Managing and adapting to coastal erosion on the West Coast: Rapahoe

NIWA Client Report: HAM2006-154
November 2006

NIWA Project: EVL06201

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Prepared for

West Coast Regional Council

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Executive Summary

This report is one of a number being prepared for West Coast Regional Council (WCRC) to aid the decision-making processes associated with ongoing erosion problems at a number of locations in the region. The advice provided in this report focuses on Rapahoe village. It relates to long-term coastal erosion associated with the ongoing retreat of the gravel barrier fronting the village. Landward migration of the barrier has previously resulted in the loss of Beach Road north of Statham Street, and now threatens the camp and caravan site and the Forbes House at the northern end of the village.

The purpose of this scoping study was to review the previous option assessments, ongoing coast defence works, and provide a present day basis for further discussions of short- to long-term coastal hazard management and adaptation options for consideration by the Rapahoe community. As such no conclusions or recommendations are made. The potential management pathways will require further discussions with the Rapahoe community and further considerations such as potential costing of the options to be carried out, before an appropriate response to managing and / or adapting to the erosion issues at Rapahoe can be developed further.

1. Introduction

1.1 Scope of the review

This report is one of a number being prepared for West Coast Regional Council (WCRC) to aid the decision-making processes associated with ongoing erosion problems at a number of locations in the region. The advice provided in this report focuses on Rapahoe village. It relates to long-term coastal erosion associated with the ongoing retreat of the gravel barrier fronting the village. Landward migration of the barrier has previously resulted in the loss of Beach Road north of Statham Street, and now threatens the camp and caravan site and the Forbes House at the northern end of the village.

This study has been supported by the Foundation for Research, Science and Technology Envirolink fund set up to assist Regional Councils in accessing environmental advice from the various Crown Research Institutes. As such these reports do not provide a detailed study, rather they are a summary of the observations made during a number of visits to both locations, discussions with West Coast Regional Council staff, various local residents at Rapahoe, and due consideration to various previous studies of coastal processes at these locations. The initial requirements of the study were to provide advice relating to a recently constructed rock revetment along part of the village frontage, specifically:

- Assess whether the structure will result in any significant physical impacts on the adjacent coastal zone, specifically whether the wall will exacerbate erosion at the southern end.

- Identify any issues relating to how the structure has been constructed which will limit its performance in terms of protecting the land behind from continued retreat of the gravel berm and overtopping during storm events.

- Identify potential mitigation options which may be required if significant environmental impacts are identified.

- Overview potential long-term options for mitigating and / or adapting to coastal change at Rapahoe.

Associated with this report is a public awareness brochure on coastal erosion in the West Coast region.

1.2 Visits and background information

The Rapahoe coastline has been inspected on a number of occasions over the last year (November 2005, May, August and October 2006) during visits associated with this specific study and in conjunction with other ongoing work.

Discussions concerning the issues at both sites have been held with Chris Ingle, Wayne Moen, Simon Moran and Mary Trayes of WCRC. Mr Wayne Moen, Senior River Engineer at WCRC, has assisted with a number of the site visits and he, and Mary Trayes, have provided background information associated with the coastal changes at Rapahoe and elsewhere in the West Coast region.

During the visits we were fortunate to have a long discussion with Mr & Mrs Ken and Irene Tiller, local landowners at the southern end of the bay overlooking Rapahoe Beach. The Tillers have been resident for 36 years and were able to provide much information on how the beach at Rapahoe has changed over this time. The issues were also discussed with Mr Peter Fletcher, the owner of the camp site at Rapahoe, and who initiated the construction of the present revetment.

A listing of previous studies, which have been reviewed in the context of this report, are included in Section 4.

2. Coastal changes at Rapahoe

2.1 Overview of the evolution of gravel barrier systems on the west coast

The coastline fronting Rapahoe village is characterised by a single gravel beach barrier backed by land that is lower in elevation than the natural height of the gravel barrier, Figure 1. Such gravel barrier systems in most places around the world including the West Coast, are typified by long-term sediment starvation, This is explained by the present geological age, characterised by relatively stable sea levels over the last 6000 years where insufficient fresh gravel enters the beach system to maintain their position. Consequently they respond by migrating landward (Schulmeister & Rouse, 2003). This migration occurs in two ways:

- Washover: where gravel on the front face of the beach is progressively moved over the crest and on to the back face of the barrier during episodic storms. It can only occur when wave run-up reaches the crest, or overtops the barrier. Typically, a gravel barrier, in a natural state, would experience wave overtopping of the crest around 2-4% of the time. Under more significant conditions larger volumes of overwashing can create localise washover fans, where gravel is washed down the backface of the barrier and spread out over the land immediately backing the barrier, or localised breaches of the barrier can occur.

- Overstepping: where the barrier is completely destroyed during a severe storm event and washed landwards simultaneously (Schulmeister & Rouse, 2003). This is more likely to occur if the barrier is backed by a lagoon rather than dry land.

Under a future with ongoing sea-level rise, such barriers tend to respond in two ways (Carter & Orford, 1993):

- The height of the barrier increases. This is the likely response where there is a wide and healthy gravel barrier to allow such a change in the beach profile to occur. The Blaketown beach, just south of the Tip Heads is one such area where such a response is likely.

- The barrier may break down and retreat shorewards. An increased rate of retreat, or even breakdown of the gravel ridge is the more likely response of many of the gravel barrier systems in the West Coast region which are presently less well nourished with gravel. As most of these systems are recessional (i.e., erosional in nature), future sea-level rise will just exacerbate or accelerate this present day trend. This is the general situation at Rapahoe and other places on the West Coast, e.g., Granity, Mokihinui etc., although other local factors will also influence future evolution of the gravel barriers and are discussed below.

Figure 1: Rapahoe beach viewed from the Tiller's land at the southern end of Rapahoe.

These long-term patterns of landward retreat are not constant. Cycles of short to medium term accretion and erosion patterns occur depending on the particular complex interactions between wave climate variability, storm occurrence, storm track and storm sequencing (i.e., the impacts due to a particular series of storms), and river flood events (which are the dominant source of sand and gravel supply to the coastline).

2.2 Gravel sediment supply and losses

The previous section noted that the retreat of the gravel barrier at Rapahoe was primarily a function of long term sediment starvation, i.e., in the present period there is insufficient fresh input of gravel, relative to the amount of gravel that is lost from the beach at Rapahoe, to maintain the beach in its present location.

Fresh gravel inputs, all of which supply relatively low volumes to the beach system, are predominantly from:

- Sand and gravel washed down Seven Mile Creek during flood events. Whilst this is likely to be the main source of gravel to Rapahoe beach, the volumes supplied are likely to be quite low.

- Erosion of the Kaiata mudstone cliffs to the north and southerly transport of gravel under north-westerly wave conditions. Whilst the mudstone is not a source of beach gravel, it is overlain by a raised sequence of marine sands and gravels, which are released as the mudstone is eroded. The road cutting for SH6 may have reduced the potential input of sediment from this deposit, but the amount of gravel that would have ended up on Rapahoe beach would still have been minimal.

- Reworking of Holocene coastal and alluvial deposits upon which Rapahoe village is situated as the gravel barrier continues to roll back.

A number of other studies, e.g., Pfarlet (1984), Neale (2000), have suggested that the effect of the Tip Heads at the Grey River mouth in blocking the northward transport of gravel, and the dredging and offshore disposal may have had a significant influence on the Grey River as a source of beach material to Rapahoe. Given the general state and evolution of the gravel beaches at Cobden and further south, and the influence of the headland and reefs at Point Elizabeth it is unlikely that gravel moved northwards along the coast and around Point Elizabeth has provided a recent source of gravel to Rapahoe, and the influence of the Tip Heads unlikely to be a significant factor in the changes occurring at Rapahoe.

The loss of gravel from the beach system at Rapahoe tends to occur primarily due to abrasion and the northward transport of gravel out of the beach system, discussed in the next section.

2.3 Geological factors influencing shoreline evolution at Rapahoe

At Rapahoe, the solid geology plays an important role in the past, and future, evolution of the beach plan shape. The beach is bounded at the southern end by Point Elizabeth (Figure 2), the cliffs of which are comprised of limestone and relatively resistant to wave erosion. Outcropping along the southern flank of Rapahoe Bay and then again to the north of Rapahoe village are Kaitai mudstones (*papa*). These are relatively soft and much more easily eroded by wave action than the limestone.

The general planshape of the coastline at Rapahoe is controlled by the interaction between the dominant south westerly swell conditions and the local geological "hinge points", Figure 2. The gravel beach is largely "swash-aligned" due to the way the dominant south westerly swell diffracts around the headland at Point Elizabeth and into the bay. This produces a shadow zone in the lee of the headland, resulting in a gradient in wave breaking height, increasing to the north (as the exposure to south westerly swell increases) along the Rapahoe frontage. This energy gradient is important for the longshore movement of gravel sized beach material and how the beach at Rapahoe has developed. Along much of the adjacent coastline swell waves from the dominant south-westerly quadrant results in a general net longshore movement of beach material (both sand and gravel) to the north.

Figure 2: Aerial view of Rapahoe showing the influence of Point Elizabeth on swell from the south-westerly quadrant.

This will be the case north of the Rapahoe village frontage. However, along much of the village frontage, and to the south, the sheltering effect of Point Elizabeth and the present day alignment (i.e., swash aligned) of the beach suggests that there is very little longshore movement of gravel due to south-westerly swell (Figure 3A).

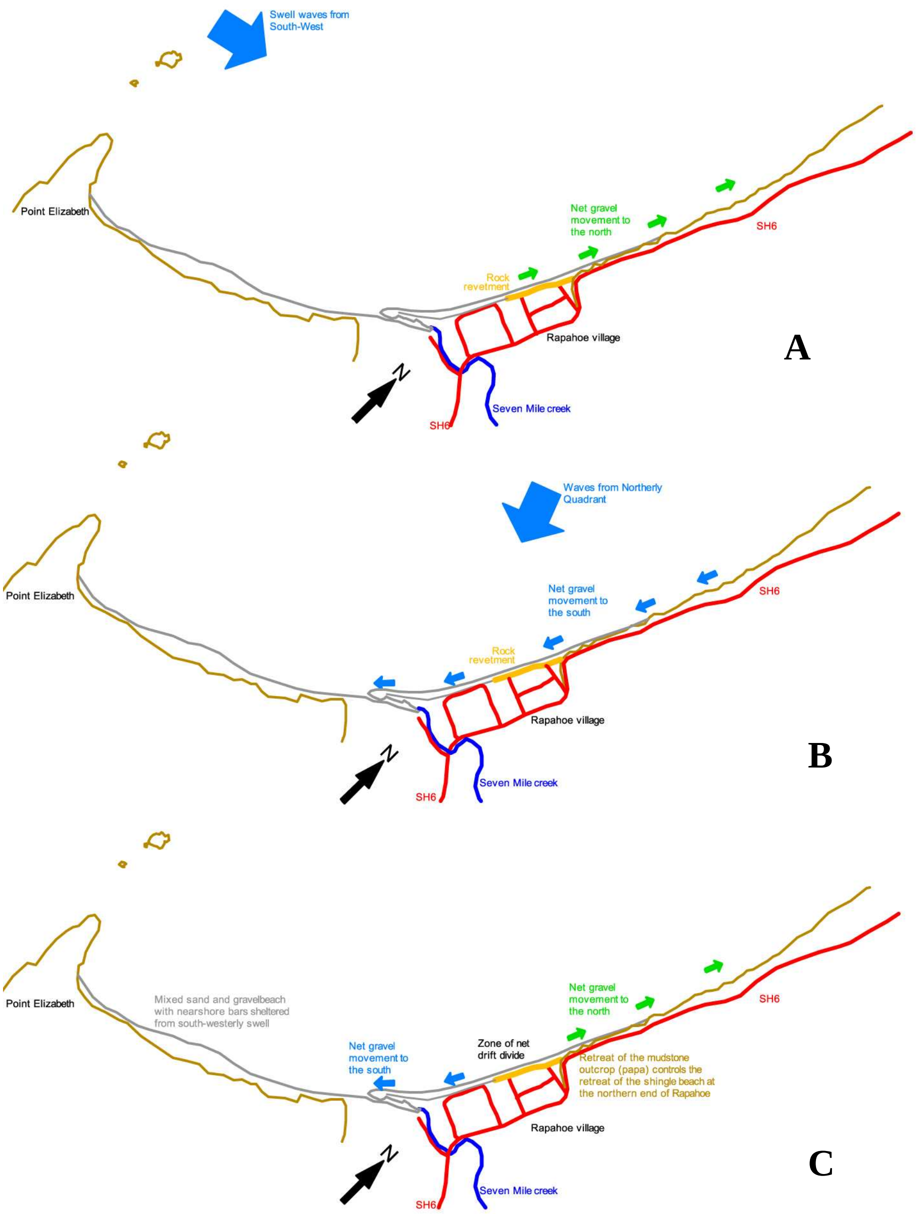

Figure 3: Schematic plot of longshore gravel movements at Rapahoe beach. The top panel (A) shows longshore movements of gravel under the prevailing waves from the south-west. The middle panel (B) longshore gravel movements from the north-west. The bottom panel (C) net gravel movements showing a potential gravel net drift divide along the northern part of the Rapahoe frontage.

Conversely, episodic storm events resulting in waves from the north-west through to north will have the potential to move gravel in a southerly direction along this entire section of coast (Figure 3B). However, due to the present day paucity of shingle on the beach fronting the active mudstone bluffs to the north of Rapahoe, the volumes of gravel being moved alongshore to the Rapahoe frontage from further north under such conditions is likely to be relatively low. Hence, in terms of nett longshore gravel transport it is suggested that the central to northern part of the Rapahaoe beach frontage is an area of net drift divide (i.e., gravel beach material tends to get moved away from the area alongshore (Figure 3C)) and as such an area that is particularly prone to erosion without significant new inputs of gravel in to the beach system at Rapahoe.

Local observations of the evolution of the beach over the last few decades (Ken Tiller & Peter Fletcher, pers. comm.) suggest that magnitude of retreat of the beach along the entire Rapahoe frontage has not been consistent with little landward movement of the beach at the southern end and more substantial retreat at the northern end, see Figure 4.

This is likely due to the influence of more local “hinge points” specifically: 1) the influence of the outlet of Seven Mile Creek at the southern end which tends to “hold” the position of the beach at the southern end (albeit this can change after a significant flood event), and 2) the influence of the position of the mudstone bluff to the immediate north of Rapahoe. The position of the present beach along the Rapahoe village frontage is closely related to the line of the bluff with the retreat of this bluff playing a significant role in the rate of landward movement of the beach. With the attempts by Transit NZ to protect the bluff immediately north of Rapahoe Beach it would be expected that the retreat of the bluff immediately north of Rapahoe would now slow or stop. In turn, ignoring the influence of the rock placed along the Rapahoe frontage for now, this would suggest that the planshape of the gravel beach would gradually reach some form of dynamic equilibrium in relation to this headland. How much more retreat of the gravel barrier would occur at the northern end before such an equilibrium is reached is uncertain but further landward movement of the barrier is still likely to occur for the foreseeable future.

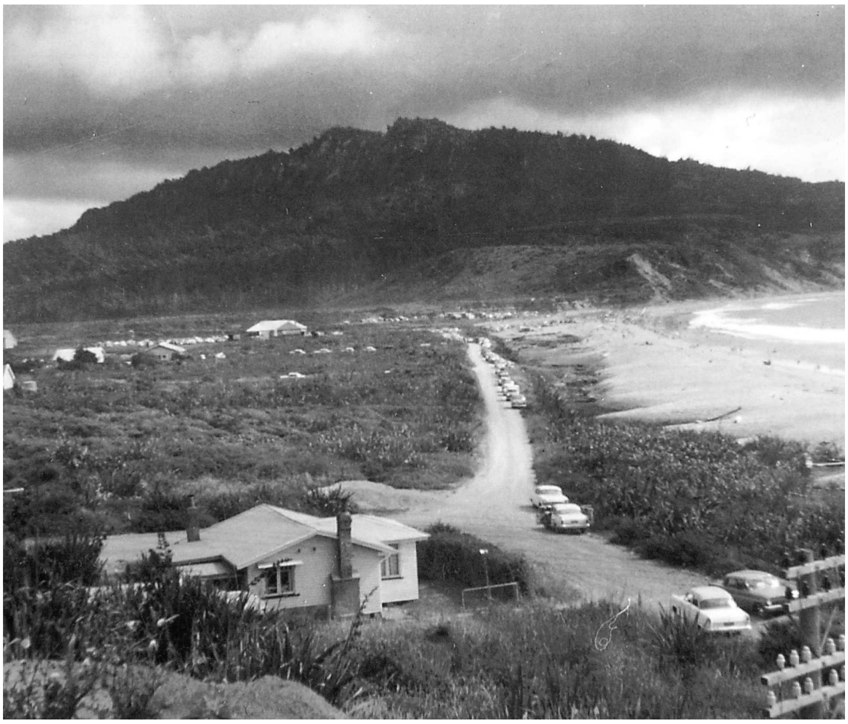

Figure 4: Looking south along Rapahoe beach in 1960 (top) – photograph courtesy of History House Greymouth, and pre 1978 (bottom) - taken by T Ulyatt and copied from handbook to S44 Greymouth Geological Map, 1978, S Nathan, NZ Geological Survey. Not long before the bottom photograph was taken the main road used to run on up the coast at bottom right. Photographs supplied by M. Trayes, WCRC.

2.4 Influence of existing protection works at Rapahoe

Attempts to reduce the rate of retreat of the northern end of the beach at Rapahoe commenced approximately 10 years ago when the local council placed some rock along the northern part of the beach. This rock, which is lighter in colour than that recently placed, can be seen at the toe of part of the present day revetment. A short stretch of consented rock revetment has also been constructed in front of the Forbes property at the northern end of the Rapahoe Beach. Rock has also been dumped down the face of sections of the mudstone cliffs immediately north of the beach at Rapahoe by Transit to prevent further erosion affecting State Highway 6.

Construction of the present rock structure at Rapahoe was commissioned by Mr Peter Fletcher, the leaseholder of the camping ground which is a DoC reserve with the lease administered by the local council. The total length of the protected section is approximately 320 m in length extending southwards from the mudstone (papa) outcrop at the northern end (i.e., including the beach section fronting the Forbes property) of the beach to Statham Street, Figure 5 (top).

The impacts of linear defences such as seawalls and revetments on surrounding beach systems are well documented (e.g., Dean, 1986) although the specific processes causing these impacts less well understood. At the time of the first inspections there was little obvious evidence of the revetment significantly impacting on the adjacent sections of coastline which in part is due to the short period since the construction of the structure and also the relatively slower response of a gravel beach (compared to a sand beach). At the northern end, the revetment is terminated close to the outcropping mudstone with outflanking of the defence due to the retreat of the bluff unlikely to be an issue due to the amount of rock placed by Transit immediately to the north.

At the southern end any significant downdrift effects exacerbating the rate of retreat of the gravel crest immediately south of the end of the defence is unlikely due to the low net longshore transport of gravel. However, the beach at the southern end of the defence will continue to retreat and will be influenced by the end of the revetment as the present defence is not aligned with the how the beach planshape along the Rapahoe frontage is developing. Whilst there has been an ongoing effort to prevent the back of the gravel ridge migrating over the top of remaining sealed section of Beach Road to the south of Stathan Street, this has resulted in the gravel barrier becoming progressively narrower and more prone to breaching which is what has subsequently occurred during a number of storm events over the preceding winter, Figure 6. The inadequate construction of the recent revetment (e.g., single layer of rock, lack of filter layer, low crest etc.) has also resulted in the underlying gravel being winnowed out between the voids in the rock resulting in the underlying gravel ridge along the protected section to continue to retreat (Figure 5 – middle & bottom). In essence whilst the rock revetment, in its present form, is not having any great detrimental impact on the surrounding beach system at present, it is not providing any real benefit in terms of increased standard of protection either.

Figure 5: Beach changes at Rapahoe looking south and north from Morpeth Street: November 2005 (top), August 2006 (middle), October 2006 (bottom).

Figure 6: Breached gravel barrier and overwashing of gravel on to the Esplanade immediately south of the end of the rock revetment at Stathan Street (August 2006).

3. Managing the impacts of coastal change at Rapahoe

3.1 Recommendations from previous studies

Potential options for managing the retreat of the coastline at Rapahoe have been assessed in previous studies, Neale (2000) and Opus (2000). Neale concluded that in the short-term a gravel stopbank located behind the active gravel beach crest would be most appropriate, with the area between the natural gravel barrier and the stopbank planted with vegetation such as flax. This would not stop the ongoing retreat of the gravel barrier but would reduce the risk of inundation from wave overtopping or breaching of the gravel barrier.

In the longer term, Neale concluded that the most appropriate options were essentially to relocate (or abandon) the existing assets and allow the beach planshape to continue to evolve, or if resources were available, to increase the width of the gravel barrier by nourishment to ‘hold the line’. This would require a rock groyne at the northern end of the beach to help prevent longshore loss of gravel along the coast to the north.

The Opus study also considered a range of options, their respective technical merits, social and physical impacts and costs. This reached a similar conclusion with beach nourishment as the most suitable option over a 50 year timeframe, although this would require a suitable gravel source and periodic maintenance. However, it was noted that the community preference was for hard protection, such as a revetment structure, particularly if the costs of the structure would be spread over the wider community or with assistance from other funding sources.

3.2 Present-day situation

The main impetus for the protection work at Rapahoe is from the campsite owner. The only other property at significant risk from coastal erosion is the house at the northern end of the beach (Forbes property), a number of privately owned undeveloped sections, and the northern end of the remaining sealed section of Beach Road (the sealed section between Holland and Statham Streets having been lost earlier). To a lesser extent at this present time, the two seaward most properties on the southern side of Holland Street are also at some risk. Objectively, there is little economic justification for adopting a “hold the line” strategy along the majority of this frontage based on the assets at present risk, given that:

1. The Forbes property could be protected with a relatively short length of revetment (upgrading the existing revetment and extending it landward along the northern bank of the stream that discharges at the northern end of Rapahoe Beach to protect access via Holland Street).

2. Camp and caravan sites are relatively easy assets to relocate assuming there is a suitable site to relocate to. Where such sites form a significant component of the assets at risk, serious consideration should be given to relocation, given that this is likely to be a much more cost-effective strategy in the long run than the capital and maintenance costs of properly constructed and maintained protection works.

3. The remaining sealed section of Beach Road south of Statham Street is not required for access to any property. Given the lack of gravel ridge between the road and the active beach, the road is highly likely to be lost even if linear defences are constructed, i.e., covered over by a stopbank that would be required to back any rock revetment or similar structure along this section.

4. If substantial protection works were to go be constructed, the area behind the defences along the entire frontage would still be considered a high risk coastal hazard zone. No further development of land could be recommended in this area.

Given the lack of protection provided by the recently constructed rock revetment in stopping continued retreat of the gravel barrier, the owner of the camp site is presently considering options. This may include upgrading the level of protection, primarily along the reserve frontage between Holland and Morpeth Streets.

3.3 Potential roadmaps for consideration

Much of the discussions and findings within the reports by Neale (2000) and Opus (2000) are still valid, and it is not intended to repeat such a review here. Rather, outlined below are possible pathways for managing or adapting to the ongoing retreat of the gravel barrier at Rapahoe based on the above reviews, the observations and discussions held over the last year, and considerations outlined in Section 3.2.

No conclusions or recommendations as to the most appropriate options are presented, rather the options outlined below are intended to be used as a basis for further discussions with the Rapahoe community and will require further considerations, such as costings to be carried out, before being taken further.

Over the short-medium term the continued retreat of the gravel barrier will be closely linked to the occurrence of coastal storm events, particularly those that coincide with higher tides. Between Holland and Statham Street, the gravel barrier will occasionally be overwashed, but only likely to be breached under a more severe storm event. Around the Forbes property the rock revetment is currently being upgraded. However, whilst this will provide protection to the during small to moderate storm events, under more severe storm conditions there will still be considerable overtopping (potentially leading to inundation around the property) and scouring of the land behind the revetment is likely (potentially leading to property damage). In turn this may lead to failure of the revetment and further reduction in the standard of protection provided by the structure.

Figure 7 attempts to conceptualise how the beach planshape at Rapahoe may respond to various protection measures over the medium-term future. The top image is where the rock revetment remains in its present form or is removed (but the bluff continues to be protected by Transit NZ) and the beach allowed to continue to roll back until it reaches some form of dynamic equilibrium with the position of bluff. Note: this does not mean that retreat will stop occurring – there will still be occasion when episodic overwashing occurs, and the balance between fresh gravel entering the beach system and the gradual loss due to abrasion will play a role).

The main area of concern in the short- to medium-term is the state of the gravel ridge over a 100-150 m section adjacent to the end of Morpheth Street. This has been much modified due to construction of the revetment (northern part) and past attempts at holding the ridge from migrating over the remaining sealed section of the esplanade south of Statham Street. This makes it more a susceptible to breaching and overwashing than a well sorted gravel ridge that has been worked by waves in to a natural form (e.g., that found towards the outlet of Seven Mile Creek). Whether a more robust gravel barrier will reform over time (as it retreats and reworks gravel behind the ridge and gravel is moved occasionally alongshore from adjacent sections) is uncertain. This will depend on the occurrence and direction of waves during storm events and also whether further protection works are constructed along the northern half of the Rapahoe frontage (effectively cutting off any longshore gravel movement from the northern half of the beach). However, in the short-term more frequent overtopping and overwashing at this location would be expected when moderate swell coincides with a high tide, potentially causing frequent inundation of the land behind and loss of the esplanade to the south of Morpeth Street.

It is with this scenario in mind that the following options are considered. All need to consider the Rapahoe frontage in total, rather than ad-hoc sections of the frontage.

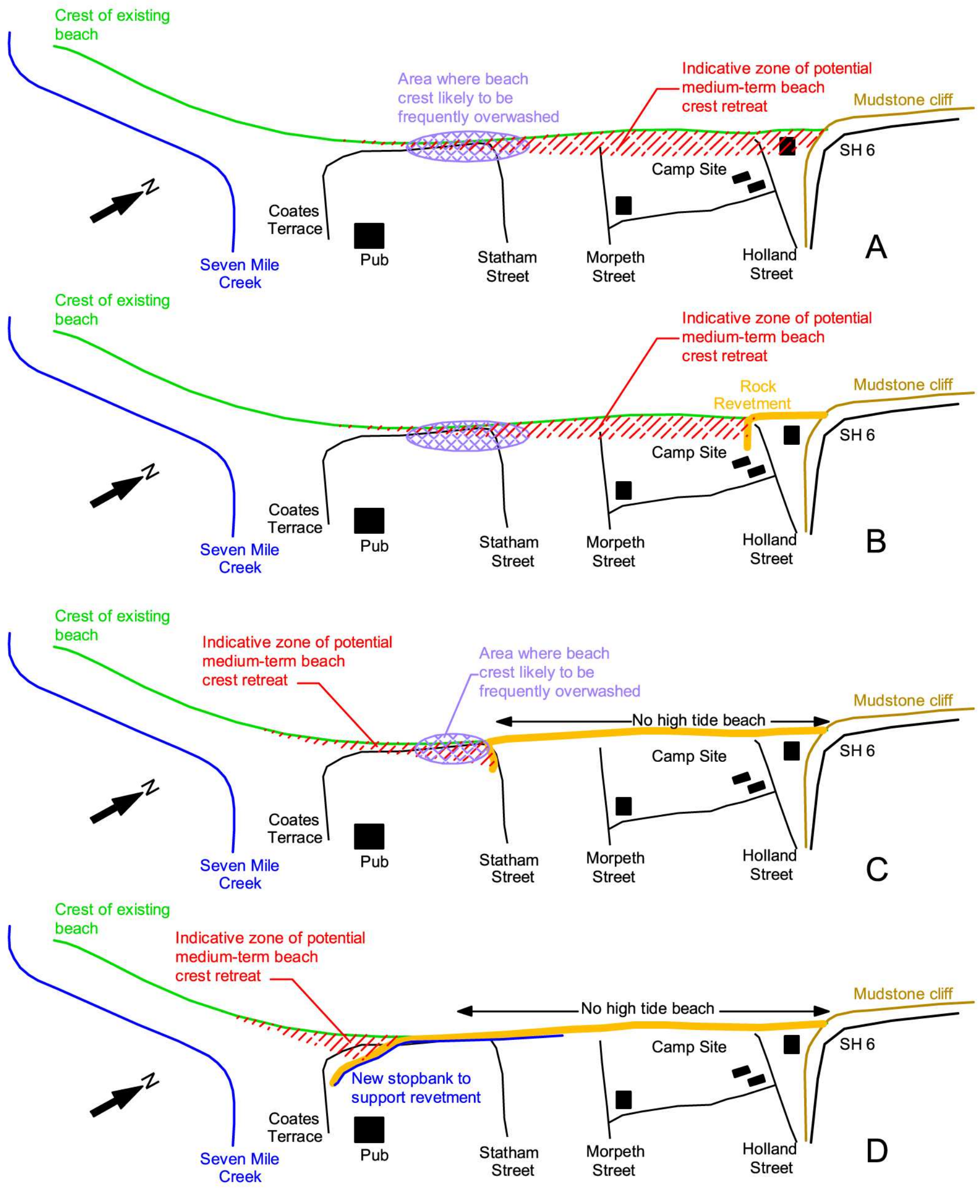

Figure 7: Conceptual potential planshape response of the gravel barrier in response to various rock protection options. A: No revetment along any part of the beach except the bluff protected by Transit NZ, B: Rock revetment around the Forbes property (note this shows an extended revetment to that presently consented), C: Rock revetment along the reserve frontage and wrapped around the end of Statham Street, D: Rock revetment along the entire frontage but re-orientated landward at southern end to prevent outflanking.

Table 1: Summary of potential options for managing or adapting to erosion at Rapahoe

Option	Time-frame	Forbes property	Holland – Morpeth Street	Morpeth – Statham Street	Statham Street - Coates Terrace	Coates Terrace to Seven Mile Creek mouth
1 Fig 7: A & B	Short	Do nothing or Rock revetment	Do nothing (vegetation replanting)	Do nothing (vegetation replanting) / (Stopbank)	Do nothing (vegetation replanting) / (Stopbank)	Do nothing
	Medium	Do nothing or Rock revetment	Relocate camp site & monitor	Monitor / (Stopbank)	Monitor / (Stopbank)	Monitor
	Long	Do nothing or Rock revetment	Monitor	Monitor	Monitor	Monitor
2	Short – Long	Rock revetment & rock groyne	Rock / revetment or Beach nourishment	Beach nourishment	Beach nourishment	Beach nourishment
3 Fig 7: C	Short - long	Rock revetment	Rock revetment	Rock revetment / Beach nourishment	Beach nourishment	Beach nourishment
4 Fig 7: D	Short - long	Rock revetment	Rock revetment	Rock revetment	Rock revetment	

3.3.1 Option 1: Ongoing or managed retreat

Given availability of rock, relatively low cost, and the limited impact on the adjacent beach, it would appear sensible to continue to protect the Forbes property at the northern end. It is assumed in all other options outlined below that this will occur. Ideally this would involve upgrading of the existing revetment and extending it landward along the northern bank of the stream that discharges at the northern end of Rapahoe Beach to protect access via Holland Street). If no other action were taken the beach planshape response along the main Rapahoe frontage (Figure 7B) would likely be similar to that if no further activities were undertaken, with the risk remaining of overwashing and inundation as outlined in the previous section. However, maintaining a buffer zone of vegetation, such as flax, along the entire frontage, would help provide some stability to the gravel barrier and reduce the magnitude of overwashing.

In the medium term, as the gravel barrier continued to retreat, this would likely require the camp site to be abandoned or relocated and the loss of a number of privately owned undeveloped sections.

Monitoring of the retreat would be required and trigger points set for the early identification of further property at risk (other than those presently identified) which may change the management approach in the future (e.g., direct protection may become a necessity).

A variation on this option is for the construction of a gravel stopbank behind the present gravel barrier (as has previously been built at Punakaiki and in front of Granity School). **This would require gravel to be brought in and not taken off the beach.** This would have greatest benefit from mid-way between Morpeth and Statham Streets to the south, where the present risk of overwashing, breaching and inundation is greatest. Such a stopbank would reduce the risk of inundation, but not the retreat of the gravel barrier (although will have some slight influence) and ultimately the gravel barrier will roll back over it. Along the northern half of the beach, such a structure will have less influence as there is a relatively lower risk of inundation due to a slightly more robust gravel barrier, and it will only have a relatively minor influence on reducing the ongoing rate of retreat of the gravel barrier.

3.3.2 Option 2: Beach nourishment

The primary factor influencing the standard of protection afforded by the gravel barrier at Rapahoe is the paucity of gravel within the barrier. Hence beach nourishment as identified by both Neale (2000) and Opus (2000) should still be considered a viable option if there is a suitable, low cost source of nearby gravel. This would need to be a well-sorted pebble to cobble sized material with little material smaller than pebble sized within the grading. It is appreciated that such a source may not be available and it is understood that there are no plans for any maintenance dredging of the Greyport berths and channel which could have provided a potential source.

The volume of gravel required (and hence potential cost) to provide a sufficiently wide profile to accommodate typical storm events will need to be determined. At present there is insufficient gravel to form a sufficient storm berm (for example as forms at Blaketown). Rather the barrier at Rapahoe is much lower, is overwashed more frequently, with gravel moved from the front to the back face of the barrier, resulting in the barrier retreating. A reasonable indication of the range of likely gravel barrier profile responses under different storm conditions, and hence indication of required gravel volume required for any nourishment, can be gained from the application of gravel profile response models such as that of Powell (1990) and is a relatively quick and straightforward assessment to make.

Both the Neale and Opus reports recommend the need for a rock groyne at the northern end of the frontage to help reduce the loss of gravel alongshore to the north. Such a structure will almost certainly be required. It is suggested that rock protection around the Forbes property would be maintained with the rock groyne extending seaward from this location. The length and profile will depend on the gravel nourishment profile but it is assumed that the existing rock forming the revetment could be reused and hence the costs relatively modest.

3.3.3 Option 3: Rock revetment along part of the frontage

The present rock revetment extends from Holland to Statham Street. The campsite owner is currently reviewing options for possibly upgrading the revetment. To provide a sufficient standard of protection, the revetment will need to be built to a similar standard as that at Punakaiki. The crest elevation of the structure will likely be required to be higher than the present elevation of the gravel barrier crest to reduce overtopping and potential for scouring.

The conceptual response of the beach planshape where the rock revetment is placed against the gravel barrier between Holland and Statham Streets is shown in Figure 7C. At present along the section between Holland and Morpeth Streets, there is still sufficient width of gravel barrier upon which to found the revetment.

Whether the intended protection works (and possible increases in ratings to cover the construction costs) are favoured by the wider community in Rapahoe is not known. A significant issue is that the benefits provided by the proposed rock revetment would essentially only benefit the camp site owner, a number of undeveloped sections, and presumably the Forbes property, whereas some of the potential negative impacts of the defences will be shared by the wider community (even if the costs are met by the owner of the campsite). The most significant of these are likely to be:

- eventually, no beach access at high tide along the front of the revetment (i.e., there is unlikely to be any significant dry beach between the toe of the revetment and the high tide mark);

- further deterioration on aesthetics and natural character of the coast;

- influence on how the beach responds to the south of the end of the proposed upgraded revetment at Statham Street (or Morpeth Street if a sorter section of revetment is built) which could alter the stability of the unprotected section of coast (discussed next).

The southern end of the rock revetment now becomes the local “hinge” point which will play a role in influencing how the planshape of the gravel barrier to the south changes in the future. The gravel barrier will respond by shifting to an equilibrium position relative to the end of the revetment. The landward extent of such movement may well be greater over a short section than if a continuous gravel barrier extended to Holland Street. There are two reasons for this. Firstly, as it is intended that the gravel on the beach to the north will form the core of the stopbank upon which the revetment is placed, rather than leaving the gravel on the beach in front of the revetment, there will be little or no gravel capable of being moved alongshore under northwesterly wave conditions, leading to some slight downdrift effect. Secondly, the influence of the revetment could potentially lower beach levels slightly in front of the wall (placing the rock revetment at as shallow a slope as possible helps reduce such effects), which in turn allows slightly higher wave conditions further up the beach along the defended and immediate adjacent section

If the revetment is not “turned in” behind the back of the existing beach crest at the southern end, or landward along the edge of the seaward end of Statham Street (Figure 7C), the revetment is likely to be outflanked, i.e., as the gravel crest retreats erosion in behind the southern end of the revetment will occur. The gravel barrier may also need to be strengthened, i.e., a widened and heightened, towards the southern end to adequately found the revetment which may increase the costs significantly.

Upgrading the revetment along part of Rapahoe Beach does not address the issues facing the southern section of Rapahoe beach and may well exacerbate these problems. Apart from accepting the impacts, there are possibly two options:

- Build up the gravel barrier via beach nourishment to prevent overwashing, breaching and inundation along the southern section to around 150 m south of Statham Street. However, any nourishment placed on the front face of the existing gravel barrier will protrude seaward of the line of the revetment and likely to be quickly moved alongshore. Rather it is suggested for this option that the gravel nourishment be placed landward of the existing barrier and the beach planshape be allowed to evolve into the nourished gravel barrier, i.e., accept that southern end of the revetment will act as a “hinge point” and in response that retreat of the barrier will occur. However, if sufficient volume of gravel is introduced, the risk of overwashing, breaching and inundation is managed.

- Protect the entire frontage with a revetment (see next section).

3.3.4 Option 4: Rock revetment along entire frontage

Finally if there is community desire for protection of the land behind the beach along the entire frontage, a rock revetment along the entire length to Beach Road would likely be the most suitable option (Figure 7D). The community would likely need to resource the construction costs through for example increasing rates, and accept the potential impacts such as loss of high tide beach for walking along, Such an option would be an expensive undertaking. From mid-way between Morpeth and Statham Streets to the southern end there is no natural barrier remaining to place the revetment against, hence a new stopbank would also need to be constructed. As in the schemes outlined above, the revetment would need to be 'turned in' landward (around the seaward side of the pub) to avoid outflanking as there will likely be some readjustment of position of the remaining section of gravel ridge.

3.4 The next steps

As discussed above, the purpose of this scoping study was to review the previous assessments and provide a present day basis for further discussions with the Rapahoe community. As such no conclusions or recommendations are made. The options will require further discussions with the Rapahoe community and further considerations such as potential costing of the options to be carried out, before an appropriate response to managing and / or adapting to the erosion issues at Rapahoe can be developed further.

4. References

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