Cowes Yacht Club Erosion Management Options Study

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1 Introduction

Cowes Yacht Club (CYC) is situated on the northern coast of Phillip Island. The beach in this area is dynamic and has experienced periods of erosion and accretion. Erosion has recently reduced the buffer of land in front of the club and threatened the Club's boat yard, notably in 2016.

Cowes Yacht Club and the Bass Coast Shire Council (Council) have engaged BMT to review the local coastal processes, coastal hazards (notably erosion), and potential long-term management options in response to this hazard. The assessment of options also considers impact on public access and beach amenity.

2 Site Description

2.1 Site overview

Cowes Yacht Club is located on the northern coast of Phillip Island, at the corner of the Esplanade and Osbourne St, as shown in Figure 2-1 below.

Figure 2-1 Cowes Yacht Club Site Plan (19 Nov 2020).

The CYC yard occupies an area of approximately 110m by 24m, located on a sandy dune area immediately behind the beach and situated within a foreshore reserve managed by Council. The Club's lease area has recently been expanded and work is underway to expand the yard to the south (away from the beach) in order to accommodate more vessels (Figure 2-1). Other club assets include the 2-storey club house and a wooden boat ramp.

There is a large stormwater drain to the west of the boat ramp which discharges onto the beach. Council maintains public beach access points on either side of these features, allowing pedestrians to bypass the ramp and drain by walking along the seaward side of the yard. The grassed area seaward of the yard and east of ramp is a popular mixed use-area, used by beach goers and the club members for access, viewing and recreation.

The area of most concern to the Club is the north-west corner of the yard where the erosion escarpment in the dune at the back of the beach is within approximately 1m of the fence.

Figure 2-2 North-west corner of yard, looking south, showing erosion escarpment and informal rock protection (29 Jan 2021)

Figure 2-3 North-west corner of yard, looking east (29 Jan 2021)

Rock rubble is visible at the toe of the dune seaward of approximately half the CYC frontage (pink dotted line in Figure 2-1), which is understood to have been placed pre-1970 to form an informal[1] revetment to limit erosion (pers. com. CYC). The rubble is mainly basalt, ranging in mass from less than 1 kg to more than 100kg. This structure is in very poor condition and is only providing limited protection from erosion. The rock appears to be highly fractured and is breaking down into smaller pieces. The rock seems to be undersized and as a result it has been moved and scattered onto the beach by wave action, lowering the original crest level. Erosion above and behind the rubble is most likely due to wave overtopping.

Figure 2-4 CYC Sediment Compartment

2.2 Coastal Processes

2.2.1 Waves and Water Levels

The wave climate across the Cowes foreshore is a combination of two predominant wave types (Figure 2-5). As described in the Westernport Local Coastal Hazard Assessment (Water Technology (WT) 2014) for the Cowes east area, this climate is described below.

- Wind waves occur when strong North to North Westerly winds blow along the West and North Arms of Westernport Bay during winter months.
- Northerly wind waves are much larger (over 0.8 m) and occur more often in winter (Figure 2-6). Predominant south easterly winds in summer cause calm conditions for the north side of Phillip Island in those months.
- Long period ocean swell waves enter Westernport from the south west (figure 3) and bend around Philip island into the study area. At Cowes, these waves have smaller wave heights than the wind waves caused by strong winds from the N-NW.

[1] An “informal” rock revetment is an erosion control structure formed by random placement, or dumping, of rock in an undifferentiated mass. As opposed to and engineered revetment which is formed from armour rock placed in layers over filter material.

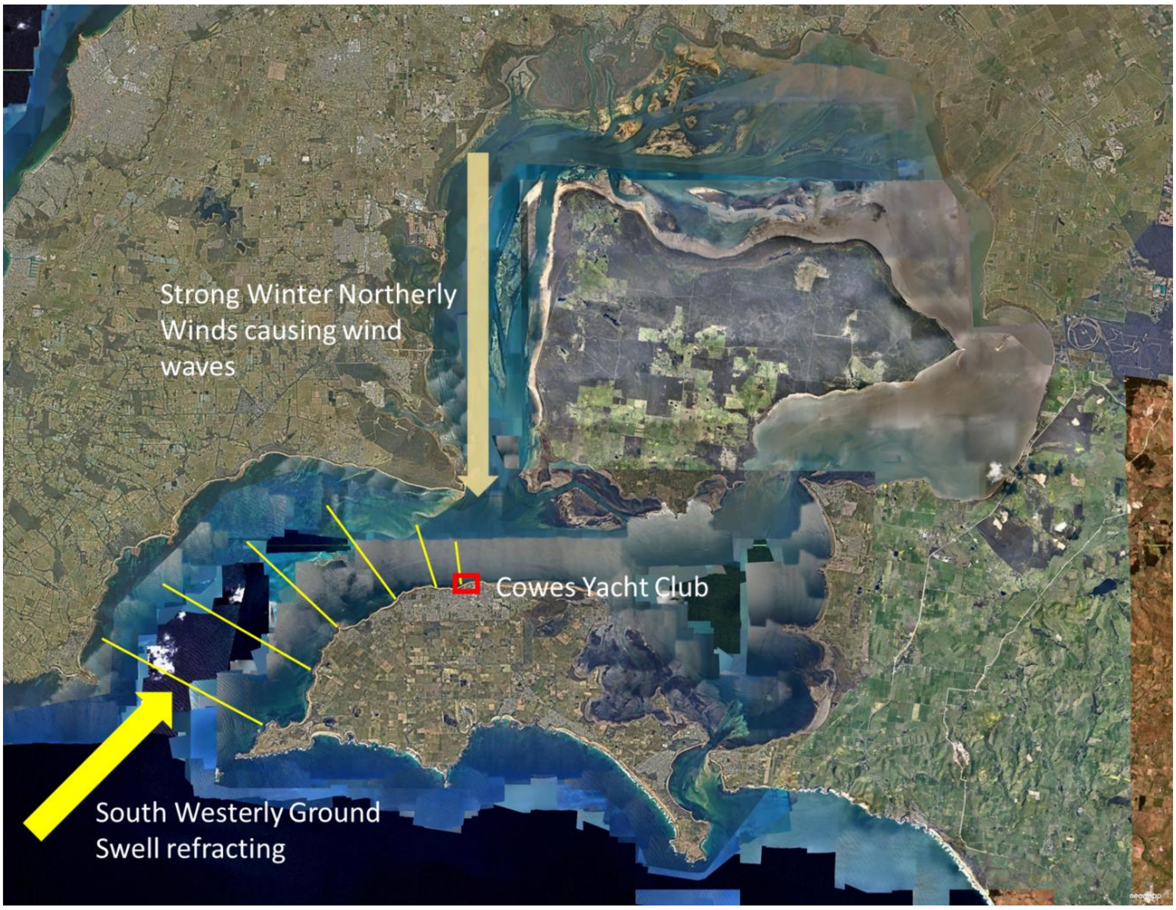

Figure 2-5 Wave climate diagram for Cowes Yacht Club. Imagery: Nearmap.

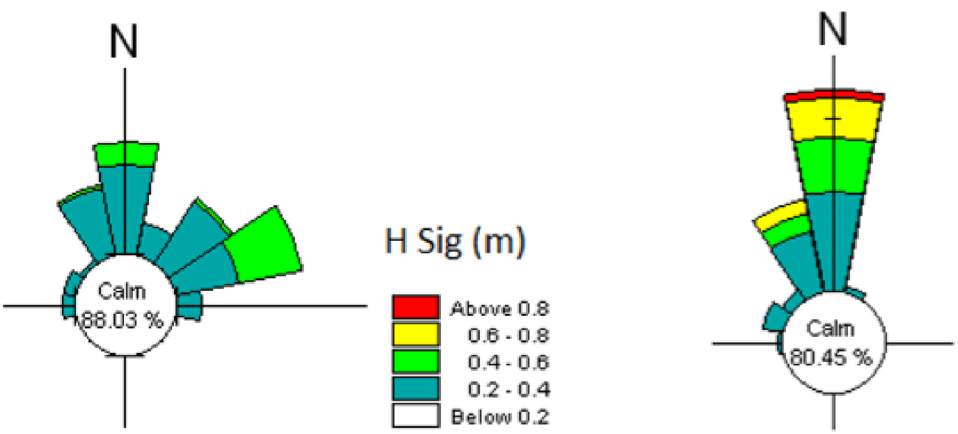

Figure 2-6 Summer (Left) and Winter (Right) summary wave roses for Cowes 2007-2009 (Water Technology 2018).

Water levels at the site are driven by astronomical tides and storm surges and water level variation in Bass Strait, as summarised in Table 2-1.

Table 2-1 Tidal and storm water levels for 2021

Astronomical Tide (Stoney Point)	Level, m AHD
Highest recorded	2.09
HAT	1.62
MHSW	1.15
MHWN	0.70
MSL	0
MLWN	-0.63
MLWS	-1.08
LAT and Chart Datum	-1.69
Storm Tide for Westernport	**Level, m AHD**
1% AEP	2.20
10% AEP	1.62

Data sources: Vic tide tables 2015, Melbourne Water 2017, McInnes 2009.

Climate models are predicting sea level rise across the globe. The forecast sea level rise in the Bass Coast area for a range of scenarios is shown below. State Government planning guidance (Victorian Coastal Strategy 2014, Melbourne Water 2017) is to allow for 0.8m sea level rise by 2100, which is consistent with the very-high emissions scenario and the observed satellite data to date.

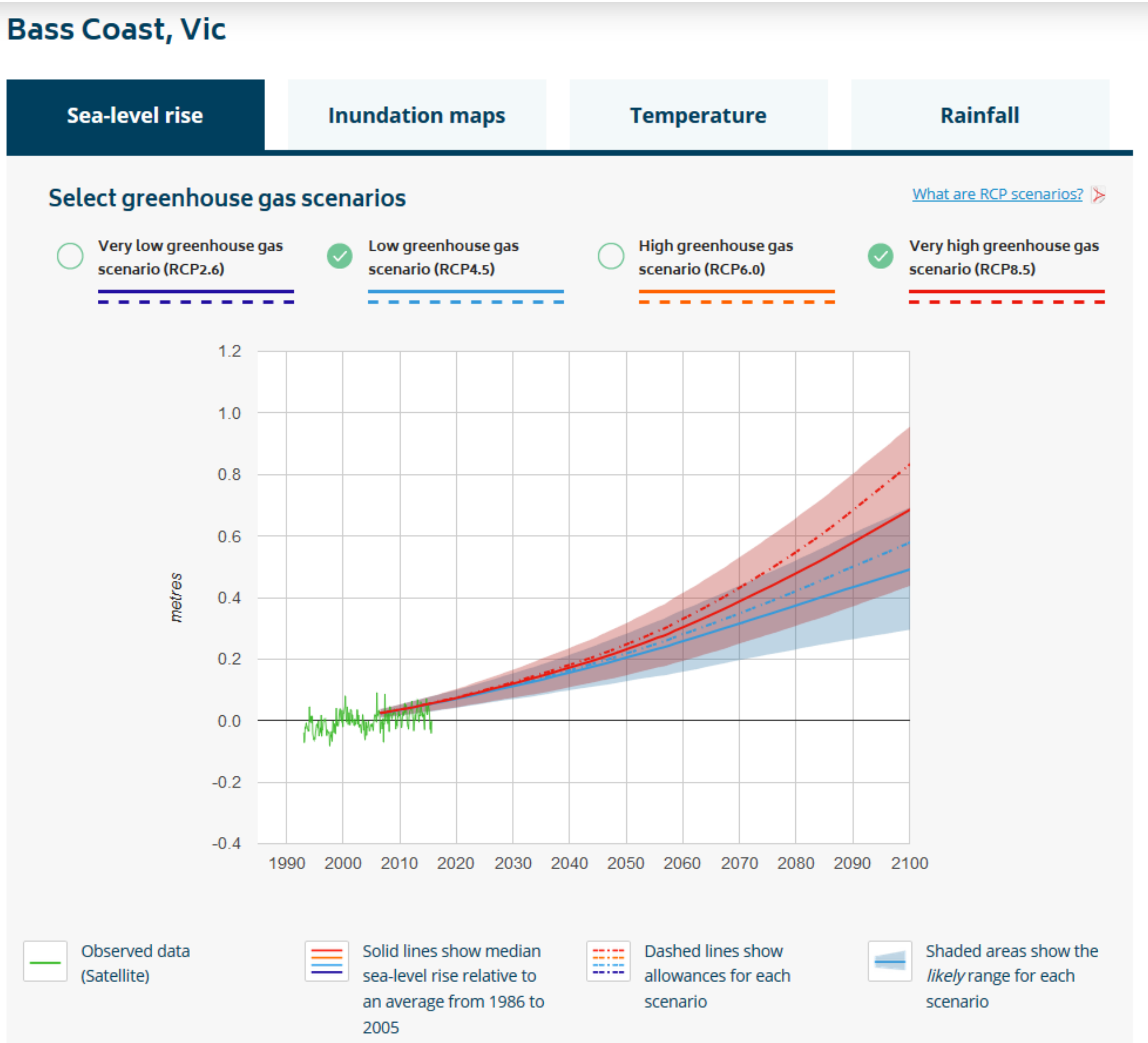

Figure 2-7 Predicted Sea Level Rise predictions for Bass Coast, from CoastAdapt.

2.2.2 Sediment Transport

2.2.2.1 Longshore Transport

Ocean swell which enters the western entrance and refracts around to approach the northern shore of Phillip Island drives a predominant west to east longshore transport system (along-shore movement of sand) (Bird 1993). During periods of northerly wind waves the sediment transport direction may reverse for a short period.

WT (2014) describe a mode of sand transport on the north coast of Phillip Island whereby successive sand ‘lobes’ travel along the beach from west to east (Figure 2-8). This shows that the beach near the leading edge of a sand lobe accretes while the trailing edge erodes.

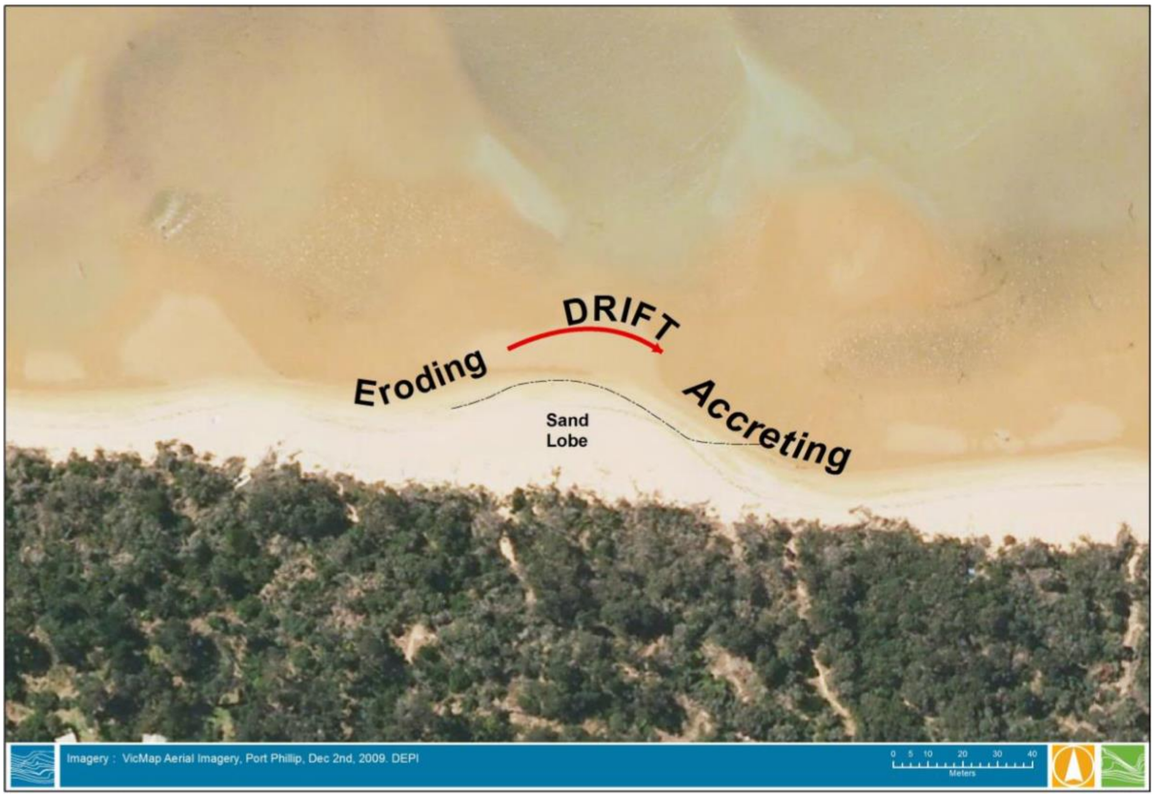

Figure 2-8 Image showing how a small sand lobe travels along Cowes East beach (WT 2014).

2.2.2.2 Cross Shore Transport

Significant cross-shore sediment transport also occurs, with sand eroded from the beach during periods of high northerly wind waves and elevated water levels (i.e. during storms). This sand is deposited on the inshore shallows forming sandbars. When the beach is depleted by this process the backshore is exposed to greater wave attack and erosion. During periods of smaller waves this sand is reworked and moved back onto the beach. This is a cyclical process, but it is not known if it is in balance, or whether a net loss of sand is occurring.

2.2.3 Impact of structures

A number of the existing structures on the site may be impacting on coastal processes:

- Rubble revetments can cause scour of the beach in front of the revetment and increased erosion at either end (end scour) during storms. The informal revetment at CYC is such poor condition that its impact on coastal processes is expected to be minor, but it has not been monitored during a storm.
- Flows from the stormwater outlet move large volumes of sand off the beach rapidly during rainfall events (refer Figure 2-9). This sand is deposited in shallow water at the waterline and may be worked back onto the beach by wave action.
- The timber boat ramp can act as a ‘groyne’, partially blocking the along-shore transport of sand and trapping sand on the up-drift side (typically the west side, but can occur on the east as well).

Based on review of aerial photos, it seems that the combined impact of these factors means that beach at CYC is often slightly wider, and sometimes lower, than surrounding areas (refer Figure 2-1).

Figure 2-9 Beach scour by stormwater flow 29 Jan 2021.

2.2.4 History of Erosion and Shoreline Change

This shoreline adjacent to CYC is dynamic and has experienced both erosion and accretion in recent history. Bird (1993) describes alternating cycles of erosion and accretion due to the passage of sand lobes but notes an overall erosion trend.

Figure 2-10 shows the position of the vegetation line (seaward edge of vegetation) in 16 aerial photos from 1992 to 2020. This provides a good indication of the advance and retreat of the dune system and the location of the erosion escarpment, when present. The position of the vegetation line on two profiles is plotted over time in Figure 2-11.

Figure 2-10 Vegetation lines from 1992 to 2020

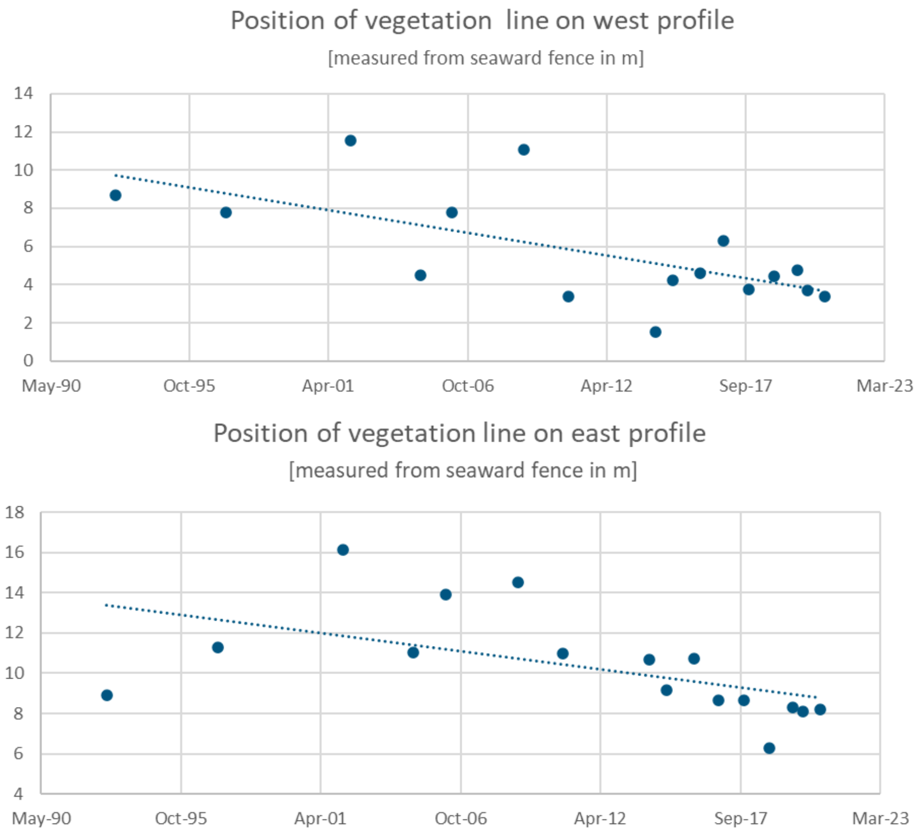

Figure 2-11 Vegetation line change with time

The air photo analysis above shows that the width of the dune buffer between the CYC yard beach fluctuates by up to 8m, but over last 6 years has been persistently low. There also appears to be an overall erosion trend (vegetation/erosion line moving closer to the yard) in the order of 0.3m/yr.

Comparison of aerial imagery over the last decade shows that while erosion is occurring in the CYC area at the eastern end of the sediment compartment (figure 2-4), sediment accretion is occurring further west, between Richards Point and Bella Vista Point. This is shown in the images below (Figure 2-12) where new dune area has been built up and colonised with vegetation. This suggests a large sand lobe is currently moving eastward from Bella Vista Point towards CYC which should reverse the erosion trend in the next 5 to 10 years.

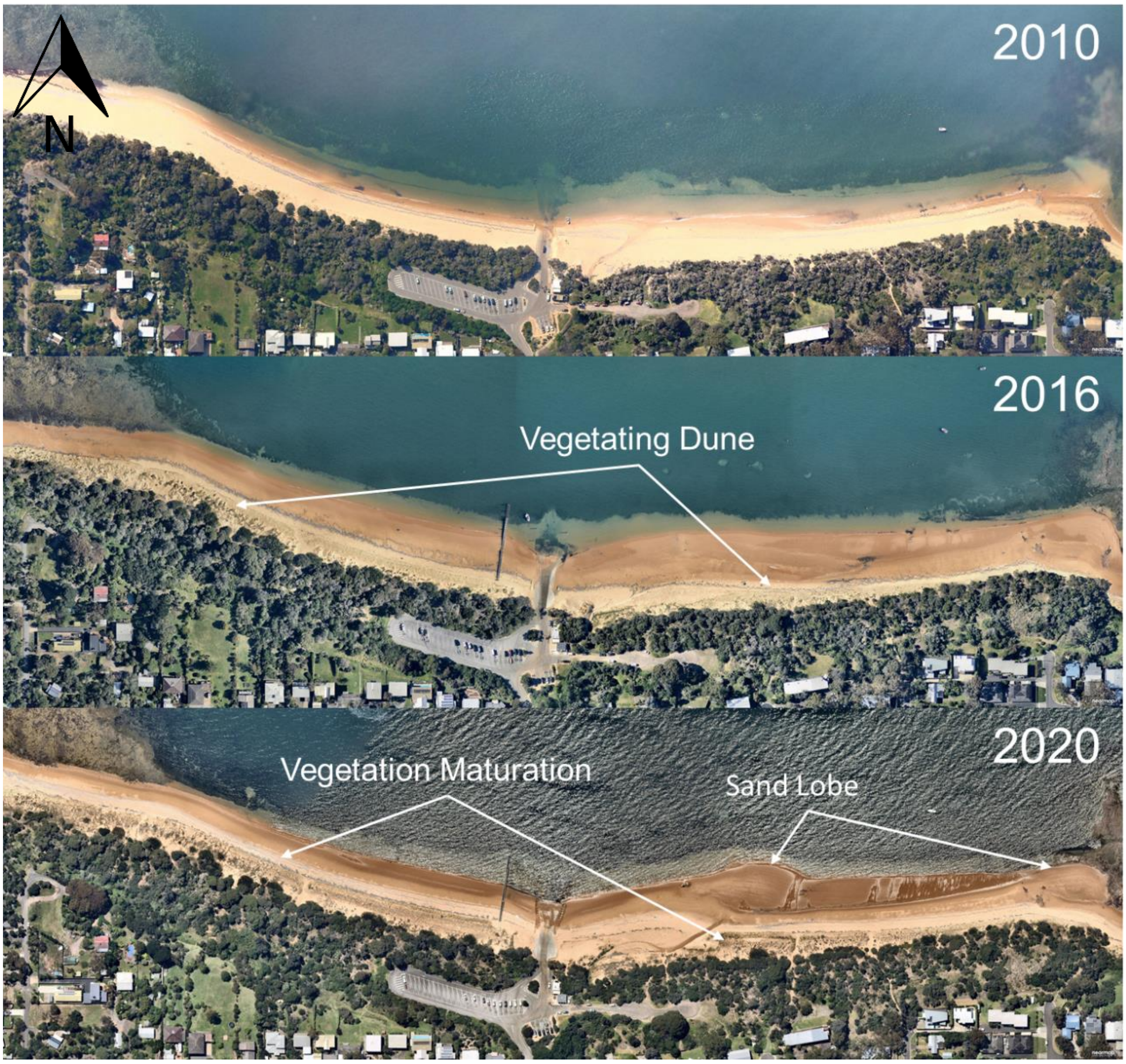

Figure 2-12 Beach accretion seen between Bella Vista Point and Richards Point, to the west of Cowes Yacht Club. Imagery by Nearmap.

3 Coastal Hazards Assessment

3.1 Erosion Hazard

Erosion hazard at the site is driven by a number of processes acting on different time scales, as discussed below. These processes combine to cause long term recession (landward movement of the shoreline) or accretion (seaward movement of the shoreline).

3.1.1 Storm Erosion

During storms with high waves and elevated water levels significant erosion of the beach can occur with sediment moved from the beach to nearshore sand bars. Water Technology modelled storm erosion for Cowes Main Beach and predicted storm erosion could cause recession of up to 2.5m in a single 100yr ARI storm event. The dune is lower at CYC and greater storm recession may be possible.

Discussions and photos provided by CYC indicate that several meters of recession has occurred during one storm event in the recent past. As such, 2.5m recession is adopted for a 10yr ARI event.

3.1.2 Recession due to sediment loss

A long term-loss of sediment from the beach can also cause ongoing erosion and recession. This can be due to an in-balance in longshore transport (more sand leaving the area than arriving) or cross shore transport (storm erosion moving sand into deep water). Based on the air photo analysis described in section 2.2.4 we have estimated the long term recession due sediment loss at approximately 0.3m/yr.

3.1.3 Recession due to Sea Level Rise

Shoreline response to sea level rise is complex and difficult to predict. It is generally assumed that on sandy beaches, the beach profile will maintain its shape while moving upwards and landward in proportion to the average beach gradient (the “Brunn rule”). In the absence of site-specific data on the nearshore bathymetry and depth of closure we have assumed a beach gradient of 1:50, which means the beach would move landward 50m for every 1m rise in sea level.

3.1.4 Future erosion hazard

To inform the options assessment a simple estimate of future erosion hazard extent has been made (Table 3-1) combing the components described above. It is important to note this is an indicative estimate only, and is based on conservative assumptions with a number of limitations to the methodology as follows:

- Assumes that all material under the foreshore is erodible sand.
- Beach recession rates for sea level rise are generic, not based on site specific data
- No allowance for the passage of sand slugs which can reverse the erosion trend for a number of years.
- Beach recession due the sediment loss rate is based on a short time series.

Table 3-1 Possible shoreline recession over the next 20 years.

Year	Sea Level Rise	Recession due to storm erosion	Recession due to sediment loss	Recession due to sea level rise	Total recession of beach from present days position
2040	0.2m	2.5m	6.7m	10m	18m

This calculation indicates that shoreline recession of around 18m is possible within 20 years, which would put the erosion escarpment in the middle of the club yard. This is a worst-case scenario based on conservative assumptions and may not come to pass in this timeframe. There are too many uncertainties in this analysis to make prediction beyond 2040.

3.2 Inundation Hazard

The CYC yard is generally at a level of around 3.5m AHD (2011 Future Coasts DEM) which is well above the Westernport Storm tide level of 2.2m AHD, and slightly above the future 2100 storm tide level of 3.0m AHD. This means the yard is not at risk from inundation by still water at high tide (including storm surge effects).

During strong northerly winds, wave set-up will elevate the water level at the shore above the storm tide level. Waves breaking on the beach under these circumstances will also ‘run-up’ the beach/dune face, potentially reaching a level 1 to 2 m above the storm tide level. This means there is a risk that storm waves could run up and overtop the grass/dune area at the back of the beach and run into the CYC yard, causing shallow flooding, damage to grass and scour of the soil beneath. Figure 3-1 shows that wave run-up was very close to overtopping the grassed area in front of the club in 2018. Wave runup and overtopping will become more severe with sea level rise.

Figure 3-1 Storm erosion and wave run up 2 July 2018 (photo supplied by Cowes Yacht Club)

4 Options Assessment

4.1 Options development

In line with the Victorian Marine and Coastal Policy (VMCP) (2020), mitigation of coastal hazard risks should be undertaken using a pathway approach. This decision-making framework considers the full range of available adaptation options, recognises that actions are not mutually exclusive, and diffident options will be needed over time depending on the changing nature of the climate.

Four feasible adaptation options have been identified to manage the existing and future coastal hazards at Cowes Yacht Club over the next 20 years, in accordance with the hierarchy given in the VMCP 2020.

- Non-intervention, where no action is taken, and the future impacts of erosion will be addressed when they occur.
- Nature-based solutions, where “soft” engineering solutions such as beach scraping or beach nourishment are used to mitigate future erosion hazards.
- Retreat, where the assets at risk (i.e., boat storage yard) are relocated so they are no longer exposed to future erosion hazards.
- Protect, where “hard” engineering structures, such as rock revetments, seawalls or groynes are used to reduce the vulnerability of the assets to future erosion hazards.

The following subsections describe each potential option in more detail and discuss the advantages and disadvantages in implementing each option. A preliminary cost estimate for each option is provided in Appendix A. It is worth noting that a combination of the options proposed here may be adopted and this is further discussed in Section 5.

Due to the lack of design definition and site information cost estimates are indicative only. Where there is significant uncertainty in the quantities and rates upper and lower bounds have been used so the final estimate is provided in terms of upper and lower bounds. The cost estimates include allowance for design, approvals and some contingency.

4.1.1 Non-intervention: “Do nothing” approach

The default, non-intervention approach allows the coastal processes and hazards to naturally occur. In this case, it involves leaving the current situation “as-is” and relying upon the existing ad-hoc armour to provide limited protection to the dunes system (see Figure 4-1). In the event of a large storm event where the dune is eroded, the boat yard fence may be damaged and require replacement.

While this option does not address the underlying erosion hazard, it may be appropriate where there is an acceptable level of risk or other options are not cost-effective. Inspection of the fence after a storm event would be required, with a nominal cost to reinstate the fence if damaged. Depending on the time frame considered, walkway access structures to the beach may also become compromised if the “do nothing” approach is adopted. It is anticipated this option involves a cost of $3k to $6k every 5 years to replace the fence.

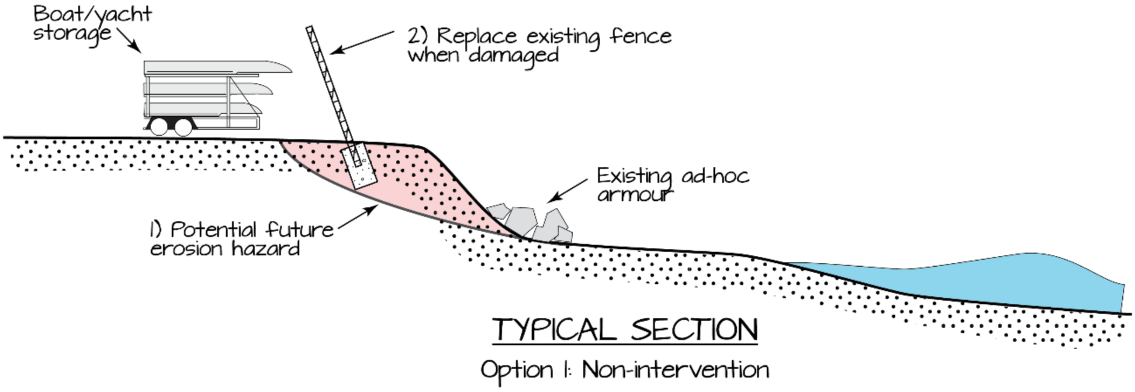

Figure 4-1 Option 1) Non-intervention

4.1.2 Nature-based: Beach scraping and beach nourishment

Two possible nature-based options to mitigating the erosion hazard are proposed: beach scraping and beach nourishment. These nature-based methods aim to enhance the natural coastal processes that already occur to reduce the erosion hazard risk. While these options avoid the use of “hard” engineering structures and can provide improvements in beach amenity and biodiversity, they often require continued maintenance.

The first nature-based option proposed is beach scraping of the beach area in front of the boat yard. Beach scraping involves using heavy plant equipment, such as an excavator or dozer, to move sand from the lower part of the beach profile to the upper part (see Figure 4-2). This process usually occurs naturally by the combined action of wind and waves during calmer periods but on a much slower timeframe. Since this approach does not remove the erosion hazard, continued scraping is required to maintain the dune in a healthy state. This may have minor implications for public amenity as access to the area would be restricted while the scraping process occurs.

It is anticipated that each beach scraping exercise would take only one day and would be required once or twice per year on average. Some years would require more and other years none, depending on the natural fluctuations in beach width. Average annual cost is estimated at $12k to $26k.

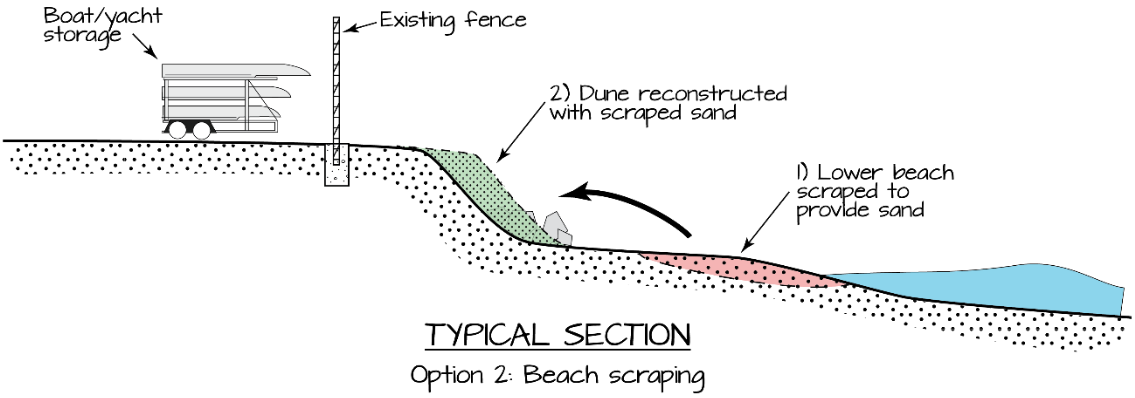

Figure 4-2 Option 2a) Beach scraping

The second nature-based approach is beach nourishment. Like the previous option, beach scraping, beach nourishment rebuilds the dune with borrowed sand (see Figure 4-3). However, instead of sand being moved from the lower part of the profile, sand is transported from another site, usually by truck. Sand could be transported from a number of sites where there is an excess of material, however, closer sites result in lower transport costs. A potential borrow site has been identified near the Anderson St boat ramp, but would require further investigation to establish the transportation routes. Trucking sand along the beach using offroad trucks would be significantly cheaper than using road trucks and the local road network. As with the previous beach scraping option, this approach does not remove the erosion hazard and continued nourishment would be required to maintain the dune. It is anticipated that beach nourishment will require $20k to $40k per year to complete, but may not be needed every year.

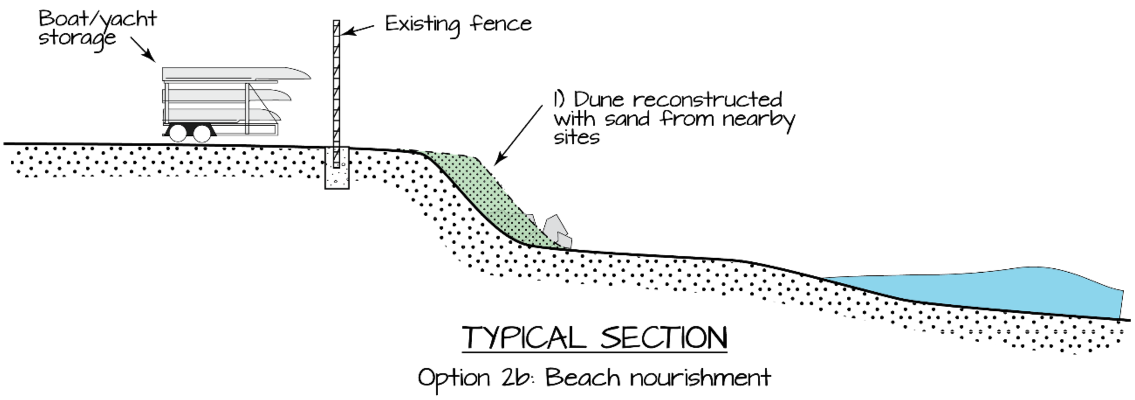

Figure 4-3 Option 2b) Beach nourishment

4.1.3 Retreat: Relocate boat storage yard

For the 'retreat' option, the boat yard and fence are relocated landward and the dune is allowed to erode. By removing the assets from the hazard, the risk is essentially fully mitigated. The minimum retreat distance should consider the recession rate of the dune and the desired 'design life' of this approach.

Figure 4-4 shows a possible reconfiguration of the boat yard under the retreat option, designed to provide a 20yr design life before further intervention is required to manage the coastal hazard risks. The red line shows the proposed yard reconfiguration and the yellow line is the currently underway yard expansion. Further movement of the yard to the south-east (landward) is not recommended because the land slopes upward here and expensive site leveling would be required. The best option is expansion to the south-west, along shore, at least as far as the beach access path (although this could be moved). This would involve clearance of native vegetation, which would require Council and DELWP approvals. Vegetation clearance could be offset by planting on the abandoned portion of the yard. A wider and fully vegetated dune area seaward of the yard would capture sand and build up over time, providing increased protection from coastal erosion and inundation due to wave run up.

It is anticipated that this option will require $26k to $56k to implement.

Figure 4-4 Option 3) Retreat - Possible reconfiguration of the boat storage yard

4.1.4 Protect: Construct hard structures

The final adaptation option available is to enhance existing physical barriers or construct new "hard" engineering structures. This is often used as a final resort as properly engineered and designed structures are costly and the benefits tend to be very localised. An armoured rock revetment was considered the most suitable engineered structure for this application; however the following alternative structures were considered:

- Continued ad-hoc armouring: Currently, informally placed, degraded rock armour is placed at the base of the dune. Continuing to place rock without an engineered design is likely to be ineffective due to the fracturing of rocks in addition to the insufficient filtering allowing sand to erode behind the rocks.
- Timber bulkhead seawall: A timber bulkhead seawall may create issues with wave reflection and localised scour issues directly in front of the wall and immediately next to the wall ends. It is also expected that there would be significant costs associated with maintaining the wall.
- Mortared rock seawall: Like a timber bulkhead seawall, a mortared rock seawall may also create issues with wave reflection and localised scour. Depending on the amount of scour expected, the toe may need to be located at a significant depth. Significant costs would also be associated with maintaining the wall.

Considering the above points, an engineered rock revetment was the most suitable structure for this application.

A rock revetment consists of amour stone layer (typically consisting stones between 100 kg – 1 t) over an underlayer of smaller rock (see Figure 4-5). Depending on geotechnical conditions, a geotextile may also be required under the underlayer. The armour and rock in the revetment are appropriately sized to prevent erosion of dune in large storm events and minimize the likelihood of wave reflection causing local scour. Construction requires the transportation of armour stone to the site, which may be a significant cost depending on the location of the quarry. There are no know sources of suitable rock on Phillip Island. Once constructed however, the revetment requires little maintenance and mitigates the ongoing threat of erosion. It is anticipated that this option will require $380k to $550k to complete.

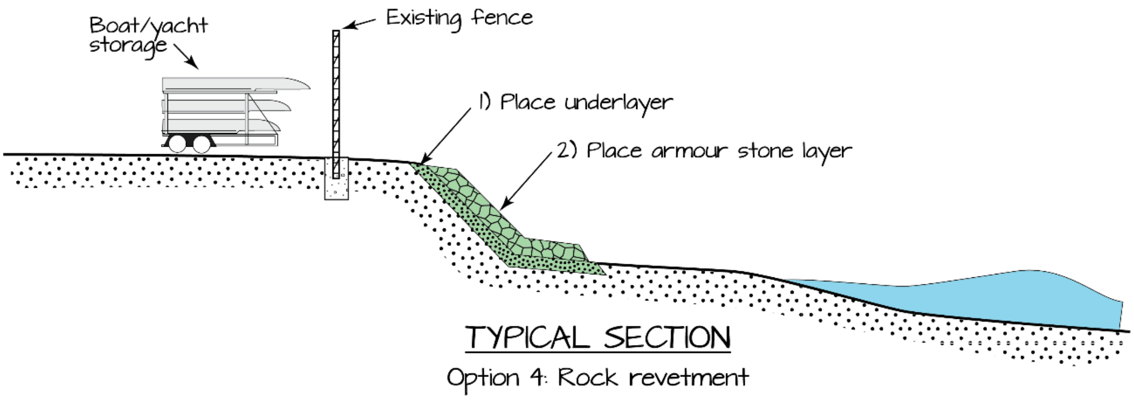

Figure 4-5 Option 4a) Rock revetment

An alternative hard structure approach involves modifying the existing timber boat ramp structure to function as a groyne. Vertical timber planks would be attached to the side of the boat ramp essentially restricting the flow of water and sand underneath the boat ramp (Figure 4-6). The reduced current velocity around the boat ramp allow more sediment to drop out of suspension and result in localised accretion. While this approach would be much cheaper than the revetment, further investigations of the local coastal processes would be required to confirm this option is feasible and effective. There is also a risk that the groyne could increase foreshore erosion to the east. It is anticipated that this option will require $35k to $65k to complete, including coastal process studies.

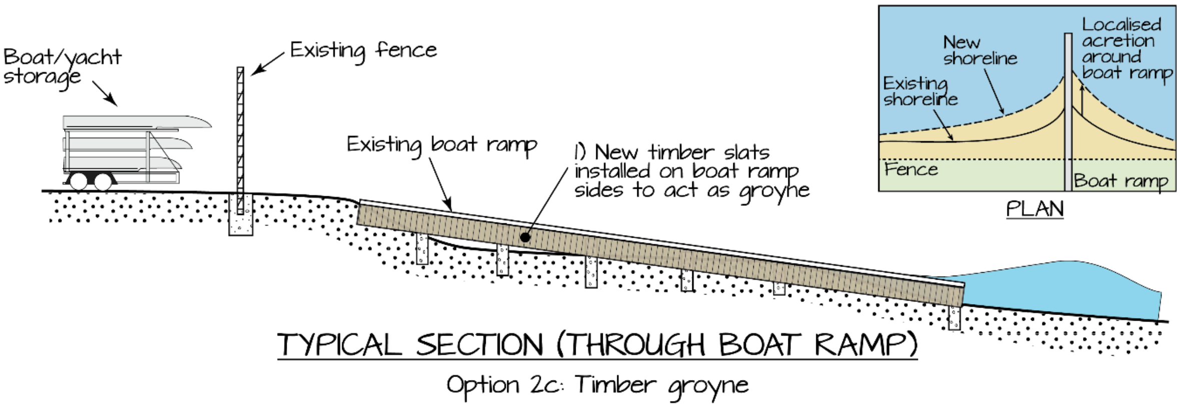

Figure 4-6 Option 4b) Timber groyne

The revetment, groyne, or any other ‘protect’ option may require several approvals including: land owner’s consent, consent under the Marine and Coastal Act, permits to clear vegetations, works permits from land and water way managers and cultural heritage plans.

4.2 Options comparison

A summary of the erosion hazard management options discussed in this section has been summarized in Table 4-1. For each option, a brief statement about the following aspects is included:

- Effectiveness: How effective is the proposed option at mitigating the ongoing erosion hazard?
- Risk: How likely is the option fail either as a concept during the design process or once implemented?
- Capital cost: How much upfront investment is required to implement the option?
- Maintenance cost & requirements: How often and how costly is it to maintain the option?
- Impact on coastal process: How likely is the option to alter the existing coastal processes in the area?
- Impact on beach amenity & public access: How affected will the public and patrons of the club be during construction and maintenance?

Table 4-1 Comparison of erosion management options

Option	Description	Effectiveness	Risk	Capital cost	Maintenance cost & requirements	Impact on coastal processes	Impact on beach amenity & public access
1) Non-intervention	Take no action, reinstate fence if damaged by erosion	**Low.** Dune erosion will continue during storm events.	**Medium/Low.** Continues with current action. Only deals with damaged caused by erosion	**Low.** Nominal cost associated with reinstating fence if damaged	**Low.** Inspection of fence and yard required after each event. Fence will need to be reinstated if damaged. Estimated $3k-$6k every 5 years.	**Low.** Local coastal processes remain unaffected.	**Low.** Beach access points unaffected
2a) Beach scraping	Reform dune in front of fence by scraping from lower on beach profile	**Medium.** Offers some protection to dune, but lowers beach level allowing higher waves to reach dune	**Low.** Can be scaled up and repeat measures will be required	**Low.** Minimal initial capital expenditure required.	**Medium**. Ongoing excavator or dozer maintenance, particularly during stormy periods. Less expensive than nourishment. Estimated $12k-$26k every year.	**Low.** Scraping accelerates the natural process of sand moving up the beach during calmer periods.	**High.** During scraping works, heavy plant equipment will be on the beach and public access would be restricted.
2b) Beach nourishment	Reform dune in front of fence with material from Anderson St boat ramp	**Medium.** Offers protection to the dune, but may require a large amount of sand to be transported	**Low** Can be scaled up and repeat measures will be required	**Low.** Minimal initial capital expenditure required.	**High.** Ongoing excavator or dozer maintenance, particularly during stormy periods. Truck routes along beach or through local streets. More expensive than scraping. Estimated $20k-$40k every year.	**Low.** Nourishment using local sites slows down natural alongshore sediment transport with minimal impact on surrounding coastal processes.	**High.** During nourishment works, heavy plant equipment will be on the beach and public access would be restricted.
3) Retreat	Relocate fence and boat yard landwards	**High.** If fence and boat yard are relocated outside of erosion hazard.	**Low/Medium.** Minimal risk in the immediate and medium-term but does not address the long-term continued erosion.	**Medium.** Nominal cost in relocating fence and yard. Estimated $26k-$56k.	**Low.** No additional maintenance.	**Low.** Local coastal processes remain unaffected	**Low/Medium.** Short term impacts while fence and yard are being relocated.

Option	Description	Effectiveness	Risk	Capital cost	Maintenance cost & requirements	Impact on coastal processes	Impact on beach amenity & public access
4a) Rock revetment	Design and construct armoured rock revetment in front of fence	**High.** Engineered rock revetment fully protects dune from further erosion	**Low.** Engineered solution mitigates erosion risk	**High.** High capital cost due to rock transportation. Estimated $380k-$550k.	**Low.** No additional maintenance required. Routine inspection after large events to check for damage.	**Medium.** Revetments can initiate scour of beach and dune at either end of structure.	**Medium.** Short term impacts while revetment is being constructed. Longer term possible reduction in beach width
4b) Timber groyne	Block underside of boat ramp to function as groyne	**Medium.** Beach naturally expected to widen, but dunes will remain in a vulnerable state unless combined with nourishment or scraping.	**High.** Relies in a thorough understanding of the local coastal processes and may prove to be unfeasible with more modelling.	**Low/Medium.** Requires a small capital cost to retrofit boat ramp with timber slats. Estimated $35k-$65k.	**Low.** Nominal routine inspection and maintenance required to ensure ramp/groyne is in good condition.	**High.** Modifies the local coastal processes and may result in impacts alongshore, downdrift (east) of the boat ramp	**Low.** Minimal impacts to amenity and public access during retrofit of boat ramp.

5 Conclusions and Recommendations

The volume of sand on the beach in front of the Cowes Yacht Club fluctuates on a multi-year cycle due to variation in the along-shore transport of sand from the west. When the beach is in a more eroded state, as it is currently, the boat storage yard is at risk from coastal erosion and potential wave overtopping in the future. There appears to be a long-term erosion trend, which combined with sea level rise means the erosion and inundation hazards will become more severe in the future.

However, in recent years the beaches to the west have been accreting (sand building up) as a ‘sand slug’ moves along the shore. It is expected that this could reach the CYC in next 5 to 10 years and result in several years of sand build up and lower coastal hazard risk.

The Victorian Marine and Coastal Policy (2020) requires that mitigation of coastal hazard risks should be undertaken using a pathway approach. This decision-making framework considers the full range of available adaptation options and recognises that diffident options will be needed over time depending on the changing nature of the climate. The policy requires different classes of options are considered in order from the least intrusive (non-intervention) to the most (protect with hard engineering structures).

Six potential adaptation options have been identified to manage the existing and future coastal hazards at Cowes Yacht Club, in accordance with the hierarchy given in the VMCP 2020.

(1) Non-intervention, i.e. manage the future impacts of erosion when they occur by repairing/moving fence as necessary.

(2) Nature-based or “soft” engineering solutions to maintain a buffer of sand Infront of the yard by:

  (a) beach scraping or

  (b) beach nourishment.

(3) Retreat, i.e. relocate the boat storage yard landwards so it is no longer exposed to erosion hazards.

(4) Protect the yard using “hard” engineering structures, either:

  (a) rock revetment, or

  (b) modify boat ramp to act as a groyne.

In the short term (0 to 10 years) the coastal hazard risks can probably be managed by beach nourishment and/or beach scaping. We recommend commencing a trial to build a sand berm in front of the club using beach nourishment, or if this is too expensive, beach scraping. The beach should then be monitored, and the nourishment repeated whenever the informal rock armour is exposed. This would also enlarge and protect the mixed-use lawn area in front to the club house, providing a public benefit.

Retreat of the yard would also be an effective response. Although there are up-front costs, once implemented the yard would not be at risk from coastal hazards for many years and maintenance costs would be low.

Hard structures, revetment or groynes, are not recommended at the current time due to high cost and impact on coastal processes and beach amenity. These solutions may be appropriate in the future when the coastal hazards can no longer be managed via other, less intrusive, measures.

6 Reference List

Water Technology (2014) *Western Port Local Coastal Hazard Assessment Report 6 (R06) – Review of Representative Locations.* Melbourne Water.

Water Technology (2018) *Cowes East Foreshore: Erosion Management Options.* Bass Coast Shire Council.

Melbourne Water (2017) *Planning for Sea Level Rise Guidelines- Port Phillip and Westernport Region*

Eric Bird (1993*) The Coast of Victoria – the Shaping of Scenery*. Melbourne University Press

Appendix A Cost Estimates

	Non-intervention: "Do nothing" approach					
	Option 1					
	Item	**Unit**	**Qty**	**Rate**	**Total**	
1.0	**Replace fence when damaged by erosion**					
	Chain link fence (seaward side of yard)	per m	70	\$50 - \$90	\$3,500 - \$6,300	
	Total Costs (excluding GST)	per 5 years			\$3,500 - \$6,300	per 5 years
	Assumes the fence of the seaward side of the yard is replaced every 5 years					

	Nature-based: Beach scraping					
	Option 2a					
	Item	**Unit**	**Qty**	**Rate**	**Total**	
1.0	**Site establishment**					
	Site establishment	Item	1	\$1,000 - \$5,000	\$1,000 - \$5,000	
2.0	**Beach scraping**					
	Moving sand from lower to upper beach profile	per m^3	1750	\$6 - \$12	\$10,500 - \$21,000	
	Total Costs (excluding GST)	per year			\$11,500 - \$26,000	per year
	Assumes 70 m long portion of beach on western side of boat ramp requires scraping					
	Assumes 25 m3/m beach scraping per year for low demand closed coast					

	Nature-based: Beach nourishment					
	Option 2b					
	Item	**Unit**	**Qty**	**Rate**	**Total**	
1.0	**Site establishment**					
	Site establishment	Item	1	\$1,000 - \$5,000	\$1,000 - \$5,000	
2.0	**Beach nourishment**					
	Moving sand from Anderson St boat ramp area	per m^3	1750	\$10 - \$20	\$17,500 - \$35,000	
	Total Costs (excluding GST)	per year			\$18,500 - \$40,000	per year
	Assumes 70 m long portion of beach on western side of boat ramp requires scraping					
	Assumes 25 m3/m beach scraping per year for low demand closed coast					

	Retreat: Relocate fence					
	Option 3					
	Item	**Unit**	**Qty**	**Rate**	**Total**	
1.0	**Site establishment**					
	Site establishment	Item	1	\$1,000 - \$5,000	\$1,000 - \$5,000	
2.0	**Relocate yard**					
	clear vegetation	per m^2	720	\$10 - \$20	\$7,200 - \$14,400	
	Dismantle and relocate chain link fence	per m	210	\$50 - \$90	\$10,500 - \$18,900	
	Lay new bitumen path	per m^2	180	\$25 - \$40	\$4,500 - \$7,200	
	planting and dune stabilisation	per m^2	900	\$3 - \$10	\$2,700 - \$9,000	
	Total Costs (excluding GST)				\$26,000 - \$54,500	one off
	Assumes entire chain link fence is dismantled and relocated					
	Assumes cost of dismantling and relocating is similar to new fence					

	Protect: Engineered rock revetment					
	Option 4a					
	Item	**Unit**	**Qty**	**Rate**	**Total**	
1.0	**Site establishment**					
	Site establishment	Item	1	\$5,000 - \$10,000	\$5,000 - \$10,000	
2.0	**Rock revetment**					
	Excavate toe	m	150	\$10 - \$15	\$1,500 - \$2,250	
	Supply and install geotextile	m^2	2250	\$10 - \$15	\$22,500 - \$33,750	
	Supply and install underlayer & armor rock	m^3	1650	\$160 - \$230	\$264,000 - \$379,500	
3.0	**Allowances**					
	Approvals and permits	item	1	\$10,000 - \$20,000	\$10,000 - \$20,000	
	Design fees	%	10%	-	\$29,300 - \$42,550	
	Contingency	%	15%	-	\$43,950 - \$63,825	
	Total Costs (excluding GST)				\$376,500 - \$552,000	one off
	Assumes 150 m long rock revetment with slope of 1V:3H, 3m high					

	Protect: Timber groyne					
	Option 4b					
	Item	**Unit**	**Qty**	**Rate**	**Total**	
1.0	**Site establishment**					
	Site establishment	Item	1	$5,000 - $10,000	$5,000 - $10,000	
2.0	**Modify existing timber ramp into groyne**					
	Excavate around existing ramp (1m below current level)	m3	60	$5 - $10	$300 - $600	
	Supply and install timber skirt onto existing ramp	m2	120	$50 - $70	$6,000 - $8,400	
3.0	**Allowances**					
	Approvals and permitts	Item	1	$10,000 - $20,000	$10,000 - $20,000	
	Design fees	Item	1	$10,000 - $20,000	$10,000 - $20,000	
	Contingency	%	30%	-	$3,390 - $5,700	
	Total Costs (excluding GST)	per year			$34,500 - $64,500	one off
	Assumes significant design process is required to verify coastal processes					
	Assumes no other strengthening works to boat ramp are required					

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