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Hurunui District Coastal Adaptation Short Listed Options

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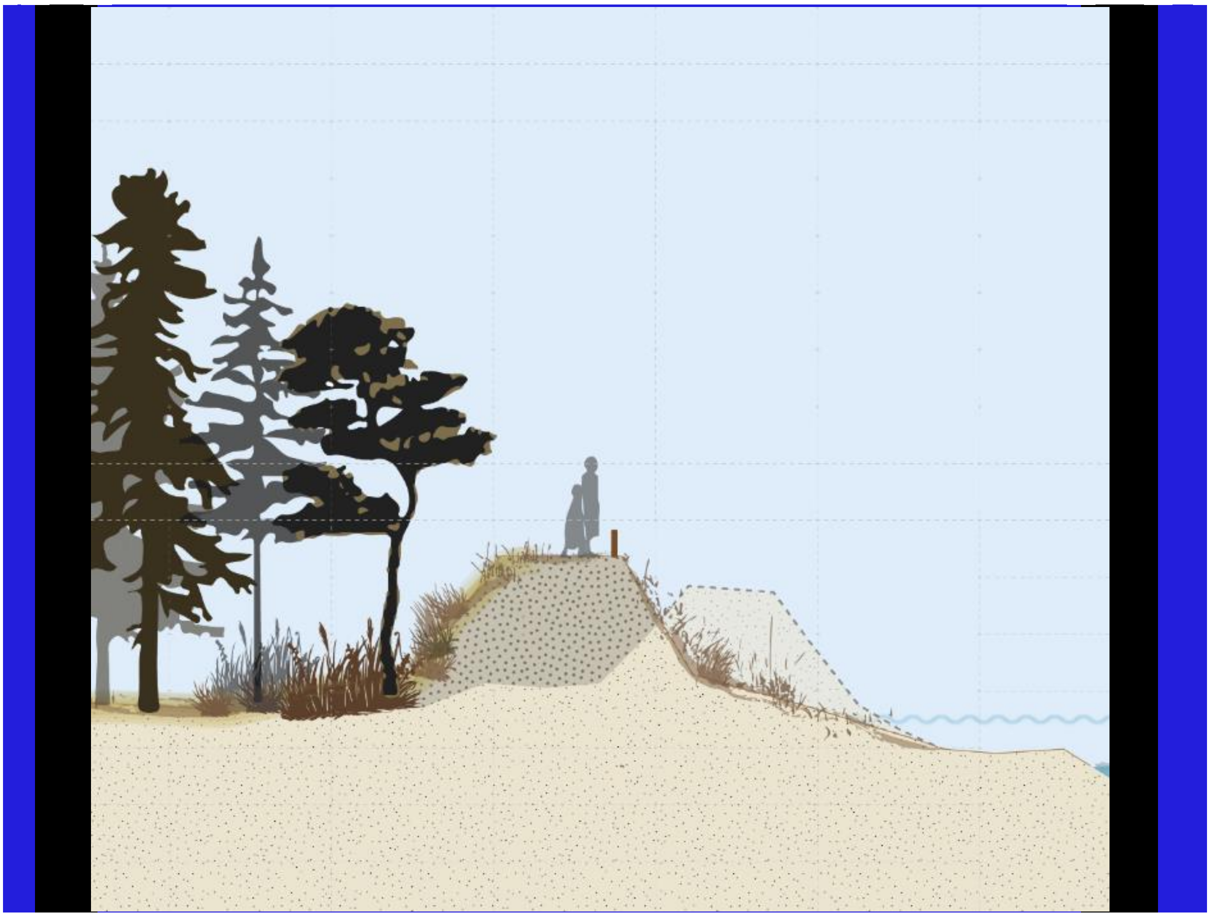
Hurunui District Council

Hurunui District Coastal Hazards
25 October 2022



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Appendices

1. Introduction

In September 2020, Hurunui District Council (HDC) began 'Coastal Conversations' with coastal communities to work towards developing a dynamic adaptive planning pathway (DAPP) for each settlement to adapt to sea level rise and the effects it is likely to have on the community. A coastal hazards assessment completed by Jacobs (2020) indicated that erosion, coastal inundation and rising groundwater could have an effect on the communities of Gore Bay, Amberley Beach, Leithfield Beach and Motunau in the future with sea level rise.

From these conversations, the communities signalled to HDC that further information was required on possible mitigation options which could be implemented in their community to adapt to these hazards and help inform a discussion around forming an adaptive pathway plan.

Hurunui District Council (HDC) commissioned Jacobs in July 2021 to undertake an investigation of potential physical erosion and inundation management options that could form part of the pathway at the above four settlements. Jacobs developed an exhaustive 'long-list' of potential mitigation options, which through a high-level options assessment reduced this long list to a 'short-list' of options at each settlement for conceptual design and indicative costing. Technical memorandums which provide details on the process of reducing the long-list down to a short-list are attached to this report in Appendix A and B.

Potential recommended short-list management options were presented to the four communities in July-October 2022 and were explored by the communities in a facilitated workshop environment along with planning and retreat options in the **Coastal Adaptation Explorer tool.**

Throughout the engagement process with communities, both prior to workshopping the Coastal Adaptation Explorer tool and during, communities signaled further additional potential short listed options that they felt should be also considered as part of pathways by both the council and the community. These options have been included in this report for completeness, but where options were not developed prior to the workshopping of the Coastal Adaptation Explorer tool, indicative costing or conceptual design has not been completed.

The purpose of this report is to outline the short-listed engineering options at each settlement which were used to inform the Coastal Adaptation Explorer tool. This report sits alongside a planning options report and a managed retreat discussion paper prepared by Hurunui District Council.

1.1 Report Structure

This report provides the details of the short-listed engineering options for each of the four coastal settlements:

- Section 2 details the short-listed engineering options for Leithfield Beach
- Section 3 details the short-listed engineering options for Amberley Beach
- Section 4 details the short-listed engineering options for Motunau
- Section 5 details the short-listed engineering options for Gore Bay

2. Leithfield Beach

The coastal frontage to the Leithfield Beach settlement is 1.5 km long, with the settlement footprint being separated from the shoreline by a 200m wide series of vegetated backshore dune ridges, which are up to 6 m above MSL in elevation. This wide beach system, together with continued high rates of sediment supply from the south is projected to continue to protect the settlement against future coastal erosion hazard with sea level rise over the next 100 years, and the continued presence of a large dune system should also continue to protect against sea water inundation along the settlement frontage. However, to the north of the settlement is the small Leithfield Beach Lagoon located behind the beach, which is not naturally open to the ocean, but wave run-up can overtop the lower beach ridge in this area and enter the lagoon and flood into the settlement. This issue will increase in frequency and depth with future sea level rise. A multi-flood hazard assessment identified that the main flood hazard comes from the low-lying coastal hinterland north of the settlement where flood water from the Kowai River can flow over the land and enter the settlement. A secondary flood source from the Ashworth's Ponds to the south was also identified.

The long-list to short-listing process is documented in Appendix A (p15-19). Short listed options included options for maintaining a healthy dune environment to reduce loss of erosion and inundation protection along the front of the settlement, as well as options to reduce water entering into the settlement in future large events with sea level rise. Physical management options chosen for further investigation in the Leithfield Beach consisted of:

- Dune management and planting
- Beach scraping
- Stop banking/earth bund on the west side of the settlement
- Stop banking/earth bund along the north and south ends of the settlement

The following information presents a description of the option, benefits and limitations of the option, and high-level indicative costings. Further breakdowns of costings are presented in Appendix C.1.

This information was presented to community members in a facilitated workshop on 5th October 2022. At this workshop the potential additional option of an engineered flood banks along the lower right bank of the Kowai River was discussed. This option has been added to the short-list, and HDC are undertaking further discussions with Environment Canterbury (ECan), who has the responsibility for river control works to understand the implications and indicatives costs of this option. At this stage concept design and indicative costing of this option has not been undertaken and is therefore not included in this report.

Option 1: Dune management and planting over total settlement frontage

Figure 2.1: (Left) Red area showing indicative area of planting; (right) Existing dune planting environment at Leithfield Beach

Description:

This option involves dune planting and access way management, including board walks over the dune and signage around vehicle access, along the length of the settlement to ensure the dune continues to grow in volume, and planting is not damaged through vehicle and pedestrian access over the dune. Options such as sand trap fencing could also be explored, although the success of is likely to be limited because of the gravel presence in the upper beach profile. Costing includes initial planting, access board works, fencing and signage, plus first year maintenance/replacement planting.

Benefits	Limitations
▪ A natural beach is a good aesthetic outcome and aligns with community objectives. ▪ While restricting access locations across the total dune area, there will still be access (to pedestrians). ▪ It is a low cost option. ▪ It will increase the longevity of the dune. ▪ Meets the requirements of Policy 26 of the NZCPS. ▪ Limited/no consenting required. ▪ Creates an opportunity to involve the community. ▪ Can be staged across multiple years to help budgeting.	▪ May not be an effective long-term (100 years) solution against sea level rise, particularly on narrow beaches with limited capacity for retreat. ▪ Does not address flood hazard around the back of the settlement.

Indicative costings:	
Option 1a: Without community labour	
Total Cost	$217,000
Total Budget (2.5% Professional Services[1] & 15% Contingency)	$255,000
Option 1b: With community labour	

[1] 2.5% Professional Service fee covers project management costs. For dune management and planting projects there are no consenting, design and construction management fees.

Option 1: Dune management and planting over total settlement frontage	
Total Cost	$127,000
Total Budget (2.5% Professional Services & 15% Contingency)	$149,000

Option 2: Beach Scraping

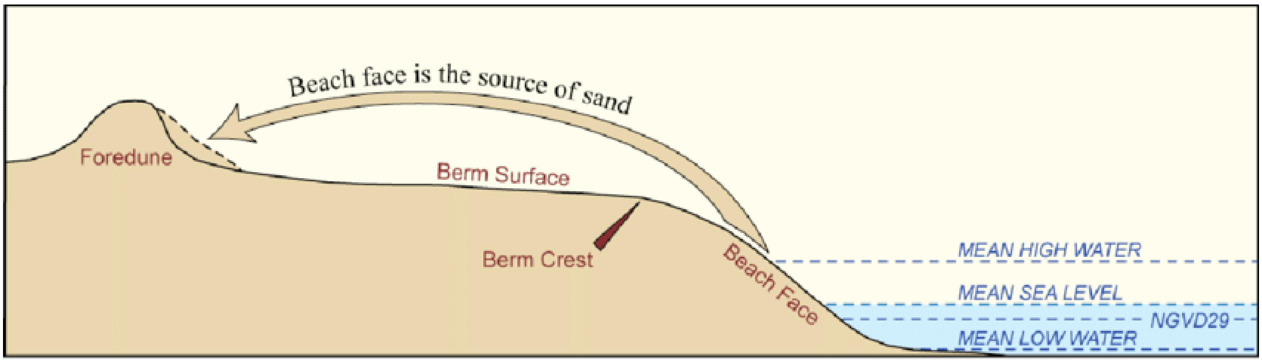

Figure 2.2: Example of beach scraping processes from Silveira and Psuty (2008).

Description:

A medium to long-term soft engineering approach which could be applied at Leithfield Beach. This option involves periodic beach scraping by bulldozer, relocating beach sediment from the foreshore to the crest to build up the crest elevation and volume to provide better protection during storms. This option could be applied to the whole beach frontage of the settlement (1.5 km) on an as required basis post storm events and a surplus of sediment on the foreshore. Costing is for a one off initial scraping, which would may be needed to be undertaken every 5-10 years to maintain the desired dune volume and elevation.

Benefits	Limitations
▪ Backshore scrapping slows shoreline recession by relocating sediment within the active beach system into the dune area. ▪ Increases protection against inundation by building up the crest level. ▪ Option is a relatively low cost when compared to renourishment as it does not involve placement of additional material from an external source. ▪ Can be a reactive response to events, or applied to only site specific areas. ▪ A natural beach is a good aesthetic outcome which aligns with community values. ▪ Allows for access to the beach to be maintained. ▪ Meets the requirements of Policy 26 of the NZCPS.	▪ Short-term response which only has temporary adjustment of highly dynamic beach profile, and therefore requires multiple interventions over time. ▪ Does not address any long term sediment deficits or sea level rise impacts, and therefore might not be an appropriate long term solution. ▪ May have impacts on beach ecology (e.g. species living in the beach that are distributed by scraping activity; burial of vegetation on crest).

Indicative costings:	
Total Cost	$89,000 per scraping
Total Budget (15% Professional Services[2] & 15% Contingency)	$116,000 per scraping

[2] 15% Professional Service fee covers 2.5% consenting costs, 5% design costs, 5% construction management fees, and 2.5% project management costs.

Option 3: Stop banking/earth bund on the west side of the settlement

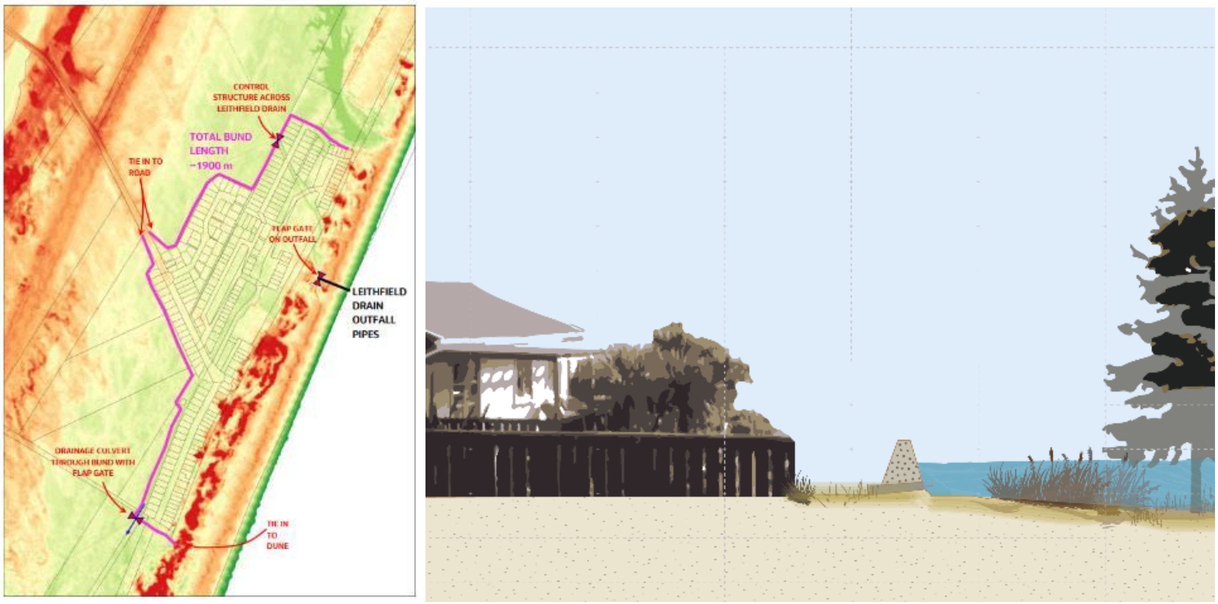

Figure 2.3: (Left) spatial layout of where the earth bund would be constructed in relation to the settlement. (Right) conceptual sketch of the bund.

Description:

A medium to long term protection option involving the construction of an engineered earth bund around the western edge of the settlement which allows water to flood the low lying land to the west, but not enter the properties in the settlement. The total bund length required would be approximately 1.9 km in length, and an average of 1.2 m high.

For conceptual design, the bund would be designed to withstand the modelled multi flood options for a 2% AEP event with 0.5 m SLR + freeboard; or 0.5% AEP with 0.5 m SLR no freeboard.

Benefits	Limitations
▪ This option is an effective way of controlling water flow in an extreme event. ▪ It could be designed or adapted for longer term protection with future sea level rise. ▪ Could be grassed over and planted edges to look more natural along the banks edge. ▪ Could provide recreational access on top (e.g. walkway, cycle path).	▪ May cause some backing up of the lagoon water levels, which could divert the flooding further upstream. ▪ Would still result in some overland flooding to occur west of the settlement boundary. ▪ If stopbanks are overtopped water can be trapped with no pathway back to the sea/river. ▪ Due to 'dam' like nature of the structure – unlikely to be easily consented, potential to be over designed in order to meet dam specification requirements, and therefore price estimate may be lower than actual cost. ▪ Potential for seepage and compaction of the bund due to the softer material it would be built on. ▪ Potential to be outflanked at the beach. ▪ Unknown what the implications of the bund would be on groundwater drainage within the settlement.

Indicative costings:	
Total Cost	$581,000
Total Budget (15% Professional Services & 15% Contingency)	$755,000

Option 4: Extended Earth bund along north and south end of the settlement

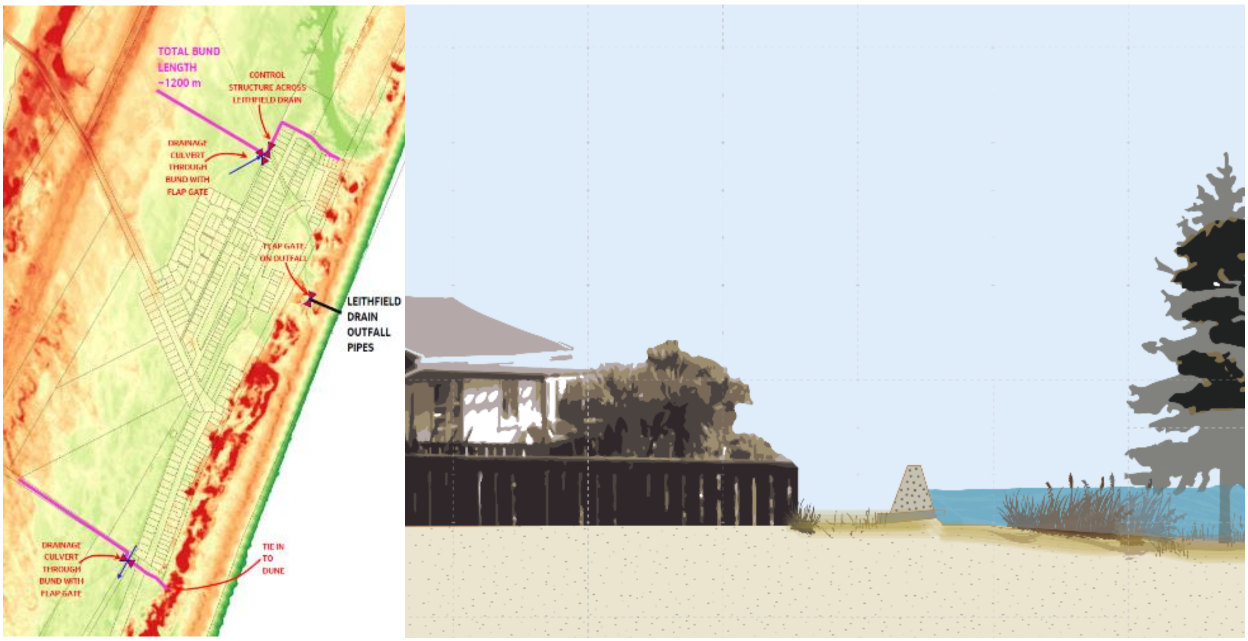

Figure 2.4: (Left) spatial layout of where the earth bund would be constructed in relation to the settlement. (Right) conceptual sketch of the bund.

Description:

Alternative arrangement to Option 3 which would involve cutting off the flow paths from the north (Kowai River and Leithfield Lagoon) and south (from Ashworths ponds/Ashley River by tying into the higher ground inland. This would be an engineered earth bund which would allow water to flood the low lying land to the north and south, but not enter the properties in the settlement. For conceptual design, the bund would be designed to withstand the modelled multi flood options for a 2% AEP event with 0.5 m SLR + freeboard; or 0.5% AEP with 0.5 m SLR and no freeboard.

Benefits	Limitations
▪ An effective way of controlling water flow in an extreme event. ▪ Can be designed or adapted for longer term protection with future sea level rise. ▪ Can be grassed over and planted edges to look more natural along the banks edge. ▪ Could provide recreational opportunities (e.g. cycle track or walking track along the top).	▪ May cause some backing up of the lagoon water levels, which may divert the flooding further upstream. ▪ If stopbanks are overtopped water can be trapped with no pathway back to the sea/river, therefore may require the installation of pump stations to drain this water. ▪ Due to 'dam' like nature of the structure – unlikely to be easily consented. There is potential to be over designed in order to meet dam specification requirements, and therefore price estimate may be lower than actual cost. ▪ Potential to be outflanked at the beach. ▪ Compared to 3, another flapped drainpipe/ culvert through the bund would be needed near the Leithfield drain for the ditch that drains northwards to the Leithfield Lagoon. ▪ Residual risk of flooding due to direct rainfall over the enclosed catchment inland of the settlement. May require the installation of pump stations to deal with this residual risk. ▪ Unknown what the implications of groundwater rise in the settlement would be on draining settlement within the bund extent. Again, may require the installation of pump stations to deal with this residual risk.

Indicative costings:	
Total Cost	$393,000
Total Budget (15% Professional Services & 15% Contingency)	$511,000

Option 5: Stopbanks on the Lower Kowai River

Figure 2.5: Approximate location of the stopbank along the Kowai River (red) relative to the Leithfield Beach settlement.

Description:

Engineered stopbank on the true right bank of the Lower Kowai River designed to withstand fluvial flooding from the Kowai River entering the Leithfield Beach settlement, and tidal contributions through the Kowai mouth. The stopbank would be designed to withstand a minimum of 1% AEP fluvial flood, and line 1.5 km along the true right bank up to State Highway 1. An indicative cost for this option has not been developed.

Benefits	Limitations
▪ Would be effective in providing protection from fluvial flooding (and tidal contributions through the Kowai mouth). ▪ Could have added benefit of recreational use – make into a pathway/cycleway.	▪ Residual tidal flooding through the Leithfield Drain outfall would still need to be addressed. ▪ Flood hazard through tidal flooding from the south (via Ashworth's Beach) may still need separate measures unless this was of a depth that could be tolerated/accepted or dealt with in another way. ▪ The stopbanking would need to extend up to to SH1 crossing as the modelling showed water leaving downstream of the bridge and flowing across to Leithfield. This will increase the cost of the structure. ▪ Drainage outlet would be needed in the lower reach to allow drainage of rainfall and any residual flooding back into the river. ▪ The stopbank would need to be of a substantial design and construction as it would be retaining fast flowing river water (with likely debris loads) rather than shallow, fairly static ponded water around the settlement. ▪ Providing stop banking along only one side of the river would tend to increase fluvial (and tidal) flows to the Amberley side, and could possibly increase the flood hazard there. Further investigation would be needed to assess the relative significance of contributions from the Kowai River to Amberley Beach. ▪ River flood controls are a regional authority responsibility, and therefore the decision on whether a stopbank could be built would sit with Environment Canterbury.

3. Amberley Beach

Amberley Beach settlement has a 1 km coastal frontage, separated from the beach over most of its length by a narrow 50-70m wide planation area. For the last 20 years there has been a man-made bund located on the storm ridge of the beach along the whole frontage of the settlement to prevent coastal inundation from wave overtopping. The bund has successfully prevented inundation of the settlement in coastal storm events over the last 20 years, however, has suffered erosion in significant storm events resulting in several nourishment top-ups of the bund being required to maintain the design level of flood protection.

To the south and north of the settlement there are small coastal lagoons (Mimimoto Lagoon to the south and Amberley Beach Lagoon to the north) into which drainage from the small coastal plain discharges, including drains across low lying land immediately west of the settlement. Neither of the lagoons have a permanent opening to the ocean with both having outlet channels normally blocked by beach sediment that prevents the regress of high lagoon water levels but also allows the ingress of sea water during coastal storm events, both of which add to the flood hazard. The muti-flood hazard assessment identified an additional flood pathway from a low point on Waipara River adjacent to the golf course.

The long-list to short-listing process is documented in Appendix A (p8-14). Short listed options had consideration for alternative arrangements of the existing bund structure, harder engineered solutions, and bunding to control inundation hazards. The short-listed physical management options chosen for further investigation at Amberley Beach consisted of:

- Increasing the elevation of the existing bund alignment by 0.5 m.
- Relocation of the bund 5m landward and increasing the crest elevation
- Extending the bund crest landward by 5m and increasing the crest elevation
- Progressive relocation of the bund up to 25 m landward of the existing footprint and increasing the crest elevation
- Rock revetment along the beach frontage
- Interlocking concrete wall along the beach frontage
- Stop banking/engineered earth bund on the western side of the settlement

The following information presents a description of the option, benefits and limitations of the option, and high-level indicative costings. Further breakdowns of costings are presented in Appendix C.2.

Indicative costings were also prepared for some of the options (1, 5 and 6) to be extended and additional 250 m north of the existing Amberley Beach Lagoon culvert. The costs of the extension are also presented in Appendix C.2. This extension is not feasible for the other bund options (2, 3, 4) involving various landward relocations as would result in the loss of the road corridor due to the presence of the lagoon wetland.

Option 1: Increasing the elevation of the existing bund alignment by 0.5 m

Figure 3.1: Conceptual sketch of raising the bund elevation in its current footprint by 0.5 m.

Description:

This option would involve increasing the crest level of the existing bund by 0.5 m (to 5.7 m LVD) to increase protection against wave overtopping over the total 1 km length of the bund. The concept design includes re-sloping the front batter of the bund to a 1:3.5 to 1:4 slope, and the back batter to a shallower 1:6 to 1:8 slope. This design is estimated to require around 11,750 m^3 of gravel material to be supplied by ReadyMix. The indicative costing only covers the initial placement of material and does not include maintenance placements to maintain the design level of protection.

Benefits	Limitations
▪ Occupies a small footprint. ▪ Provides good flood protection and some erosion protection. ▪ Crest level increased as adaptation for SLR for at least 30-year timeframe. ▪ The material is locally sourced and therefore reduces the cost. ▪ Designed to withstand overtopping events, so limited back scour. ▪ Can be easily repaired or ‘topped up’ by maintenance injections of additional gravel. ▪ Any erosion damage adds material to the foreshore and down drift beaches, acting as a renourishment. ▪ It does not impede on the existing pedestrian access to and along the beach. ▪ It has a natural appearance. ▪ Meets the requirements of Policy 26 of the NZCPS. ▪ If required, can be deconstructed/removed more easily than hard engineering protection options.	▪ In its current position, recent work by the University of Canterbury showed that the bund was located too close to the swash zone for storm wave energy to be absorbed before running up the beach and overtopping. Therefore, enhancing the bund in its current alignment may not be as effective for providing inundation protection as relocating to a more landward position. ▪ There is likely to be some narrowing of the beach in front of the bund if the beach cannot retreat through the bund to the land behind. ▪ Will be exposed to greater wave attack and increasingly rapid sediment losses over time, hence will be likely to require more frequent maintenance injections than in the past. Therefore, it is a shorter timeframe before it becomes unsustainable. ▪ Any water overtopping the structure needs to be contained by a secondary bund.

Indicative costings:	
Total Cost	$292,000
Total Budget (15% Professional Services & 15% Contingency)	$380,000 ($380/ linear metre)

Option 1: Increasing the elevation of the existing bund alignment by 0.5 m	
Additional total budget for 250 m extension north of Amberley Beach Lagoon culvert	$300,000

Option 2: Relocation of the bund 5m landward and increasing the crest elevation

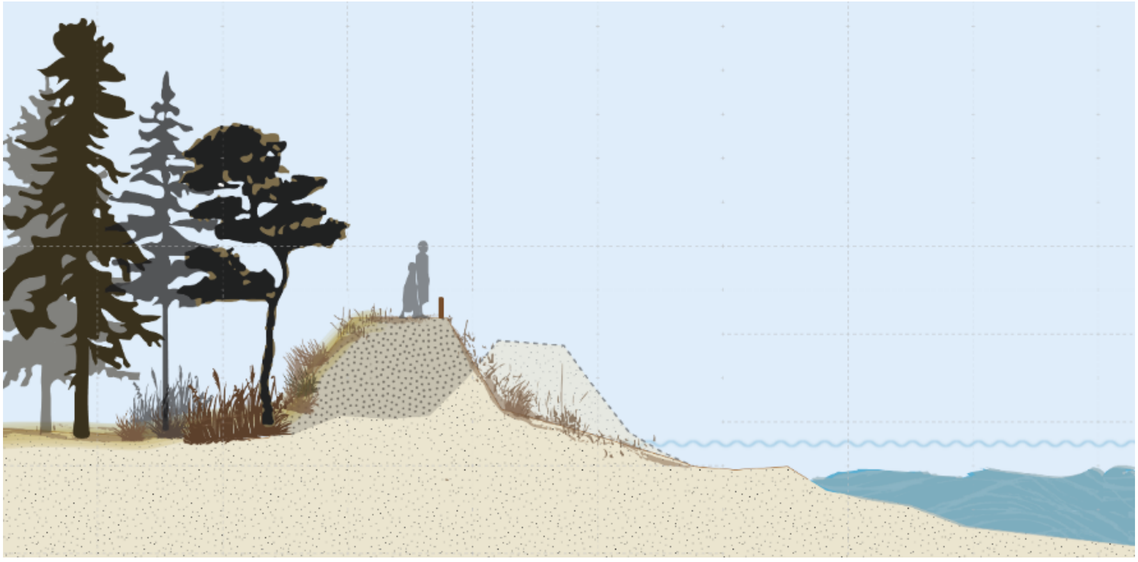

Figure 3.2: Conceptual sketch of total landward relocation of existing bund.

Description:

In this option, the total bund would be relocated in full approximately 5 m landward from its current footprint. The crest of the bund would be increased by +0.5m to be 5.7m LVD to provide a greater level of inundation protection in storm events, and to deal with SLR over the next 30 years. The front batter of bund would have a steeper 1:3.5 to 1:4 slope than at present, with the back batter being a shallower 1:6 to 1:8 slope. This option would be applied along the whole 1 km frontage in front of the settlement. It would require the relocation of an estimated 19,600 m^3 of gravel in the existing bund and an estimated 11,750 m^3 of additional gravel material (supplied by Ready Mix Christchurch). The indicative costing only covers the initial relocation and placement of material and does not include maintenance placements to maintain the design level of protection.

Benefits	Limitations
▪ Crest level increased for SLR in at least a 30-year timeframe. ▪ Will create (in the short term) an increased beach width, greater wave dissipation, therefore, most likely to be more effective at providing inundation protection that current position. ▪ Greater wave dissipation over increased foreshore width, therefore likely to require less maintenance top ups than Option 1. ▪ Material can be locally sourced and therefore reduces the cost. ▪ Can be easily repaired or 'topped up' by maintenance injections of additional gravel if there are any breaches or failures. ▪ Any erosion damage adds material to the foreshore and down drift beaches, acting as a renourishment. ▪ Does not impede existing access to and along the beach. ▪ It has a natural appearance. ▪ It can be deconstructed/removed more easily than hard engineering protection options. ▪ Meets the requirements of Policy 26 of the NZCPS, therefore likely to be less contested consent path than hard engineering protection options.	▪ Occupies a new footprint in the backshore which is currently occupied by the carpark and plantation. This will require tree removal and loss of some carpark area. ▪ Progressively will become exposed to greater wave attack and increasingly rapid sediment losses, hence likely to require more frequent maintenance injections over time. ▪ Any water overtopping the structure needs to be contained by a secondary bund. ▪ Any northern extension would also require rock protection around the Amberley Beach Lagoon culvert, and would likely overlap with the existing road access on Golf Links Road. ▪ Weakness of tie-in at northern end to existing Golf Links Road.
Indicative costings:	
Total Cost	$595,000

Option 2: Relocation of the bund 5m landward and increasing the crest elevation	
Total Budget (15% Professional Services & 15% Contingency)	$774,000 ($770 / linear metre)

Option 3: Extending the bund crest landward by 5 m and increasing the crest elevation

Figure 3.3: Conceptual sketch of the landward extension of the bund crest and increase in crest elevation.

Description:

This option involves the increase of crest elevation by 0.5 m (to 5.7 m LVD), and landward extension of the bund crest by 5 m. The area between the extension and the existing bund crest would be infilled to form an over widened crest along the total 1 km length. This would require an additional 24,500 m^3 of material supplied by ReadyMix Christchurch. As with the other bund options, the front batter of the bund would be re-sloped to be 1:3.5 to 1:4; and the backslope would be re-sloped to be 1:6 to 1:8 slope. The indicative costing only covers the initial placement of material and does not include maintenance placements to maintain the design level of protection.

Benefits	Limitations
▪ Over widened bund crest provides greatest erosion protection and allows for some erosion/regrading of the front slope. There would be a reduced likelihood of maintenance in initial time frame. ▪ Material slowly lost from the front of the bund goes into the beach system as renourishment material. ▪ Crest level increased as adaptation for SLR over at least 30-year timeframe. ▪ Material can be locally sourced, reducing the cost. ▪ Can be easily repaired or 'topped up' by maintenance injections of additional gravel if there are any breaches or failures. ▪ Does not impede existing pedestrian access to and along the beach, with widened path along the bund crest initially improving recreational opportunities (e.g. cycle way). ▪ It has a natural appearance. ▪ Can be deconstructed/removed more easily than hard engineering protection options. ▪ Meets the requirements of Policy 26 of the NZCPS, therefore likely to be less contested consent path.	▪ Occupies a new footprint in the backshore which is currently occupied by the carpark and plantation. Would require tree removal and loss of some carpark area. ▪ Progressively will still be exposed to greater wave attack and increasingly rapid sediment losses, hence likely to require more frequent maintenance injections over time. ▪ Any water overtopping the structure needs to be contained by secondary bund. ▪ Any northern extension of the re-aligned bund would further comprise road access along Golf Links Road, as the bund footprint would overlap with the road footprint. ▪ Any northern extension would also require rock protection around the lagoon culverts. ▪ Weakness of tie-in at northern end to existing Golf Links Road.

Indicative costings:	
Total Cost	$664,000
Total Budget (15% Professional Services & 15% Contingency)	$863,000

Option 4: Progressive relocation of the bund over a 25 m landward footprint and increasing crest elevation

Figure 3.4: Conceptual sketch of the progressive relocation of the bund structure over a 10-30 year period, with the darker grey showing the bund footprint at the end of the consent period, 25 m landward of the existing bund structure.

Description:

This option involves the progressive relocation landward over a 25 m footprint and increasing the crest elevation by 0.5 m (to 5.7 m LVD). Landward relocation would happen incrementally on an as-required basis in association with bund maintenance (approximately every 5 years), where material would be added to the back of the bund footprint, as opposed to maintaining the front position as is the current practice. This relocation would occur along the total 1 km length. As with the other bund options, the front batter of the bund would be re-sloped to be 1:3.5 to 1:4; and the backslope would be re-sloped to be 1:6 to 1:8 slope. The indicative costing only covers the initial placement of material to the back of the bund (estimated 19,400 m^3) and does not include subsequent relocations to maintain the design level of protection.

Benefits	Limitations
▪ Progressive landward relocation of bund crest by adding material to back of structure reduces maintenance volumes, maintains integrity, and increases longevity of the bund. ▪ Material slowly lost from the front of the bund feeds into the beach system as renourishment. ▪ Crest level increased as adaptation for SLR for at least 30-year timeframe. ▪ Material can be locally sourced and reduces the cost. ▪ Can be easily repaired or 'topped up' by maintenance injections of additional gravel to the back of the bund if there are any breaches or failures. ▪ Does not impede existing pedestrian access to and along the beach, with a path along the bund crest. ▪ Has a more natural appearance than hard engineering options. ▪ Can be deconstructed/removed more easily than hard engineering protection options. ▪ Meets the requirements of Policy 26 of the NZCPS and is therefore likely to be less contested consent path than for other hard engineering protection options.	▪ Will progressively be exposed to greater wave attack and increasingly rapid sediment losses, hence likely to require more frequent maintenance injections over time. ▪ Occupies a new footprint in the backshore which is currently occupied by the carpark and plantation. This would require tree removal and loss of some carpark area. ▪ Any water overtopping the structure needs to be contained by secondary bund. ▪ Northern section of bund footprint would be located on the current Golf Links Road, therefore compromising this access to the Golf Club. ▪ Any northern extension of the re-aligned bund (north of the Amberley Beach Lagoon culvert) would totally compromise road access along Golf Links Road. ▪ Any northern extension would also require hard engineering protection around the lagoon culverts. ▪ Weakness of tie-in at northern end to existing Golf Links Road.

Indicative costings:

Option 4: Progressive relocation of the bund over a 25 m landward footprint and increasing crest elevation	
Total Cost	$543,000
Total Budget (15% Professional Services & 15% Contingency)	$705,000

Option 5: Rock Revetment

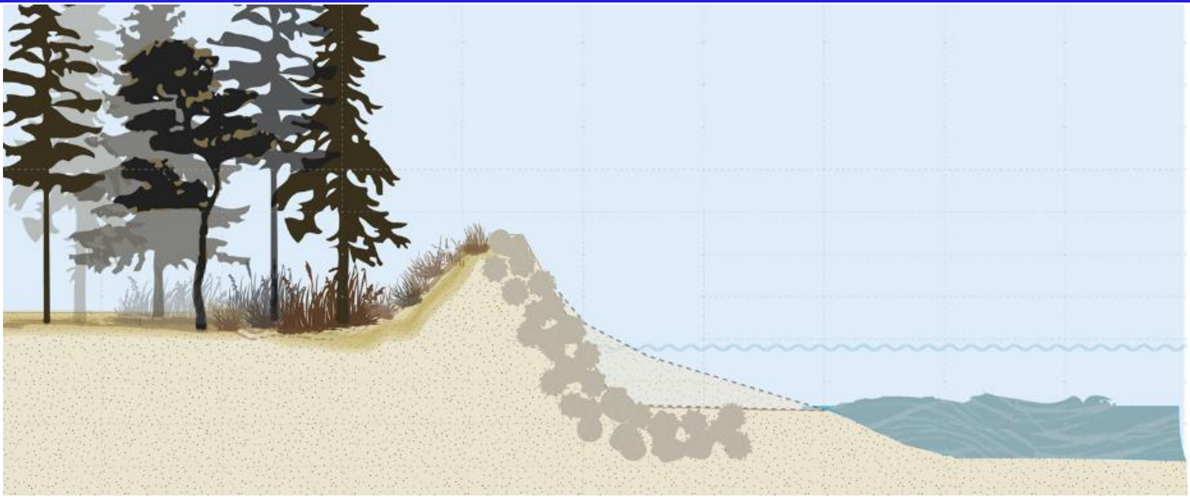

Figure 3.5: Conceptual sketch of the rock revetment structure along the existing bund alignment.

Description:

An armoured sloping rock revetment which aligns along the existing bund. The armoured rock would have a underlayer of filter rock and geotextile to replace the front of the existing bund. The armoured rock size would be Dn50 = 1 m, with a slope and toe depth designed to withstand storm wave climate and beach scour, and have a design life of 50 years. The crest level would be increased from current 5.2m (LVD) to 5.5 m to account for SLR over next 30 years. Existing bund and beach material excavated from the beach for construction would be returned to the profile as additional protection following construction The southern extent of the rock revetment is to tie into the existing natural shoreline south of the Amberley Beach settlement, and the northern extent to tie into the existing shoreline protection at the northern lagoon mouth culvert.

Benefits	Limitations
▪ Replacement of front half of existing bund enhances the lifetime of protection. ▪ Can be designed or adapted for longer-term protection with future sea level rise. ▪ Longshore flexibility of alignment to fit existing bund alignment. ▪ High durability, particularly if use high density rock types, therefore limited maintenance requirements, particularly in the initial life of the structure. ▪ When required, relatively easy maintenance by adding additional armour rocks to crest or front face. ▪ Voids between armour rock and irregular front face dissipates wave energy, reducing wave run-up and resulting in less crest height required to prevent over topping compared to vertical walls.	▪ Needs suitable rock availability (size and material), which will drive up the cost if suitable rock source is located considerable distance from Amberley Beach. ▪ Larger footprint than bund or vertical seawalls. ▪ Need for site works and disturbance of the beach to ensure the structure is well founded against toe scour. ▪ Requires good tie in at the ends of structure to reduce end effects erosion. ▪ Could suffer long-term permanent beach losses from in front of the seawall, potentially reducing beach recreational value (e.g. ability to walk along beach at all tides). ▪ Difficult transition from this type of structure other protection options in the future. ▪ Difficulty in providing access over revetment to the beach ▪ Would result in an unnatural look in the Amberley Beach coastal environment, which may not meet the requirements of Policy 13 of the NZCPS. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS (discourage hard protection structures), so likely to be a more difficult consenting path than bund options.

Indicative costings:	
Total Cost	$17,306,000
Total Budget (15% Professional Services & 15% Contingency)	$22,500,000 ($22,385 / linear metre)

Option 5: Rock Revetment	
Additional total budget for 250 m extension north of Amberley Beach Lagoon culvert	$5,345,000

Option 6: Interlocking concrete wall

Figure 3.6: Conceptual sketch of the interlocking concrete wall option along existing bund alignment.

Description:

A solid near vertical barrier constructed by interlocking concrete blocks. These blocks would be placed along the existing bund alignment, with the tiered blocks using the existing bund for support. The structure would be similar to the Westlock Ltd Design, and prices have been sourced from Westlock directly. The approximate lifetime of the structure would be 50+ years with limited maintenance, with the crest level of the structure being 0.5 m above the existing crest level.

Benefits	Limitations
▪ This option occupies a relatively small footprint compared to rock revetment. ▪ Has good durability, would require limited maintenance over 50+ years. ▪ Can be easily designed or adapted for longer-term protection with future sea level rise by adding blocks. ▪ Irregular shape variations in the front face breaks up wave run-up onto structure reducing overtopping potential and reflection of energy back onto the foreshore, therefore could also reduce beach losses in front of the wall. ▪ Flat top and width of the interlocking wall could allow for pedestrian access along the top of the structure.	▪ Need for relatively large-scale site works and disturbance of the beach to ensure the structure is well founded against toe scour. ▪ Requires good tie in at the ends of structure to reduce end effects erosion, which is common issue with seawalls on open coasts. ▪ Still likely to suffer some beach losses from in front of the seawall, potentially reducing beach recreational value (e.g. ability to walk along beach at all tides), but this will be at slower rates than for straight vertical seawalls. ▪ Difficult transition from this type of structure into other protection options in the future. ▪ Initial construction costs will be relatively expensive compared to soft engineering options. ▪ Difficulty in providing access over seawalls - limited to fixed locations of steps which will add cost. ▪ Would result in an unnatural look in the Amberley Beach coastal environment, which may not meet the requirements of Policy 13 of the NZCPS. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS (discourage hard protection structures), so likely to be a more difficult consenting path than bund options.

Indicative costings:	
Total Cost	$6,832,000
Total Budget (15% Professional Services & 15% Contingency)	$8,882,000 ($8,445/linear metre)
Additional total budget for 250 m extension north of Amberley Beach Lagoon culvert	$2,075,000

Option 7: Engineered earth bund on the western side of the settlement

Description:

A medium to long term protection option involving the construction of an engineered earth bund around the western edge of the settlement which allows water to flood the low lying land to the west, but not enter the properties in the settlement. The bund would be an average of 1.2 m high, and tie into higher areas of the road. For conceptual design, the bund was designed to be an average of 1.2 m high to withstand the modelled multi flood options for a 2% AEP event with 0.5 m SLR + freeboard; or 0.5% AEP with 0.5 m SLR no freeboard. The design included tying into roads through either speed bumps or higher ground, and the inclusion of flood gates.

Benefits	Limitations
▪ An effective way of controlling water flow into the settlement in an extreme event. ▪ Can be designed or adapted for longer term protection with future sea level rise by increasing its elevation. ▪ Can be grassed over and planted to look more natural.	▪ May need to adhere to standards for dams, and therefore would be difficult to consent, and likely to become more expensive. ▪ Could cause some backing up of the lagoon water levels, which may divert the flooding further upstream. ▪ Would still result for some overland flooding to occur up to the settlement boundary, depending on existing land uses. ▪ If the bund is overtopped water can be trapped with no pathway back to the sea/river, therefore may require the installation of pump stations to drain this water ▪ Unknown what the interaction between groundwater rise and the bund would be, which may also require the installation of pump stations to deal with flooding within the settlement. ▪ Could trap flooding from rainfall sources within the settlement, which may again require the installation of pump stations to drain this water.

Option 7: Engineered earth bund on the western side of the settlement Indicative costings:	
Total Cost	$611,000
Total Budget (15% Professional Services & 15% Contingency)	$794,000 ($570/ linear metre)

4. Motunau

The Motunau settlement sits on top of a 25-40 m near vertical loess capped mudstone cliff, which has a 60 to 145 m wide inter-tidal mudstone shore platform at the base. A smaller portion of the properties reside on the lower river terrace of the Motunau River. The Motunau River mouth is at the eastern end of the cliff face, which has a dredged entrance channel across the shore platform between river mouth training walls on both banks. West of the cliff face is Sandy Bay, a composite beach backed by a stable vegetated mudstone cliff. Erosion of the cliff face has been the primary concern of the community and is caused through the combination of two processes: (1) wetting and drying processes of the mudstone cliff as a 'top-down' erosion process, and (2) from cliff toe erosion and cliff oversteepening as a 'bottom-up' erosion process.

The long-list to short-listing process is documented in Appendix B (11-14). Short listed options considered reducing the rate of cliff erosion in front of the settlement through both erosion processes, as that was the highest priority for the settlement. Engineered options chosen for further investigation at Motunau consisted of:

- Armoured rock trip wall (30 year and 50 year design life)
- Cast concrete block wave trip wall (30 year and 50 year design life)
- Interlocking block wave trip wall
- Re-directing stormwater flows on the cliff top to the north

The proposed alignment of the first three trip wall options is shown in Figure 4.1.

Figure 4.1: Proposed alignment of trip wall options.

This information on the short-listed options was presented to the Motunau Community in July 2022, where they signalled several further options they would like investigated, including:

- Sand renourishment at Sandy Bay
- Reinstatement of rocks on the rockshore platforms
- Rock toe at Sandy Bay.

Information on these additional options was included in the Coastal Adaptation Explorer Tool and presented to the community in a workshop alongside other shortlisted engineering, planning and retreat options in October 2022. At this workshop the community put forward an additional option of extending the existing true right river mouth training wall seaward to provide a greater level of protection to the cliff from southeast wave conditions. Information on this option has been included in this report for completeness.

The following information presents a description of the option, benefits and limitations of the option, and high-level indicative costings. Further breakdowns of costings are presented in Appendix C.3

Option 1 - Armoured rock trip wall

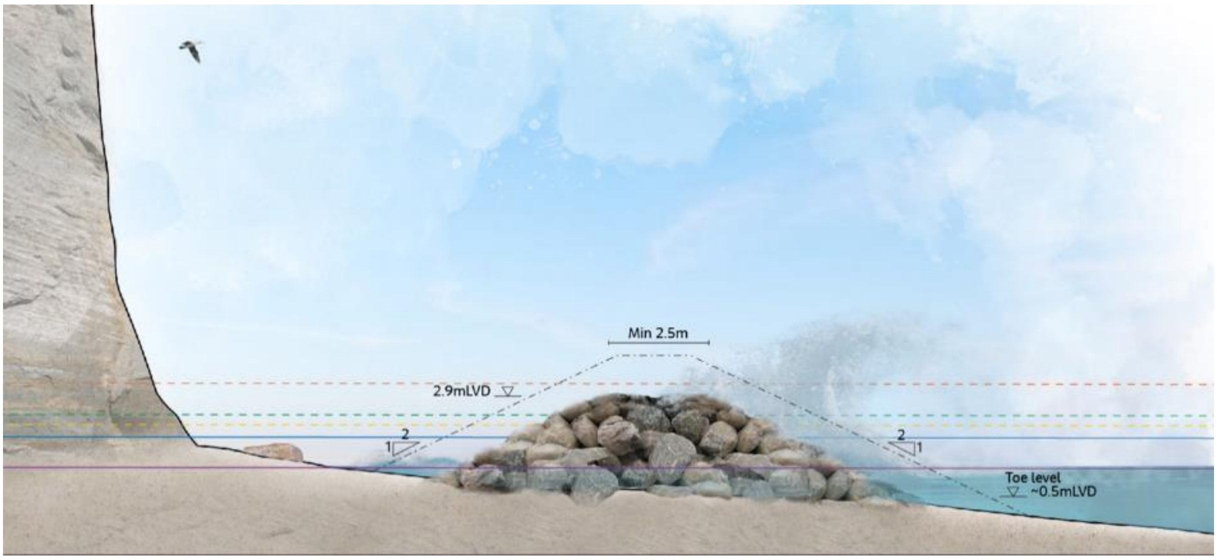

Figure 4.2: Conceptual design of wave trip wall (30 year design) at the toe of the cliff against water levels in an extreme storm event.

Description:

Placed armour rock trip wall designed to protect the cliff toe from a 1% AEP storm water level and wave impacts with SLR over a 30-year period (present day +0.3 m). The wall would be placed10-20 m from the cliff toe with base width to be sufficient to have additional rock added to the top of the structure in the future to protect against SLR over 50-year period (present day +0.5 m). Being set seaward of the cliff toe allows for material that is eroding from the top of the cliff to be trapped and provide additional protection to the toe.

Benefits	Limitations
▪ Dual protection of reducing wave attack and trapping cliff fall material ▪ Limited site preparation required - can incorporate existing shore platform rocks within wall footprint. ▪ Easy transition to other protection options and can be adapted to deal with SLR. ▪ Longshore flexibility to fit to shoreline shape. ▪ Easy maintenance. ▪ Good durability. ▪ Looks more natural in a coastal environment than other hard engineering options. ▪ The flow of water through and over the wall maintains inter-tidal ecological habitat values behind the wall.	▪ Suitable rock availability is required (material and size). Rocks need to be large enough to withstand displacement in storm wave events. ▪ Could be a large footprint to achieve base requirements for adaptation to future sea level rise. ▪ Generally, less expensive than sea walls, but depends on rock availability and distance to source. ▪ Does not deal with erosion processes occurring at the top of the cliff (e.g. wetting and drying), so erosion will continue but at a slower rate. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS (discourage hard protection structures).

Indicative costings: 30 year design	
Total Cost	$3,261,000
Total Budget (15% Professional Services & 15% Contingency)	$4,240,000 ($9,400/linear m)

Indicative costings: 50 year design	
Total Cost	$3,989,000
Total Budget (15% Professional Services & 15% Contingency)	$5,186,000 ($11,500/ linear m)

Option 2: Wave trip wall – cast concrete blocks

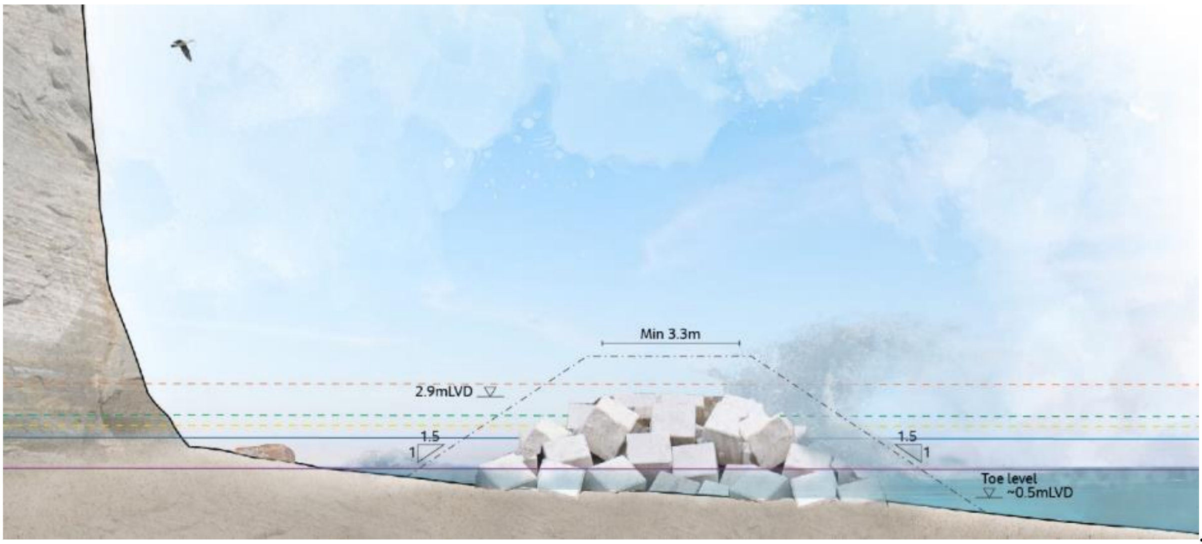

Figure 4.3: Conceptual diagram of a wave trip wall constructed from cast concrete blocks for a 30-year design life at the toe of the cliff.

Description:

Irregularly placed precast concrete block units to form a wave trip wall designed to protect the cliff toe from a 1% AEP storm water level and wave impacts with SLR over a 30-year period (present day +0.3 m). The wall would be placed 10-20 m seaward of the cliff toe, with the base width will be sufficient to have additional concrete units added to the top in the future to protect against SLR over 50-year period (present day +0.5 m). Being set seaward of the cliff toe would allow for material that is eroding from the top of the cliff to be trapped and provide additional protection to the toe.

Benefits	Limitations
▪ Dual protection of reducing wave attack and trapping cliff fall material to provide additional protection. ▪ Limited site preparation – structure can incorporate existing shore platform rocks within the footprint. ▪ Longshore flexibility to fit to shoreline shape. ▪ Easy to maintain. ▪ Good durability. ▪ Can be designed or adapted for longer-term protection with future sea level rise. ▪ The flow of water through and over the wall maintains inter-tidal ecological habitat values behind the wall.	▪ Precast block units would have to be transported long distances to site, increasing the price of the option. ▪ Could require a large footprint to achieve base requirements for adaptation to future sea level rise. ▪ Does not look natural in the coastal environment. ▪ Does not deal with erosion processes occurring from the top of the cliff, so erosion will continue but at a slower rate. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS (discourage hard protection structures).

Indicative costings: 30 year design	
Total Cost	$2,795,500
Total Budget (15% Professional Services & 15% Contingency)	$3,634,000 ($8,100/linear m)

Indicative costings: 50 year design	
Total Cost	$3,365,000
Total Budget (15% Professional Services & 15% Contingency)	$4,369,000 ($9,710/linear m)

Option 3: Wave trip wall Interlocking concrete blocks

Figure 4.4: (Left) front view of Westlock interlocking concrete wall design; (right) top of interlocking concrete wall structure. Photos sourced from: Westlock Ltd.

Description:

Interlocking concrete wall structure to form a wave trip wall designed to protect the cliff toe from a 1% AEP storm water level and wave impacts with SLR over a 30-year period (present day +0.3 m). The wall would be placed 10-20 m seaward of the cliff toe, with the option to add additional concrete units to the top in the future to protect against SLR over 50-year period (present day +0.5 m). Being set seaward of the cliff toe would allow for material that is eroding from the top of the cliff to be trapped and provide additional protection to the toe. The wall would need to be 3 blocks high and require being founded 800 mm into a trench excavated across the rock shore platform, resulting in a 2 m high wave trip wall. This will provide protection for close to a 30 year period but would require an additional row of blocks for 50 years protection.

Benefits	Limitations
▪ Dual protection of reducing wave attack and trapping cliff fall material to provide additional protection. ▪ Easy maintenance. ▪ Good durability. ▪ Can be designed or adapted for longer-term protection with future sea level rise by adding additional blocks.	▪ Transport distance for the cast block units could increase the cost of the structure. ▪ Does not look natural in the coastal environment. ▪ Would require disturbance of the foreshore and significant site preparation to excavate the placement trench across the platform, and therefore may be difficult to get consent. ▪ Does not deal with erosion processes occurring from the top of the cliff, so erosion will continue but at a slower rate. ▪ Nonporous nature of wall would totally exclude water behind the wall, effecting inter-tidal habitat values. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS (discourage hard protection structures).
Indicative costings: Option 3a - 30 year design	
Total Cost	$1,929,000
Total Budget (15% Professional Services & 15% Contingency)	$2,508,000($5,600/linear m)
Indicative costings: Option 3b - 50 year design	
Total Cost	$2,440,000

Option 3: Wave trip wall Interlocking concrete blocks	
Total Budget (15% Professional Services & 15% Contingency)	$3,172,000 ($7000/linear m)

Option 4: Reinstating Rocks

Figure 4.5: Approximate shore platform area where rocks would be sporadically placed at a spacing of 1 every 4 m^2 to break up wave energy approaching the cliff toe.

Description:

Sporadic placement of rocks across the shore platform area to break up wave energy as it approaches the toe of the cliff. This option was suggested by the community to restore the shore platform to how it was prior to the rocks being removed in the early 1970's for use in various other locations, which is perceived to have increased erosion of the cliff toe. To perform a protection function, the placed rocks will need to be in the order of Dn = 0.7 m in size, and placed at a spacing of around one rock per 4 m^2. This would equate to approximately 8,500 rocks being required. The rocks would not be founded into the shore platform.

Benefits	Limitations
▪ Limited site preparation required - can incorporate existing shore platform rocks. ▪ Longshore flexibility to fit to shoreline shape. ▪ Easy maintenance. ▪ Looks more natural in a coastal environment than other hard engineering options. ▪ The flow of water around the rocks maintains inter-tidal ecological habitat values across the shore platform.	▪ Suitable rock availability is required (material and size). Rocks need to be large enough to withstand displacement in storm wave events. ▪ When rocks are not tied together in a structure, likely to move around more frequently. ▪ Does not deal with erosion processes occurring at the top of the cliff (e.g. wetting and drying), so erosion will continue but at a slower rate. ▪ Does not offer the dual protection of reducing wave attack and trapping cliff fall material ▪ Not an engineered design, no guarantee of success. ▪ Likely to be ecological impacts of placing the rock on the platform, and therefore may be difficult to gain consent.

Indicative costings:	
Total Cost	$1,623,000
Total Budget (15% Professional Services & 15% Contingency)	$2,110,000

Option 5: Re-direct stormwater flows to the north

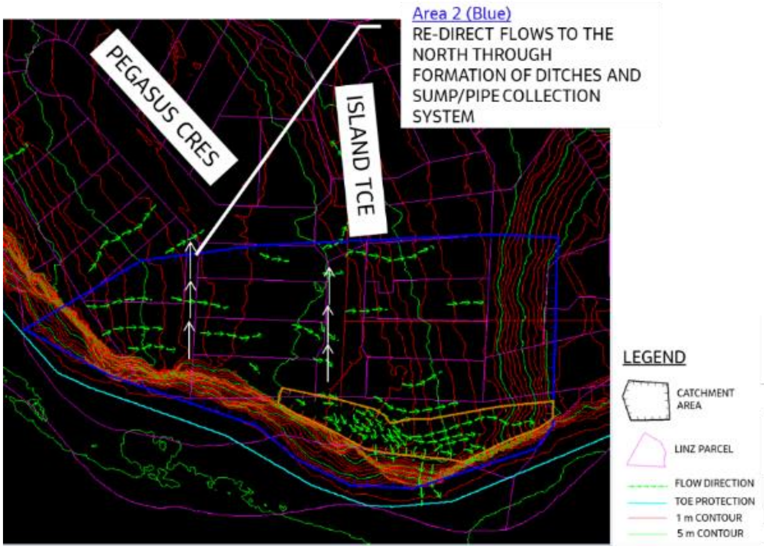

Figure 4.6: Figure showing the natural flow direction of water across the settlement across the topography (green arrows), and where that water could be directed to (white arrows)

Description:

Involves re-directing stormwater flows to the north away from the cliff edge into a roadside collection ditch combined with a sump and piped into the existing stormwater collection system at the intersection of Island Terrace and Pegasus Crescent, and within the road reserve at Island Terrace. This could divert flows north in two locations: through the private property of 3 Pegasus Crescent (with property owner consent), and within the road reserve at Island Terrace. The purpose of this option is to reduce surface flow across the top of the cliff increasing the saturation (and subsequent drying and flaking) of the cliff, reducing the erosion of the cliff from top-down processes.

Benefits	Limitations
▪ A cost-effective exercise to reduce cliff erosion occurring by processes acting on the top of the cliff causing erosion. ▪ Added benefit of redirecting stormwater away from properties. ▪ No effect on the CMA or any natural aesthetic changes to the coast. ▪ Likely to be an easier consenting pathway due to works being out of the CMA.	▪ Cost and extent of works reliant on outcomes of current investigation. ▪ Does not solve erosion of cliff from processes occurring at the base of the cliff, so erosion will continue but at a slower rate.

Indicative costings:	
Total Cost	$70,200
Total Budget (15% Professional Services & 15% Contingency)	$91,000

Option 6: Sandy Bay Upper Beach Renourishment (Sand)

Figure 4.7: (left) Sand renourishment; (right) approximate area of Sandy Bay where sand would be placed.

Description:

Involves the placement of introduced sand at the back of the Sandy Bay beach to re-establish the back beach slopes and elevation to its 1991 conditions. This would involve the placement of approximately 1800 m^3 of sand, which would need to be carted to site and placed. The purpose of the renourishment is to slow the retreat and oversteepening of the toe of the vegetated cliff at Sandy Bay.

Benefits	Limitations
▪ Natural beach is a good aesthetic outcome. ▪ Maintains good access to the beach. ▪ No adverse effects on coastal processes. ▪ Erosion of nourishment placement adds sand to the beach profile ▪ Doesn't cut off any future adaptation pathways that could involve putting in more permanent engineered structures along the toe of the cliff at Sandy Bay. ▪ Meets the requirements of Policy 26 of the NZCPS.	▪ High energy environment will likely move the sediment away from the nourishment area fairly quickly, and therefore unlikely to be a long term solution unless end containments barriers (e.g. small artificial headlands) are included along with regular maintenance top ups and replacements. ▪ Sediment movement processes around the Sandy Bay and cliff area are fairly unknown, so success of the option is relatively unknown. ▪ There would be an on-going whole of life costs involved in continuously providing increasing maintenance requirements. ▪ Need readily available source of renourishment material near to the site. ▪ There is likely to be significant (and unaccounted for) costs in getting the material to Sandy Bay. There could be significant disturbance of the shore platform to cart the material to Sandy Bay, or permissions and significant cost would be required to form a more direct haulage road (e.g. along pedestrian access at the end of Sandy Bay Road).

Indicative costings:	
Total Cost	$255,000 per renourishment
Total Budget (15% Professional Services & 15% Contingency)	$331,500 per renourishment

Option 7: Sandy Bay Rock Toe

Figure 4.8: Approximate spatial location of the placement of rock along the toe of the cliff at Sandy Bay.

Description:

Involves the placement of large rocks (Dn = 0.7 m) at the base of the cliff toe along 750 m of Sandy Bay to stabilise the cliff toe. This would involve placing a line of rocks along the base of the cliff. In the future it could be adapted to deal with SLR by adding more rocks to increase the elevation of the structure in the future.

Benefits	Limitations
▪ Longshore flexibility to fit to shoreline shape. ▪ Good durability, particularly if use high density rock types. ▪ Easy maintenance in adding additional rocks as required. ▪ Can be designed or adapted for longer-term protection with future sea level rise. ▪ Will look reasonably natural in this environment.	▪ Needs suitable rock availability in order to get right size and durability, and cost will be dependent on rock availability and distance to source. ▪ Need for site works and disturbance of the beach to ensure the structure is well founded against toe scour. Also need for area for on-site rock stock piling. ▪ There is likely to be significant (and unaccounted for) costs in getting the rocks to Sandy Bay. There could be significant disturbance of the shore platform to cart the material to Sandy Bay, or permissions and significant cost would be required to form a more direct haulage road (e.g. along pedestrian access at the end of Sandy Bay Road). ▪ Still likely to suffer beach losses from in front of the rocks, potentially pedestrian access more difficult and reducing beach recreational value (e.g. ability to walk along beach at all tides). ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS, so likely to be a more difficult consent path than for soft engineering and natural enhancement options, unless can satisfy the requirements of Policy 27(c) (only practical means).

Indicative costings:	
Total Cost	$1,428,000
Total Budget (15% Professional Services & 15% Contingency)	$1,856,000

Option 8: Upgrade of river mouth training wall

Figure 4.9: Extent of existing river mouth training wall providing some protection to the cliff from south-east waves, the predominant wave direction effecting the cliff coming from the south east as shown in the wave rose on the top left.

Description:

An upgrade of the existing training in a south-west direction. The wall would likely be constructed of concrete blocks (1m x 1m), and would need to be approximately 3 blocks high (based on calculated design levels for wave trip wall). It is assumed that the concrete blocks would be placed on top of the existing rock shore platform. This would reinstate protection of the cliff from wave approaching from the south-east, that occurs 32% of the time (based on 1993-2019 hindcast). It is our understanding that the consent holder, the Fishermans' Association are undertaking the works for this upgrade at no cost to the community. It is also our understanding that discussions with ECan have indicated up to an additional 20 m of blocks could be placed under the existing consent, which is included in the solid black training wall line in Figure 4.9.

Benefits

- Would increase the protection to the cliff from south easterly waves.
- It is an extension of an existing structure, so may be less barriers to consenting as opposed to consenting a new structure.
- Potential to act as a groyne and trap sediment in the lee, however further information about sediment transport processes would be required to give more certainty on this.
- Fishermans' Association currently hold consent for an upgrade of the existing structure with donated concrete blocks.
- Additional benefit of providing protection to properties around the cliff edge, as well as an enhanced training wall for recreational purposes.

Limitations

- Limited information on rockshore platform extent and elevations around the rivermouth, and therefore the proposed alignment may not be feasible.
- Does not provide protection from south or south-west waves, which residents suggested caused more damage to the cliff. Hindcast data suggests <1% of waves greater than 3m come from SW, and 20% come from a southerly direction.
- Although it is an extension of the existing structure, will require additional elevation and footprint across the foreshore, which will have implications on the landscape.
- Does not address any erosion issues at Sandy Bay.

Indicative costings:

Total Cost: It is our understanding that the cost of upgrade and potential 20 m extension will be covered by the Fishermans' Association (current consent holder); and therefore we have not developed costs for this option.

Option 9: Extension of river mouth training wall

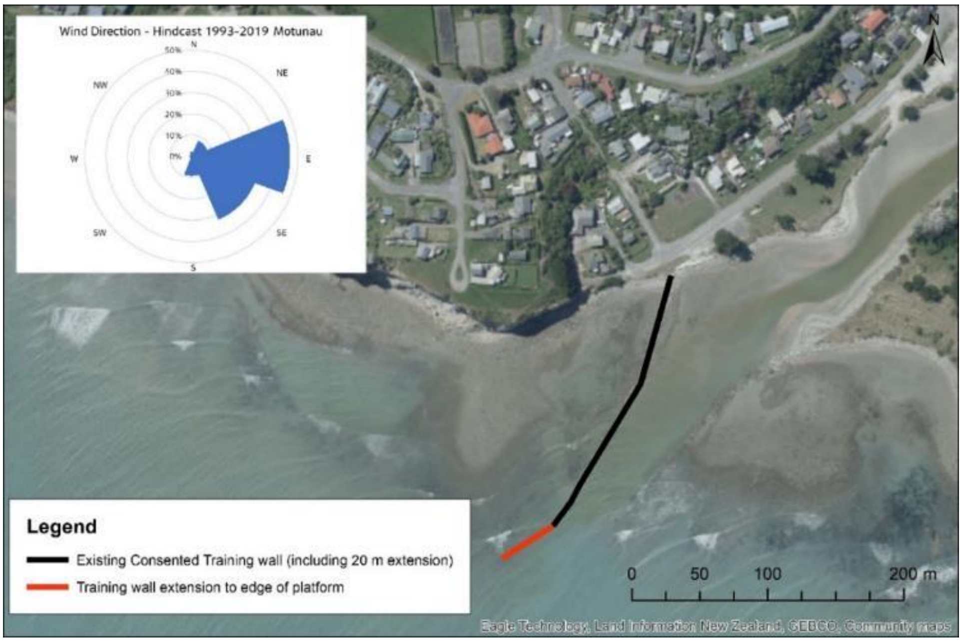

Figure 4.10 Approximate alignment of extended river mouth training wall providing protection to the cliff from south-east waves.

Description:

An extension of the existing consented wall by an additional 45 m in a south-west direction to provide further protection to the cliff. The wall would be constructed of concrete blocks (1m x 1m) similar to those used in the reconsented wall design in Option 8. The wall would need to be approximately 3 blocks high (based on calculated design levels for wave trip wall). It is assumed that the concrete blocks would be placed on top of the existing rock shore platform. The extension of the river mouth training wall would provide protection for the cliff from wave approaching from the south-east, as shown to be the predominant wave direction that could affect the cliff in Figure 4.10. Costings for this option are based on a reduced length of the concrete block wave trip wall (Option 2).

Benefits	Limitations
▪ Would increase the protection to the cliff from south easterly waves. ▪ It is an extension of an existing structure, so may be less barriers to consenting as opposed to consenting a new structure. ▪ Potential to act as a groyne and trap sediment in the lee, however further information about sediment transport processes would be required to give more certainty on this. ▪ Fishermans' Association currently hold consent for an upgrade of the existing structure with donated concrete blocks. ▪ Additional benefit of providing protection to properties around the cliff edge, as well as an enhanced training wall for recreational purposes.	▪ Limited information on rockshore platform extent and elevations around the river mouth, and therefore its proposed alignment may not be feasible. ▪ Does not provide protection from south-west waves, which residents suggest cause damage to the cliff. ▪ Although it is an extension of the existing structure, will require additional elevation and footprint across the foreshore, which will have implications on the landscape, and will also require a new consent. ▪ Does not address any erosion issues at Sandy Bay. ▪ Likely to be ecological impacts of placing the rock on the platform, and therefore may be difficult to gain consent for an extension beyond what has already been consented.

Indicative costings:

Total Cost	$556,000
Total Budget (15% Professional Services & 15% Contingency)	$723,000

5. Gore Bay

The Gore Bay settlement is located on a narrow raised coastal plain of Holocene sand and gravel bounded by the gravel beach system to the east and tall alluvial and loess cliffs of tertiary sediment to the west that mark the likely shoreline position 6500 years ago. The beach at Gore Bay varies between composite and a Mixed Sand and Gravel (MSG) beach state with a sandy lower foreshore (particularly at south end) and a flat gradient across the surf zone. There have been several periods where erosion was of such concern to the residents of Gore Bay that action was taken including following 1934-1940, 1951-1952, and 1975-1978. As a result, groynes and seawalls have been undertaken along much of the Gore Bay coastline, as well as ad hoc measures seaward of individual properties at various times. At the southern end of the settlement, the beach is backed by a low scarp or former beach ridge up to 7-8 m AMSL providing some protection from coastal inundation. At the north end of the settlement, along Gore Bay Road the coastal plain is lower as it dips towards Buxton Creek and the Jed River that discharges to the beach at the northern limit of the settlement in a combined channel, although neither have a permanent mouth to the ocean.

The long-list to short-listing process is documented in Appendix A (p3-7). Short listed engineered protection options at Gore Bay were skewed towards mitigating the erosion hazard, which could affect the access to the settlement for all residents over the next 30 years. These short-listed options included:

- Behind beach vegetation enhancement at the northern end of the settlement
- Beach scraping on the seaward side of the beach total settlement
- Rock revetment along Cathedral Road and Gore Bay Bay Road
- Interlocking concrete seawall along Cathedral Road and Gore Bay Bay Road

The following information presents a description of the option, benefits and limitations of the option, and high-level indicative costings. Further breakdowns of costings are presented in Appendix C.4

This information was presented to community members in a facilitated workshop on 1st October 2022, where community members could explore the effectiveness, costs, and multi-criteria analysis criteria of each option. At this workshop the potential options of offshore breakwaters and reinstatement of a timber pole seawall in the beach system were discussed as potential options the community would like explored.

Offshore breakwaters were considered in the original long listing process (Appendix A, page 26), but was not considered to be appropriate at Gore Bay due to the extremely high cost for the volume of material and the size of the individual units required to withstand the high energy wave environment. It would be an extremely high cost to the community, and little certainty on how successful it would be.

Timber poles were placed at the back of the Gore Bay beach system to form a seawall barrier to deal with the coastal erosion issues in the mid to late 1970's. This option was not investigated in the long list to short listing process, and were not included in the Coastal Adaptation Explorer for Gore Bay. However, they were perceived to have been a successful option by members of the community at the workshop and should be further explored. For completeness, further information on this option is included in this report below.

Option 1: Vegetation enhancement at the northern settlement

Figure 5.1: (Left) Red area showing indicative area of planting; (right) Existing backshore planting environment at Gore Bay

Description:

A short-term mitigation option that involves planting and bank stability to reduce storm erosion at the northern end of the settlement for around 500 m from the tennis courts to Buxton Creek (e.g Gore Bay Road, Gore Bay Reserve and Buxton campground). This approach could also involve controlling pedestrian and vehicle access through designated walkways to reduce damage to plantings. Vegetation enhancement is not recommended along Cathedral Road at the southern end of the settlement as it is understood that community attempts to enhance back beach planting along this section has not been successful due to a lack of beach width and elevation resulting in plantings frequently being washed out by wave run-up. Costing includes initial planting and access fencing, plus first[t] year maintenance/replacement planting.

Benefits	Limitations
▪ Natural beach is a good aesthetic outcome. ▪ While restricting access across the total dune area, there will still be designated pedestrian and vehicle access at locations. ▪ Low-cost option. ▪ Opportunity for community engagement. ▪ Will increase the longevity of the backshore against erosion. ▪ Meets the requirements of Policy 26 of the NZCPS. ▪ Limited/no consenting required. ▪ If labour is provided by the community, cost will reduce significantly (approx. 50%). ▪ Can be staged across multiple years to assist with budgeting.	▪ Not likely to be an effective long-term (100 years) solution against sea level rise, particularly on narrow beaches with limited capacity for retreat. ▪ Not effective option to address erosion issues at Cathedral Road due to width and elevation limitations.

Indicative costings:	
Option 1a: No community labour	
Total Cost	$51,000
Total Budget (2.5% Professional Services & 15% Contingency)	$60,000
Option 1b: With community labour	
Total Cost	$28,000
Total Budget (2.5% Professional Services & 15% Contingency)	$33,000

Option 2: Beach scraping along the whole settlement frontage

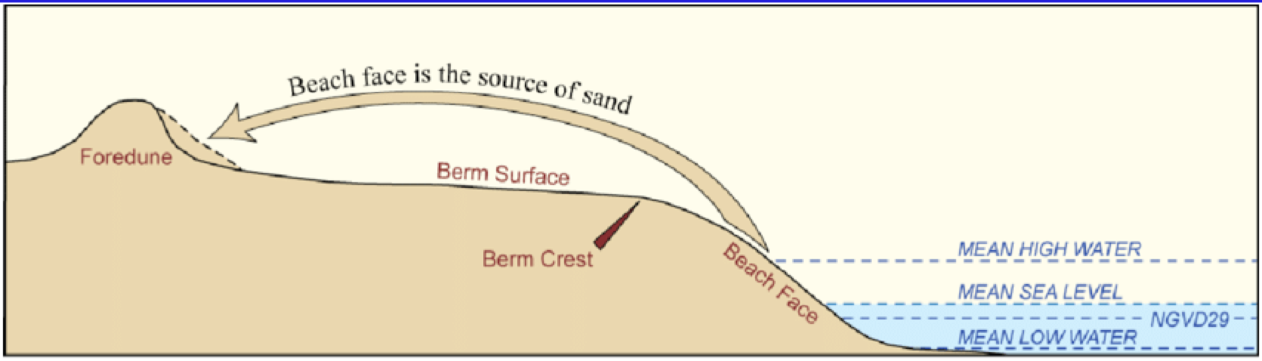

Figure 5.2: Example of beach scraping processes from Silveira and Psuty (2008).

Description:

A medium to long-term soft engineering approach which could be applied at Gore Bay. This option involves periodic beach scraping by bulldozer, relocating beach sediment from the foreshore to the crest to build up the crest elevation and volume to provide better protection during storms. Scraping slows shoreline erosion by relocating sediment within the active beach system to the dune area. This option could be applied to whole beach frontage of the settlement (1.3 km) on an as required basis post storm events and a surplus of sediment on the foreshore. Costing is for a one-off scraping, and it is likely it would need to be undertaken every 5-10 years to maintain the desired dune volume and elevation.

Benefits	Limitations
▪ Increases protection against inundation by building up the crest level. ▪ Low cost as it does not involve placement of additional material from an external source. ▪ Can be a reactive response to events, and target site specific areas. ▪ Natural beach is a good aesthetic outcome that meets the community objectives. ▪ Can maintain existing access to the beach. ▪ Meets the requirements of Policy 26 of the NZCPS.	▪ Short-term response which only has temporary adjustment of highly dynamic beach profile, so requires multiple interventions over time. ▪ Doesn't address any long-term sediment deficits or sea level rise impacts, and therefore might not be an appropriate long-term solution. ▪ May have impacts on beach ecology (e.g. species living in the beach that are distributed by scraping activity, or feeding off those species (oyster catchers); buried vegetation on the crest). ▪ Community believed that the beach was too dynamic up to the backshore for this to be a viable option.

Indicative costings:	
Total Cost	$79,000
Total Budget (15% Professional Services & 15% Contingency)	$103,000

Option 3: Rock revetment along Cathedral Road and Gore Bay Road.

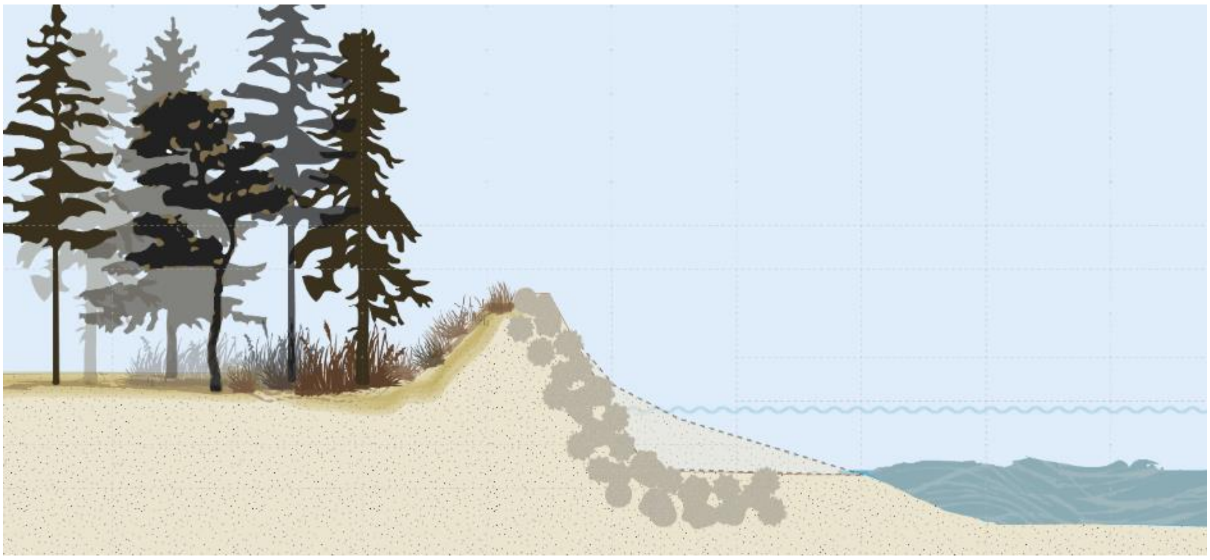

Figure 5.3: Conceptual sketch of a rock revetment structure at Gore Bay.

Description:

A medium-long term protection option of placed armoured rock to a designed slope and crest elevation to (1) protect the elevated bank edge from erosion at its toe, and (2) reduce wave overtopping with SLR over a 50-year period (present day + 0.5 m SLR). The revetment would be sloped against the current bank, with sufficient rock size, core material and area of land behind to adapt the structure to increase the structure to protect for higher levels of SLR if required. The revetment is restricted to protecting key access roads for 400 m along Cathedral Road and for 300 m along Gore Bay Road.

Benefits	Limitations
▪ Voids between armour rock and irregular front face dissipates wave energy, reducing wave run-up and resulting in less crest height required to prevent over topping compared to vertical walls. ▪ The design can be placed over existing raised banks, scarps and bunds to enhance protection. ▪ Longshore flexibility to fit to shoreline shape. ▪ Good durability, particularly if use high density rock types. ▪ Easy maintenance in adding additional rocks as required. ▪ Can be designed or adapted for longer-term protection with future sea level rise.	▪ Needs suitable rock type and size availability to ensure success. Cost will be dependent on availability of rock and the distance from Gore Bay. ▪ Larger footprint than vertical seawalls. ▪ Need for site works and disturbance of the beach to ensure the structure is well founded against toe scour. ▪ Will require an area for on-site rock stock piling. ▪ Requires good tie in at the ends of structure to reduce end effects erosion, which is common issue with seawalls/revetments on open coasts. ▪ Still likely to suffer beach losses from in front of the seawall, potentially reducing beach recreational value (e.g. ability to walk along beach at all tides), but this will be at slower rates than for vertical seawall options. ▪ Difficult transition from this type of structure other protection options in the future. ▪ Difficulty in providing access over the revetment, designated accessways will add to the cost. ▪ Does not look natural in the coastal environment. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS, so likely to be a more difficult consent path than for soft engineering.

Indicative costings:	
Total Cost	$9,371,000
Total Budget (15% Professional Services & 15% Contingency)	$12,182,000

Option 4: Interlocking concrete seawall along Cathedral Road and Gore Bay Road

Figure 5.4: Conceptual diagram of the placement of the interlocking concrete wall.

Description:

This is a medium-long term protection option of interlocking concrete units forming a vertical or tiered seawall up to a designed elevation which could (1) protect the elevated bank edge from erosion at its toe, and (2) reduce wave overtopping with SLR over a 50-year period (present day + 0.5m SLR). These blocks would be placed along the existing bank at the southern end, and smaller bund alignment at the northern end. The structure would be similar to the Westlock Ltd Design, and prices have been sourced from Westlock directly. The approximate lifetime of the structure would be 50+ years with limited maintenance, with the crest level of the structure being 0.5 m above the existing crest level. It would be constructed along the 400 m along Cathedral Road and/or 300 m along Gore Bay Road to protect access to the communities.

Benefits	Limitations
▪ Occupies a relatively small footprint compared to rock revetment. ▪ Has good durability, would only require limited maintenance over 50+ years. ▪ Can be designed to be adapted for longer-term protection with future sea level rise. ▪ Irregular shape variations in the front face breaks up wave run-up onto the structure, reducing overtopping potential and reflection of energy back onto the foreshore, therefore also reducing the potential beach losses in front of the wall. ▪ Flat top and width of the interlocking wall allow for pedestrian access along the structure.	▪ Need for relatively large-scale site works and disturbance of the beach to ensure the structure is well founded against toe scour. ▪ Requires good tie in at the ends of structure to reduce end effects erosion. ▪ Still likely to suffer some beach losses from in front of the seawall, potentially reducing beach recreational value (e.g. ability to walk along beach at all tides), but this will be at slower rates than for straight vertical seawalls. ▪ Difficult transition from this type of structure other protection options in the future. ▪ Initial construction costs will be relatively expensive compared to soft engineering options. ▪ Difficulty in providing access over seawalls - limited to fixed locations of steps. ▪ Would result in an 'unnatural look" in the Gore Bay coastal environment, which may not meet the requirements of Policy 13 of the NZCPS. ▪ Does not meet the requirements of Policy 25 (e) of the NZCPS (discourage hard protection structures), so likely to be a more difficult consenting path than bund options.

Indicative costings:	
Total Cost	$4,618,500
Total Budget (15% Professional Services & 15% Contingency)	$6,004,000

Option 5: Timber poles (terminal wall) along whole settlement frontage (1.2 km)

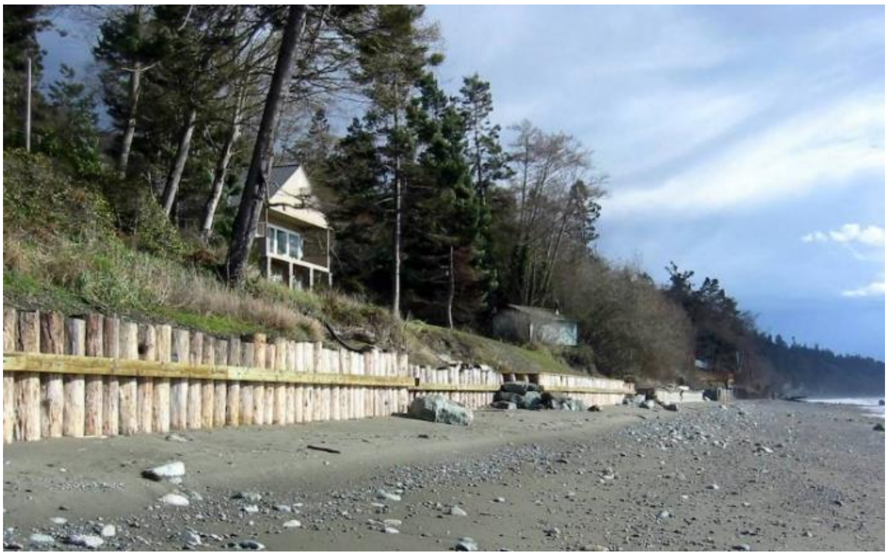

Figure 5.5: (left) example of timber wall in Puget Sound, USA.

Description:

A backstop timber wall at the landward limit of where it is acceptable for the beach to retreat to at some time in the future. Normal beach processes would continue in the intervening years, with the wall slowly becoming exposed until it was acting as a fully functional protection structure holding the shoreline in place. Over time the timber breaks down in the beach system. This option was put forward by the community for further investigation as they thought it could be suitable based on previous experience in implementing this option.

Benefits	Limitations
▪ Provides some certainty in future proofing erosion, particularly where dynamic short-term shoreline movements are a major issue. ▪ Is buried behind the existing beach, so does not become visible until erosion becomes a significant issue and exposes the wall. ▪ Can act as a trigger to show when erosion is becoming a significant issue requiring other planning actions (e.g. managed retreat). ▪ Beach could erode up to the structure then reform in the front again as it recovers. ▪ Provides a final line of defence for erosion, generally to protect assets which are located at the back of the beach. ▪ Would allow for access to the beach whilst it is still buried. ▪ Potentially easier consenting path depending on earthworks rules, but still need to be consistent with NZCPS as still in the coastal environment.	▪ Does not address inundation hazards. ▪ Significant land disturbance required in burying the wall, which may disturb existing infrastructure (roads, pipework etc). ▪ Requires good tie in at the ends of structure to reduce future end effects erosion. ▪ Still likely to suffer beach losses from in front of the seawall once it was exposed. ▪ Timber is not as robust as rock or concrete, and is likely to break down quicker in a coastal environment. ▪ Does not meet the requirements of Policy 25(e) of the NZCPS.

Indicative costings:	
Total Cost	$3,587,000
Total Budget (15% Professional Services & 15% Contingency)	$4,663,000

Appendix A. Gore Bay, Amberley Beach, Leithfield Beach: Long List Adaption Options Assessment (Technical Memorandum, February 2022)

Appendix B. Motunau: Long List Options Assessment (Technical Memorandum, August 2021)

Appendix C. Indicative Costings Breakdown[3]

C.1 Leithfield Beach

Option 1a Dune management and planting over total frontage (without community labour)

Item	Cost
Mobilisation, demoblisation, site ammenities, office etc.	$10,000
Planting - Includes plants, supply	$45,500
Labour (100% non-community)	$43,500
Board walks - Includes supply of materials and construction	$45,000
Signage and fencing for access	$20,000
Contractors Overhead, Margin and Risk (20%)	$31,000
First year maintenance (assumed 25% of plants are unsuccessful)	$22,000
Total Cost	**$217,000**
Total Budget (2.5% Professional Services & 15% Contingency)	$255,000

Option 1b Dune management and planting over total frontage (with community labour)

Item	Cost
Planting - Includes plants, supply	$46,000
Board walks - Includes supply of materials and construction	$45,000
Signage and fencing for access	$20,000
Misc for community tools (e.g. wheel barrows, gloves, shovels)	$5,000
First year maintenance (assumed 25% of plants are unsuccessful)	$11,500
Total Cost	**$127,000**
Total Budget (2.5% Professional Services & 15% Contingency)	$149,000

[3] Professional Service fees include: consenting (2.5%), design (5%), construction monitoring (5%), and project management (2.5%). For dune management planting options, this is reduced to 2.5% for project management as consenting, design, and construction monitoring is not applicable.

Option 2: Beach Scraping

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$10,000
Excavator use and hire (assume 30 days)	$24,000
Labour cost (assume 2 workers per day)	$42,000
Contractors Overhead, Margin and Risk	$13,000
Total Cost	**$89,000**
Total Budget **(15% Professional Services & 15% Contingency)**	$116,000

Option 3: Stop banking/earth bund on the west side of the settlement

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$10,000
Tree Removal	$12,000
Site prep - Top Soil prepping, stock piling	$155,000
Material and Placement	$165,500
Reinstate topsoil on new bund	$64,500
Tie into dune on South end	$10,000
Tie into Kings Road	$20,000
Flap gate for Leithfield drain outfall	$10,000
Float gate for Leithfield drain	$15,000
Flapped pipe/culvert at southern end	$10,000
Contractors Overhead, Margin and Risk (20%)	$92,500
Maintenance (10%)	$16,500
Total Cost	**$581,000**
Total Budget **(15% Professional Services & 15% Contingency)**	$755,000

Option 4: Extended Earth bund along north and south end of the settlement

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$10,000
Tree Removal	$12,000
Site prep - Top Soil prepping, stock piling	$98,000
Material and Placement	$104,500
Reinstate topsoil on new bund	$41,000
Tie into dune on South end	$10,000
Flap gate for Leithfield drain outfall	$10,000
Float gate for Leithfield drain	$15,000
Flapped pipe/culvert	$20,000
Contractors Overhead, Margin and Risk (20%)	$62,000
Maintenance (10%)	$10,500
Total Cost	**$393,000**
Total Budget **(15% Professional Services & 15% Contingency)**	$511,000

C.2 Amberley Beach

Option 1: Increasing the elevation of the existing bund alignment by 0.5 m (1km length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Material and placement (Estimate 11,750 m^3)	$235,000
Overheads (on-site & off-site) (Estimate 20%)	$47,000
Total Cost	**$292,000**
Total Budget (15% Professional Services & 15% Contingency)	**$380,000**
Additional total budget for 250 m extension north of Amberley Beach Lagoon culvert	**$300,000**

Option 2: Relocation of the bund 5m landward and increasing the crest elevation (1 km length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Tree Removal	$36,000
Current bund material relocation and reconstruction (Estimate 19,600 m^3)	$196,000
Extra Material and placement (Estimate 11,750 m^3)	$235,000
Tie into North end at Golf links Road	$20,000
Overheads (on-site & off-site) (Estimate 20%)	$98,000
Total Cost	**$595,000**
Total Budget (15% Professional Services & 15% Contingency)	**$774,000**

Option 3: Extending the bund crest landward 5m and increasing the crest elevation (1 km length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Tree Removal	$36,000
Material and placement (Estimate 24,500 m^3)	$489,000
Tie into North end at Golf links Road	$20,000
Overheads (on-site & off-site)	$109,000
Total Cost	**$664,000**
Total Budget (15% Professional Services & 15% Contingency)	**$863,000**

Option 4: Progressive relocation of the bund over a 25 m landward footprint and increasing crest elevation (1 km length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Tree Removal	$36,000
Material and placement (Estimate 19,400 m^3)	$388,000
Tie into North end at Golf links Road	$20,000
Overheads (on-site & off-site)	$89,000
Total Cost	**$543,000**
Total Budget (15% Professional Services & 15% Contingency)	**$705,000**

Option 5: Rock Revetment along the beach frontage (1km length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Site prep - removal and replacement of current bund and beach material (Estimate 51,000 m^3)	$436,000
Temporary stockpile beach material	$50,000
Supply and cartage of rock armour to site (Estimate 55,400 m^3 from Oxford)	$8,316,000
Supply and cartage of underlayer to site (Estimate 25,800 m^3)	$2,578,000
Temporary stockpile rock	$100,000
Supply and placement of geotextile layer	$98,000
Placement of rock armour and underlayer	$2,843,000
Tie-in at each end	$20,000
Overheads (on-site & off-site) (Estimate 20%)	$2,883,000
Total cost	**$17,306,000**
Total Budget (15% Professional Services & 15% Contingency)	**$22,500,000**
Additional total budget for 250 m extension north of Amberley Beach Lagoon culvert	**$5,345,000**

Option 6: Interlocking concrete wall along the beach frontage (1km length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Site prep - removal and replacement of current material	Not required
Temporary stockpile Beach material	$50,000
Supply and placement of geotextile layer	$37,000
Transport of blocks - factory to site	$13,000
Temporary stockpile of blocks	$50,000
Supply and installation of concrete block - westlock wall (5 blocks high)	$6,348,000
Tie-in at each end	$20,000
Overheads	Included in cost
Total cost	**$6,832,000**
Total Budget (15% Professional Services & 15% Contingency)	**$8,882,000**
Additional total budget for 250 m extension north of Amberley Beach Lagoon culvert	**$2,075,000**

Option 7: Engineered earth bund on the western side of the settlement

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Tree Removal	$12,000
Site Prep - top soil prepping , stock piling	$121,000
Material and placement (Estimate 9200 m^3)	$138,000
Reinstate topsoil on new bund	$50,000
Tie into golf links road	$20,000
Golf links road speed hump (potential)	$10,000
Tie into Amberley road (Flood gate & raising of road)	$150,000
Overheads (on-offsite) (Estimate 20%)	$100,000
Total cost	**$611,000**
Total Budget (15% Professional Services & 15% Contingency)	**$794,000**

C.3 Motunau Beach

Option 1a Armored Rock Trip Wall (30 year design)

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Trim ground prior to placement (assume 50mm site scrape)	$50,000
Supply and cartage of rock to site	$1,920,600
Temporary Stockpile	$50,000
Place rock armour	$448,200
Tie-in at each end (North and South)	$40,000
On-site and off-site overheads	$652,200
Total Cost	$3,261,000
Total Budget **(15% Professional Services & 15% Contingency)**	$4,240,000

Option 1b Armored Rock Trip wall (50-year design)

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Trim ground prior to placement (assume 50mm site scrape)	$50,000
Supply and cartage of rock to site	$2,372,300
Temporary Stockpile	$75,000
Place rock armour	$553,500
Tie-in at each end (North and South)	$40,000
On-site and off-site overheads	$797,700
Total Cost	$3,989,000
Total Budget **(15% Professional Services & 15% Contingency)**	$5,186,000

Option 2a Wave Trip Wall – Cast Concrete Blocks (30-year design)

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Trim ground prior to placement (assume 50mm site scrape)	$50,000
Supply and cartage of rock to site	$1,697,000
Temporary Stockpile	$50,000
Place rock armour	$299,500
Tie-in at each end (North and South)	$40,000
On-site and off-site overheads	$559,000
Total Cost	$2,795,500
Total Budget (15% Professional Services & 15% Contingency)	$3,634,000

Option 2b Wave Trip Wall – Cast Concrete Blocks (50-year design)

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Trim ground prior to placement (assume 50mm site scrape)	$50,000
Supply and cartage of rock to site	$2,060,000
Temporary Stockpile	$75,000
Place rock armour	$363,500
Tie-in at each end (North and South)	$40,000
On-site and off-site overheads	$672,000
Total Cost	$3,365,000
Total Budget (15% Professional Services & 15% Contingency)	$4,369,000

Option 3a Wave trip wall – Interlocking concrete blocks 30 year design

Item	Cost
Cost supplied by Westlock Concrete Solutions Limited, includes: - Blocks - Instillation Cost excludes transportation	$1,929,000
Total Cost	$1,929,000
Total Budget **(15% Professional Services & 15% Contingency)**	$2,508,000

Option 3b Wave trip wall – Interlocking concrete blocks 50 year design

Item	Cost
Cost supplied by Westlock Concrete Solutions Limited, includes: - Blocks - Instillation Cost excludes transportation	$2,440,000
Total Cost	$2,440,000
Total Budget **(15% Professional Services & 15% Contingency)**	$3,172,000

Option 4 Reinstating rocks

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Supply and cartage of rock to site	$935,700
Temporary Stockpile	$50,000
Place rock armour	$218,300
On-site and off-site overheads	$326,000
Total Cost	$1,623,000
Total Budget **(15% Professional Services & 15% Contingency)**	$2,110,000

Option 5 Re-direct stormwater flows to the north

Item	Cost
Site Establishment	$5,000
Setout	$4,000
Excavation, installation, seal	$21,000
MH's	$6,000
Tie-in to existing sites	$3,000
Haulage to remote area	$23,400
P&G	$7,800
Total Cost	$70,200
Total Budget (15% Professional Services & 15% Contingency)	$91,000

Option 6 Sandy Bay Upper Beach Renourishment (Sand)

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Supply	$95,000
Cartage	$50,000
Placement	$10,000
Total Cost	$255,000 per renourishment
Total Budget (15% Professional Services & 15% Contingency)	$331,500 per renourishment

Option 7 Sandy Bay Rock Toe

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Supply and cartage of rock to site	$843,500
Temporary Stockpile	$50,000
Place rock armour	$197,000
On-site and off-site overheads	$258,000
Total Cost	$1,428,000
Total Budget (15% Professional Services & 15% Contingency)	$1,856,000

Option 9 Extension of river mouth training wall

Item	Cost
Mobilisation, demoblisation, site amenities, office etc.	$100,000
Trim ground prior to placement (assume 50mm site scrape)	$50,000
Supply and cartage of rock to site	$170,000
Temporary Stockpile	$75,000
Place rock armour	$30,000
Tie-in to existing training wall	$20,000
On-site and off-site overheads	$111,000
Total Cost	$556,000
Total Budget **(15% Professional Services & 15% Contingency)**	$723,000

C.4 Gore Bay

Option 1a Vegetation enhancement and management – no community labour

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Planting - Includes plants, supply (assumed 2000 m^2 area; plant spacing of 1.1 m^2)	$10,000
Fencing to limit access around	$10,000
Labour (e.g. no community labour)	**$10,000**
Overheads (on-site & off-site) (Estimate 20%)	$6,000
First year maintenance (25% due to plants dying in first 12 months)	$5,000
Total Cost	**$51,000**
Total Budget (2.5% Professional Services & 15% Contingency)	$60,000

Option 1b - Vegetation enhancement and management – with community labour

Item	Cost
Planting - Includes plants, supply	$10,000
Fencing to limit access	$10,000
Misc for community planting (e.g. wheelbarrows, tools)	$5,000
First year maintenance (25% due to plants dying in first 12 months)	$3,000
Total Cost	**$28,000**
Total Budget (2.5% Professional Services & 15% Contingency)	$33,000

Option 2: Beach Scraping along the whole settlement frontage

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Excavator use and hire (approx. 26 days)	$21,000
Labour cost (2 workers/day)	$36,500
Contractors Overhead, Margin, Risk (20%)	$11,500
Total Cost	**$79,000**
Total Budget (15% Professional Services & 15% Contingency)	$103,000

Option 3: Rock Revetment along Cathedral Road (400 m length) and Gore Bay Road (300m length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Site prep - removal and replacement of current material	$183,500
Temporary stockpile Beach material	$50,000
Supply and cartage of Rock Armour to site	$3,970,000
Supply and cartage of Underlayer to site	$2,144,500
Temporary Stockpile Rock	$100,000
Supply and placement of geotextile layer	$33,000
Placement of rock armour and underlayer	$1,280,000
Tie-in at each end	$40,000
Overheads (on-site & off-site 20%)	$1,560,000
Total Cost	**$9,371,000**
Total Budget **(15% Professional Services & 15% Contingency)**	$12,182,000

Option 4: Interlocking Concrete wall along Cathedral Road (400 m length) and Gore Bay Road (300m length)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Temporary stockpile Beach material	$50,000
Supply and placement of geotextile layer	$25,000
Transport of blocks - factory to site (5% of supply cost)	$211,500
Temporary stockpile of blocks	$50,000
Supply and installation of concrete blocks (5 blocks high)	$4,232,000
Tie-in at each end	$40,000
Total Cost	**$4,618,500**
Total Budget **(15% Professional Services & 15% Contingency)**	$6,004,000

Option 5: Timber Poles (terminal wall) along whole settlement frontage (1.2 km)

Item	Cost
Mobilisation, demobilisation, site amenities, office etc.	$10,000
Site prep - removal and replacement of current material	$6,000
Supply and pile H6 posts in relatively easy ground	$3,120,000
Whaler post – front beam fastened to intermediate posts	$120,000
Backfill/remediation behind wall	$6,000
Contractors Overhead, Margin and Risk	$325,000
Total Cost	$3,587,000
Total Budget **(15% Professional Services & 15% Contingency)**	$4,663,000