Appendix E

Option Summary Sheets

CH1_B	**Northcove Road Upgrade**
Location(s): Maloneys Beach	
Coastal threat(s) to be addressed: Beach Erosion and Coastal Inundation	
Outcome of CMP Assessment The existing erosion risk to Northcove Road is low and as such only the investigation and design of the Northcove Road upgrade is recommended for action in the CMP. This will allow the implementation of the works to be undertaken as part of a future CMP.	

Option Description:

The Stage 2 Coastal Hazards Assessment determined that Northcove Road was at risk of coastal erosion impacting the road at both the 2017 and 2100 100-year ARI extents (**Figure 1**). While not identified as being within the direct erosion zone currently, the road runs through the zone of reduce foundation capacity and is therefore at risk of being structurally undermined following a large storm event.

Northcove Road and bridge at the western end of Maloneys Beach can also be inundated at both the 20-year and 100-year ARI, with the potential to cause access issues during severe coastal events. This is due to both coastal inundation, and coincident catchment flooding landwards of Northcove Road, and also wave run-up and overtopping of the roadway (**Figure 2**).

Consultation with the Maloney's community during the public exhibition of the Batemans Bay Urban Creeks Flood Study (Rhelm 2020) also saw this issue raised, with community suggesting the road needed to be upgraded, or an alternate route be provided.

Wave overtopping also has the potential to impact a significant length of the road, causing access issues during a coastal storm and potential damage to the road surface, requiring maintenance following a storm event.

To address these risks, road raising of a 100m-120m section of Northcove Road along with a vertical retaining structure with a wave return barrier at its crest has been conceptually designed to protect the public road from erosion and wave damages and to maintain continuous access to Maloneys Beach during severe coastal storms, as shown in **Figure 3**.

Figure 1 Maloneys Beach Erosion Extents

Figure 2 Maloneys Beach Inundation at 20-year ARI

Figure 3 Alignment and extent of Road Raising and retaining structure at Maloneys Beach

The conceptual design of the retaining structure has prioritised the following:

- Ensuring a small footprint so as to minimise the disturbance to the existing beach and dune areas
- Placing the structure outside of the area of direct coastal erosion to remove any influence of the structure on the nature and extent of coastal erosion.

A typical section for the retaining structure is presented in **Figure 4** which includes construction of a vertical wall on the seaward edge of the road alignment. The wall could comprise of reinforced concrete panels (as shown in **Figure 5**) or driven sheet pile (as shown in **Figure 6**) and would require approximately 5m embedment below the desired crest level, which could be reduced if ground anchoring was adopted. Based on current estimates the retaining wall would not be directly exposed to coastal hazards and hence scour protection is not required. The structure crest would be at a level consistent with the existing road surface (+5 to +5.5mAHD at eastern end) and would comprise a wave return barrier of varying height (example shown in **Figure 7**).

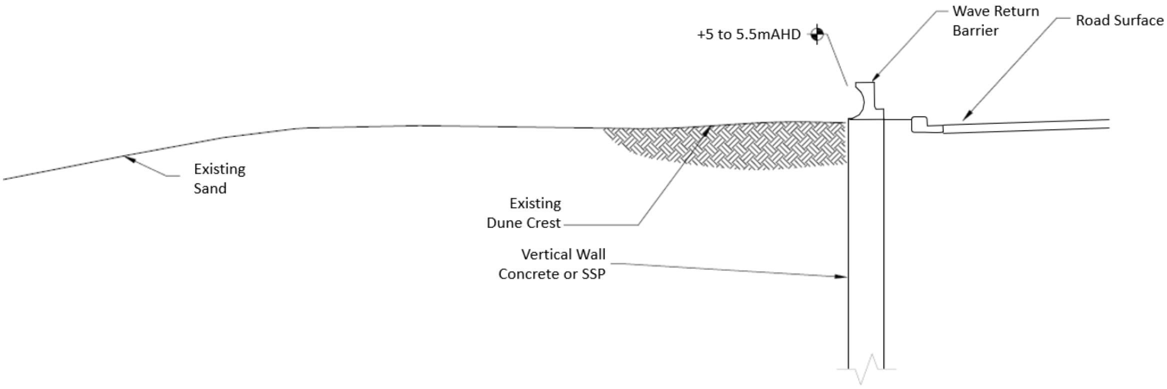


Figure 4 Typical section of a retaining structure with a wave return barrier at the crest

Figure 5 Example of Reinforced concrete wall for stabilisation of a section of the Great Ocean Road, Vic

Figure 6 Example of sheet pile wall with concrete capping beam and anchoring

Figure 7 Example of a concrete wall return barrier

The costed option comprises a sheet pile retaining wall of 5m embedment with a concrete wave return barrier of 1.2m height (Just East of Bridge) reducing in height to the east along the alignment of the wall. The image below provides an indication of the structure form (sheet pile with concrete capping beam), noting that following construction it would buried within the dune and not be at risk of exposure due to coastal erosion from 100year ARI event both now and at 2100.

Road raising could be incorporated into the design to also mitigate inundation associated with catchment flooding, and if undertaken would reduce the required height of the wave return barrier. This design would need to be optimised in consultation with the floodplain risk management program and may include upgrading of the culverts under the bridge.

CMP Assessment:

No detailed design of the retaining structure has been completed, however an assessment of wave runup and overtopping was performed using methods outlined in Eurotop (2018) to test the feasibility of the conceptual design and to ensure adequate protection of the roadway against overtopping, both under present day and future sea level rise scenarios

The following table summarises the results, noting an average overtopping rate of less than 25 L/s/m is targeted to reduce the risk to cars transiting near the crest (Eurotop, 2018).

Mean Overtopping Rates (q) for the 100year ARI coastal storm under sea level rise scenarios just east of the Northcove Road Bridge (road level of 2.8mAHD)

	Present	2050	2065	2100
q (L/s/m)	70	150	200	540

The required crest level of the wave return wall to reduce mean wave overtopping to an acceptable rate (i.e. 25 L/s/m) is presented in the table below.

Required Wave Return wall height (m above road level) to reduce risk to cars for the 100year ARI coastal storm under sea level rise scenarios

	Present	2050	2065	2100
Just East of Bridge (Northcove Road)	1m	1.2m	1.3m	1.7m
Maloneys Drive	0m	0.2m	0.3m	0.7m

Effectiveness and benefits:

- The retaining structure would provide structural support to road following severe storm erosion of Maloneys Beach and enable continued access to Maloneys Beach.
- If the crest level of the retaining structure is of sufficient height, coastal inundation and overtopping will be reduced to a tolerable level for the safe access of cars and will minimise road surface failures due to coastal processes.
- Road raising of Northcove Road would be required to manage the impact of catchment flooding on the road. This should be considered as part of the floodplain risk management process to attract appropriate funding mechanisms.
- The alignment of the road (and proposed wall) does not fall within the direct erosion hazard zone. The function of the proposed wall is to support the road that lies within the zone of reduced foundation capacity. As such, no need for nourishment post event or management of scour is considered in the development of this option.

Timing:

- The current inundation and erosion risk associated with coastal events, does not necessitate the need for immediate action (as shown in the Cost Benefit Assessment below). Therefore, the program of works includes the following:
  - Stage 1: Investigation and Design (Year 2 to 4)
  - Stage 2: Retaining structure (after current CMP timeframe; greater than 10 years unless triggered by a larger than predicted erosion event)
  - Stage 3: Wave return barrier (after current CMP timeframe; greater than 10 years unless triggered by a larger than predicted erosion event)
- A design life of ~50 years could reasonably be applied to the retaining structure and raised roadway, assuming wave overtopping is reduced to tolerable levels.

Cost Benefit Assessment

Costs: As above

Benefits:

This option derives benefits from avoided costs that arise from the closure of Northcove Road when exposed to modelled inundation events. Through coastal inundation modelling it was evident to see that the Northcove Road would be flooded and highly damaged for between 12 to 36 hours under major inundation events. Moreover, under events whereby erosion is predicted to occur on Northcove Road, a four week timeline is implemented. The avoidance of Northcove Road's closure results in the following benefits:

- **Avoided road resurfacing** is a benefit that would occur due to the proposed seawall that will shielding Northcove Road from inundation events. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $143 m^2.
- **Avoided isolation** is a benefit that would occur due to the proposed sea wall's wave return structure. This would prevent costal inundation flooding of Northcove Road and allow for the sustained access for emergency evacuation or the continuation of normative activity by the residents of Maloneys beach (371 people) in an inundation or storm event.
- The cost of emergency access was derived from Batemans Bay hospitalisation rates for Eurobodalla residents and the triage severity of each visit and the cost of damages for which each case if untreated. These inputs were drawn from TfNSW's *Flood Risk Management Measures (2022)* and *flowinfo v 17 (2017).*
- The cost of ordinary activities was derived from the average cost per household per vehicular trip that would normally be undertaken and the cost of isolation (i.e. expenditure on goods and services that is no longer possible). These costs were derived from the averagely weekly spend per household for Eurobodalla and the average daily trips per household. This resulted in an avoided benefit of $40.54 per trip and $157 for each of the 257 households for each day of isolation. Given the uncertainty regarding level of disposable income, a 50% adjustment factor was applied to foregone daily expenditure to represent the cost of isolation.
- Additionally, a costing of $71.43 per person affected by an isolation period is implemented, to account for the cost of potential mental health related therapy and loss of production that occur as a result of prolonged isolation. This costing is derived from Deloite (2016) 'The Economic Cost of Social Impacts of Natural Disasters', and is scaled by a factor of 0.1 to account for the relative severity of possible inundation events. **Avoided road replacement (erosion)** is a benefit that would occur as a result of constructing the proposed seawall, as it will reduce the probability of the road encountering erosion and having to be

reconstructed. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $3,429 per metre of a two-lane, flexible pavement road, where the road length is 205 metres. Additionally, there is an avoided cost of the temporary road which is required in the estimated two week period of road reconstruction. The value of avoiding this cost is derived from the pricing the anticipated 250 metres of metal temporary road sheeting which will allow for continued road access to properties along Northcove Road and access to from Maloneys Drive to Northcove Road. Over a four week period the cost per metre of the temporary road is $269, which totals to $134,500 per erosion event. The analysis assumes a 1% p.a. probability of road replacement within the first ten years, 2% p.a. for the next 30 years, and 3% p.a. subsequently.

Results:

The table below highlights that this option does not have a positive NPV and has a BCR well below 1 indicating that it is not economically feasible to implement at this point in time. This is primarily due to the small number of properties impacted by the isolation. However, this option may proceed based on unquantified benefits, or support from other funding mechanisms.

BCR		**NPV**	
0.75		-$438,864	
Benefit		**Costs**	
Access	$1,106,453	Capital Costs	$1,550,966
Erosion	$168,117	Maintenance Costs	$229,555
Resurfacing	$67,087		

CH1_D and CH1_E	Long Beach Erosion Protection: Low crested revetment to protect Bay Road

Location(s): Long Beach

Coastal threat(s) to be addressed: Beach Erosion and Coastal Inundation

Outcome of CMP Assessment
The Stage 1 (CH1_D) works (250m at eastern end of Long Beach) are recommended for inclusion in the CMP.

Costs:

In total, 530m of rock revetment is identified along the length of the Long Beach foreshore between Long Beach Road and the eastern end of Bay Road. There is an opportunity to stage the construction in two parts, with the first stage (CH1_D) focussing on the 250m length near Fauna Ave extending to the north east, which is at risk of coastal erosion under present conditions.

- CH1_D Phase 1: Investigation and design including environmental assessment for coastal erosion structure: $60,000
- CH1_D Phase 2: Construction of ≈ 250m coastal protection works and beach nourishment: $3,100,000
- CH1_D Phase 3: Maintenance and nourishment of beach: 1% of capital costs over life of structure
- CH1_E (Not recommended within the 10 year delivery of this CMP) Future Capital Cost in approximately 2050) : $3,500,000 (280m)

Option Description:

Construct a low crested revetment to protect Bay Road from coastal erosion impacts under present day and future sea level rise scenarios. The intention of this option is to preserve the foundation of Bay Road under severe coastal storm events.

CMP Assessment:

Deterministic calculation of coastal erosion extents based on storm demand identified that approximately 250m of Bay Road was at risk of erosion as a result of a 100year ARI storm event under present day sea levels. Under future projected sea level rise, the full length of Bay Road adjacent to the Long Beach foreshore (~530m in length) is at risk of erosion.

The erosion risk is shown in **Figure 1**. Further details are provided in the Stage 2 CMP Report (Rhelm, 2022).

Whilst coastal inundation does not pose a risk to the area under current sea levels, Bay Road and approximately 15 properties become increasing at risk of inundation from a 100 Year ARI storm as sea level rise.

The 100yr coastal inundation risk is shown in **Figure 2**. Further details are provided in the Stage 2 CMP Report (Rhelm, 2022).

Figure 1 Long Beach Erosion Risk

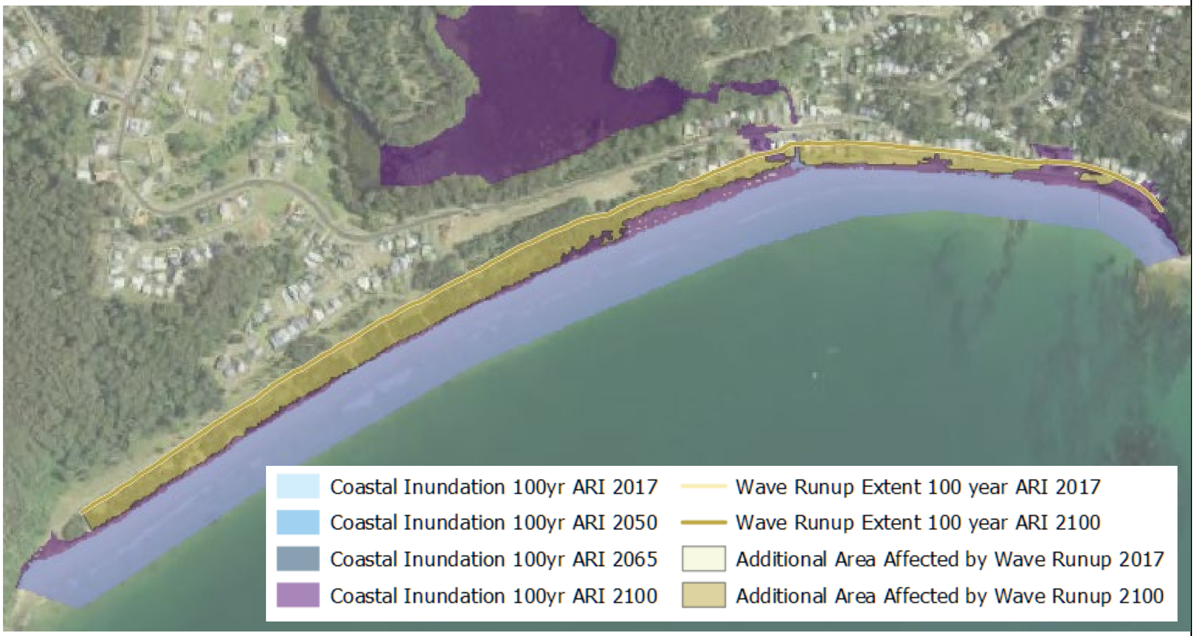


Figure 2 100yr ARI Coastal Inundation Risk

To address this risk a low crested rock revetment has been conceptually designed to protect the public road from being impacted by coastal erosion. The conceptual design has prioritised the following:

- Minimising the crest level to not disturb the visual amenity and beach access currently experienced at Long Beach.
- Considering community working group preference regarding construction material and design.
- Minimising the footprint of the rock revetment so as to minimise the disturbance to the existing beach and dune areas.

A typical section for the revetment design is presented in **Figure 3** which includes construction of a rock structure on the seaward edge of the road alignment that would remain buried below the dune system. The structure crest would be at a level consistent with the existing road surface (+2.8 to +3.2mAHD) with a concrete footpath running along its length between the structure crest and the road. The design for the 250m length would accommodate the existing culvert outlets (located in front Fauna Ave and near cul-de-sac). Beach access points over the structure will also need to be considered including the number provided and design. It is proposed that design refinement of CH1-D including construction material in Figure 3, alignment in Figure 4 and other considerations I.e. seawall edge effects, stormwater outlets, beach access, nourishment requirements be refined during investigation and design (Phase 1). This would allow opportunity for additional consideration of community preference and environmental assessment outcomes to be considered including whether the Nolfolk Pines are to remain, if they do remain would placement of geotextile bags be more suited in front of the pines to balance beach amenity and use considerations.

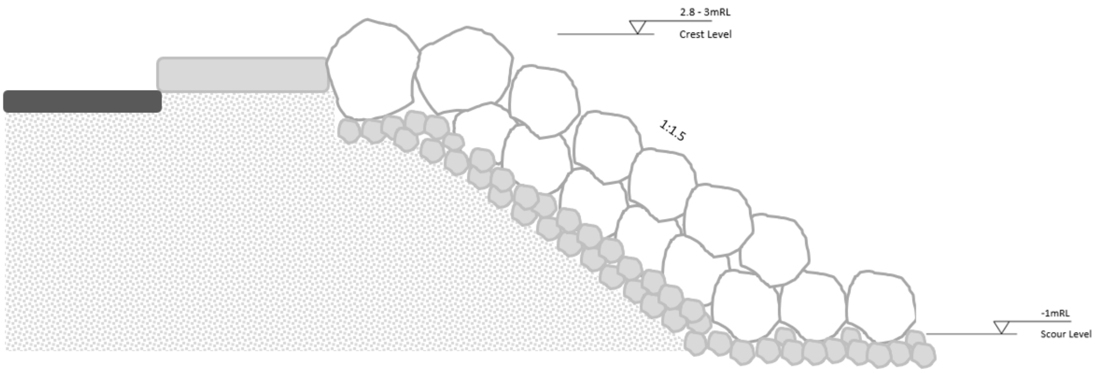


Figure 3 Typical cross section for low crested rock revetment at Long Beach

In addition to erosion protection to Bay Road the benefits of the proposed revetment would be a reduction in still water inundation as a result of elevated coastal water levels, with a crest level of +2.9mAHD providing protection for the 100year ARI still water level under sea level rise out to 2100.

Wave runup and overtopping of the revetment crest would occur, as is currently experienced across the dune crest, road and into properties. Under future sea level rise conditions, this wave run-up and overtopping may be significant with damage to the road surface likely. Estimates of wave overtopping under present day sea levels, indicate mean overtopping rates remain only marginally above tolerable limits for cars directly behind the crest (Eurotop, 2018). The presence of a concrete footpath that is integrated with the revetment, sets the road back from the revetment crest and will reduce the potential for damage to the road surface in the near term. Longer term wave overtopping would be significant.

While wave overtopping hazard would remain, the nature of the road, its limited use and the short duration of the overtopping hazard (at the peak of the tide), the risk does not warrant large scale coastal protection works in the near future, particularly when impacts to user amenity of the beach is considered.

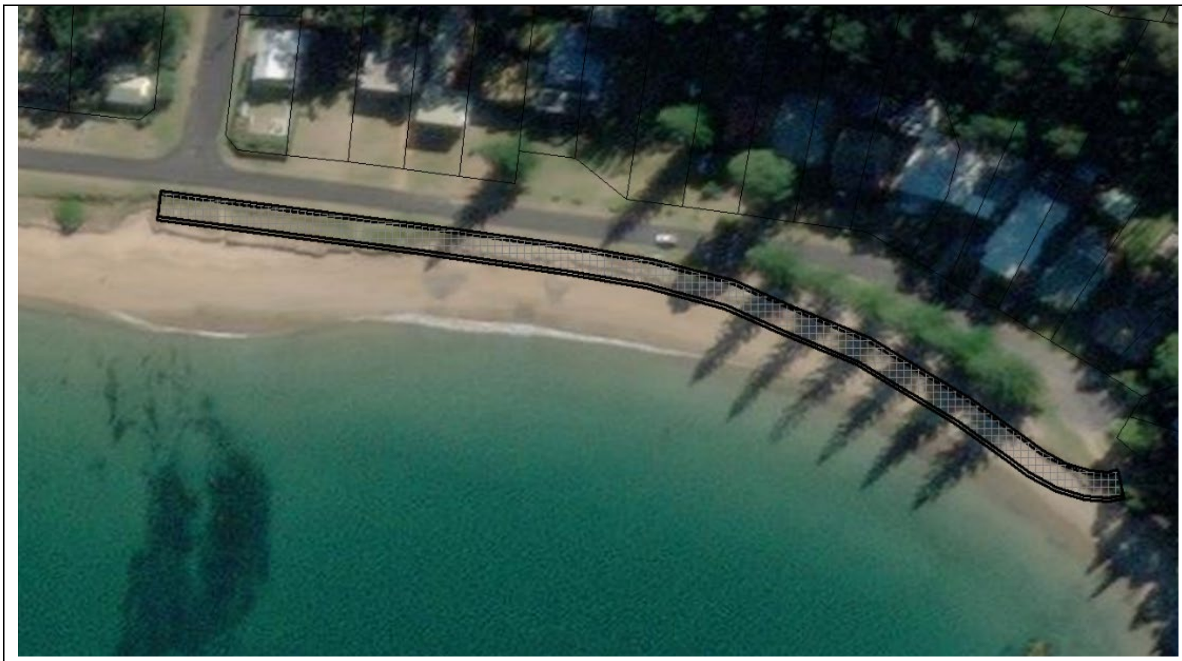


Figure 4 CH1_D conceptual revetment alignment at Long Beach (250m)

Effectiveness:

- Highly effective for the protection of public assets from coastal erosion (Bay Road and carpark) against a 100-year ARI storm event in the present day and future sea level scenarios.
- Effective in reducing coastal inundation elevated water levels out to 2065
- Moderately effective in reducing the hazard associated with wave overtopping (risk to life and damage to road surface) under existing sea levels, with reducing effectiveness as sea levels rise.

Benefits:

- Preserves Bay Road from critical damage from erosion and maintains access route for up to 20 foreshore properties.
- Provides opportunity to establish formal and controlled access to the beach across the dunes.

Disadvantages:

- Formalising a hard structure at the shoreline (in addition to the existing road surface) may exacerbate the potential for edge effect at the ends of the sea wall. The alignment and design of the structure would need to be considered to minimise these potential impacts.
- In future, as sea levels rise and shoreline recession is realised, beach nourishment will be required in front of the sea wall to preserve the beach width and public access.

Timing:

- Option for staging of works to target areas at higher risk.
- Initial 250m length of revetment, near Fauna Ave, would provide immediate protection to the section of road at risk of coastal erosion under present day sea levels.
- The remaining 280m length of revetment along Bay Road, including the public carpark, would progressively become at risk of coastal erosion to 2065.

- With regular inspection and maintenance, the revetment could be expected to have a design life in excess of 50 years. Replacement of the footpath may be required over this timeframe.

Cost Benefit Assessment (Stage 1 Works Only)

Costs: as above

Benefits:

This option derives benefits from avoided costs that arise from the closure of Bay Road when exposed to modelled inundation events. Through coastal inundation modelling it was evident to see that the Bay Road would be flooded and highly damaged for between 12 to 36 hours under major inundation events. Moreover, inundation modelling provided evidence to suggest that sections of Bay Road and the beachfront carpark would need to be replaced in numerous scenarios, incurring a four week timeline for replacement works. Consecutive East Coast Low (ECL) storm events in early 2022 have exacerbated the susceptibility of Bay Road, with undercutting of the road visible from the beach in multiple locations. Avoidance of this costs provides the following benefits:

- **Avoided road resurfacing** is a benefit that would occur due to the proposed revetment that will shielding Bay Road from inundation events. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $143 per metre of road. Moreover, with the presence of the proposed wall the destruction of these sections of tarmac are avoided and so their complete replacement costs are avoided too. This is valued at $3,429 per m^2 of road and $8,853 per carpark space (TfNSW Economic Parameters, 2020).
- **Avoided road replacement (erosion)** is a benefit that would occur as a result of constructing the proposed revetment, as it will reduce the probability of the road encountering erosion and having to be reconstructed. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $3,429 per metre of a two-lane, flexible pavement road, where the road length is 300 metres. Additionally, there is an avoided cost of the temporary road which is required in the estimated two week period of road reconstruction. The value of avoiding this cost is derived from the pricing the anticipated 485 metres of metal temporary sheeting which will allow for continued road access from residential driveways along Bay Road to connect to Long Beach Road. Over a four week period the cost per metre of the temporary road is $269, which totals to $260,930 per erosion event. The analysis assumes a 1% p.a. probabilityy of road replacement within the first ten years, 2% p.a. for the next 30 years, and 3% p.a. subsequently. It is noted that approximately 100m in length of the Long Beach Road is in poor condition and is currently failing from erosion which is underpinning the road. As a result, it is assumed that this section of the road will fail within one year of the assessment period, resulting in a complete replacement of that 100 m section.
- **Avoided Isolation (access)** is a benefit that can be included as the closure of Bay Road would deny vehicle access for up to 35 households along the Eastern side of Bay Road (depending on event severity). The avoided loss of daily trips via vehicle is valued at $40.54 per household. Given the uncertainty regarding level of disposable income, a 50% adjustment factor was applied to foregone daily expenditure to represent the cost of isolation. Additionally, a costing of $71.43 per person affected by an isolation period is implemented, to account for the cost of potential mental health related therapy and loss of production that occur as a result of prolonged isolation. This costing is derived from Deloite (2016) 'The Economic Cost of Social Impacts of Natural Disasters' and is scaled by a factor of 0.1 to account for the relative severity of possible inundation events.

Results:

The table below highlights that this option does not have a positive NPV and has a BCR well below 1 indicating that it is not economically feasible to implement at this point in time. This is primarily driven by the low likelihood of road failure in the period of economic assessment. However, if a large storm event did cause significant erosion of the beach and dune, and threaten the road, this option may increase in viability. This option has therefore been included as a 'recovery' action in the CZEAS.

The economic feasibility of this option should be reviewed with the CMP review in 10 year time based on sea level rise occurrence and updated projections of sea level rise and the impacts on beach erosion and recessions analysis.

BCR		NPV	
0.36		-$2,479,698	
Benefit		**Costs**	
Resurfacing	$635,190	**Capital Costs**	$3,056,931
Erosion	$579,375	**Maintenance Costs**	$797,400
Access	$160,069		

Overtopping of Bay Road, Long Beach, 6 June 2012 (Mr Lindsay Usher) – from WRL, 2017

Overtopping of Bay Road, Long Beach, 4th April 2022 (Mr Cameron Whiting ESC)

Existing Riprap Structure East of Fauna Ave, Long Beach, 16 Mach 2021 (Baird Site Visit)

CH1_I	Offshore Breakwater and Beach Nourishment
Location(s): Surfside Beach	
Coastal threat(s) to be addressed: Beach Erosion	
Outcome of CMP Assessment This option is not recommended for inclusion in the CMP. The option: • Relatively expensive, and needs maintenance and periodic sand nourishment campaigns • Creates a navigation hazard. • The Stage 2 Coastal Hazard assessment identified that the transport of sand along the beach is generally low but travels from north to south under normal ambient conditions. An offshore breakwater would not impact these processes, and therefore does not mitigate the recessional trend at the northern end of the beach.	
Costs: Direct costings of the offshore breakwater were not undertaken as part of this options analysis. However, a similar design was the most-expensive option assessed in the Batemans Bay Independent Coastal Impact Assessment Stage 2 (2020), costed at approximately double the price of a revetment and beach nourishment. For beach nourishment, a capital cost of $35,000 per nourishment campaign is estimated, with no ongoing maintenance cost, to be repeated every 5-10 years (on average). It is assumed that the cost of nourishment does not include the dredging costs, as this cost would be borne by the agency responsible for maintaining navigable depths in the Clyde River and Batemans Bay. Therefore, the cost of dredged sand placement is estimated from the additional cost of transporting and placing the dredged material at Surfside. A cost of approximately $35,000 for placement of dredge material is based on a rate of $5/ m3. Maintenance Costs: N/A	
Option Description: The Stage 2 Coastal Hazards Assessment determined that Surfside Beach (East) was at risk of beach erosion and recession, with risks to public property and amenity at the 2017 planning level, and to private property by 2100 (**Figure 1**). To address these risks of severe beach erosion and recession, breakwaters located offshore Surfside have been identified as an option, in conjunction with beach nourishment. Breakwaters would reduce wave exposure during severe coastal storms by causing waves to break offshore, reducing wave energy reaching the beach. This would reduce long- and cross-shore sediment transport and thereby erosion. The breakwaters would not significantly impact sediment transport processes under benign conditions, if suitably located, allowing natural sediment circulation to continue. Beach nourishment would ensure sufficient sand volume to maintain beach width and amenity and provide a natural buffer for any erosion that occurs by increasing the sub-areal beach volume. Two potential breakwater configurations are presented in **Figure 2.** The yellow line indicates a solid breakwater of approximately 200 m in length, whilst the red line indicates two breakwaters, each approximately 70 m in length. For beach nourishment, the sub-aerial beach condition should be assessed, with a sufficient beach width of at least 30 m at the northern end. If beach width is less than 30 m, sediment should be placed according to the equilibrium profile shown in **Figure 3**. If beach width is greater than 30 m, target nourishment of the dune to achieve a target crest level of 2.55 mAHD (2050 100-year ARI Still Water Level, WRL (2017)), and 3.04 mAHD towards 2100 (2100 100-year ARI Still Water Level, SWL (2017)).	

Figure 1 Surfside Erosion Hazard Lines for 2017 and 2100 planning periods

Figure 2 Surfside Offshore Breakwaters, with two potential configurations

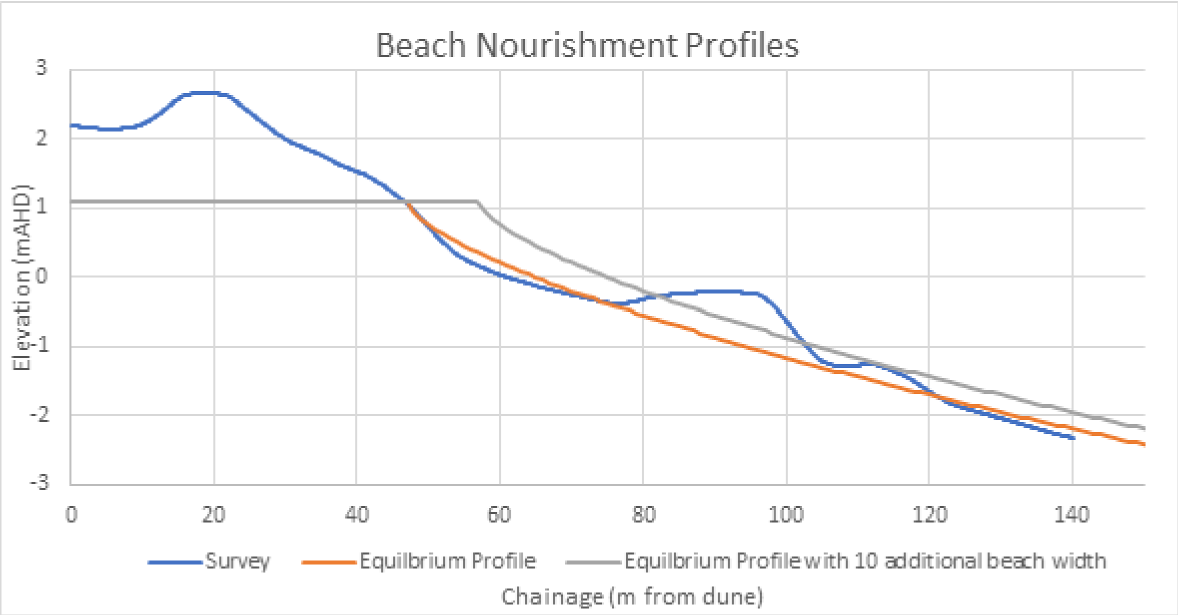


Figure 3 Surfside Beach Nourishment Profiles

Effectiveness and benefits:

- Effective at reducing erosion potential at Surfside.
- Has limited impedance on beach access and natural amenity.
- Provides an artificial reef.

Disadvantages:

- Is not a holistic coastal hazard management option; only addresses erosion, not tidal or coastal inundation.
- Relatively expensive, and needs maintenance and periodic sand nourishment campaigns
- Creates a navigation hazard.
- The Stage 2 Coastal Hazard assessment identified that the transport of sand along the beach is generally low but travels from north to south under normal ambient conditions. An offshore breakwater would not impact these processes, and therefore does not mitigate the recessional trend at the northern end of the beach.

Overall, this option is not recommended due to the lack of holistic hazard management, high costs and the ongoing maintenance required.

CH1_Ka	Wharf Road Stage 1: Priority coastal protection works , remediation and reinstatement of beach for public use

Location(s): Wharf Road, North Batemans Bay

Coastal threat(s) to be addressed: Coastal Erosion

Outcome of Detailed Assessment

This option is recommended for inclusion in the CMP to address existing and future coastal erosion and inundation risk to Wharf Road and surrounds areas. This action requires action CH_1 M (Acquisition of private property) to firstly occur with the following stages to enable public access and use of the beach: action will be undertaken in 3 phases:

1. Undertake site remediation assessment and investigation and design of coastal protection structure including reuse of onsite materials.
2. Complete coastal protection works identified in phase 1 and rehabilitation of beach to enable public use, improve amenity and environmental restoration outcomes. Renaming the rehabilitated beach to also be explored following community consultation.
3. Maintain and enhance coastal vegetation and beach for safe public use

Costs:

- Phase 1: Site remediation assessment and I&D for coastal protection structure: $200,000
- Phase 2: Construction of coastal protection works and beach rehabilitation: $2,200,000
- Phase 3: Maintenance and enhancement of beach and coastal vegetation: $ 60,0000 over 6 years ($10K per annum)

Maintenance costs of coastal protection works: 1% of capital costs annually over life of structure.

Option Description:

The corner of Wharf Road at North Batemans Bay was identified as being at extreme risk of coastal erosion and asset failure under existing conditions due its proximity to the existing shoreline. There currently exists a form of coastal protection along the road corner with quarry stones having been placed in an ad hoc manner (see Site Photo below). During site visits, an inspection of the area concluded that the structural integrity of the rock protection could not be relied upon, and the road and sewer is at risk of damage under extreme coastal conditions.

Figure 1. Site Photo of Wharf Road Corner and ad hoc rock protection (Site Visit: 16 March 2021)

Conceptual design of a seawall has been developed to address this risk, with the following objectives:

- Provide structural protection to Wharf Road against existing and future coastal erosion risk
- Limit the rate of wave overtopping to the roadway to maximise the duration of safe access along Wharf Road during elevated coastal storm conditions
- Tie in with existing coastal protection to the west, at the Easts Riverside Holiday Park
- Provide formal public access and connection from the Holiday Park to the beach and public open space to the east.

The option firstly requires that acquisition of the properties identified in the certified Wharf Road CZMP (action CH1_M in this CMP) is taken up by the landholders which is currently underway, and the beach area is returned to public open space.

Figure 2. The properties identified for voluntary acquisition by the NSW State Government, as identified in the Wharf Road CZMP

A typical section for the seawall design concept is presented in **Figure 2** and includes construction of a 3.0m wide crest at +3.5mAHD and 1 in 1.5 seawall slope that extends down to a toe level of -1 mAHD. Behind the crest of the seawall a concrete cut-off wall would reduce the permeability of structure (thereby providing a barrier to still water inundation). A footpath could also be integrated into the structure at detailed design. This footpath could occur at the crest of the structure to facilitate views or at the base of the structure cut-off wall in keeping with the existing road level as depicted in the image below.

The proposed design and cost estimates are for the coastal hazard protection purpose of the seawall only. Additional public benefits could be incorporated at the detailed design stage, such as viewing platforms, beach access and other amenity details.

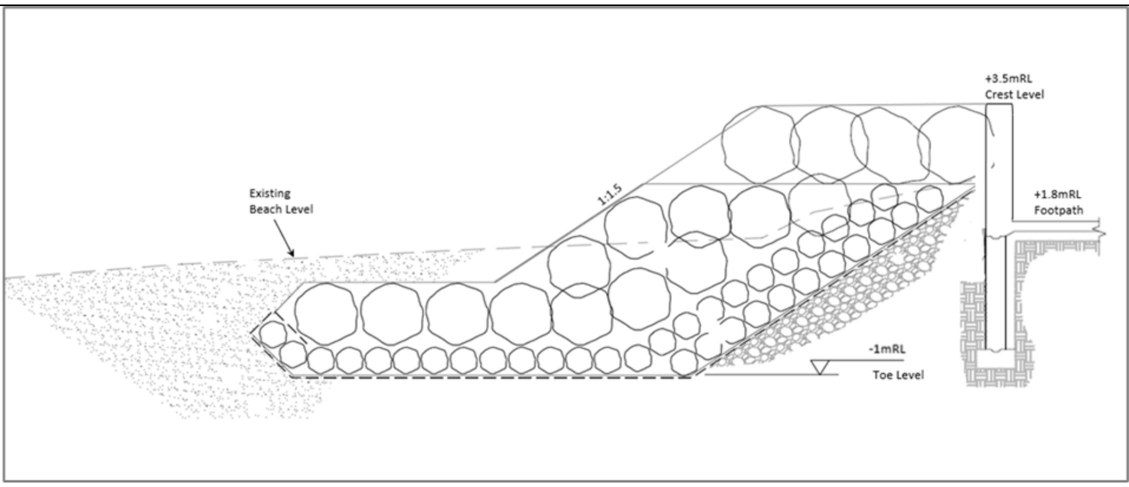


Figure 3. Typical Cross Section of Seawall Concept at Wharf Road Corner.

The alignment of the structure would run between the existing seawall that protects Holiday Park to the west and along approximately 85m of Wharf Road (100m in total length), as shown in **Figure 3**. Given the alignment of the seawall, the structure would block the natural drainage of the landside area, which is a low point in the area. As such drainage would need to be incorporated into the seawall design and may take the form of a pipe outlet through the structure with non-return value to inhibit the ingress of coastal waters during elevated sea level conditions.

Both the existing protection (see **Figure 1**) and from the unapproved structure to the east (see **Figure 5**) would be removed and armour stones could be reused as material for the new structure.

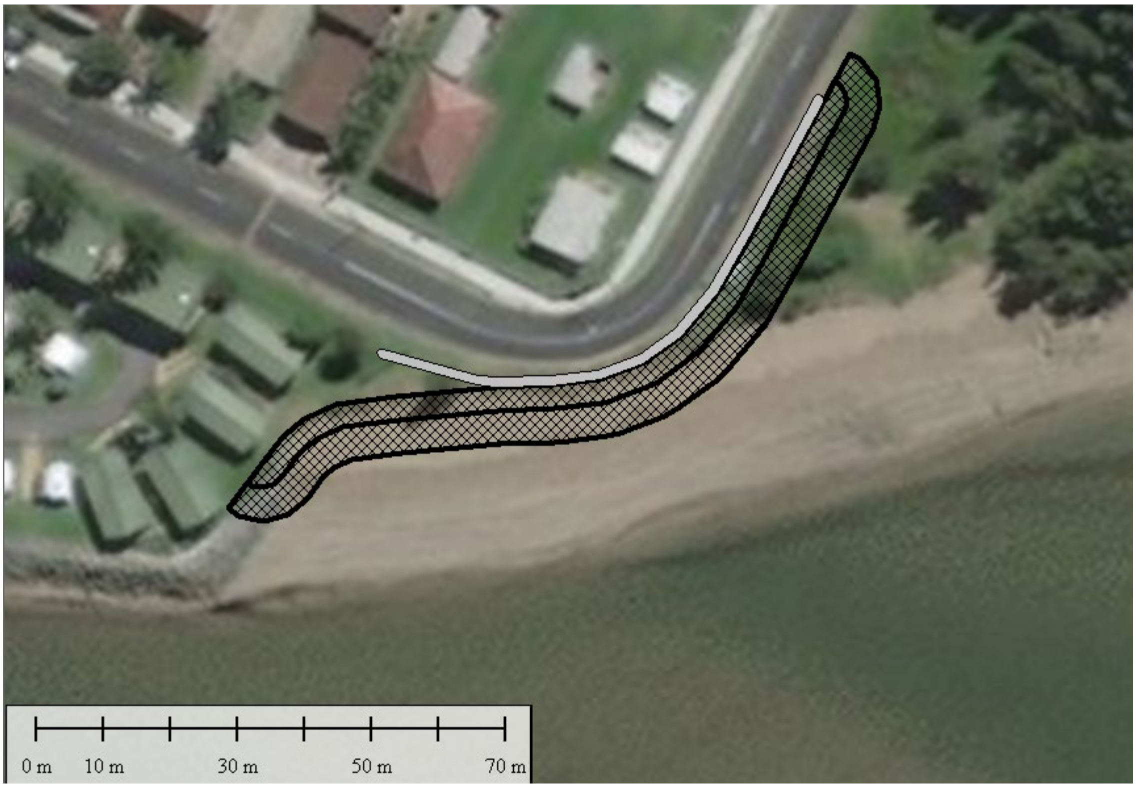


Figure 4. Alignment and footprint of Seawall Concept at Wharf Road Corner.

Figure 5. Photo and location of unapproved coastal protection structure at the Wharf Road subdivision.

CMP Assessment:

The seawall concept has been assessed as follows:

- Preliminary structural design – armour stone sizing and wave overtopping
- Shoreline response.

Preliminary structural design of the sea wall concept has considered a 100yr ARI design storm under present day and 2050 sea level conditions. These works are considered priority works for the area to address an extreme present-day risk. Options to address future risk under sea level rise scenarios need to consider coastal inundation of the wider area in a more wholistic manner and are considered in subsequent management options:

- Seawall raising in front of the holiday park and seawall along Wharf Road to provide inundation protection (Option CH1_Kb)
- Raising of Wharf Road surface levels (Option CH1_Kc)
- Trigger based protection of sewer line and remainder of Wharf Road from erosion (Option CH1_Kd).

A crest level of +3.5mAHD is established to reduce the rate of overtopping of the structure under severe coastal storm conditions. To meet a tolerable overtopping threshold of <50 L/s/m, a threshold for the safety of vehicles behind the crest (i.e. on Wharf Road), a crest elevation of +3.5mAHD with a crest width of 3m is required (based on wave overtopping calculations for rubble mound structures in Eurotop, 2018 under the 2100 scenario). Armour stone sizing of 3-4t is required to ensure stability under design wave conditions (using the empirical stability methods of van der Meer, 1988).

The removal of the unapproved coastal protection structure from the Wharf Road subdivision will have an influence on the shoreline shape to the east of Wharf Road corner. This shoreline has seen large fluctuations is beach width over relatively short periods of time, as shown in **Figure 6**, and is attributed to the balance between coastal processes (that supply sediment from east to west) and flood flows from Clyde River (that scour and rework sediments across the area).

In an accreted condition, the removal of the unapproved structure will not have an influence on the shoreline position, however in times of a more receded shoreline, a modified shoreline alignment would be expected. An assessment of the future vegetation line and shoreline positions without the presence of the unapproved structure is presented in **Figure 7**.

Figure 6. Shoreline positions in September 2018 accreted state (top) and September 2019 receded state (bottom).

Figure 7. Shoreline positions following removal of the unapproved coastal protection structure. Green is permanent vegetation line. Orange is the receded shoreline alignment. Yellow is the accreted shoreline position.

Benefits:

- The structure will provide protection to Wharf Road and maintain the road as a vital access way for the area.
- Provides the opportunity to establish formal connection between the existing developments and open space to the east (note that it is assumed voluntary acquisition of the Wharf Road subdivision is completed and the area is returned to public open space)

Effectiveness:

- The structure has been designed to address the existing extreme risk of damage to the Wharf Road corner. A correctly designed and constructed seawall will continue to provide effective protection against coastal erosion under future sea level rise scenarios.
- A seawall designed for present day conditions will reduce in effectiveness as sea level rises under future scenarios, as the associated wave overtopping rate under extreme coastal storms will increase. As such the effective crest of the seawall will need to be raised into the future in line with this increasing risk. This is considered as part of a staged management approach for the area (see Options CH1_Kb, Kc, Kd). The proposed crest level would provide effective protection from wave overtopping to the Wharf Road corner to 2040.

Timing:

- The seawall should be implemented as a high priority item to protect against an existing coastal erosion risk, with design and construction to commence in 'Year 1' of the CMP.
- The seawall, in its initial form, would have a limited lifespan (~20years) and form a foundation for further management works to address coastal inundation across the wider Wharf Road area.

Timing of these works, and associated works is outlined below.

2023

- Property acquisition (CH1_M)
- Stage 1 Wharf Road works (CH1_Ka) commenced

2024-2026

- Property acquisition (CH1_M) to continue
- Stage 2 Wharf Road works (CH1_Kb)

2027 Onwards

- Wharf Road incremental raising (CH1_Kc)

Cost Benefit Assessment

Costs: as above.

Benefits:

This option derives benefits from avoided costs that arise from the flooding and damages to Wharf Road under different modelled inundation events. Further benefit arises from the construction materials, which are sourced from the illegal foreshore protection structure. The removal of the groyne would allow for the build-up of more sand naturally, extending and widening the beach. As a result of the proposed works the following benefits are anticipated:

- **Avoided road replacement (erosion)** is a benefit that would occur as a result of constructing the proposed seawall, as it will reduce the probability of the road encountering erosion and having to be reconstructed. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $3,429 per metre of a two-lane, flexible pavement road, where the road length is 85 metres. The analysis assumes a 1% p.a. probability of road replacement within the first ten years, 2% p.a. for the next 30 years, and 3% p.a. subsequently.

Results:

The table below highlights that this option has a negative NPV and has a BCR of 0.03 indicating that the option not economically feasible to implement at this point in time.

BCR		**NPV**	
0.03		-$1,898,790	
Benefit		**Costs**	
Erosion	$68,572	**Capital Costs**	$1,714,226
		Maintenance Costs	$253,136

Inundation at Wharf Road, 6 June 2012 (Mr Dick Crompton) from WRL, 2017

Debris strewn across the beach from the dilapidated seawall, Wharf Road, 4th April 2022 (Mr Cameron Whiting, ESC)

C1_Kb	Wharf Road Protection Stage 2: Inundation protection. Seawall raising in front of Holiday Park, seawall along Wharf Road

Location(s): Wharf Road, North Batemans Bay

Coastal threat(s) to be addressed: Coastal Inundation

Outcome of CMP Assessment

This option is recommended for inclusion in the CMP to address existing erosion risk to Wharf Road and ensure the ongoing viability of this road.

Costs:

Stage 2 consists of raising 440m of existing seawall and installation of 250m of flood wall. The effectiveness of the option is reliant on the implementation of the Stage 1 seawall to provide a continuous protection from inundation around North Batemans Bay.

Seawall Capital Cost: $3,800,000

Flood Wall Capital Cost: $2,100,000

Maintenance Costs: 1% of capital costs annually over life of seawall. Negligible maintenance costs for flood wall.

Option Description:

The low-lying areas of North Batemans Bay along Wharf Road have been identified as being at risk of coastal inundation under a present day 100yrARI coastal water level, with inundation depth exceeding 1m in some areas. Inundation depth maps for the present day and including projected sea level rise out to 2100 are presented in **Figure 1**. Options to address the existing and future risk of coastal inundation across the wider area have been considered. Given the topography of the area, inundation protection will require a mix of structures to produce a continuous elevated barrier to repel coastal inundation from Batemans Bay.

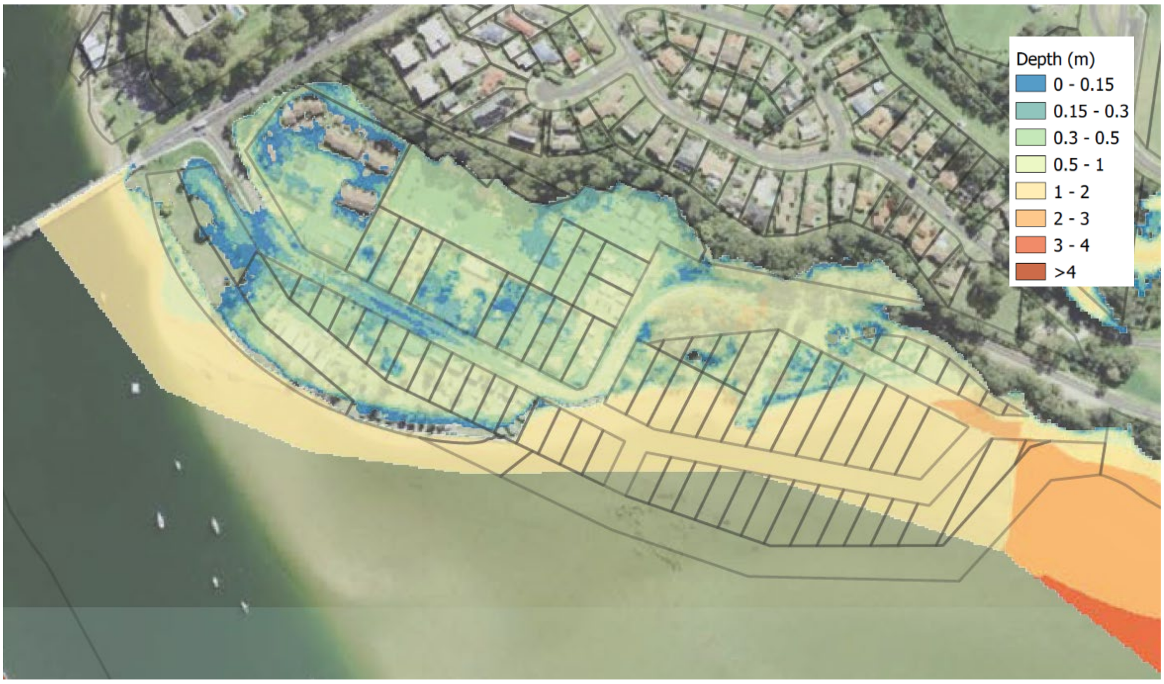


Figure 1. 100year ARI Coastal Inundation Depth across Wharf Road area. Top: Present Day. Bottom: 2100.

The concept design for Stage 2 coastal inundation protection assumes the following:

- Stage 1 (Option CH1_Ka) includes the construction of a seawall that extends from the existing coastal protection to the west, at the Easts Riverside Holiday Park, and along 85m (approx.) of Wharf Road, providing protection to ensure tolerable wave overtopping rates to the year 2050.
- Opportunistic raising of Wharf Road will be implemented as maintenance works are undertaken or funding becomes available to maintain access during inundation events and act as flood control structure to the suburb over longer timeframes (Option CH1_Kc).
- Inclusion of tidal valves on stormwater outlets (Option CH4_G).

Conceptual design of Stage 2 protection of Wharf Road consists of the following:

- Raising of the existing seawall that fronts the Holiday Park (440m in length).
- Construct a flood wall along the seaward alignment of Wharf Road east of the Wharf Road corner, consisting of a Steel Sheet Pile wall (250m in length).

The alignment and extent of structures is presented in **Figure 2**. The flood protection would be constructed to a level that will prevent coastal still water inundation up to the year 2100 (for 100-year ARI immunity – crest level ~3mAHD) and will tie into the Stage 1 protection works (Option CH1_Ka). Wave overtopping of the holiday park would be reduced by the seawall raising, however would not be a targeted outcome of the works as this would reduce the amenity of the holiday park foreshore.

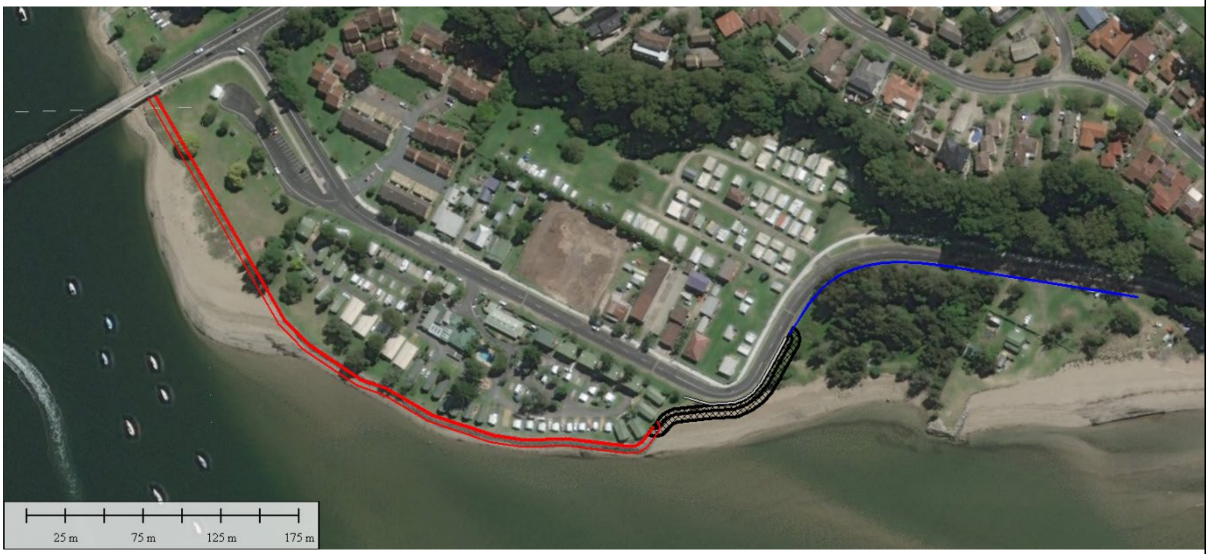


Figure 2 Alignment and extent of Stage 2 Inundation Protection of Wharf Road (Red: Raising of Seawall, Blue: Vertical SSP).

A concept seawall raising option has been designed that would leverage of the existing seawall as a foundation but increase the crest level to +3.0mAHD, above the 100-year ARI Storm Tide level in 2100. A typical section for the seawall raising design is presented in **Figure 3** and includes construction of a 1m wide crest and 1 in 2 seawall slope that is placed on top of the existing seawall armour layer (also 1 in 2 slope). At the back of the crest of the raised seawall a concrete cut-off wall would reduce the permeability of structure and neatly tie the seawall into the land behind.

A typical section for the flood wall along Wharf Road is presented in Figure 4 which includes installation of a vertical Steel Sheet Pile (SSP) structure on the seaward edge of the road alignment. The SSP panels could be concealed with capping and facia and would also provide structural support for future road raising works.

The proposed design and cost estimates are for the coastal hazard protection purpose of the seawall only. Additional public benefits could be incorporated at the detailed design stage, such as viewing platforms, beach access and other amenity details.

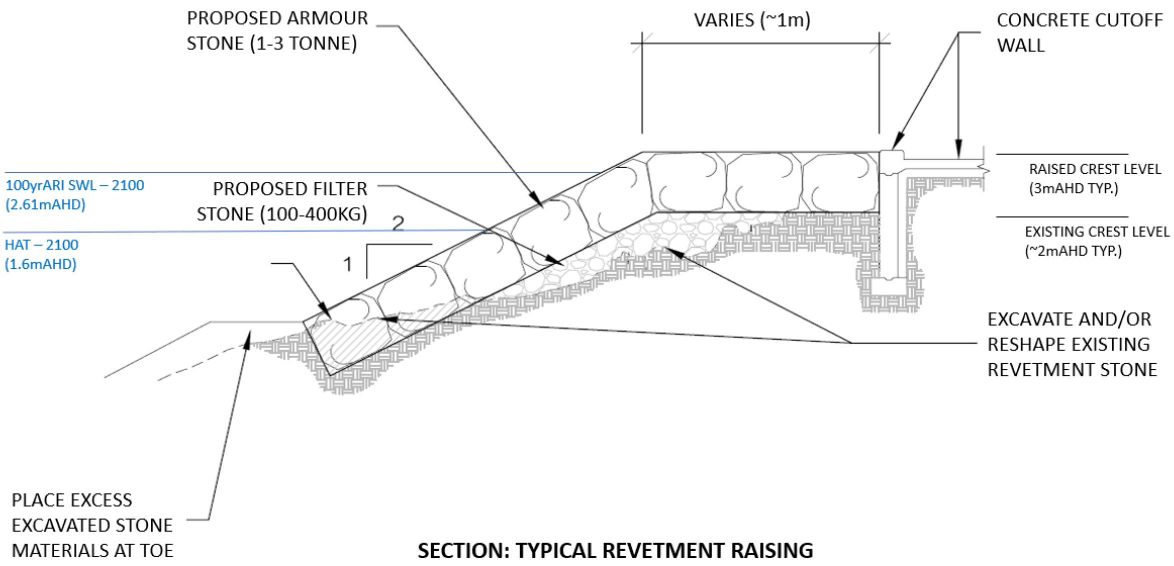


Figure 3 Typical cross section for raising of the Seawall fronting the Easts Riverside Holiday Park

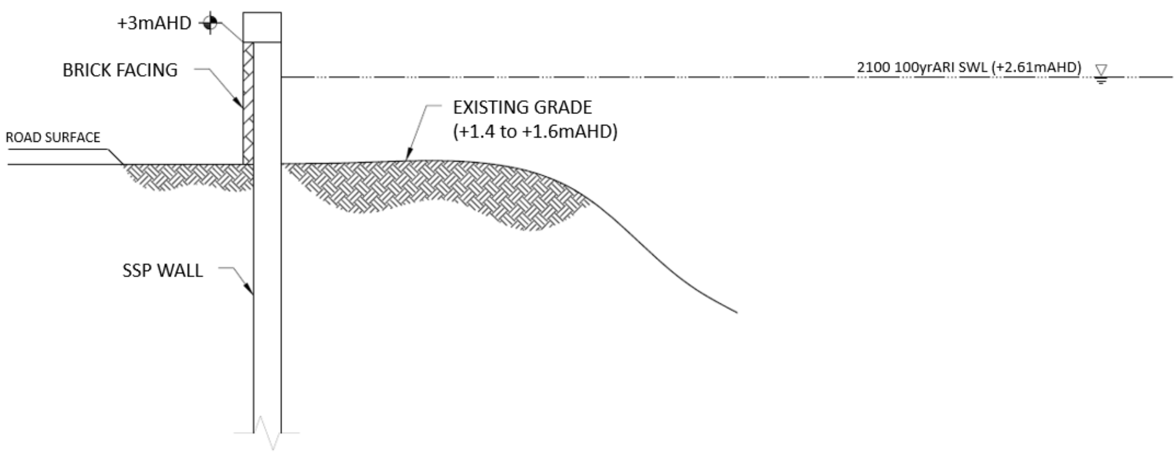


Figure 4 Typical cross section for SSP Wall along Wharf Road

Benefits:

- The structure will provide protection from coastal inundation to the North Batemans Bay area and maintain Wharf Road as a vital access way for the area.

Effectiveness:

- The conceptual design of the structure has been designed as three separate structures that together address the existing and future extreme risk of inundation to the North Batemans Bay area (out to 2100).
- The effectiveness of the option is reliant on the implementation of the Stage 1 seawall to provide a continuous protection from inundation around North Batemans Bay.
- Wave overtopping of the Holiday Park foreshore is not eliminated under future sea level rise scenarios by this option, as this would severely reduce the amenity of the foreshore. Rising sea levels may trigger a need for further protection against wave overtopping in the

future that would be solely targeted at reduction of overtopping hazard of the Holiday Park foreshore.

Timing:

- There is an existing inundation risk that would be eliminated through implementation of the coastal inundation protection.
- These works are seen as secondary priority to the Stage 1 seawall to protect against a severe coastal erosion risk of the Wharf Road corner.

Timing of these works, and associated works is outlined below.

2023
- Property acquisition (CH1_M)
- Stage 1 Wharf Road works (CH1_Ka)

2024-2026
- Stage 2 Wharf Road works (CH1_Kb)

2027 Onwards
- Wharf Road incremental raising (CH1_Kc)

Cost Benefit Assessment

Costs: As above

Benefits:

This option derives benefits from avoided costs that arise from the flooding and damages to Wharf Road and the surrounding caravan parks and mobile homes in North Batemans Bay under different modelled inundation events. The extension of the seawall to surround the entirety of the foreshore area from Korners Park to Surfside, would remove the potential for detrimental flooding under 1% or 5% AEP events. Further benefit arises from the walls construction materials, which will be partially sourced from an existing illegal structure, which is preventing natural sand build up in the bay. The removal of the groyne would allow for the build up of more sand naturally, extending and widening the beach.

As a result of the proposed works the following benefits are anticipated:

- **Avoided road resurfacing** is a benefit that would occur due to the proposed seawall that will shielding the entirety of Wharf Road from inundation events. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of \$143m^2.
- **Avoided Property Damages** is a benefit that arises from protection of residential and commercial properties from coastal inundation events. The damages are calculated based on damage curves from the DPE and include maintenance, replacement and relocation costings. This is translated into an Average Annual Damage reading which summaries the potential damages in any given year, based on the severity and likelihood of the damages occurring.
- **Avoided isolation** is a benefit that would occur due to the proposed sea wall's wave return structure. This would prevent costal inundation flooding of Wharf Road and allow for the sustained access for emergency evacuation or the continuation of normative activity by the

residents and visitors of the caravan parks and North Batemans Bay (500 people) in an inundation or storm event.

- The cost of emergency access was derived from Batemans Bay hospitalisation rates for Eurobodalla residents and the triage severity of each visit and the cost of damages for which each case if untreated. These inputs were drawn from TfNSW's *Flood Risk Management Measures (2022)* and *flowinfo v 17 (2017).*
- The cost of ordinary activities was derived from the average cost per household per vehicular trip that would normally be undertaken and the cost of isolation (i.e. expenditure on goods and services that is no longer possible). These costs were derived from the averagely weekly spend per household for Eurobodalla and the average daily trips per household. This resulted in an avoided benefit of $40.54 per trip and $157 for each of the 229 households for each day of isolation. Given the uncertainty regarding level of disposable income, a 50% adjustment factor was applied to foregone daily expenditure to represent the cost of isolation.
- Additionally, a costing of $71.43 per person affected by an isolation period is implemented, to account for the cost of potential mental health related therapy and loss of production that occur as a result of prolonged isolation. This costing is derived from Deloite (2016) 'The Economic Cost of Social Impacts of Natural Disasters' and is scaled by a factor of 0.1 to account for the relative severity of possible inundation events.

Results:

The table below highlights that this option has a indicating NPV and has a BCR of less than 1 indicating that the option not economically feasible to implement at this point in time.

BCR		NPV	
0.76		-$1,270,166	
Benefit		**Costs**	
AAD	$2,638,439	**Capital Costs**	$4,816,157
Amenity	$967,733	**Maintenance Costs**	$483,273
Resurfacing	$423,092		

Inundation at Wharf Road, 6 June 2012 (Mr Dick Crompton) from WRL, 2017

Inundation at Wharf Road, 6 June 2012 (Mr Dick Crompton) from WRL, 2017

CH1_L	**Undertake nourishment at northern Batemans Bay beaches when dredging is undertaken in Batemans Bay / Clyde River as required for navigational purposes**
Location(s): Surfside Beach, Surfside Beach West (Dog Beach / Mcleods Beach), North Batemans Bay Beach (Wharf Road), Long Beach	
Coastal threat(s) to be addressed: Beach Erosion	
Outcome of CMP Assessment Recommended for inclusion in the CMP due to benefits for beach amenity and asset protection at northern Batemans Bay.	
Costs: A capital cost of $500,000 per nourishment campaign, with no ongoing maintenance cost, to be repeated every 1 to 5 years (on average).	

Option Description:

Protection of the existing Northern Batemans Bay shorelines by increasing the sub-areal beach volume through beach nourishment. Maintenance dredging of navigable areas of Batemans Bay produces a volume dredged material that is suitable for beach nourishment on adjacent shoreline areas.

Dredging of Batemans Bay and Clyde River has occurred on an infrequent basis since at least the early 1900s, with dredge spoil deposited at Corrigans Beach and Surfside throughout the century. Recent dredging and nourishment campaigns have occurred in 2013, 2016 and 2020. The 2020 campaign deposited sand offshore Surfside Beach, consisting of 10,000 m^3 of Clyde River sand. In 1996 12,000 m^3 of sand from navigational dredging was deposited on the northern end of Surfside Beach. This management action would redirect all dredged material to the Northern shorelines of Batemans Bay to increase the sub-areal beach volume of Surfside Beach, Surfside Beach West (Dog Beach), North Batemans Bay Beach (Wharf Road) and Long Beach.

Beach nourishment is opportunistic and would occur as and when dredge sediment from Batemans Bay /Clyde River becomes available.

Nourishment would be subject to environmental planning approvals and suitability of dredged material.

It is noted that DPI Fisheries will only support dredging and nourishment programs that are compliant with the Marine Estate Management Act and Fisheries Management Act and is not supportive of expanding these activities beyond existing channel maintenance programs in Batemans Bay. The rules relating to dredging and beach nourishment within a Marine Park can vary between zones and the Draft CMP needs to acknowledge the relevant Clauses of Marine Estate (Management Rules) Regulation 1999 to determine the permissibility of any proposed dredging activities.

Surfside Beach Nourishment

The 100 Year ARI storm demand at Surfside Beach is approximately 55m^3/m of beach length. Therefore, the volume of sand required to replace erosion after a 100 Year ARI event for the full 800m length of beach is approximately 50,000m^3.

However, if nourishment were to occur in response to navigation dredging within the Clyde River channel, it is estimated that placement of approximately 10,000m^3 of sand at the northern end of Surfside Beach (as shown on **Figure 1**), would result in approximately a 10m gain in beach width.

It should be noted placement of dredge material directly on the beach or marginally offshore (within 100m of shoreline as per **Figure 1**) is required to ensure nourishment of the beach is achieved. It has been shown offshore placement may not result in movement of sand to the beach shoreline particularly if it coincides with Clyde river flood flows.

Long Beach

The 100 Year ARI storm demand at Long Beach is approximately $90m^3/m$ of beach length. Therefore, the volume of sand required to replace erosion after a 100 Year ARI event for the full 1,000m length of beach is approximately $90{,}000m^3$.

However, if nourishment were to occur in response to navigation dredging within the Clyde River channel, it is estimated that placement of approximately $15{,}000m^3$ of sand at the eastern end of Long Beach (as shown on **Figure 2**), would result in approximately a 15m gain in beach width.

It should be noted placement of dredge material directly on the beach or marginally offshore (within 100m of shoreline) is required to ensure nourishment of the beach is achieved (as per **Figure 2**).

Surfside Beach West (Dog Beach / Mcleods Beach)

Placement of $5{,}000m^3$ of sand in response to navigation dredging within the Clyde River channel, would result in a 15m gain in beach width.

It should be noted placement of dredge material directly on the beach or marginally offshore (within 50m of shoreline) is required to ensure nourishment of the beach is achieved (as per figure below). Placement heights if directly on the beach should be graded to ensure the dredge material is at least ½ meter lower than the foredune crest height to minimise sand loss by wind, over the foredune into property and onto the road.

Dune Nourishment

If beach width is greater than 30 m at all Northern Batemans Bay beaches when navigation dredging of the Clyde River channel occurs, targeted nourishment of the dune system at Surfside Beach or Surfside Beach West (Dog Beach / Mcleods Beach)) will be undertaken to achieve an elevated dune crest level to protect against coastal inundation under future climate change scenarios.

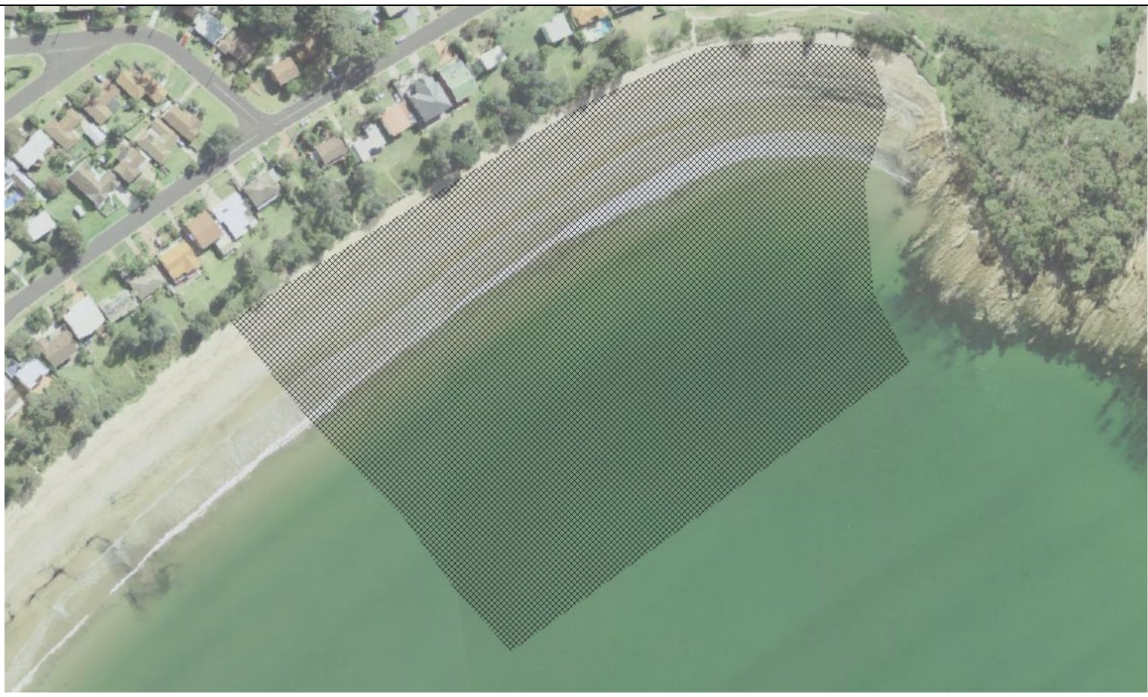


Figure 1 Surfside Beach Sand Nourishment

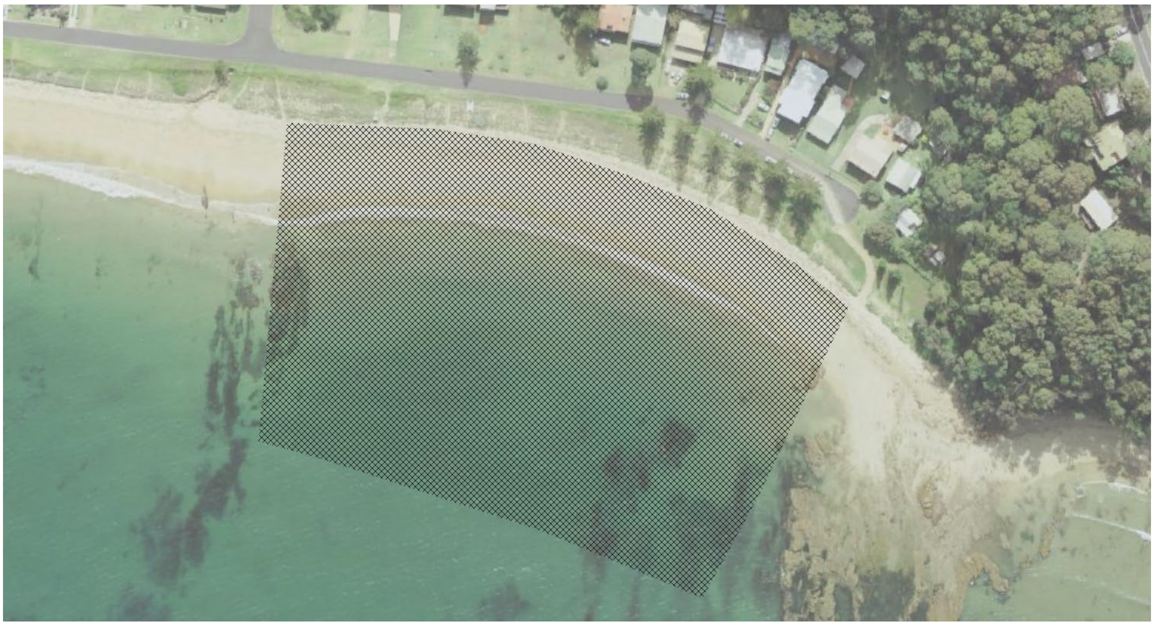


Figure 2 Long Beach Sand Nourishment

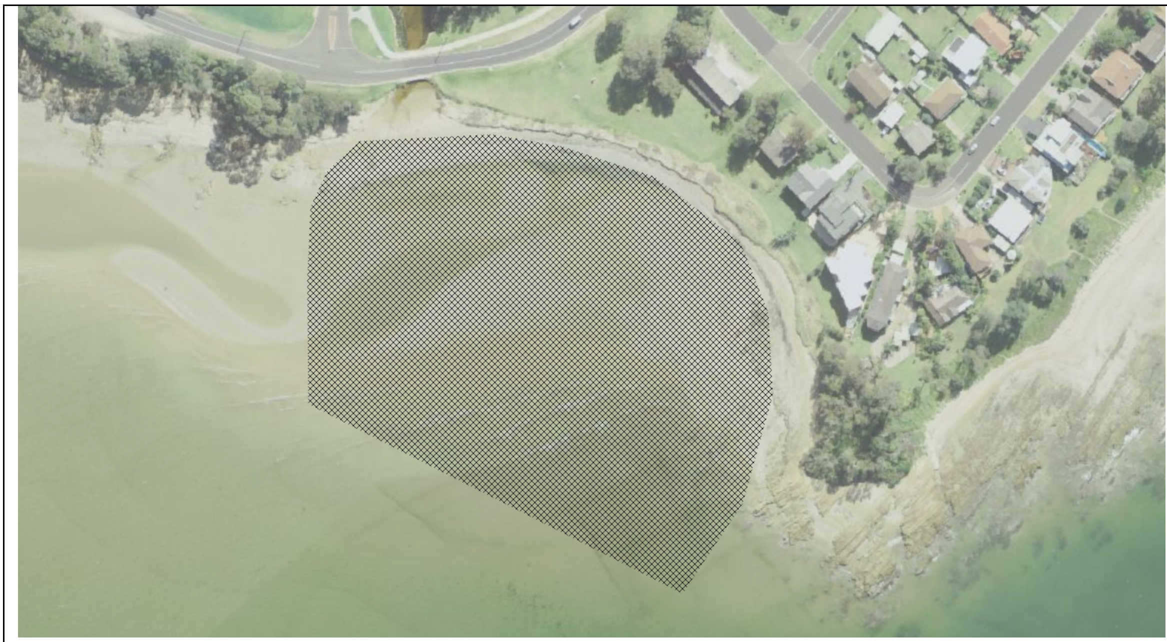


Figure 3 Surfside Beach West (Dog Beach / Mceods Beach) Nourishment

CMP Assessment:

The approximate volume needed to nourish the northern end of Surfside Beach is 7,000 m^3, based on a beach length of 400 m. This assumes the beach that has not recently been eroded due to storm action (i.e. similar profile to the survey profile in Figure 2). Additional sand may be needed if the beach profile is significantly more eroded. The volume and beach profile was based on an equilibrium beach slope using a profile scale parameter of 0.16 m$^{1/3}$ (Dean, 2002).

The coastal erosion assessment in the Stage 2 hazard study identified a storm demand of 50-60m^3/m of beach (equivalent to ~30m of beach width) at Surfside. Maintaining a beach width of greater than 30m, through nourishment will improve the capacity of the beach to accommodate large storm events and minimise the landward limit of storm erosion when it occurs.

Recession rates at Northern Surfside are estimated as -0.08m/year. Over a 10-year period (upper estimate between nourishment campaigns), a loss of <1m of the nourished beach width would be expected which should not undermine the effectiveness of the nourishment volume in protecting against coastal erosion.

Effectiveness:

- Moderate to high effectiveness, as it ensures natural processes are not disturbed unnecessarily, beach width, amenity and usability are maintained, and private property protected
- While the intent is to provide additional beach width as a buffer against storm demand and recession, these processes will drive a reduction in the nourished beach volume over time. The effectiveness of the option is reliant on regular nourishment and will deteriorate in effectiveness if dredging, and thereby nourishment, is very infrequent

Timing:

From present-day, on an on-going basis with a frequency of approximately 5-10 years.

Cost Benefit

Costs: The cost of this option, is considered to be the slight increase in costs associated with placing the dredged material on the northern shoreline rather than a more convenient offshore location. The reason for this is that the 'base case' against which this option is being assessed, also include the dredging operations.

Benefits:

The benefits of this option have been assessed for Surfside only, as the volume of dredge material available for the purpose of nourishment would likely only fulfil the requirements on one location of the three priority locations identified, per dredging program.

This option derives benefits from avoided loss of access and amenity to the eastern side of Surfside Beach during a storm event. Despite storm events affecting the length Surfside Beach, it has been deemed most cost effective to nourish the north-eastern corner as sand naturally moves on shore in a southwestern direction. Sand nourishment would prevent the large losses of sandy beach space after a storm or inundation event, which in turn produces the following benefit:

- **Preserved Amenity** is a benefit that is anticipated to occur from avoidance of sand loss after a storm event. This has been valued by assuming that post inundation events, the eastern half of the beach will be reduced in size by around 6000m^2 and so its use-value will decrease in following year by an estimated 50% whilst the beach naturally recovers with the help of nourishment.

No property damages have been included in this analysis, as the erosion hazard does pose a threat to properties within the 50 year economic assessment period.

Results:

The table below highlights that this option does not have a positive NPV and has a BCR well below 1 indicating that it is not economically feasible to implement at this point in time. However, it is acknowledged that this option may proceed for rationale other than economic factors.

BCR		NPV	
0.62		-$36,531	
Benefit		**Costs**	
Amenity	$60,604	**Capital Costs**	$97,134

CH1_M	**Property acquisition and restore land to safe public use area**

Location(s): Wharf Road, North Batemans Bay

Coastal threat(s) to be addressed:

- CH Threat 1 Beach Erosion
- CH Threat 4 Coastal Inundation
- CH Threat 5 Tidal Inundation
- RA Threat 3 Poorly located, poorly maintained and/or inappropriate access and supporting facilities
- CD Threat 4 Coastal development encroaching onto natural coastal processes to exacerbate hazard impacts

Outcome of CMP Assessment

This option is recommended for inclusion in the CMP to address a range of coastal risks associated with erosion and inundation and to achieve public benefits associated with improved access, public space and improved environmental outcomes.

Costs:

Property acquisition through the Coastal Lands Protection Scheme amounts to $4,000,000

Option Description:

Public ownership of beaches has long been a foundation of the coastal management approach in NSW. Public ownership of the beach at Wharf Road was a priority issue for the Wharf Road CZMP. Despite the zoning somewhat managing coastal risk without the need for land acquisition, it is considered appropriate to incorporate in this plan a priority action for the NSW Government to purchase the private property. This would return the areas of beach and the beach access to public ownership. The location of private lots for acquisition is shown Figure 1 below in pink.

DPE-Planning will require the land to be free of debris and in an uncontaminated state as part of any condition of purchase. It is noted that Given the residual risk of unknown quantities of buried material being unearthed, it is likely that, even if cleaned up by the current owner(s), the sites may still require some remediation to make the land suitable for open space.

Access to the existing and future Public reserve should be improved to a safe standard. As part of the site remediation, the illegal foreshore structures should be removed. The use of the rock contained within this structure should be considered for use in the Wharf Road Stage 1 Protection Works (CH1_Ka).

Additional site improvements and opportunities can be explored (such as revegetation, biobanking and a recreational use plan), however, they would be additional to the core aspects of this option included in the CMP and completed under CH1_Ka.

Figure 1: Properties identified for acquisition

Timing:

Voluntary acquisition of private lots should occur in 2023 – 2026 subject to private landowner decisions.

Remediation of public land should commence immediately, with remediation of future public land to occur following completion of property acquisition process and site contamination and remediation plan.

Cost Benefit Assessment

Costs: as above

Benefits:

This option derives benefits from anticipated creation of nearly 11,575m^2 of public beach and vegetated open space from the purchase of 42 lots from private owners. This will allow for greater access to the beach for the public increasing its use values. This results in the following benefit realisation:

- **Created Amenity** is a benefit that is anticipated to occur from the transition of private land to public reserve and beach area. This area is predicted to provide both non-use value and use value for local residents, with greater access to sheltered family friendly beach. The created amenity is estimated to be valued at $29.75 per m^2 annually.

Additional non-quantifiable benefits could include improved habitat and connection to Country opportunities.

Results:

The table below highlights that this option has a negative NPV and has a BCR of 0.62 indicating that the option is not economically feasible to implement at this point in time.

BCR		NPV	
0.62		-$1,224,824	
Benefit		**Costs**	
Amenity	$2,040,368	**Capital Costs**	$3,265,192

CH1_P	Casey Beach Seawall
Location(s): Caseys Beach	
Coastal threat(s) to be addressed: Beach Erosion and Coastal Inundation (from wave overtopping)	
Outcome of CMP Assessment This option is recommended for inclusion in the CMP to address existing coastal erosion risk and wave overtopping of Beach Road.	

Costs:

In total, 535m of seawall proposed along the length of Beach Road.

Two options have been considered in the assessment of this option:

- Construct seawall to meet risk requirements out to 2065 (nominally a ~50year design life)
- Construct rubble mound seawall to address present day risks, and retrofit a vertical crest wall in future (approximately 2035)

Option 1: construct with crest wall (to address future risk to 2065)

- Capital Cost: $7,900,000
- Maintenance Costs: 1% of capital costs over life of structure

Option 2: construct without crest wall (rubble mound to address present day risk, including wave overtopping):

- Capital Cost: $6,600,000
- Future Capital Cost (~2035): $3,400,000
- Maintenance Costs: 1% of capital costs over life of structure

Option Description:

Replacement of the existing coastal protection works at Caseys Beach to protect Beach Road and reduce the likelihood of damage from wave overtopping during storm events.

There currently exists a proposed seawall design for Caseys that has been developed and approved by Council. Modification of the existing design would be required to ensure the proposed seawall design meets overtopping estimates under future sea level rise scenarios.

CMP Assessment:

The proposed seawall design (Aurecon, 2019) will provide adequate protection to ensure Beach Road is not impacted by coastal erosion and is adequately designed to withstand extreme coastal conditions. However, the crest level of the proposed design was limited to not exceed 1 armour stone (~1m) above the existing foreshore levels due to impacts on visual amenity (Aurecon, 2019). Wave overtopping of the existing seawall is a known issue, with damage to the road surface being experienced during extreme coastal events.

The proposed design targeted an average overtopping rate of less than 50 L/s/m to reduce the risk of such damage and the proposed design is stated as achieving this rate under existing conditions (i.e. current mean sea level conditions) as confirmed during physical model testing of the seawall (WRL, 2019). Future sea level rise will increase the overtopping rates at the seawall.

Wave runup and overtopping calculations for the proposed seawall design at Caseys Beach were performed using methods outlined in Eurotop (2018) and benchmarked against the physical model results (WRL, 2019) to provide an indication of rate over overtopping under future sea level rise scenarios. The following table summarises the results, noting an average overtopping rate of less than 50 L/s/m is targeted to reduce the risk of damage to the foreshore and road surface.

Mean Overtopping Rates (q) for the 100year ARI coastal storm under sea level rise scenarios

	Present	2050	2065	2100
q (L/s/m)	47	98	121	324

Initial analysis suggests that the proposed crest level and seawall design does not adequately protect against overtopping under future sea level rise conditions (based on the 100-year ARI storm event) and could therefore result in road and infrastructure damage.

To manage the risk of future wave overtopping a modification of the seawall design will be required. A possible modification to the seawall design is presented in **Figure 1** below and incorporates a vertical wall directly behind the structure crest. A similar wave return barrier example is provided in **Figure 2**.

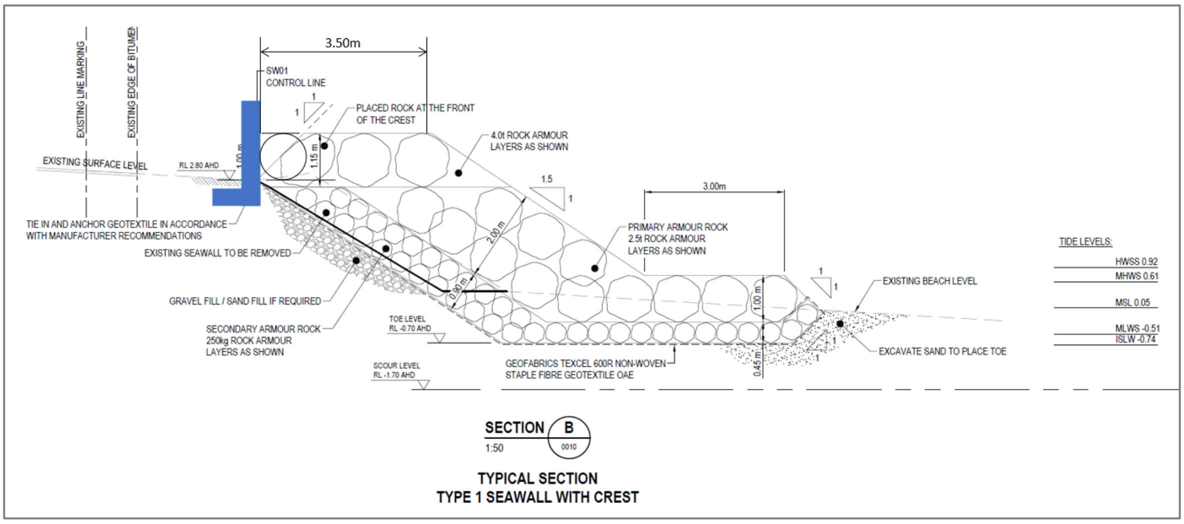


Figure 1 Seawall with Crest Typical Section

Figure 2 Example of wave return barrier, Port Kembla (from MHL, 2021)

Adopting a sea level rise over a reasonable structural design life (say to ~40 years to the year 2065), the required height of the vertical wall (above the existing foreshore level) to reduce mean wave overtopping to an acceptable rate (i.e. 50 L/s/m) is presented in the table below. If Option 2 is actioned, the suitable height of the vertical wall would be assessed in the next revision of the CMP.

Height of Vertical Crest Wall to reduce overtopping hazard for the 100year ARI coastal storm under sea level rise scenarios

	Present	2050	2065	2100
Wall Height* (m)	1.2	1.45	1.6	1.95

* above existing foreshore level of 2.8mRL to reduce overtopping rate to <= 50 L/s/m

^ assumes a 3.5m wide rubble mound crest in front of the vertical wall

Modifications to the proposed seawall design would need to subject to detailed design, including physical modelling if deemed required.

Beach nourishment to offset the increased footprint of the seawall should be considered to improve/restore beach width and amenity following the proposed seawall construction. This is not specifically included as part of this management option.

Reprofiling/raising of the road in conjunction with seawall crest raising may be desirable to ensure adequate drainage of the overtopped volume of water. Such works would need to consider access and drainage of private property along Beach Road.

Effectiveness:

- A correctly designed and constructed seawall will provide adequate protection to both undermining (from coastal erosion) and surface damage (from wave overtopping) to Beach Road and will ensure the safe use of the road and associated infrastructure under a greater range of coastal conditions.
- A seawall designed for present day conditions will reduce in effectiveness as sea level rises under future scenario, as the associated wave overtopping rate under extreme coastal storms will increase. As such the effective crest of the seawall will need to be raised into the future in line with this increasing risk. Should this be achieved then the seawall will be effective in protecting Beach Road from undermining and surface damage.

Timing:

- 2025. Identified as a priority option to manage an existing risk to undermining and damage of Beach Road.
- A design life of ~50 years could reasonably be applied to the coastal structure assuming the seawall design incorporates the vertical crest wall to protect against future sea level rise to 2065.
- The option could be staged to initially construct the rubble mound (rock) seawall and address the existing present day risk, with subsequent construction of a vertical crest wall to reduce the risk of wave overtopping under future sea level rise. Initial estimates indicate that by 2035 (SLR of 0.12m), an overtopping rate of 70 L/s/m would be expected under a 100 year ARI coastal event which meets the upper limit of tolerable overtopping rates for cars behind the crest in Eurotop (2018).

Cost Benefit Assessment

Costs: As above for both options

Benefits:

This option derives benefits from avoided costs that arise from the flooding and damages to waterfront properties on Beach Road and the Casey Beach Caravan Park. Additionally, the avoidance of road resurfacing costs as a result of water damage is another benefit which was included in the CBA modelling for this option. As a result of the proposed works the following benefits are anticipated:

- **Avoided road resurfacing** is a benefit that would occur due to the proposed seawall protecting Beach Road from wave runup and overtopping. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $143 per metre.
- **Avoided road replacement (erosion)** is a benefit that would occur as a result of constructing the proposed seawall, as it will reduce the probability of the road encountering erosion and having to be reconstructed. The value of this benefit was taken from the TfNSW Economic Parameters (2020) with the cost of $3429 per metre of a two-lane, flexible pavement road, where the road length is 535 metres. Additionally, there is an avoided cost of the temporary road which is required in the estimated two week period of road reconstruction. The value of avoiding this cost is derived from the pricing the anticipated 565 metres of metal temporary road sheeting which will allow for continued road access to properties along Beach Road. The temporary road will run adjacent to the existing road with connections to each property's driveway. Over a four-week period the cost per metre of the temporary road is $269, which totals to $303,970 per erosion event. The analysis assumes a 1% p.a. probability of road replacement within the first ten years, 2% p.a. for the next 30 years, and 3% p.a. subsequently.
- **Avoided isolation** is a benefit that would occur due to the proposed sea wall's wave return structure. This would prevent wave overtopping of Northcove Road and would mitigate against erosion damages to the road. Thus, allowing for the continuation of normative activity and emergency access for the residents of Caseys beach (371 people) 36 hours after an inundation or storm event.
- The cost of emergency access was derived from Batemans Bay hospitalisation rates for Eurobodalla residents and the triage severity of each visit and the cost of damages for which each case if untreated. These inputs were drawn from TfNSW's *Flood Risk Management Measures (2022)* and *flowinfo v 17 (2017).*
- The cost of ordinary activities was derived from the average cost per household per vehicular trip that would normally be undertaken and the cost of isolation (i.e. expenditure on goods and services that is no longer possible). These costs were derived from the averagely weekly spend per household for Eurobodalla and the average daily trips per household. This resulted in an avoided benefit of $40.54 per trip and $157 for each of the 38 households for each day of isolation. Given the uncertainty regarding level of disposable income, a 50% adjustment factor was applied to foregone daily expenditure to represent the cost of isolation.
- Additionally, a costing of $71.43 per person affected by an isolation period is implemented, to account for the cost of potential mental health related therapy and loss of production that occur as a result of prolonged isolation. This costing is derived from Deloite (2016) 'The Economic Cost of Social Impacts of Natural Disasters' and is scaled by a factor of 0.1 to account for the relative severity of possible inundation events.

Results:

The table below highlights that this option does not have a positive NPV and has a BCR well below 1 indicating that it is not economically feasible to implement at this point in time. However, the non-quantifiable benefits may be determined to add significantly to the low economic benefits, such as those associated with community expectations regarding continued and ongoing use of Beach Road during and following a storm event, and certainty of road use during high tourist demand periods.

Option 1 (CH1_Pa)

BCR		**NPV**	
0.15		-$6,321,984	
Benefit		**Costs**	
Resurfacing	$491,997	**Capital Costs**	$6,448,753
Erosion	$429,315	**Maintenance Costs**	$954,464
Access	$159,921		

Option 2(CH1_Pb)

BCR		**NPV**	
0.14		-$6,925,394	
Benefit		**Costs**	
Resurfacing	$491,997	**Capital Costs**	$6,798,445
Erosion	$429,315	**Maintenance Costs**	$1,208,182
Access	$159,921		

CH1_S	Sand nourishment post erosion event – Tomakin Cove

Location(s): Tomakin Cove

Coastal threat(s) to be addressed: Beach Erosion

Outcome of CMP Assessment

No viable source of sand can be identified at the time of CMP preparation. As such, this option is not recommended for inclusion in the CMP or CZEAS. Nourishment at Tomakin Cove could be considered in future CMPs if a suitable sand source can be identified.

Costs:

A capital cost of $115,000 per nourishment campaign, with no ongoing maintenance cost. This is a trigger-based nourishment and may be repeated after an extreme erosion event that results in 20-year to 100-year ARI erosion extents.

It is assumed that the cost of nourishment does not include the dredging costs, as dredging location and available sediment sources will have to be determined at the time of nourishment. A cost of approximately $115,000 for placement of dredge material is based on a rate of $5/ m^3.

Option Description:

Sand nourishment of Tomakin Cove sub-aerial dune system after large beach erosion events to protect public infrastructure and private property.

CMP Assessment:

- The Stage 2 Coastal Hazards Assessment, in conjunction with WRL (2017), identified that Tomakin Cove has a 20-year ARI storm demand volume of 59 m^3/m, and 100-year ARI storm demand of 90 m^3/m.
- Deterministic calculation of zone of slope adjustment (ZSA) based on storm demand, underlying shoreline movement, beach slope and beach volume, revealed that large erosion events could have significant impacts on the following locations at the 2017 and 2100 planning periods (Attachment 1):
    - 2017 100-year ARI event: dune system that protects private property.
    - 2100 100-year ARI event: private property along Sunpatch Parade.
- WRL (2017) identified a small recessional trend of -0.03 m/year, exacerbated to -0.05 m/year when incorporating sea level rise. These values have been incorporated into the ZSA hazard lines.
- Nourishment of the beach face post event would allow the dune system to recover and thereby protect infrastructure for future erosion events. If the dune system was not nourished, the next erosion event could significantly impact private property and eradicate the dune system.
- Trigger-based sand nourishment of the beach to the 'Nourished Profile + 10m Beach Width' nourishment profile shown in Figure 1. This will form a small dune at 1.6 mAHD, the location of a small natural berm shown in the 'Non-eroded Profile'. The nourishment will also accrete the beach by 10 m to allow a greater buffer to form and therefore protect private property and assist in the recovery of the remaining dune.
- The equilibrium slope that is the basis of the nourished profile was calculated by using a profile scale parameter of 0.16 $m^{1/3}$ (Dean, 2002). This was performed so that the nourished profile was in line with the 'Non-eroded' profile extracted from 2022 photogrammetry of Tomakin Cove.

- Based on a beach length of 250 m, an approximate total nourishment volume requirement is 22,500 m^3. At a cost/m^3 of $5, the capital costs of placement are ~$115,000

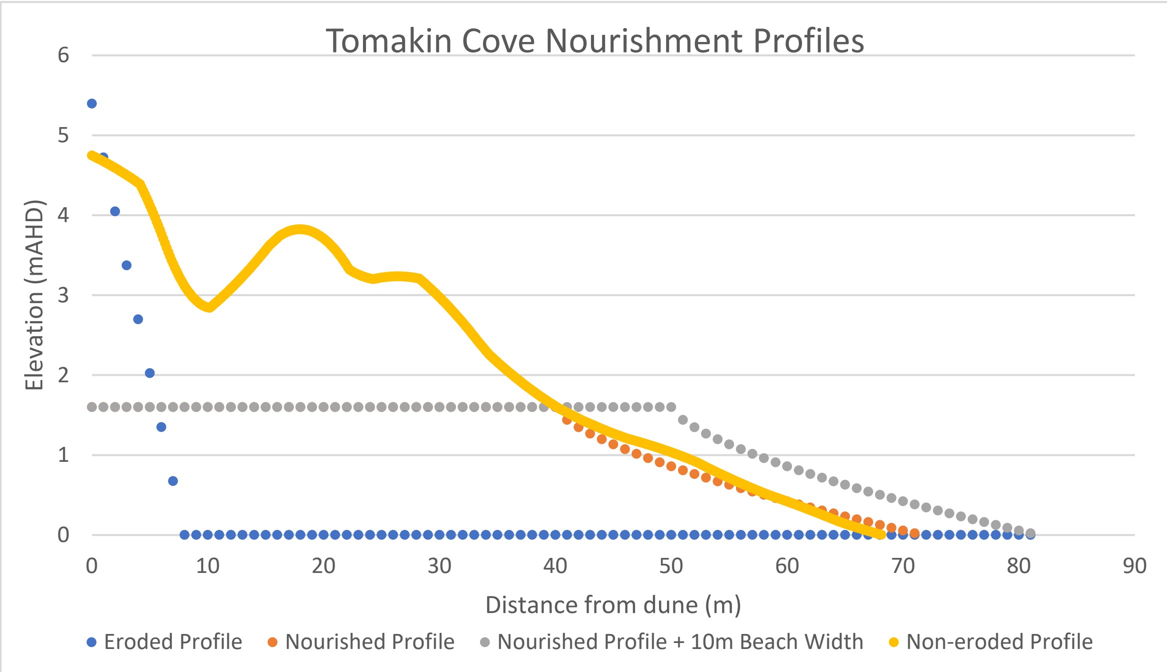


Figure 1 Beach Nourishment Profiles for Tomakin Cove

Effectiveness:

- Protection of private property at Sunpatch Parade from erosion – highly effective against a 100-year ARI storm event in the present day.
- For 2050, 2065 and 2100 planning periods, it is moderately effective in reducing impacts for private property. However, the dune must be in a nourished and healthy state with sufficient allowance for the requisite storm demand, to provide protection.
- A revision of nourishment amounts, and placement strategies may be warranted by 2050 to ensure that the impacts from sea level rise and associated landwards migration of the dune system are sufficiently accounted for and mitigated against to allow a consistently healthy dune buffer.

Timing:

- Trigger based following a large coastal erosion event

Attachment 1:

CH1_T	Stabilisation of sand spit to rocky outcrop
Location(s): Tomakin Cove	
Coastal threat(s) to be addressed: Beach Erosion	
Outcome of CMP Assessment This option is not recommended for inclusion in the CMP as it would not moderate the effects of sea level rise induced recession, with limited impact on the predicted 2100 Erosion Hazard Line.	
Costs: Not Costed	
Option Description: The rocky outcrop at the south-west end of Tomakin Cove provides significant protection to the cove from wave-induced erosion as it promotes the formation of a tombolo feature in its lee. If this tombolo was eroded, it would change the shape and sediment dynamics at Tomakin Cove, increasing long-shore sediment transport and erosion. This option would be triggered in the event of a severe erosion event, where the sand between the dune system and the rocky outcrop is eroded. The construction of a small seawall/groyne (located in red in **Attachment 1**) could be constructed, to promote the regrowth of the tombolo, reduce longshore sediment transport potential and maintain a protected embayment at Tomakin Cove. This would minimise the risk of a changed beach shape and increased wave exposure.	

CMP Assessment:
• The Stage 2 Coastal Hazards Assessment, in conjunction with WRL (2017), identified that Tomakin Cove has a 20-year ARI storm demand volume of 59 m^3/m, and 100-year ARI storm demand of 90 m^3/m.
• Deterministic calculation of zone of slope adjustment (ZSA) based on storm demand, underlying shoreline movement, beach slope and beach volume, revealed that large erosion events could have significant impacts on the following locations at the 2017 and 2100 planning periods (**Attachment 1**):
  ◦ 2017 100-year ARI event: dune system that protects private property.
  ◦ 2100 100-year ARI event: private property along Sunpatch Parade.
• WRL (2017) identified a small recessional trend of -0.03 m/year, exacerbated to -0.05 m/year when incorporating sea level rise. These values have been incorporated into the ZSA hazard lines.	

Effectiveness: • The construction of a rubble mound groyne structure would act as a sediment trap to allow natural processes to re-build the sand spit. This would maintain the existing embayment under existing conditions and reinforce and retain the natural erosion buffer provided by the dune system. • Would not moderate the effects of sea level rise induced recession, with limited impact on the predicted 2100 Erosion Hazard Line.	
Timing: • Trigger based following a large coastal erosion event that removed the sandspit to the rocky outcrop.	

Attachment 1:

CH1_U	Offshore Reef
Location(s): Tomakin Cove	
Coastal threat(s) to be addressed: Beach Erosion	
CMP Assessment Outcome This option is not recommended for inclusion in the CMP as the existing risk to private property and dune systems is relatively low and does not justify the expense of an offshore reef. The option also does not provide adequate protection against recession caused by sea level rise. Further limitations are discussed below.	
Costs: No detailed design or costings have been performed for this option as the assessment did not identify suitable merits to warrant implementation.	
Option Description: Offshore reef located between the rocky outcrops at Tomakin to reduce wave-induced beach erosion.	

CMP Assessment:
• The Stage 2 Coastal Hazards Assessment, in conjunction with WRL (2017), identified that Tomakin Cove has a 20-year ARI storm demand volume of 59 m^3/m, and 100-year ARI storm demand of 90 m^3/m.
• Deterministic calculation of zone of slope adjustment (ZSA) based on storm demand, underlying shoreline movement, beach slope and beach volume, revealed that large erosion events could have significant impacts on the following locations at the 2017 and 2100 planning periods (**Attachment 1**):
  • 2017 100-year ARI event: dune system that protects private property.
  • 2100 100-year ARI event: private property along Sunpatch Parade.
• WRL (2017) identified a small recessional trend of -0.03 m/year, exacerbated to -0.05 m/year when incorporating sea level rise. These values have been incorporated into the ZSA hazard lines.
• An offshore reef would be located between the rocky outcrops (**Figure 1**). This would provide an effective wave dissipation under coastal storms and reduce wave energy entering the cove, thereby significantly decreasing sediment transport and associated erosion of the beach face.
• However, it would not prevent sea level rise associated recession, thereby reducing effectiveness in the long-term.	

Effectiveness/Benefits: • Protection of private property at Sunpatch Parade from erosion – considered effective against a 100-year ARI storm event in the present day. • For 2050, 2065 and 2100 planning periods, it is considered moderately effective (but reducing with time) in limiting impacts for private property. • Act as an artificial reef and increase habitat.	
Limitations: • Would not prevent sea level rise associated recession, which is a key issue long terms at Tomakin Cove. • Expensive to design, build and maintain.	

- If the sandy spit to the rocky outcrop disappears, would not limit long-shore sediment transport and reduce effectiveness.

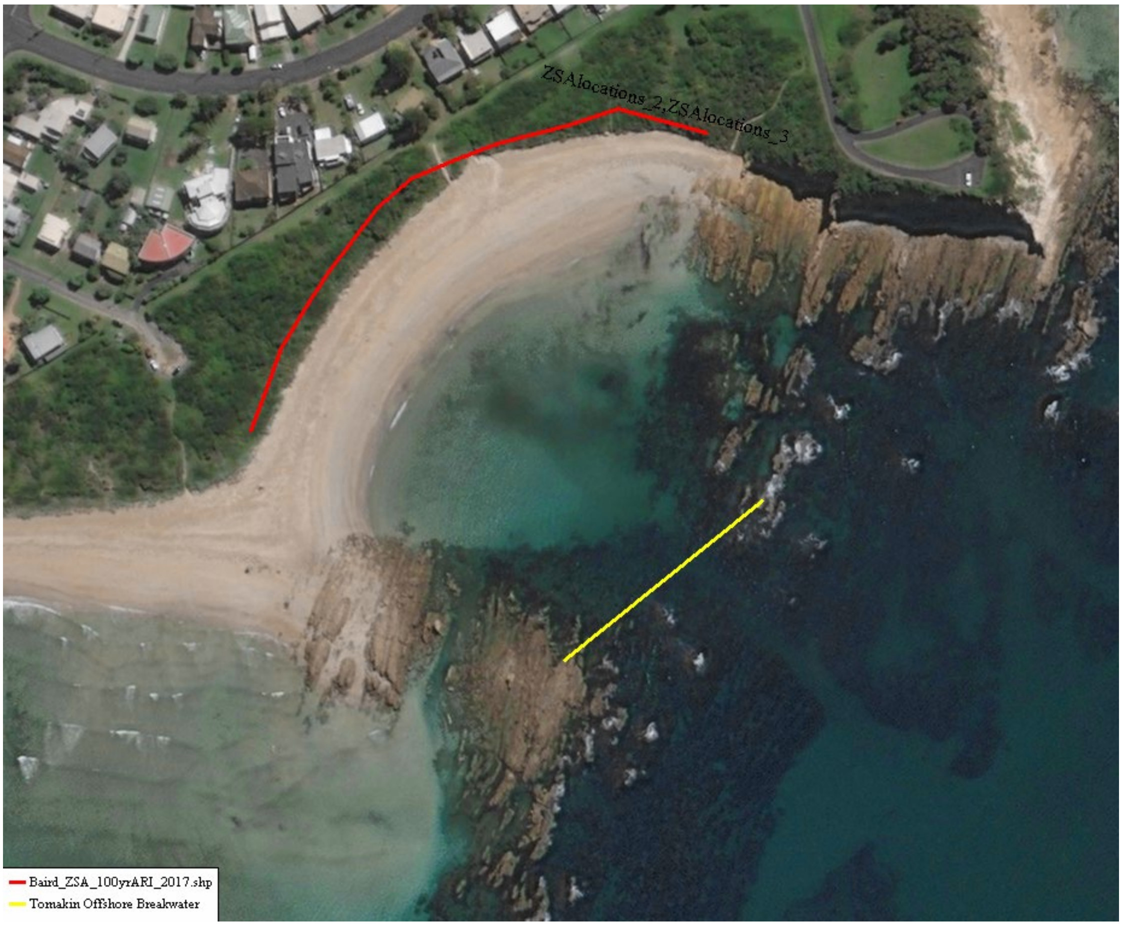


Figure 1 Tomakin Cove Offshore Breakwater Potential Location

Attachment 1:

Scale : 1:1000@A3
Date : 22 November 2021
Revision : B
Created by : LRE
Coordinate System : MGA 94

20 0 20 40 60 m

Legend
- Erosion Hazard Line 2017
- Reduced Foundation Capacity 2017
- Erosion Hazard Line 2100
- Reduced Foundation Capacity 2100

RG-04-01
Stage 2 Assessments
Erosion Risk
Tomakin Cove

CH1_V	Private land acquisition and restoration to public dune and beach
Location(s): Broulee	

Coastal threat(s) to be addressed:

- CH Threat 1 Beach Erosion
- CH Threat 2 Shoreline Recession
- CD Threat 1 Coastal development resulting in loss of plant and animal species (habitat disturbance or loss)
- CD Threat 4 Coastal development encroaching onto natural coastal processes to exacerbate hazard impacts

CMP Assessment Outcome

This option is not recommended for inclusion in the CMP as there is no existing erosion risk to the subject properties and future erosion risk can be managed through implementation of development controls.

Costs:

- Capital costs for this option consists of an initial $4.8 million in capital costs to acquire the private properties and clear them to create public land.
- Maintenance costs for this option are $5,000 per year to maintain scrubland

Responsible agencies:

Eurobodalla Shire Council, supported by DPE and Crown Lands

Option Description:

Four properties seaward of Coronation Drive, Broulee will come under increasing risk from beach erosion and shoreline recession towards 2100.

This option assesses the merits of purchasing these properties and returning the land to public reserve. The viability of this option has to be weighed against the suitability of using development controls alone to manage the risk to property, assets and lives at this location.

Timing:

It has been assumed There is no existing erosion risk to the subject properties, however, properties from about 2075 are predicted to be at risk. If the dwellings on the properties were to be redeveloped, they could extend the life of the structure increasing likely future public expenditure costs for purchase and removal as well as potential amenity incursions in the interim. Therefore the economic analysis of this option assumes that the property purchase would occur within the next 10 years.

Cost Benefit Assessment

Costs: as above

Benefits:

This option derives benefits from anticipated creation of public coastal dune vegetation from the purchase of three lots from private owners. This isn't anticipated to create greater access to the beach for the public or substantial alter use values but does increase its non-use values for the creation of preservation of dune structures and scrubland ecosystems. This results in the following benefit realisation:

- **Created Amenity** is a benefit that is anticipated to occur from the transition of private land to public coastal dune vegetation area. This area is predicted to provide non-use value for local residents. The created amenity is estimated to \$5.83 per m^2 of scrubland.

There is no erosion risk to the properties within the 50 year economic analysis period, so benefits associated with hazard mitigation are not included.

The reduction in coastal erosion risk has not been included in the CBA as the benefits occur beyond the timeframe of the economic assessment.

Results:

The table below highlights that this option has a negative NPV and has a BCR well below 1 indicating that the option not economically feasible to implement. If opportunities to enhance the public utilisation of this area were identified, an improved economic feasibility may be realised.

BCR		**NPV**	
0.03		-\$3,841,417	
Benefit		**Costs**	
Amenity	\$137,221	**Capital Costs**	\$3,918,230
		Maintenance Costs	\$60,409

CH1_Y	**Sewage pump stations and reticulation infrastructure at risk to be include in future works plans**
Location(s): Long Beach, Malua Bay Beach and Broulee Beach	
Coastal threat(s) to be addressed: Beach Erosion	
Outcome of CMP Assessment At-risk assets identified in this option assessment should be included in future works plans to incorporate management and/or protection measures when undertaking works (maintenance, upgrades, replacements, etc) on these assets. The CMP will include this reporting as an action.	
Costs: Monitoring only. Existing Council staff time and resources during the operational period of this CMP.	
Option Description: Council maintains a network of reticulation and sewer infrastructure, with a number of assets located along the coastline. The CMP identified which assets are at risk (both existing and future) of damage during erosion events. The identification of at-risk assets allows Council to incorporate management and/or protection measures when undertaking works (maintenance, upgrades, replacements, etc) on these assets.	
CMP Assessment: The Council data set for reticulation and sewer stations were overlaid on erosion risk zones for current and 2100 scenarios. All sewer pump stations were found to be outside identified 2100 erosion hazard zones. All reticulation assets were found to be outside the existing 1% AEP erosion risk zone. It should be noted however that some assets in Long Beach are only marginally outside this extent. Reticulation assets become at risk to erosion damage in 2100 in Long Beach, Malua Bay Beach and Broulee Beach The locations are shown below.   	

Effectiveness:

Early identification of reticulation assets that are expected to experience erosion risk in future years allows for proactive management measures to be implemented. The fact that no assets are currently at risk allows Council to incrementally address future risks for identified assets as required, to ensure that the network does not experience damage in large storm events.

Timing:

No structural works are required during the expected operational period of this CMP. However, it is recommended that Council review the assets expected to become at risk in future years, and to begin developing appropriate management strategies. This would allow management works to be undertaken when repair or replacements works are being undertaken on these assets in the future.

CH1_Z	Monitor stormwater assets in erosion areas

Location(s): Long Beach, Surfside, Malua Bay Beach, Tomakin Cove

Coastal threat(s) to be addressed: Beach Erosion.

Outcome of CMP Assessment

At-risk assets identified in this option assessment should be included in future works plans to incorporate management and/or protection measures when undertaking works (maintenance, upgrades, replacements, etc) on these assets. The CMP will include this reporting as an action.

Costs:

Existing Council staff and resources only.

No works required in next 10 years unless opportunity arises.

Responsible agencies: Eurobodalla Shire Council

Option Description:

A number of locations have been assessed as at risk of erosion, under existing as well as future catchment conditions.

This option identifies stormwater assets currently within erosion risk zones, so that monitoring plans can be put in place to check the condition of these assets following large storm events.

CMP Assessment:

Councils stormwater asset GIS data set was overlaid on the erosion hazard zones prepared as part of the Stage 2 works. Where assets were located within these zones, they were mapped for monitoring. The locations are shown in the figure below.

At risk assets were identified in Long Beach (9), Surfside (6), Malua Bay Beach (1), and Tomakin Cove (1).

Long Beach and Surfside

Malua Bay Beach

Effectiveness:

The implementation of a management plan for these assets would ensure that any damage to these assets is quickly noted and addressed following large storm events.

The plans could also be used to inform the future relocation and/or protection of these assets against beach erosion.

The plans would remain usable under future climate scenarios, and indeed would become more important as the frequency of significant events increases as a result of climate change.

Timing:

- The plans could be prepared and implemented as soon as resources permit.
- The plans would remain affective for the lifetime of each particular asset.

CH1_ZA	**Culvert Extension / Groyne and Beach Nourishment**
Location(s): Surfside West Beach (Dog Beach)	
Coastal threat(s) to be addressed: Beach Erosion / Shoreline Recession	

Outcome of CMP Assessment

The option is not recommended for inclusion in the CMP as the works result in:

- Likely increases in the frequency of Wharf Road overtopping from catchment flow.
- Minor increases in catchment flood levels upstream of Wharf Road.
- Significant alterations to the entrance of a Class 3 stream and Type 1 Fisheries habitat.
- Protrusion into a Habitat Protection Zone of Batemans Marine Park.

In addition, the protection of Wharf Road and the adjoining area from erosion can be achieved without the negative impacts above through the implementation of road and culvert protection works (option CH1_ZB) and a flood levee (option CH4_D). Beach amenity will also be protected through ongoing nourishment when sand is available from Clyde River navigation dredging operations (option CH1_L),

Costs:

The construction of the structure would be a single upfront capital cost with ongoing maintenance of the structure required. Maintenance would include that of both a coastal and drainage structure and nourishment as required.

Capital Cost: $3,600,000

Maintenance Costs: 2% of capital costs annually over life of structure

Design Life: 50 years

Option Description

Construct a culvert extension that would also function as a groyne structure to retain sand on Surfside West Beach (Dog Beach).

Surfside West Beach (Dog Beach) was identified as being a beach with high usage, however, is subject to large fluctuations in beach width as a result of the dynamic shoals between the Clyde River entrance and Pinnacle Point, as well as flood flows out of Surfside Creek that regularly reshape and erode the beach compartment.

To stabilise the beach compartment, a culvert extension has been assessed that would have a dual purpose of moving the Surfside Creek outlet away (offshore) of the beach face and also act as groyne to anchor the western end of Surfside West Beach (Dog Beach).

Figure 1 provides an indicative alignment of the structure, with an anticipated shoreline response. The structure would be approximately 90m long with its toe located below 0mAHD.

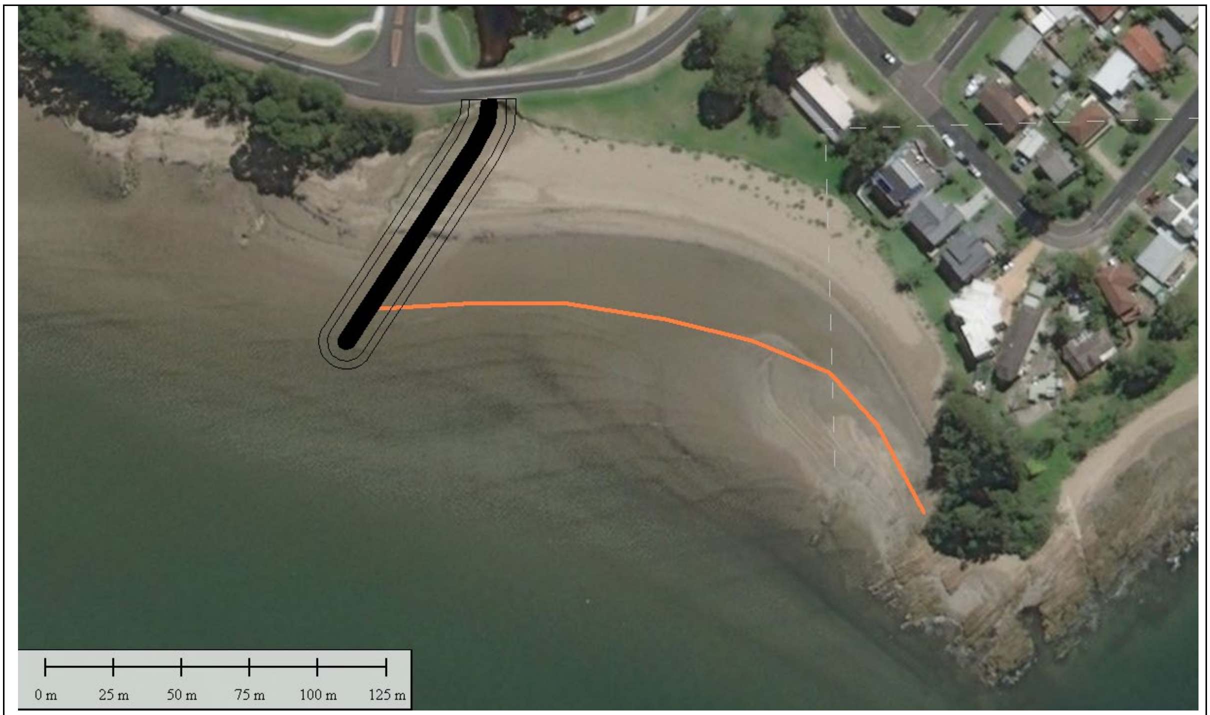


Figure 1. Indicative alignment of a culvert extension/groyne structure (black) at Macleod's beach with anticipated shoreline response (orange)

Surfside Creek drains to Batemans Bay via three culverts under Wharf Road, each with a diameter of 1.8m. The groyne structure would therefore need to accommodate the cross-sectional area of the culvert pipes through its trunk and provide adequate protection against damage from coastal storms (waves) and flood flows (from the Clyde River).

Figure 2 provides indicative cross sections along the groyne length and width and includes double armour stone layers across the structure slopes and crest, and a single armour layer around the toe to act as scour protection. The structure crest would be constructed at ~2.2mAHD, with a concrete path integrated to allow public access, tying in with the level of Wharf Road across the existing outlets, and allow suitable fall between the existing outlet inverts and the new outlet position. A flood gate could be added to the seaward end to reduce the ingress of elevated coastal water levels (subject to sediment dynamics at the outlet).

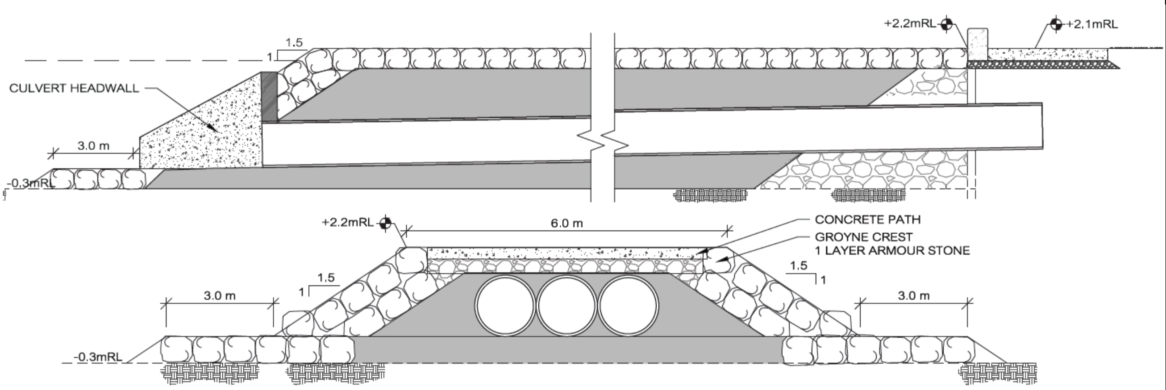


Figure 2. Indicative cross sections of a culvert extension/groyne structure at Macleod's beach

CMP Assessment

Structural design of the structure would include sizing of the armour stones on the side slopes and crest which would be sized to be stable under extreme coastal conditions and require 1-3t armour stones on the side slopes and 3-4t armour stones on the crest. Scour protection would consider wave action, but also peak flood flow velocities from the Clyde River, and require stones in range 750kg-1.5t. Detailed design and optimisation of the outlet structure (headstock), scour protection and foundation at the head would be required.

The capacity of the existing three culverts is estimated as 15 m^3/s of flow, which would be maintained under this groyne extension. This capacity is only achievable when water levels are below the culvert invert. As levels rise above the invert, the capacity of the culvert drops significantly. The capacity was assessed in the Batemans Bay Urban Creeks Flood Study (2021) as being sufficient for flood flows out of Surfside Creek up to the 5% AEP. In the 1% AEP the Flood Study found that flows broke out of the creek and flowed over Wharf Road immediately to the east of the culvert. As such, the groyne extension would be effective in diverting low magnitude flood flows away from Macleod's beach but would be overwhelmed under the 1% AEP flood. The invert level at the outlet would need to be raised and optimised based on coincident downstream (coastal) water level considerations.

The alignment and crest height would mean the structure acts as an effective trap for longshore sediments that travel in a westerly direction under ambient conditions. Further, it would afford the Macleod's beach compartment some protection from flood flows from the Clyde River by deflecting flows away from the shoreline. As such, a stable beach compartment width could be achieved between Pinnacle Point and the groyne structure. An assessment of the anticipated shoreline response to the presence of the groyne structure was completed using the parabolic beach shape equation (Evans and Hsu, 1989). The method estimates the expected static equilibrium shape of a beach between two controlling points and assumes a sandy beach with swell incident at the beach from a narrow directional band and where longshore sediment transport is largely driven by swell energy. The resulting anticipated shoreline alignment is presented in Figure 1.

The impacts to shorelines to the west of the structure are likely to be minimal as they consist of rocky outcrops with limited sub-aerial beach. The lack of notable beach width along Wharf Road is due to the oblique incident waves and resulting large longshore transport rates. The proposed structure would have limited and localised impacts to this incident waves along the length shoreline.

Preliminary flood modelling has been undertaken to assess the impacts of the proposed culvert extension. Modelling was undertaken for the 5% AEP and 1% AEP events. Results shown in **Figures 2 and 3**. For the full length culvert, minor upstream increases were observed in both AEP events. In the 1% AEP, the increases impacted properties between the creek and the eastern arm of Timbara Crescent.

Figure 2 - Flood Impacts 5% AEP

Figure 3 - Flood Impacts 1% AEP

Effectiveness:

The proposed structure has two principal objectives.

- *Diverting flows from Surfside Creek further offshore away from Macleod's shoreline*. The effectiveness of the structure to divert flood flows depends on the capacity of the culverts and the invert levels that can be achieved. In this regard the option is constrained by the existing creek outlet, particularly in terms of invert levels. Levels would need to optimised to ensure efficient drainage of creek flows and the interaction with tides and elevated coastal water level. As a result, the structure would be effective in diverting flood flows, but be ineffective when the coastal water levels are elevated (particularly beyond MHWS).
- *Trapping longshore transport to retain a stable beach compartment*. A structure in the order of 90m in length will provide an efficient trap for westerly longshore sediment. There may be a need for periodic nourishment of the beach compartment after severe coastal events, however the supply of westerly transport under ambient coastal driven conditions should be sufficient to maintain a full beach compartment and provide recovery of the beach volume after storm induced erosion.
- Sea level rise will reduce the effectiveness of the structure as an outlet for Surfside Creek, with increased sea levels reducing the effectiveness of the outflow. However, with a crest level above +2mAHD the structure will continue to act as an effective groyne.

Incorporation of a tidal gate could also be considered in the future and incorporated in current headstock design.

Benefit

The proposed structure would act to stabilise the Macleod's beach compartment, providing the following benefits:

- Increased protection against coastal storm induced erosion by maintaining a stable and wide beach profile.
- Provide for improved beach amenity. Community consultation noted that the beach is a popular spot and frequently used by the local community, it being easily accessible from Wharf Road.

The groyne structure also has the potential negative impacts:

- Increased frequency of Wharf Road overtopping from catchment flow.
- Increases in catchment flood levels upstream of Wharf Road.
- Significant alterations to the entrance of a Class 3 stream and Type 1 Fisheries habitat.
- Protrusion into a Habitat Protection Zone of Batemans Marine Park.

Timing: Medium priority works

Cost Benefit Assessment

Costs: as above

Benefits:

This option derives benefits from anticipated creation of over 4,000m^2 of beach from the entrapment of westerly longshore sediment by the 90m groyne. Due to this beach's popularity amongst local residents this beach extension is anticipated to create greater use value for the beach. As a result the following benefit is anticipated to be realised after the completion of works:

- **Created Amenity** is a benefit that is anticipated to occur from the build-up of sand along the Surfside bay area. This area is predicted to provide use value for local residents, with greater access to sheltered dog and family friendly beach. The created amenity is estimated to increase the use factor of the beach by 5%. This is valued at \$29.75 per m^2 per year for the created beach area.

The build-up of sand is also likely to provide future erosion protection to the properties located at McClouds Beach. However, the erosion risk to these properties occurs beyond the timeframe of the economic assessment.

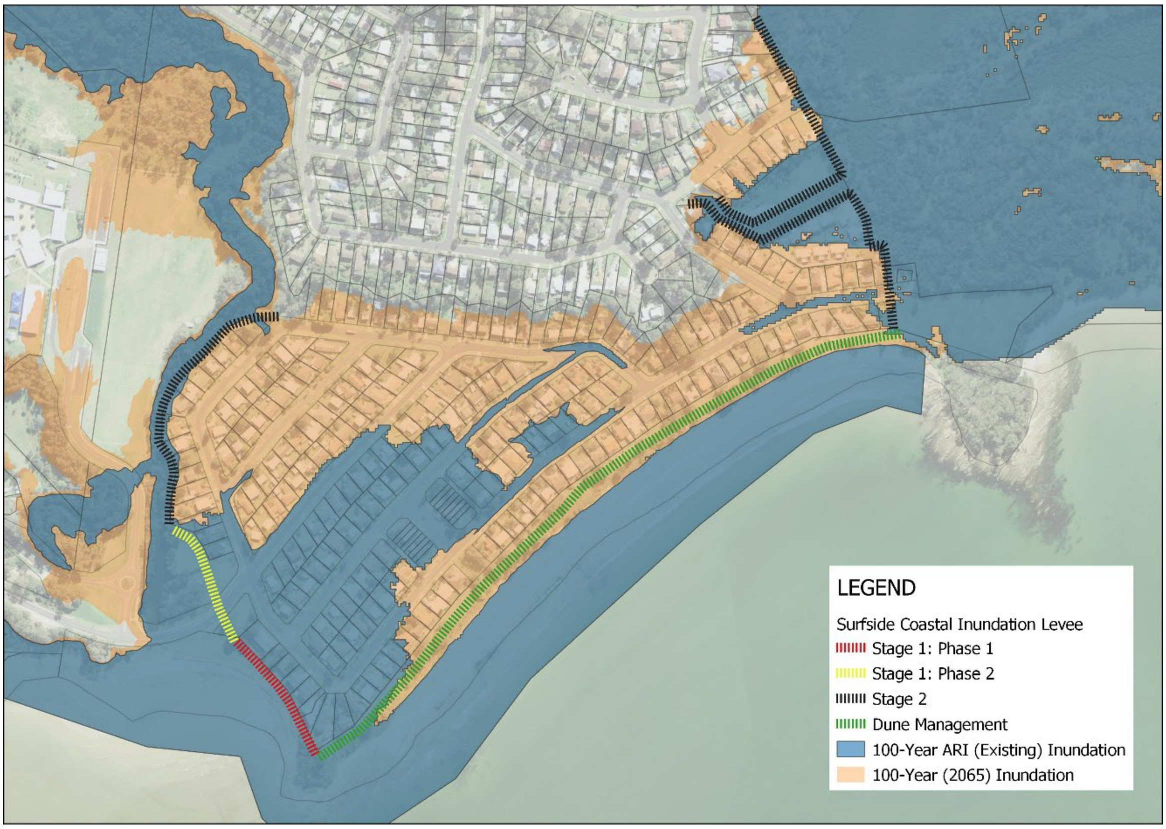
Results:

The table below highlights that this option has a positive NPV and has a BCR of 1.36 indicating that the option economically feasible to implement at this point in time.

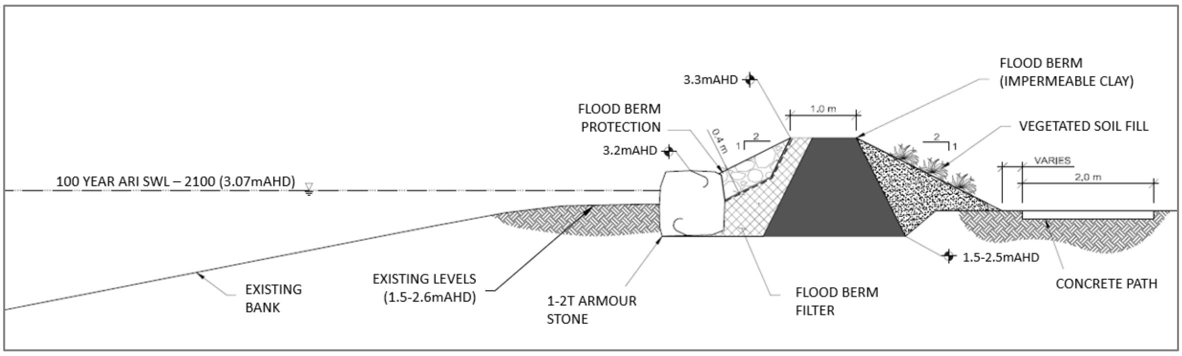
BCR		NPV	
1.03		\$132,414	
Benefit		**Costs**	
Amenity	\$3,940,978	**Capital Costs**	\$2,938,672
		Maintenance Costs	\$869,891

CH4_D	Surfside Coastal Inundation Levee
Location(s): Surfside	
CMP Assessment Outcome Stage 1 of this option is recommended for inclusion in the CMP. The works are recommended to be undertaken over two phases.	
Coastal threat(s) to be addressed: Coastal Inundation	
Costs: In total, 1200m of Coastal Inundation Levee is required to protect Surfside from flooding to the 2100 100-year ARI coastal flood level. The costs of each stage to progressively construct and raise Coastal Inundation Levee are: • Investigation and Design (costs included in Stage 1 below) • Stage 1: 300m of levee with crest level of +2.5mAHD. Capital cost: $3,100,000 • Stage 2: Raise Stage 1 levee to crest level of +2.8mAHD and construct further 630m of levee to same level. Dune management to ensure the dune crest level is at or above 2.8mAHD. Capital Cost: $5,300,000 • Stage 3: Raise Stage 1 and 2 levee to crest level of +3.3mAHD and undertake dune management to ensure dune crest height is also at 3.3mAHD. This stage has not been costed as part of the CMP assessment; it falls outside of the cost benefit analysis time period. Maintenance Costs: 1% of capital costs per annum over life of structure	
Option Description: The urban regions of the Surfside subcatchment adjacent to the bay are low lying and at risk of inundation in coastal storm events. Development is currently affected in the 20-year ARI coastal storm event, and affectation and associated risks increases in the future due to sea level rise exacerbating flood levels. The option would see the staged construction of a Coastal Inundation Levee to protect the low-lying residential precinct adjacent to the bay. The levee is proposed to be constructed in stages, as illustrated below. The first stage would see a levee constructed along the western boundary of the precinct in order to protect the region from inundation in a 100-year ARI ocean storm. This stage could be undertaken in two phases, the first being the 150m closest to the foreshore, and the second phase, which involves integration with Wharf Road undertaken as part of the Floodplain Risk Management Plan for Surfside to optimise the design for dual benefits associated with catchment flood protection. By 2065, to ensure this protection remains despite raising sea levels, the levee height would be increased, its length extended along the western boundary, and a second levee on the eastern boundary added to protect against flooding from Cullendulla. Minor dune stabilisation works would also be required along isolated regions to infill existing low points along the dune to the proposed levee level. By 2100, when sea levels are projected to be higher again, the full length of both eastern and western levees will require further raising, and additional works will be required along the full length of the bay-side dune to build it up to the levee level.	

Whilst the option has been developed in response to ocean flooding, it will also protect the region from catchment driven flood events.

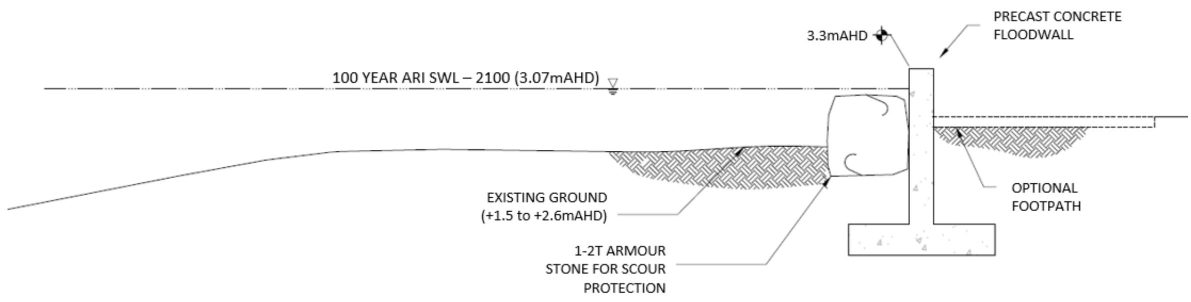


A concept design for a Coastal Inundation Levee is presented in the cross-section figure below. The levee effectively consists of an impermeable core with armouring on the flood prone side and a vegetated slope on the protected side.



The horizontal footprint of the Coastal Inundation Levee will be dependent on crest level targeted and existing ground level. Existing ground levels along the first stage of levee vary between 1.5 and 2mAHD, such that a Coastal Inundation Levee with height of 0.5-1m and width (at the base) of 3 to 5m would be required to achieve a crest level of +2.5mAHD. Increasing the crest height to +3.3mAHD (above the 2100 100year ARI ocean flood level) would require a levee height of 1.3 to 1.8m with a width of up to 8m.

Where such a footprint is not feasible or desired an alternate structure type could be constructed, consisting of a vertical wall (precast concrete flood walls or SSP) to provide the same protection with reduced footprint. Such an option is schematised in the Figure below.



CMP Assessment:

A provisional flood damages assessment was undertaken for the 100-year ARI ocean flood depths. All properties were identified from the aerial and an indicative ground level sampled for each based on LiDAR data. As property survey was not available, it was assumed that all property floor levels were 0.3m above ground level.

Residential damage curves were generated based on the curves prepared by the Department of Natural Resources (now DPIE) in 2007. The curves estimate flood damages for standard residential properties based on the extent of over floor flooding. The damage curves are calculated based on an assumed floor area of 240m^2, and a warning time of 0-hours.

The over floor flooding depths in the 100-year ARI was determined based on the modelled flood level, the sampled ground level, and the assumed 0.3m floor height. The assessment was done for the existing, 2065, and 2100 100-year ARI flood events. The estimated damages for these events was:

- $2,525,000 in the existing scenario
- $14,910,000 in the 2065 scenario
- $33,950,000 in the 2100 scenario

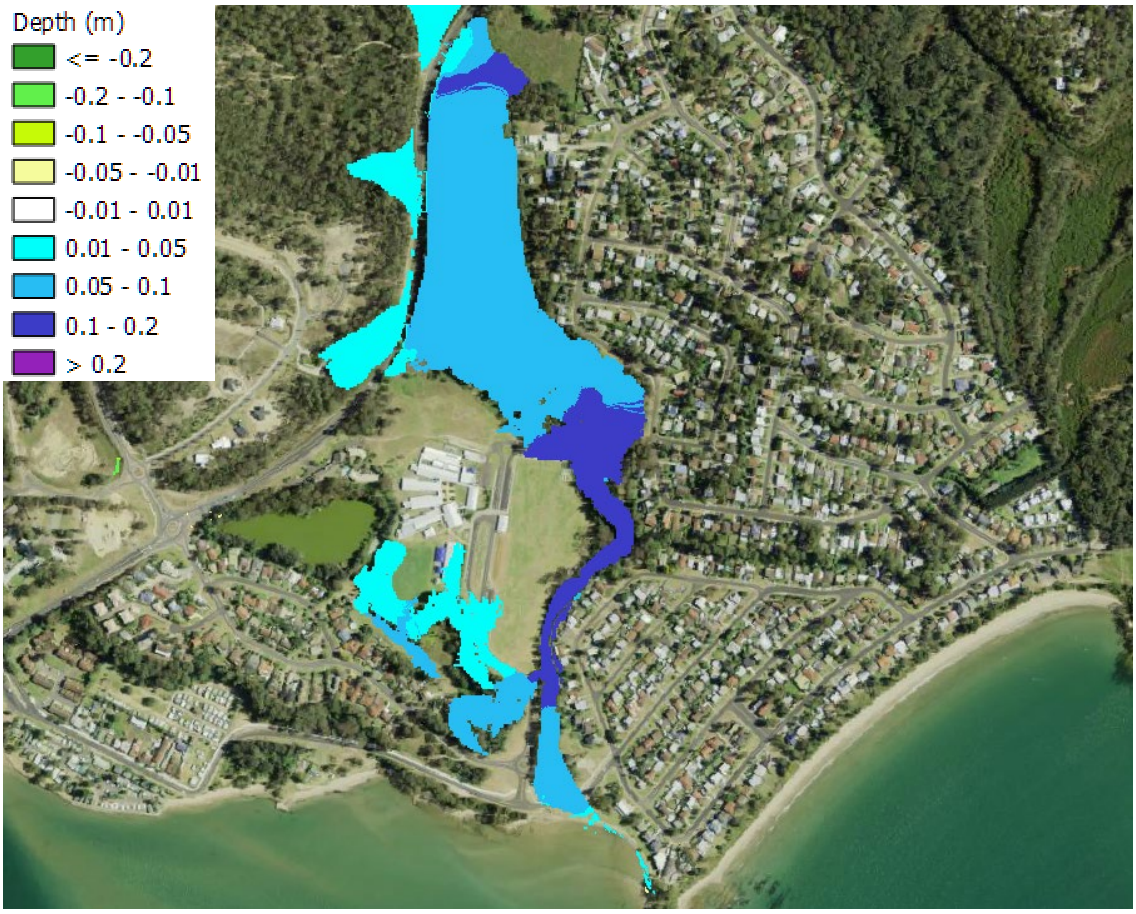
Higher damages in future events are due to sea level rise which increases both the extent of inundation and the flood depths experienced.

The levee was also assessed for the 1% AEP local catchment event to determine its impacts and effectiveness on catchment flood events.

The levee was found to protect the region from local catchment floods. However, the levee reduced the overbank conveyance in Surfside Creek resulting in peak flood level increases in the adjacent creek by up to 0.12m. Increases of up to 0.02m occurred upstream to the highway. Impacts were typically fully contained within the creek and vegetated back areas, save for some increases of up to 0.03m which affected Batemans Bay public school. Given the relatively small size of these impacts, it is expected that they could be resolved during detailed design by minor adjustments to the levee alignment.

It is noted that the levee passes through private property and would need the approval of these properties to proceed. It is also noted that it would need all property owners to accept the works and easements gained to be feasible. If property owners object, it may be possible to instead raise Timbarra Crescent, which would still provide benefits for the wider residential region.

The construction of the levee would also necessitate upgrades to the existing drainage network. As part of this option, the outlets would require flood gates to prevent surcharge from the pits when sea levels are elevated.



Effectiveness:

- The Coastal Inundation Levee will protect the residential precinct (and the associated infrastructure and Council assets) in events up to and including the 100-year ARI ocean storm.
- Whilst the option has been developed in response to ocean flooding, it will also protect the region from catchment driven flood events.
- The effectiveness of the option will be dependent on the ongoing monitoring and maintenance of the levee and dune works to ensure they remain higher than projected storm levels.
- Climate change will reduce the effectiveness of a given levee level. To address this, the works are proposed to be staged, to lift the height of the levee in line with projected increases in ocean flood levels.

Timing:

- The Stage 1 levee is recommended for construction when funds are available. It will offer an immediate benefit to currently flood affected properties.
- The proposed extents and levels of future stages should be re-assessed when this CMP is revised in the future, in light of the most recent advice of projected sea level rise.

Cost Benefit Assessment

Costs: as above

Benefits:

This option derives benefits from avoided costs that arise from the flooding and damages to residential properties within Surfside that were forecasted in the coastal inundation modelling. As a result of the proposed works the following benefit is anticipated:

- **Avoided Property Damages** is a benefit that arises from protection of residential properties from coastal inundation events. The damages are calculated based on damage curves from the DPE and include maintenance, replacement and relocation costings. This is translated into an Average Annual Damage reading which summaries the potential damages in any given year, based on the severity and like hood of the damages occurring.

Results:

The tables below highlights that this option in both scenarios has a positive NPV and has a BCR above 1 indicating that the option economically feasible to implement at this point in time.

Option 1:

BCR		NPV	
1.41		$2,102,035	
Benefit		**Costs**	
AAD	$7,219,966	**Capital Costs**	$3,619,786
		Maintenance Costs	$1,498,145

CH4_G	Installation of flood gates on priority outlets
Location(s): Surfside	
Coastal threat(s) to be addressed: Beach Erosion and Coastal Inundation	
Outcome of CMP Assessment This option is recommended for inclusion in the CMP.	
Costs: Capital cost: $35,000 (average of $5,000 per gate) Maintenance cost: Up to $3000 / Year	

Option Description:

Low-lying areas of land, while protected by adjacent coastal protection structures or dunes, can experience inundation as a result of surcharge from the local pit network when adjacent bay / ocean levels are high. The option would see the installation of flood flaps on selected pipes to prevent this surcharge. The locations, and their respective priority (high / medium / low) are:

- Wharf Rd, Surfside West (high)
- Korners Park (low)
- Clyde St, CBD (high)
- Beach Rd, CBD (low)
- Beach Road at Club Catalina (high)
- Batemans Bay Marina Resort, Catalina (two outlets) (high)

Sites noted as high priority have the potential to impact a significant number of existing properties or to impact major access routes. Medium priority sites impact either some properties or interfere with minor access routes. Low priority sites largely affect open space.

CMP Assessment:

An analysis was undertaken to determine what regions of the study area were lower-lying than the adjacent level along the water front. Of these regions, those connected to the stormwater system were identified. The assessment indicated that there were seven outlets connected to low-lying with the potential to be affected by surcharge in Surfside, Batemans Bay, and Corrigans Beach. The locations of the outlets and the potential extent of inundation are shown in Attachment 1.

Effectiveness:

All of the identified surcharge locations affect existing development including private dwellings, commercial premises and roadways.

The installation of flood flaps would increase the flood immunity of these locations, so that flooding would only commence when the adjacent waterfront structure (whether sand dune or sea wall) overtops. As smaller events are more comment, it would also serve to reduce the frequency of inundation for these locations.

The works become increasingly beneficial under future sea level rise scenarios, as the trigger levels for surcharge would be reached with increasing frequency under a higher sea level condition.

Timing:
• The works could be implemented as soon as possible and would provide an immediate benefit.
Benefits
The flood gates would reduce nuisance inundation of low lying locations where high tides are able to back up the stormwater system. This does not result in quantifiable economic benefits. As such, no cost benefit analysis has been provided.

Attachment 1

CH4_K	Seawall Raising and wave return barriers
Location(s): Batemans Bay to Batehaven	
Coastal threat(s) to be addressed: Coastal Inundation	

Outcome of CMP Assessment

Recommended for inclusion in the CMP due to inundation risk reduction for the CBD, including assets and property protection, maintaining emergency access routes, safety and risk to life. The option also aligns with existing Masterplan for the CBD.

Costs:

In total, 1200m of seawall raising is proposed along the length of the CBD foreshore and south to Herarde Street.

Two options:

1. Raise seawall and install crest wall to meet risk requirements out to 2100 and integrate with urban design of adjacent shared pathway.
2. Raise seawall with no crest wall to meet risk requirements out to 2065, and retrofit a vertical crest wall in future (for example, 2050). Integrate seawall structure with urban design of adjacent shared pathway.

Option 1: raise seawall and construct crest wall (to address future risk to 2100)

- Capital Cost: $15,500,000
- Maintenance Costs: 1% of capital costs over life of structure

Option 2: raise seawall without crest wall initially (to address future risk to 2050) and retrofit crest wall:

- Capital Cost: $10,500,000
- Future Capital Cost (~2050): $6,000,000
- Maintenance Costs: 1% of capital costs over life of structure

Option Description:

Raise the existing seawall protecting the Batemans Bay foreshore, to reduce impact of wave overtopping in the short to medium term. The seawall will incorporate urban design features to align with the guiding principles established in the Batemans Bay Waterfront Masterplan & Activation Strategy (the Masterplan) adopted by Council in 2020.

CMP Assessment:

An assessment of coastal inundation hazard has identified that significant portions of the CBD seawall are subject to existing risks of wave overtopping. Under future climate scenarios, as sea levels rise, storm tide (still water) inundation and increased wave overtopping will be experienced.

Adaption to future climate risks has been identified in the Batemans Bay Waterfront Masterplan and Activation strategy and should incorporated into the implementation of the masterplan.

Under current mean sea levels, the existing risk of inundation is predominantly limited to wave overtopping as shown in Figure 1 for the 20-year ARI (infrequent) and 100-year ARI (extreme) event. For the medium term up to 2065, under sea level rise scenarios, the likelihood and extent of inundation only increases, with up to 95% of the seawall length inundated under a 100-year ARI event (see Figure 2).

Based on an analysis of the existing crest levels, the priority areas for seawall raising would be the 400m length of seawall between North Street and Beach Road, followed by the 250m length of seawall along Beach Road further south to provide immediate protection against infrequent coastal storm events (up to the 20-year ARI). However, by 2065 the vast majority of the seawall length is inundated under both the 20-year and 100-year ARI events.

A proposed seawall raising option has been designed that would leverage off the existing seawall as a foundation but increase the crest level to +3.0mAHD, above the 100-year ARI Storm Tide level in 2100. A typical section for the seawall raising design is presented in Figure 3, and includes construction of a 1-2m wide crest and 1 in 2 seawall slope that keys into the existing seawall armour layer. At the back of the crest of the raised seawall a concrete cut-off wall would reduce the permeability of structure and neatly tie the seawall into the promenade behind.

Figure 1 CBD Seawall Inundation for the 100year ARI still water level under present day sea levels. Left: 20year ARI. Right: 100year ARI (red = existing seawall crest submerged)

Figure 2 CBD Seawall Inundation for the 100year ARI still water level at 2065 (red = existing seawall crest submerged)

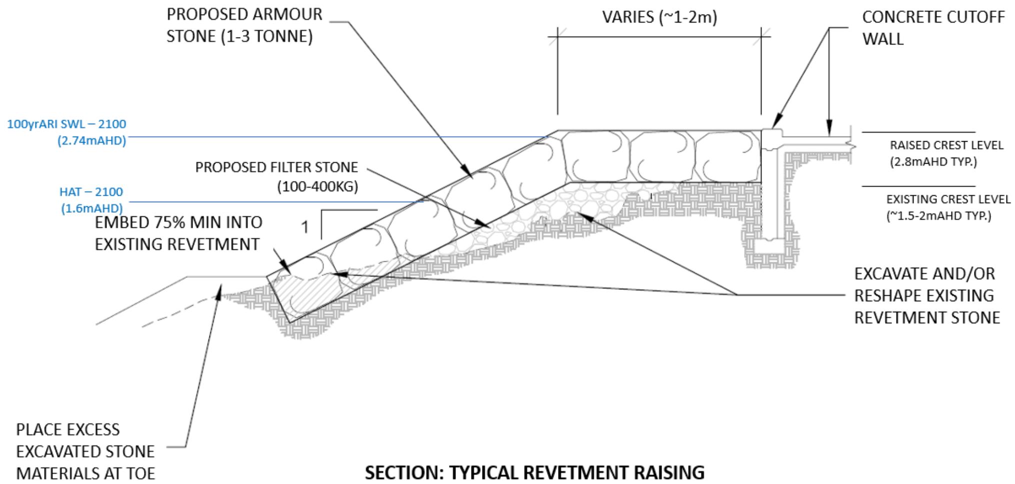


Figure 3 Typical cross section for raising of the CBD

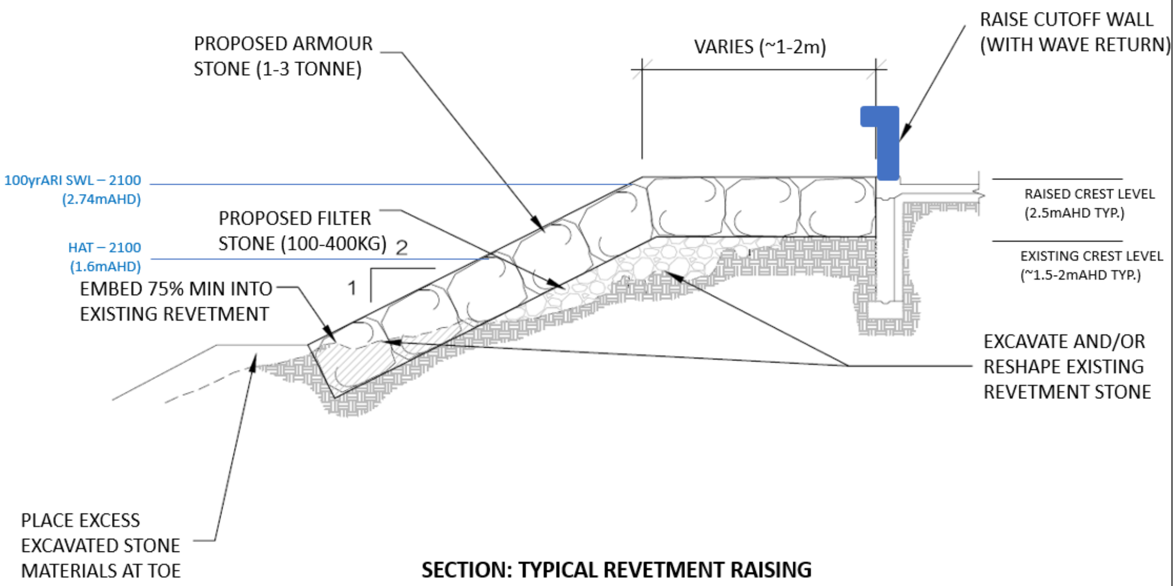
An assessment of wave runup and overtopping for the proposed raised seawall design along the CBD were performed using methods outlined in Eurotop (2018) to determine if the proposed seawall section (with crest at +3.0mAHD) would provide adequate protection against overtopping, both under present day and future sea level rise scenarios. The following table summarises the results, noting an average overtopping rate of less than 20 L/s/m is targeted to reduce the risk people at or near the seawall crest (based on a design wave height of 1m from Eurotop, 2018).

Mean Overtopping Rates (q) for the 100year ARI coastal storm under sea level rise scenarios

	Present	2050	2065	2100
q (L/s/m)	2	17	49	850

Initial analysis suggests that the proposed crest level and seawall design would be sufficient to ensure pedestrian safety up to the year 2050 (based on a 100-year ARI design storm). Beyond this, overtopping rates become hazardous for people near the crest and additional protection would be required to manage this future risk of wave overtopping.

A possible modification to the seawall design is presented in the Figure below and incorporates a vertical wall directly behind the structure crest (as an extension to the vertical cut-off wall). The vertical wall could include a wave return lip to further reduce an overtopping risk. Further overtopping calculations indicate a vertical wall of 0.5m in height (above the seawall crest) would reduce overtopping risk to within acceptable levels out to the year 2100.



SECTION: TYPICAL REVETMENT RAISING

Effectiveness:

- A correctly designed and constructed seawall will provide effective protection to both coastal flooding (from elevated storm tides) and foreshore hazard (from wave overtopping) along the length of the CBD and will ensure the safe use of Beach Road and foreshore promenade areas under a greater range of coastal conditions.
- A seawall designed for present day conditions will reduce in effectiveness as sea level rises under future scenarios, as the associated wave overtopping rate under extreme coastal storms will increase. As such the effective crest of the seawall will need to be raised into the future in line with this increasing risk. Should this be achieved then the seawall will be effective in protecting foreshore areas behind the crest.
- Seawall raising would not impact on the sediment dynamics of Batemans Bay, beyond the influence of the existing seawall, as all works would occur at elevations above the active channel bed and margins and would have negligible influence on tidal and flood hydrodynamics along the length of the seawall. As such, no detrimental impacts to shorelines on the northern side of the Bay area expected from raising of the seawall.

Benefits:

- Reduced inundation and flooding to the wider CBD area. The seawall raising would need to be considered along with Clyde River flood levels (to the west of the CBD) that were not considered as part of the CMP.
- Impacts to public and private infrastructure and amenity along the CBD foreshore and reduced hazard to people using these areas.
- Raising of the foreshore is already proposed as part of the Batemans Bay Waterfront Masterplan and Activation strategy. Raising of the seawall and protection of the CBD and foreshore areas must also incorporate place-making and urban design principles as identified in the Masterplan.

Timing:

- Option for staging of works to target areas at higher risk.
- Initial 400m length of seawall between North Street and Beach Road, followed by the 250m length of seawall along Beach Road further south would provide immediate protection against infrequent coastal storm events (up to the 20year ARI). Raising the remainder of seawall would provide coastal flood protection up to the 100year ARI event out to 2100.
- Without a crest wall, wave overtopping risk of the foreshore is minimised up to the year 2050 (for a 100-year ARI condition).
- Future retrofitting of a crest wall with wave return barrier would provide adequate protection from wave overtopping to the 2100 (for a 100-year ARI condition) and could be installed around the 2050.
- An initial design life of 50 years is considered reasonable for a coastal structure of this nature. With regular maintenance and future enhancement a 100-year design life could be achieved.

Cost Benefit Assessment

Costs: As above

Benefits:

This option derives benefits from avoided costs that arise from the flooding and damages to commercial and residential properties within the Batemans Bay CBD that was forecasted in the coastal inundation modelling. As a result of the proposed works the following benefit is anticipated:

- **Avoided Property Damages** is a benefit that arises from protection of residential and commercial properties from coastal inundation events. The damages are calculated based on damage curves from the DPE and include maintenance, replacement and relocation costings. This is translated into an Average Annual Damage reading which summaries the potential damages in any given year, based on the severity and like hood of the damages occurring.

Results:

The table below highlights that this option in both scenarios has a positive NPV and has a BCR well above 1 indicating that the option economically feasible to implement at this point in time.

Option 1 (CH4_Ka)

BCR		NPV	
3.27		$32,935,194	
Benefit		**Costs**	
AAD	$47,460,493	**Capital Costs**	$12,652,617
		Maintenance Costs	$1,872,682

Option 2 (CH4_Kb)

BCR		NPV	
4.02		$35,666,376	
Benefit		**Costs**	
AAD	$47,460,493	**Capital Costs**	$9,800,617
		Maintenance Costs	$1,993,500

From Batemans Bay Waterfront Masterplan and Activation strategy

- All new development should address anticipated coastal hazards and flood risks.
- Shade trees and/or shade structures should be liberally provided along the waterfront to address rising temperatures and to provide UV light protection for users.
- Selection of tree and plant species allow for anticipated changes in growing regimes (i.e. hotter and drier weather).

Key:

- Expand and raise waterfront edge
- Expand waterfront edge
- Existing waterfront edge which may require raising in some locations (e.g. Murra Mia)

CH4_M	Adaptation plan for low lying areas to be impacted by tidal inundation
Location(s): Batemans Bay	
Coastal threat(s) to be addressed: • CH Threat 3 Coastal Inundation • CH Threat 4 Tidal Inundation	
Outcome of CMP Assessment Adaptation planning will be undertaken as part of the CMP for low lying areas in Batemans Bay that have existing exposure to large ocean storms and will increasingly be at risk under sea level rise. Adaptation planning will look to identify suitable approaches to continue to viability of this land. The planning will investigate a combination of rezoning land, landform adaptation through filling and raising of assets and roads, and property development controls.	
Costs The action for inclusion in the CMP is the preparation of an adaptation plan and associated flood modelling, civil design and community engagement. This has been estimated at a cost of $200,000.	
Option Description: There are low lying areas in Batemans Bay that have existing exposure to large ocean storms and will increasingly be at risk under sea level rise. The coastal vulnerability modelling undertaken in Stage 2 of the CMP identified locations in Batemans that will be inundated several times a year by 2100 (i.e. these areas are below the 2100 HHWS tidal level). Shown in blue hatching on the map below. The modelling also identified that even greater areas will be impacted on average annually by inundation from ocean storm events. Shown in pink hatching on the map below. This frequency of inundation is an unacceptable level of risk, and would likely result in these areas being uninhabitable not only due to regular inundation, but sub-ground level impacts on structural foundations, underground assets etc. Adaptation planning should commence immediately for these areas to identify suitable approaches to continue to viability of this land. This may involve a combination of rezoning land, landform adaptation through filling and raising of assets and roads, and property development controls. Detailed assessments are required to ensure the effectiveness of the strategy, including consideration of: • Access to imported fill, • Design to tie into existing surrounding levels, • Access to existing properties (e.g. driveways), • Land acquisition, • Management of inter-lot drainage, • Existing manhole levels/depths, • Electricity clearance heights, • Drainage improvements for local rainfall events, • Sequence of works and timeframe for overall scheme, • Determine acceptable cumulative impacts on flood behaviour as scheme is implemented, • Multi stakeholder involvement.	

Timing

The timing for adaptation planning will be dependent on identifying the "Thresholds" and "Triggers" for continued liveability of the low lying areas of Batemans Bay. These would be established as part of the adaptation planning. However, for the purpose of CMP planning, it can be seen that frequent inundation of the low lying areas of Batemans Bay will likely occur by 2065. This may be considered the threshold where these locations begin to lose their liveability. The trigger point for this threshold requires analysis of the timeline between when the threshold is reached and when a response is required to avoid losing liveability of the area. This analysis would include consideration of a monitoring period, response time, and a safety buffer for uncertainty.

In order to adequately plan, prepare and implement adaptation, the planning should commence as soon as possible. The preparation of an adaptation plan at a concept stage has been included in this CMP and could be completed jointly as part of the floodplain risk management study and plan for this location depending on timing. If the concept stage plan identifies the need for more detailed planning, this would then proceed. This could also include implementing actions from the flood risk management study and plan ensuring joint outcomes for dealing with coastal inundation hazards identified through this CMP.

CH4_T	Offshore Reef
Location(s): Caseys Beach	
Coastal threat(s) to be addressed: Coastal Inundation	
Outcome of CMP Assessment This option is not recommended for inclusion in the CMP as the option: • Would not protect from north-easterly swells or wind-waves. • Would not effectively mitigate future coastal inundation under sea level rise. • High-cost relative to the degree of protection and mitigation of coastal inundation and wave runup. Overall, this option is not recommended to proceed, due to the high cost and degree of risk management it would provide	
Costs: Whilst not costed up in this stage of the Coastal Management Plan, this option is expected to be relatively expensive for the level of protection it would provide, based on other offshore breakwater costs of similar dimensions and the depths involved.	
Option Description: Artificial reef located offshore Caseys Beach (Figure 1) aimed at increasing wave dissipation, thereby decreasing wave runup and inundation of the road and bridge. This would allow increased access and reduced road damage during coastal storm events.	
CMP Assessment: • The Stage 2 Coastal Hazards Assessment, in conjunction with WRL (2017), identified that Caseys Beach had significant coastal inundation risk, in particular at Beach Road running the length of the beach and at the bridge towards the south of the beach. These areas are highly impacted from coastal inundation and wave runup, even at the 2017 100-year ARI level (**Figure 1**). • An offshore reef would dissipate wave energy coming from the south-east, which is the dominant wave direction at this site, and therefore reduce the wave runup level, resulting in reduced coastal hazard risk to the road and bridge. The approximate potential location of this reef is indicated in **Figure 1**, and designed to protect the beach from large south-easterly and southerly swells.	
Effectiveness: • Would minimise wave impacts on the existing seawall along Beach Road and reduce associated wave runup. • Would not protect from north-easterly swells or wind-waves. • Would not effectively mitigate future coastal inundation under sea level rise.	

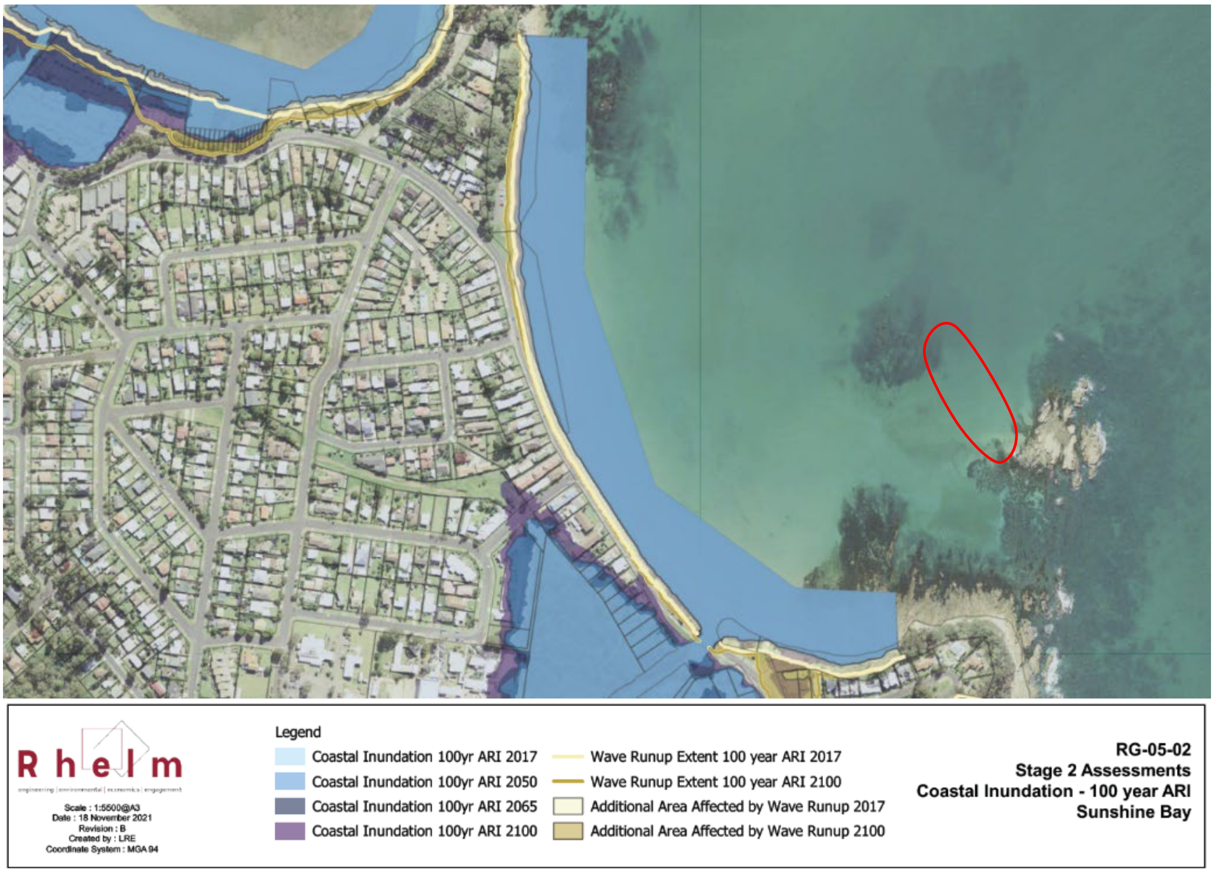


Figure 1 Caseys Beach (as part of wider Sunshine Bay) coastal inundation and wave runup for 2017 to 2100 planning period at 100-year ARI. Red circle indicates approximate position of a proposed wave dissipation breakwater