation is based on the nature of the materials and the observed concave shape of the coastal slope (Figure 6, Appendix A), which is indicative of a low erosion cliff buried by accumulated shore gravel and wind blown sand.
- The eastern end of the coastal slope exhibits historical erosion exposing bedrock and gravel from the 10m RL river terrace (Figure 1 and 5, Appendix A). Vegetation in front of the slope indicates no, or insignificant erosion along the toe in this area (Figure 3, 5 and 6, Appendix A).
- The position of property boundaries and/or position of the dwellings relative to the crest of the coastal slope varies (Figure 1, 3 and 6, Appendix A). In the east the seaward boundaries are set back some 20m from the crest of the coastal slope, while in the central to west end the boundaries are close to the crest of the coastal slope. Dwellings are set back varying distances from the seaward boundary, with the examples on Figure 6 (7, 23, 41 Bluecliffs Beach Road) being close to the seaward boundary.
- The distance between the dwellings and current erosion limit varies from about 25m to 35m (Figure 6, Appendix A).

3 Erosion Hazard and Risk

3.1 Setting

The Waiau River discharges into Te Waewae Bay on one of the most exposed coastlines in New Zealand, dominated by persistent south westerly winds and swells. The bay is ringed by a relatively narrow beach and 10 to 40m high cliffs. The cliffs are indicative of long-term landward erosion that has been occurring since the sea level rose to approximately the current level about 8,000 years ago. In other words, the coastline is slowly moving landwards over time irrespective of any human induced changes.

The outflow of the river and deposition of a river delta or fan is restricted by the gravel beach ridge, formed and maintained by the strong southwest swell. This limits the opening of the river mouth under 'normal' (non-flood) flow conditions. The result is a T shaped estuarine lagoon compressed between the seaward beach ridge and landward sea cliffs. This is a reasonably common type of river

mouth around New Zealand coasts where the gravel and sand discharged by the river is shaped and moved along the coast by the relatively high energy coastal processes.

3.2 Erosion cycles and trends

The aerial images observed provide an insight into the cyclical/episodic nature of erosion and sedimentation at the mouth of the river. Broadly, the cycle is characterised by:

- Two or more decades of 'quiet' conditions and a relatively consistent landform with little change to the beach, lagoon and shoreline in front of the properties.
- Interrupted by a decade or so of activity triggered by a flood/storm event(s), river mouth 'break out' and then re-establishment of the 'quiet' conditions through a series of changes in the beach ridge and river mouth location. Erosion by flood flows or wave attack across the beach ridge and open mouth may occur during the initial flood event and/or during subsequent shifts in river mouth position and the re-building of the beach ridge by the southwest swell.

The possible trends noted are:

- Reduction in the width of the shore between the lagoon and the coastal slope from about 40m in the 1970s to 5 - 15m in 2023.
- Landward migration of the ocean side of the beach ridge over the past 75 years. Preliminary comparisons suggest no significant change within about +/- 10%, but if a trend were present, it would be in the order of 20 to 50m of landward migration over 75 years.

These trends are described as possible because we do not have enough information to confirm that they are occurring. They may be a part of century scale cycles of flooding, erosion and deposition around the river mouth and estuary.

Changes in the past 50 to 75 years that may contribute to the noted trends include:

- Reduction of sediment load at the river mouth and reduction in replenishment of the beach ridge due to the control of Lake Manapouri levels by the Mararoa Weir structure. Our judgment is that this may be insignificant at this time given that:
  - The weir is more than 70km upstream of the coast and was installed about 50 years ago. Sediment stored in the river will 'buffer' the river mouth from any change in the short to medium term.
  - The weir is built to convey/flush gravel through from the Mararoa catchment, which is a major sediment contributor to the Waiau River. There is no coarse sediment input to the Waiau River from Lakes Manapouri and Te Anau.
  - The sediment input from catchments off the Takatimu Mountains is unaffected.
- Climate related changes acting at the river mouth and along the coastline:
  - Sea level rise and subsequent adjustment of the coastline (approximately 0.2m rise in past century). Rate of rise expected to increase so coastline 'equilibrium' will not be reached in the coming decades.
  - Increased frequency of storm events, both storm waves acting on the beach ridge and river floods leading to 'break out' of the river mouth.

3.3 Hazard and risk

The hazard at Bluecliffs Beach road is episodic erosion of the shoreline along the estuarine lagoon and ongoing landward erosion of the coastal slope due to flood/storm events. Following the apparent trends of past decades, the ongoing erosion of the coastal slope during flood/storm events is expected at some stage to encroach onto the properties.

The risk to the properties is the product of the likelihood of the hazard occurring and the consequence of erosion to the properties leading to loss of land and eventually loss of dwellings and outbuildings if they are not relocated.

Based on the information reviewed the recurrence of flood/storm related erosion events is in the order of every 20 to 30 years. The disruption to river mouth and beach development from the flood/storm event(s) lasts for about 10 years, followed by about 20 or more years of relatively consistent lagoon and beach ridge conditions.

The local extent of erosion and the amount of erosion retreat will vary for each property and each flood storm event, but in general there may be erosion threatening dwellings and outbuildings within the next 1 to 3 (or more) flood/storm events. It is unlikely that this would occur within the next 1 to 2 decades but cannot be ruled out, particularly if a storm similar in size to September 2023 were to occur within the next few years before the beach ridge and lagoon shore had built up a 'buffer' of sediment in front of the coastal slope.

The permutations for the level of risk are complex and beyond the scope of this assessment. Broadly the qualitative risk may be considered as high in that the hazard is likely to occur and the consequence for property loss or damage is major.

4 Mitigation measures

4.1 Issues with ad-hoc erosion protection

A common measure that has been used by property owners to mitigate coastal erosion risk to property and structures is to protect or armour the coast in an ad-hoc fashion to limit or slow the rate of retreat of the coastline.

Typically, ad-hoc construction is undertaken in front of individual properties without design, permissions or consents from the relevant landowners and authorities. Permission to build on to neighbouring land and consents to build in the coastal zone are legal requirements.

Ad-hoc measures can fail or provide limited protection in a significant storm or flood event. Common reasons for failure of ad-hoc protection, armouring or revetments include:

- The sizes of elements are often too small and the range of sizes too restricted to resist the erosive forces. Elements might include rocks, concrete demolition rubble or concrete blocks, which have the potential to be effective. Other elements such as tires, vehicles, whitegoods are generally ineffective and pose a potential contamination risk to the environment.
- A single layer of protection is often placed. This is too permeable, and material can be washed out from behind the protection and lead to collapse of the slope behind.
- The base of the protection is not founded deep enough, and scour can undermine the slope, leading to collapse.
- The crest of the protection is not placed high enough, and overtopping scour can lead to collapse of the slope.
- The ends of the protection can be outflanked leading to erosion behind the protection and collapse of the slope.

4.2 Potential mitigation measures

This section describes potential mitigation measures and table B1 (Appendix B) provides a summary of a range of possible responses to the erosion risk to the 21 properties on Bluecliffs Beach Road.

This is not an exhaustive list of options, combinations, and permutations to mitigate the risk to the properties, but the range of options covers commonly discussed and/or adopted approaches in New Zealand.

4.2.1 Do nothing and Planned Retreat

Watch and wait options require the minimum upfront investment and are relying on the likely decadal timeframe before a dwelling will be threatened. The likely decadal timeframe until erosion may threaten dwellings is based on the observed erosion cycles and the overall amount of erosion that is observable in the historic images.

Moving back towards the road (Figure 7, Appendix A), either moving the existing house, or demolishing and using a relocatable or mobile dwelling may allow for several decades of future occupation of the properties.

4.2.2 River Mouth Control

4.2.2.1 Emergency action

Opening of the river mouth through the beach ridge directly in front of the riverbed, approximately 1km east of the Bluecliffs Beach Road properties is considered feasible as a short-term emergency measure. Such a measure would likely require the cooperation of SDC, Environment Southland and other parties as appropriate.

Successful opening of the mouth would allow bunding off the lagoon to reduce water levels and flow velocities in front of the properties and provide access to place erosion protection as appropriate to specific areas being threatened by erosion.

4.2.2.2 Medium to long term

In the long term the purpose of river mouth control would be to maintain the mouth in a central position with the aim of limiting erosion of the lagoon shoreline, and hence threat to the properties during flood events.

Building river training structures or regular clearing of the mouth with dozers and excavators over many decades are not considered practicable, having significant uncertainty in performance (will it work?), ability to gain consent and either high capital or operational costs.

4.2.3 Erosion protection

4.2.3.1 Emergency protection

Planning to undertake emergency works after the next erosion event that encroaches onto properties is worthy of consideration. This is a response used successfully by Waka Kotahi and KiwiRail around the country. Materials can be stockpiled on site or available at short notice.

A typical arrangement is shown on Figure 7 (Appendix A), with examples of alternatives to armour rock illustrated on Figures 11 and 12 (Appendix A).

4.2.3.2 Palisade Walls

Palisade walls are generally used for slope stability/landslide problems but can be adapted to coastal erosion. As shown on Figure 8 (Appendix A) piles can be installed on the property before erosion affects the property. When erosion exposes the wall, it will require toe protection with rock armour (or similar) and installation of anchors to provide sufficient capacity for the wall to operate as retaining wall.

Installation on individual properties may lead to irregular erosion along the frontage and potential for outflanking of the walls by erosion. Consenting requirements are likely simplified by keeping all work within the property boundary.

4.2.3.3 Revetments

Rock armoured slopes are a commonly adopted option due to the flexibility of design, absorption rather than reflection of wave energy and ability to perform after some damage.

The positioning of a revetment onto the existing slope is shown on Figure 9 (Appendix A), with typical section details of a fully designed revetment is presented on Figure 10 (Appendix A).

A long lead time is required for design and consenting, with significant upfront costs of this work. The revetments protrude from the existing coastal slope with attendant uncertainties regarding permissions and consents.

4.2.3.4 Groynes

Groynes are usually adopted because they use less materials to construct than revetments and rely on accumulation of sediment between the groynes as part of the protection. Erosive forces need to be directed parallel or oblique to the shoreline for groynes to be effective.

In this case the erosion may be occurring from combinations of shore parallel erosion and direct wave attack over the beach ridge or through the open river mouth, meaning that there is a risk that groynes may not be effective. The potential required size and spacing of groynes may require similar materials to a revetment and therefore similar cost and consenting uncertainties.

5 Discussion

Based on our understanding of erosion cycles which have occurred over the period of time for which records are available, and the observations and assessments provided above there is time available to consider and develop a planned approach to mitigation of the property risk at Bluecliffs Beach Road. A possible approach would be to plan for action after the next storm/flood event of similar magnitude to September 2023.

In order to develop a plan of action it will be necessary to consider cost, timing and practicality of the various options available. A plan outline might include:

- **Emergency works**
  - Investigate costs and logistics of emergency repair options with the suppliers of materials and contractors.
  - Consider the costs and practicality of stockpiling of materials on site, such as rock nets, or geotextile bags, or rock, possibly for a decade or more, for rapid deployment to buttress and protect short sections of erosion that threaten dwellings.
- **Retreat**
  - In the first instance investigate options for uplifting and relocating dwellings to the rear of each property.
  - It might not be practical to move some structures in which case demolition and replacement with a relocatable or mobile dwelling could be considered.
  - These options might allow continued occupation of the properties for several more decades.
  - Relocation to nearby land (a new subdivision) might be a longer-term consideration.
- **Erosion Protection**

- While there are options for protection, the case for a rock revetment is considered a good test of the practicality and cost of providing protection to the coastal slope in front of the properties.
- As a starting point, the potential cost of a 450m long revetment with a 20m wide base, 6m vertical height and a 2(H):1(V) front slope built from 1t to 4t-sized durable rock can be considered.
- If the cost is 'palatable' then take a concept design and an outline consent plan to the landowners (the Crown) and regulatory authority (SRC) to assess the possibility of being granted permission and consents to build a revetment in front of the coastal slope.
- If the proposal proves consent-able then a full investigation and design process could be undertaken to understand any effects on the river, estuary and neighbouring land, and to optimise the revetment materials and arrangement.
- The design would form the basis for a consent application that would also require the investigation and consideration of effects on the environment, ecology, heritage, and will require engagement and consultation with Iwi.

- **Design and outline plan for consenting**
  - Once preferred mitigation options or steps have been decided a program of design and consent planning work can be started. The program will depend on option(s) selected and how far alternative options need to be investigated.
  - Emergency works and longer-term protection works will require analysis of coastal and river mouth process to inform the design of protection structures.
  - The design of protection structures, arrangements and combinations that will provide protection, and meet consenting and constructability considerations.
  - The development of an outline plan for early consent notification and consultation with stakeholders. This would include work on ecology, heritage and culture to inform the plan.
  - Modifications to designs and development of a full consent application.

6 Applicability

This report has been prepared for the exclusive use of our client Southland District Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:

.....

Barry McDowell
Senior Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

.....

Anna Sleight
Project Director

Reviewed by Peter Cochrane, Discipline Manager - Water Engineering

9-Feb-24
T:\Christchurch\projects\1092596\issueddocuments\2024.02.08 – Bluecliffs Beach Road Ltr

Appendix A Figures

See Figure 6 for Cross sections at 7, 23 and 41 Bluecliffs Beach Rd

Notes:
1. Aerial image sourced from LINZ

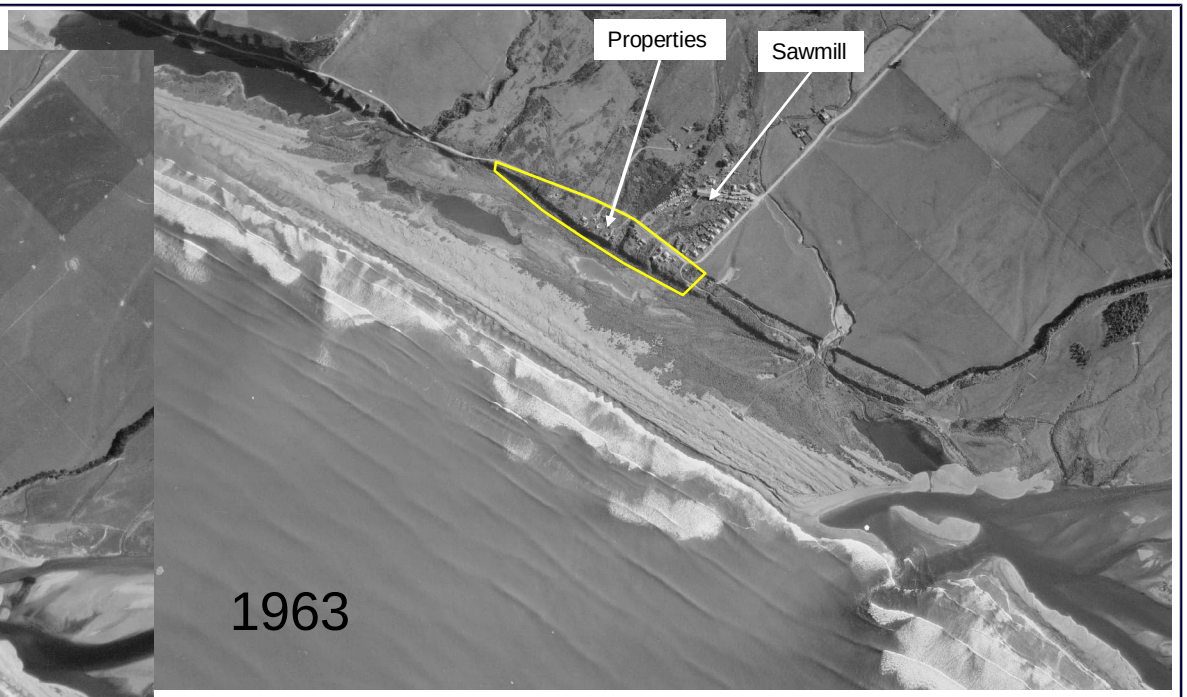
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Site Plan of Properties on Bluecliffs Beach Rd

FIG. No. Figure 1

REV. 0



Examples of historical images:

- **1963** infilled lagoon, beach ridges, alluvial fans and remnant ponds. Similar to 1946 and 1955.
- **1984** long lagoon, west end mouth closed, alluvial fans rebuilding, approx. 40m wide shore in front of properties.
- **2013** remnant ponds from long lagoon that was present in 2003, mouth has been in front of properties, likely erosion has occurred at east end of properties.

Notes:
1. Aerial image sourced from Retrolens and Google earth

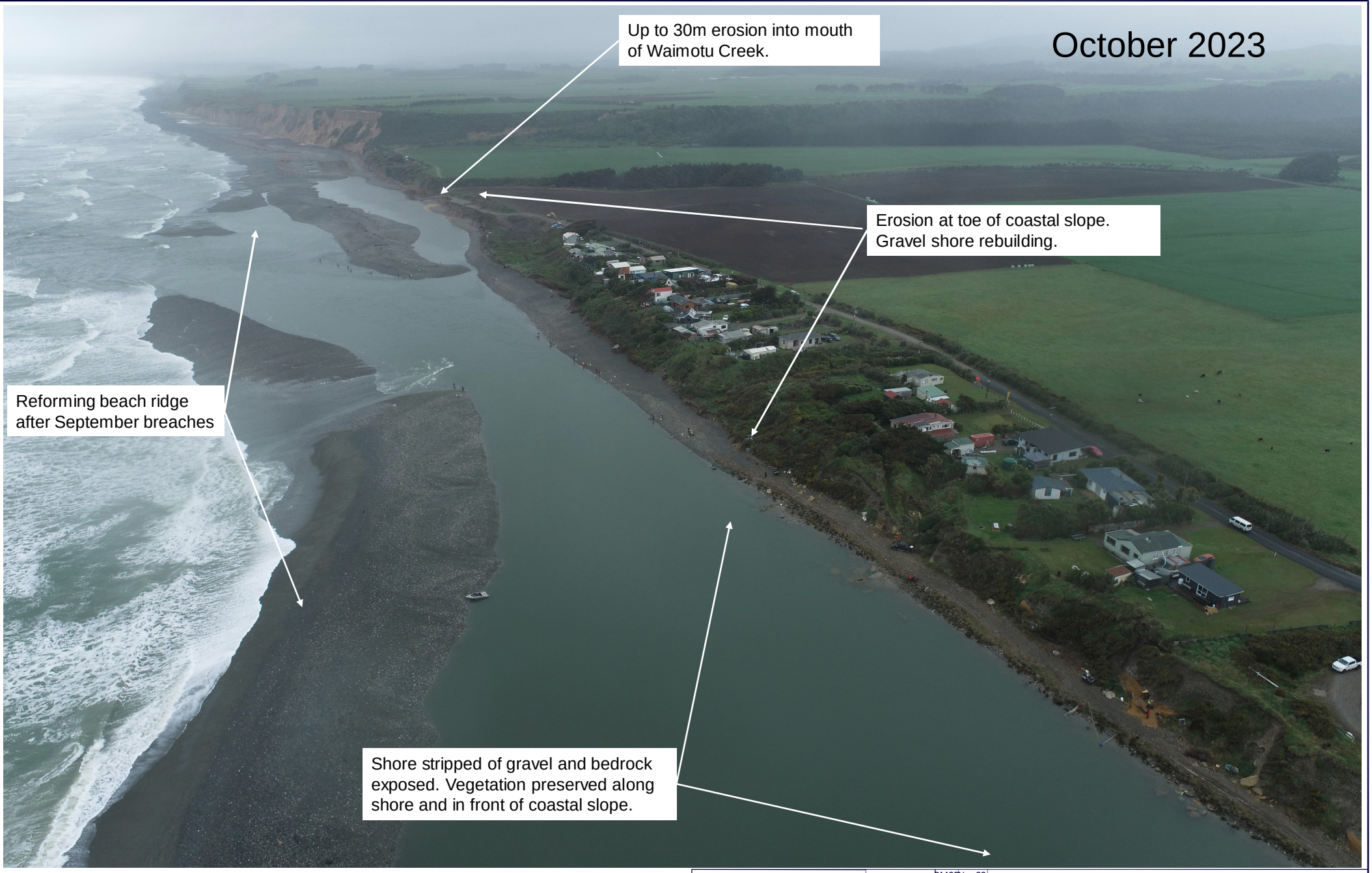
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Historic Aerials

FIG. No. Figure 2

REV. 0



Notes:
1. Aerial image sourced T+T UAV

Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

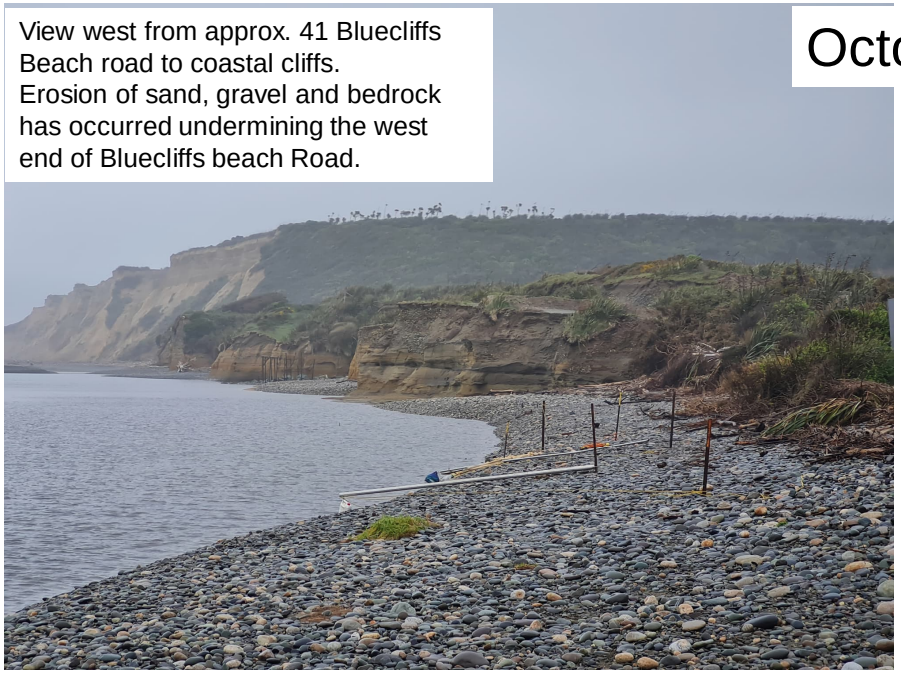
Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
October 2023 Aerial

FIG. No. Figure 3

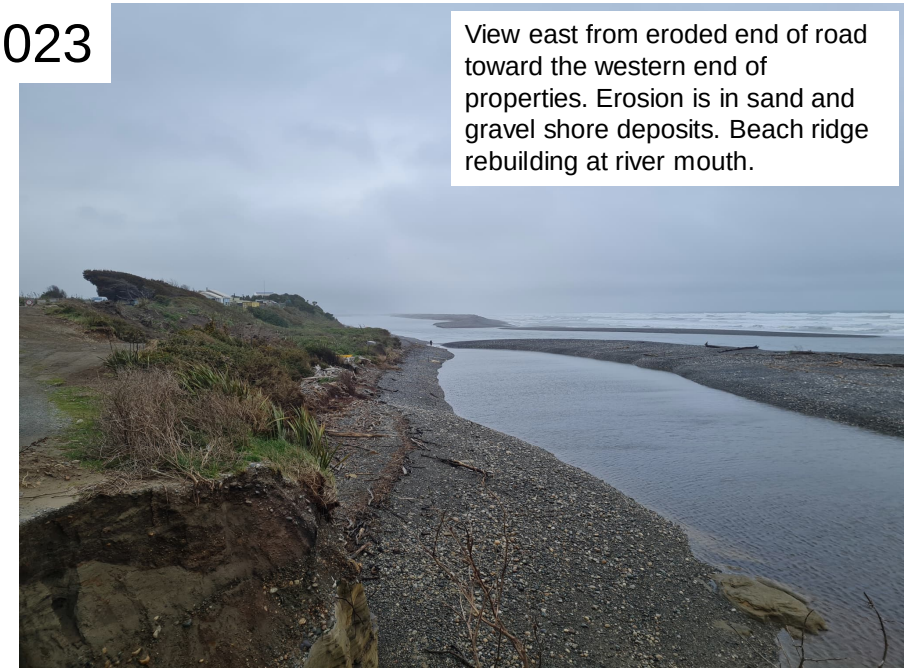
REV. 0

October 2023

View west from approx. 41 Bluecliffs Beach road to coastal cliffs.
Erosion of sand, gravel and bedrock has occurred undermining the west end of Bluecliffs beach Road.



View east from eroded end of road toward the western end of properties. Erosion is in sand and gravel shore deposits. Beach ridge rebuilding at river mouth.



Recent shore sand in eroded coastal slope.

View east from approx. 23 Bluecliffs Beach road.
Coastal slope erosion into sand at toe. Gravel beach/shore is rebuilding in front of erosion.

Tonkin+Taylor www.tonkintaylor.co.nz	DRAWN	BMCD	Nov 23
	DRAFTING CHECKED	PRC	Dec 23
	APPROVED	AFS	Dec 23
	FILE: FILE		
	APPROX. SCALE (AT A3 SIZE): AS SHOWN		
	PROJECT No.: 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
October 2023 Photos

FIG. No. Figure 4

REV. 0

October 2023

View east from approx. 15 Bluecliffs Beach road.
Coastal slope erosion into sand toe. Gravel beach/shore rebuilding in front of erosion.

View east from approx. 9 Bluecliffs Beach road.
Pre-September vegetation intact, minor coastal slope erosion.

View east from approx. 7 Bluecliffs Beach road.
Bedrock exposed in lagoon. Pre-September vegetation intact. Historic coastal slope erosion, exposing gravel over bedrock.

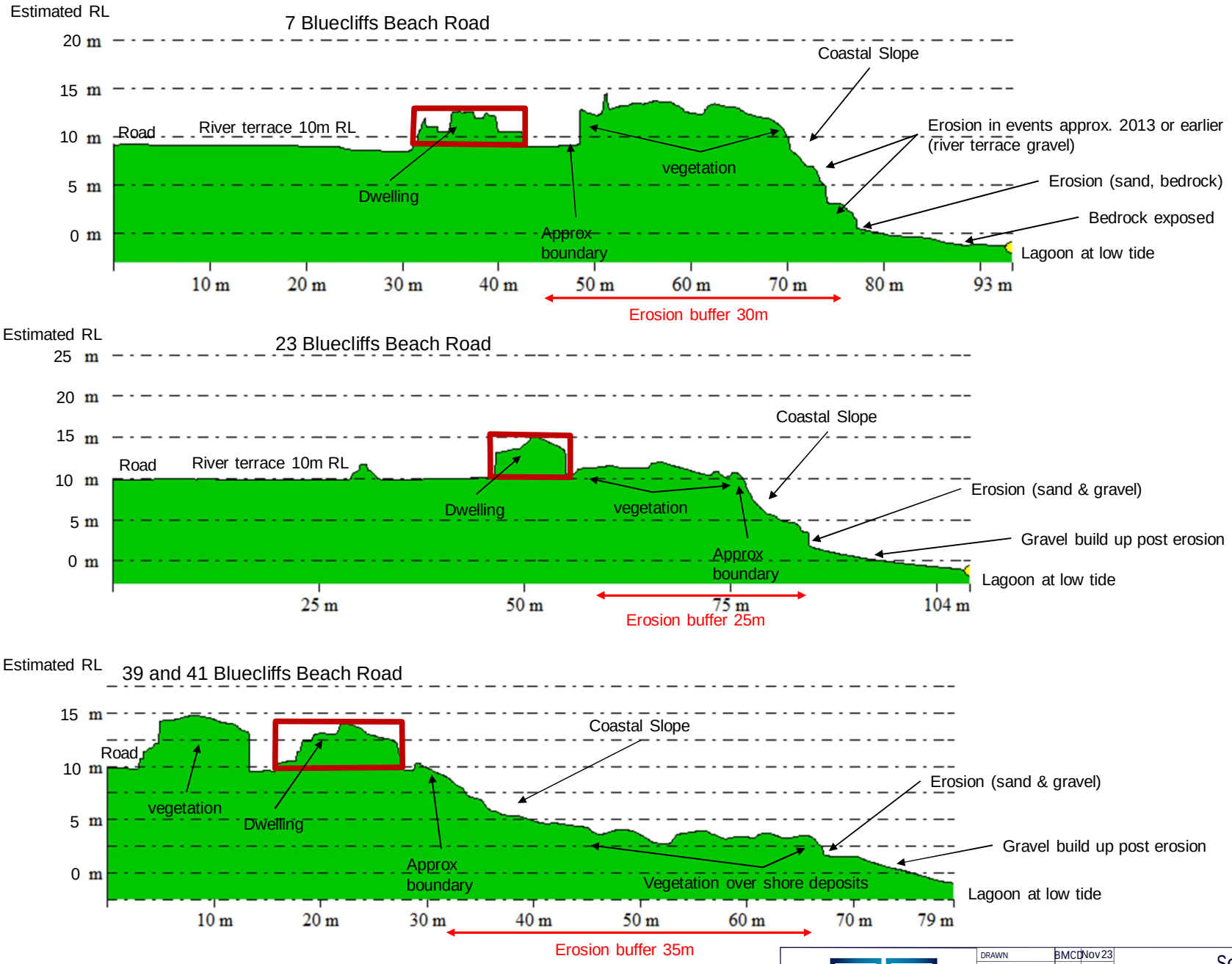
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
October 2023 Photos

FIG. No. Figure 5

REV. 0



Notes:
1. Cross sections from T+T UAV derived dsm, October 2023

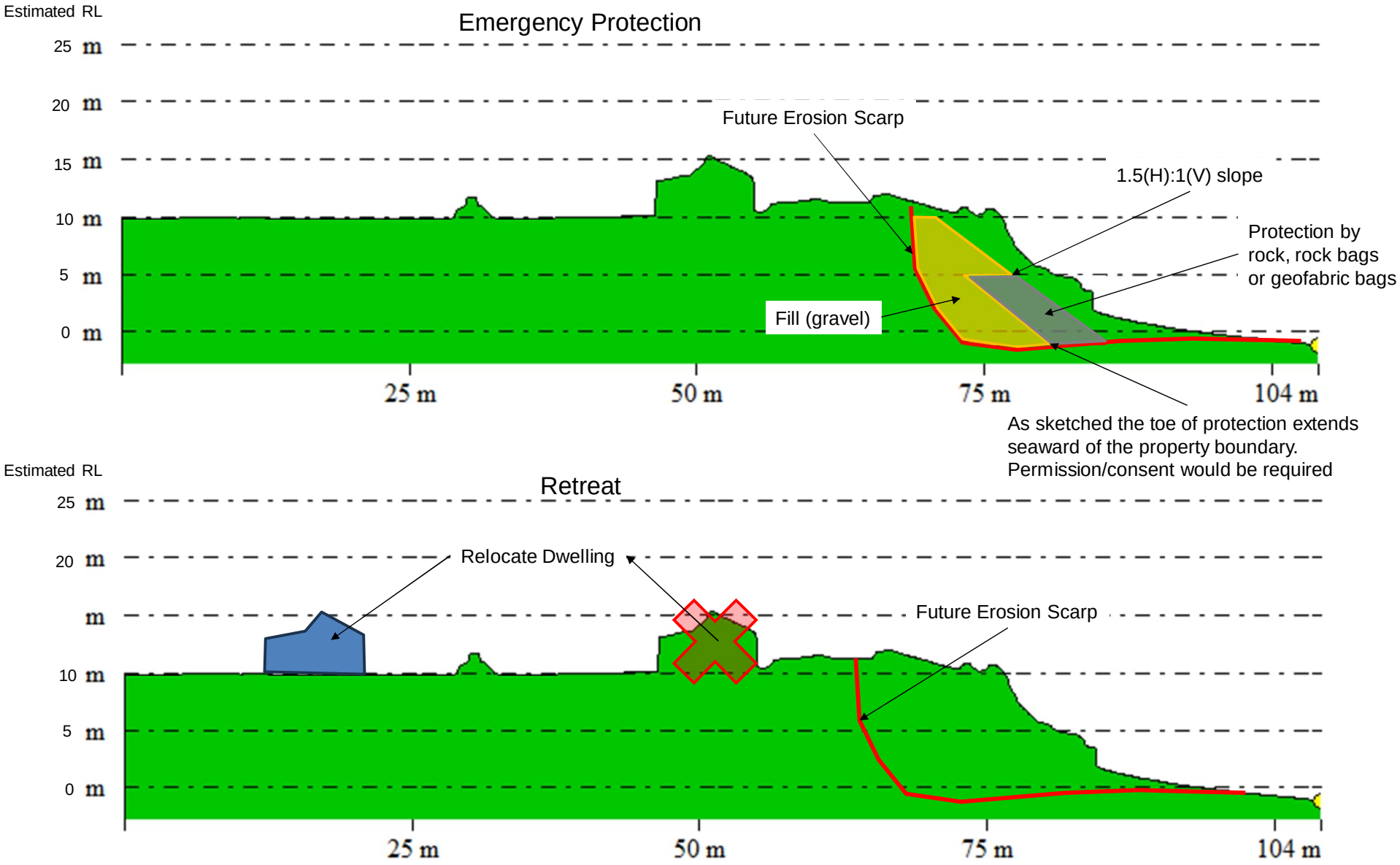
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE)	AS SHOWN	
PROJECT No.	1092596.0000	

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Cross Sections at 7, 23, 41 Bluecliffs Beach Rd

FIG. No. Figure 6

REV. 0



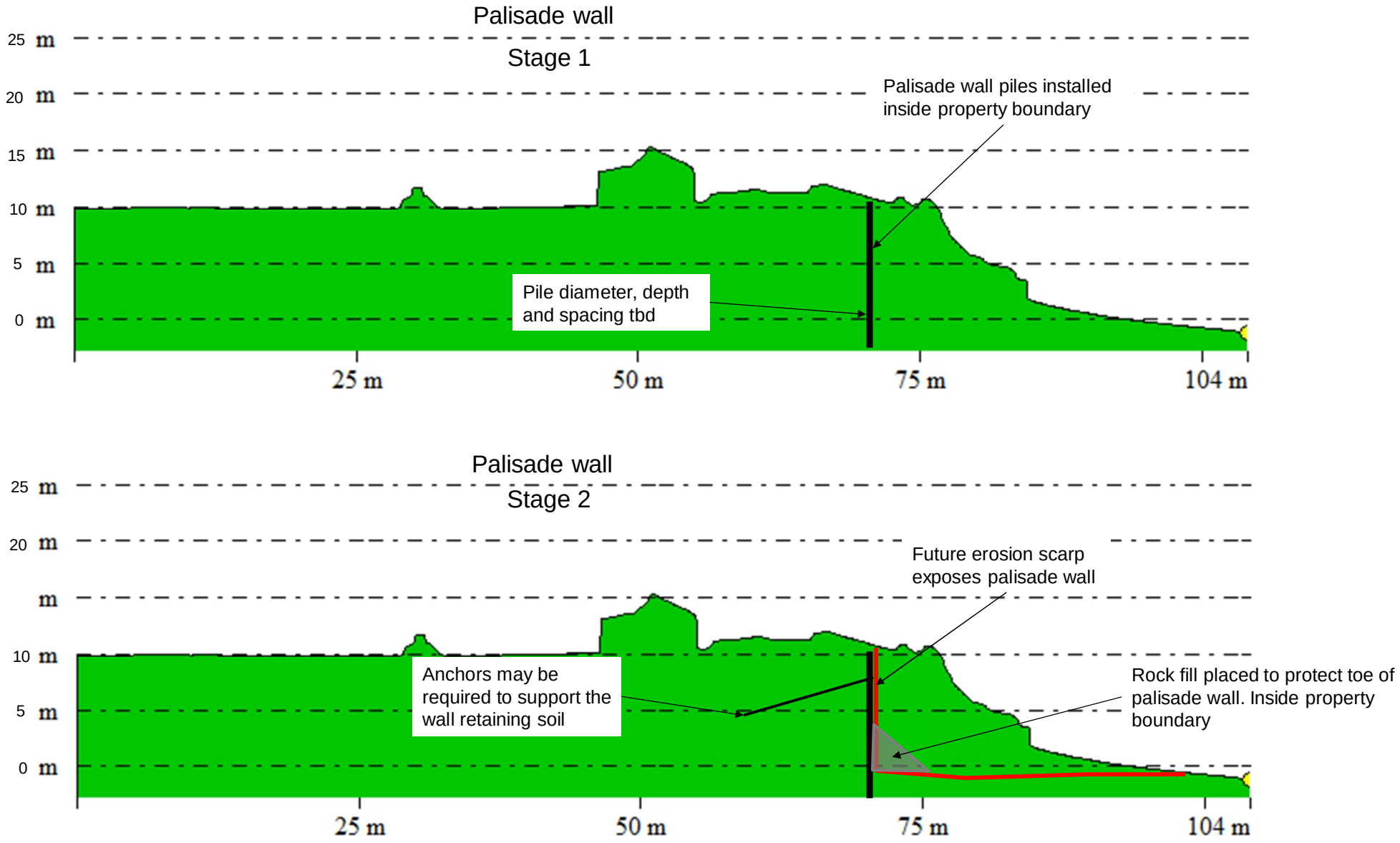
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Mitigation Sketches. Emergency and Retreat

FIG. No. Figure 7

REV. 0



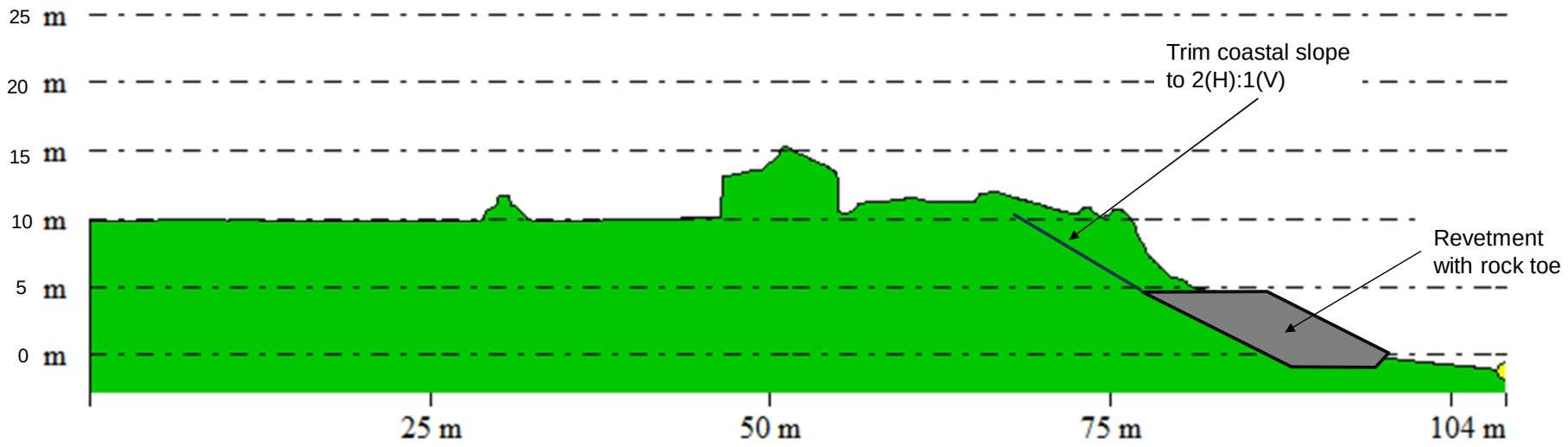
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

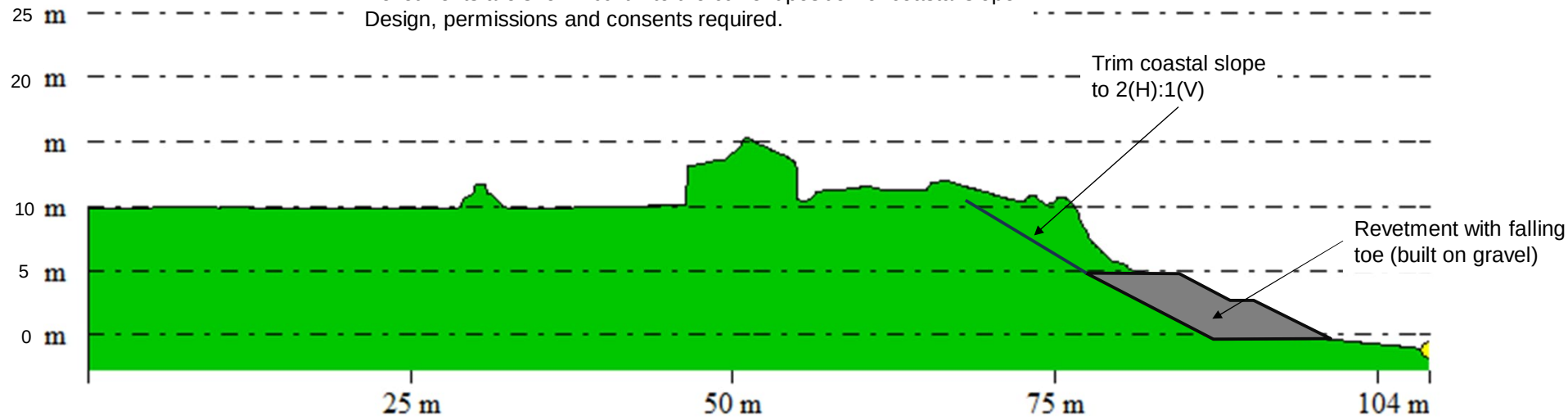
Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Mitigation Sketches. Palisade Wall

FIG. No. Figure 8

REV. 0



Revetments are shown built into the current position of coastal slope.
Design, permissions and consents required.



See Figure 10 for typical arrangements

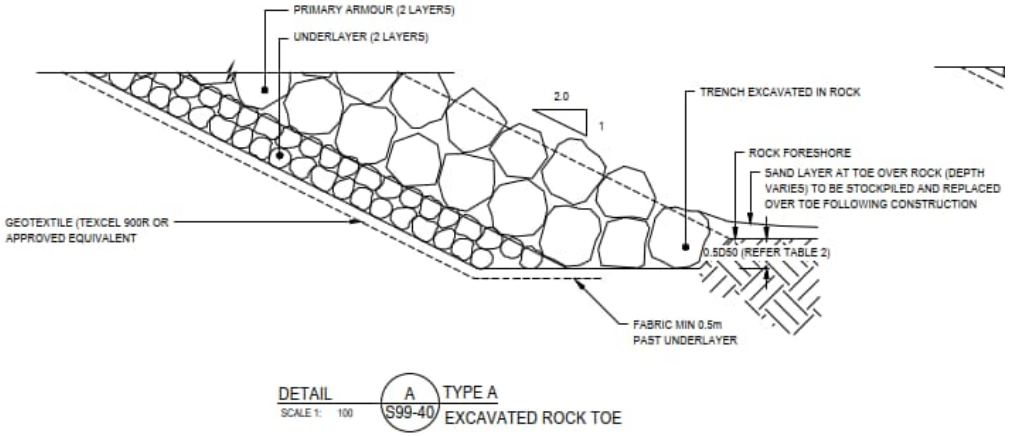
Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Mitigation Sketches. Rock Revetments

FIG. No. Figure 9

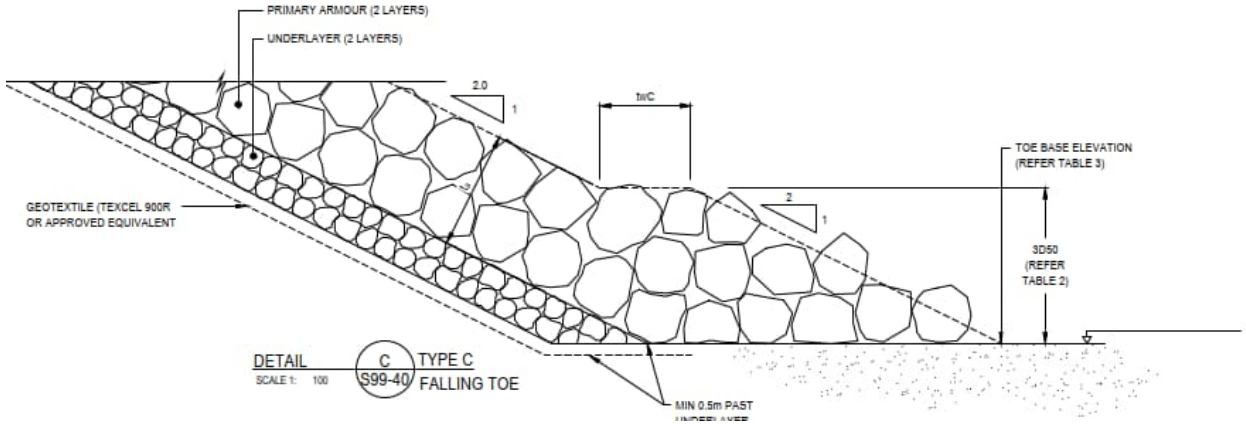
REV. 0



DETAIL A S99-40 TYPE A EXCAVATED ROCK TOE
SCALE 1: 100

Rock toe applies at eastern and possibly western end of properties

Typical arrangement
2(H):1(V) slope
2 layers of rock
2 layers of bedding
Geofabric at base



DETAIL C S99-40 TYPE C FALLING TOE
SCALE 1: 100

Falling toe applies in central section where rock is not seen

Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Mitigation Sketches. Typical Rock Revetment

FIG. No. Figure 10
REV. 0

Example applications of ‘Kyowa’ rock bags

Notes:
1. Images from Bluemont.com.au website

Tonkin+Taylor www.tonkintaylor.co.nz	DRAWN	BMCD	Nov 23
	DRAFTING CHECKED	PRC	Dec 23
	APPROVED	AFS	Dec 23
	FILE: FILE		
	APPROX. SCALE (AT A3 SIZE): AS SHOWN		
	PROJECT No.: 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Mitigation. Example Rock Bags for Emergency Response

FIG. No. Figure 11

REV. 0

Geofabrics Elcorock bags

Notes:
1. Images from Geofabrics Australasia Pty Ltd Coastal Brochure

Tonkin+Taylor
www.tonkintaylor.co.nz

DRAWN	BMCD	Nov 23
DRAFTING CHECKED	PRC	Dec 23
APPROVED	AFS	Dec 23
FILE: FILE		
APPROX. SCALE (AT A3 SIZE) AS SHOWN		
PROJECT No. 1092596.0000		

Southland District Council
Preliminary Coastal Erosion Assessment
Bluecliffs Beach Road, Papatotara
Mitigation. Example Geofabric Bags for Emergency Response

FIG. No. Figure 12

REV. 0

Appendix B Summary of Mitigation Measures

Appendix B

Table B1 Summary of Mitigation Measures

Measure	Description	Technical Uncertainties and indicative relative cost[1]	Regulatory Uncertainties
Do nothing and observe	Possible that the risk does not materialise for many decades. At least 25m of erosion is required to threaten some dwellings.	Uncertainty if one erosion event can undermine properties and collapse some structures. Defer decisions and expense.	Not immediately
Planned Retreat	Plan to relocate structures to the landward/road boundary of the properties	Can increase buffer for erosion from current 25m to >50m. May allow several more decades of occupation. $20,000 to $100,000 per property	Unlikely any significant issues.
	Plan for removal of structures. Removal so they don't collapse into the sea and spread debris along the coast.	Able to react once erosion reaches the crest of the slope. Uncertainty if 1 erosion event can undermine properties and collapse structures. $20,000 to $100,000 per property	Unlikely any significant issues.
	Plan to remove and relocate structures to new properties. Plan for somewhere to move to. Possibly land nearby?	Able to react once erosion reaches the crest of the slope. Or move early, once new properties acquired. >$100,000 per property	Consent for new sites (subdivision and land use consent).
	Occupy land with mobile dwellings that can be carried, towed or driven away.	Could provide decades of use of the properties after structures have been removed. $20,000 to >$100,000 per property	Unlikely, but may be issues for permanent residents.
River mouth Control	River training using groynes and an armoured channel to create a 'permanent' centrally located mouth and limit likelihood of flood related erosion at the properties	Impracticable in terms of constructability and performance. $20,000,000 to $100,000,000	Unlikely to be consent-able
	Regular clearance of channel by machinery to maintain river mouth in central location and limit likelihood of flood related erosion at the properties.	Possible. Performance in a flood is uncertain, ongoing year on year commitment of machinery to salt water. $500,000 to >$1,000,000 per decade	Difficult to unlikely to be consent-able

Erosion protection	**Emergency**. Plan and have materials available for rapid deployment after next erosion event. Placement of protection elements along specific areas of erosion to limit ongoing deterioration.		Geotextile bags or Rock bags are possible options. Lifted and stacked with excavator boom. Durable rock, as would be used in an engineered revetment is also possible for emergency/temporary structures. Performance uncertain, look to address ad-hoc issues described in report Section 4.1 >$100,000 to $1,000,000 allowance for materials and placement along approx. 150m of slope.	Emergency measures possible after the next erosion event. Consent/permission required. Current erosion situation unlikely to 'qualify' as an emergency situation given distance between erosion property boundaries and dwellings.
	Medium and long term.	Palisade wall. Bored piles installed on a property before erosion. Retrofit toe protection when/if erosion exposes the base of the palisade wall.	Long term. Uneven erosion if built on a property by property basis. Might require wing walls to prevent outflanking if neighbours choose to not build walls. $200,000 to >$1,000,000 allowance per property.	Protection is on each property, so permission/ consents on Crown land not required.
		Revetment. See Figures 9 and 10 (appendix A) for typical arrangements. Approx. 450m long. Rock or concrete blocks could be used as the armour material. Assume 1t to 4t weight range.	Critical parameters such as depth of toe, height or crest and size of armour rock to be determined at a design stage can drive prohibitive cost increases over the preliminary concept. $5,000,000 to>$10,000,000	Permission/ consents required on Crown Land. Considerable protrusion into the lagoon and potential loss of recreational access along the toe.
		Groynes. Allowing 20m long groynes at 50m spacing is equivalent to about 200m of revetment. Similar design parameters and materials to a revetment.	Uncertainty of effectiveness. Can work if erosion is due to shore parallel flood velocities. Ineffective if erosion is due to beach wave action acting normal to the shore (potentially the governing case). $2,000,000 to >$10,000,000	Permission/ consents required on Crown Land. Considerable protrusion into the lagoon and potential loss of recreational access along the toe.
		Combine groynes and revetment. Consider if elements can be downsized resulting in an overall smaller construction and hence less cost.	Potentially additional cost for no gain, as elements may not be downsized without compromising performance of the structures. $5,000,000 to >$10,000,000	Permission/ consents required on Crown Land. Considerable protrusion into the lagoon and potential loss of recreational access along the toe.

Note

1. Dollar brackets are order of magnitude 'guesstimates' in 2023 dollars to assist with the relative comparison of mitigation measures presented in this report. Any future planning and decision making should include the seeking of cost estimates from suppliers and contractors to allow QS estimates of concept level costs for specific options. Allowance is made for all 21 properties (450m frontage) unless stated otherwise.