

**REVIEW OF ENVIRONMENTAL FACTORS (REF)
FORESHORE PROTECTION AND ENHANCEMENT
LAKE CONJOLA FORESHORE
LOTS 486 AND 487 DP 861543**

Contents

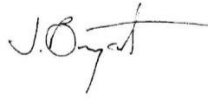
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Document control

Item	Details
Project	Foreshore Protection and Enhancement Works – Lake Conjola Foreshore – Lots 486 and 487 DP 861543
Client/Proponent	Environmental Services, Shoalhaven City Council
Prepared By	City Services, Shoalhaven City Council

Document status

Version	Author / Reviewer*	Name	Signed	Date
V1.0	Author	Geoff Young		27/08/2025
	Reviewer	Jeff Bryant		29/08/2025
	Client	Evan Astbury		01/09/2025

*Review and endorsement statement:

"I certify that I have reviewed and endorsed the contents of this REF document and, to the best of my knowledge, it is in accordance with the EP&A Act, the EP&A Regulation and the Guidelines approved under clause 170 of the EP&A Regulation, and the information it contains is neither false nor misleading".

Assessment and approvals overview

Item	Details
Assessment type	Division 5.1 (EP&A Act) - Review of Environmental Factors (REF)
Proponent	Shoalhaven City Council – Environmental Services
Determining authority / authorities	Shoalhaven City Council
Required approvals (consents, licences and permits)	"Fisheries Permit" - Section 205 of the NSW <i>Fisheries Management Act 1994</i>. "Crown Lands Licence" – Section 5.21 of the NSW <i>Crown Lands Management Act 2016</i>
Required publication	Yes – as per Section 171(4)(b)(i) of the NSW <i>Environmental Planning and Assessment Regulation 2021</i>

1. PROPOSAL AND LOCATION

1.1 Overview

The proposed activity is foreshore protection and enhancement works along the Lake Conjola foreshore in the vicinity of the Holiday Haven Tourist Park and adjacent public reserve being Lots 486 and 487 DP 861543 (Figure 1 and Figure 2 below).

The proposed activity would involve the following works (refer to Appendix A for plans and Section 1.2 of this REF for more details):

- Removal of the existing concrete reinforcement along the edge of the foreshore and replacing with and supplementing the existing rock beaching with new, additional graded angular quarry rock.
- Revegetation and establishment of endemic saltmarsh, sedges and grasses along the shore and foreshore.
- Planting and maintaining native trees and shrubs along the top of the foreshore bank.
- Protection of revegetated areas with temporary fencing in the short-term and, once established, with bollard fence.
- Creation of rock fillet and benched area for the establishment of saltmarsh.
- Relocation and formalisation of waterway access.
- Replacement of concrete stormwater outfalls with vegetated swales

Further explanation and justification of the works is provided in Sections 1.2 and 1.3 below.

Works would also involve the implementation of safeguards and mitigation measures prescribed in Section 7 of this Review of Environmental Factors (REF).

Shoalhaven City Council (SCC) is the proponent and the determining authority under Part 5 of the EP&A Act. The environmental assessment of the proposed activity and associated environmental impacts has been undertaken in the context of Clause 171 of the *Environmental Planning and Assessment Regulation 2021*. In doing so, this REF helps to fulfil the requirements of Section 5.5 of the Act that SCC examine and take into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity.

Figure 1 Location of the proposed activity



Figure 2 Location of the proposed treatments (refer to Appendix A for further details)



1.2 The proposed works

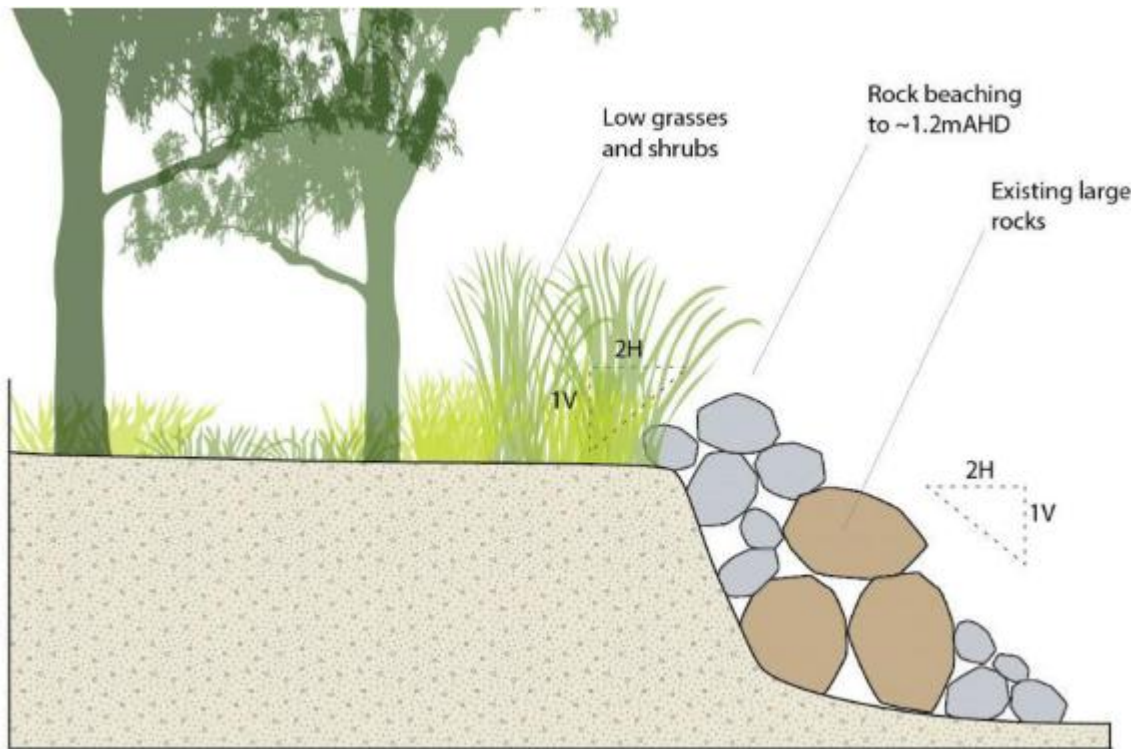
The proposed works consist of several treatment options to improve the stability of the foreshore alignment. Each option may be applied at varying locations along the foreshore and a combination of options may be applied at any one point. The concept design drawings (Appendix A), indicate an ideal arrangement that may change or be staged depending on budget, stakeholder pressure or other influences.

The works were devised by Water Technology Pty Ltd in collaboration with SCC and the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW). More information can be obtained in the technical report prepared by Water Technology (2025) provided as Appendix B of this REF, but summarised below:

Supplementing existing rock beaching

The existing rock beaching consists of one to two rows of large rocks, 500 – 700 mm diameter on the bank face (Figure 3 below). The existing rock beaching is in poor condition and the rocks are providing limited protection to the bank. The large rock beaching would be supplemented with smaller, graded rocks to form an interlocking rock riprap. Rock beaching should be formed from graded quarry rock with a median rock size (D50) of approximately 350mm. The intent of the smaller rocks is to provide more complete protection to the foreshore bank by filling the large gaps in the existing rocks. Furthermore, the smaller rock arrangement will be flexible enough to accommodate minor changes in the foreshore geometry that are expected to occur over time. The supplemented rock beaching arrangement is also expected to improve upon the ad hoc and uneven appearance of the existing arrangement and provide a safer and more consistent surface for tourist park users. (Water Technology 2025).

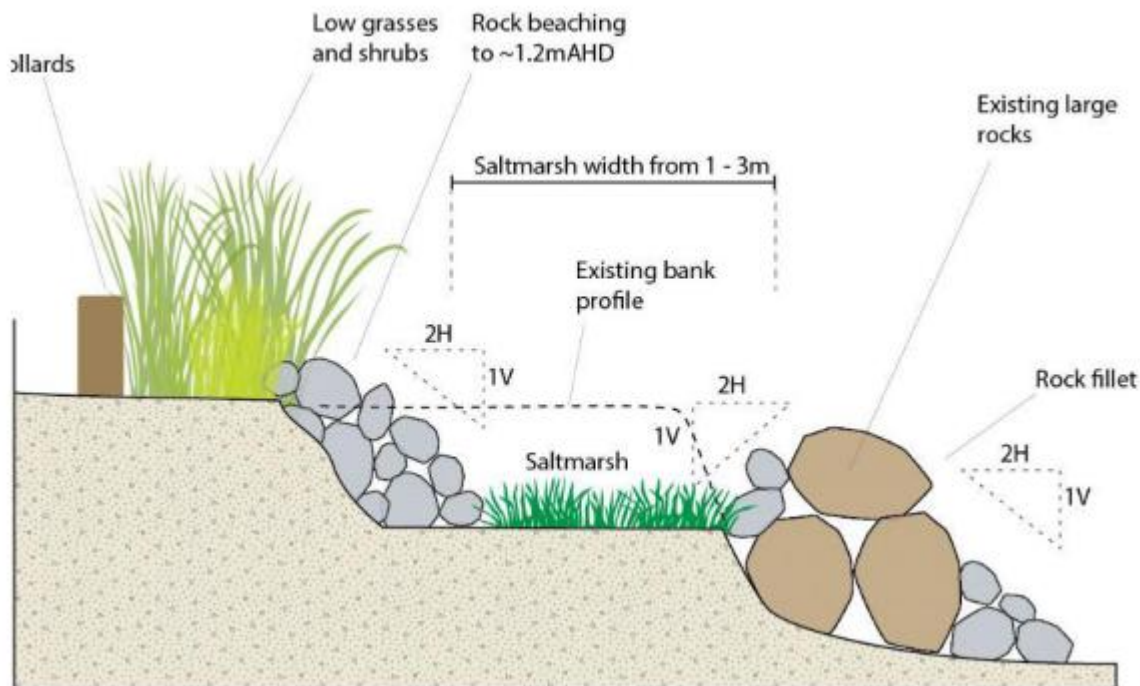
Figure 3 Rock Beaching



Saltmarsh Bench

This involves the formation of saltmarsh benches in targeted locations along the length of the foreshore (Figure 4 below). A bench is formed by locally excavating the foreshore surface that will be periodically inundated with tides (e.g. during spring tides) to allow the planting and establishment of saltmarsh comprising locally occurring species (e.g. Sea Rush *Juncus kraussii*, Bare Twig-rush *Baumea juncea*, Saltwater Couch *Sporobobulus virginicus*) and mangroves. The saltmarsh bench is to be protected at the lakeward side by a low rock fillet and the landward bank is to be armoured with rock beaching. The intent of the saltmarsh bench is to provide a stable buffer between the lake and the tourist park that will accommodate minor changes in the foreshore geometry that are expected to occur over time. Furthermore, there are many expected co-benefits of the saltmarsh benches including creation of marine habitat, filtering of stormwater runoff and providing the opportunity for education through interpretive signage.

Figure 4 Saltmarsh Bench



Fencing and vegetation management

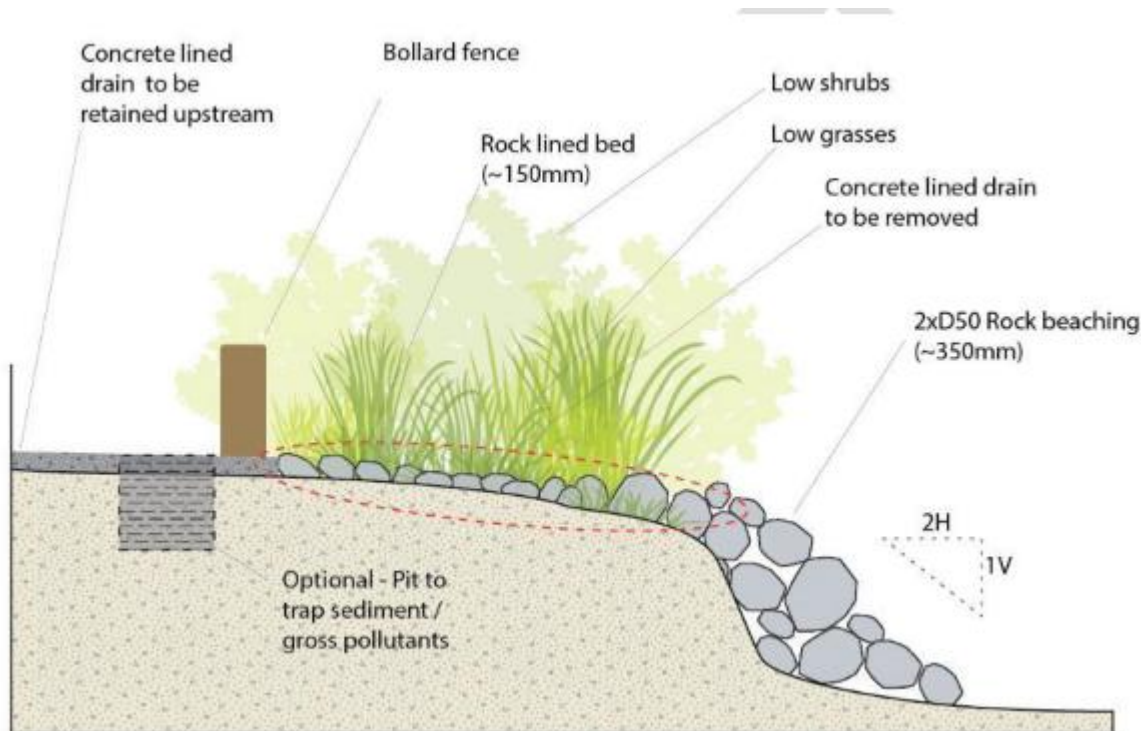
Management of vegetation along the foreshore is recommended to help control pedestrian traffic and to provide second line of foreshore protection beyond the rock beaching. Vegetation management is widely considered the most cost-effective form of long-term erosion control. At Lake Conjola, management of vegetation will have to account for competing objectives of erosion control and push back from local residents and caravan park users. It is likely certain stakeholders will perceive foreshore vegetation as obstructing views and access to the water. As such, revegetation efforts should focus on low height grass and shrub species. Given the existing foreshore bank height is approximately one metre, plants that grow to a similar height should provide effective erosion control.

The primary intent of the fencing is to delineate a no mow zone along the foreshore to ensure a vegetated buffer is maintained. The fence would not need to be high, no more than 300mm, and may be formed by posts and chain or simply regularly spaced bollards. Possible material for the posts may be hardwood, concrete or recycled plastic.

Vegetated swale / stormwater outlet

A vegetated swale is a shallow, open channel designed to convey stormwater overland while also filtering pollutants and reducing runoff velocity. Unlike the existing concrete drainage systems, vegetated swales use grass, shrubs, and other vegetation to slow down water flow, allowing sediments and contaminants to settle before reaching the lake. The outlets may contain pit drains that will allow easy maintenance. This would be approximately 0.8 x 0.8 x 0.8m inline pit with metal grate that one person can clean out without specialised equipment.

Figure 5 Typical design profile of vegetated swale / stormwater outlet



1.3 Justification and consideration of alternatives

Justification for the proposed activity is provided in a report prepared by Water Technology Pty Ltd (2025, Appendix B). Water Technology (2025) found that the existing rock and concrete works are not providing effective erosion control and protection. Whilst the existing rock and concrete revetment would be providing some protection from waves perpendicular to the bank (boat wash, smaller wind waves), the revetment is ineffective against flows parallel to the bank (flood flows, tidal currents, storm surge). This is exacerbated by the intensive use of the shore by the community and tourist park patrons (fishing and swimming and watercraft access).

The conveyance of stormwater runoff along multiple stormwater drainage outlets exacerbates foreshore erosion at and around the discharge points

Further bank retreat is expected to lead to the loss of public land and amenity of the site. Doing nothing would be unacceptable to the community and there would be a significant safety risk and loss of amenity for park users.

1.4 Location of the proposed activity

The proposed activity would be undertaken in and on the shore of Lake Conjola (Figure 1 below) and undertaken on lands described in Table 1 below.

The site of the proposed activity would be accessed by Lake Conjola Entrance Road which is a public road to which SCC is the Roads Authority under the NSW *Roads Act 1993*.

Table 1: Lands affected by the proposed activity

Land details	Components of activity	Pertinent land information
Part Lot 487 DP 861543 1A Lake Conjola Entrance Road	- Removal of concrete and replace and supplement with new graded angular quarry rock. - Revegetation and associated temporary fencing and longer-term bollard fencing. - Construction / establishment of access facilities.	- Crown reserve (R62146) with SCC appointed as Crown Land Manager. - Subject area is associated with the Lake Conjola Boat Ramp and associated carpark and public park. - Subject of undetermined Native Title and Aboriginal Land Rights claims.
Lot 486 DP 861543 Lake Conjola Entrance Road	- Supplement revetment wall with new graded angular quarry rock. - Revegetation and associated temporary fencing and longer-term bollard fencing. - Construction / establishment of access facilities.	- Crown reserve (R62146) with SCC appointed as Crown Land Manager - Subject area managed in association with the Holiday Haven Tourist Park management by SCC. - Subject of undetermined Native Title and Aboriginal Land Rights claims.
Lake Conjola waterway (below mean high water mark)	- Supplementing rock for the revetment. - Establishment of rock fillet and associated saltmarsh benches. - Construction / establishment of access facilities.	- Key Fish Habitat for the purposes of the NSW <i>Fisheries Management Act 1994</i> - Crown land below mean high water mark (MHWM). - Contains protected marine vegetation regulated under the NSW <i>Fisheries Management Act 1994</i>.

2. EXISTING ENVIRONMENT

Photos of the site are provided in Section 2.5 below.

The site of the proposed activity was assessed by a SCC Environmental Operation Officer on 22 July 2025. Site investigations involved vegetation and habitat assessment, recording flora species within and immediately adjacent to the proposed activity, determination of vegetation communities including the presence of threatened ecological communities, Aboriginal heritage objects, seagrass and saltmarsh, and investigation of habitat availability for threatened flora and fauna species.

The site of the proposed activity is on the foreshore of Lake Conjola in the vicinity of the Holiday Haven Tourist Park and a public reserve to the east. The foreshore is used heavily by the local community and Tourist Park patrons for swimming, watercraft and fishing access.

Immediately (~75 metres) to the west of the boat ramp the associated public park has been previously treated with revegetation pockets including Swamp Oak *Casuarina glauca* and native grasses/reeds with interpretative / educational signage. It is understood that the revegetation was undertaken approximately 10 years ago. The vegetation is in good condition (albeit having the environmental weed Sharp Rush *Juncus acutus* contributing to the vegetation community) and appears to be effective in controlling erosion (Water Technology 2025). This area is not part of the proposed activity.

The area of the proposed activity is generally depauperate of native vegetation. Previous foreshore erosion treatment in the eastern portion of the site (Lot 487 DP861543) consists of poorly graded (*i.e.* little variation in size) large rocks (~400-500mm diameter). The rock protection consists of a few isolated rows of rocks that are approximately one metre wide. The rocks are only one rock deep (not stacked or interlocking) and there are gaps between rocks. Scouring is occurring behind the rocks, and the foreshore is receding. As a result, the existing foreshore alignment is unarmoured. (Water Technology 2025).

The foreshore fronting the tourist park is also generally sparse of vegetation with the occasional Swamp Oak and Sea Rush *Juncus kraussii* clump. The revetment consists of a combination of large rock (1-2 rows of 500-700 mm diameter) on the bank face and cast in-situ, concrete on the top of the bank. The concrete treatment is inconsistent, absent in parts and up to one metre wide in others. The condition of the concrete is generally poor (cracked and uneven) with scour of the bank material behind the concrete. (Water Technology 2025)

Stormwater from the impervious areas of the caravan park discharges to the lake from at least seven locations. While only minimal scour/erosion was observed at these sites, they present a long-term risk to the bank stability. Some of these drains are also used as watercraft launch points. There is also a spoon drain that enters a stormwater pit below the foreshore and discharges through a culvert pipe into the lake. This allows for dense riparian vegetation to grow along the foreshore at this location and ensure stormwater discharges directly into the lake and not over the banks of the foreshore, thereby reducing the potential for foreshore erosion. (Water Technology 2025)

2.1 Habitat and vegetation assessment

The terrestrial area of proposed activity site is generally denuded of vegetation as it has been cleared for the existing development and recreational use.

The reserve at the site of the proposed activity consists of short-mown grass with scattered remnant Swamp Oaks. Endemic saltmarsh species in the form of Sea Rush is also present in a few restricted areas of the foreshore (Figure 6 below). An introduced rush, Sharp Rush *Juncus acutus*, is present in the eastern end of the site (Figure 6 below). Sharp Rush is an invasive weed that outcompetes native foreshore plants and is a threat to the endangered coastal saltmarsh ecological community. It can also form dense infestations that restrict the movement of people and animals. The removal of this plant is a component of the proposed activity.

Eelgrass *Zostera spp.*, a single mangrove *Avicennia marina* seedling, and macroalgae (predominantly Neptunes Necklace *Hormosira banksii*) is present along the shoreline and within the waterway. This vegetation will be directly impacted by the proposed activity.

No threatened flora nor suitable habitat for locally occurring threatened orchid species was identified on site during site environmental examinations.

No South-eastern Glossy Black-cockatoo (*Calyptorhynchus lathami lathami*) feed trees (e.g. *Allocasuarina littoralis* with characteristic chewed cones), nor Yellow-bellied Glider (*Petaurus australis*) feed trees (e.g. e.g. *Corymbia gummifera* or *Eucalyptus punctata* with v-shaped feeding scars) occur within or in close proximity to the site. No signs of potential threatened fauna use of the site (e.g. bandicoot diggings, owl white-wash or other threatened fauna scats) were noted.

There are no hollow-bearing trees in the area that would be affected by the proposed activity.

Figure 6 Vegetation – relevant to the proposed activity



2.2 The Waterway

The proposed activity would be undertaken within Lake Conjola, an 'ICOLL' (intermittently closed and open lakes and lagoons) and with a surface area of 6.9km² in a catchment area of 145km² (Royal Haskoning DHV 2024).

The Lake's entrance occasionally closes, sometimes requiring SCC intervention to mitigate potential flooding of low-lying areas, however it is predominantly open to the ocean and receives tidal interchange of marine waters.

The entrance area comprises a broad tidal delta of clean marine sand, with pronounced sand lobes, which are elevated at up to one metre above mean sea level. The proposed activity would be undertaken west of the delta adjacent to a shallow (one to two metres) entrance channel.

The substrate of the Lake at the site of the proposed activity comprises estuarine deposits of silt and medium-grain sand, generally of marine origin. Benthos and signs of benthic life were not observed at the time of inspection but the substrate is likely to support invertebrate infauna and mobile invertebrates (e.g. Hermit Crabs, Soldier Crabs). Similarly, fish such as Yellowfin Bream

Acanthopagrus australis, Dusky Flathead *Platycephalus fuscus*, Sand Whiting *Sillago cilliata*, Stingaree *Urolophus sp.*, and Weeping Toadfish *Torquigener pleurogramma* would be expected to occur in the waterway at the site of the proposed activity from time to time. Rock Oyster *Saccostrea glomerata* and littorinid snails (periwinkles) were present on the existing rock revetment.

The waterway is mapped by the NSW Department of Primary Industries - Fisheries as 'key fish habitat' for the purposes of the NSW *Fisheries Management Act 1994*.

The site is within flood liable land being mapped by SCC as existing Flood Planning Area for the purposes of the SCC Development Control Plan and Shoalhaven Local Environmental Plan 2014 (SLEP).

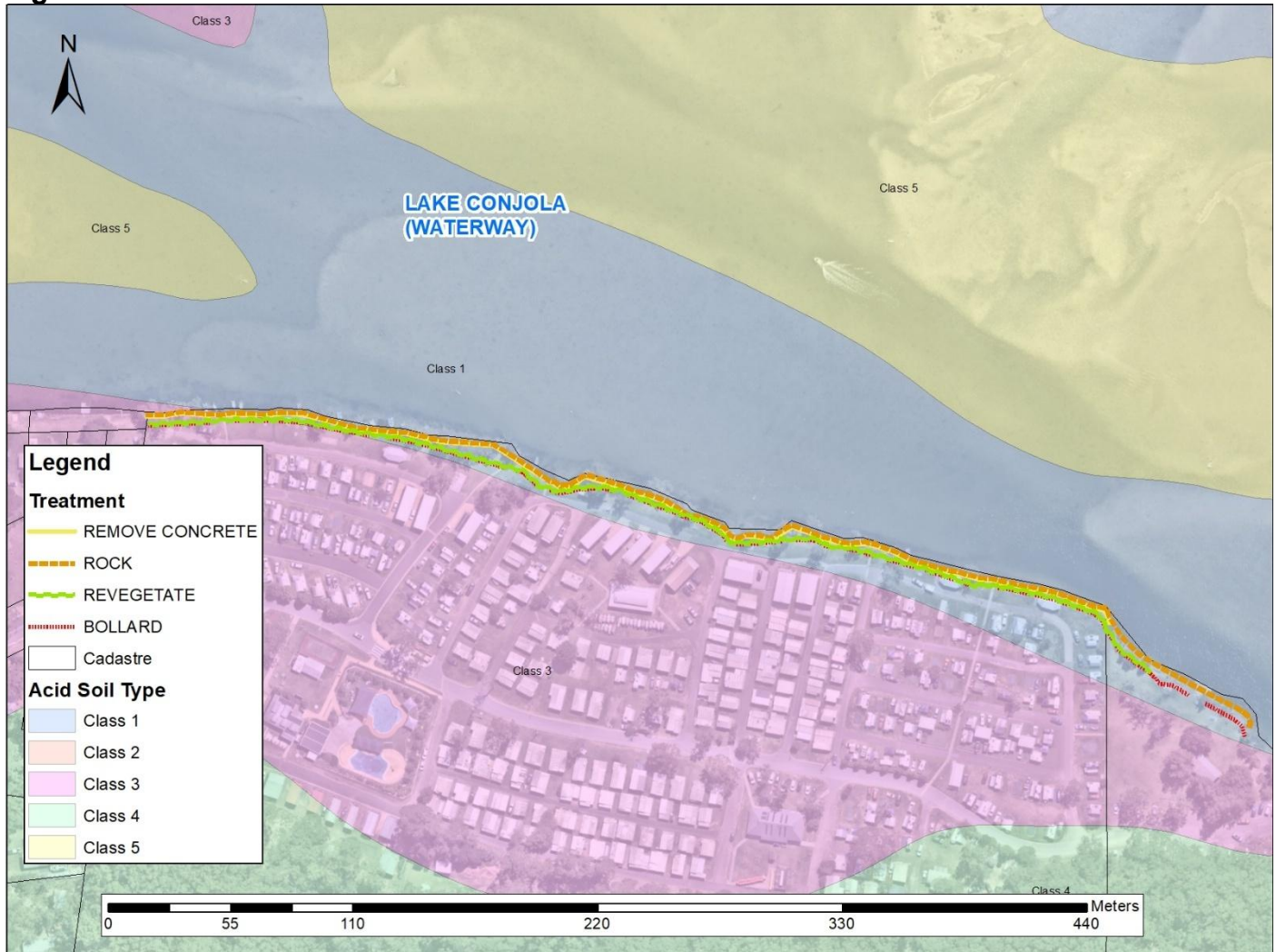
2.3 Geology

Being located on an estuarine tidal-delta flat and estuarine channel, the geology of the proposed activity site comprises estuarine deposits of fine to medium-grained lithic-carbonate-quartz sand (marine-deposited), silt, clay, shell material, and polymictic gravel of a Holocene age (MinView 2025¹).

Being Holocene and estuarine in origin, the soils at the site have a higher risk of containing iron sulfides which when exposed to oxygen generate sulfuric acid *i.e.* acid sulfate soils. This is reflected in the acid sulfate soil risk map where the site is predominantly mapped as "class 1" risk (Figure 7 below).

¹ <https://minview.geoscience.nsw.gov.au/#/?lon=148.5&lat=-32.5&z=7&l=>

Figure 7 Acid Sulfate Soils Risk



2.4 Infrastructure and other features

Along the foreshore a number of infrastructure features will require protection during the proposed activity including water level gauges and an existing stormwater outlet pipe (Figure 8 below and photos in Section 2.5).

A couple of memorial plaques have also been installed on rocks forming the existing revetment wall (Figure 8 below and photos in Section 2.5). Although these plaques have been installed without approval it is recommended that they be retained or relocated if possible. This may avoid emotive reactions from owners/installers of the plaque.

Figure 8 Infrastructure and other features that require protection or other considerations



2.5 Photos

Photo 1: Manly Hydraulics monitoring equipment to be protected during rock placement works. Also showing invasive species Sharp Rush to the left.



Photo 2: Water level monitoring equipment to be protected during rock placement works.



Photo 3: Environmental weed Sharp Rush to be removed as part of the proposed activity



Photo 4: Native Sea Rush and Swamp She-oak to be protected during works



Photo 5: Zostera at the toe of the existing revetment. Also showing the concrete reinforcement proposed to be removed



Photo 6: An example of a memorial plaque that may require relocation when concrete reinforcement is removed.



3. ASSESSMENT OF LIKELY IMPACTS ON THE ENVIRONMENT

3.1 Impacts associated with the proposed activity

The proposal would involve the following disturbance and direct impacts:

- Potential pollution of water.
- Impact to vegetation.
- Excavation of potentially acid sulfate soils.
- Dredging and reclamation of waterway.

Other impacts on the environment, including indirect impacts have been considered, including:

- threatened species
- indigenous and non-indigenous heritage
- development of flood liable land

Each is discussed below.

3.2 Pollution

Pollution of the waters could occur during the proposed activity including:

- hydrocarbons e.g. oil and fuel spills and leaks,
- erosion of exposed soils during the removal of concrete, benching and other land forming.
- fines from rock used to form the new retaining wall.

All excavation works and placement of rocks by the excavator would be undertaken during the lower tidal phases and from the upper embankment of the shore. No plant would be operated from the waterway.

Erosion and sediment control measures in accordance with the Blue Book (Landcom 2004) would be in place during the proposed activity and would include the use of hydrocarbon floating booms with silt curtain, sediment fences for stockpiled earthen material, and rapid stabilisation.

The implementation of the above measures as well as the environmental measures prescribed in Section 7 of the REF (e.g. spill-kits, working during lower tide periods) would also minimise potential pollution events and mitigate impacts if they inadvertently occur.

3.3 Vegetation

The supplementary rock revetment works would likely impact a thin strip (0.5 metres) of seagrass (*Zostera spp.*) of varying densities where it currently occurs at the base of the existing rock revetment in patches over a length of approximately 170 metres (Figure 6 p.15). The proposed activity may also, inadvertently, harm a single mangrove seedling currently growing within the existing rock revetment (Figure 6 p.15). Both the Eelgrass and Mangrove are “protected marine vegetation” regulated under the NSW *Fisheries Management Act 1994*. A Fisheries Permit would be required prior to commencement of works (refer to Section 4.3 of this REF for further information).

The Fisheries Permit may require some form of rehabilitation and compensation measures. The *Policy and Guidelines for Fish Habitat Conservation and Management* provides for habitat rehabilitation and environmental compensation to mitigate damage to fish habitat. Initial consultation with NSW Fisheries (Messer *pers.comm.* 2025) suggests that the proposed foreshore enhancements, *i.e.*, revegetation, removal of concrete in exchange for angular rock, saltmarsh benches, removal of Sharp Rush, and formalising and hardening of water access points would likely to be suitable compensation to mitigate the damage to the seagrass (SCC document reference D25/369974). This would be confirmed when a Fisheries Permit is submitted.

The other native vegetation present, *i.e.*, scattered Swamp Oaks and a few clumps of Sea Rush, would be retained and protected from harm during works. These measures would include providing temporary fencing to the clumps of Sea Rush and utilising the provisions of Australia Standard 4970 *Protection of trees on development sites* to protect the remaining Swamp Oaks from inadvertent harm as far as practicable.

These protection safeguards and proposed revegetation works would have a positive impact to vegetation and the environment. An Environmental Impact Statement in relation to vegetation impact would therefore not be warranted.

3.4 Threatened species impact assessment (NSW)

Section 1.7 of the EP&A Act 1979 applies the provisions of Part 7 of the NSW *Biodiversity Conservation Act 2016* and Part 7A of the *NSW Fisheries Management Act 1994* that relate to the operation of the Act in connection with the terrestrial and aquatic environment. Each are addressed below.

3.4.1 Part 7A Fisheries Management Act 1994

Part 7A relates to threatened species conservation. Section 220ZZ provides a “7-Part test of significance” to determine whether a proposed action is likely to significantly affect threatened species, populations or ecological communities and thereby require a species impact statement (SIS). The assessment is provided below:

Part 1 In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is to be placed at risk of extinction.

Several saltwater species listed in the schedules of the Act are known to occur or have occurred on the south coast of NSW²:

- Grey Nurse Shark *Carcharias taurus* and Blind Slug *Smeagol hiliaris* are listed as Critically Endangered.
- Southern Bluefin Tuna *Thunnus maccoyii* and Scalloped Hammerhead Shark *Sphyrna lewini* are listed as Endangered.

² All threatened species information in Section 3.2.1 sourced from NSW DoPI Threatened Species database: <https://www.dpi.nsw.gov.au/fishing/threatened-species/what-current>

- Great White Shark *Carcharodon carcharias* and Black Rockcod *Epinephalus daemeli* are listed as Vulnerable.
- Green Sawfish *Pristis zijsron* is listed as Presumed Extinct.

Populations of these species have primarily been reduced by over-harvesting, habitat degradation and human interference or hazards (e.g. nets) in habitat.

Grey Nurse Shark

Grey Nurse Sharks *Carcharias taurus* have the potential to enter Lake Conjola. Grey Nurse Sharks are, however, found predominantly in inshore coastal waters. They have been recorded at various depths but mainly found in waters between 15 and 40 metres deep.

In the unlikely event that a Grey Nurse Shark was present during works, it would swim away and not be impacted.

Works would not impact on habitat for this species.

Blind Slug

This is a pulmonate (with lung) slug. It has only been collected from a small, isolated location at Merry Beach, south of Ulladulla. The species lives in gravel and cobble filled rocky crevices and beaches at Merry Beach. The proposal would therefore have no effect on the lifecycle of this species.

Southern Bluefin Tuna

The Southern Bluefin Tuna are pelagic fish occurring in the oceanic waters normally on the seaward side of the continental shelf. The proposal would therefore have no effect on the lifecycle of this species.

Scalloped Hammerhead Shark

The Scalloped Hammerhead Shark is a coastal pelagic species with a circum-global distribution in warm temperate and tropical coastal areas. They are known to form large migratory schools and in Australia tend to move as far south as Sydney during the warmer months. The proposal would therefore have no effect on the lifecycle of this species.

Great White Sharks

Great White Sharks have the potential and are known to enter Lake Conjola. However they are normally found in inshore waters around rocky reefs and islands and often near seal colonies. They have been recorded at varying depths down to 1,200 metres. In the unlikely event that a Great White Shark was present during works, it would swim away and not be impacted.

Black Rockcod

Black Rockcod live in relatively shallow rocky reefs where they are usually found in caves, ledges, gutters and beneath bommies. Small juveniles are often found in coastal rocky pools, and larger juveniles around rocky shores in estuaries. Although the site of the proposed activity would provide habitat for juveniles, the proposed activity would overall supplement and improve habitat.

Green Sawfish

Green Sawfish (presumed extinct in NSW) are bottom dwelling rays commonly found in near-coastal environments including estuaries, river mouths, embankments and along sandy and muddy beaches. It has been recorded in Jervis Bay, but the last confirmed sighting of the species in NSW was in 1972 from the Clarence River at Yamba. The proposal would not directly impact the species and is unlikely to negatively affect suitable habitat for the Green Sawfish, such that the species (if not already extinct) would be impacted.

Part 2 In the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the lifecycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

The endangered populations listed under the Act are:

- *Ambassis agassizii* Steindachner Agassiz's glassfish, olive perchlet, western New South Wales population
- *Craterocephalus amniculus* Darling River Hardyhead, Hunter River population
- *Gadopsis marmoratus* river blackfish, Snowy River population
- *Tandanus tandanus* freshwater catfish, eel tailed catfish, Murray-Darling Basin population
- *Posidonia australis* seagrass, Port Hacking, Botany Bay, Sydney Harbour, Pittwater, Brisbane Waters and Lake Macquarie populations

These areas would be unaffected by the proposed activity.

Part 3 In the case of an endangered ecological community or critically endangered ecological community whether the proposed development or activity:

- I. is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or***
- II. is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***

The endangered ecological communities listed under the Act are:

- Aquatic ecological community in the natural drainage system of the lower Murray River catchment
- Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River
- Aquatic ecological community in the natural drainage system of the lowland catchment of the Lachlan River
- Aquatic ecological community in the catchment of the Snowy River in NSW

These areas would be unaffected by the proposed activity.

Part 4 In relation to the habitat of a threatened species or ecological community:

- I. The extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and***
- II. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and***
- III. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.***

N/A – The area affected by the activity does not provide habitat for threatened species, populations or ecological communities (refer responses to Part 1 through Part 3 above)

Part 5 Whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly),

The only critical habitat currently on the register is “Critical Habitat of Grey Nurse Shark” with listed and mapped areas of:

- Bass Point (Shellharbour)
- Big and Little Seal Rocks
- Fish Rock and Green Island (South West Rocks)
- Julian Rocks (Byron Bay)
- Little Broughton Island (Port Stephens)
- Magic Point (Maroubra)
- Montague Island (Narooma)
- The Pinnacle (Forster)
- Tollgate Islands (Batemans Bay)

These areas would be unaffected by the proposed activity.

Part 6 Whether the proposed development or activity is consistent with a Priorities Action Statement

As demonstrated in Part 1 above, the proposed activity would have no effect on threatened species.

Part 7 Whether the proposed development constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Key Threatening Process	Assessment
Degradation of native riparian vegetation along NSW water courses	Not applicable – The subject waterway is estuarine. Estuarine and marine waters are excluded from this KTP as the degradation of riparian vegetation in

Key Threatening Process	Assessment
	these areas does not adversely affect two or more listed threatened species, populations or ecological communities (Fisheries Scientific Committee 2007).
Hook and line fishing in areas important for the survival on threatened fish species	Not applicable – proposal does not comprise or facilitate hook and line fishing.
Human-caused climate change	Not applicable – the proposal does not contribute to human-caused climate change.
Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams	Not applicable – the proposal does not involve the installation or operation of instream structures that would alter the natural flow regime.
Introduction of fish to waters within a river catchment outside their range	Not applicable – the proposal does not involve releasing fish.
Introduction of non-indigenous fish and marine vegetation to the coastal waters of NSW	Not applicable – the proposal does not involve the introduction of non-indigenous fish.
Removal of large woody debris from NSW rivers and streams	Not applicable – the proposal does not involve the removal of woody debris.
The current shark meshing program in NSW waters	Not applicable – the proposal does not involve shark meshing.

3.4.2 Part 7 Biodiversity Conservation Act 2016

An assessment of the potential for NSW threatened flora and fauna species occurring on-site or otherwise being impacted by the proposal was undertaken (refer to Appendix C). No threatened species are known to occur on-site or are considered to have some potential to occur on-site or be otherwise impacted by the proposal, requiring further assessment under Part 7 of the NSW *Biodiversity Conservation Act 2016*.

Section 7.3 of the Act provides a 'five-part' test to determine whether a proposed development or activity is likely to significantly affect threatened species or ecological communities, or their habitats. Each Part is addressed below:

Part A - In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the lifecycle of the species such that a viable local population of the species is likely to be place at risk of extinction.

No breeding, refuge or foraging habitat which is important for any threatened fauna species, was found to occur within or in close proximity to the site.

No suitable habitat for any locally occurring threatened flora species occurs within the site.

Highly mobile threatened species such as birds, microbats and migratory species may occur transiently within or in proximity to the site, but are unlikely to utilise and rely on any available habitat.

The proposal is therefore unlikely to impact on any threatened species or their habitats, such that a viable local population of any threatened species is placed at risk of extinction.

Part B - In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

- (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or***
- (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction***

Based on the remnant vegetation present on site (Swamp Oak, Sea Rush and Boobialla *Myoporum acuminatum*), soils, and the position in the landscape, the site may have once comprised the endangered ecological community (EEC) *Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions* (hereafter referred to as Swamp Oak Floodplain Forest). This community is found on the coastal floodplains of NSW associated with grey-black clay loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes. It typically has a dense to sparse tree layer in which Swamp Oak is the dominant species (NSW Scientific Committee 2011).

The area of the proposed activity is highly disturbed being cleared and maintained as caravan and tourist park and associated recreational foreshore area. This land-use is likely to remain for the long-term. The community currently consists of scattered remnant Swamp Oaks, a few small clumps of Sea Rush, and one individual Boobialla. The site does not contain any other trees, shrubs, grasses or vines listed in the NSW Scientific Committee's (2011) description of the EEC. The local extent of the community can therefore be considered extinct and the continuity of the

area to revert back to the EEC is considered unviable. A species impact statement (SIS) or entry into the Biodiversity Offset Scheme is therefore not required. It is however recommended that the proposed revegetation along the foreshore utilise species known to occur within this community including:

- Swamp Oak *Casuarina glauca*
- Bare Twig-rush *Baumea juncea*
- Sea Rush *Juncus kraussii*
- Swampweed *Selliera radicans*
- Spiny-head Mat-rush *Lomandra longifolia*
- Blue Flax-lily *Dianella caerulea*
- Swamp Paperbark *Melaleuca ericifolia*

This is reflected in the Environmental Impact Mitigation measures prescribed in Section 7 of this REF.

Part C - In relation to the habitat of a threatened species or ecological community:

- (i) **the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity**
- (ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and**
- (iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.**

No important habitat for threatened species would be removed or otherwise significantly impacted (see Part A).

No EEC would not be fragmented or isolated, nor removed or modified to an extent that would affect the long-term survival of the EEC occurring in the locality (refer to Part B).

The proposal will therefore not affect the long-term survival of any threatened species or endangered ecological community in the locality.

Part D – Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).

No “areas of outstanding biodiversity values” have been declared in the City of Shoalhaven.

Part E – Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

There are no key threatening process listed in the NSW *Biodiversity Conservation Act 2016* considered relevant to the proposed activity.

3.5 Indigenous heritage

Under Section 86 of the NSW *National Parks and Wildlife Act 1974* (NPW Act) it is an offence to disturb, damage, or destroy any Aboriginal object without an Aboriginal Heritage Impact Permit (AHIP). The Act, however, provides that if a person who exercises ‘due diligence’ in determining

that their actions will not harm Aboriginal objects has a defence against prosecution if they later unknowingly harm an object without an AHIP (Section 87(2) of the Act). To effect this, the NSW Department of Environment, Climate Change and Water have prepared the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (hereafter referred to as the 'Due Diligence Code') (DECCW 2010) to assist individuals and organisations to exercise due diligence when carrying out activities that may harm Aboriginal objects and to determine whether they should apply for an AHIP.

A search on the Aboriginal Heritage Information Management System (AHIMS) on 31 July 2025 indicated that there are no recorded Aboriginal sites or places in the vicinity of the proposal (refer to AHIMS report below in Figure 9 below).

The site of the proposed activity is within a landscape feature listed in the Due Diligence Code that has a higher propensity for Aboriginal objects *i.e.* within 200 metres of waters. As such a targeted site survey was undertaken on 22 July 2025. No objects were found with at least 80% visibility.

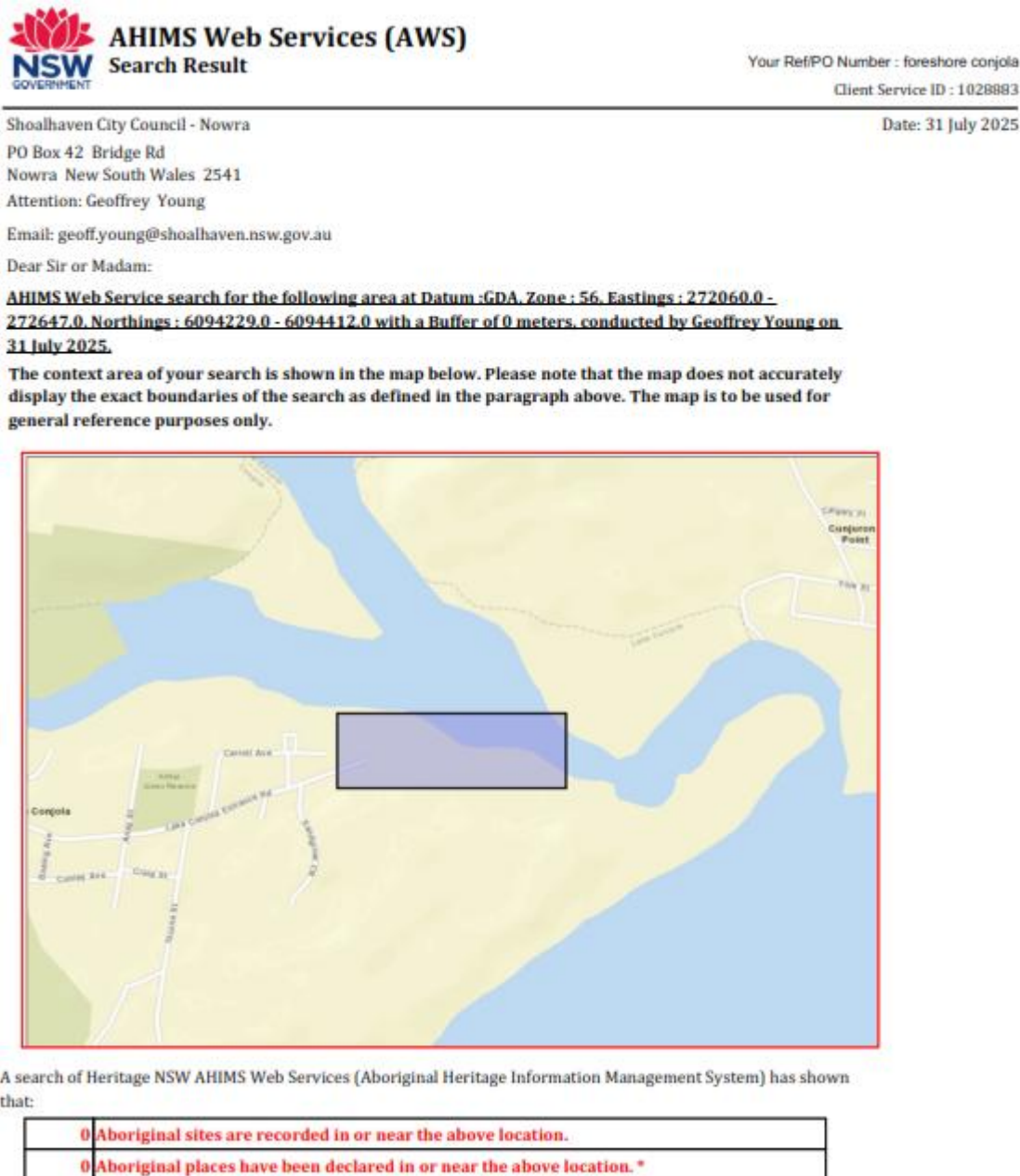
The site of the proposed activity is "disturbed land" or "land already disturbed by previous activity" as defined in the Due Diligence Code (DECCW 2010):

"Land is disturbed if it has been the subject of human activity that has changed the land's surface, being changes that remain clear and observable. Examples include ploughing, construction of rural infrastructure (such as dams and fences), construction of roads, trails and tracks (including fire trails and tracks and walking tracks), clearing vegetation, construction of buildings and the erection of other structures, construction or installation of utilities and other similar services (such as above or below ground electrical infrastructure, water or sewerage pipelines, stormwater drainage and other similar infrastructure) and construction of earthworks".

The site of the proposed activity is considered to be highly disturbed land through the previous activities associated with constructing and maintaining the existing revetment and establishment and use as a tourist park as well as the natural erosional and depositional processes associated with the Lake Conjola waterway.

As the proposed activity would be undertaken on disturbed land and not impact any recorded or visible Aboriginal sites or places, the Due Diligence Guidelines requires no further assessment. An AHIP is not required, and the activity can proceed with caution. Cautionary measures are prescribed in Section 7 of this REF.

Figure 9 Results of AHIMS Aboriginal heritage search



3.6 Non-indigenous heritage

No items of local heritage significance or any items on the State Heritage Register or listed in the Shoalhaven Local Environmental Plan occur near the site such that the proposed works might impact them. No further consideration is required.

3.7 Acid Sulfate Soils

The site of the proposed activity is mapped as Class 3 and Class 1 risk for acid sulfate soils (Figure 7 p.17).

The *Shoalhaven Local Environmental Plan 2014* (SLEP) indicates that a risk of exposure of acid sulfate soils exist on land mapped as Class 3 where works occur more than one metre below the natural ground surface or where works by which the water table is likely to be lowered more than one metre below the natural ground surface. For Class 1 areas any excavation works would carry risk of exposure of acid sulfate soils.

Excavation for the proposed activity would be for:

- saltmarsh benches
- installation of bollards, access steps and FRP Platform supports

Consequently, three soil samples were taken in the vicinity of the proposed saltmarsh benches at approximate depth of 1 metre. Samples were submitted to ALS Laboratories for a “SPOCAS” Acid Base Account Test (Suspension Peroxide Oxidation Combined Acidity and Sulphur) on 3 September 2025.

Test results obtained on 12 September indicates that the soils are not actual or potential acid sulfate soils (refer to SCC document reference [D25/406578 - Acid Sulfate Soil test results - Lake Conjola foreshore works](#)). An Acid Sulfate Soil Management Plan is therefore not required, and the excavated soil can be disposed of without treatment.

3.8 Flooding

The entire site and adjacent low-lying areas are mapped as flood liable land. The lake regularly overtops the shoreline at this location inundating the adjacent tourist park.

Flooding of Lake Conjola can be the result of a few very different circumstances, including:

- Catchment flooding from the local catchment rainfall.
- Oceanic inundation as a result of high ocean tides plus storm surge.
- Low-level persistent flooding due to elevated Lake levels during periods of entrance closure.

Flooding of the site of the proposed activity could occur at each circumstance with different velocity and depth effects (BMT WBM Pty Ltd 2013). Overall, however, the proposed activity would be in flood prone land with a high hazard floodway combined hazard and hydraulic category (BMT WBM Pty Ltd 2013).

The proposed activity is to make the area less vulnerable to further storm and flood damage. In comparison to the existing situation, the proposed activity would provide increased fortification to the shore (Water Technology 2025).

The proposed rock treatment would be of similar height to the existing shoreline and the increased bulk is insignificant and would not change flood patterns other than to a minor extent.

A Notice of Intention was sent to SCC's Senior Flood Engineer on 31 July 2025. Refer to Section 5.1 of this REF for details.

3.9 EP&A Regulation – Clause 171 matters of consideration

Clause 171(2) of the *Environmental Planning and Assessment Regulation 2021* lists the factors to be taken into account when consideration is being given to the likely impact of an activity on the environment under Part 5 of the EP&A Act. The following assessment in Table 2 below deals with each of the factors in relation to the proposed activity.

Table 2: Clause 171(2) Factors

Does the proposal:	Assessment	Reason
a) Have any environmental impact on a community?	Positive	The proposed activity involves the stabilisation and fortification of the foreshore used by the community for public recreation and passive enjoyment. Although some community members, particularly nearby residents and tourists, may be affected by slight increase in noise during construction, the proposed activity would benefit the community and visitors to the area. The proposed activity would not have any impact on other community services and infrastructure such as power, water, waste water, waste management, educational, medical or social services.
b) Cause any transformation of a locality?	Positive	The locality, being foreshore for public recreation, would not change. Indeed, the proposed activity would make improvements to the locality and repair damaged caused by storms and flood events.
c) Have any environmental impact on the ecosystem of the locality?	Low adverse	An assessment provided in Section 3.2 of this REF concludes that the proposed activity would not have a significant impact upon threatened species or endangered ecological communities. No significant habitat features would be removed or otherwise impacted. No food resources critical to the survival of a particular species would be removed. Aquatic ecosystems are not likely to be significantly affected by the proposed activity and there is not likely to be any long-term or long-lasting impact through the input of sediment and nutrient into the ecosystem. Environmental safeguards and mitigation measures (Section 7) would be employed to minimise risk of impacts.
d) Cause a diminution of the aesthetic, recreational, scientific or other	Low adverse / positive	In the context of the locality, with consideration of residential nearby, the visual impact of the activity would be minimal and complimentary. The proposed activity introduces a structure adjacent to a substantially altered

Does the proposal:	Assessment	Reason
environmental quality or value of a locality?		environment, <i>i.e.</i> caravan park, recreational areas and cleared foreshore. The area that would be affected by the proposed activity has no significant value in terms of science or other environmental qualities. The proposed activity would have no impact on these values.
e) Have any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific, or social significance or other special value for present or future generations?	Negligible	The site of the proposed activity has no significant aesthetic, architectural, cultural, historical, scientific or social values. As such, the proposed activity would have no impact on these items. No items in the vicinity of the work site which are listed on the State Heritage Register and the Shoalhaven Local Environmental Plan would be impacted by the proposal. The site is not within an Aboriginal Place declared under the <i>National Parks and Wildlife Act 1974</i>. In accordance with the NSW Department of Environment, Climate Change and Water's Due Diligence Code of Practice, the proposed activity does not require an Aboriginal Heritage Impact Permit as the activity is unlikely to harm an Aboriginal artefact (refer to Section 3.5).
f) Have any impact on the habitat of protected fauna (within the meaning of the Biodiversity Conservation Act 2016)?	Low adverse	No fauna habitat will be removed by the activity. No important habitat will be removed or otherwise impacted. The potential impact is therefore considered to be insignificant or inconsequential. The proposed activity would not have a significant impact upon threatened fauna (refer to Section 3.2 of this REF). The specified environmental mitigation measures (Section 7) would mitigate indirect impacts to fauna and habitat.
g) Cause any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air?	Negligible	There are no species likely to rely on the site of the proposed works to the extent that modification would put them further in danger. The prescribed environmental safeguards and mitigation measures (Section 7 of this REF) would minimise the risk of impact on resident fauna, fish, and flora.
h) Have any long-term effects on the environment?	Negligible	Works would be relatively short term, and the noise generated will occur during normal working hours. There are no sensitive receivers in the vicinity of the proposed works.

Does the proposal:	Assessment	Reason
		The proposed activity would not use hazardous substances or use or generate chemicals which may build up residues in the environment. The possible impacts have been discussed in detail under Section 3. Refer also to the conclusions and recommendations in Section 7.
i) Cause any degradation of the quality of the environment?	Low-adverse	Aquatic ecosystems are not likely to be affected by the proposed activity and there is not likely to be any long-term or long-lasting impact through the input of sediment and nutrient into the ecosystem. The proposal would not intentionally introduce noxious weeds, vermin, or feral animals into the area or contaminate the soil. Environmental safeguards and mitigation measures (Section 7) would be employed to minimise risk of impacts.
j) Cause any risk to the safety of the environment?	Negligible	The proposed activity would not involve hazardous wastes and would not lead to increased bushfire or landslip risks. The activity is not anticipated to adversely affect flood behaviour or exacerbate flooding risks.
k) Cause any reduction in the range of beneficial uses of the environment?	Positive	The site and local environment will remain relatively unchanged. The area is currently being used as a boat launching facility in a significantly modified environment. The proposed activity would improve this use and reduce the shore erosion currently occurring.
l) Cause any pollution of the environment?	Low adverse	The proposal would involve a temporary and local increase in noise during the construction phase due to the use of machinery. However this will not affect any sensitive receivers such as residential areas, schools, childcare centres and hospitals. Nearby residents and the Tourist Park management would be notified of noise-generating works. Turbidity, sediment and erosion control in accordance with the Blue Book will be implemented to minimise movement of sediment into the Lake. It is unlikely that the activity (including the environmental impact mitigation measures) would result in water or air pollution, spillages, dust, odours, vibration or radiation. The proposal does not involve the use, storage or transportation of hazardous substances or the generation of chemicals which may build up residues in the environment.

Does the proposal:	Assessment	Reason
		The material that would be excavated shall be tested for the presence of potential acid sulfate soils. A full Acid Base Account assessment utilising the SPOCAS analysis shall confirm the presence of acidity, potential acidity and liming rate to neutralise the acid prior to disposal. If necessary, an acid sulfate soil management plan would be prepared to facilitate treatment.
m) Have any environmental problems associated with the disposal of waste?	Negligible	The waste that would be disposed off-site can be recycled or re-used in accordance with resource recovery exemptions or taken to a licensed waste facility. The material that would be excavated shall be tested for the presence of potential acid sulfate soils. A full Acid Base Account assessment utilising the SPOCAS analysis shall confirm the presence of acidity, potential acidity and liming rate to neutralise the acid prior to disposal. If necessary, an acid sulfate soil management plan would be prepared to facilitate treatment. There would be no trackable waste, hazardous waste, liquid waste, or restricted solid waste as described in the <i>NSW Protection of the Environment Operations Act 1997</i>.
n) Cause any increased demands on resources (natural or otherwise) which are, or are likely to become, in short supply?	Negligible	The amount of resources that would be used are not considered significant and would not increase demands on current resources such that they would become in short supply.
o) Have any cumulative environmental effect with other existing or likely future activities?	Negligible	The assessed low adverse or negligible impacts of the proposal are not likely to interact. Mitigation measures (Section 7) shall be implemented to minimise the risk of cumulative environmental effects. The current proposal would not significantly affect habitat connectivity or reduce any significant vegetation. No further construction activities are planned for this location.
p) Any impact on coastal processes and coastal hazards, including those under projected climate change conditions	Negligible	The proposed activity would have no effect on coastal processes including those projected under climate change conditions.

Does the proposal:	Assessment	Reason
q) applicable local strategic planning statements, regional strategic plans or district plans made under the Act, Division 3.1	Positive	The proposed activity is consistent with the <i>Shoalhaven 2040 Strategic Land-use Planning Statement</i>, including Planning Priority 2 <i>Delivering infrastructure</i> and Planning Priority 11 <i>Adapting to natural hazards through building resilience</i> and Priority 10 <i>Protecting the environment</i> https://doc.shoalhaven.nsw.gov.au/displaydoc.aspx?record=D20/437277. The activity is consistent with the Illawarra Shoalhaven Regional Plan 2041 particularly <i>Objective 12: Build resilient places and communities</i> https://www.planning.nsw.gov.au/plans-for-your-area/regional-plans/illawarra-shoalhaven-regional-plan-2041
r) other relevant environmental factors	n/a	Environmental factors have been addressed in Section 3 of this REF.

4. PLANNING APPROVALS

4.1 NSW Environmental Planning & Assessment Act 1979

Section 4.1 (Development that does not need consent) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) states that:

“If an environmental planning instrument provides that specified development may be carried out without the need for development consent, a person may carry the development out, in accordance with the instrument, on land to which the provision applies.”

Section 2.16(2)(a)(iv) of the *NSW State Environmental Planning Policy (Resilience and Hazards) 2021* (Resilience and Hazards SEPP) states “development for the purpose of coastal protection works may be carried out on land to which this Chapter applies by or on behalf of a public authority – (a) without development consent – if the coastal protection works are – (iv) routine maintenance works or repairs to any existing coastal protection works”. In this regard:

- the relevant “Chapter” of the SEPP applies to the site of the proposed activity *i.e.* “land within the coastal zone”
- the proposed activity constitutes “coastal protection works” as defined in both the SEPP and the Coastal Management Act 2016 *i.e.* “activities or works to reduce the impact of coastal hazards on land adjacent to tidal waters, including (but not limited to) seawalls, revetments and groynes”
- the proposed activity is for the repair of existing coastal protection works.

As the proposed activity does not require development consent, and as it constitutes an ‘activity’ for the purposes of Part 5 of the EP&A Act, being carried out by (or on behalf of) a public authority, environmental assessment under Part 5 of the EP&A Act is required. This REF provides this assessment.

Additionally, Section 2.165(1) of the *NSW State Environmental Planning Policy (Transport and Infrastructure) 2021* (Transport and Infrastructure SEPP) provides that the “(1) development for the purpose of waterway or foreshore management activities may be carried out by or on behalf of a public authority without consent on any land”. This is applicable to the proposed activity as “Waterway or foreshore management activities” include (refer to Section 2.164 of the Transport and Infrastructure SEPP) “(a) riparian corridor and bank management, including erosion control, bank stabilisation, re-snagging, weed management, revegetation and the creation of foreshore access ways”.

4.2 NSW Coastal Management Act 2016

This Act relates to development and implementation of Coastal Management Programs (CMPs). SCC is currently in the process of developing CMPs for coastal areas of the Shoalhaven in accordance with the Act. The Lake Conjola CMP has not yet been finalised and certified. As of 25 August 2025, the CMP is at Stage 4 of the 5-stage process for certification by the relevant State Minister. Stage 4 is the presentation of a draft CMP for public comment, finalisation, presentation to Council for consideration, and then to the relevant NSW Minister for certification. Following

certification, the CMP will be gazetted and enter Stage 5 where Council will implement, monitor, evaluate and report on management actions identified in the final CMP.

The current Stage 4 CMP (Royal HaskoningDHV 2024) addresses and supports the proposed activity within *Table 4-1: Recommended Coastal Management Actions ID FB1*.

“Action name: *Investigate, remediate and monitor impacted or vulnerable bank areas.*

Action description: *The action will involve detailed design of foreshore management activities followed by remediation of bank areas with Lake Conjola that have been impacted or are vulnerable to erosion. The main tasks for this action will include:*

- *Preparation of detailed site assessments and designs for foreshore management activities (under the State Environmental Planning Policy (Transport and Infrastructure) 2021) including treatment of eroding and unprotected foreshore areas and working with relevant stakeholders to enable establishment or restoration of riparian vegetation, where identified as lacking, as foreshore management activities.*
- *Preparation of detailed designs for areas of inconsistent foreshore protection works, which include opportunities for installation of environmentally friendly seawalls (DECC 2009) including benches of estuarine vegetation and a uniform approach to foreshore management activities...*
- *Progressive implementation of riparian vegetation restoration (as per Action EV1) combined with foreshore protection remediation works. Integrate riparian vegetation (including estuarine plants like saltmarsh, mangroves and reeds) management with stabilisation works to reduce erosion, improve bank stability, and enhance biodiversity....*

Foreshore areas of publicly-owned land that have been identified as priority areas are shown on Figure 4-3.

The proposed activity is within *Table 4-1: Recommended Coastal Management Actions ID FB.01 through to FB.07* (Figure 10 below and Figure 12 to 13 below):

Figure 10 Extract from Draft Lake Conjola CMP (Royal HaskoningDHV 2024)

FB1.01	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - foreshore west of boat ramp carpark	Repair of existing foreshore protection, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009).
FB1.02	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - eastern portion of Caravan Park foreshore	Upgrade existing rock protection and construct new rock protection where it does not exist, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009). Upgrading to also include raising crest level and improving filtration design. Retain existing localised swimming areas and provide areas of access.
FB1.03	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - central portion of Caravan Park foreshore	Upgrade existing rock protection and construct new rock protection where it does not exist, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009). Upgrading to also include raising crest level and improving filtration design. Remove existing concrete works.
FB1.04	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - Caravan Park central swimming area embayment	Upgrade existing rock protection and construct new rock protection where it does not exist, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well
			as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009). Upgrading to also include raising crest level and improving filtration design. Retain existing localised swimming areas and provide areas of access.
FB1.05	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - section west of central swimming area embayment	Upgrade existing rock protection and construct new rock protection where it does not exist, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009). Upgrading to also include raising crest level and improving filtration design. Remove existing concrete works.
FB1.06	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - western portion of Caravan Park foreshore	Upgrade existing rock protection and construct new rock protection where it does not exist, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009). Upgrading to also include raising crest level and improving filtration design. Retain existing localised swimming areas and provide areas of access.
FB1.07	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - western portion of Caravan Park foreshore to Post Office	Upgrade existing rock protection and construct new rock protection where it does not exist, as foreshore management activities under the <i>State Environmental Planning Policy (Transport and Infrastructure) 2021</i> . Rock protection works to incorporate benches of estuarine vegetation and plantings amongst rocks, as well as pockets of riparian vegetation behind rock protection in accordance with the principles of the Environmentally Friendly Seawall Guidelines (DECC, 2009). Upgrading to also include raising crest level and improving filtration design.

The proposed activity is also referenced in within *Table 4-1: Recommended Coastal Management Actions ID EV1*:

“Action name: *Protect and/or rehabilitate riparian and foreshore areas to enhance estuarine vegetation.*

Action description: *This action will involve a range of measures and environmental protection works to ensure the protection of existing riparian and estuarine vegetation, as well as rehabilitation of currently impacted areas, and would consider the following aspects:*

- installation of informative signage and fencing in key areas to protect vegetation and habitats.*
- continuation of existing Council programs for pest control (e.g. foxes, rabbits, Indian Mynas) and weed management and biosecurity.*
- undertake rehabilitation works in damaged vegetated areas and ongoing implementation of ecological restoration and environmental protection works in Council-managed coastal reserves with reference to the objectives of the associated coastal management areas. These works would be informed by ground-truthing surveys (refer Action LG8) and should support the ecological restoration of identified Threatened Ecological Communities (TECs) based on Council's 2023 report Assessment of Endangered Ecological Communities In Coastal Hazard Areas: Shoalhaven LGA Tidal Inundation and Coastal Erosion Study Sites (Ecoplanning, 2023), refer Figure 4-10 and Figure 4-11. Prioritisation will be given to areas that comprise areas of Coastal Wetland and Littoral Rainforest (refer Figure 4-9) and/or house TECs, and targeted weed species control works. Tidal flows and natural tidal regimes should be considered in undertaking ecological restoration works.*
- restoration of riparian vegetation areas (consistent with Actions EV1.01, EV1.02, EV1.03, EV1.04, EV1.05 and EV1.06, refer to Figure 4-9) and implement environmental protection works to enhance ecological communities in coastal and estuarine reserves.*
- establish a monitoring and evaluation framework to assess the effectiveness of vegetation restoration and control measures, ensuring alignment with environmental goals and continuous improvement. This should be included within the Shoalhaven Integrated Environmental Monitoring Program.”*

The proposed activity is within *Table 4-1:Recommended Coastal Management Actions ID EV.01* (Figure 11 below and Figure 14 p.45):

Figure 11 Extract from Draft Lake Conjola CMP (Royal HaskoningDHV 2024)

EV1.01	Investigate, remediate and monitor impacted or vulnerable bank areas	Conjola Village - foreshore adjacent to boat ramp carpark	Environmental protection works to restore riparian vegetation, including revegetation and controlling weeds.
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The proposed activity is therefore consistent with the draft CMP.

Section 27 of the Act deals with coastal protection works and matters of consideration when granting development consent for coastal protection works. However as discussed in Section 4.1 above, development consent is not required, and further consideration of Section 27 is not required.

Figure 12 Extract from Lake Conjola CMP – Foreshore Remediation Areas

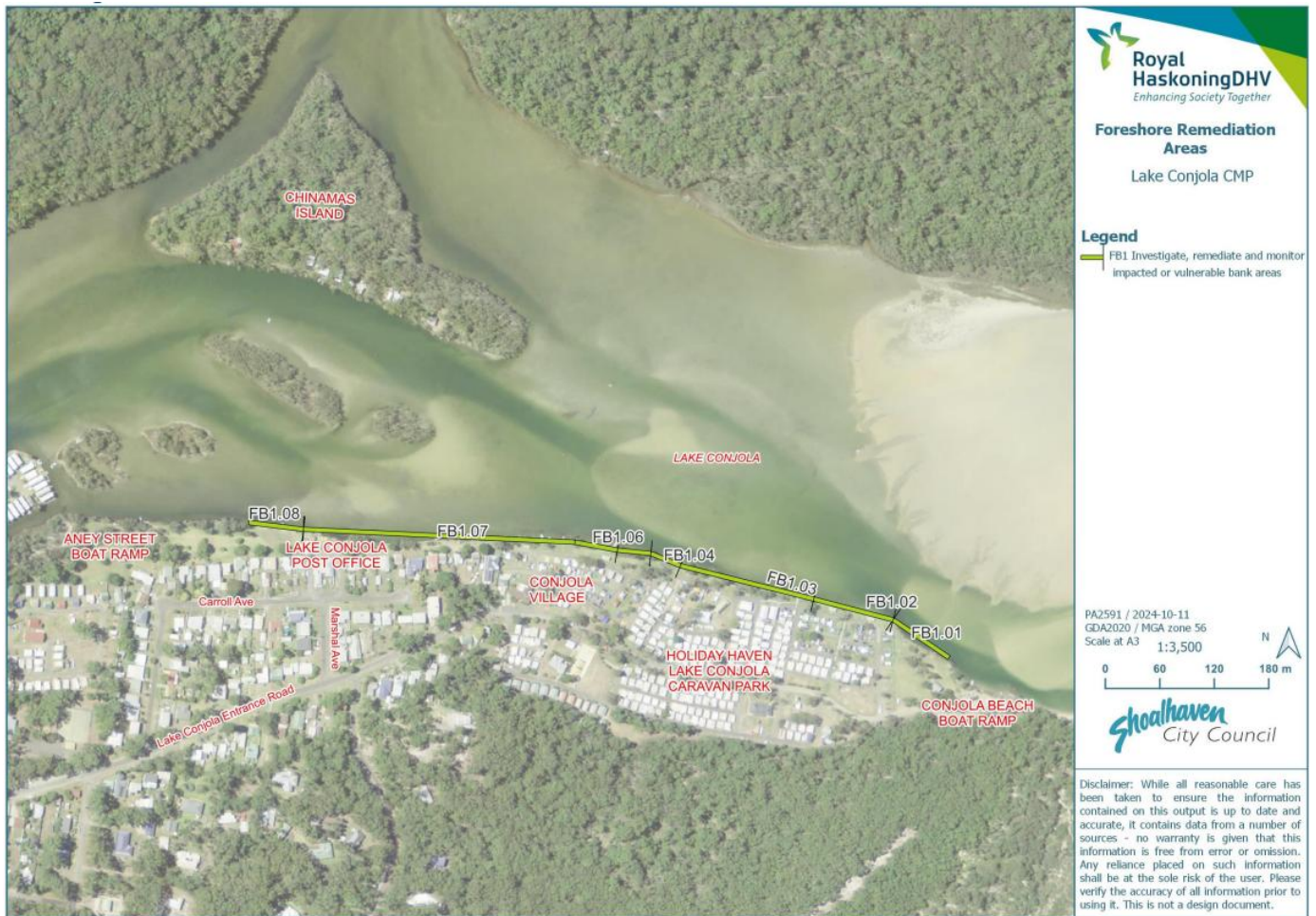


Figure 13 Extract from Lake Conjola CMP – Stormwater Runoff Management

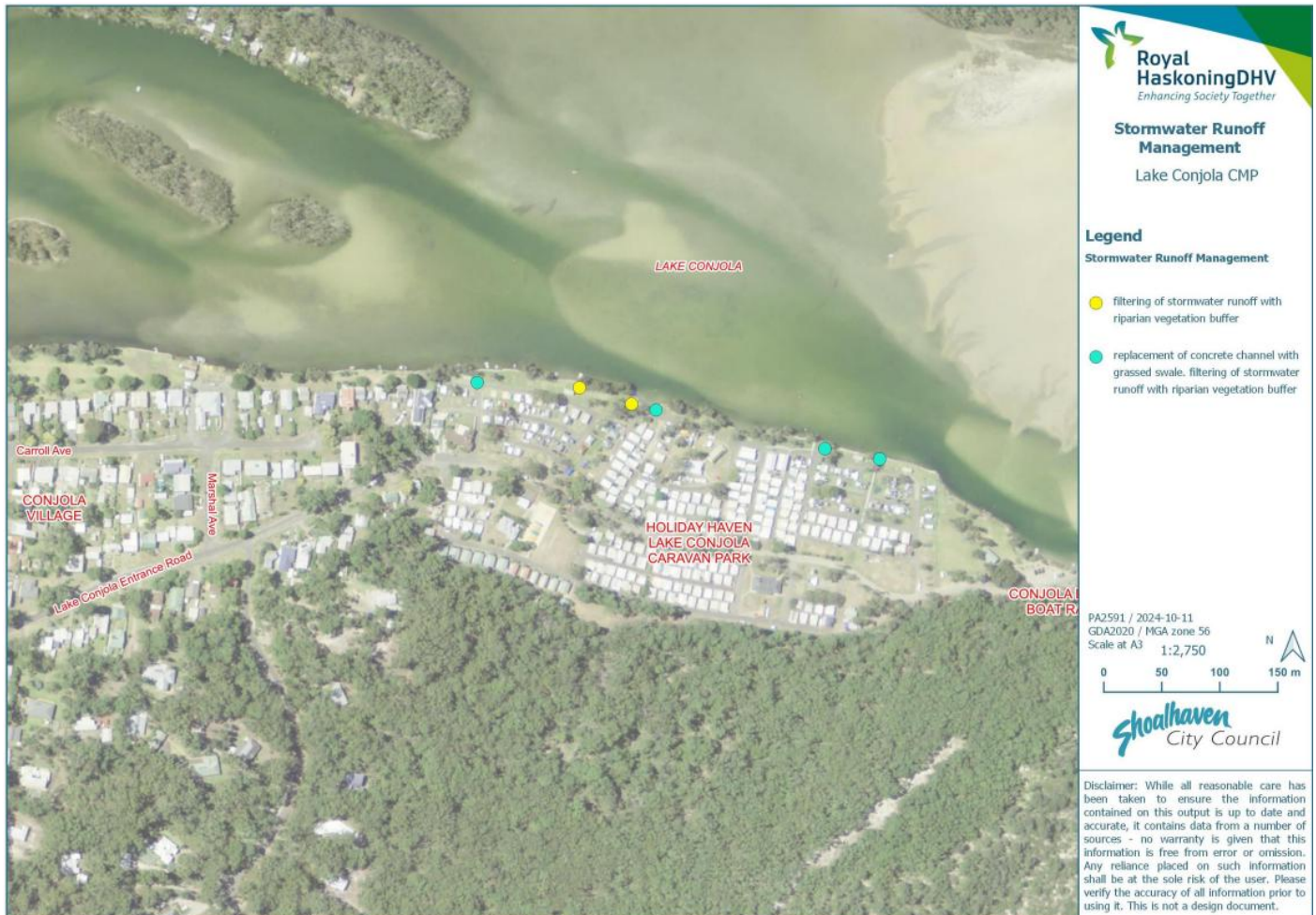
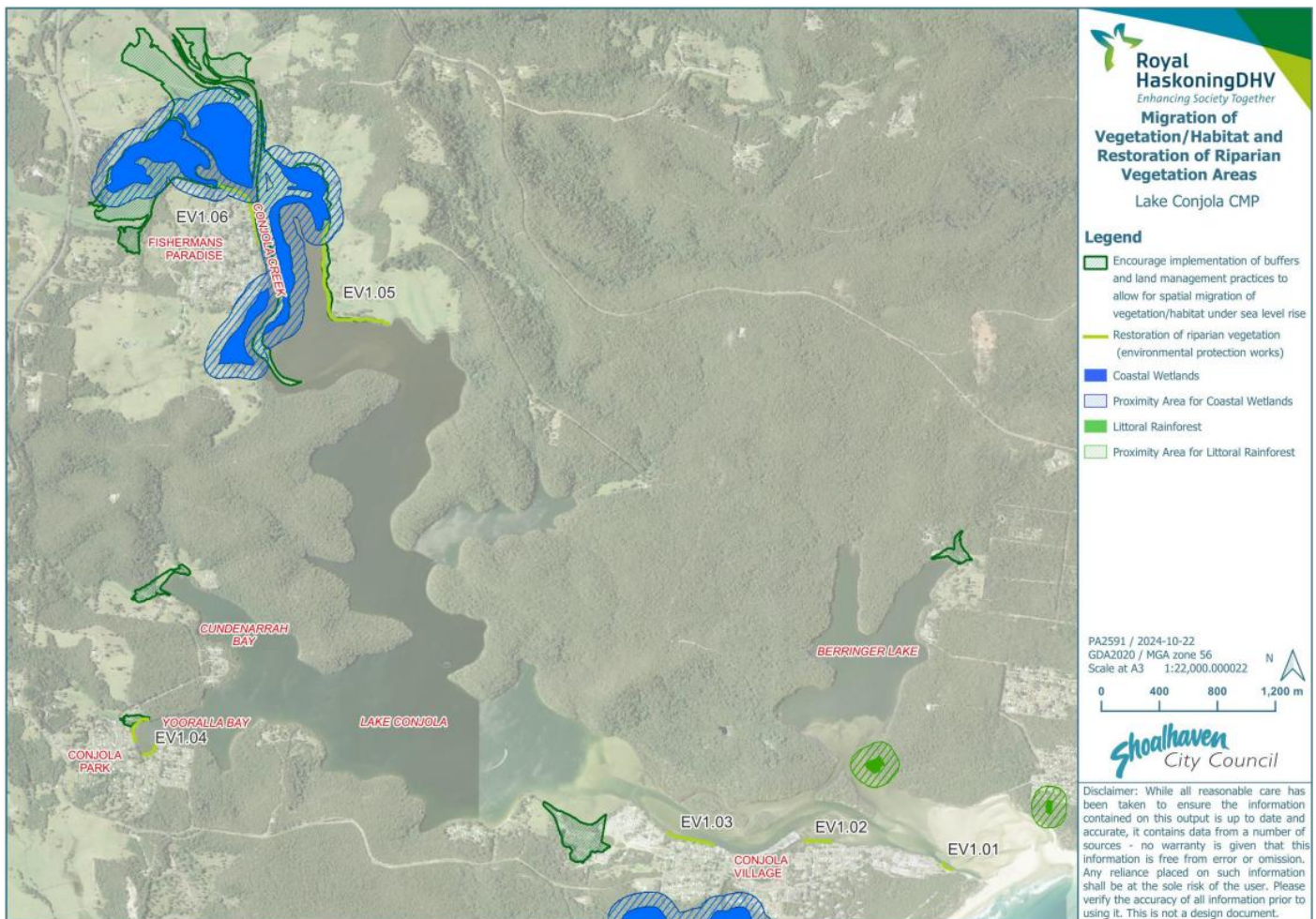


Figure 14 Extract from Lake Conjola CMP – Habitat and Restoration of Riparian Vegetation Areas



4.3 NSW Fisheries Management Act 1994

Lake Conjola is mapped as Key Fish Habitat for the purposes of the *Fisheries Management Act 1994*.

The proposed activity would harm marine vegetation (*Zostera spp.* and potentially one Mangrove seedling) which is regulated under Section 205 of the Act. A permit from the Department of Primary Industries and Regional Development – Fisheries (DoPIRD – Fisheries) is therefore required prior to the commencement of works.

Section 200 of the Act (Circumstances in which a local government authority may carry out dredging or reclamation) would normally apply to the proposed activity. As the dredging and reclamation work, however, would be authorised under the Crown Land Management Act 2016 (refer to Section 4.5 of this REF) a Fisheries Permit for this component of works would not be required (s.200(2)(a)). Instead, Crown lands department would refer the Crown lands licence application to DoPIRD - Fisheries for comment prior to authorising the dredging and reclamation work proposed in the licence application.

Regarding the other provisions and controls in the Act the proposed activity:

- would not affect declared aquatic reserves (Part 7, Division 2 of the Act);
- would not involve blocking the passage of fish (s.219);
- would not involve disturbance to gravel beds where salmon or trout spawn (s.208 of the Act);
- does not involve the release of live fish (Part 7, Division 7);
- does not involve the construction of dams and weirs (s.218);
- would not use explosives in a watercourse (Clauses 70 and 71 of the *Fisheries Management (General) Regulation 2019*).

The seven-part test of significance, provided in Section 3.4.1 of this REF, determined that the proposed activity is unlikely to significantly affect threatened species, populations or ecological communities. A species impact statement is not required.

4.4 NSW Local Government Act 1993

Part of the proposed activity (above mean high water mark) would be undertaken on Crown Land Reserve R62146 to which SCC is the appointed land manager under the NSW *Crown Land Management Act 2016* (CLM Act). Section 3.21 of the CLM Act provides that a Council manager can manage its dedicated or reserved Crown land as if it were public community land within the meaning of the NSW *Local Government Act 1993* (LG Act). Under Section 35 of the LG Act, community land is required to be used and managed in accordance with the plan of management (PoM) applying to the land. It is likely that the proposed activity site would be managed under the Generic Community Land PoM – General Community Use

https://doc.shoalhaven.nsw.gov.au/LinkGeneratorAPI/record/9388973/preview_latest_final_version_pdf. The proposed activity is consistent with this PoM as it meets many of the prescribed objectives such as “*To develop riparian buffers along watercourses to stabilise banks and reduce erosion*” and “*ensure the maintenance and use of land does not negatively impact on the natural environment or biodiversity*”.

4.5 NSW Crown Land Management Act 2016

The part of the proposed activity undertaken below mean high water mark (MHWM) would be undertaken within a waterway regulated by the *Crown Land Management Act 2016* (CLM Act). Under Section 9.2 of the *Crown Land Management Act 2016* a person must not “*erect a structure on Crown land*” or “*interfere with any substance on, in or forming part of Crown land*”. The proposed activity involves such activities. Section 5.21 of the Act provides for licences to conduct activities and use of Crown land. A Crown land licence shall therefore be obtained prior to the commencement of works.

4.6 Other

A summary of other relevant legislation and permissibility is provided in Table 3 below.

Table 3: Summary of other relevant legislation and permissibility

NSW STATE LEGISLATION	
<i>Environmental Planning and Assessment Act 1979 (EP&A Act)</i>	
Permissible	✓ Not permissible ☐
Justification: Both the Hazards and Resilience SEPP and the Transport and Infrastructure SEPP provides for the proposed works to be undertaken without development consent (refer to Section 4.1 above). In circumstances where development consent is not required, the environmental assessment provisions outlined in Part 5 of the Act are required to be complied with. This REF fulfils this requirement.	
<i>Protection of the Environment Operations Act 1997</i>	
Permissible	✓ Not permissible ☐
Justification: The proposed activity does not constitute scheduled development work or scheduled activities as listed in Schedule 1 of the Act. The proposed activity therefore does not require an environmental protection licence.	
<i>Local Land Services Act 2013</i>	
Permissible	✓ Not permissible ☐
Justification: Any clearing of vegetation would be of a kind authorised under Section 60O(b)(ii) of the <i>Local Land Services Act 2013</i> ("an activity carried out by a determining authority within the meaning of Part 5 of the Act after compliance with that Part."). No separate authorisation under the Act is required.	
<i>National Parks and Wildlife Act 1974 (NP&W Act)</i>	
Permissible	✓ Not permissible ☐
Justification: - The proposed activity would not encroach into National Park estate. - The Act provides the basis for the legal protection and management of Aboriginal sites in NSW. Under Sections 86 and 90 of the Act it is an offence to disturb an Aboriginal object or knowingly destroy or damage, or cause the destruction or damage to, an Aboriginal object or place, except in accordance with a permit of consent under section 87 and 90 of the Act. - As there are no recorded sites or visible objects and as the site is on 'disturbed land', the Due Diligence Guidelines (DECCW 2010) requires no further assessment as it is reasonable to conclude that there is a low probability of objects occurring in the area of	

the proposed activity and an AHIP is not required. Refer to Section 3.5 of this REF for more information.

Biodiversity Conservation Act 2016

Permissible ☒ Not permissible ☐

Justification:

- The proposed activity is unlikely to have a significant impact on species and communities listed in the schedules of the Act (refer to Section 3.2 of this REF).
- The proposed development is not within an area declared to be of "outstanding biodiversity value" as defined in the Act.
- The design and mitigation measures (Section 7) would ensure that no *serious and irreversible impacts on biodiversity values* (as defined by the BC Act) occur at the site of the proposed activity.

The proposed activity therefore is not deemed to be *likely to significantly affect threatened species* and an environmental impact statement (EIS) or a Biodiversity Development Assessment Report (BDAR) is not required.

It is also a defence to a prosecution for an offence under Part 2 of the Act (harming animals, picking plants, damaging the habitat of threatened species or ecological communities *etc*) if the work was essential for the carrying out of an activity by a determining authority within the meaning of Part 5 of the *Environmental Planning and Assessment Act 1979* after compliance with that Part. The activity will not remove vegetation that is listed under Schedule 1 Threatened Species, Schedule 2 Threatened ecological communities and Schedule 6 Protected Plants. Therefore the activity is considered permissible as this REF has been prepared and determined in accordance with the EP&A Act.

Aboriginal Land Rights Act 1983

Permissible ☒ Not permissible ☐

The Crown Reserve over Lot 166 DP723104 (Sussex Inlet Lions Park R69668) is subject to the 7 February 2017 multiple and blanket claims made over all Crown lands in NSW. Although the Act does not preclude the proposed activity, there is a risk that if the claim is successful the infrastructure on the site is also transferred to the claimant or easements or similar may be required. This risk is low as the reserve is unlikely to be 'claimable Crown land' as defined by Section 36 of the Act being lawfully used and occupied (existing park, retaining wall, carpark, boating facilities, *etc*) prior to the 2017 claim.

Water Management Act 2000

Permissible ☒ Not permissible ☐

Justification:

- Local councils are exempt from s.91E(1) of the Act in relation to all controlled activities that they carry out in, on or under waterfront land by virtue of clause 41 of the *Water Management (General) Regulation 2018*.
- The proposal would not interfere with the aquifer and therefore an interference licence is not required (s.91F).

Heritage Act 1977

Permissible ☒ Not permissible ☐

The proposed activity would not disturb an item of state heritage significance. The proposal would constitute 'minor works' under 'Relics of local heritage significance: a guide for minor works with limited impact'. The proposal would not result in any direct impacts on heritage items or values. Works can be undertaken with caution under an applicable exception under s139(1) and (2) of the Act.

COMMONWEALTH LEGISLATION

Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EP&BC Act)

Permissible ☒ Not permissible ☐

Justification:

The proposed activity would not be undertaken on Commonwealth land and no matters of National Environmental Significance are likely to be significantly impacted by the proposed activity. The proposed activity is therefore not a controlled action and does not require commonwealth referral.

Commonwealth *Native Title Act 1993*

Permissible ☒ Not permissible ☐

Justification:

- The proposed activity would affect Native Title.
- The proposed activity would however comply with the applicable provisions of the *NSW Native title Act 1993* being valid future acts under Section 24JA or Section 24KA.
- As the proposed act involve the construction or establishment of a public work, Council was required to notify and give the opportunity to comment to the South Coast People as native title claimants. This was undertaken on 5 August 2025 with the notification period expiring on 2 September 2025 (refer to SCC document D25/3438652). There were no comments received so the proposed activity can proceed.

5. CONSULTATION WITH GOVERNMENT AGENCIES

5.1 Transport and Infrastructure SEPP

Section 2.10 – Consultation with councils - development with impacts on council-related infrastructure or services

The proposed activity would:

- (a) not have an impact on stormwater management
- (b) unlikely generate traffic to an extent that it would strain the capacity of the road system
- (c) not involve connection to, or have a substantial impact on the capacity of the sewerage system
- (d) not involve connection to, and use of a substantial volume of water from the water supply system
- (e) unlikely to cause a disruption to pedestrian or vehicular traffic
- (f) not involve excavation of a footpath or road.

Consultation under Section 2.10 is therefore not required.

Section 2.11 – Consultation with councils - development with impacts on local heritage

No impacts to any local heritage item would occur. Consultation under Section 2.11 is therefore not required.

Section 2.12 – Consultation with councils - development with impacts on flood liable land

The proposed activity would be on flood liable land. Consequently, a notice of intention was sent to the SCC Senior Floodplain Engineer on 31 July 2025 (SCC document reference D25/336711). A response was received on 12 August 2025 (D25/372398). The response states *“No comment from me. The rock sizing is appropriate for the flood velocities in these localities.”*

No further consultation is required.

Section 2.13 – Consultation with State Emergency Service (SES) - development with impacts on flood liable land

Although the proposed activity would be on flood liable land, the proposed activity does not constitute a “relevant provision” prescribed in the SEPP (Section 2.13(2) <https://legislation.nsw.gov.au/view/html/inforce/current/epi-2021-0732#sec.2.13>) . Notification to SES is therefore not required.

Section 2.14 – Consultation with councils - development with impacts on certain land within the coastal zone

The proposal would not occur within a coastal vulnerability area. Consultation is therefore not required.

Section 2.15 – Consultation with public authorities other than councils

The proposed activity comprises a fixed or floating structure in or over navigable waters. Consultation with Transport for New South Wales (TfNSW) Maritime division is therefore required pursuant to section 2.15 for development in or over navigable waters. Written notification to TfNSW Maritime was submitted on 22/08/2025 (SCC document D25/372454). A response was received on 4 September 2025. The response (SCC document D25/393902) stated that TfNSW had no objections to the proposed activity. TfNSW however requested that consideration be given to the securing of vessels in the vicinity of the formalised access points by the provision of placed supporting infrastructure. TfNSW also reminded SCC that SCC or any entity or contractor acting on SCC's behalf, are not exempt from the provisions of the *Marine Safety Act 1998*, or any other relevant legislation, and all parties must comply with any direction given by NSW Maritime authorised officers with regard to safe navigation or the prevention of pollution. These considerations are included in the environmental impact mitigation measures prescribed in Section 7 of this REF.

In consideration of the other consultation requirements specified under Section 2.15 of the Transport and Infrastructure SEPP, the proposed activity:

- would not be undertaken adjacent to land reserved under the *National Parks and Wildlife Act 1974* or land acquired under that Act
- would not be undertaken on land in Zone C1 National Parks and Nature Reserves or in an equivalent land use zone.
- would not increase the amount of artificial light in the night sky and located on land within the dark sky region as identified on the dark sky region map
- would not be undertaken within Defence communications facility buffer (only relevant to the defence communications facility near Morundah)
- would not be undertaken on land in a mine subsidence district within the meaning of the *Mine Subsidence Compensation Act 1961*
- would not have an impact on the Willandra Lakes Region World Heritage Property
- would not occur in a Western City operational area specified in the *Western Parkland City Authority Act 2018*.

These prescribed consultation requirements therefore do not apply.

Section 2.16 – Consideration of Planning for Bush Fire Protection (PBP)

The proposed activity is not a development prescribed in this section (health services facilities, correctional centres, residential accommodation). Consideration of PBP is therefore not required.

5.2 SCC Functional Area Manager

The SCC internal Functional Area Managers associated with the proposed activity are:

- Holiday Haven for the Lake Conjola Tourist Park within Lot 486 DP861543
- Shoalhaven Swim Sport Fitness (SSF) for the park associated with the boat ramp within Lot 487 DP861543

- Environmental Services – Coastal Management for the Lake Conjola foreshore area

The Works and Contracts Manager for Holiday Haven (John Visser) was engaged via a 24 June 2025 site meeting. Several comments were made (SCC document reference D25/336134). These comments and associated responses are provided in Table 4 below.

Table 4: Holiday Haven comments and associated responses

Holiday Haven Comment	Response
Formalised FRP access points will not be more cost effective than moving the stairs but will provide greater access to the lake if the foreshore is planted.	Noted – FRP access points are proposed at some locations particularly near stormwater outlets.
Access is currently unrestricted for fishing, boating etc and limiting this to the stairs for a couple of thousand visitors may be prohibitive.	Noted – Fishing and boating access would still be available on-site and off-site.
The estimate does not allow for a watercraft launch platform.	Noted – Estimate was updated.
Can the existing watercraft anchors be retained or included in the rock protection either side of each access point.	Existing watercraft access anchors may be retained immediately adjacent to each access point and avoid revegetation areas. Anchors in the concrete would be removed.
Planting types and locations to consider the number of park users, lake access points and outlook from accommodation.	Low growing grasses and shrubs would predominantly used. Trees (Swamp Oaks) may be planted only occasionally where currently absent.
A typical design profile shows widths ranging from approx.. 3m – 10m. Is this correct?	Yes – saltmarsh bench may be up to 10 metres.
Consider the benefits to program, cost and safety when completing the work in the low season. Program to be confirmed.	If practicable works would be outside of high visitation periods.
If the saltmarsh benches are located next to formalised access points, without any physical separation they may be vulnerable over time.	Saltmarsh benches would be appropriately fenced in consultation with the Tourist Park and the Reserve manager.
Dependent on lake levels, the stormwater design will filter debris / contaminants through vegetated rip-rap, pipes and pits with minimum or no impact to discharge.	Noted.

Holiday Haven Comment	Response
The single strand low-cost fencing may not be a sufficient deterrent to Kangaroos and could be an issue during heavy rain / flood events.	Noted. Fence may require inspection and repair after flood events.
The need and benefit for bollards with interlinking chains is to be confirmed.	Confirmed – Bollards will be installed as recommended by the consultant Water Technology
Will there be a 12-month defect liability period following Practical Completion?	Yes – for the rock work.
Holiday Haven will be responsible for maintenance after the DLP.	Yes.

Under SCC's Functional Asset Model, the boat ramp public reserve would be managed by Shoalhaven Swim Sport Fitness (SSF). Consequently, a notice of intention and invitation to comment was sent to Shoalhaven SSF on 31 July 2025 (SCC document reference D25/336711). As of 01 October 2025, there has been no response. No further engagement is necessary for the planning stage of the proposed activity.

6. COMMUNITY ENGAGEMENT

In accordance with Council's Community Engagement Policy, the proposal constitutes a *Local Area – Low Impact* activity.

The proposed activity is identified in the *Lake Conjola Coastal Management Program* (CMP, refer to Section 4.2 of this REF). The CMP is the subject of a specific SCC webpage that provides detailed information and has been subject to numerous community engagement phases such as (refer to webpage <https://getinvolved.shoalhaven.nsw.gov.au/lake-conjola-cmp> for more detail):

- community workshops
- invitations to comment through submissions and “interactive mapping”
- surveys
- invitation to comment on potential management actions (including the proposed activity, <https://getinvolved.shoalhaven.nsw.gov.au/lake-conjola-cmp>)

As prescribed in Section 7 of this REF, SCC will continue to update the community through the SCC website and directly through the community consultative body.

7. ENVIRONMENTAL SAFEGUARDS AND MEASURES TO MINIMISE IMPACTS

Safeguard / Measure	Responsibility
<i>Works planning, approvals, consultation & notification</i>	
1. A Fisheries Permit shall be obtained for the harm to marine vegetation prior to commencement of works.	SCC Project Manager (PM), SCC Environmental Operations Officer (EOO)
2. A Crown Lands licence shall be obtained for works below the mean high water mark prior to the commencement of works.	SCC PM, SCC EOO
3. This REF shall be published on the NSW Planning Portal prior to the commencement of works.	SCC EOO
4. The community shall be regularly updated on the progress of the proposed activity through SCC website and through the community consultative body.	SCC PM
5. A construction environmental management plan (CEMP) shall be developed by the Construction Contractor and must be approved by SCC Project Manager, SCC Environmental Officer and DPIRD Fisheries prior to commencement of works. The CEMP shall include (but not be limited to): • environmental management structure, responsibilities and contacts • relevant approvals and permits and associated conditions • site plan showing construction compound, machinery, vehicles, equipment storage, port-a-loos, and emergency items including first-aid and spill kits • environmental management activities and controls • Staged sediment and erosion control plans • emergency and incident procedures • management of potential acid sulfate soils • unexpected finds procedures.	Construction Contractor
<i>Site Establishment</i>	
6. Erosion and sediment controls in accordance with the 'Blue Book' (Landcom 2004) shall be installed and maintained to prevent the entry of sediment into waterways i.e. water	Site Manager

Safeguard / Measure	Responsibility
diversion, minimising disturbance, erosion control, sediment capture and rapid re-establishment.	
7. A hydrocarbon floating boom with high-vis reflective surface or banding and turbidity curtain shall be installed in the waterway around the work site and: a. the curtain shall be installed prior to the commencement of the activity. b. a minimum of one curtain shall be installed to form a perimeter around the works site. c. the turbidity curtain shall be affixed so that there are no breaches or gaps between the curtain, hydrocarbon boom, and shoreline interface. d. In areas adjacent to seagrass areas, the turbidity curtain shall also be fixed within the waterway (e.g. star-pickets or timber stakes) to ensure it is not dragging over the seagrass. e. the curtain shall be appropriately managed throughout the duration of the works. The primary curtain shall continually be monitored for visible signs of fuel spills or turbidity plumes, the perimeter of the curtain shall be inspected prior to undertaking the works each day and following a major rainfall or stormwater event. f. If the turbidity curtain is damaged and/or breached and pollution of the surrounding waters is imminent, all work shall immediately cease. Works shall not recommence until turbidity in the vicinity of the works area has returned to baseline conditions, the curtain repaired or replaced and the cause of the damage/breach is established and preventative measures implemented. g. Prior to the removal of the turbidity curtain and hydrocarbon floating boom, any sediment / turbidity shall be allowed to settle to further minimise the dispersion of suspended sediments.	Site Manager
Construction works	
8. All occurrences of Sharp Rush in the area of the proposed activity shall be removed with small excavator with the	SCC PM and Construction Contractor

Safeguard / Measure	Responsibility
plants removed to a licenced waste facility. Care shall be taken to contain and avoid the spread of seed.	
9. Works shall be compliant with the conditions of the Fisheries Permit and Crown Lands Licence.	SCC PM and Construction Contractor
10. All parties must comply with any direction given by authorised officers of the Transport for NSW Maritime, NSW Department of Primary Industries, and NSW Environment Protection Authority with regard to safe navigation and the prevention of pollution.	All staff on-site
11. All machinery to be used shall be cleaned, degreased and in good working order prior to entering the site.	SCC PM and Construction Contractor
12. An emergency spill kit shall be always kept on-site with procedures to contain and collect any leakage or spillage of fuels, oils, greases, etc from plant and equipment.	SCC PM and Site Manager
13. All plant and machinery shall operate from the upper embankment on the shore and not within the waterway	SCC PM and Construction Contractor
14. Works within the waterway shall be undertaken in the lower half of the tidal cycle	SCC PM and Site Manager
15. The contractor or Council shall maintain public access to the nearby boat ramp reserve.	SCC PM and Site Manager
16. Rock used in beaching construction shall be clean and free of fines. Rock work should be in accordance with the following recommendations: a. Individual rocks supplied to the site for construction of the rock work shall be fresh or only slightly weathered, non-friable, and free from cracks, joints, seams, bedding planes, cross-laminations, sand balls, carbonate concretions, chemical alterations and other defects which could contribute to the accelerated breakdown of the stone. b. Rock shall be placed to minimise its breakdown on handling, production of fines and water contamination. c. The finished slope shall be no steeper than the slope specified in the typical cross-section <i>i.e</i> 2H:1V. d. The requirement for 'standard placement' shall be achieved by individually placing rock to achieve a fully	SCC PM and Construction Contractor

Safeguard / Measure	Responsibility
interlocked layer with each rock having at least three points of contact with other rocks in the same layer. Rocks shall be wedged and locked together such that they cannot be moved without disturbing adjacent rocks. Rocks shall be placed in such a way that they obtain their stability from interlocking and frictional resistance, and not from friction on one plane alone. e. Placement of the rock shall commence at the toe and proceed upwards towards the crest. f. Rocks with natural depressions should be placed facing up, to act as intertidal pools. g. Surface of the armoured slope shall present an angular uneven face to the water h. Rock smaller than the specified grading shall not be used to fill voids or to prop larger units to achieve the required profile.	
17. Erosion and sediment controls and the hydrocarbon boom and silt curtain shall be maintained in good working order for the duration of the works and subsequently until the site has been stabilised and the risk of erosion, sediment dispersal or hydrocarbon pollution (fuels and oils) is minimal.	SCC PM and Site Manager
18. The Swamp Oak trees near the revetment shall be retained and protected in accordance with <i>AS4970 – Protection of trees on development sites</i>. Protection measures include: a. Having SCC's Tree Management Officer (or another arborist) present during any excavation works near any trees. b. Careful excavation near the trees shall be undertaken with any tree roots greater than 40mm in diameter cleanly cut with a sterile saw. c. Bog mats, rumble boards or similar load distribution devices should be used where machines will be located within a minimum 5 m radius from the trees to minimise compaction or root damage.	SCC PM and Construction Contractor
19. Where works are occurring near the clumped occurrences of Sea Rush, the clumps shall be fenced off with high-visibility para-webbing to prevent inadvertent damage.	SCC PM and Construction Contractor

Safeguard / Measure	Responsibility
20. The revegetation of the foreshore shall use species representative of the endangered ecological community Swamp Oak Floodplain Forest, including but not limited to: • Swamp Oak <i>Casuarina glauca</i> • Bare Twig-rush <i>Baumea juncea</i> • Sea Rush <i>Juncus kraussii</i> • Swampweed <i>Selliera radicans</i> • Spiny-head Mat-rush <i>Lomandra longifolia</i> • Blue Flax-lily <i>Dianella caerulea</i> • Swamp Paperbark <i>Melaleuca ericifolia</i>	SCC PM and Construction Contractor
21. Noise-generating construction activities shall be limited to the following hours to limit noise and traffic impacts to adjacent residents: 7:00 am to 6:00 pm Monday to Friday and 8:00 am to 5:00 pm Saturdays.	SCC PM and Site Manager
22. Any stockpiles of soil shall be located at least 10 metres away from the waterway and any stormwater flow-paths with erosion and sediment controls in place in accordance with the 'Blue Book' (Landcom 2004).	SCC PM and Site Manager
23. Any waste shall be managed, transported, stored, collected and disposed of in an environmentally satisfactory manner pursuant to NSW <i>Protection of the Environment Operations Act 1997</i>, and that all reasonable measures regarding the control and prevention of pollution and waste from being introduced into the estuary are implemented.	SCC PM and Site Manager
24. Everyone working on site shall be instructed to stop work immediately on identification of any suspected Aboriginal heritage object. If any objects are found, NSW Department of Planning, Industry and Environment (ph:131 555) shall be contacted.	SCC PM and Site Manager
Post construction	
25. An asset form <u>must</u> be trimmed to file 44574E on commissioning of the assets in Accordance with POL15/8 Asset Accounting Policy section 3.1.4 and POL16/79 Asset Management Policy section 3.3.	SCC PM

Safeguard / Measure	Responsibility
26. Any post-construction conditions of the Fisheries Permit shall be accomplished.	SCC or EOO

8. SIGNIFICANCE EVALUATION & DECISION STATEMENT

This Review of Environmental Factors has assessed the likely environmental impacts, in the context of Part 5 of the *Environmental Planning and Assessment Act 1979*, of a proposal by Shoalhaven City Council to foreshore protection and enhancement works along the Lake Conjola foreshore in the vicinity of the Holiday Haven Tourist Park and adjacent public reserve being Lots 486 and 487 DP 861543.

In consideration of the proposal as described in Section 1, in accordance with any design plans referred to in this report, and assuming the implementation of all proposed safeguards and mitigation measures (Section 7), it is determined that:

1. It is unlikely that there will be any significant environmental impact as a result of the proposed work and an Environmental Impact Statement is not required for the proposed works.
2. The proposed activity will not be carried out in a declared area of outstanding biodiversity value and is not likely to significantly affect threatened species, populations or ecological communities, or their habitats and a Species Impact Statement / BDAR is not required.
3. A Fisheries Permit and a Crown Lands licence is required. No additional statutory approvals, licences, permits and external government consultations are required.
4. The proposed activity may proceed.

In accepting and adopting this REF, Shoalhaven City Council commits to ensuring the implementation of the proposed safeguards and mitigation measures identified in this report (Section 7) to minimise and/or prevent detrimental environmental impacts.

Determined by:



Peter Swanson
(Acting) Environmental Services Manager
Shoalhaven City Council

Date: 29/09/2025

9. REFERENCES

- ASSMAC (Acid Sulfate Soils Management Advisory Committee) 1998 *Acid Sulfate Soils Manual*. ISBN 0 7347 0000 8
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- OEH (Office of Environment and Heritage, NSW) 2009 *Environmentally Friendly Seawalls* ISBN 978 1 74232 254 4. <https://www.environment.nsw.gov.au/sites/default/files/environmentally-friendly-seawalls-090328.pdf>
- Water Technology 2025 *DRAFT Connecting Community to Shoalhaven Waterways – Bank Stabilisation Projects – Options Assessment*. Unpublished report for Shoalhaven City Council. Document Number 25020130_R01V02_Technical Report.

Personal communications

Mark Stone 2025 Senior Flood Engineer, Shoalhaven City Council

Emily Messer 2025 Fisheries Manager, NSW Department of Primary Industries and Regional Development (refer to document [D25/369974 - advice - NSW Fisheries - compensatory measures for impact to seagrass - Lake Conjola Foreshore improvement works](#))

APPENDIX A – Concept Designs of the Proposed Activity



VERSION CONTROL			
V01	DRAFT CONCEPT DESIGN	28/04/2025	DMT
V02	FINAL CONCEPT DESIGN	06/06/2025	DMT

CLIENT:
SHOALHAVEN CITY COUNCIL
36 Bridge Road, Nowra, 2541

CONSULTANT
Water Technology Pty Ltd
ABN: 60 093 377 283
Parramatta T (02) 9354 0300



DRAWN
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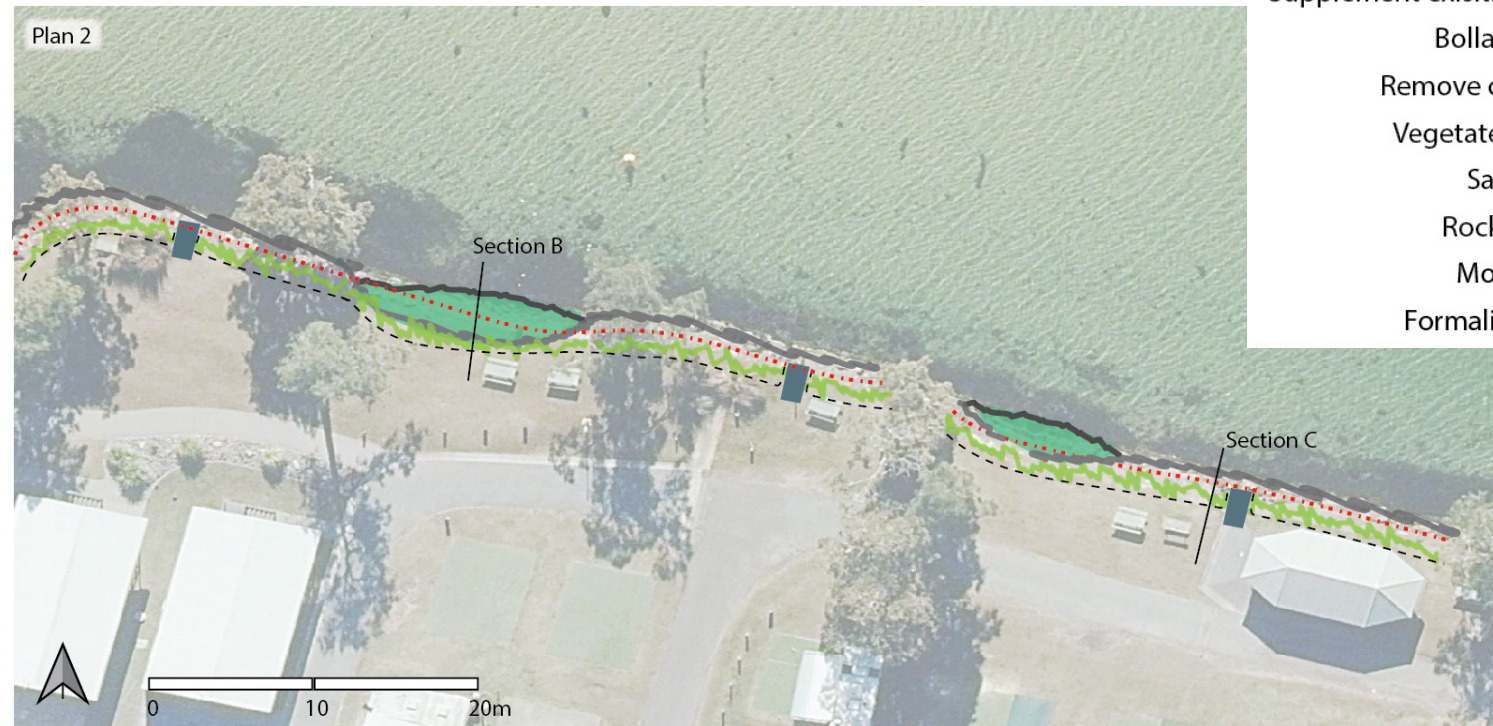
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- Low grasses and shrubs
- Supplement existing rock*
- Bollard fence
- Remove concrete
- Vegetated swale
- Salt marsh
- Rock groyne
- Move stairs
- Formalise access



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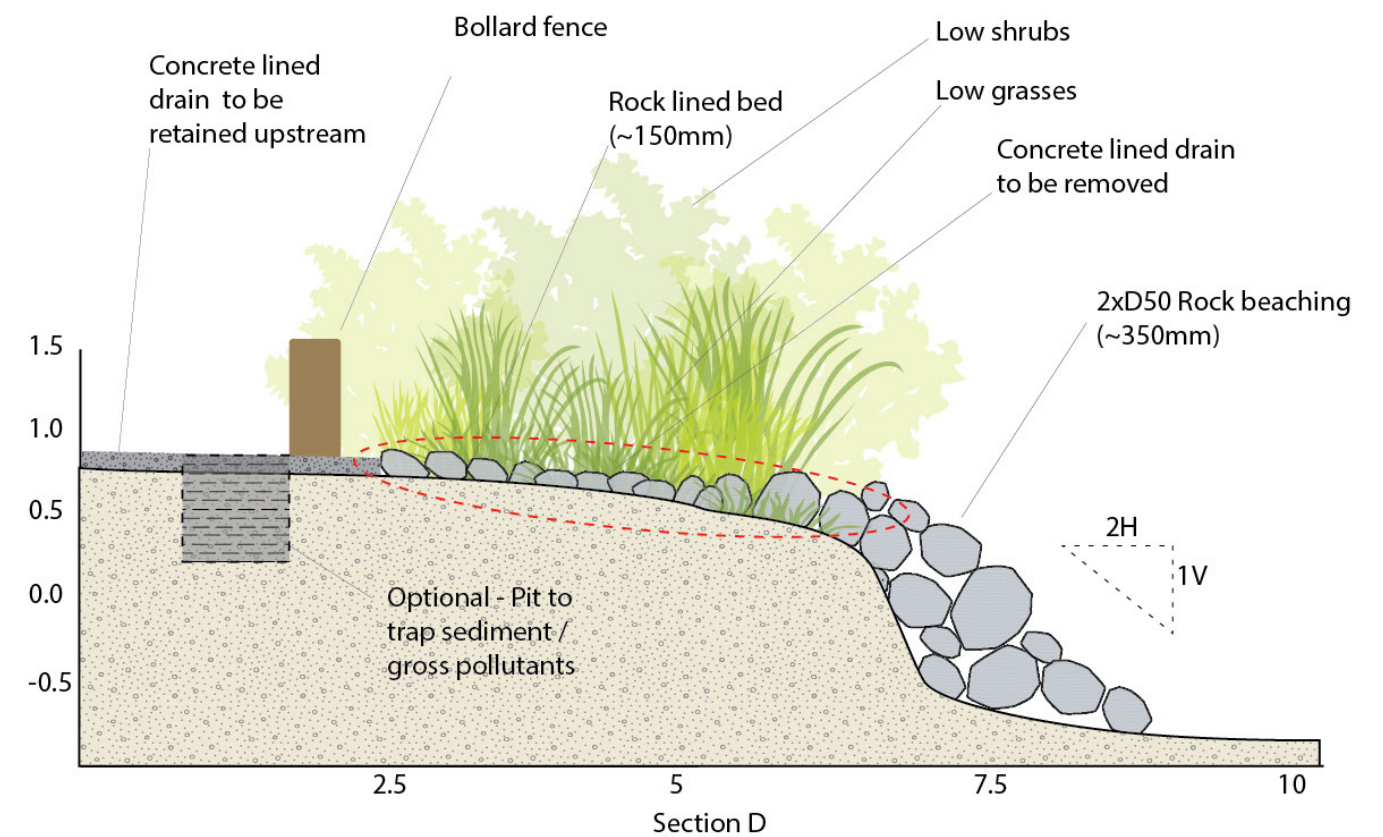
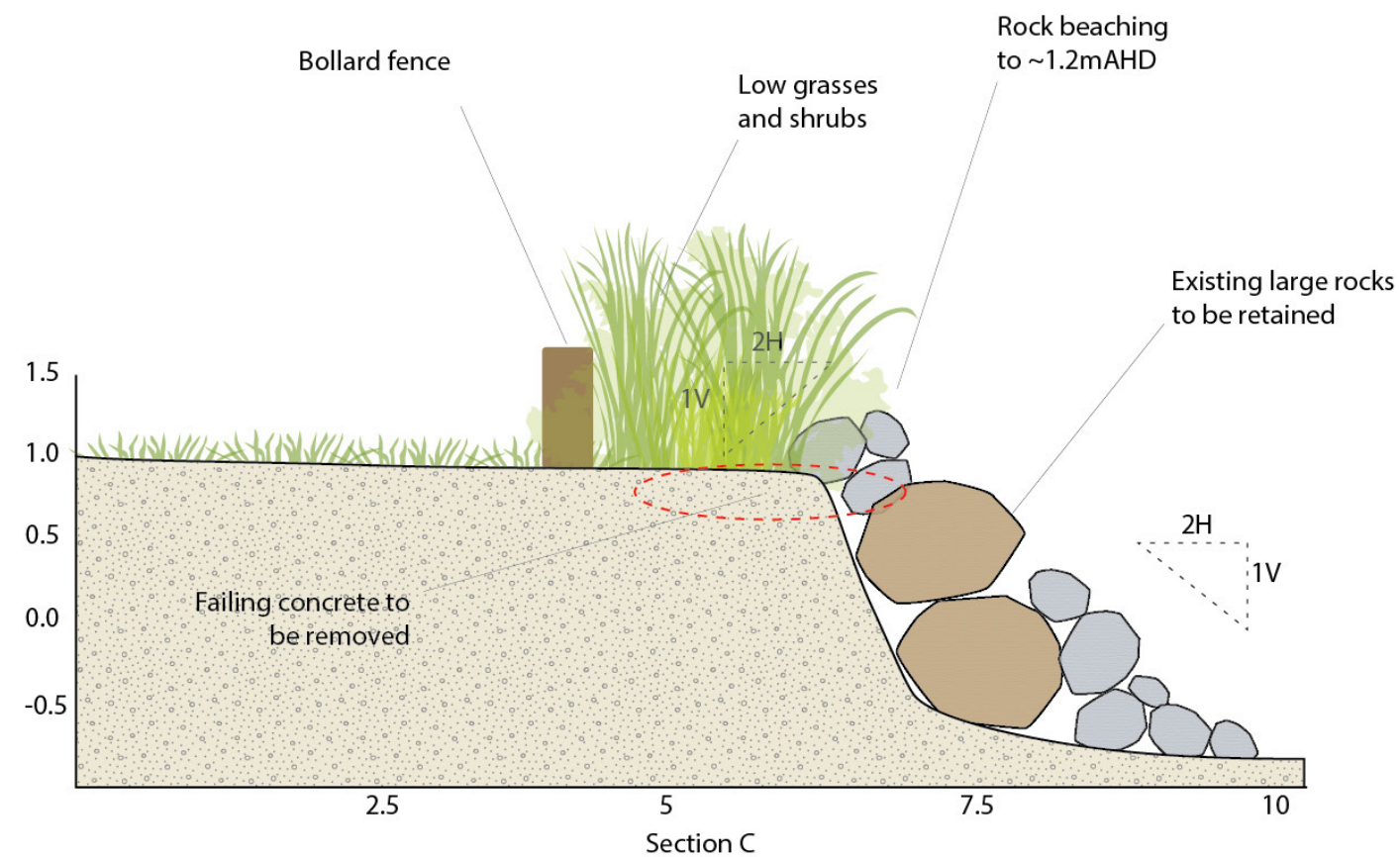
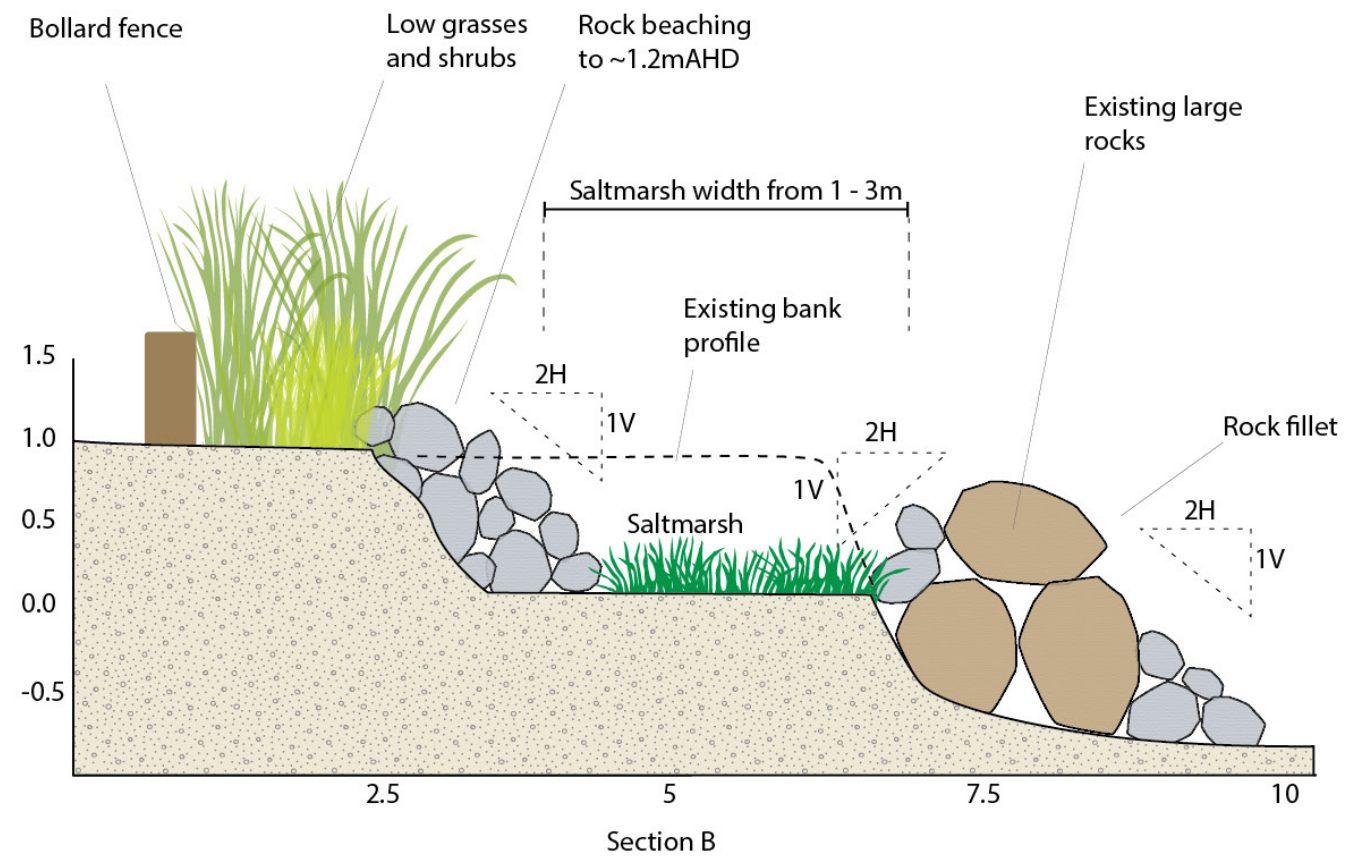
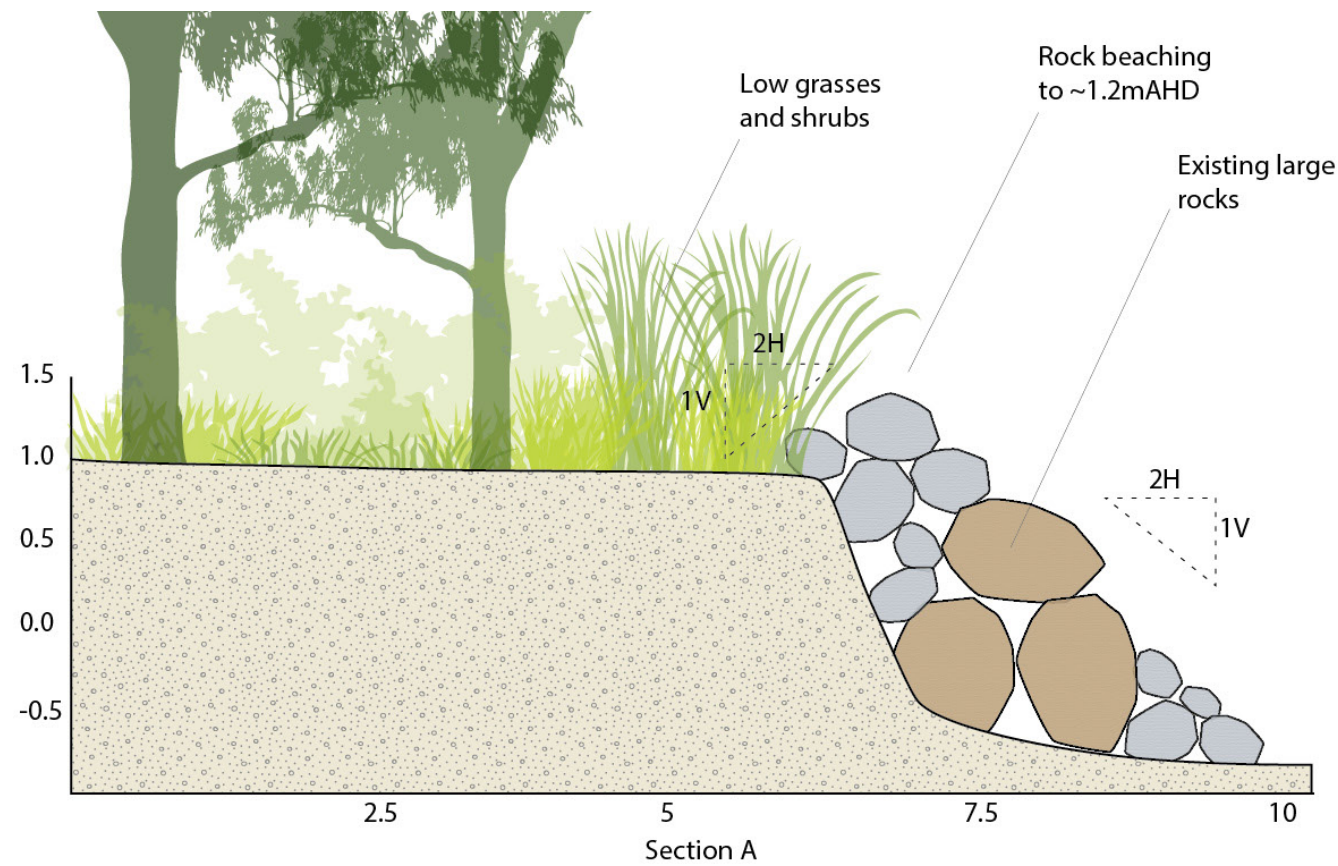
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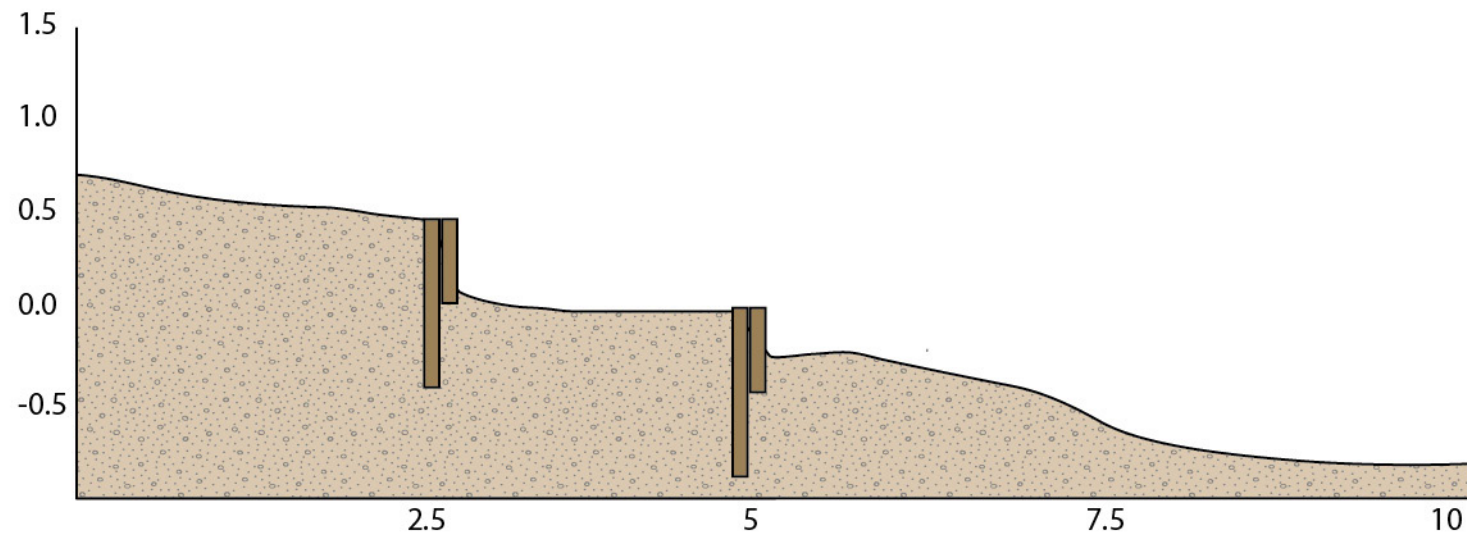


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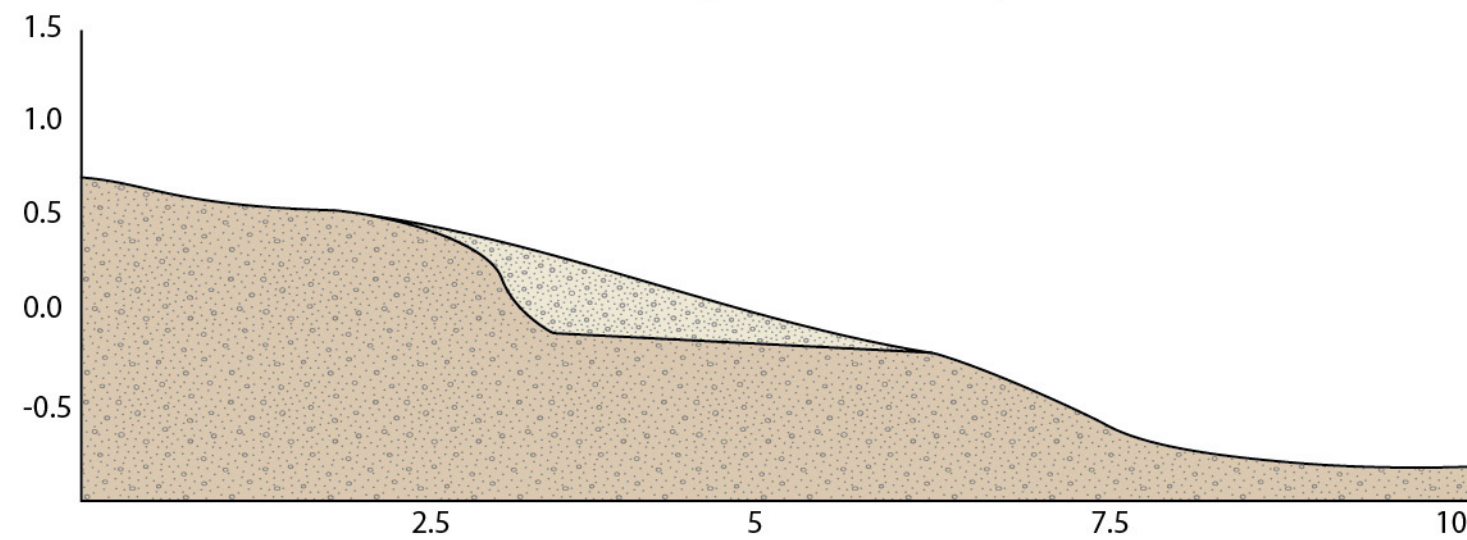
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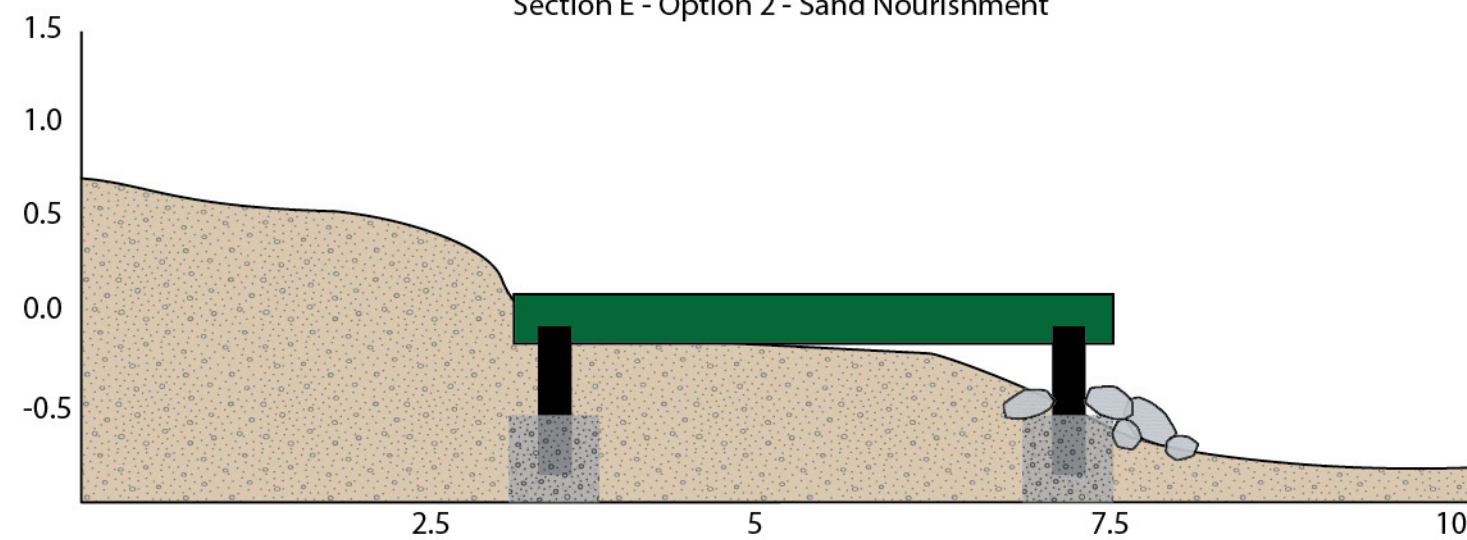
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Section E - Option 1 Hardwood Steps



Section E - Option 2 - Sand Nourishment



Section E - Option 3 - FRP Plafrom

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VERSION NO. V02

APPENDIX B – Draft Water Technology Report – Connecting Community to Shoalhaven Waterways – Bank Stabilisation Projects – Options Assessment



Report

Connecting Community to Shoalhaven Waterways - Bank Stabilisation Projects – Options Assessment

Shoalhaven City Council

13 June 2025



Document Status

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Water Technology Project Manager	Dan Trnovsky
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Authors	Dan Trnovsky, Dr. Daryl Lam
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Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150
Telephone (02) 9354 0300
ACN 093 377 283
ABN 60 093 377 283





ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.



Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- Seven circles representing each of the States and Territories in Australia where we do our work
- Blue dots between each circle representing the waterways that connect us
- The animals that rely on healthy waterways for their home
- Black and white dots representing all the different communities that we visit in our work
- Hands that are for the people we help on our journey



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1 PROJECT OVERVIEW

Shoalhaven City Council (Council) has previously received an Urban Rivers and Catchment Program grant from the Department of Climate Change, Energy, the Environment and Water (DCCEEW). The grant has allowed for the preliminary studies in the ongoing development of various Coastal Management Programs (CMPs) and a Bushfire Recovery Plan, with aims to determine bank condition, erosion causes and foreshore issues, riparian health and assessment of management options and priorities. This project builds upon the studies completed thus far and specifically seeks to i) assess the feasibility of bank treatment options and ii) develop concept designs of preferred treatment options. The scope of works is across seven sites within Council's Area (Figure 1-1), each with varying spatial extents, issues and required scope of works. Table 1-1 provides a summary of the sites and the remediation options recommended by the Decision Support Tool for Bank Erosion Management in NSW Estuaries (DST) as derived from the preliminary studies.

The project methodology includes the synthesis of findings from:

- A desktop review of existing documents and reports,
- Spatial analysis of available relevant data,
- Site assessment:
 - Site assessment was undertaken between 24 and 25 Feb 2025. Attendees include: Danny Wiecek (DCCEEW), Nigel Smith (Council) (Site 1, 3a and 3b only), Evan Astbury (Council), Daniel Trnovsky (Water Technology), Daryl Lam (Water Technology), Ermano de Almeida (Water Technology) (Sites 5a and 5b only), Braiya White (Site 5b only)
- Design Workshop:
 - Online design workshop was held on 10 April, 2025 and was attended by Danny Wiecek (DCCEEW), Nigel Smith (Council), Evan Astbury (Council), Daniel Trnovsky (Water Technology) and Daryl Lam (Water Technology). The intent of the workshop was to discuss the design options for each site and to determine the options that would be presented as concept designs.

Table 1-1 Summary of Sites and recommendations provided by the Decision Support Tool.

ID	Sites	Issue	DST Recommendation
1	Lake Conjola Foreshore Erosion Protection	▪ Foreshore erosion.	▪ Better to establish riparian vegetation or apply foreshore protection treatments in areas of concern. ▪ Consolidate ongoing monitoring, foreshore management and treatment and stormwater management with bank erosion treatments.
2	Coorong Rd erosion protection	▪ Undercutting and bank slumping. ▪ Likely occurring due to upper bank failure during flood draw down.	▪ Large woody debris as a primary recommendation with rock fillets or groynes an alternative. ▪ Riparian vegetation management as an alternative.
3a	Sussex Inlet erosion protection	▪ Foreshore erosion due to adjustment of the main tidal channel.	▪ Maintenance of the existing bank protection structures. ▪ Alternatively, geotextile sand containers, rock revetments or provision of a timber wall.



ID	Sites	Issue	DST Recommendation
3b	St Georges Basin	Moderate erosion of foreshore.	- Establishment of a cobble beach which could be used in conjunction with bank re-profiling, sand fill, coir logs or rock revetment. - Riparian vegetation management also recommended to be used in conjunction with cobble beaches in areas of severe erosion that require public access.
4	Mavromattes Reserve	Erosion from wind and boat waves.	- Establishment of a cobble beach for the eastern section with large woody debris for the central section. - Widening of riparian zone in combination with exclusion fencing with formalised access points is likely to be more feasible.
5a	Crookhaven Heads	Shoreline erosion and retreat.	- Sand renourishment. - Sand or rock bags may be more feasible given access restrictions.
5b	Crookhaven Heads Living Shoreline	Foreshore bank degradation.	Outside of Urban Rivers and Catchment Program.

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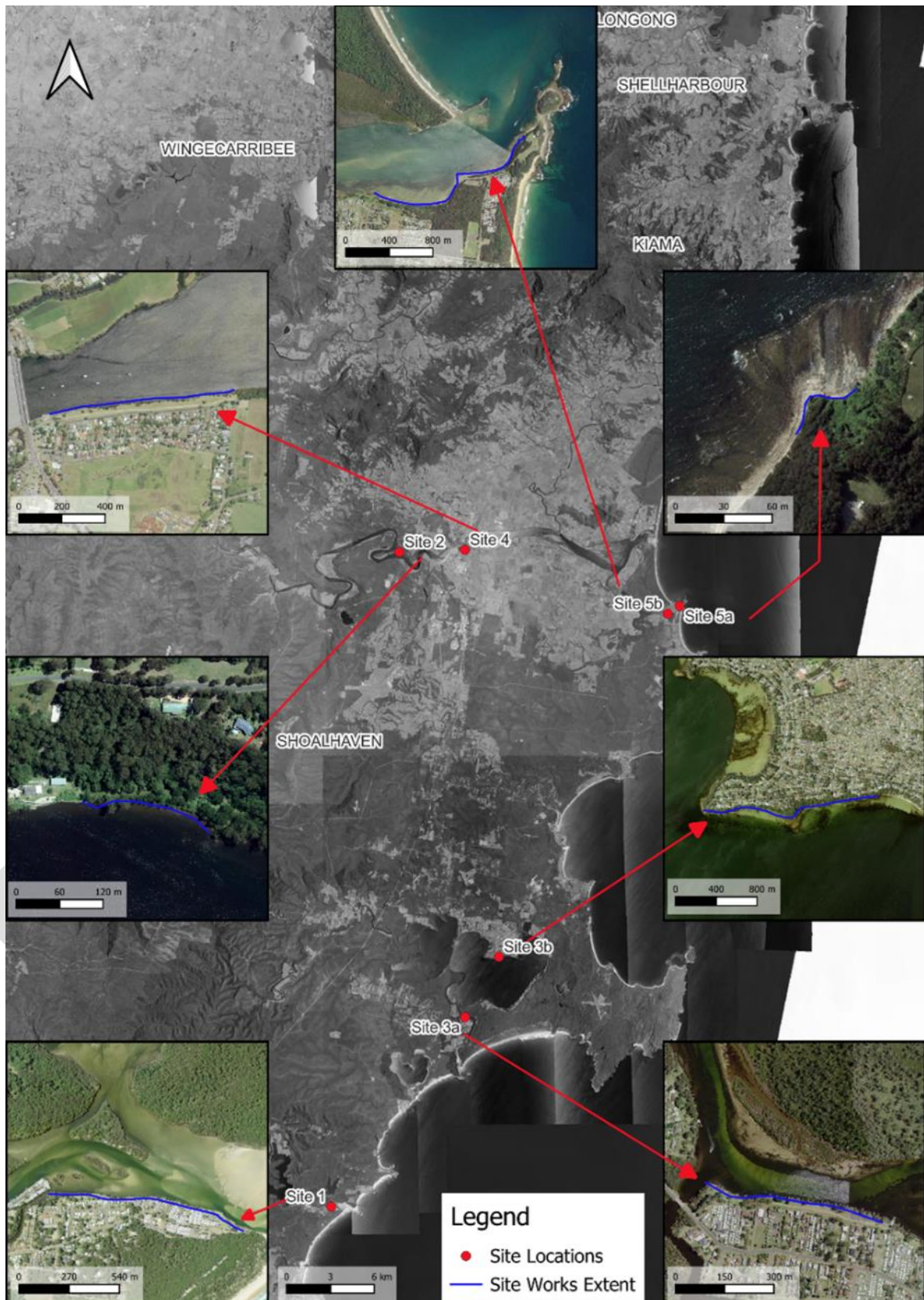


Figure 1-1 Sites



2 OVERVIEW OF FORESHORE EROSION REMEDIATION OPTIONS

Erosion may be natural but is often exacerbated by anthropogenic actions. Factors influencing foreshore erosion can act in isolation and/or in combination. They can be episodic as a result of individual events, or the processes can be ongoing over time. Table 2-1 provides a summary of factors influencing foreshore erosion.

Table 2-1 Factors influencing foreshore erosion

Factors influencing Foreshore Erosions	Causes
Tides	Constant physical wave action due to the rise and fall of the of the tides.
Boat wash	Physical wave actions impacting the foreshore.
Onshore wind	Wind set-up caused by wind blowing over the water surface, generating waves
Informal public access	Human traffic and activities on the foreshore causing.
Informal structures	Erosion can occur around structures (e.g. local scour around piers of informal jetties can lower foreshore banks and deepen foreshore banks).
Severe storm events	Significant wave actions from storm surges.
Large runoff events from the catchment	- Flow velocity and shear stress on the foreshore banks. - Hydraulic drawdown in soil profile of foreshore banks as floodwater recedes.
Removal of riparian vegetation	- Lack of roots to hold the soil together. - In channel vegetation can be physical barrier to wave actions.
Mowing of grass to the edge of the foreshore	Limiting the opportunity for riparian vegetation establishment.
Sea level rise	- Increase in water levels and physical erosive forces on the foreshore. - Increase in the frequency of storm surges.
Sediment availability from upstream and coast	Inability to replenish sediment loss within the foreshore area.
Changes in river hydrodynamics	Due to foreshore and channel realignment and dredging, upstream changes (urbanisation)

As a way of providing background information to foreshore bank stabilisation options, this section provides an overview of some of the potential remediation options for the sites within this scope of works. Management of foreshore erosion can be broadly categorised into soft engineering or hard engineering, acknowledging that a combination of both is not uncommon to address foreshore erosion at a given location. There is an increasing preference for foreshore managers to first consider nature-based solutions (soft engineering) to address environmental challenges, and to avoid hard engineering solutions where possible (NSW Coastal Design Guidelines, DPE, 2023).



2.1 Nature Based Solutions

2.1.1 Vegetation Management

Revegetation is considered the most cost-effective form of erosion control within the project area in the long term. Revegetation should be planned and tailored to each section of the foreshore or river bank. Typical planting of riparian zones occurs in three zones. The upper, middle, lower banks, with varying vegetation types in each zone.

- Upper Bank: Large trees, with deep roots are ideal for this zone along with shrubs and ground cover.
- Middle Bank: Medium size trees, shrubs and ground covers will help to bind the soils and reduce flow velocities along the bank.
- Lower Bank: Trees, shrubs and groundcovers with matted root systems and flexible branches protect the bank from undercutting and scour.

Planting layouts can be varied where required. Revegetation can occur in belts, rows and clumps. Rows should be planted perpendicular to the flow of the river to have a maximum effect on velocity reduction. Maintenance is essential to the successful establishment of the vegetation. Maintenance may include watering, guarding and replacing plants as required.

- Revegetation activities must involve a mixture of indigenous species to assist bank stability. Grasses, reeds, rushes, sedges and shrubs all have a significant role in assisting bank stability and should be the primary focus of revegetation activities aimed at assisting bank stability.
- A comprehensive revegetation program should aim to plant native species from the toe of the bank or top of rock armouring, the bank face, and top of bank and beyond the top of bank to a suitable distance back from the top of bank as described above.
- Revegetation specifically aimed at erosion control should be planted at a maximum of one-metre intervals. Natural selection shall ensure that a sustainable plant density results.

Another form of vegetation management is simply to establish a buffer zone on the edge of the riparian zone or foreshore bank to prevent the mowing of grass right to the edge of the foreshore. This will provide an opportunity for natural recruitment of vegetation and therefore an extension of the vegetated riparian buffer zone. A well vegetated riparian buffer can prevent informal access point into the water. Importantly, the roots of established riparian woody vegetation bind the soil of the foreshore bank and provides stability to the foreshore.

2.1.2 Mangrove Establishment

Mangrove are effective in attenuating waves and building up sediment on the foreshore environment. In addition to bank protection, they provide habitat and encourage sediment deposition and toe protection. Compared to many other foreshore remediation solutions, they are relatively low in cost and require low maintenance. Maintenance is mainly in the initial phase of revegetation, once established, they are generally capable of natural regeneration through self-propagation.

Assisted mangrove planting can be advantageous in locations where existing mangrove plants are already present. It provides assurance that they survive and thrive in the given locations. Mangrove planting can be complemented with temporary or permanent solutions, such as sandbags (Figure 2-1) or rock structures to create a more conducive environment for the mangrove seedlings to thrive (see section 2.2.4).

Along the coast of NSW, the Grey Mangrove (*Avicennia marina*), and the River Mangrove (*Aegiceras corniculatum*), are the two most common species. Grey Mangrove are commonly found on the seaward edge of the mangroves, while River Mangrove are found on riverbanks across a wide saline range. Grey Mangrove

high tolerance to cool temperature allows them to thrive in most mangrove environments. Both species generally thrive in the fringing zone (above Mean Sea Level (MSL) and Mean High Water Springs (MHWS). Other favourable growing conditions include:

- Warm temperatures, above freezing (ideal range 20°C -35°C).
- Sheltered shorelines, away from large waves.
- Fine substrate.
- Shallow gradient of foreshore bank.
- Tidal fluctuation.



Figure 2-1 Sandbags and fencing used to shelter mangrove seedlings along Shoalhaven River (Source: Shoalhaven Riverwatch, 2013)

2.1.3 Saltmarsh Establishment

Saltmarshes are vital for coastal defence, serving as natural barriers that absorb wave energy, reduce wave run-up during storms, mitigate foreshore erosion, and provide a buffer against storm surges and rising sea levels. Saltmarsh is an intertidal community of plants, that include varieties that are tolerant to high soil salinity and occasional inundation by high spring tide. These include sedges, rushes, reeds, grasses, succulent herbs and low shrubs.

Saltmarshes and mangroves often coexist in foreshore environment, creating diverse and dynamic intertidal ecosystems. Saltmarshes are usually found at higher elevations, experiencing flooding primarily during spring tides, while mangroves are more common in lower-lying zones below MHWS. These interconnected habitats facilitate sediment capture and stabilisation and also support biodiversity by serving as nurseries for various species.



Distribution of saltmarsh species is typically determined by relative elevation which influences tide levels and the frequency of inundation, both of which also affects the salinity of soil. Dominant species in NSW are summarised in Figure 2-2.

Table 2-2 Dominant Species of Saltmarshes in New South Wales (Source: Coastal Saltmarsh Factsheet, DPI NSW)

Relative Elevation	Dominant Species in NSW
Lower elevations	Samphire (<i>Sarcocornia quinqueflora</i>)
Mid-level	Saltwater Couch (<i>Sporobolus virginicus</i>)
Higher elevations	Sea Rush (<i>Juncus kraussii</i>)
	Bare Twig Rush (<i>Baumea juncea</i>)

2.1.4 Environmentally Friendly Seawalls

Environmentally friendly seawalls focus on enhancing the ecological value of seawalls and seawall-lined foreshores in estuaries. This is achieved through design that mimics natural intertidal shorelines in a way that seawall designs typically don't, emphasising the loss of habitats and microhabitats due to traditional seawall designs. There are many ways to enhance the ecological value of seawalls including:

- **Estuarine Vegetation:** Planting mangroves or other native vegetation directly in front of seawalls can create habitats for marine life and improve water quality. These plants act as natural buffers, reducing wave energy and erosion.
- **Artificial Reef Habitats:** Adding structures like reef balls or textured panels near seawalls can mimic natural habitats. These features provide shelter and breeding grounds for fish, crustaceans, and other marine organisms.
- **Surface Texture and Variation:** Modifying the seawall surface with grooves, crevices, or rough textures can encourage the growth of algae and other organisms. This increases biodiversity and creates microhabitats.
- **Riparian Vegetation Buffers:** Establishing vegetation landward of the seawall helps filter runoff and provides additional habitat for terrestrial and aquatic species.

2.1.5 Oyster Reefs

Constructed oyster reef acts as a natural breakwater, attenuating wave energy and reducing foreshore erosion. The physical structure of the reef also helps to capture sediments and further enhance foreshore protection. A key advantage of a well-established oyster reef is its adaptability to climate change and associated sea levels rise. Oyster reefs can grow in height and keep pace with increasing water levels.

There are several key considerations for site selection for adopting oyster reef as a form of foreshore protection. These include hard substrate, presence of shells on the bed, water quality (including temperature) and the location setting (e.g. slope, tidal range, water depth). The latter has a direct impact of the optimal growth conditions of the oyster reefs. Specifically, the percentage (%) time the reef is exposed (above water) is a key consideration for the successful implementation (Figure 2-2).

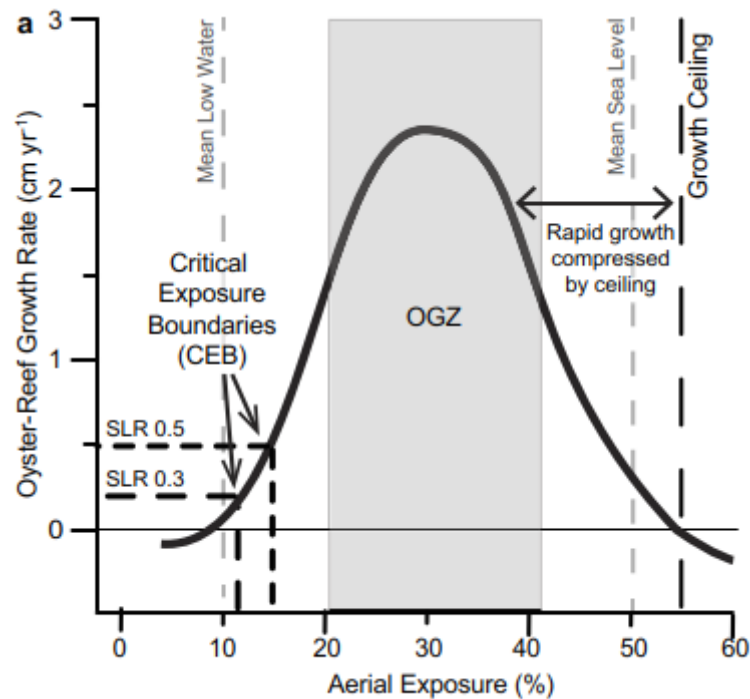


Figure 2-2 Oyster Reef Optimal Growth Zone (OGZ) at exposures between 20-40% (Source: Ridge et al. 2015)

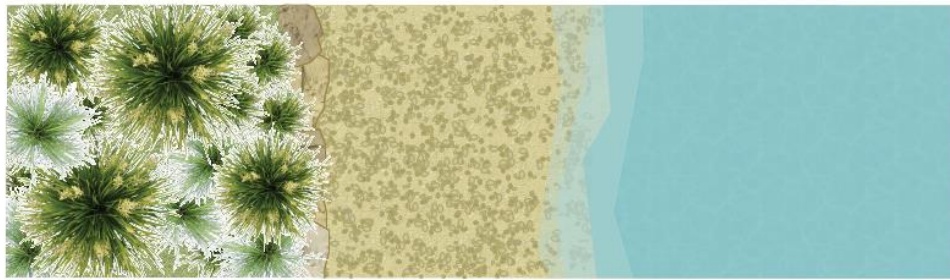
2.2 Engineered Interventions

2.2.1 Cobble Beach

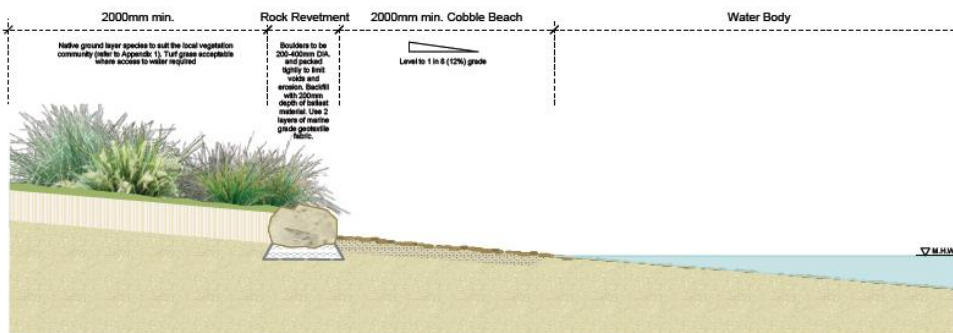
Cobble beach can be an effective measure to restore foreshore slopes and act as a barrier to foreshore erosion. It typically comprises of small cobble-sized stones overlain on the existing foreshore. Cobble beach will be suitable for foreshore that has a gentle foreshore gradient and typically encounters low wave energy. If the foreshore bank has a steep escarpment, additional treatments, such as rock revetment can be used in conjunction with a cobble beach (Figure 2-3).

Findings from a review of previous foreshore stabilisation approaches along over 30km of Lake Macquarie, NSW, indicate that cobble beaches were unsuccessful in sections of high wave energy (AECOM, 2010). It is therefore important to consider the maintenance requirement and frequency of the cobble beach. If the cobbles are frequently removed from the beach and there is no available supply within the system to replenish naturally, it may result in a costly maintenance regime.

Plan



Precedent Images



Section

Figure 2-3 Concept design of rock revetment on foreshore bank with cobble beach extending into the water
(Source: Lake Macquarie City Council, 2024)

2.2.2 Rock Beaching

Rock Beaching involves the placement of graded angular quarry rock against a stream or foreshore bank to remove the pressures of moving water against the material contained within the bank profile, and therefore protect it from most mechanisms of bank erosion (Figure 2-4). Revegetation behind the rock beaching is essential to the long-term stability of the site.

A foundation of rock is usually placed across or excavated into the riverbed to ensure that scour of the bed does not undermine the rock beaching. Rock is placed to a design thickness to ensure that it forms an interlocking mass and is not easily washed away. It is essential that the rock beaching is designed with a geometry and rock size appropriate to the expected hydraulic conditions. This will ensure that the structure remains stable under a range of expected flow conditions.



Figure 2-4 Rock Beaching, Logan River, Beaudesert.

Angular quarry rock is often preferred for rock rip rap due to its shape and stability. The angular edges of quarry rock allow the stones to interlock effectively, creating a stable and durable structure that resists movement and can withstand strong water currents and wave action. The relative stability of rock riprap (against the force of gravity) is indicated by its 'angle of repose'. Simons and Senturk (1979) show that the angle of repose for rock riprap increases with rock mean diameter (D_{50}) but is significantly greater for angular rock, compared to rounded rock (Figure 2-5). Additionally, quarry rock is often graded and sized specifically for rip rap applications, ensuring consistency and reliability in its performance, and is often supplied with specifications such as specific gravity. In contrast, other stone, such as river stones, can be rounded and smooth, which makes them more prone to shifting and rolling under pressure. This not to say that only angular graded quarry rock can be used for rock riprap applications, rather that, if using other rock, the following should apply:

- Hydraulic calculations that inform the riprap design should account for the angle of repose and specific gravity associated with the rock being used. The program *RipRap* (Keller, 2005) allows for such parameters to be directly input.
- Where possible, rock should be tested to confirm these parameters.
- Rock should be graded and stockpiled on site prior to placement.
- Final placement of rock should be overseen by a suitably qualified and experienced engineer.

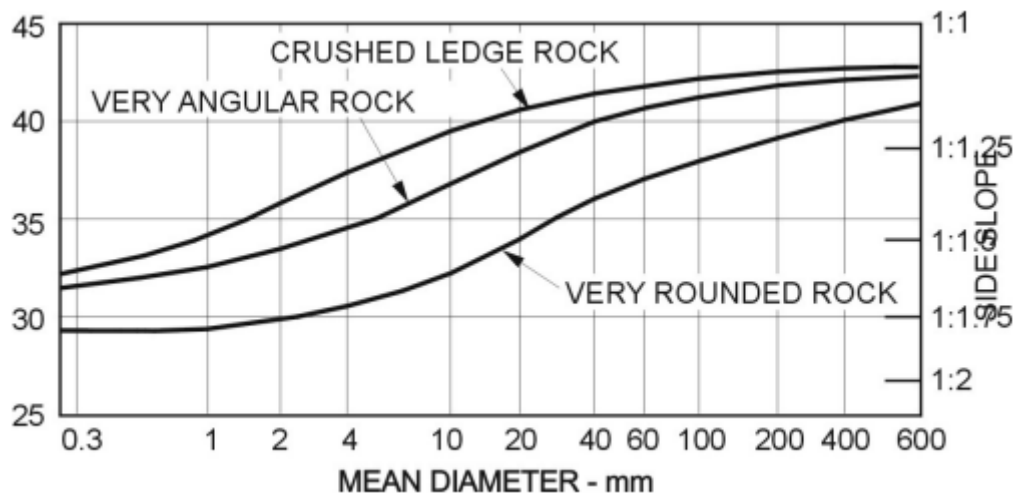


Figure 2-5 Angle of repose of dumped riprap. (Source: Simons and Senturk, 1977)

Note that river cobbles, gravels and silts are not suitable materials for rock armouring. These sediments will be easily transported by water during high flow events due to their rounded shape, small diameter, and unconsolidated nature.

2.2.3 Bank Battering

Battering is a technique that involves excavation works to reduce the slope of the bank face to improve slope stability, bank stability and create more favourable conditions for vegetation establishment. In many instances, bank battering is limited to the upper bank profile. This technique is often utilised in conjunction with other forms of bank erosion control (e.g. rock beaching, timber revetment) to achieve a stable finished bank angle.

This technique generally has limited application as a standalone erosion control technique for the following reasons:

- Battering will generally not address the cause of erosion.
- Battering disturbs soil and results in the bank being more vulnerable to erosion in the short term whilst the revegetation establishes. This may not only impact on bank stability but also water quality.
- Potential for high disturbance during excavation including vegetation removal and heavy machinery within waterways.
- Battering may remove values that are important to bank stability such as vegetation and root structure. These works also reduce geomorphic diversity, removing habitat values associated with vertical banks, undercut banks and overhanging vegetation.

2.2.4 Rock fillet

Rock fillets are structures made of rocks placed along the edges of waterways, such as riverbanks or shorelines, to address erosion issues. They are designed to stabilise these areas by acting as barriers, dissipating the energy of waves or currents and preventing further erosion of the bank or shoreline. In addition to providing erosion control rock fillets encourage the deposition of sediments, which can help rebuild eroded areas. Critically, rock fillets also promote the growth of vegetation, such as mangroves or other riparian plants, which further stabilize the area and provide habitats for aquatic and terrestrial species. Figure 2-6 shows how placement of rock fillets in front of an eroding bank provides shelter for establishing mangroves.



(a)



(b)

Figure 2-6 Rock fillet work allowing mangrove seedlings to establish (a) Hasting Rivers and (B) Dumaresq Island, Manning River (Source: AECOM, 2010)

These structures are particularly effective in areas with erosion caused by natural forces like tides and floods, as well as human activities such as boating. They are, however, limited as they may fail in areas with highly dynamic flood flows or extreme wave energy.



3 SITE 1 – LAKE CONJOLA

3.1 Site Overview, Background and Literature Review

Site 1 is located on the southern foreshore of Lake Conjola. The site, approximately 500m in length, is part of the parcel of Crown land where the Holiday Haven Lake Conjola Caravan Park is located. Site 1 runs the length of the caravan park and carpark of Conjola Beach Boat Ramp. This foreshore site is heavily used by locals and patrons of the caravan park. This include accessing the lake for swimming, kayaking and fishing.

It was confirmed on site that the assessment will be limited to this 500m length and does not extend beyond to include the adjacent foreshore between the caravan park and the Anney Street Boat Ramp. Rationale to limit the spatial extent include, available budget, ease of implementation, land ownership and site access for remediation. For the purpose of the condition assessment the site has been separated into three reaches as shown in Figure 3-1.

The *Lake Conjola Coastal Management Program* (Royal Haskoning DHV, 2024) and its interactive Mapping portal identified and mapped out some areas of foreshore with issues that potentially require some form of intervention and management. Table 3-1 provides a summary of the issues and recommendations.

Table 3-1 Summary of Issues Identified and actions recommended from Lake Conjola Coastal Management Program Action

Reach	CMP Ref. No.	CMP Management Actions	Actions Descriptions
1	FB1	Investigate, remediate and monitor impacted or vulnerable bank areas	Restoration of riparian vegetation
2	FB1	Investigate, remediate and monitor impacted or vulnerable bank areas	Repair of existing foreshore protection
3	FB1	Investigate, remediate and monitor impacted or vulnerable bank areas	- Upgrade existing rock protection and construct new rock protection where it does not exist. - Upgrading to include raising crest level and improving filtration design. - Retain existing localised swimming areas. - Remove existing concrete works.
	FB2	Management of stormwater runoff	- Replacement of concrete channel with grassed swale. - Filtering of stormwater runoff with riparian vegetation buffer
	FB5	Investigate appropriate and permissible use of public foreshores by private structures	- Investigate permissibility of foreshore structures. - Identify illegal structures for removal

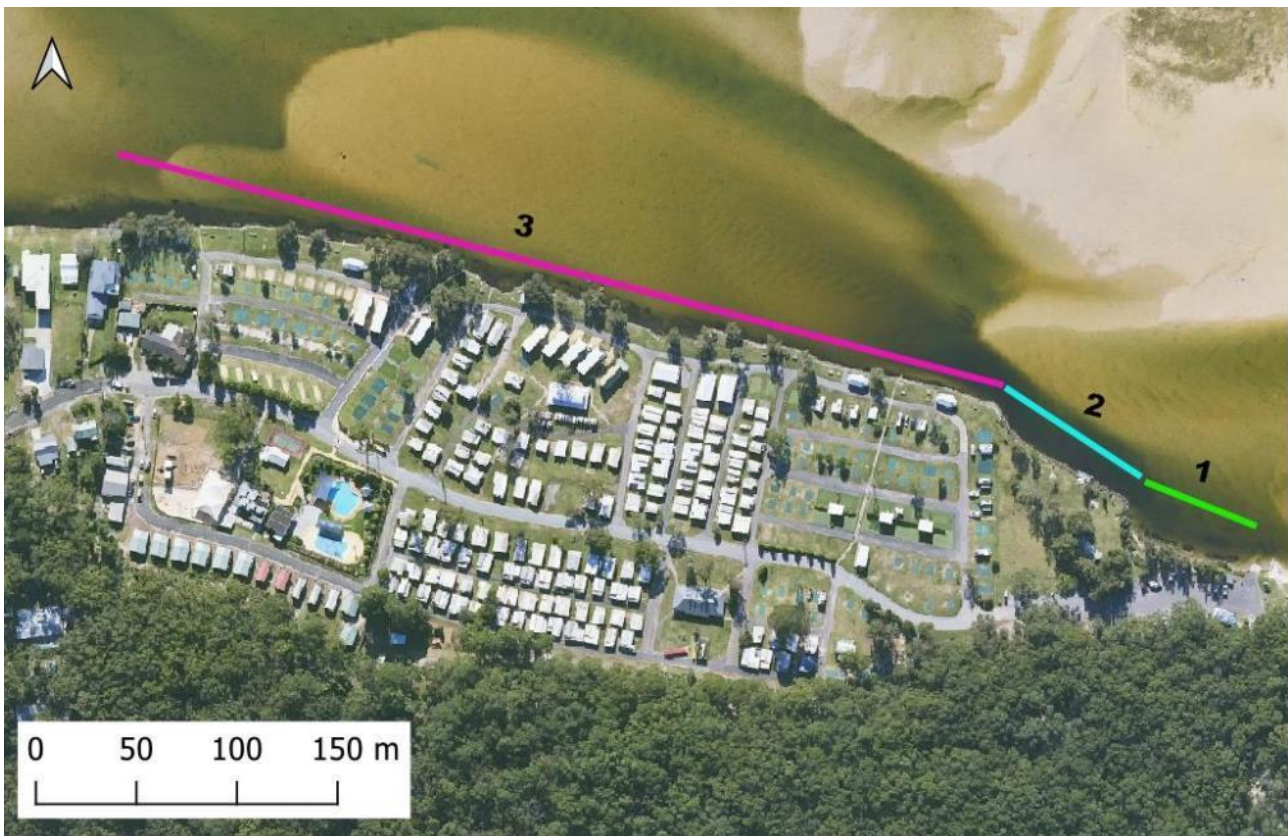


Figure 3-1 Map of the extent of the three identified reaches

3.2 Current Condition

The first 50-100m (Reach 1) from Conjola Beach Boat Ramp has been previously treated with revegetation pockets including a mix of casuarina and native grasses/reeds (Figure 3-2) with interpretive/educational signage also in place. It is understood that the revegetation was undertaken approximately ten years ago. The vegetation is in good condition and appears to be an effective erosion control measure. This provides a good indication that vegetation can be an effective measure in this reach. As such, this is a useful reference reach for foreshore remediation for Site 1. It is noted on site that there is a minor erosion risk associated with informal access to the water at points where vegetation buffer is narrow.

The next 50-100m (Reach 2) is an open space area – grass parkland with isolated tall woody vegetation on the foreshore, poor and discontinuous reeds (Figure 3-3). Previous foreshore erosion treatment consists of poorly graded (i.e. little variation in size) large rocks (~400-500mm diameter). The rock protection consists of a few isolated rows of rock that are approximately 1m wide. Importantly, they are only one rock deep (not stacked or interlocking) and there are significant gaps between the rocks. The rocks are providing a good substrate habitat for aquatic life such as fish and oysters. Juvenile mangroves are also observed growing up through the rocks. It is observed on site that scouring is occurring behind the rocks and the foreshore is receding (Figure 3-4). As a result, the existing foreshore alignment is unarmoured.

The remaining extent of the site (Reach 3) is the approximately 400-450m of the caravan park frontage (Figure 3-5). There exist pockets of vegetation, and open channel stormwater drains. Juvenile mangroves observed growing up through the rocks, the rocks are providing a good substrate for various aquatic life.



Seagrass appears to be growing well beyond the toe of the rocks. This section is mapped as 'Revetment' in the Foreshore Protection Walls spatial dataset with a condition rating of 3¹.

The bank is mostly unvegetated and treated with a combination of large rock (1-2 rows of 500-700mm diameter) on the bank face and cast in-situ, reinforced concrete on the top of bank. The concrete treatment is inconsistent, absent in parts and up to 1m wide in others. However, concrete is not sympathetic with any natural processes. The condition of concrete is generally poor (cracked and uneven), with moderate scour of bank material behind the concrete (Figure 3-6). While the concrete has failed in parts, failure does not seem imminent for most of the remaining concrete. Given time however, the concrete will almost certainly fail along the whole reach. In addition, rocks are observed to have fallen away from the concrete and into the lake in some locations (Figure 3-7).

Stormwater from the impervious areas of the caravan park discharges to the lake from at least seven locations. Council's stormwater spatial dataset identified only one of these, as a surface drain. There are four other similar concrete spoon drains that discharge into Lake Conjola along Reach 3 (Figure 3-8). In addition, there is a grassed swale (drainage line) that drains a small section of the road within the caravan park and into the lake. It is of note that they discharge stormwater directly over the bank with no formalised outlet. While only minimal scour/erosion was observed at these sites, they present a long-term risk to the bank stability. Some of these drains are also used as watercraft launch points (Figure 3-8). There is also a spoon drain that enters a stormwater pit below the foreshore and discharges through a culvert pipe into the lake (Figure 3-9). This allows for dense riparian vegetation to grow along the foreshore at this location and ensure stormwater discharges directly into the lake and not over the banks of the foreshore, thereby reducing the potential for foreshore erosion.

There are some formalised access points, such as steps into the lake, in Reach 3 (Figure 3-5). However, there is evidence of access and usage of the foreshore outside the formalised access points. For example, boat mooring rings are seen bolted into some of the rocks used for foreshore erosion protection. A few informal access points for launching kayaks are also noted during the site assessment (Figure 3-8).

¹ Rating from 1 to 5, with the 5 being the best condition.



Figure 3-2 Reach 1 of Site 1



Figure 3-3 Reach 2 of Site 1



Figure 3-4 Ineffective Foreshore Rock Protection



Figure 3-5 Example section of Reach 3



Figure 3-6 Examples of concrete reinforcement in poor conditions



Figure 3-7 Rocks collapsed into the lake



Figure 3-8 Example of Spoon Drain in Reach 3 of Site 1 (Left: Looking away from Lake and Right: Looking towards Lake)



Figure 3-9 Spoon drain terminating at a stormwater pit.

3.3 Expected Trajectory

For Reach 1 in Site 1, the existing vegetation treatment is likely to continue to provide effective erosion control. However, there is the possibility of minor erosion continuing at informal access points.

The rock works at Reach 2 in Site 1 are not providing effective erosion control. While the rocks would be providing some protection from waves perpendicular to the bank (boat wash, smaller wind waves) they are ineffective against flows parallel to bank (flood flows, tidal currents, storm surge). Further bank retreat is expected in this location leading to the loss of public land and amenity of the site.



The foreshore at Reach 3 in Site 1 will continue to be utilised by locals and patrons of the caravan park. Foreshore erosion is expected to persist, and the degradation of existing protection works will continue. These include:

- Foreshore material behind the concrete and rocks will continue to scour.
- The concrete will deteriorate over time and eventually fail.
- Rock protection is likely to be undermined at various locations, eventually falling forward into the lake. This is identified at some locations already and will exacerbate the foreshore erosion.

The conveyance of stormwater runoff along the multiple stormwater drainage outlets will exacerbate foreshore erosion at and around the discharge points. The increased foot traffic along the foreshore and informal access points to the lake also adds to the foreshore erosion risk. Overall, there is significant safety risk and potential loss of amenity for park users in the foreshore erosion is not better managed.

3.4 Technical Analysis Summary

A summary of the foreshore erosion technical analysis for Site 1: Lake Conjola is provided below:

Specific Issues

- Foreshore erosion.
- Degradation of existing erosion protection structures.
- Poor riparian vegetation cover.
- Informal access by patrons to use the lake.
- Multiple Stormwater discharge points into the lake.

Associated Risks

- Loss of public/crown/private land.
- Loss of public amenity due to degraded foreshore zone.
- Safety of locals and patrons accessing the foreshore.
- Degradation of seagrass and other aquatic habitats currently in the foreshore area.

Constraints

- The presence of good aquatic habitat in front of existing rock revetment (seagrass, oyster reef) constraints the extension of erosion protection towards the water.
- It will be costly to completely remove all the existing rocks and concrete protection.
- Retention of existing recreation areas such as swimming area and formal access points (steps).

Opportunities

- One of the existing stormwater drains which discharges to a pit and out through a pipe into the lake is a good example of managing stormwater discharge, alleviating foreshore erosion and allowing space for riparian vegetation to thrive.
- To remove the concrete drains and replace with a vegetated swale.
- Upgrade existing stormwater drainage to not only reduce erosion potential but also manage stormwater flow and improve water quality entering the lake.



- Reach 1 provides a good reference to the success of using riparian vegetation to protect the foreshore at Site 1.
- To increase riparian and lake frontage vegetation.
- To incorporate native vegetation to the options.
- To assist revegetation such as saltmarsh or mangroves.
- To formalise access points for launching of small watercrafts
- To remove illegal mooring points and set up designated boat mooring sites.

Other considerations

- Local community is likely to want to have a say in the remediation options. Community consultation/engagement will be a key issue.

Review of DST option

There is no DST options derived for this site, but the CMP management actions are detailed in Table 3-1. Overall, the findings from this assessment align well with the management actions from the CMP.

Recommendations

Site 1 is of significant length, and it is recommended to prioritise sections of Site 1 for future works. For example, Reach 1 is a low priority site and focus can be on Reach 2 and Reach 3. Given the length of Reach 3 and the various issues identified, it is recommended to focus on sections of Reach noting the current budget available for the site is unlikely to incorporate the entire reach.

For Reach 2, pockets of revegetation should be undertaken with reference to Reach 1. Formalise access points between these pockets of revegetation will be appreciated by the local communities. The existing rock protections should remain as they are providing some form of protection and have ecological/habitat value. The rocks should be supplemented with smaller, more varied rock (~300mm D50) to form an interlocking mass between the current top of bank and existing rock.

For Reach 3, the rocks protection along Reach 3 should be retained as much as possible. They are providing some form of foreshore protection and importantly have developed habitat value. The rocks should be supplemented with smaller, more varied rock (~300mm D50) to form an interlocking mass between the current top of bank and existing rock. Incorporate fish friendly design as per NSW Govt. *Environmentally Friendly Seawalls*. Ideally all concrete along the rock protection works should be removed but priority should be given to areas where condition is worst.

Similar to Reach 2, pockets of riparian vegetation frontage, separated by formalised access points is also recommended for Reach 3. This will help manage access and use of the entire length of the foreshore and therefore mitigate erosion potential. Assisted revegetation of salt marsh and/or mangrove should be considered where appropriate.

The concrete drains along Reach 3 should be removed where possible and replaced with grass swale and a pit and culvert arrangement in line with WSUD principles.

A 'shopping list' of recommended treatments for each of the identified issues at Site 1 is given in Table 3-2.



Table 3-2 List of recommended treatments for identified issues at Site 1

Issue	Recommendation
Voids in rock beaching / insufficient material/volume	▪ Back fill voids with smaller sized rocks
Scouring behind rock beaching	▪ Back fill voids with smaller sized rocks ▪ Revegetate a buffer strip
Rocks fallen into lake	▪ Redesign and replace rocks
Informal watercraft access points	▪ Formalise watercraft access points
Informal boat mooring points	▪ Revegetate foreshore and channel boat mooring to specific locations
Stormwater drainage outlets	▪ Design pits and pipe flow underground and into lake ▪ Remove concrete spoon drain and replace with grass swale where possible
Lack of riparian vegetation	▪ Plant tall trees where possible along the foreshore. ▪ Plant low height varieties where view is preferred. ▪ Plant mangrove in suitable locations ▪ Signage for educating native revegetation and erosion management
Lack of estuarine vegetation	▪ Construct intertidal benches for establishment of saltmarsh and mangroves

With the nominated budget of \$250,000 we propose a focus on Reach 2 and a target section of Reach 3. Any remaining budget can be used for revegetation of Reach 1.

3.5 Concept Design and Indicative Costing

The concept design for the Lake Conjola foreshore consists of several treatment options to improve the stability of the foreshore alignment. These options have been selected through discussion between Water Technology, Council and DPIE, both on site and during the Design Workshop. Each option may be applied at varying locations along the alignment and a combination of options may be applied at any one point. The concept design drawings, included in Appendix A, indicate an ideal arrangement, from a foreshore stability perspective, noting that the arrangement may be subject to change according to budget, stakeholder pressure or other influences. The relevant design elements are presented below and summarised in Table 3-3.

3.5.1 Supplement Existing Rock Beaching

The existing rock beaching consists of one to two rows of large rocks, 500-700mm diameter on the bank face. The rock beaching is in poor condition and the rocks are providing limited protection to the bank from the identified mechanisms of erosion. It is recommended that the large rocks be supplemented with smaller, graded rocks to form an interlocking rock riprap. Rock beaching should be formed from graded quarry rock with a d_{50} of approximately 350mm. The intent of the smaller rocks is to provide more complete protection to the foreshore bank by filling the large gaps in the existing rocks. Furthermore, the smaller rock arrangement will be flexible enough to accommodate minor changes in the foreshore geometry that are expected to occur over time. The supplemented rock beaching arrangement is also expected to improve upon the ad hoc and uneven appearance of the existing arrangement and provide a safer and more consistent surface for caravan park users. A profile view of the recommended arrangement is shown in Figure 3-10.

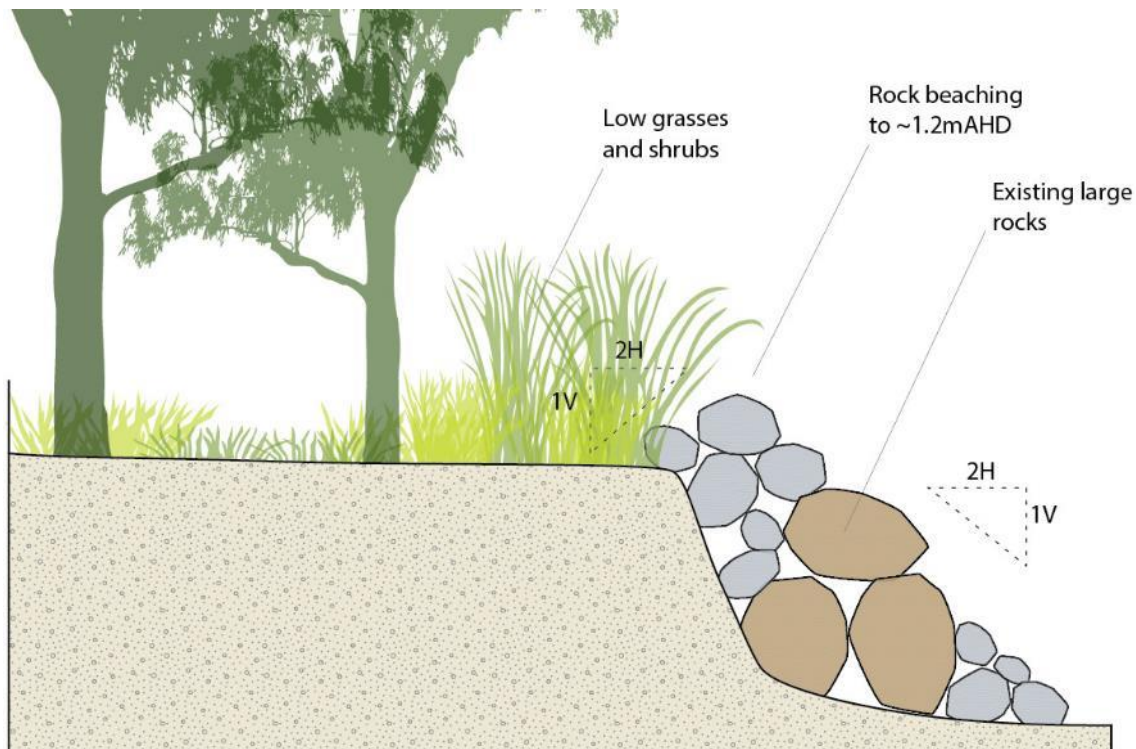


Figure 3-10 Rock beaching

3.5.2 Saltmarsh bench

This involves the formation of saltmarsh benches in targeted locations along the length of the foreshore. A bench is formed by locally excavating the foreshore surface that will be periodically inundated with tides (e.g. during spring tides) to allow establishment of saltmarsh. The saltmarsh bench is to be protected at the lakeward side by a low rock fillet and the landward bank is to be armoured with rock beaching. The intent of the saltmarsh bench is to provide a stable buffer between the lake and the caravan park that will accommodate minor changes in the foreshore geometry that are expected to occur over time. Furthermore, there are many expected co-benefits of the saltmarsh benches including creation of marine habitat, filtering of stormwater runoff and providing the opportunity for education through interpretive signage. Figure 3-11 shows examples of recently constructed saltmarsh benches in similar environments. Figure 3-12 shows a typical design profile of a saltmarsh bench for Lake Conjola.

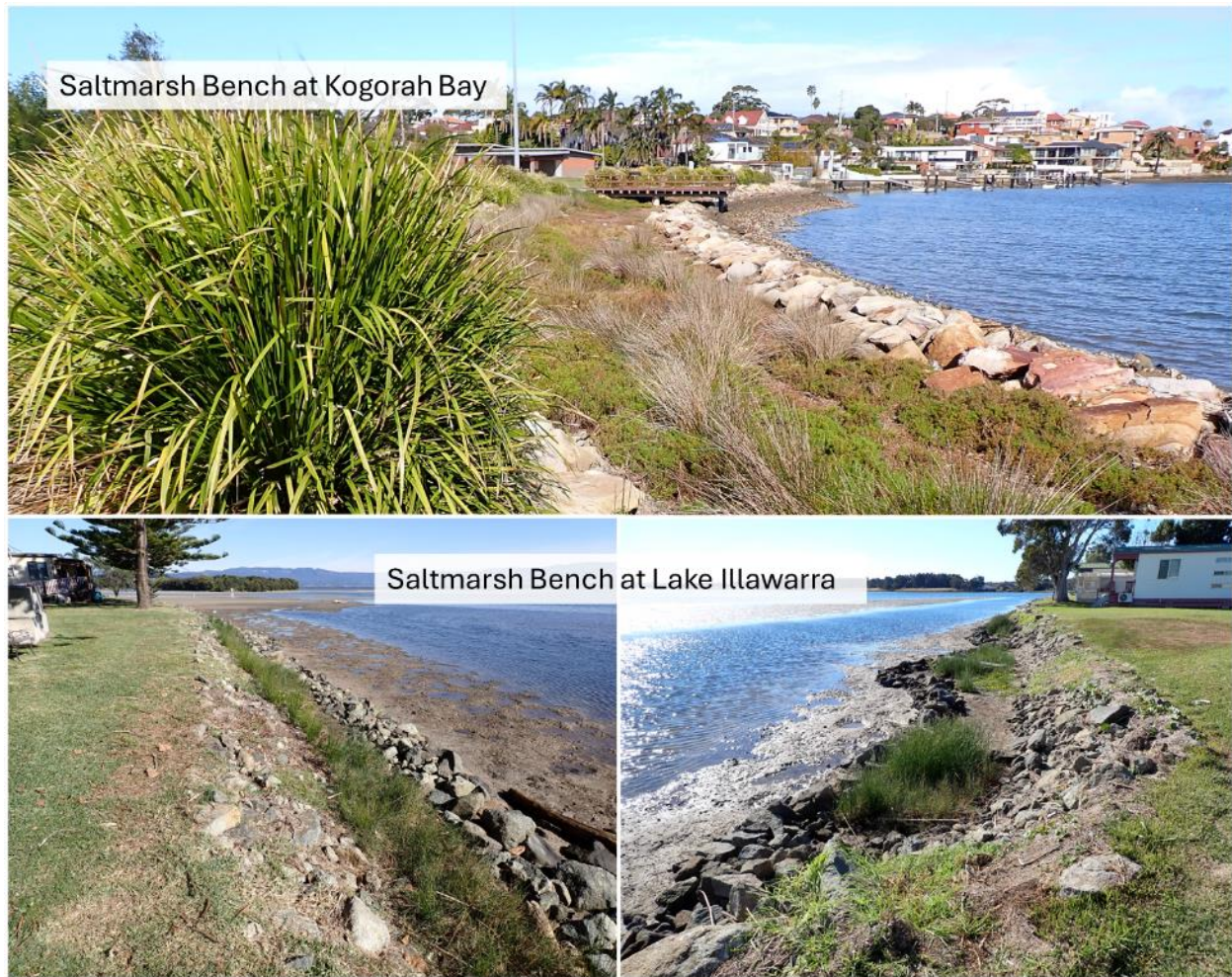


Figure 3-11 Example of saltmarsh benches at Lake Illawarra and Kogorah Bay.

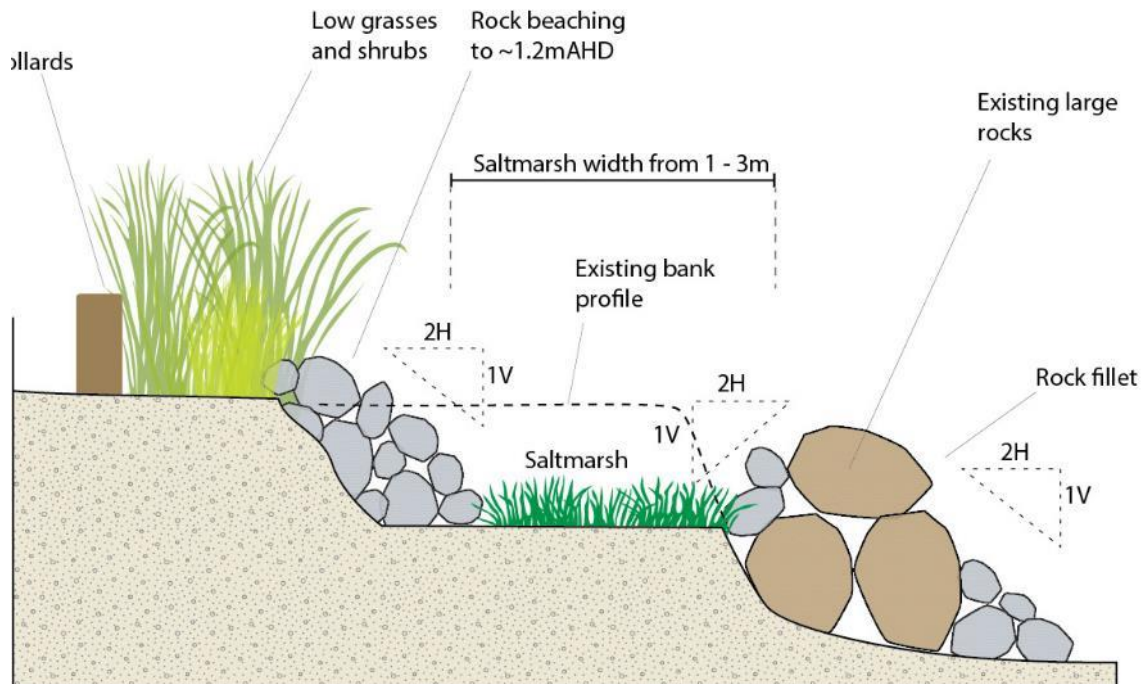


Figure 3-12 Typical design profile for saltmarsh bench

3.5.3 Fencing

It is recommended fencing is incorporated into the design solution for the site. The primary intent of the fencing is to delineate a no mow zone along the foreshore to ensure a vegetated buffer is maintained. The fence does not need to be high, no more than 300mm, and may be formed by posts and chain or simply regularly spaced bollards. Possible material for the posts may be hardwood, concrete or recycled plastic.

3.5.4 Vegetation Management

Management of vegetation along the foreshore is recommended to help control pedestrian traffic and to provide second line of foreshore protection beyond the rock beaching. Vegetation management is widely considered the most cost-effective form of long-term erosion control. At Lake Conjola, management of vegetation will have to account for competing objectives of erosion control and push back from local residents and caravan park users. It is likely certain stakeholders will perceive foreshore vegetation as obstructing views and access to the water. As such, revegetation efforts should focus on low height grass and shrub species. Given the existing foreshore bank height is approximately one metre, plants that grow to a similar height should provide effective erosion control.

3.5.5 Vegetated Swale / Outlets

A vegetated swale is a shallow, open channel designed to convey stormwater while also filtering pollutants and reducing runoff velocity. Unlike the existing concrete drainage systems, vegetated swales use grass, shrubs, and other vegetation to slow down water flow, allowing sediments and contaminants to settle before reaching the lake. The outlets may contain pit drains that will allow easy maintenance. This would be approximately 0.8x0.8x0.8m inline pit with metal grate that one person can clean out without specialised equipment. Figure 3-13 shows a typical design profile of a vegetated swale/ stormwater outlet for Lake Conjola.

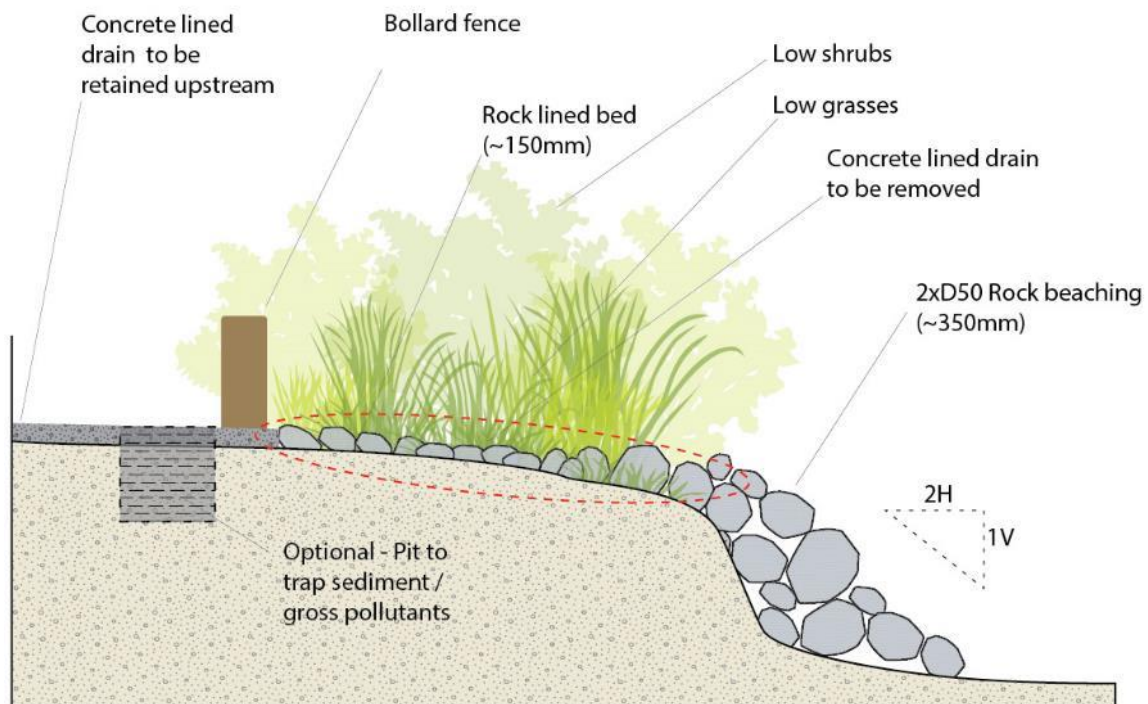


Figure 3-13 Typical design profile of a vegetated swale/ stormwater outlet for Lake Conjola

3.5.6 Summary



Table 3-3 Site 1 Lake Conjola

Treatment	Description	Intent	Location	Co-benefits	Indicative Cost
Supplement Existing Rock	Supplement the existing large rocks with smaller rocks (~350mm) to form interlocking rock riprap.	Protect foreshore from wind/boat waves and flood flows.	Along the entire foreshore reach with regular gaps to facilitate lake access.	- Improve uneven/ adhoc appearance of existing arrangement. - Improve safety - Provide substrate for oysters	\$180/Lm
Saltmarsh bench	Locally excavate a low surface that will be periodically inundated with tides to allow establishment of salt marsh.	Protect foreshore from wind/boat waves and flood flows.	At selected locations along the foreshore reach.	- Marine habitat - Filter Runoff - Opportunity for education	\$360/Lm
Bollard fence	A low fence formed by short (~300mm) hardwood, recycled plastic or concrete posts.	- Delineate no-mow zone. - Control pedestrian traffic.	To be implemented along most of the foreshore reach with regular gaps to facilitate lake access.		\$50/Lm
Remove existing concrete cap along foreshore	Concrete is not sympathetic to foreshore processes as it inhibits vegetation growth and cannot adjust to accommodate minor topographic changes.	Removal of the concrete will allow for the implementation of a more suitable design.	Along the entire foreshore reach.	- Improve uneven/ adhoc appearance of existing arrangement. - Improve safety	\$100/Lm



Treatment	Description	Intent	Location	Co-benefits	Indicative Cost
Revegetation - low grasses and sedges	Plant and maintain a narrow (~2m) strip of native grasses and sedges along the top of the foreshore bank. Signage may be incorporated to describe the role of vegetation in foreshore protection.	- Control pedestrian traffic. - Provide second line of foreshore protection from wind/boat waves and flood flows.	To be implemented along most of the foreshore reach with regular gaps to facilitate lake access.	- Visual amenity - Habitat - Education	\$60/Lm
Revegetation - trees	Plant and maintain native trees along the top of the foreshore bank.	- Control pedestrian traffic. - Provide second line of foreshore protection from wind/boat waves and flood flows.	Selected section of the foreshore reach	- Visual amenity - Habitat - Education	\$60/Lm
Vegetated Swale	Replace concrete stormwater outfalls with vegetated swales.	Provide stable outlet of stormwater flows to Lake.	Existing open concrete stormwater drains	Stormwater treatment	\$1000/each
Move access stairs	Where water access stairs are adjacent to existing stormwater outfalls that are to be replaced with vegetated swales, stairs should be moved to a more appropriate location.	Separate lake access points and stormwater outlets.	Where stairs are currently adjacent stormwater outlets		\$1000/each



3.5.7 Cost Estimate

A cost estimate for the works at Lake Conjola is given in Table 3-4. The estimate is based on indicative costs given in Table 3-3 and the corresponding measurements from Appendix A. Indicative costs are a high-level estimate only.

Table 3-4 Cost Estimate for Site 1

Item	Estimated price	Unit	Measurement	Cost
Supplement Existing Rock	\$180.00	Lineal metre	560	\$100,800.00
Saltmarsh bench	\$360.00	Lineal metre	45	\$16,200.00
Bollard fence	\$50.00	Lineal metre	560	\$28,000.00
Remove existing concrete cap along foreshore	\$100.00	Lineal metre	500	\$50,000.00
Revegetation - low grasses and sedges	\$60.00	Lineal metre	500	\$30,000.00
Revegetation - trees	\$60.00	Lineal metre	100	\$6,000.00
Vegetated Swale	\$1,000.00	Each	4	\$4,000.00
Move access stairs	\$1,000.00	Each	1	\$1,000.00
Total				\$236,000.00

4 SITE 2 – SHOALHAVEN RIVER, COORONG ROAD

4.1 Site Overview

Site 2 is located on a private property in North Nowra. The property dwelling is situated on higher ground atop bedrock cliffs, with steep track leading down to a terrace. The terrace is located on an outside bend of the Shoalhaven River atop a 5-6m bank.

4.2 Current Condition

The riverbank in this location is approximately 5–6 meters high and the reach of concern, approximately 160 meters in length. Active bank erosion is progressing towards the bedrock cliffs. The erosion is occurring in sections, with other sections stabilised by a combination of exposed bedrock outcrops, individual large rocks and large trees (Figure 4-1). The primary erosion mechanism appears to be slumping and undercutting of the bank. The bank is undercut in some areas, and tension cracks are visible on the surface at the top of the bank (Figure 4-2).



Figure 4-1 Vegetated bedrock outcrops, resistant to erosion



Figure 4-2 Undercutting of the bank captured by the drone and from the bank. Tension cracks in the top of the bank viewed from above.

Rocks have been informally placed by the landholder on the upper bank face, but this measure is unlikely to address the identified erosion mechanism. Overland flow is concentrating in low points on the terrace and discharging down the bank face, likely contributing to the erosion. Informal repairs have also been made to address this process by backfilling the erosion extent. Similarly, this is not likely to address the erosion mechanism.



Figure 4-3 Informal works to treat erosion.

Multi temporal topographic datasets are not available to measure the extent of erosion over time. Measuring the top of bank alignment from the 2010 LiDAR and the 2020 aerial imagery indicates bank retreat in the order of 5m over this time (Figure 4-4).

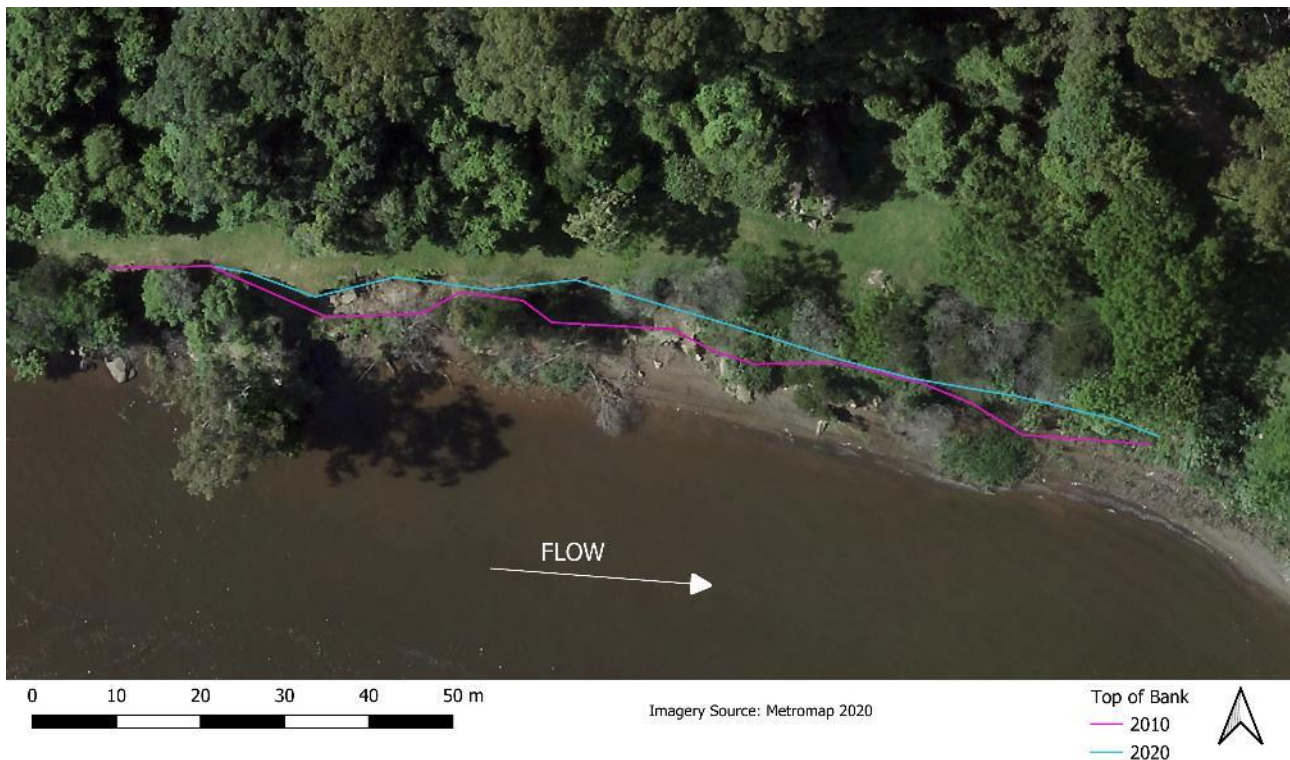


Figure 4-4 Indication of bank movement based on 2010 LiDAR and 2020 aerial imagery.

4.3 Flood Behaviour

Historical flood records are available since 1860, with the largest floods recorded in 1870, 1873, 1925, 1860, 1978, 1916 and 1891 (in order of magnitude). The flood of April 1870 is estimated to have been greater than a 0.5% Annual Exceedance Probability (AEP) event. It inundated the Terara Township by over a metre and swept away approximately one third of the village. Five lives were lost in rural areas along the Shoalhaven River.

In the recent past, the Lower Shoalhaven River catchment was flooded in 2013, 2015, 2016 and 2020. Minor flooding has occurred several times between March 2021 and June 2024.

According to the Lower Shoalhaven Flood Study Report (Cardno, 2022) while the lower Shoalhaven River is tidal for a large extent upstream the Coorong Road site, riverine flood flows are dominant in determining water levels during floods within the Shoalhaven River upstream of Nowra. Review of the Lower Shoalhaven Flood Study model results suggest that relative depths of flow at the site range from over 8 metres in the 10%AEP flood to over 12 metres in the 1%AEP event². Flood maps indicate that parts of the terrace are inundated in events greater than the 10%AEP flood (Figure 4-5).

² These depths are estimated from the published model results in the Lower Shoalhaven Flood Study Report (Cardno, 2022) and are not taken directly from the model results maps.

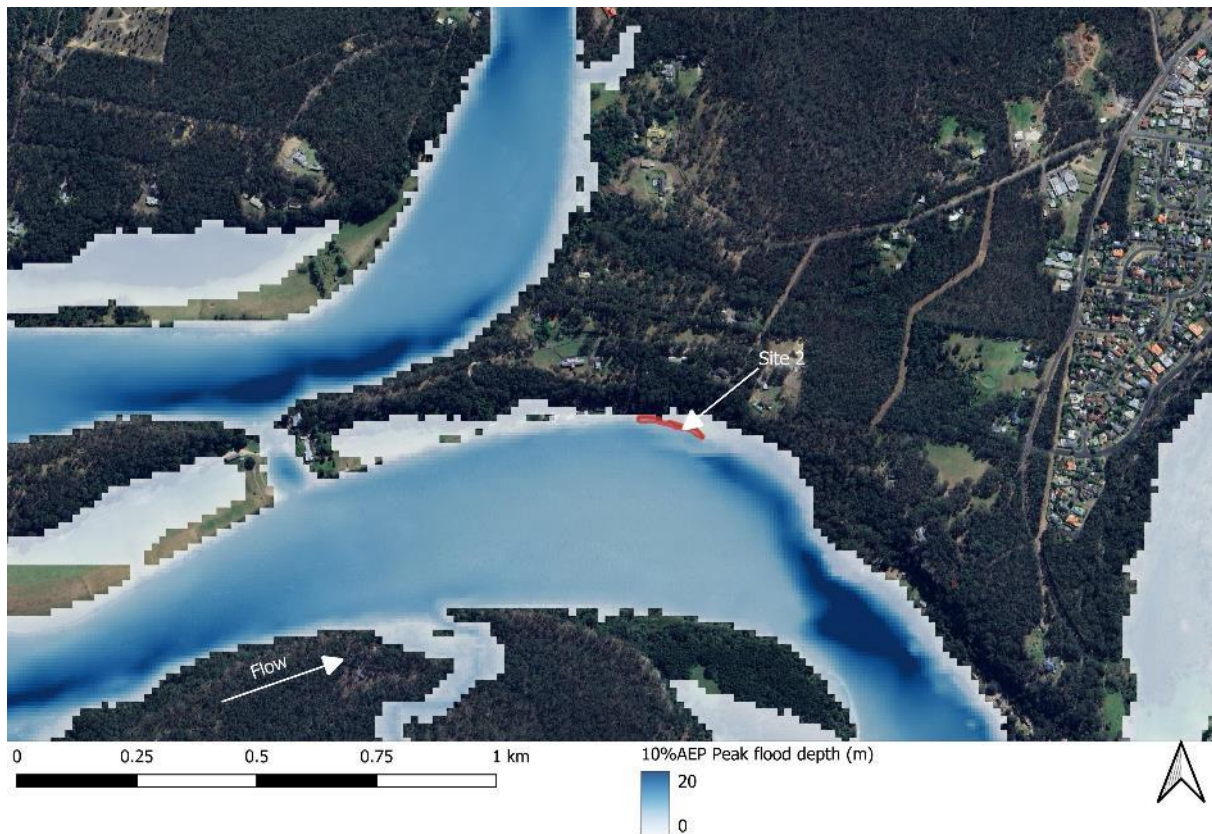


Figure 4-5 10% AEP flood extent and depth (Cardno, 2022)

4.4 Expected Trajectory

Given the steep vertical bank profile, the observed undercutting and tension cracks, and the bank location on the outside of a bend, further bank retreat associated with flood events is likely, without intervention. Bank retreat is likely to be limited to the sections of bank that are currently retreating and not the sections that are currently stabilised with bedrock.

The estimated retreat of up to 5m between 2010 and 2020 gives a good indication of the likely rate of future retreat, that is approximately 0.5m per year, though this is highly dependent on the magnitude and frequency of flood events. The ultimate extent of bank retreat, however, will be limited by the bedrock cliffs. While the presence of bedrock can be visually detected on site, geotechnical survey would be required to confirm and map the extent of the bedrock. The bedrock appears near to the top of bank, approximately 10m, at the upstream extent of the site and further at the downstream extent of the site (>50m).

Continued erosion at this site will lead to loss of private land. Due to the presence of bedrock, the loss of land will be limited to the low terrace and will not threaten the stability of the dwelling at the property. Eroded material will be transported downstream during flood events. Predicting the fate of that sediment is beyond the scope of this investigation but there is potential for it to be deposited in sensitive downstream environments where it may be problematic.

4.5 Technical Analysis Summary and Recommendations

A summary of the riverbank erosion technical analysis for Site 2: Coorong Road is provided below:

Specific Issues



- Riverbank erosion

Associated Risks

- Loss of private land.
- Sediment transport into sensitive downstream environments.

Constraints

- Site geometry: The bank is up to 6m high and very steep in parts. Forming a stable grade of 2(H):1(V) up to 12m in the horizontal plane. Due to the height of the bank, any engineered works will be large in scale, involve considerable disturbance (earthworks and vegetation clearing) and have a high cost.
- The presence of bedrock and, or other large rocks will constrain the extent to which excavation is possible.
- Budget:
 - \$23,000 design
 - \$220,000 construction
 - Rock ~\$25,000

Opportunities

- Landholder has a significant stockpile of sandstone rocks.
- Maintain private land.
- Prevent downstream sediment transport.
- Increase riparian vegetation.

Review of DST option

- Large woody debris (LWD) as a primary recommendation.
 - LWD is not likely to address the observed mechanism of erosion as it will not work to stabilise the undercut banks or the tension cracks at the top of bank.
 - LWD is typically installed at the bank toe. Anchoring the wood in this location would require heavy machinery at the bank toe. Access to the bank toe may require a barge, which is not likely to be possible given the nominated budget.
- Rock fillets or rock groynes
 - While rock fillets may be appropriate for protecting lower banks from the erosive force of flows, they are likely to be less effective in this location where flood depths are typically between 3 and 5 metres or more.
- Riparian vegetation management
 - Riparian vegetation management alone, is not likely to address the observed mechanism of erosion as it will not work to stabilise the undercut banks or the tension cracks at the top of bank in the short term.
 - In the longer term however, establishing a suitable mix of native large woody vegetation and understorey plants on top of the bank will increase the resilience of the bank to erosion and work to slow, or stop the bank retreat.
 - Riparian vegetation management is recommended to supplement any engineered design solution.

Summary and Recommendation



Due to the location and constraints of the site, any effective engineered intervention will be large scale and high cost. Engineered intervention is likely necessary to avoid the further loss of private land, however the amount of land lost is difficult to predict and will ultimately be limited by the extent of bedrock. Engineered intervention should:

- Be targeted at addressing the identified mechanisms of erosion and remediating the existing instabilities. The toe of the bank should be armoured to protect against further undercutting and retreat and the upper bank should be battered back to form a stable grade.
- Be targeted to prioritise sections that:
 - Are actively eroding. I.e sections that are not currently stabilised by existing rock and vegetation.
 - Have greater potential for retreat based on proximity to bedrock.
- Make use of the stockpile of rocks on site. Section 2.2.2 above discusses important considerations for rock used for rock beaching.
- Be supplemented by riparian vegetation management including planting of an appropriate mix of suitable native species.

If an engineered intervention is not deemed feasible, establishing a suitable mix of native large woody vegetation and understorey plants on top of the bank offers a longer-term solution to slow, or stop the bank retreat. This option is associated with a low degree of certainty as the vegetation will take time (>5yrs) to establish and offer effective erosion control.

4.6 Preliminary Options Development

The following options have been developed based on discussions held on site between WT, council and the landholder, WT's experience at similar sites and the analysis above.

4.6.1 Do Nothing

The "do nothing" scenario is that which all other options are compared to. Whereas the 'do nothing' scenario does not decrease the risks associated with further erosion it comes at a far lower cost and has no impacts associated with intervention. The do-nothing scenario is likely to result in continued bank erosion and loss of private land. Due to the presence of bedrock, the loss of land will be limited to the low terrace and will not threaten the stability of the dwelling at the property.

4.6.2 Vegetation Management

This option aims to increase bank stability and reduce erosion through a targeted revegetation program. Revegetation of the site should occur according to the recommendations outlined in Section 2.1.1 above. Establishing a suitable mix of native large woody vegetation and understorey plants on top of the bank offers a longer-term solution to slow or stop the bank retreat. This option is associated with a low degree of certainty as the vegetation will take time (>5yrs) to establish and offer effective erosion control. Furthermore, it is likely that parts of the currently degraded banks are too steep to establish vegetation on. Vegetating the top of bank will have a limited effect on the stability on the bank face below it.

4.6.3 Rock beaching, bank battering and vegetation management

This option involves the construction of rock beaching at nominated points along the reach. Rock beaching is to be keyed into the toe of the bank and may extend between half bank height and three quarters bank height. The bank beyond the rock would be battered and revegetated.



4.7 Concept Design and Indicative Costing

It was generally agreed at the Design Workshop (April 10, 2025), that the preferred option for amelioration of Site 2 is a combination of rock beaching and bank battering with revegetation. It was agreed that Water Technology would undertake a preliminary design analysis for the works, based on the hydraulic modelling results (Lower Shoalhaven Flood Study Report, Cardno, 2022), which have been provided by council. The intent of the preliminary design analysis is to determine a nominal rock size and design thickness, which will, in turn, inform costing. The preliminary design analysis is detailed below.

4.7.1 Preliminary Design Analysis

The Catchment Modelling Toolkit 'RipRap' was used to determine design parameters for the rock beaching. The riprap analysis uses the hydraulic modelling outputs provided to determine a suitable rock armouring design to protect the riverbank from further fluvial erosion. The 'RipRap' program calculates a suitable rock grading to be used depending upon the bank angle of the finished riprap surface utilising both the hydraulic energy gradient and depth of flow. The energy gradient is defined by the change in elevation head (water surface level) and velocity head as water flows past the site. Note that the energy gradient, in this instance, has been calculated from the model outputs provided, which only indicate the maximum flood water surface level and velocity. Given the maximum energy gradient will not necessarily occur when the water level is at its peak, the calculated energy gradient may be an underestimate of the peak flood energy gradient. To account for this the nominated design rock D_{50} will be larger than that output from the Riprap analysis.

Table 4-1 shows the general RipRap input parameters and Table 4-2 shows the specific flow related inputs and resultant rock size for each event. Several events were analysed as the largest event won't necessarily output the largest rock size.

Table 4-1 Assumed parameters used in the rock beaching analysis.

Parameter	Units	Value
Specific Gravity of Rock	kg/m ³	2650
Angle of Repose of Rock	°	41
Factor of Safety	-	1.4
Bank Angle	°	30 (1.75(H):1(V))

Table 4-2 RipRap analysis results for Site 1

Design Event (AEP)	Depth (m)	Energy Slope (m/m)	Output Rock D_{50} (mm)
1%	11.15	0.00093	260
5%	7.25	0.00068	145
10%	7.13	0.00053	95

The results of the RipRap analysis show that, for the flood events analysed, the greatest hydraulic forces are experienced during the 1%AEP event.

To provide some context for the results, standard D_{50} rock riprap sizes typically range from 350mm through to approximately 500mm for ease of transportation and placement, and to form a suitable interlocking mass. The largest rock size output by the Riprap analysis is 260mm. Given the modelling limitations discussed above, a more conservative rock D_{50} of 350mm is nominated. This also fits within the typical rock riprap size in riparian environments.



4.7.2 Concept Design

This section provides information pertaining to the design details for rock beaching at Site 2. The design has been developed based on the existing bank profile, observed geomorphic processes and the preliminary design analysis. The design is concept level only and is limited by the absence of contemporary topographic survey. Key design characteristics of the rock beaching include:

- The rock beaching is to be fully keyed into the bed and banks and not left proud of the existing surface.
- Rock beaching is to extend to the approximately 2/3 bank height.
- The bank beyond rock beaching is to be battered to form a stable slope and revegetated with an appropriate mix of native vegetation.
- The rock beaching is to have a finished slope of no greater than 1.75(H) to 1(V).
- Rock beaching is to incorporate a 1m rock ledge at the base of the bank.
- Rock is to have a D_{50} of 350mm.
- All rock beaching is to have a minimum thickness of 2 by D_{50} .
- The rock beaching will transition to match the existing bank profile at both the upstream and downstream extent of the site.
- Existing native trees are to be maintained where possible according to advice from a suitably qualified arborist. Rock beaching and bank battering may be locally altered to account for trees and tree roots.
- Dead trees and woody debris are to be removed and stockpiled.

Figure 4-6 and Figure 4-7 illustrate this concept. Note that the design footprint presented in Figure 4-6 may be refined to exclude some area based on topographic or geotechnical survey and to suit budget constraints. The design footprint indicated, and the associated material and cost estimates, are therefore conservative, representing maximum likely values.

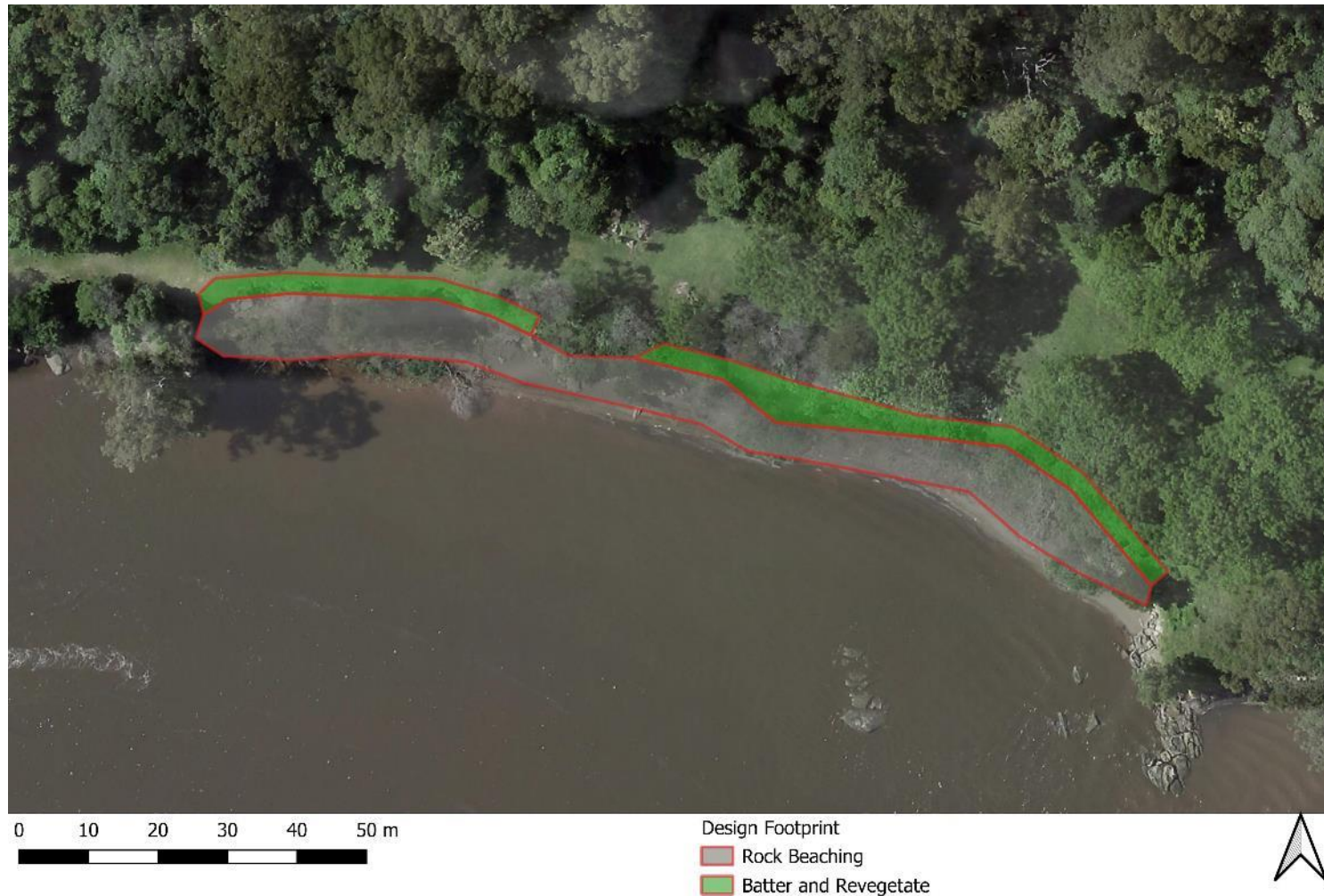


Figure 4-6 Plan view of rock beaching concept

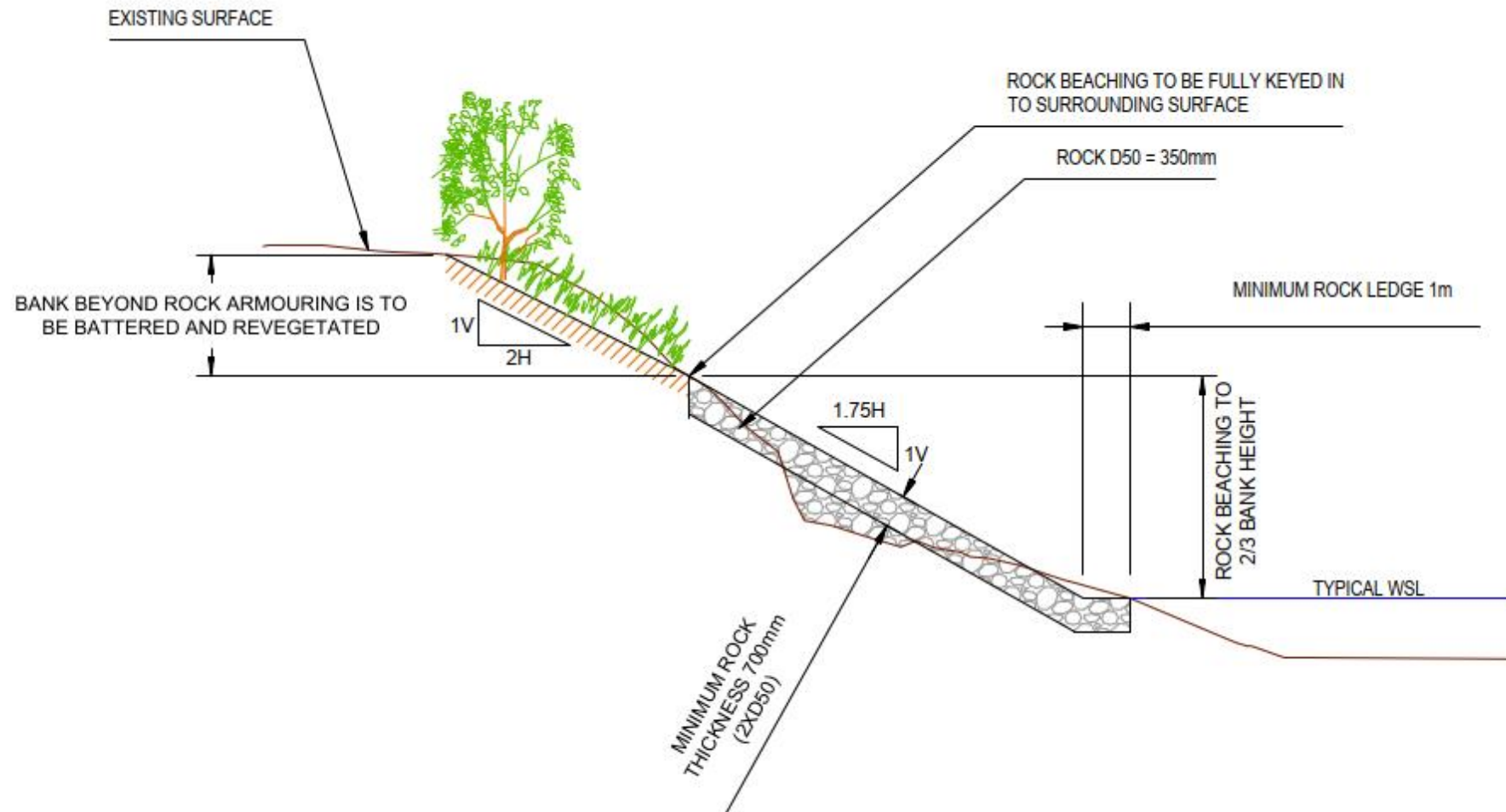


Figure 4-7 Section view of rock beaching concept



4.7.3 Material Estimate and Costing

Quantity estimates for the works, are given in Table 4-4. Quantities given are based on assumed parameters that are likely to change considerably with incorporation of detailed survey. Assumed parameters are stated in Table 4-3. A high-level cost estimate, based on the quantity estimates is given in Table 4-5.

Table 4-3 Rock beaching parameters assumed in the following estimates

Parameter	Units	Quantity
Length of bank treated	m	150
Height of rock beaching	m	3.5
Slope of rock beaching	m(h):m(v)	1.75:1
Rock D50	m	0.35
Thickness of Rock Beaching	m	0.70

Table 4-4 Quantity estimates

	Item	Unit	Quantity
Rock Beaching	350mm D ₅₀ Rock	m ³	890
	Rock available onsite	m ³	200
Earthworks	Excavation	m ³	720
Revegetation	Planting and Maintenance	m ²	900

Table 4-5 Cost Estimate for Site 2

	Unit	Quantity	Rate	Cost
Excavate bank and spoil locally	m3	720	\$20.00	\$ 14,400.00
Supply and Placement of d50 rock	m3	890	\$180.00	\$ 160,200.00
Subtract rock onsite	m3	-200	\$125.00	-\$ 25,000.00
Planting inc. Maintenance	m2	900	\$30.00	\$ 27,000.00
Erosion Sediment Control		1	\$5,000.00	\$ 5,000.00
Site Access		1	\$5,000.00	\$ 5,000.00
Subtotal				\$186,600.00
Indirect costs: Contractor's project management, site facilities, insurances, bank guarantees, offsite overheads, margin etc		1	20%	\$37,320.00
Contingency		1	10%	\$22,392.00
Total				\$246,312.00



5 SITE 3A – SUSSEX INLET

5.1 Site Overview

Site 3A is located on an outside bend of the Sussex Inlet with bank height ranging between 0.3m to 1.0m. The reach is bounded by a confluence on the upstream end and Nielson Lane boat ramp. The reach assessed extends for approximately 400m. A significant number of private jetties (fishing and mooring structures) are located along this reach with a higher concentration of these structures on the eastern half of the reach. Immediately behind the foreshore, there is a strip of grassed reserve of approximately 30m wide.

This reach is mapped as Site S004 in the *St Georges Basin, Sussex Inlet, Swan Lake and Berrara Creek Coastal Management Program - Foreshore Erosion Assessment* (Advisian, 2023) and demarcated as an area of moderate bank erosion. In addition, findings from the community workshops include the desire to have effective erosion protection while maintaining sufficient access to the waterway for the community. The report suggested the following management actions based on the DST:

- Primary Management Action: Maintenance of the existing bank protection.
- Alternative Management Actions:
 - Geotextile sand containers.
 - Rock revetment.
 - Timber wall.
 - Establishment of a cobble beach to protect the bank (Recommended by DST but not recommended by the report).



Figure 5-1 Site 3A – Sussex Inlet

5.2 Current Condition

Foreshore erosion is active on this outside bend of the inlet as the channel migrates laterally in an unconfined setting. The erosion extent varies across the reach, with sporadic sections of the foreshore banks currently held together by tree roots (Figure 5-2). Overall, foreshore vegetation is discontinuous and very narrow. The mowing of the grass on the reserve extends to the edge of the foreshore banks. Seagrass appears to be doing well in the area. There are also isolated pockets of mangroves and individual seedlings identified in isolated spots along the reach.

There is an array of inconsistent and informal foreshore protection treatments installed along the reach. These include the use of timber, rocks, concrete blocks, bricks, gravel and geotextile and they all appear to be ineffective in mitigating erosion (Figure 5-3 to Figure 5-7). Many of these have failed or are failing. Scouring is evident behind some of these structures with further informal remediation treatment added to them, such as adding bricks behind the log revetment.

A small beach is present at the western end of the site (Figure 5-8). The presence of beach in this location is likely facilitated by the localised hydrodynamics of flows entering Sussex Inlet from the waterway to the west. It is not typical to have a gentle sloping sandy beach on the outside bend of a waterway.



Figure 5-2 Exposed tree roots at the edge of the foreshore bank



Figure 5-3 Undermined concrete slab and failed geotextiles on an eroding bank



Figure 5-4 Rock beaching undermined and collapsed into the water



Figure 5-5 Foreshore erosion and failed log revetment



Figure 5-6 Bricks added to fill the scour hole behind the log revetment



Figure 5-7 Scouring behind wood revetment



Figure 5-8 Small beach on the western end of the reach



5.3 Expected Trajectory

Without intervention, lateral migration of the waterway will continue to provide erosion pressure on the bank. The ad hoc and inconsistent erosion control measures were not designed properly and will continue to be ineffective in mitigating foreshore erosion. Similarly, the shallow rooted grass will do little to slow erosion. In the short term, erosion will affect access to jetties and some public land may be lost. In the longer term, the migration of the waterway may potentially impact the concrete path and private properties.

5.4 Technical Analysis Summary and Recommendations

A summary of the foreshore erosion technical analysis for Site 2: Sussex Inlet is provided below:

Specific Issues:

- Foreshore erosion due to lateral migration of the waterway.
- Degradation of existing erosion protection structures.
- Poor riparian vegetation cover.
- Large numbers of jetties and informal access by patrons.

Associated Risks:

- Loss of public/crown/private land.
- Loss of access to public jetties.
- Safety of locals and patrons accessing the foreshore.

Constraints:

- The presence of good aquatic habitat (seagrass) constraints the extension of erosion protection towards the water.
- The number of jetties on the foreshore will complicate any extensive remediation design.
- Retention of existing jetties.
- Budget - \$150k split with Site 3B - St Georges Basin

Opportunities

- Available space to revegetate the riparian zone
- To increase riparian and lake frontage vegetation.
- To incorporate native vegetation to the options.
- To assist revegetation such as mangroves.
- To formalise access points through funnelling access between pockets of riparian revegetation.
- To remove illegal mooring points and set up designated boat mooring sites.

Other Considerations

- Local community is likely to want to have a say in the remediation options. Community consultation/engagement will be a key issue.
- Budget for remediation is shared between this site and Site 3b.

Review of DST option



The primary recommended DST option is to maintain the existing protection structures. This is unlikely to be useful based on the existing condition of the structures. Alternative management options recommended by the DST include the use of geotextile sand containers, rock revetment, timber wall. These are potentially viable options but will require careful design to work around the existing jetties.

Recommendations

Ideally, an engineered solution would be continuous along the entire reach. This is not possible with the existing jetties. However, there may be some opportunity to target sections of foreshore erosion mitigation at the western end where there are fewer jetties. This may take the form of rock beaching or rock revetment.

It is also recommended to focus the solution on revegetation behind the foreshore banks. A no-mow zone of at least 2-3m can be created to allow establishment of taller grasses/reeds with deeper roots. This can be achieved by fencing and putting up education signs. In addition, assisted revegetation of mangrove seedlings can be undertaken to establish pockets of mangrove on the foreshore.

Preliminary recommendations for Site 3a are presented in Table 5-1 below.

Table 5-1 Preliminary Options for Site 3a

Option	Pros	Cons	Relative Cost
Rock Beaching	High degree of certainty of addressing erosion issues in the long term.	Difficult to implement with existing jetties.	\$ \$ \$
Timber Revetment	- High degree of certainty of addressing erosion issues medium term. - Sympathetic with the visual amenity of the site.	- Difficult to implement with existing jetties. - Potential for timber to degrade over time.	\$ \$ \$
Geotextile Sand Containers	High degree of certainty of addressing erosion issues in the short term.	- Prone to failure in the long term. - Not sympathetic with the visual amenity of the site.	\$ \$ \$
Vegetation Management	- Can include mangroves, low riparian vegetation and trees. - Moderate degree of certainty of addressing erosion issues in the long term. - Look to incorporate terrestrial veg other than casuarinas - Mangroves	Potentially difficult to gain landholder acceptance, especially around views to the water.	\$ \$
No mow zones.	- Easy to implement. - Moderate degree of certainty of addressing erosion issues in the long term.	Potentially difficult to gain landholder acceptance, especially around views to the water.	\$
Saltmarsh benches	Protection against erosion and positive environmental outcomes.	Potentially difficult to gain landholder acceptance, due to loss of grassed area.	

5.5 Concept Design and Indicative Costing

The concept design for the Sussex Inlet foreshore consists of several treatment options to improve the stability of the foreshore alignment. These options have been selected through discussion between Water Technology, Council and DPIE, both on site and during the Design Workshop. Each option may be applied at varying locations along the alignment and a combination of options may be applied at any one point. The concept design drawings, included in Appendix B, indicate an ideal arrangement, from a foreshore stability perspective, noting that the arrangement may be subject to change according to budget or stakeholder pressure.

5.5.1 Rock Beaching

It is recommended that, where possible, the foreshore bank is treated with rock beaching. Rock beaching should consist of graded quarry rock with a d_{50} of approximately 350mm to form an interlocking rock riprap. The intent of the rock is to provide protection to the foreshore bank in such a way that is flexible enough to accommodate minor changes in the foreshore geometry that are expected to occur over time. A key physical constraint at the Sussex Inlet site is the presence of many private pontoons and jetties. The most effective rock beaching arrangement would consist of rock beaching applied consistently along a continuous reach of the foreshore. It is recognised that the presence of jetties and pontoons will not allow for this to be the case. As such, rock beaching should tie in as close as practicable to the jetty infrastructure. It may also be beneficial to attempt to install rock on the bank underneath the jetties. A profile view of the recommended arrangement is shown in Figure 5-9.

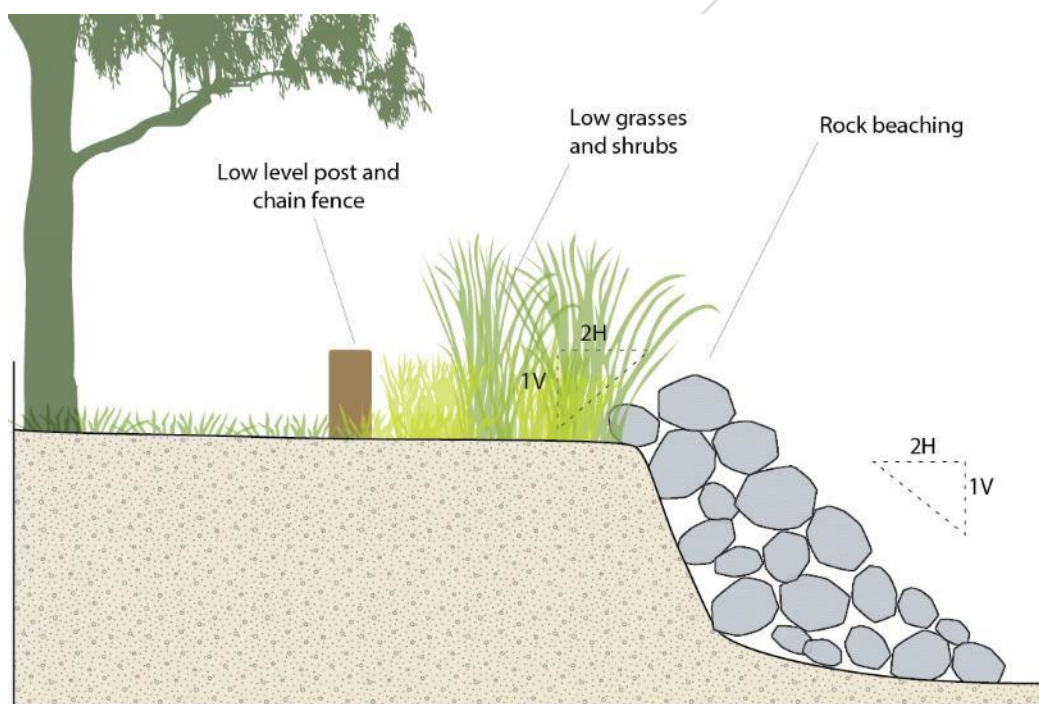


Figure 5-9 Rock beaching

5.5.2 Saltmarsh bench

This involves the formation of saltmarsh benches in targeted locations along the length of the foreshore. A bench is formed by locally excavating the foreshore surface that will be periodically inundated with tides to allow establishment of saltmarsh. The saltmarsh bench is to be protected at the lakeward side by a low rock fillet and the landward bank is to be armoured with rock beaching. The intent of the saltmarsh bench is to provide a stable buffer between the lake and the caravan park that will accommodate minor changes in the

foreshore geometry that are expected to occur over time. Furthermore, there are many expected co-benefits of the saltmarsh benches including creation of marine habitat, filtering of stormwater runoff and providing the opportunity for education through interpretive signage. Figure 3-11 above shows examples of recently constructed saltmarsh benches in similar environments. Figure 5-10 below shows a typical design profile of a saltmarsh bench for Sussex Inlet.

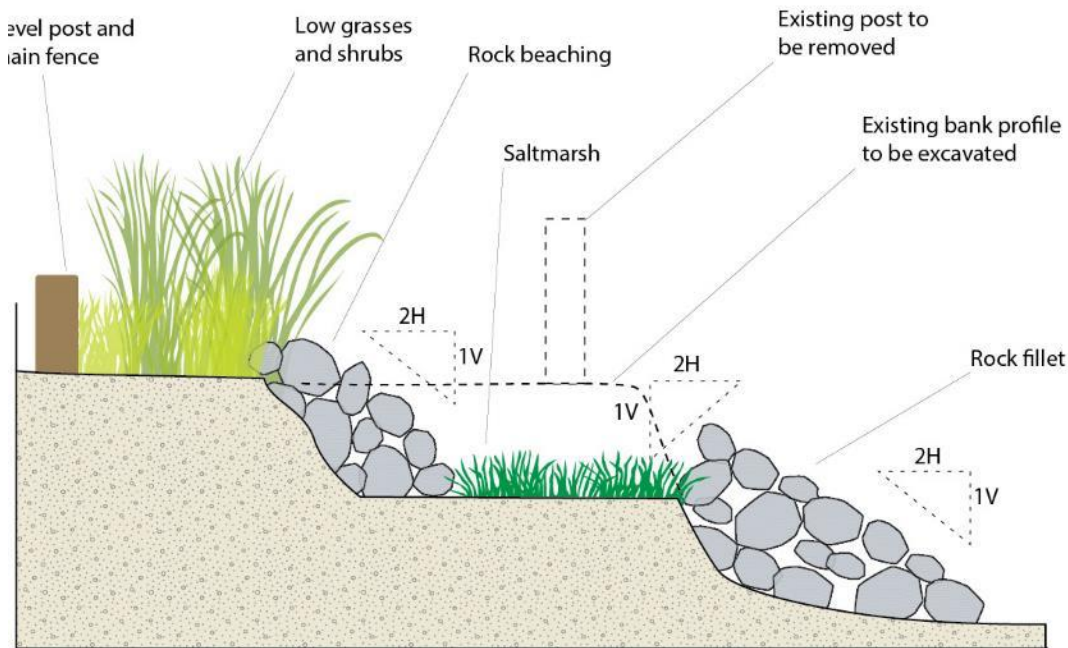


Figure 5-10 Typical design profile for saltmarsh bench

5.5.3 Fencing

It is recommended fencing is incorporated into the design solution for the site. The primary intent of the fencing is to delineate a no mow zone along the foreshore to ensure a vegetated buffer is maintained. The fence does not need to be high, no more than 300mm, and may be formed by posts and chain or simply regularly spaced bollards. Possible material for the posts may be hardwood, concrete or recycled plastic.

5.5.4 Vegetation Management

Management of vegetation along the foreshore is recommended to help control pedestrian traffic and to provide second line of foreshore protection beyond the rock beaching. Vegetation management is widely considered the most cost-effective form of long-term erosion control. At Sussex Inlet, management of vegetation will have to account for competing objectives of erosion control and push back from residents and park users. It is likely certain stakeholders will perceive foreshore vegetation as obstructing views and access to the water. As such, revegetation efforts should focus on low height grass and shrub species. Given the existing foreshore bank height is approximately one metre, plants that grow to a similar height should provide effective erosion control.

5.5.5 Summary



Table 5-2 Site 3A Sussex Inlet foreshore

Treatment	Description	Intent	Location	Co-benefits	Indicative Cost
Rock Beaching	Rock beaching should have a bank angle of 2:1 with rocks (~350mm) to form interlocking rock riprap.	Protect foreshore from wind/boat waves and flood flows.	- Along the entire foreshore reach. - Rock beaching will necessarily be discontinuous and should tie in as best as possible to the existing jetties	- Improve uneven/ adhoc appearance of existing arrangement. - Improve safety - Provide substrate for oysters	\$180/Lm
Saltmarsh benches	Locally excavate a low surface that will be periodically inundated with tides to allow establishment of salt marsh.	Protect foreshore from wind/boat waves and flood flows.	At selected locations along the foreshore reach.	Fish habitat	\$360/Lm
Bollard fence	A low fence formed by short (~300mm) hardwood, concrete or recycled plastic posts.	- Delineate no-mow zone. - Control pedestrian traffic.	To be implemented along most of the foreshore reach with regular gaps to facilitate lake access.		\$50/Lm
Revegetation - low grasses and sedges	Plant and maintain a narrow (~2m) strip of native grasses and sedges along the top of the foreshore bank.	- Control pedestrian traffic. - Provide second line of foreshore protection from wind/boat waves and flood flows.	To be implemented along most of the foreshore reach with regular gaps to facilitate lake access.	- Visual amenity - Habitat - Education	\$60/Lm
Revegetation - trees	Plant and maintain native trees along the top of the foreshore bank.	- Control pedestrian traffic. - Provide second line of foreshore protection from wind/boat waves and flood flows.	Selected section of the foreshore reach	- Visual amenity - Habitat - Education	\$60/Lm



5.5.6 Cost Estimate

A cost estimate for the works at Sussex Inlet is given in Table 5-3. The estimate is based on indicative costs given in Table 5-2 and the corresponding measurements from Appendix B. Indicative costs are a high-level estimate only.

Table 5-3 Cost Estimate for Sussex Inlet

Item	Estimated price	Unit	Measurement	Cost
Rock Beaching	\$180.00	Lineal Metre	450	\$81,000.00
Saltmarsh bench	\$360.00	Lineal Metre	45	\$16,200.00
Bollard fence	\$50.00	Lineal Metre	450	\$22,500.00
Revegetation - low grasses and sedges	\$60.00	Lineal Metre	450	\$27,000.00
Total				\$146,700.00



6 SITE 3B – ST GEORGES BASIN

6.1 Site Overview

The south-facing foreshore are exposed to southerly fetch, known to generate wind waved across the basin. Three reaches, namely Reach 1 (Irene Street off Greville Ave), Reach 2 (Palm Beach) and Reach 3 (Walmer Avenue) were assessed (Figure 6-1).

The Coastal Management Program – Foreshore Erosion Assessment (Advisian, 2023) mapped this site as “Area of moderate bank erosion”, with generally low impacts and an anticipated trajectory of continuing erosion (Figure 6-1). The report suggested the following management actions based on the DST:

- Establishment of a cobble beach for eroded areas where public access is required.
- In area where no public access is required, the use of fallen trees may be appropriate in place of the cobble beach.
- Riparian vegetation management also recommended to be used in conjunction with cobble beaches in areas of severe erosion that require public access.



Figure 6-1 Reaches Assessed in Site 3B



Table 6-1 Summary of Condition, impacts and trajectory from Advisian 2023

ID (This Report)	Bank segment ID (Advisian, 2023)	Erosion Severity	Environmental Impacts	Infrastructure / commercial impact	Amenity / safety impact	Future Trajectory
Site 5, Reach 1 and 2	MP01 (McLeans Point east)	Medium	Medium	Low	Low	Occurring and continuing
Site 5, Reach 3	LAW01 (Loaralyn Ave East)	Medium	Low	Low	Low	Occurring and continuing

6.2 Current Condition

Reach 1 extends for approximately 400m. Site was accessed from Irene Street. The foreshore gradient is fairly gentle and water level in front of the shoreline is shallow (< 0.5m). The seagrass habitat appears to be thriving near the foreshore area. Acute and significant foreshore erosion is limited in this reach. Bedrock outcrop is observed at multiple locations along the foreshore (Figure 6-2). The bedrock setting in this reach acts as a physical limit to further erosion of the foreshore.

There are a number of she-oak trees that have fallen over (Figure 6-3). They appear to have very shallow root plate, likely due to the shallow soil layer available above the bedrock. Foreshore erosion processes undercutting the banks is likely to have contributed to their collapse (Figure 6-4), but the shallow root plate does not provide a strong foundation for the she-oaks.

Reach 2 consists of Palm Beach and the foreshore to its west. Approximately 300m of the foreshore was assessed. Some informal beach nourishment appears to have been undertaken on the western section of Palm Beach (Figure 6-5). The foreshore to the west of the beach is similar to Reach 1 in its physical attribute. The seagrass habitat is also thriving. Similarly, the presence of bedrock outcrops will act as a control to foreshore erosion (Figure 6-6).

Compared to Reach 1 and 2, Reach 3 has a slightly steeper gradient of approach towards the foreshore. There is some minor erosion of the foreshore but it does not appear to be a major concern. Bedrock is also present at multiple locations along the foreshore of Reach 3.

There is a headcut developing at the foreshore along a drainage line. A stormwater drainage outlet is located upslope. The drainage line appears to have incised previously and informally infilled with rocks of various sizes by landholder.



Figure 6-2 Site 3b, Reach 1 - Bedrock outcrop along the foreshore



Figure 6-3 Site 3b, Reach 1 - Example of a fallen she-oak with very shallow root system



Figure 6-4 Site 3b, Reach 1- Undercutting of the foreshore exposing tree roots



Figure 6-5 Site 3b, Reach 2 -Beach nourishment on Palm Beach



Figure 6-6 Site 3b, Reach 2 - Bedrock outcrop



Figure 6-7 Site 3b, Reach 3 – Minor erosion on the foreshore



Figure 6-8 Site 3b, Reach 3 – Bedrock outcrop



Figure 6-9 Site 3b, Reach 3 - Fallen she-oak with shallow root plate



Figure 6-10 Headcut developing on a drainage line on the foreshore



Figure 6-11 Drainage line infilled with rocks (looking downstream)



6.3 Expected Trajectory

Without intervention, foreshore erosion as a result of wave action is likely to continue to provide erosion pressure on the foreshore. However, the presence of bedrock control is likely to be a key erosion control limiting the extent of erosion. Repeat survey of the erosion scarp would allow for estimation of the rate of retreat.

6.4 Technical Analysis Summary and Recommendations

A summary of the foreshore erosion technical analysis for Site 2: Sussex Inlet is provided below:

Specific Issues:

- Foreshore erosion due to wind generated wave actions.
- Fallen she-oaks in the foreshore.

Associated Risks:

- Loss of public/crown/private land.
- Damage to boardwalk along the foreshore
- Safety of locals and patrons accessing the foreshore.

Constraints:

- The presence of good aquatic habitat (seagrass) constraints the extension of erosion protection towards the water.
- Site access for remediation works for Reach 1.
- Provision of public access to the foreshore.
- Budget: \$150,000 split with site 3a (Sussex Inlet).

Opportunities

- There is space to revegetate the riparian zone
- To increase riparian and lake frontage vegetation.
- To incorporate native vegetation to the options.
- To assist revegetation.
- To formalise access points through funnelling access between pockets of riparian revegetation.

Other Considerations

- Budget for remediation is shared between this site and Site 3a.

Review of DST option

The primary recommended DST option is to establish a cobble beach for eroded area where public access is required. It is noted on site that cobble beach is not a typical natural setting on the foreshore. The seagrass habitat can potentially be at threat during the construction phase of the cobble beach.

The use of fallen trees to manage eroded foreshore in area where public access is not required is a possible treatment option, but the size of the fallen she-oaks at the site are fairly small and is unlikely to provide good erosion protection over time.

Preliminary recommendations for Site 3b are presented in Table 6-2 below.



Table 6-2 Preliminary Options for Site 3b

Option	Pros	Cons	Relative Cost
Cobble Beach	Provide amenity for park users.	- Potential for damage to seagrass habitat during construction. - Not a typical natural setting on the foreshore.	\$ \$ \$
Beach Nourishment	Provide amenity for park users.	Likely to require repeat nourishment in the long term.	\$ \$ \$
Use of fallen trees	Use locally sourced material	Unlikely to provide good erosion protection over time.	\$ \$
Vegetation Management	- Can include mangroves, low riparian vegetation and trees. - Moderate degree of certainty of addressing erosion issues in the long term.	Low degree of certainty of addressing erosion issues in the immediate term.	\$ \$
No mow zones.	- Easy to implement. - Moderate degree of certainty of addressing erosion issues in the long term.	Potentially difficult to gain landholder acceptance, especially around views to the water.	\$
Monitor /Survey	Repeat topographic survey would allow for bank retreat to be monitored and predicted.	Does not directly address erosion.	\$

6.5 Concept Design and Indicative Costing

It was decided at the Design Workshop that the condition and trajectory of the issues investigated at Site 3b are of less concern than what has been investigated at Site 3a. As such, the concept design effort for Site 3 is concentrated on Site 3a -Sussex Inlet.

7 SITE 4 – MAVROMATES RESERVE

7.1 Site Overview

Mavromates reserve is a linear reserve that runs approximately 900m along the Shoalhaven River between the riverbank and a constructed levee approximately 5m high, downstream of Princes Hwy bridge. The levee bank is covered in mown grass with the occasional large tree. A residential street is situated immediately behind the levee, with houses positioned to take in views of the river. A public water access point is located at the downstream extent of the site alongside a stormwater outlet discharging into the river via a grass swale (Figure 7-1). The outlet has a non-return valve but is partially buried with sediments. It is noted that 250 mangroves were planted along the riverbank in 2021³.

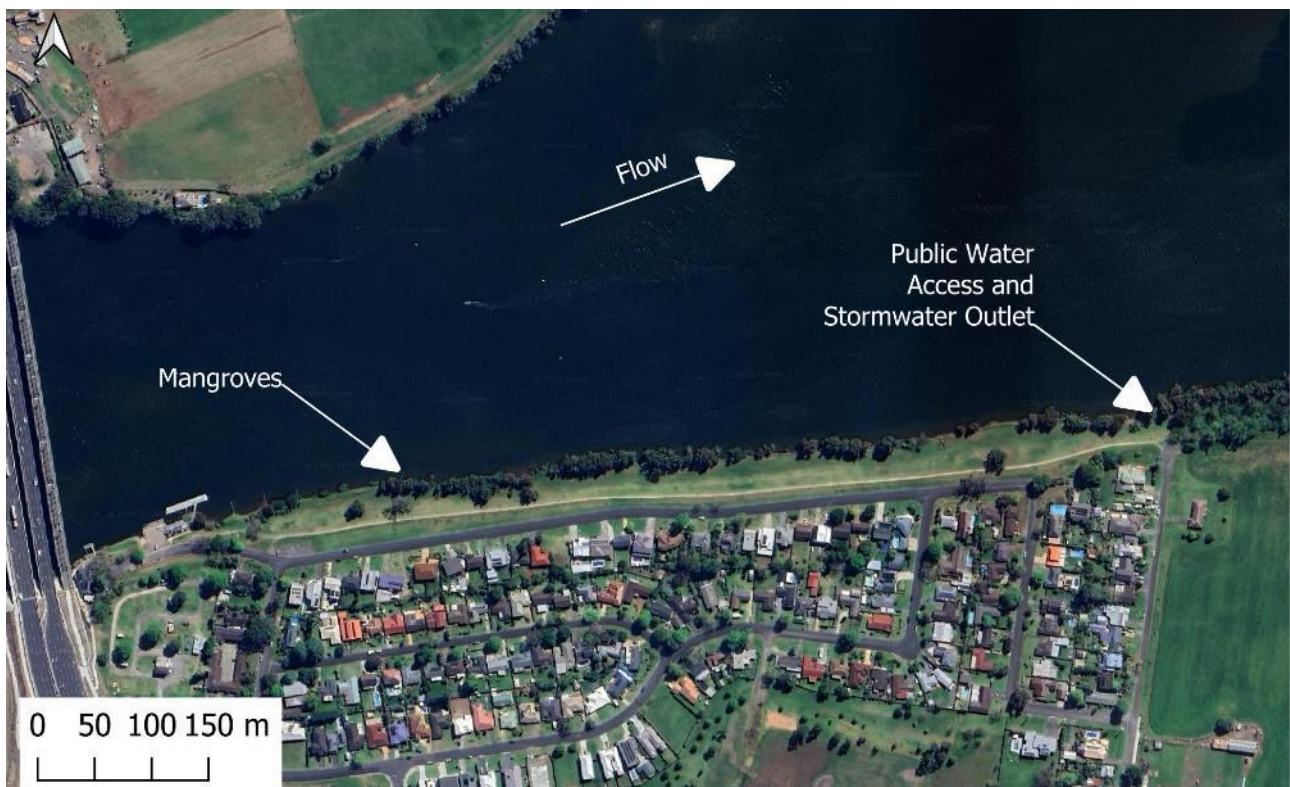


Figure 7-1 Mavromates Reserve

7.2 Current Condition

The condition of the bank varies along the reach. In some sections, there is a narrow strip of riparian vegetation, less than 2m wide, which is present in parts but absent in others. The vegetation primarily consists of casuarinas, with reeds and grasses underneath. Expansion of the riparian vegetation via natural recruitment is currently limited by lawn mowing, in some places the lawn is mown very close to the top of the bank. It is understood that mowing is carried out both by Council and by locals. Mangroves are observed at the upstream extent and in isolated spots along the reach. Signs of recent erosion are evident, including exposed overhanging roots, steep or vertical banks reaching up to 1.5m in height and failed bank material deposited at

³ <https://www.riverwatch.org.au/bank-restoration.html>



the toe of the bank. Further downstream, the banks are generally lower, typically less than 1 m. In some areas, the banks are undercut, with bank retreat appearing to be more pronounced where vegetation is absent.

Two stormwater outlets were observed, although council mapping indicates six in total; none of these have outfall protection. The furthest downstream outlet consists of a 375mm pipe discharging into the river via a grass swale. The outlet is currently partially buried. While the swale itself is in good condition, there is evidence of scour at the bank near the outlet (Figure 7-3). A small beach located upstream of the outlet, identified by the council as a public water access site, features an eroding bank approximately 40mm high. Partially buried gabions are present along the bank and on the beach, but they are not effectively controlling erosion (Figure 7-2).





Figure 7-2 Eroding bank at the beach, with partially exposed gabions



Figure 7-3 Stormwater outlet eroding at riverbank



7.3 Expected Trajectory

Vertical and undercut banks are unstable and prone to continued erosion, with the issue expected to be more pronounced in areas where vegetation is absent. Sections where a narrow strip of vegetation is present remain at risk due to the ongoing bank undercutting. The vegetated buffer is extremely narrow, typically consisting of no more than one tree, leaving no secondary line of defence if the trees fall. Continued mowing will continue to limit any recruitment and expansion of the riparian vegetation. Without intervention, continued, minor bank retreat is anticipated, resulting in the loss of public land. In the longer term, bank retreat may threaten the integrity of the levee, however, given the distance to the levee relative to the height of the bank this is not deemed imminent.

The exposed gabions at the public water access point are likely to continue to degrade. This will pose an ongoing risk to public safety due to the sharp, exposed steel wire.

7.4 Technical Analysis Summary and Recommendations

A summary of the riverbank erosion technical analysis for Site 2: Coorong Road is provided below:

Specific Issues:

- Riverbank erosion.
- Very narrow riparian vegetation buffer providing limited protection to the bank.
- Exposed, damaged gabions at public water access point.

Associated Risks:

- Minor loss of public land.
- Loss of public amenity due to degraded riparian zone.
- Safety of locals and patrons accessing the river.
- Long term threat to levee integrity.

Constraints:

- Lawn mowing will continue to limit any recruitment and expansion of the riparian vegetation.
- Local landowners real or perceived concerns about amenity, which may make them unsympathetic to increasing riparian vegetation. Concerns may include:
 - Obstruction of views to the water.
 - Use of mown grass area for recreation, dog walking etc.
- Budget: \$46,000.

Opportunities

- Maintain public land.
- Assist natural regeneration including riparian vegetation and mangroves.
- Decrease maintenance burden.
- Improve access points for launching of small watercrafts.
- Improve public safety.

Other considerations



- Local community is likely to want to have a say in the remediation options. Community consultation/engagement will be a key issue.

Review of DST option

- Establishment of a cobble beach for the eastern section.
 - Cobble beach would work to cover exposed gabions and may make the site more attractive to users of the reserve.
 - An important consideration is the natural cobble supply. It is not certain if cobbles are currently being transported downstream along the riverbank. The absence of an upstream supply of cobbles would mean that, if a cobble beach were artificially installed, there would be no cobbles to replenish any that are transported downstream. A cobble beach, in this location, would need to be monitored following flood events and topped up with cobbles when necessary.
- Large woody debris (LWD) for the central section.
 - The installation of in stream LWD along the bank alignment would work to increase hydraulic roughness and may decrease the risk of erosion along the bank.
 - This option is highly dependent on a suitable source of timber.
 - Positioning of LWD would need to account for movement during flood flows and would likely require anchoring.
 - The placement of LWD would necessitate heavy machinery on the bank (unless installed from a barge) and potentially require clearing of some of the existing riparian vegetation. The potential for disturbance may not be justified in this instance.
- Widening of riparian zone in combination with exclusion fencing with formalised access points.
 - This option is likely to be the most feasible at this site.

Summary and Recommendation

While the risks of continued erosion at this site are minor, in the short term, there are some easy to implement options that may work to improve stability and amenity of the site. Widening of riparian zone in combination with exclusion fencing with formalised access points would work to increase bank stability. This could primarily be achieved with no-mow zones, delineated with short post and chain fences. This would allow for the recruitment of casuarinas, and supplementary planting and weed control within the no-mow zones would allow for more diverse riparian vegetation.

Rock beaching at locations where erosion is acute would provide long term stability to those locations. This includes the riverbank at the furthest downstream stormwater outlet shown in Figure 7-3. A cobble beach arrangement at the small beach located upstream of the outlet, could provide erosion protection and increase public amenity at this water access site. Rock beaching could be incorporated into the design as shown in Figure 2-3. Partially buried gabions should be removed to the extent that this is possible.

Preliminary recommendations for Site 4 are presented in Table 7-1 below.

Table 7-1 Preliminary Options for Site 4

Option	Pros	Cons
Cobble Beach	■ Improve public safety and amenity	■ Not a typical natural setting on the riverbank. Would likely require maintenance in the medium term.



Option	Pros	Cons
Rock Beaching	Rock beaching in discrete locations where erosion is acute would provide long term stability to those locations.	Unlikely to provide good erosion protection over time
Vegetation Management	- Can include mangroves, low riparian vegetation and trees. - Moderate degree of certainty of addressing erosion issues in the long term. - Mangroves	- Low degree of certainty of addressing erosion issues in the immediate term. - Potentially difficult to gain landholder acceptance, especially around views to the water.
No mow zones.	- Easy to implement. - Moderate degree of certainty of addressing erosion issues in the long term.	Potentially difficult to gain landholder acceptance, especially around views to the water.
Remove failed gabions	Improve public safety and amenity	May be difficult to completely remove failed gabions.

7.5 Concept Design

The concept design for Mavromates Reserve consists of several treatment options to improve the stability of the riverbank alignment. These options have been selected through discussion between Water Technology, Council and DPIE, both on site and during the Design Workshop. The options may be applied at varying locations along the alignment and a combination of options may be applied at any one point. The concept design drawings, included in Appendix C, indicate an ideal arrangement, from a foreshore stability perspective, noting that the arrangement may be subject to change according to budget or stakeholder pressure.

7.5.1 Rock Beaching

It is recommended that, where possible, the foreshore bank is treated with rock beaching. Rock beaching should consist of graded quarry rock with a d_{50} of approximately 350mm to form an interlocking rock riprap. The intent of the rock is to provide protection to the foreshore bank in such a way that is flexible enough to accommodate minor changes in the foreshore geometry that are expected to occur over time. A profile view of the recommended arrangement is shown in Figure 5-9.

7.5.2 Cobble Beach and Rock Groyne

At Mavromates Reserve, this option would comprise of small cobble-sized stones overlain on the existing foreshore at the the public water access point (Figure 7-1). Establishment of a cobble beach would work to cover exposed gabions and may make the site more attractive to users of the reserve. An important consideration is the natural cobble supply. It is not certain if cobbles are currently being transported downstream along the riverbank. The absence an upstream supply of cobbles would mean that, if a cobble beach were artificially installed, there would be no cobbles to replenish any that are transported downstream. A cobble beach, in this location, would need to be monitored following flood events and topped up with cobbles when necessary. Incorporating a rock groyne immediately upstream of the cobble beach would protect the site from some the energy associated with river flows and may work to inhibit the downstream transport of cobbles.

7.5.3 Fencing

It is recommended fencing is incorporated into the design solution for the site. The primary intent of the fencing is to delineate a no mow zone along the foreshore to ensure a vegetated buffer is maintained. The fence does



not need to be high, no more than 300mm, and may be formed by posts and chain or simply regularly spaced bollards. Possible material for the posts may be hardwood, concrete or recycled plastic.

7.5.4 Vegetation Management

Management of vegetation along the foreshore is recommended to help control pedestrian traffic and to provide second line of foreshore protection beyond the rock beaching. Vegetation management is widely considered the most cost-effective form of long-term erosion control. At Sussex Inlet, management of vegetation will have to account for competing objectives of erosion control and push back from residents and park users. It is likely certain stakeholders will perceive foreshore vegetation as obstructing views and access to the water. As such, revegetation efforts should focus on low height grass and shrub species. Given the existing foreshore bank height is approximately one metre, plants that grow to a similar height should provide effective erosion control.

7.5.5 Summary



Table 7-2 Site 4 – Mavromates Reserve

Treatment	Description	Intent	Location	Co-benefits	Indicative Cost
Rock Beaching	Rock beaching should have a bank angle of 2:1 with rocks (~350mm) to from interlocking rock riprap.	Protect bank from wind/boat waves, stormwater flows and flood flows.	- Where acute bank erosion is observed, i.e.. Stormwater outlet at downstream extent. - Behind Cobble beach.	Improve safety	\$180/Lm
Cobble beach	Small cobble-sized stones overlain on the existing beach.	Improve public safety and amenity.	Existing beach/public access point at the upstream extent of the site.	Protect bank from wind/boat waves	\$100/m²
Rock Groyne	Short rock structure immediately upstream of cobble beach.	Protect beach from some of the energy associated with river flows	Immediately upstream of cobble beach.		\$180/m³
Remove failed gabions	To the extent that it is possible, all damaged wire should be detached from the bank and disposed of. Rocks can remain on site.	Improve public safety and amenity.	Existing beach/public access point at the upstream extent of the site		\$50/m²
Bollard fence	A low fence formed by short (~300mm) hardwood, concrete or recycled plastic posts.	- Delineate no-mow zone. - Control pedestrian traffic.	To be implemented along most of the foreshore reach with regular gaps to facilitate lake access.		\$50/Lm
Weed control	Management of invasive, non-native plants within the delineated no-mow zone.	Facilitate the natural regeneration of native grasses, shrubs and trees.	To be implemented along most of the riverbank reach within the delineated no-mow zone.	- Visual amenity - Habitat improvement	



Treatment	Description	Intent	Location	Co-benefits	Indicative Cost
Revegetation - low grasses and sedges	Plant and maintain a narrow (~2m) strip of native grasses and sedges along the top of the foreshore bank.	- Control pedestrian traffic. - Provide second line of foreshore protection from wind/boat waves and flood flows.	To be implemented along most of the riverbank reach with regular gaps to facilitate river access access.	- Visual amenity - Habitat improvement	\$60/Lm
Mangrove establishment	Plant, or otherwise facilitate the recruitment and maintain mangroves along the riverbank.	Provide second line of foreshore protection from wind/boat waves and flood flows.	To be implemented along selected parts of the riverbank reach particularly where mangroves are currently observed.	- Visual amenity - Habitat improvement	\$60/Lm



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8 SITE 5A– CROOKHAVEN HEADS

8.1 Site Overview, Background and Literature Review

Site 5A is located at the entrance of the Crookhaven River, approximately 500 metres Southwest of the Crookhaven Lighthouse, as illustrated in Figure 8-1. This site is characterized by a perched coastal dune system sitting atop a wide long rock platform that extends offshore (approximately 70 metres long), providing a natural partial barrier against coastal erosion – through both the dissipation of incident offshore swell wave energy, and limiting the erosion scour depth at the foreshore. This rock platform is in the intertidal zone (with a platform elevation of approximately +0.2 to +0.6 m AHD), being exposed during low tides, and submerged during high spring tides.

The site's aspect and underlying geology offer natural protection from erosion during ambient wave and tide conditions, and it is particularly sheltered from the dominant south-easterly Tasman Sea swells. However, the foreshore at the site becomes more exposed during elevated tides combined with high wave energy, particularly when north-easterly swell conditions prevail. This is demonstrated by the fact that the shoreline at Site 5A has experienced episodic erosion events over the last 5 to 10 years.

The Crookhaven Headland is a focal point for traditional cultural activities for the Jerrinja people, with site register records displaying a natural ceremonial King's Chair, natural water holes, ceremonial artefacts, shell middens, a tribal burial, and a traditional swimming hole (Water Technology, 2023). Importantly, the foreshore at Site 5A is known to include shell middens, which are considered to be at risk of permanent damage if erosion is not ameliorated at the foreshore. Preserving this heritage is crucial, not only for safeguarding a unique piece of history but also for mitigating further environmental degradation in the area.

A key constraint in addressing erosion at the site is the lack of practical access for construction plant and machinery. The nearest available access point is the public boat ramp, located approximately 800 metres west of Site 5A. The foreshore between this point and the site is predominantly intertidal, generally ranging from 0 to +1 m AHD. These shallow, periodically submerged conditions significantly limit physical access for equipment and restrict the duration and timing of construction works once on site. Furthermore, while barge access is technically feasible, it is likely to be prohibitively expensive and would still be subject to the same tidal constraints once plant and materials are delivered.

The site, however, is accessible to pedestrians via a staircase located immediately adjacent to it. This presents an opportunity to consider solutions that utilise lightweight materials, which can be manually transported to the foreshore using this access point. As a result, erosion mitigation options that minimise reliance on heavy machinery and focus on modular or hand-carried construction elements are likely to be more feasible under the site's access constraints.



Figure 8-1 Site 5A location in Crookhaven Heads

8.2 Current Condition

Over the last 5 to 10 years, Site 5A has experienced significant coastal erosion, as illustrated in Figure 8-2. The coastline has progressively retreated by up to 5 metres between 2016 and 2025 – which has occurred progressively as a result of a sequence of east coast low events in 2016, 2020, 2021, and 2022 (Water Technology, 2023). During these events, high offshore wave energy coincided with elevated tide levels, which would have resulted in submergence of the rock platform by storm tides and high levels of wave energy reaching the base of the vegetated foreshore.

Currently there are no structural coastal protection measures in place to effectively prevent or mitigate coastal erosion at Site 5A. Furthermore, location and aspect of the site mean that it receives little to no natural beach recovery after storm events. During storm events, foreshore sand are eroded and transported offshore into the Crookhaven Channel, and the low level of ambient wave energy is insufficient to drive the sediment back onshore from the depths of the channel. In this way, the channel essentially becomes a sediment trap, and in the absence of these recovery mechanisms, the ongoing erosion is expected to persist and potentially accelerate in the future.

The rock platform currently provides a certain level of protection to the site, but sea level rise will gradually increase the water depth over the platform, leading to a direct increase in the wave height able to propagate towards the coastline. Over time, this increase in water levels and wave incident wave heights will lead to a accelerated erosion rates (compared to historically observed rates), exposing the middens and other critical coastal features to even greater risks. The lack of current coastal protection measures further underscores the urgent need for comprehensive strategies to address these vulnerabilities and preserve the site's ecological and cultural heritage.

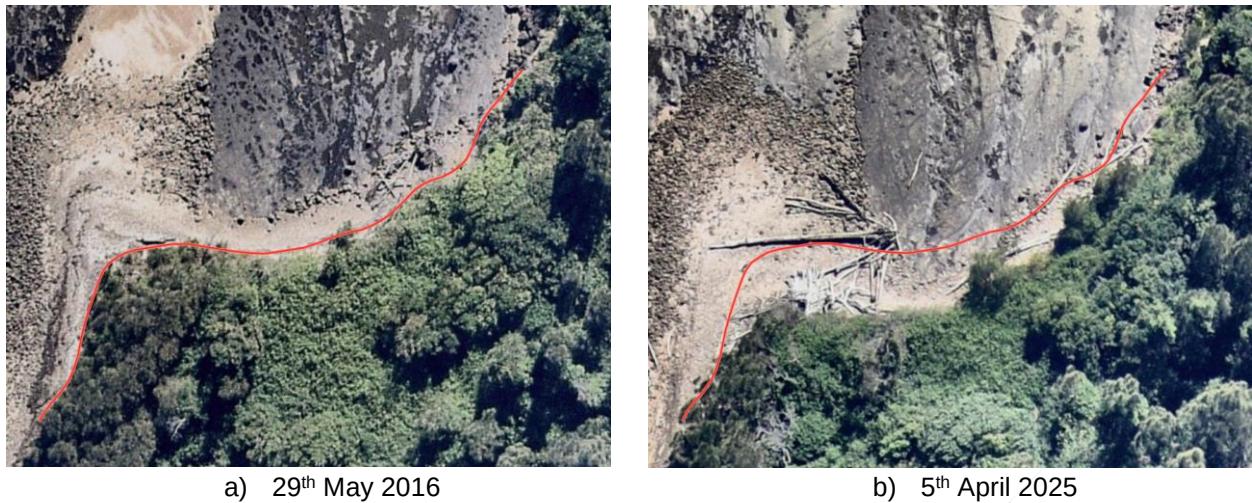


Figure 8-2 Visualization of coastal retreat between May 2016 (a, left) and April 2025 (b, right). The red line in both images represent the coastline position in April 2025.

Figure 8-3 shows a front view of the site, highlighting its current state facing ongoing coastal erosion. The wide rock platform contains a scattering of natural headland reef-rocks of various dimensions, and wooden debris trees are present in the area. At the time of writing there is no confirmation regarding the origin of those fallen trees. It is unlikely that the woody debris or scattered rocks are providing partial coastal protection to the site – as this material is not fixed in places and would be readily mobilised under storm conditions. Nevertheless, the coastal protection provided by those fallen trees are not quantifiable by any standard coastal engineering methodology, nor reliable.



Figure 8-3 Site 5A front view

The middens at this site (see Figure 8-4), are subsequently directly exposed to the incident wave energy during periods of high spring tides and during storm events, causing accelerated erosion that threatens their fragile structure.



Figure 8-4 Middens exposed to coastal erosion in Site 5A

Figure 8-5 provides additional insights into the characteristics of Site 5A. To the northeast (image a), the coastline is increasingly stable with the presence of larger rock units. Moving to the southwest (image b), the coastline becomes increasingly unstable, experiencing larger coastal retreat and with the presence of smaller rocks and loose sand. The rocky platform in the central part of the site (images c and d) is mostly free of any rocks or sand. This lack of material at the central part of the rock platform is at the same time the consequence and the cause of larger waves propagating towards the middens.



a) View form Northeast



b) View from Southwest



c) Rock platform front view



d) Rock platform offshore view

Figure 8-5 Additional overview of Site 5A

8.3 Expected Trajectory

Without adequate intervention, the erosion at Site 5A is expected to continue, leading to further coastal retreat and unrepairable degradation of the middens. This would result in the loss of significant cultural heritage that hold deep meaning for the local Traditional Custodians. The presence of scattered rocks and trees will not provide sufficient coastal protection to the area, as their limited coverage and stability fail to counteract the increasingly energetic sea action. Sea level rise will gradually increase the water depth over the rock platform, leading to a direct increase in the wave height able to propagate towards the coastline. This will exacerbate the vulnerability of the site, creating conditions for more frequent and severe coastal erosion events that would accelerate the degradation of this site.

8.4 Technical Analysis Summary and Recommendations

A summary of the coastal erosion technical analysis for Site 5A: Crookhaven Heads is provided below:

Specific Issues

- Coastal erosion.
- Potential loss of cultural heritage sites (shell middens).

Associated Risks

- Loss of high historical and cultural significance.
- Loss of public/crown/private land.
- Loss of public amenity due to degraded foreshore zone.



Constraints

- Limited access to the site for construction plant and materials.
- Logistical and cost issues related to the difficult to access location.

Opportunities

- Presence of a solid rock platform as foundation for structural coastal protection works.
- Improve the conservation of historical and cultural heritage.

Other considerations

Local Traditional Custodian stakeholders are heavily invested in the future of the Site, and expected to have a say in the intervention alternatives, in particular because of the presence of middens. Thus, stakeholder engagement will be a key issue.

Review of DST option

- Sand renourishment.
 - Sand (of quantity approximately 100m³) would likely have to be sourced from a nearby quarry – and may not therefore match the physical characteristics of the local site (particle size, sediment composition, and colour).
 - The transportation, and placement of sand is likely to be unfeasible at this location due to lack of access for plant and machinery.
 - The sand potentially placed over the rock platform in front of the middens will most likely be quickly mobilised and removed from the site area during storm events.
 - The absence of natural beach recovery processes means that beach nourishment would only offer a short-term solution unless supported by a sustained, long-term replenishment program.
 - The availability of sand, the access of equipment and the cost are additional concerns.
- Sand or rock bags - these options may be more feasible given access restrictions and have been assessed in more detail in Section 8.5 below.

Recommendations

Due to location and constraints of the site, it is recommended to explore a number of additional alternatives:

- Rock revetment.
- Sand bag revetment.
- Rock bag revetment.
- Timber low crested wave barrier.
- Concrete low crested wave barrier.

8.5 Preliminary Options Development

The following options have been developed based on discussions held in different circumstances between WT and council, WT's experience at similar sites and the analysis above.

8.5.1 Do nothing

This option involves leaving the site as it is, allowing the natural processes to continue without intervention. While this approach avoids immediate costs and logistical challenges, it does not provide any form of protection



against the advancing coastal erosion. Consequently, it could lead to considerable degradation and eventual loss of the midden's heritage and ecological value. Based on discussions with the council and the conducted analysis, this alternative is not recommended due to its inability to address the issues threatening the site.

8.5.2 Geotextile Sand Container (GSC) revetment

Geotextile Sand Container (GSC) revetments can represent practical solutions to mitigate the effects of coastal erosion, particularly in situations where immediate intervention is necessary. Under certain conditions, GSC revetments can represent highly constructable and inexpensive materials, making them a good choice for short-to-medium term erosion control. However, there are a number of logistical challenges associated with the use of GSC units at the project site:

- The presence of sharp or uneven rock surfaces increases the risk of abrasion, punctures, and tearing of the geotextile fabric, particularly during high-energy wave events or when bags shift under wave loading. Over time, repeated movement and contact with rough substrates can lead to premature degradation and loss of structural integrity. Additionally, achieving proper placement and stability on irregular rocky ground is more difficult, which can compromise performance and increase maintenance requirements.
- Given the wave energy at the site – where depth limited design wave conditions would be expected to reach upwards of $H_s = 0.7$ m (based on modelling undertaken by Stantec), it is likely that GSC units of 1.2m^3 (1.6 tonne). Such units could not be hand carried down to site – and the logistics of “frame-filling” the units in site would be challenging given the narrow tidal windows.
- Smaller GSC units of 40 kg (which may be hand carried) could potentially offer short term protection from ambient wave conditions – however such units are typically used for inland protection works, and would be expected to be mobilized under long period swell conditions of even moderate storm intensity. This introduces a significant risk of post-storm damage, including dislodged units becoming coastal debris. There is limited information available regarding the design wave conditions for such smaller units as they are not typically used in coastal environments – however it is expected that with such low mass, even lower wave heights (of $\sim 0.3\text{--}0.5$ m) on a frequent basis would be sufficient to introduce deformation and displacement of such light weight units.
- Alternatives such as lightweight hessian sandbags are typically suited only for very short-term protection under low-energy conditions. At this site, where wave heights can exceed 0.5 m during energetic events, hessian bags are likely to degrade rapidly, become displaced, or fail structurally. They are particularly vulnerable to UV exposure, rot, and mechanical damage from repeated wetting and drying, especially on a rocky foreshore.
- In addition, the sand to be used in the bags would need to be transported to site to avoid erosion issues in the adjacent coastline, representing an additional logistical challenge.

8.5.3 Rock bag revetments

Rock bags can offer hydraulic performance comparable to Geotextile Sand Containers (GSCs) under similar wave loading conditions. Given the design wave climate at the site, it is likely that one of the smaller commercially available rock bag sizes – likely Bluemont 2 tonne units or similar - would provide sufficient stability.

These units offer several advantages. The mesh netting used in rock bags is generally more resistant to abrasion, particularly on uneven or rocky substrates, as it is specifically engineered for high-durability applications. In addition, sourcing suitable rock in the relatively small quantities required is likely to be cost-effective and locally achievable.

However, there are notable logistical constraints. On-site filling of the bags is not feasible due to the difficulty of transporting rock to the foreshore and the impracticality of storing a rock stockpile on the platform. As such, the units would need to be filled off-site - most likely in the carpark area located at the top of the slope.

Placement could then potentially be achieved using a long-reach boom, similar to methods employed at Wamberal Beach following the 2020 storm events (see Figure 8-7).

The viability of this approach, however, would depend on several factors. Construction risk assessments would be required, particularly in relation to slope stability and the ability to safely operate long-reach machinery near the top of the slope. Furthermore, the use of such machinery is likely to exceed Council's current financial constraints, which may limit its feasibility without additional funding or staged implementation.



Figure 8-6 Example of rock bags being placed with a long reach boom at Wamberal Beach circa 2020.

8.5.4 Rock revetment

This intervention option could provide a long-term solution to protect both the coastline and the middens from ongoing coastal erosion. Constructing a rock revetment on Site 5A would involve significant logistical challenges due to the requirement for heavy machinery in order to transport and position the rocks along the shoreline. Despite the high financial costs associated with material procurement, labour, and ongoing maintenance, the rock revetment remains a suitable long-term coastal protection option because of its ability to withstand high-energy wave action in the long term.

By fortifying the shore, a rock revetment could act as a stabilizing force, not only preserving the ecological and heritage value of the middens but also serving as a robust defence against future erosion. Furthermore, its design can be tailored to minimize disruption to the natural landscape, integrating elements that improve resilience without detracting from the site's aesthetic or ecological balance. Additionally, it may provide an opportunity for ecological enhancement, as the gaps between the rocks could serve as habitats for marine and coastal species, promoting biodiversity and contributing to the environmental sustainability of the project.

However, there are a range of logistical challenges, including:

- Transportation of heavy rock units to site – as there is restricted site access for construction plant and machinery, with no direct vehicular access to the foreshore.



- Limited construction windows to place and interlock armour units

8.5.5 Timber low crest wave barrier

A timber low crested wave barrier presents a balanced approach to addressing the coastal erosion at Site 5A. Conceptually, the design of the barrier would be similar to that of timber groynes (see example in Figure 6), which have been proven to perform in areas with low-to-moderate open coast wave energy. The structure would be founded into the rock platform and likely between 1-1.5m high.

This barrier would consist of a series of vertical supports, which could be constructed using either timber or steel, depending on the suitability and feasibility of each material. During detailed design, the best method for building and anchoring the vertical supports to the rock platform would be chosen to ensure structural stability in a technical and costly efficient manner.

Additionally, the structure could incorporate a panel made of marine grade timber planks (such as those used in port and maritime settings) or more naturally looking “log” units, offering flexibility in design based on site-specific characteristics and environmental conditions. There may also be opportunities to be able to reuse some existing woody debris at the site in order to enhance the natural visual character.

The use of short length timber units could also allow those units to be manually transported by 1-2 persons down the staircase at the site – avoiding the need for transport via machinery or barge.

This barrier not only serves its functional purpose but also harmonizes with the natural coastal aesthetics, minimizing visual disruption while preserving the ecological integrity of the area. Furthermore, the timber structure and the gaps between the timber elements could potentially serve as micro-habitats for marine life, promoting biodiversity alongside erosion control, and enhancing the site's ecological value. Taking into account the local characteristics of the site, including the presence of the rock platform, an alternative low crested wave barrier constructed with concrete may offer advantages at a favourable cost.

However, this solution would be best considered as an interim measure - as the design life of the structure would be likely more of the order of 15-25 years, given the harsh marine environment. Factors limiting lifespan include:

- Biological degradation, such as marine borer or fungal attack on timber elements.
- Mechanical wear, particularly from wave-driven debris and abrasion against the rock platform.
- Saltwater corrosion, if steel fixings or reinforcements are used.
- UV exposure, which can accelerate timber weathering and reduce structural integrity over time.
- Maintenance demands, as ongoing inspections and repairs would be required to maintain performance over the life of the structure.



Figure 8-7 Example of timber groyne, similar to the proposed timber low crest wave barrier.

8.5.6 Concrete low crest wave barrier

A concrete alternative of a low crested wave barrier would provide the highest level of protection against coastal erosion and is particularly suited to harsh maritime environments, such as the one encountered in Site 5A. The structure would be founded into the rock platform and likely around 1 m high. The structure could be located between 1-3 m seawards of the vertical erosion scarp and backfilled with free drainage material and geotextile fabric.

This solution would be the most durable among all different alternatives, requiring minimal maintenance over time compared to other coastal protection interventions. The presence of the rock platform in front of Site 5A (see Figure 8-1) represents a considerable advantage for this approach, as it could reduce construction complexities and potentially lower associated costs. In addition, concrete could be pumped to the site from atop the slope via a long hose extension, overcoming the logistical challenges faced by other intervention alternatives. Essentially, the formwork for the wall would comprise the main material to be transported down the slope by hand.

Moreover, the concrete low crested wave barrier could be designed to avoid overt negative impacts on the natural aesthetics of the foreshore. In addition to its low height, the use of dye-packs in the concrete mix could help the structure blend in with the surrounding rock platform. The structure's design could integrate features that foster biodiversity growth, such as crevices and surfaces suitable for colonization by different organisms. Additionally, it could reflect the site's cultural value by emphasizing its cultural significance through embedded motifs. See Figure 7 for an example of a revetment concrete armour unit used in New Zealand, with similar patterning



Figure 8-8 Xblock+ armour unit used in New Zealand, incorporating embedded motifs

8.6 Concept Design

A concept design has been developed for the proposed low crest wave barrier, both:

- Timber - to provide a short to medium term (interim) solution and
- Concrete – to provide a long term (terminal) solution).

A concept design is as illustrated in Figure 8-9 and Appendix D.

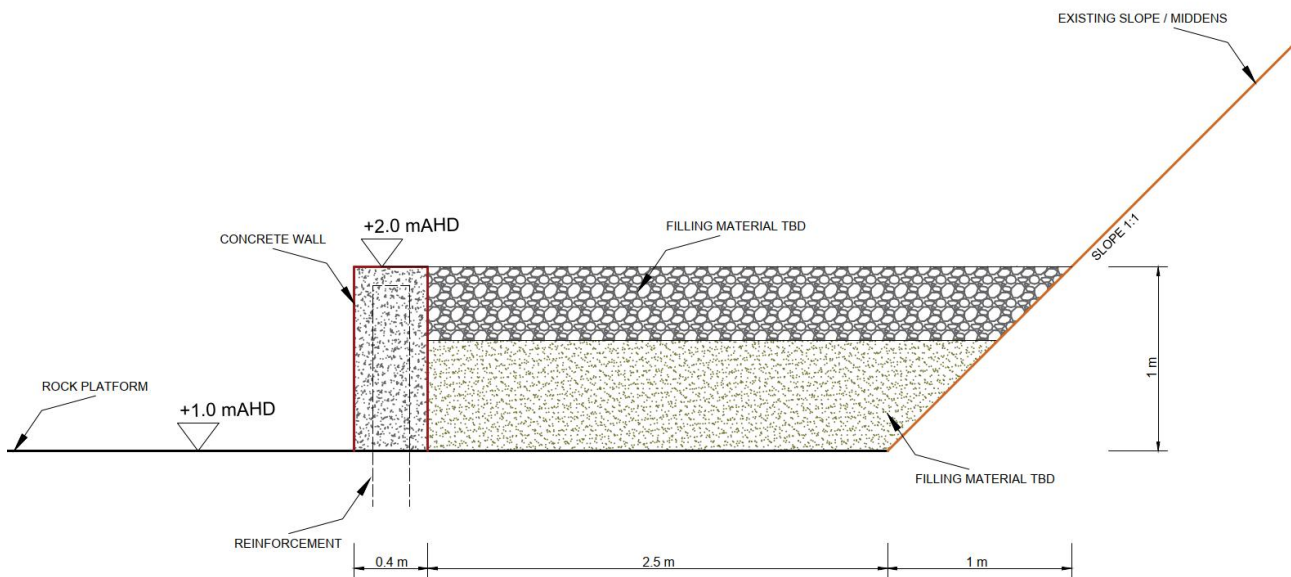


Figure 8-9 Proposed concrete low crest wave barrier

Further details of the proposed concept design, including summarized technical specifications and proposed geometry, are included Appendix A for review. This annex provides additional information on the solution, recommended for its long-term durability, constructability advantages and the opportunity to use the solid foundation provided by the rocky platform.

8.6.1 Cost Estimate

A cost estimate for the works are given in Table 8-1 and Table 8-2. Indicative costs are a high-level estimate only, and due to the construction complexity the costs will be heavily dependent upon contractor construction work methods. As a result, a likely cost range for each option has been provided.

Table 8-1 Cost Estimate for Low Height Timber Wave Barrier

Item	Estimated price	Unit	Meas.	Cost
Timber wall (1 m high) – includes Marine-grade timber materials such as Includes treated hardwood or recycled timber sleepers, marine-grade fixings (e.g. stainless steel or galvanised), and bracing elements.	\$400-1,200	Lineal metre	40 m	\$16,000-\$48,000
Rock platform preparation & anchoring – includes drilling into rock, installing footings, epoxy or mechanical fixing systems.	\$200-800	Lineal metre	40 m	\$8,000-\$32,000
Access & construction management - includes tidal window constraints, site establishment, safety, and limited access.	\$250-1,000	Lineal metre	40 m	\$10,000-\$40,000
Total				\$34,000-\$120,000



Table 8-2 Cost Estimate for Low Height Concrete Wabe Barrier

Item	Estimated price	Unit	Meas.	Cost
Reinforced concrete wall (1 m high) – includes formwork, reinforcement, concrete supply, and placement. Higher rate reflects marine-grade durability and intertidal complexities	\$1,000-2,500	Lineal metre	40 m	\$40,000- \$100,000
Rock platform preparation & anchoring - Includes saw-cutting, drilling, anchoring starter bars or dowels, and grouting.	\$500-1,000	Lineal metre	40 m	\$20,000- \$40,000
Access & construction management - includes tidal window constraints, site establishment, safety, and limited access.	\$500-1,000	Lineal metre	40 m	\$20,000- \$40,000
Total				\$80,000- \$180,000



9 REFERENCES

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APPENDIX A CONCEPT DESIGN DRAWINGS SITE 1





VERSION CONTROL			
V01	DRAFT CONCEPT DESIGN	28/04/2025	DMT
V02	FINAL CONCEPT DESIGN	06/06/2025	DMT

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CONSULTANT
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LAKE CONJOLA FORESHORE CONCEPT DESIGNS

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VERSION NO. V02



- Low grasses and shrubs
- Supplement existing rock*
- Bollard fence
- Remove concrete
- Vegetated swale
- Salt marsh
- Rock groyne
- Move stairs
- Formalise access



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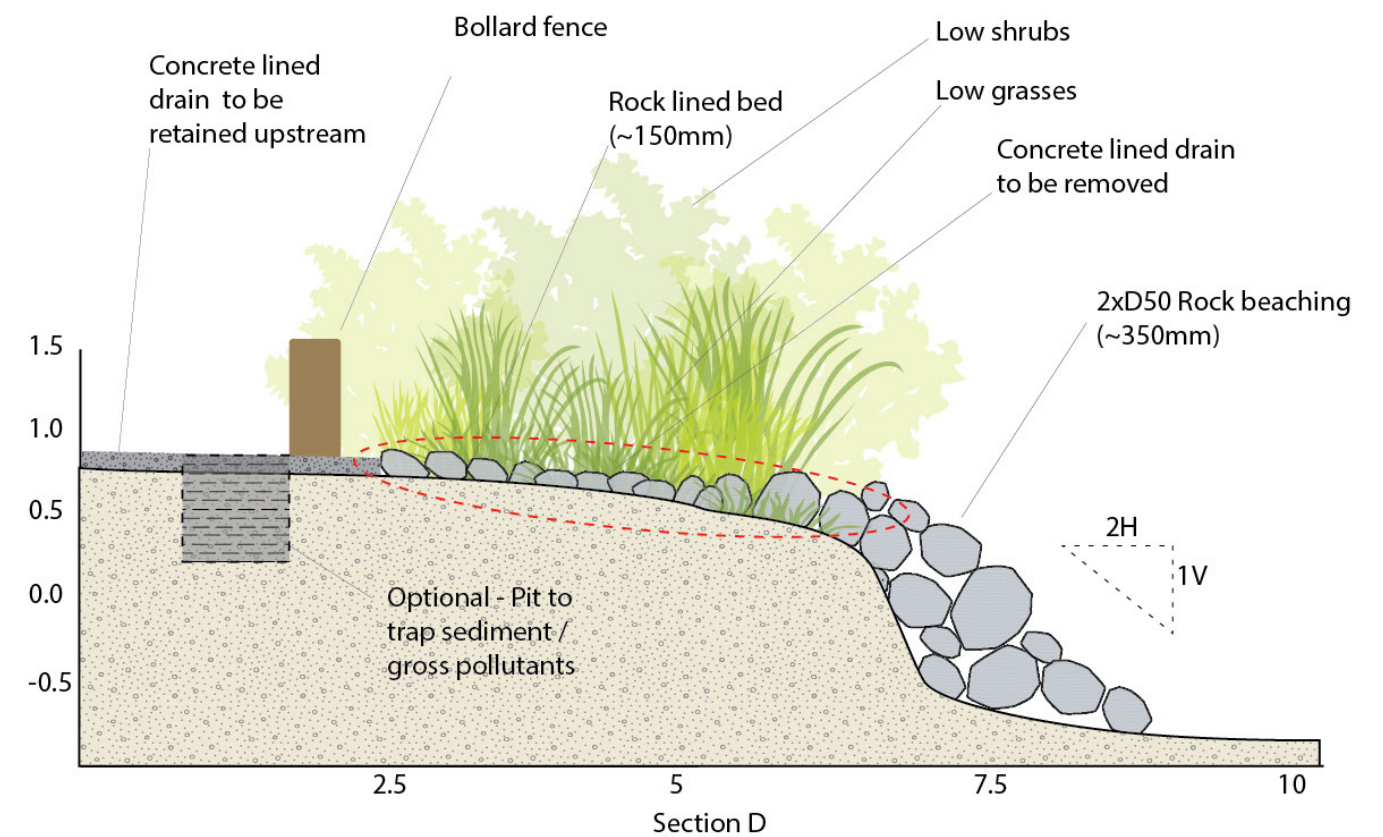
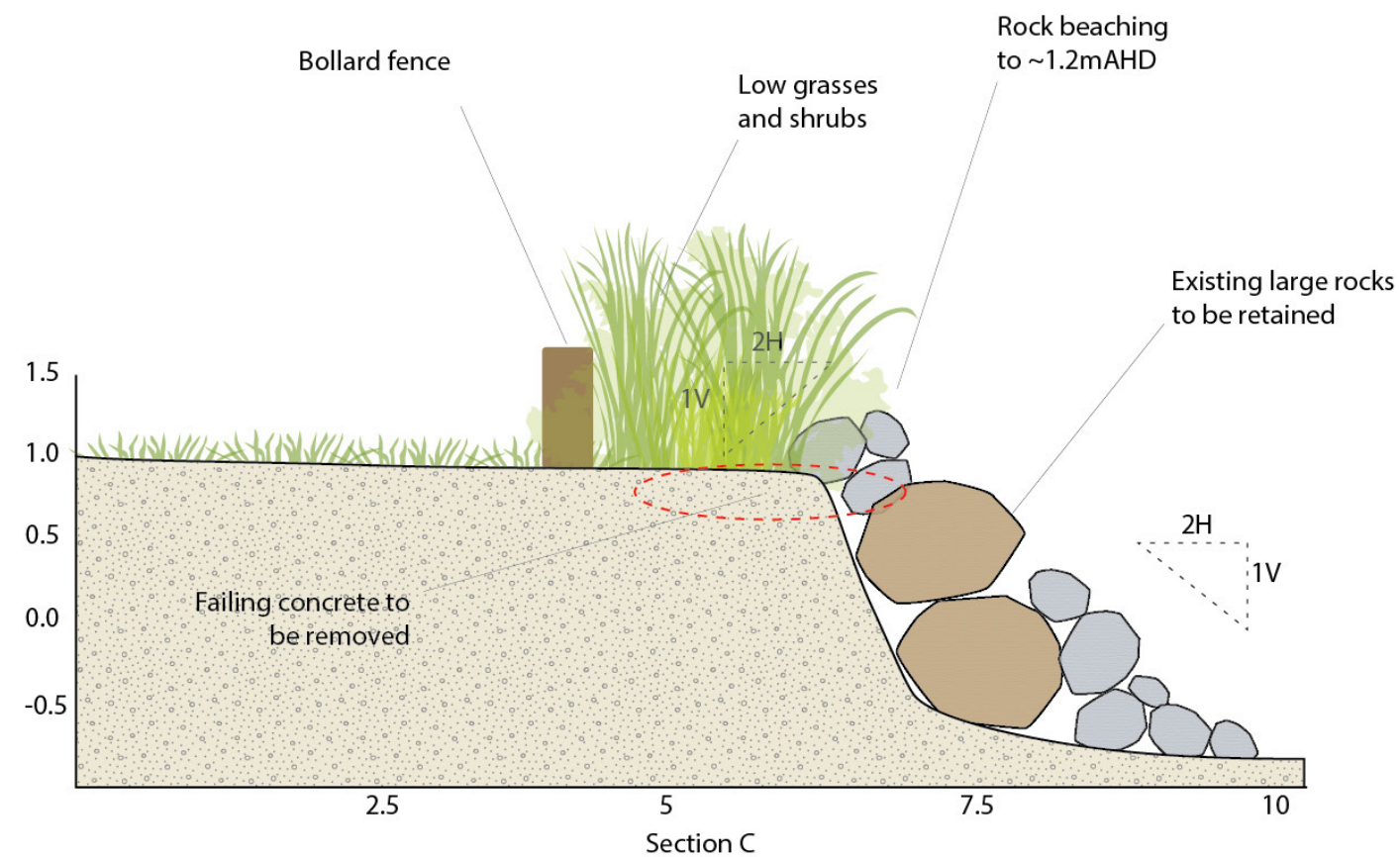
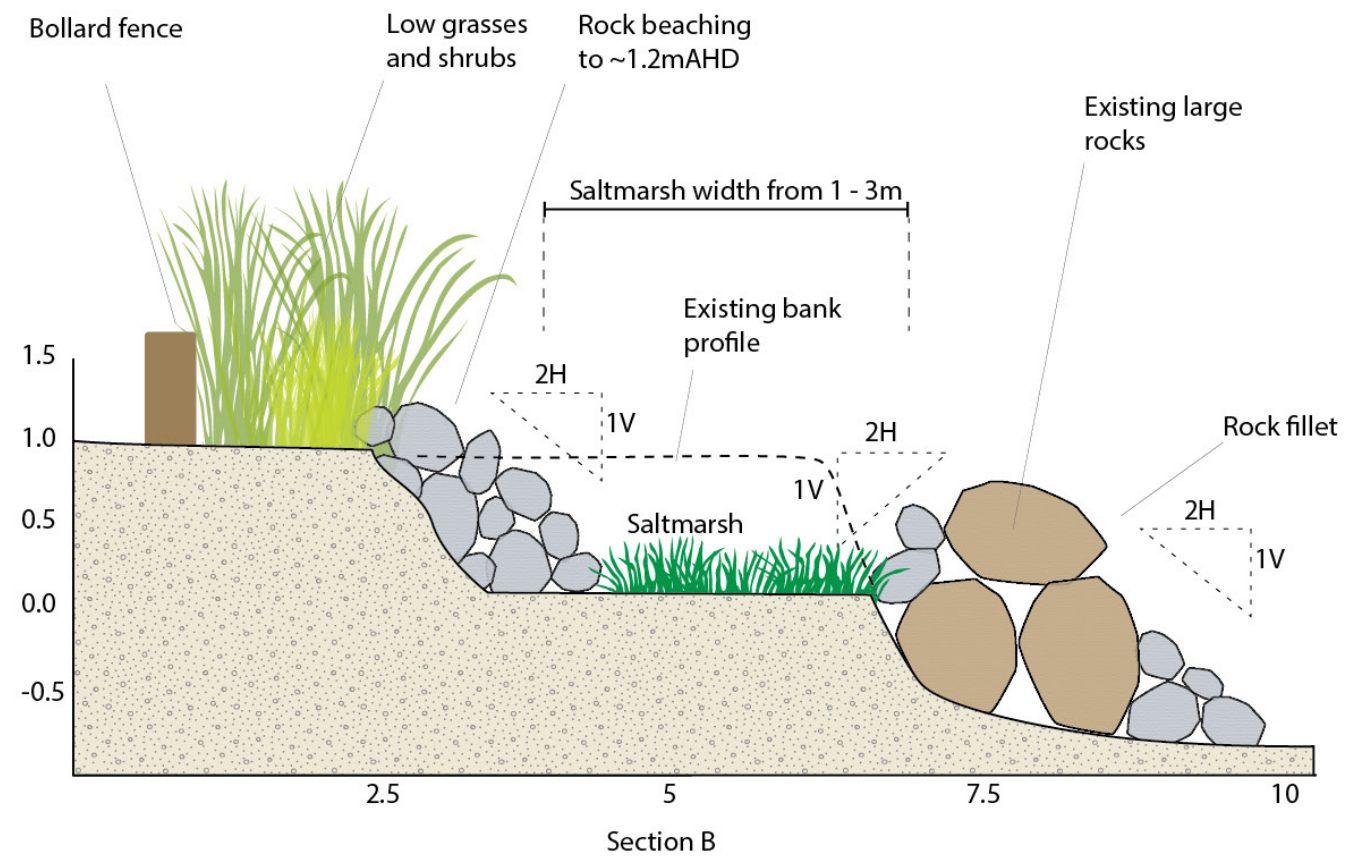
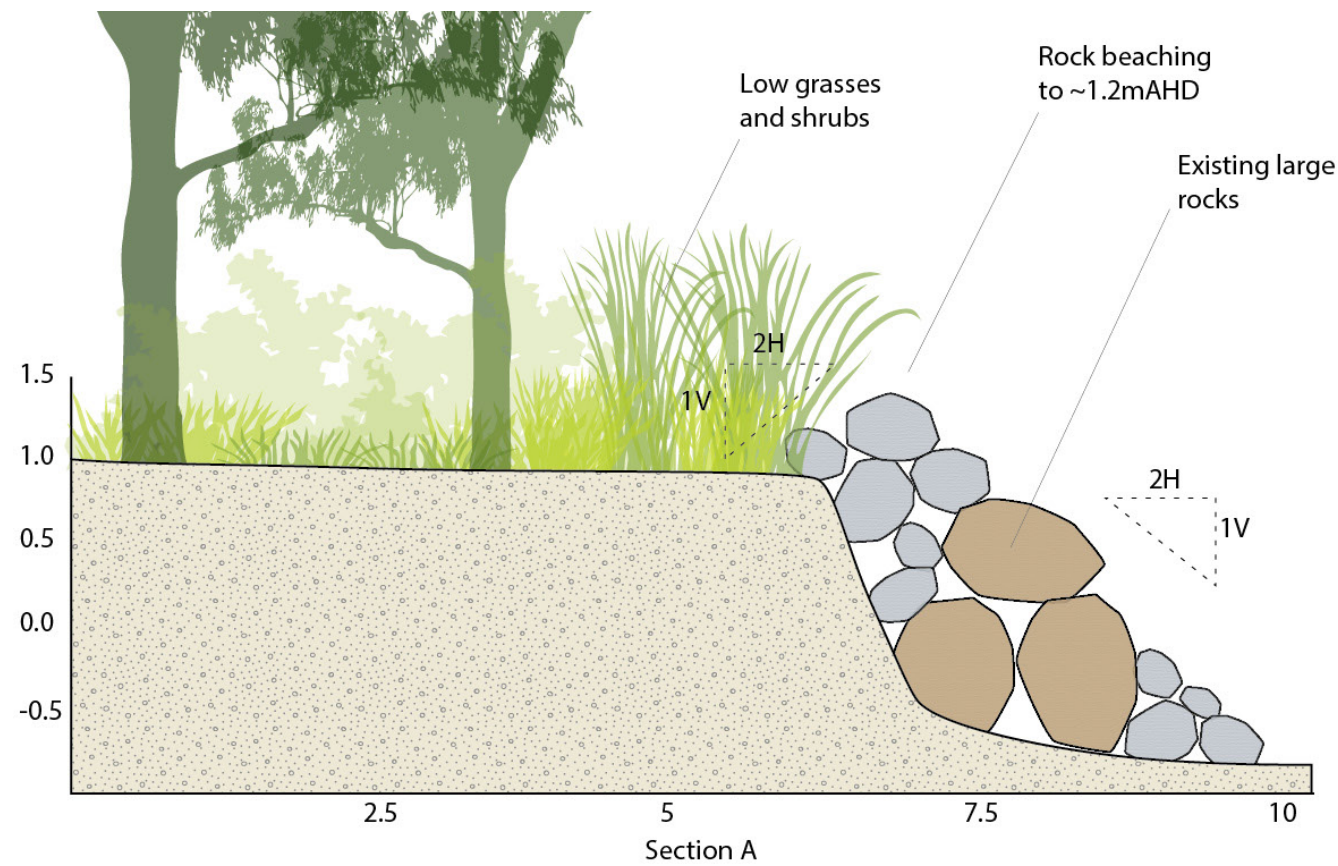
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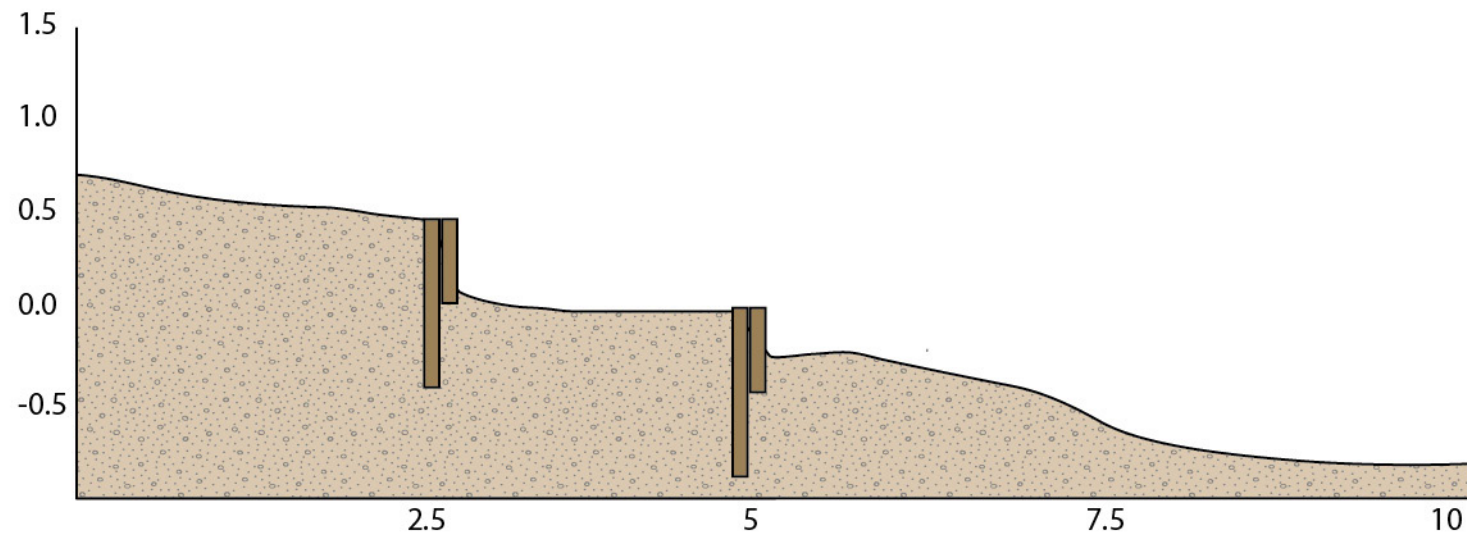


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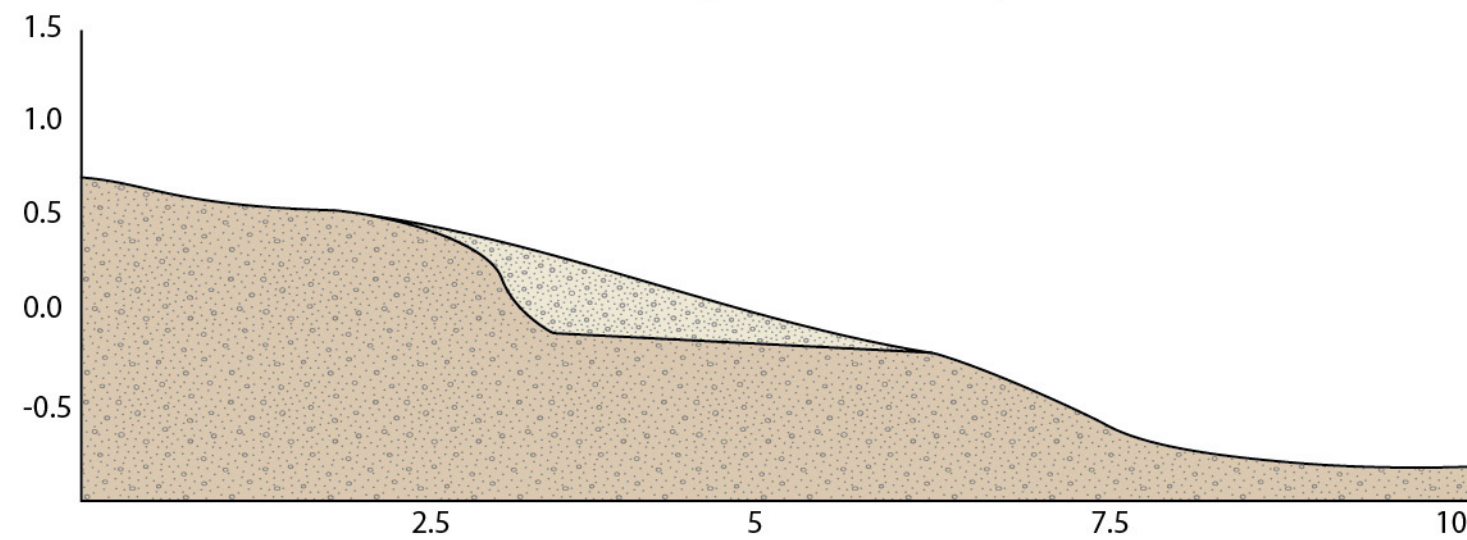
LAKE CONJOLA FORESHORE CONCEPT DESIGNS

SECTION VIEW 1
JOB NO. 25020130
SHEET 3 OF 5

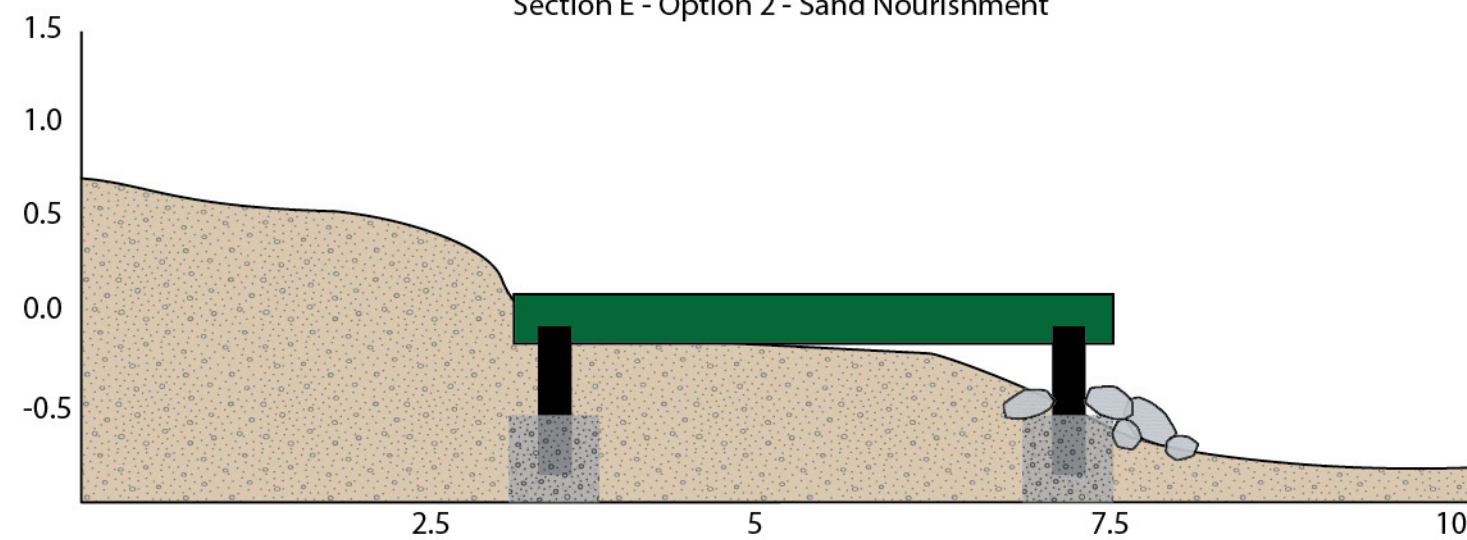
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Section E - Option 1 Hardwood Steps



Section E - Option 2 - Sand Nourishment



Section E - Option 3 - FRP Plafrom

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APPENDIX B CONCEPT DESIGN DRAWINGS SITE 3A





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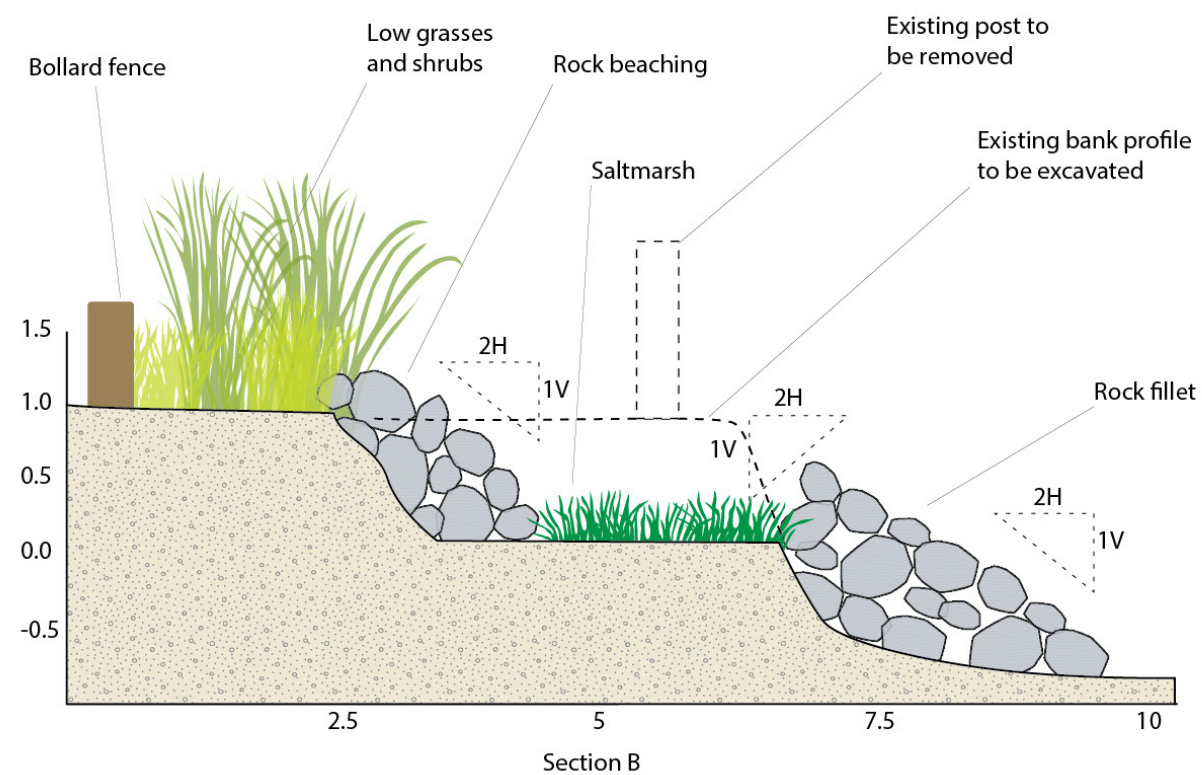
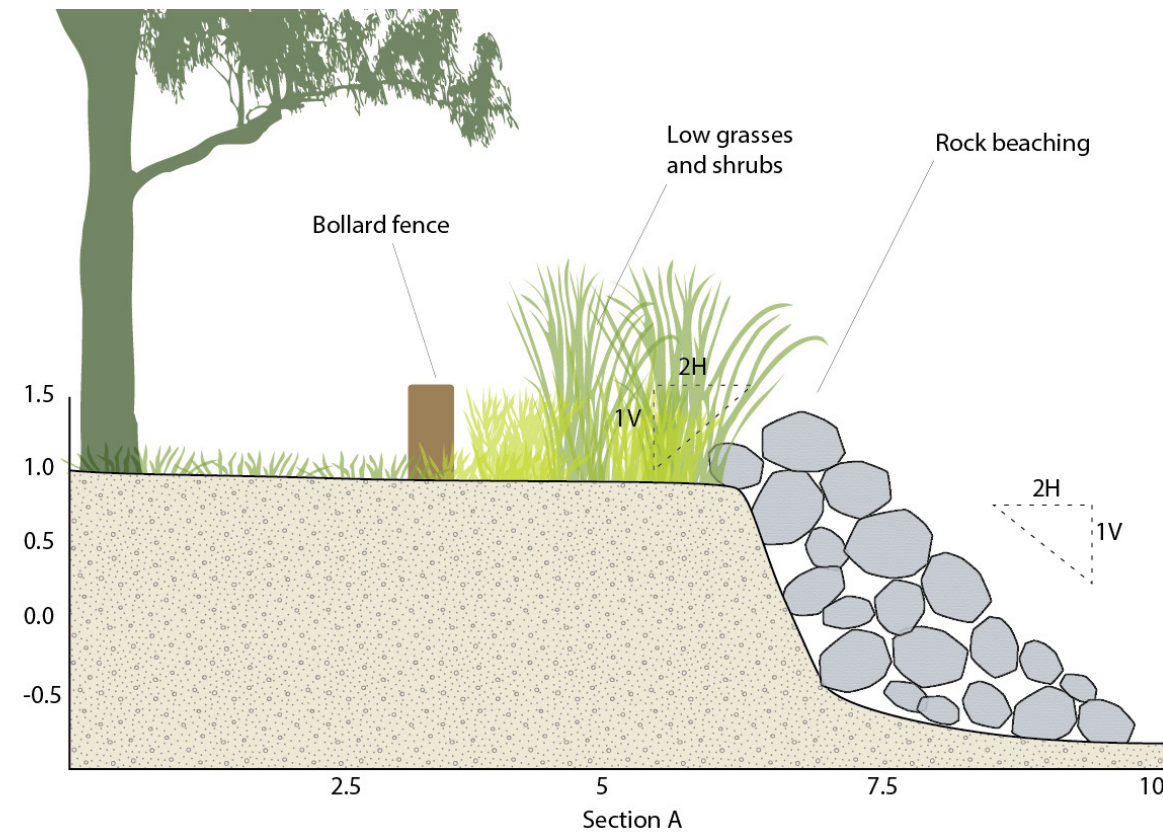


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APPENDIX C CONCEPT DESIGN DRAWINGS SITE 4





- Rock Beaching
- Rock Groyne
- Post and chain fence
- Cobble beach
- Formalise access
- Mangrove establishment
- Vegetation management

VERSION CONTROL			
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VERSION NO. V02



APPENDIX D CONCEPT DESIGN DRAWINGS SITE 5A



CROOKHAVEN HEADS COASTAL PROTECTION

NOTES

- 1. DIMENSIONS ARE IN MILLIMETRES (MM) UNLESS NOTED OTHERWISE.
- 2. ALL LEVELS ARE RELATIVE TO AUSTRALIAN HEIGHT DATUM (mAHD).
- 3. ALL COORDINATES ARE REFERRED TO MGA2020 ZONE 56.

DESIGN CONDITIONS

DESIGN WAVE CONDITIONS PROVIDED BY STANTEC ON 15/04/2025 ARE THE FOLLOWING:

- Hs = 0.8 m, 1.0 m, 1.3 m (SIGNIFICANT WAVE HEIGHT FOR A 100 YEARS ARI)
- Tp = 11.9 s, 4.6 s, 4.6 s (PEAK PERIOD FOR A 100 YEARS ARI)

DETAILED WAVE MODELING SHOULD BE CARRIED PRIOR TO DETAILED DESIGN, INCLUDING INCIDENT WAVES LOCALLY GENERATED AND OFFSHORE FROM VARIOUS DIRECTIONS.

MATERIALS - CONCRETE WALL

THE CONCRETE WALL WILL BE REINFORCED WITH STEEL ELEMENTS AND CONNECTED TO THE ROCK PLATFORM. THE CONNECTION OF THE WALL REINFORCEMENT TO THE ROCK PLATFORM SHALL BE WITH HILTI HIT-RE 500 V4 EPOXY ANCHOR. THE DETAILED DESIGN OF THE WALL AND CONNECTIONS WILL BE DELIVERED WITH THE DETAILED DESIGN

MATERIALS - FILLING MATERIAL

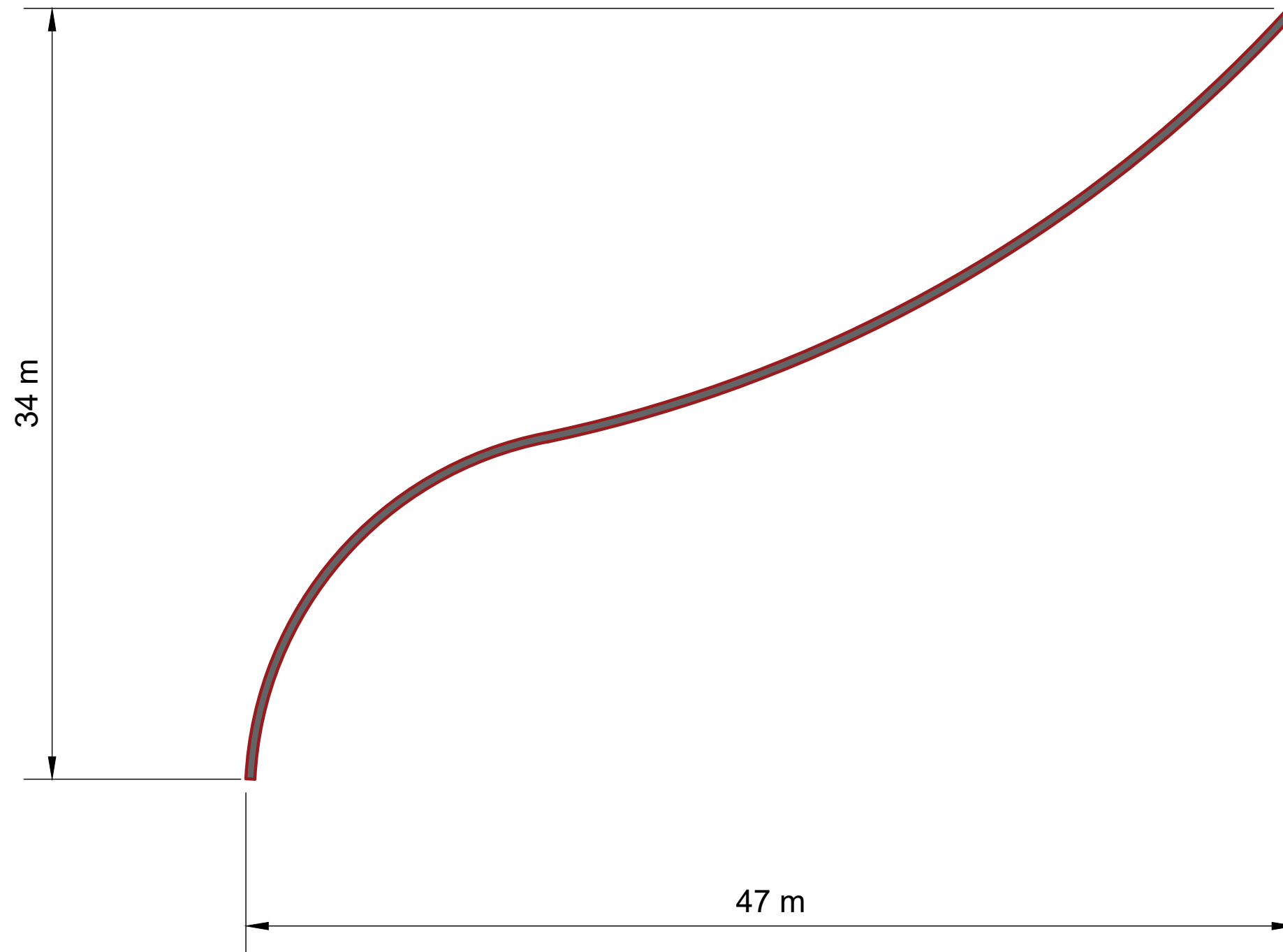
THE FILLING MATERIAL CHARACTERISTICS ARE TO BE DEFINED DURING THE DETAILED DESIGN, CONSIDERING THE AVAILABILITY OF LOCAL SUPPLY. A FILLING MATERIAL WHICH ALLOWS THE DEVELOPMENT OF VEGETATION SHALL BE CONSIDERED.

FUTURE DESIGN STEPS

THIS CONCEPTUAL DESIGN IS TO BE OPTIMIZED COMBINING REVEGETATION MEASURES AND ADDITIONAL NATURE BASED SOLUTIONS, AFTER CONSULTATION WITH THE LOCAL COMMUNITY. GIVEN THE ARCHEOLOGICAL AND CULTURAL SIGNIFICANCE OF THE AREA, AN ARCHEOLOGICAL ASSESSMENT IS RECOMMENDED BEFORE CONSTRUCTION STARTS.

PRELIMINARY ISSUE

				CLIENT: 	PROJECT: CROOKHAVEN HEADS COASTAL PROTECTION SHOALHAVEN	DESIGNED BY: EDA	DRAWN BY: EDA	WT-25050032-D01 NOTES AND SPECIFICATIONS		
						DRAWING DATE: 05.05.2025	CHECKED: CJB			
						SHEET: 2 OF 4	SCALE: AS SHOWN			
A	05.05.2025	ISSUED FOR CLIENT REVIEW				FILE: 25020130__Shoalhaven__A.dwg		PROJECT No. 25020130	DRAWING No. D01	REV. C
Amendments										



PRELIMINARY ISSUE

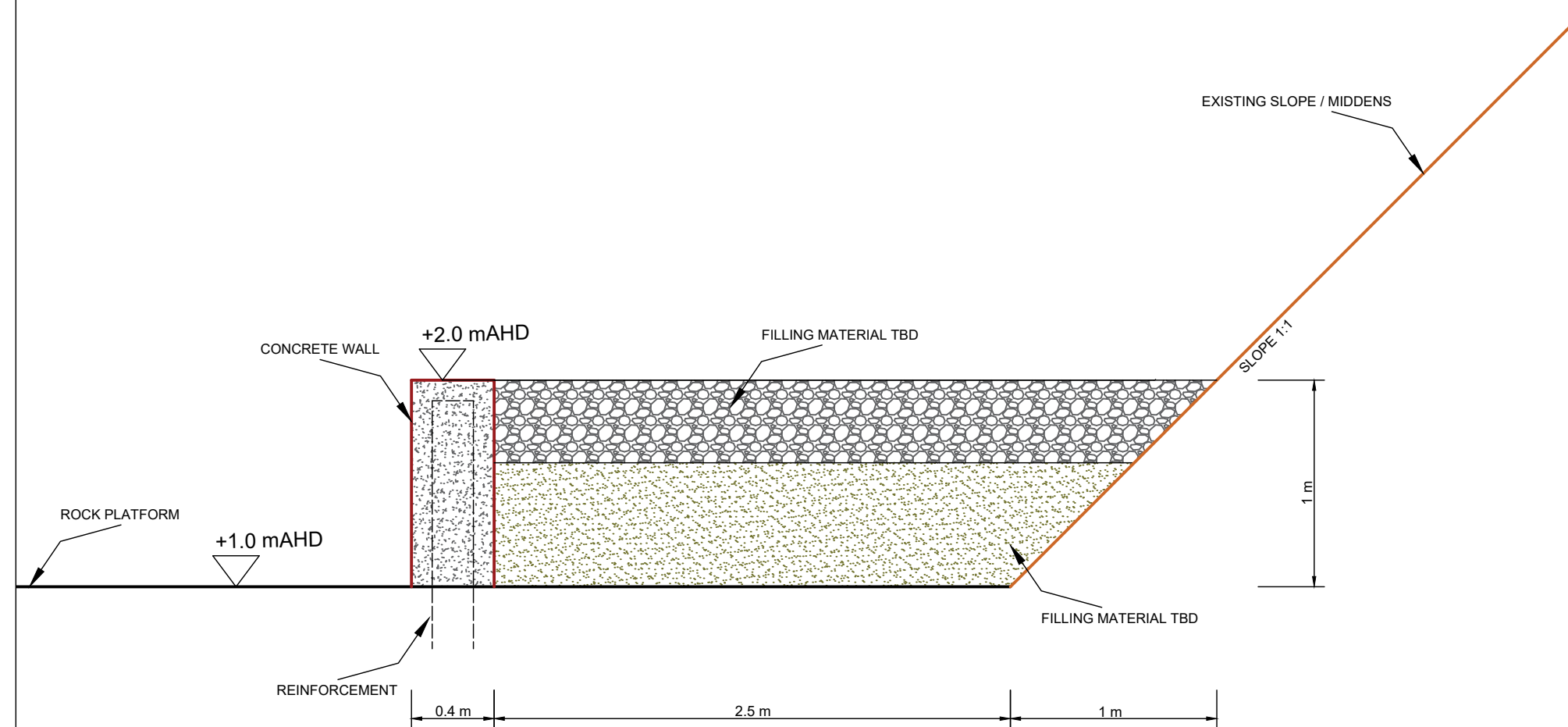
A	05.05.2025	ISSUED FOR CLIENT REVIEW
Amendments		



PROJECT:
**CROOKHAVEN HEADS
COASTAL PROTECTION
SHOALHAVEN**

DESIGNED BY: EDA	DRAWN BY: EDA
DRAWING DATE: 05.05.2025	CHECKED: CJB
SHEET: 3 OF 4	SCALE: AS SHOWN
FILE: 25020130__Shoalhaven__A.dwg	

WT-25050032-D02 PLAN VIEW		
PROJECT No. 25020130	DRAWING No. D02	REV. C



ELEVATIONS TO BE
CONFIRMED DURING
DETAIL DESIGN

PRELIMINARY ISSUE

A	05.05.2025	ISSUED FOR CLIENT REVIEW
Amendments		



CLIENT:

Shoalhaven
City Council

PROJECT:

**CROOKHAVEN HEADS
COASTAL PROTECTION
SHOALHAVEN**

DESIGNED BY:

EDA

DRAWN BY:

EDA

DRAWING DATE:

05.05.2025

CHECKED:

CJB

SHEET:

4 OF 4

SCALE:

AS SHOWN

FILE:

25020130__Shoalhaven__A.dwg

**WT-25050032-D03
SECTIONS AND DETAILS**

PROJECT No.

25020130

DRAWING No.

D03

REV.

C

Melbourne

15 Business Park Drive
Notting Hill VIC 3168

Brisbane

Level 5, 43 Peel Street
South Brisbane QLD 4101

Perth

Level 1, 21 Adelaide Street
Fremantle WA 6160

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677

Wimmera

597 Joel South Road
Stawell VIC 3380

Darwin

5/5 Goyder Road
Parap NT 0820

Sydney

Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150

Adelaide

1/198 Greenhill Road
Eastwood SA 5063

New Zealand

7/3 Empire Street
Cambridge New Zealand 3434

Geelong

51 Little Fyans Street
Geelong VIC 3220

Gold Coast

Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227

Sunshine Coast

Office #4 of the Regatta 1 Business Centre
2 Innovation Parkway
Birtinya QLD 4575

1300 198 413



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APPENDIX C - Likelihood of Occurrence Table (NSW Threatened Species)

NSW Threatened Species Likelihood of Occurrence Table

The table of likelihood of occurrence evaluates the likelihood of threatened species to occur on the subject site. This list is derived from previously recorded species within a 5 km radius (taken from NSW BioNet Atlas on 21/08/2025) around the subject site. Ecology information unless otherwise stated, has been obtained from the *Threatened Biodiversity Profile Search* on the NSW OEH (Office of Environment & Heritage) online database (<https://www.environment.nsw.gov.au/threatenedspeciesapp/>).

Likelihood of occurrence in study area

1. Unlikely – Species, population or ecological community is not likely to occur. Lack of previous recent (<25 years) records and suitable potential habitat limited or not available in the study area.
2. Likely – Species, population or ecological community could occur and study area is likely to provide suitable habitat. Previous records in the locality and/or suitable potential habitat in the study area.
3. Present – Species, population or ecological community was recorded during the field investigations.

Possibility of impact

1. Unlikely – The proposal would be unlikely to impact this species or its habitats. No NSW *Biodiversity Conservation Act 2016* “Test of Significance” or EPBC Act significance assessment is necessary for this species.
2. Likely – The proposal could impact this species, population or ecological community or its habitats. A NSW *Biodiversity Conservation Act 2016* “Test of Significance” and/or EPBC Act significance assessment is required for this species, population or ecological community.

Note that where further assessment is deemed required, this is undertaken within the REF as a Test of Significance (in the case of NSW listed species) or an EPBC Significant Impact Assessment (in the case of Commonwealth listed species).

Species name	Status	Habitat requirements (www.environment.nsw.gov.au)	Likelihood of presence within areas impacted by the activity
FLORA			
Narrow-leaved Wilsonia <i>Wilsonia backhousei</i>	Vulnerable BC Act	This is a species of the margins of salt marshes and lakes.	Not likely – no suitable habitat – too disturbed. Not detected at the site during site investigations
Scrub Turpentine <i>Rhodamnia rubescens</i>	Endangered BC Act, and Critically Endangered EPBC Act	Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils.	Not likely – no suitable habitat – too disturbed. Not detected at the site during site investigations
Leafless Tongue Orchid <i>Cryptostylis hunteriana</i>	Vulnerable BC Act and EPBC Act	Larger populations typically occur in woodland dominated by Scribbly Gum, Silvertop Ash, Red Bloodwood and Black Sheoak and appears to prefer open areas.	Not likely – no suitable habitat. Highly disturbed site.
Bauer's Midge Orchid <i>Genoplesium baueri</i>	Endangered BC Act and Endangered EPBC Act	Grows in dry sclerophyll forest and moss gardens over sandstone.	Not likely – no suitable habitat. Highly disturbed site.
AMPHIBIANS			
Green and Golden Bell Frog <i>Litoria aurea</i>	Endangered BC Act Vulnerable EPBC Act	Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (<i>Typha</i> spp.) or spikerushes (<i>Eleocharis</i> spp.)	Not likely – no suitable habitat.
REPTILES			
Green Turtle <i>Chelonia mydas</i>	Vulnerable BC Act and EPBC Act	Ocean-dwelling species spending most of its life at sea.	Not likely – no suitable habitat. In the unlikely event that it is present at the site of the proposed activity it is likely to swim away without harm.

BIRDS			
White-throated Needletail <i>Hirundapus caudacutus</i>	Vulnerable and Migratory EPBC Act	Almost exclusively aerial, from heights of less than 1 m up to more than 1000 m above the ground. Because they are aerial, it has been stated that conventional habitat descriptions are inapplicable, but there are, nevertheless, certain preferences exhibited by the species. Although they occur over most types of habitat, they are probably recorded most often above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy, but they are less commonly recorded flying above woodland. They also commonly occur over heathland, but less often over treeless areas, such as grassland or swamps. When flying above farmland, they are more often recorded above partly cleared pasture, plantations or remnant vegetation at the edge of paddocks. In coastal areas, they are sometimes seen flying over sandy beaches or mudflats, and often around coastal cliffs and other areas with prominent updraughts, such as ridges and sand-dunes. They are sometimes recorded above islands well out to sea.	Possibly occurring over or in proximity to the site, but unlikely to utilise or rely on available habitat within the site.
Shy Albatross <i>Thalassarche cauta</i>	Endangered NSW BC Act and EPBC Act	This pelagic or ocean-going species inhabits subantarctic and subtropical marine waters, spending the majority of its time at sea.	Possibly occurring over or in proximity to the site, but unlikely to utilise or rely on available habitat within the site.
Black Bittern <i>Ixobrychus flavicollis</i>	Vulnerable NSW BC Act	Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves.	Unlikely – no suitable habitat
White-bellied Sea-Eagle <i>Haliaeetus leucogaster</i>	Vulnerable BC Act	The habitat for this species is characterised by the presence of large areas of open water including larger rivers, swamps, lakes and the sea. Breeding habitat consists of mature tall open forest, open forest, tall woodland, and swamp sclerophyll forest close to foraging habitat. Nest trees are typically large emergent eucalypts.	Possible – but not likely to be affected by the proposed activity as no vegetation removal is proposed. The species are transient and far ranging. It is possible that the species would fly over the site from time to time or to rest briefly. The proposed activity is unlikely to impact the species as the area does not provide important or useful habitat for the species. The species use of the site

			(flying over or resting) would not be affected by the proposal. No further assessment is therefore required.
Little Eagle <i>Hieraaetus morphnoides</i>	Vulnerable BC Act	The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW. Nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter.	Possible – but not likely to be affected by the proposed activity as no vegetation removal is proposed. The species are transient and far ranging. It is possible that the species would fly over the site from time to time or to rest briefly. The proposed activity is unlikely to impact the species as the area does not provide important or useful habitat for the species. The species use of the site (flying over or resting) would not be affected by the proposal. No further assessment is required.
Square-tailed Kite <i>Lophoictinia isura</i>	Vulnerable BC Act	Found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses.	Possible – but not likely to be affected by the proposed activity as no vegetation removal is proposed. The species are transient and far ranging. It is possible that the species would fly over the site from time to time or to rest briefly. The proposed activity is unlikely to impact the species as the area does not provide important or useful habitat for the species. The species use of the site (flying over or resting) would not be affected by the proposal. No further assessment is required.
Eastern Osprey <i>Pandion cristatus</i>	Vulnerable BC Act	Favour coastal areas, especially the mouths of large rivers, lagoons and lakes. Feed on fish over clear, open water. Breed from July to September in NSW. Nests are made high up in dead trees or in dead crowns of live trees, usually within one kilometre of the sea.	Possible – but not likely to be affected by the proposed activity as no vegetation removal is proposed. The species are transient and far ranging. It is possible that the species would fly

			over the site from time to time or to rest briefly. The proposed activity is unlikely to impact the species as the area does not provide important or useful habitat for the species. The species use of the site (flying over or resting) would not be affected by the proposal. No further assessment is required.
Beach Stone-curlew <i>Esacus magnirostris</i>	Endangered NSW BC Act	Beach Stone-curlews are found exclusively along the coast, on a wide range of beaches, islands, reefs and in estuaries, and may often be seen at the edges of or near mangroves. They forage in the intertidal zone of beaches and estuaries, on islands, flats, banks and spits of sand, mud, gravel or rock, and among mangroves. Beach Stone-curlews breed above the littoral zone, at the backs of beaches, or on sandbanks and islands, among low vegetation of grass, scattered shrubs or low trees; also among open mangroves.	Unlikely – no suitable habitat
Sooty Oystercatcher <i>Haematopus fuliginosus</i>	Vulnerable NSW BC Act	Shore bird – breeds in sand or coral scrapes on offshore islands. Favours rocky headlands, rocky shelves, exposed reefs with rock pools, beaches and muddy estuaries.	Not likely – no suitable habitat
Pied Oystercatcher <i>Haematopus longirostris</i>	Endangered NSW BC Act	Favours intertidal flats of inlets and bays, open beaches and sandbanks. Forages on exposed sand, mud and rock at low tide, for molluscs, worms, crabs and small fish. Nests mostly on coastal or estuarine beaches although occasionally they use saltmarsh or grassy areas. Nests are shallow scrapes in sand above the high tide mark, often amongst seaweed, shells and small stones.	Not likely – no suitable habitat
Lesser Sand-plover <i>Charadrius mongolus</i>	Vulnerable NSW BC Act and Endangered EPBC Act	The Lesser Sand-plover breeds in central and north eastern Asia, migrating further south for winter. In Australia the species is found around the entire coast but is most common in the Gulf of Carpentaria, and along the east coast of Queensland and northern NSW. Individuals are rarely recorded south of the Shoalhaven estuary, and there are few inland records. Almost entirely coastal in NSW, favouring the beaches of sheltered bays, harbours and estuaries with large intertidal sandflats or mudflats; occasionally occurs on sandy beaches, coral reefs and rock platforms. Highly gregarious, frequently seen in flocks exceeding 100 individuals; also often seen foraging and roosting with other wader species.	Not likely – no suitable habitat

		Roosts during high tide on sandy beaches, spits and rocky shores; forage individually or in scattered flocks on wet ground at low tide, usually away from the water's edge.	
Eastern Hooded Dotterel <i>Thinornis cucullatus cucullatus</i>	Critically Endangered NSW BC Act Vulnerable EPBC Act	In south-eastern Australia Eastern Hooded Dotterels prefer sandy ocean beaches, especially those that are broad and flat, with a wide wave-wash zone for feeding, much beachcast seaweed, and backed by sparsely vegetated sand-dunes for shelter and nesting. Occasionally Hooded Plovers are found on tidal bays and estuaries, rock platforms and rocky or sand-covered reefs near sandy beaches, and small beaches in lines of cliffs. They regularly use near-coastal saline and freshwater lakes and lagoons, often with saltmarsh. They often nest within 6 m of the fore-dune, mostly within 5 m of the high-water mark, but occasionally among or behind dunes.	Not likely – no suitable habitat
Eastern Curlew <i>Numenius madagascariensis</i>	Endangered NSW BC Act and Critically Endangered EPBC Act	It generally occupies coastal lakes, inlets, bays and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats and sometimes saltmarsh of sheltered coasts. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. It forages in or at the edge of shallow water, occasionally on exposed algal mats or waterweed, or on banks of beach-cast seagrass or seaweed. It roosts on sandy spits and islets, especially on dry beach sand near the high-water mark, and among coastal vegetation including low saltmarsh or mangroves. May also roost on wooden oyster leases or other similar structures	Not likely – no suitable habitat. Site is too highly disturbed.
Little Tern <i>Sternula albifrons</i>	Endangered NSW BC Act	Migrating from eastern Asia, the Little Tern is found on the north, east and south-east Australian coasts, from Shark Bay in Western Australia to the Gulf of St Vincent in South Australia. Almost exclusively coastal, preferring sheltered environments; however may occur several kilometres from the sea in harbours, inlets and rivers (with occasional offshore islands or coral cay records). Nests in small, scattered colonies in low dunes or on sandy beaches just above high tide mark near estuary mouths or adjacent to coastal lakes and islands. The nest is a scrape in the sand, which may be lined with shell grit, seaweed or small pebbles.	Not likely – no suitable habitat. Site is too highly disturbed.

Gang-gang Cockatoo <i>Callocephalon fimbriatum</i>	Vulnerable NSW BC Act, Endangered Commonwealth EPBC Act	In summer and spring the species is generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In autumn and winter, the species often moves to lower altitudes in drier more open eucalypt forests and woodlands, particularly box-gum and box-iron bark assemblages, or in dry forests in coastal areas and often found in urban areas.	Not likely – no suitable habitat
South-eastern Glossy Black Cockatoo <i>Calyptrorhynchus lathamii lathamii</i>	Vulnerable NSW BC Act	The species inhabits open forest and woodlands of the coast and the Great Dividing Range where stands of sheoak occur. Black Sheoak <i>Allocasuarina littoralis</i> and Forest Sheoak <i>A. torulosa</i> are important foods.	Not likely – no suitable habitat and no food and breeding resources.
Little Lorikeet <i>Glossopsitta pusilla</i>	Vulnerable NSW BC Act	The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs. Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity.	Not likely – no suitable habitat.
Eastern Ground Parrot <i>Pezoporus wallicus wallicus</i>	Vulnerable NSW BC Act	The Ground Parrot occurs in high rainfall coastal and near coastal low heathlands and sedgeland, generally below one metre in height and very dense (up to 90% projected foliage cover). These habitats provide a high abundance and diversity of food, adequate cover and suitable roosting and nesting opportunities for the Ground Parrot, which spends most of its time on or near the ground. When flushed, birds fly strongly and rapidly for up to several hundred metres, at a metre or less above the ground.	Not likely – no suitable habitat.
Powerful Owl <i>Ninox strenua</i>	Vulnerable NSW BC Act	Coastal Woodland, Dry Sclerophyll Forest, wet sclerophyll forest and rainforest- Can occur in fragmented landscapes Roosts in dense vegetation comprising species such as Turpentine <i>Syncarpia glomulifera</i> , Black She-oak <i>Allocasuarina littoralis</i> , Blackwood <i>Acacia melanoxylon</i> , Rough-barked Apple <i>Angophora floribunda</i> , Cherry Ballart <i>Exocarpus cupressiformis</i> and a number of eucalypt species. requires old growth elements-hollow bearing tree resources for nesting and prey resource. Nests in large tree hollows in large	Possible occurring at the site. However, no further assessment is required for the following reasons: No breeding habitat (hollow-bearing trees) would be removed.

		eucalypts that are at least 150yrs old. Often in riparian areas. Large home range	- The amount of vegetation that may be removed is insignificant relative to the habitat in the locality. - The vegetation that would be removed is marginal habitat without food sources essential to the species.
Masked Owl – <i>Tyto novaehollandiae</i>	Vulnerable NSW BC Act	Dry eucalypt forests and woodlands from sea level to 1100 m. Inhabits forest but often hunts along the edges of forests, including roadsides. Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting. Requires old growth elements-hollow bearing tree resources for nesting and prey source.	Possible occurring at the site. However, no further assessment is required for the following reasons: - No breeding habitat (hollow-bearing trees) would be removed. - The amount of vegetation that may be removed is insignificant relative to the habitat in the locality. - The vegetation that would be removed is marginal habitat without food sources essential to the species.
Sooty Owl <i>Tyto tenebricosa</i>	Vulnerable NSW BC Act	Occurs in rainforest, including dry rainforest, subtropical and warm temperate rainforest, as well as moist eucalypt forests	Unlikely to occur. No suitable habitat present on site.
Brown Treecreeper <i>Climacteris picumnus victoriae</i>	Vulnerable NSW BC Act and Vulnerable EPBC Act	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and River Red Gum (<i>Eucalyptus camaldulensis</i>) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also	Unlikely to occur. No suitable habitat present on site.

		recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.	
Regent Honeyeater <i>Anthochaera phrygia</i>	Endangered NSW BC Act and Critically Endangered Commonwealth EPBC Act	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests. The Regent Honeyeater is a flagship threatened woodland bird whose conservation will benefit a large suite of other threatened and declining woodland fauna. The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.	Unlikely to occur. No suitable habitat present on site.
Varied Sittella <i>Daphoenositta chrysoptera</i>	Vulnerable NSW BC Act	Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland	Unlikely to occur. No suitable habitat present on site.
Dusky Woodswallow <i>Artamus cyanopterus cyanopterus</i>	Vulnerable NSW BC Act	Primarily inhabit dry, open eucalypt forests and woodlands, including mallee associations, with an open or sparse understorey of eucalypt saplings, acacias and other shrubs, and ground-cover of grasses or sedges and fallen woody debris. It has also been recorded in shrublands, heathlands and very occasionally in moist forest or rainforest. Also found in farmland, usually at the edges of forest or woodland	Unlikely to occur. No suitable habitat present on site.

Scarlet Robin <i>Petroica rodinogaster</i>	Vulnerable NSW BC Act	The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.	Unlikely to occur. No suitable habitat present on site.
Pink Robin <i>Petroica rodinogaster</i>	Vulnerable NSW BC Act	Inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies.	Unlikely to occur. No suitable habitat present on site.
MAMMALS			
Spotted-tailed Quoll <i>Dasyurus maculatus</i>	Vulnerable BC Act and Endangered EPBC Act	Recorded across a range of habitat types. Quolls use hollow-bearing trees, fallen logs, other animal burrows, small caves and rock outcrops as den sites	Unlikely to occur. No suitable habitat present.
Koala <i>Phascolarctos cinereus</i>	Vulnerable BC Act	The koala inhabits eucalypt woodland and forest.	Unlikely to occur. No suitable habitat present.
Eastern Pygmy-possum <i>Cercartetus nanus</i>	Vulnerable BC Act	Found in a broad range of habitats from rainforest through sclerophyll forest and woodland, but in most areas woodlands and heath appear to be preferred. Feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes. The species shelters in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests, dreys or thickets of vegetation	Unlikely to occur. No suitable habitat present.
Yellow-bellied Glider - <i>Petaurus Australis</i>	Vulnerable NSW BC Act	Forest with old growth elements. Large Eucalypt Hollows for denning. Inhabits mature or old growth Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia mid storey. Feed primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein. Extract sap by incising (or biting into) the trunks and branches of favoured food trees, often leaving a distinctive 'V'-shaped scar. Very mobile and occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally variable food resources.	Unlikely to occur. No suitable habitat present.
Southern Greater Glider <i>Petauroides volans</i>	Endangered NSW BC Act and Commonwealth EPBC Act	Feeds exclusively on eucalypt leaves, buds, flowers and mistletoe. Shelters during the day in tree hollows and will use up to 18 hollows in their home range.	Unlikely to occur. No suitable habitat present.

Grey-headed Flying-fox <i>Pteropus poliocephalus</i>	Vulnerable BC Act and EPBC Act	The species occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Feeds on the nectar and pollen native trees, in particular <i>Eucalypts</i> , <i>Melaleuca</i> and <i>Banksia</i> , and fruits of rainforest trees and vines.	Possibly could occur at the site. However, no further assessment is required as: • The site is not a camp. • The amount of vegetation that may be removed is insignificant relative to the habitat in the locality. • The vegetation that would be removed is marginal habitat and not useful to the species. • The species will not reduce the amount of food or breeding resources nor create barriers to movement
Eastern Coastal Free-tailed Bat <i>Micronomus norfolkensis</i>	Vulnerable BC Act	The bat is found along the east coast from south Queensland to southern NSW. Occurs in dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in man-made structures.	Possibly could occur at the site. However no further assessment is required as: • The amount of habitat that may be removed is insignificant relative to the habitat in the locality. • No roosting habitat would be removed. • The species will not reduce the amount of food or breeding resources nor create barriers to movement. • The species has not actually been recorded at the site.

Eastern False Pipistrelle <i>Falistrorellus tasmaniensis</i>	Vulnerable BC Act	Prefers moist habitats, with trees taller than 20 m. Generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings.	Possibly could occur at the site. However no further assessment is required as: - The amount of habitat that may be removed is insignificant relative to the habitat in the locality. - No roosting habitat would be removed. - The species will not reduce the amount of food or breeding resources nor create barriers to movement. - The species has not actually been recorded at the site.
Southern Myotis <i>Myotis Macropus</i>	Vulnerable BC Act	The species is found in the coastal band from-west of Australia, across the top-end and south to western Victoria. Generally roost in groups of 10 to 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forages over streams and pools catching insects and small fish by raking their feet across the water surface.	Possibly could occur at the site. However, no further assessment is required as: - The amount of habitat that may be removed is insignificant relative to the habitat in the locality. - No roosting habitat would be removed. - The species will not reduce the amount of food or breeding resources nor create barriers to movement. - The species has not actually been recorded at the site.
Greater Broad-nosed Bat <i>Scoteanax rueppellii</i>	Vulnerable BC Act	The species is found mainly in the gullies and river systems that drains the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet	Possibly could occur at the site, however, no further assessment is required as: The amount of habitat that may be removed is

		forest and rainforest, though it is commonly found in tall wet forest. Although this species usually roosts in tree hollows, it is also been found in buildings.	insignificant relative to the habitat in the locality. - No roosting habitat would be removed. - The species will not reduce the amount of food or breeding resources nor create barriers to movement. - The species has not actually been recorded at the site.
New Zealand Fur-seal <i>Arctocephalus forsteri</i>	Vulnerable NSW BC Act	Prefers rocky parts of islands with jumbled terrain and boulders.	Not likely to occur.
Australian Fur-seal <i>Arctocephalus pusillus doriferus</i>	Vulnerable NSW BC Act	Prefers rocky parts of islands with flat, open terrain. They occupy flatter areas than do New Zealand Fur-seals where they occur together.	Not likely to occur.
Southern Right Whale <i>Eubalaena australis</i>	Endangered NSW BC Act and Commonwealth EPBC Act	Whale that lives in the open ocean.	Not likely to occur.
Sperm Whale <i>Physeter macrocephalus</i>	Vulnerable NSW BC Act	Whale that lives in the open ocean.	Not likely to occur