Minnamurra Rock Wall Assessment

Concept Design Report

Kiama Municipal Council

February 2022

311010-00189

Advisian
Worley Group

advisian.com

Disclaimer

Advisian has prepared this document on behalf of Kiama Municipal Council with financial assistance from the NSW Government through the Department of Planning, Industry and Environment. This document does not necessarily represent the opinions of the NSW Government or Department of Planning, Industry and Environment.

Company details

Advisian Pty Ltd
ABN 50 098 008 818
Level 17, 141 Walker Street
North Sydney NSW 2060
Australia
T: +61 2 9495 0500
F: +61 2 9810 5777

PROJECT 311010-00189 311010-00189-MA-RP: Minnamurra Rock Wall Assessment - Concept Design Report

Rev	Description	Author	Review	Advisian approval	Revision date	Client approval	Approval date
A	Issued for Discussion	L.Freeman	B.Morgan	B.Morgan	01.12.21		
B	Issued for Client Review	L.Freeman	B.Morgan	B.Morgan	10.01.22		
C	Final	L.Freeman	B.Morgan	B.Morgan	02.02.22		

Table of contents

Table list

Figure list

1 Introduction

1.1 Study Area and Background

The Minnamurra River, derived from the Aboriginal word *Mema Mora* 'river of many fish', is a mature wave dominated estuary located on the South Coast of NSW (Figure 1-1) within the Kiama and Shellharbour Local Government Areas (LGAs). It is a relatively small estuary that has been impacted by catchment changes, including sedimentation and erosion (Reinfelds, 1999) (Patterson Britton and Partners, 1995).

Figure 1-1 Minnamurra River Entrance and Stack Island (Source: Mark Fitz Photography)

The study area extends from James Oates Reserve, along the public foreshore area of Charles Avenue, to James Holt Reserve (Figure 1-2). The foreshore exhibits varying levels of active shoreline erosion, as such, Kiama Municipal Council (Council) intends to carry out staged foreshore stabilisation works.

Figure 1-2 Study Area

1.2 Scope of Works

Council has engaged Advisian to undertake a condition assessment of the existing shoreline and provide concept options and costings for repair. The project is divided into the following tasks:

- Review of background information
- Inception meeting and Site Inspection/Condition Assessment
- Preparation of Concept Design Report including ranking of priority areas and draft concept options for bank remediation works to a level of detail suitable for discussion
- Preparation, presentation and discussion on proposed concept options

2 Site Description

2.1 Site Description

Charles Avenue Foreshore is situated on the southern side of the Minnamurra River in the Kiama Local Government Area (LGA). The study area extends approximately 700m along the alignment of the foreshore from James Oates Reserve to James Holt Reserve. Some sections of the shoreline are backed by private properties and have not formed part of the assessment. The investigated foreshore is approximately 15 to 25m wide, grassed and relatively flat at an approximate RL 2 - 4 m AHD. The foreshore exhibits differing levels of active shoreline erosion and there are several ad-hoc and formalised shoreline stabilisation methods in place with varying degrees of structural integrity.

The site was initially inspected on 26th August 2021 and again on the 2nd November 2021 with Byron Robinson (Council), Mitchell Golding (Council), Cherie Parmenter (DPIE), Libby Freeman (Advisian) and Ben Morgan (Advisian). The site inspection involved observation on the effectiveness and condition of existing foreshore stabilisation measures, influence of trees on stability/instability, riparian vegetation as an indicator of possible recent instability/slumping, proximity and influence of stormwater outlets, wave exposure and typical tidal level fluctuations. The implementation of various conceptual options was discussed at the site inspection.

The study area has been divided into Areas A, B and C with chainages marked in 100 m intervals as shown in Figure 2-1. The condition of the shoreline protection works is detailed in Section 4.

Figure 2-1 Study Area Divided into Chainages and Areas A, B and C

3 Basis of Design

3.1 Purpose

The stabilisation works are required to address erosion, condition and issues affecting existing stabilisation structures along Charles Avenue foreshore. The designs adopted shall aim to accommodate the following where possible:

- Be of a soft treatment design where achievable
- Reinstate a natural, sloping foreshore with the aim of improving reserve and amenity
- Provide access to the water and inter-tidal habitat
- Increase recreational amenity and safety
- Improve habitat value using environmentally friendly seawall design
- Recycle existing material onsite where possible
- Minimise excavation and removal from site to reduce Acid Sulfate Soil risk
- Be applied elsewhere in the estuary where prevailing estuarine processes and bathymetry allow
- Be adaptive for accommodating future sea level rise

3.2 Guidelines, Standards and Project Documents

The following Guidelines, Standards and Project Documents were considered in the design of the foreshore stabilization.

Guidelines and Standards

Coastal management Act 2016

Australian Standard AS1170.2-2002 Structural Design Actions – Wind Actions

Australian Standard AS 2758.6-2008 Aggregated and Rock Engineering Purposes, Part 6: Guidelines for the Specification of Armourstone

Australian Standard AS4997-2020 Guidelines for the Design of Maritime Structures

Coastal Engineering Manual (CEM) prepared by US Army Corps of Engineers 2002

Coastline Management Manual (CMM) prepared by the NSW Government in 1990

Environmental Engineering for Coastal Shore Protection prepared by USACE

Environmentally Friendly Seawalls Guide prepared by DECC

Primfact 746 Mangroves prepared by NSW Department of Primary Industries 2008

Primfact 1256 Saltmarsh prepared by NSW Department of Primary Industries 2013

The Rock Manual prepared by CIRIA

Shore Protection Manual (SPM) prepared by US Army Corps of Engineers in 1984

Key Historical Project Documents

Kiama Coastline Coastal Management Program Stage 1 Scoping Study 2020

Coastal Zone Management Plan for the Minnamurra River 2015

Geomorphology of the Minnamurra River Estuary 2004

Minnamurra River Estuary Management Plans 1995 and 2003

3.3 Design Life

A nominal design life of 25 years has been selected for the rock and concrete components of the foreshore treatments.

3.4 Datums and Units

Levels and elevations are referred to the Australian Height Datum (AHD) unless stated otherwise.

3.5 Survey

The foreshore along Charles Avenue is at a height of approximately 2- 4m AHD (Figure 3-1).

Figure 3-1 Approximate Foreshore Levels Relative to Australian Height Datum (AHD) (Source: NSW Spatial Portal)

3.6 Geometry

The concept designs have taken into consideration the following geometric constraints:

- Existing shoreline profiles
- Existing structures (e.g., Seawalls, fences, stairs and buildings)
- Existing trees and other vegetation
- Aimed at minimising the need for excavation

3.7 Erosion

The general causes of bank erosion occurring along the foreshore are:

- Natural migration of the river
- Scouring during flood events
- Wave action from wind, boats and ocean swell penetration
- Runoff flowing down the banks
- Absence of riparian and marine vegetation (e.g., mangroves)
- Mobilisation of sediment by human and animal traffic

3.8 Wave Climate

The wave climate at the site is resultant from boat wake, locally generated wind waves and ocean swell penetration. Wind waves at the site are limited by the available fetch (distance of water over which the wind blows). The erosion assessment conducted for the 1995 Estuary Management Plan (PBP, 1995b) found that long period ocean waves were identified as the prime source of energy for the erosion, however, boat wake were considered to exacerbate the erosion problem.

3.9 Water Level

Historic tidal information for the site has been obtained from the Manly Hydraulics Laboratory tidal gauge. A summary of the tidal planes relative to Australian Height Datum (AHD) is presented in Table 4-4.

Table 3-1 Tidal Planes for Minnamurra River (MHL)

Tidal Planes	Water Level (m)
High High Water Springs (HHWS)	0.943
Mean High Water Springs (MHWS)	0.590
Mean High Water (MHW)	0.508
Mean Sea Level (MSL)	0.113
Mean Low Water (MLW)	-0.282
Mean Low Water Springs (MLWS)	-0.364

Tidal Planes	Water Level (m)
Indian Spring Low Water (ISLW)	-0.616

3.10 Sea Level Rise

Sea levels can influence the surface water levels of connected rivers and estuaries.

The most recent Intergovernmental Panel on Climate Change (IPCC) emissions scenarios used are described as Representative Concentration Pathways (RCPs) and range from very low (RCP2.6) to very high (RCP8.5) concentrations. Projections for Kiama are presented in Figure 3-2. The South Coast Regional Sea-level Rise Planning and Policy Response Framework (Whitehead and Associates, 2014) provides guidance regarding sea level rise scenarios for the south coast region. The report recommended "RCP8.5 is a suitable basis for sea level rise projection" and "that RCP8.5 be adopted as a basis for decision making".

As such for a 25 year design life a sea level rise of approximately 0.25m shall be adopted (RCP8.5).

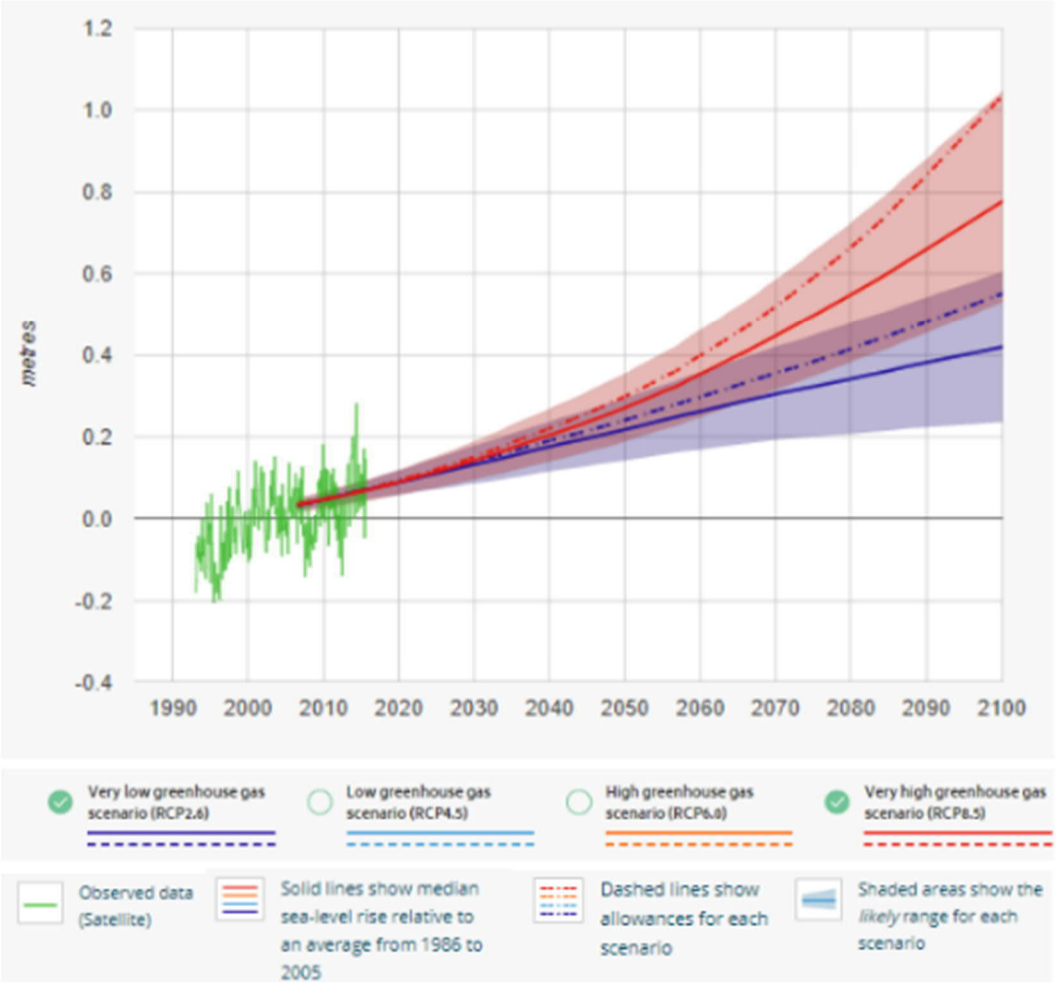


Figure 3-2 Predicted Sea Level Rise for Kiama for Very Low and Very High Scenarios (Source: Coast Adapt, 2018)

3.11 Flood Levels

The average maximum flood level on Terragong Swamp is approximately 4.0 m AHD (Panayotou, 2004).

3.12 Geotechnical Stability

Conventional low height design profiles have been used that would not be subject to a geotechnical stability analysis. Further geotechnical investigation may be required for the detailed design of access steps.

3.13 Vegetation

Vegetation has been proposed in each of the concept options. Vegetation can improve bank stability by dissipating wave energy, encouraging the accumulation of organic and inorganic sediment, and acting as a sediment binder that resists erosion. It is proposed to adopt native vegetation in keeping with the surrounding environment.

4 Condition Assessment

4.1 Condition Assessment

The condition of the shoreline protection works was assessed during the site inspection undertaken on the 2nd of November 2021 and is detailed below.

Area A (Chainage 0 – 100 m) is presented in Figure 4-1 and comprises of the following:

- Grassed eroded foreshore, approximate 0.5 to 1 m vegetated scarp.
- Varying sized small angular rubble.
- Larger stacked blocks (3 blocks high), total height of approximately 1 m at approximate Chainage 0 and Chainage 100 m.
- Well established Mangroves adjacent to Chainage 0.

Area B (Chainage 100 – 350 m) is presented in Figure 4-2 to Figure 4-4 and comprises the following:

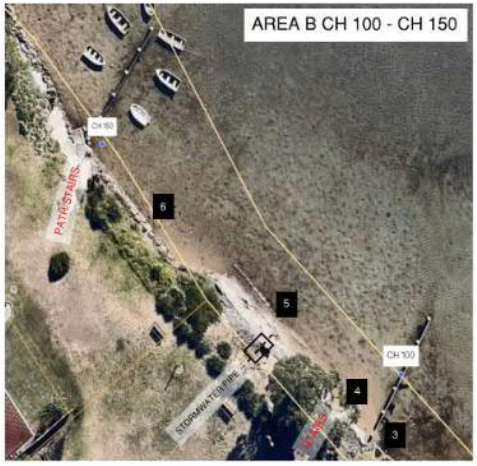
- Three timber groynes with missing planks, necking of the timber piles and generally showing signs of timber deterioration.
- Concrete access steps at CH 100 experiencing settlement and scour at toe. Concrete access steps at approximate CH 150, 250 and 350.
- Concrete matting approximate CH 120 experiencing washout behind matting and damage.
- Concrete stormwater pipe ~CH 120 exposed reinforcement.
- Vertical block seawall with mortared areas along the crest. In areas where the larger blocks (~600mm) two stones high have been adopted. Wall is performing well.
- CH 170 rock wall experiencing scour along crest due to inadequate height, exposed geotextile and areas where mortar, small rubble has been placed along crest.
- CH 300 well vegetated (Carpobrotus glaucescens (Pigs Face)) rock wall performing well.
- Established mangroves at chainages 200, 250 and 300 m where sediment is accumulating and providing protection to the foreshore.
- Two concrete reinforced stormwater pipes (CH 350) with gabions as scour protection. No signs of deterioration of pipes. Implement large rock around pipes to provide support and protect the banks.

2. Bank erosion, scarp ~1m high. Add riprap, rock pool or beach nourishment along extent of shoreline as per concept options provided. Vegetate crest with pigs face or similar to sprawl over edge as existing elsewhere. Alternatively, can consider a salt marsh berm in the riprap design.

1. Small erosion scarp ~0.5 - 1m high. Add riprap, rock pool or beach nourishment along bank as per concept options provided. Vegetate crest with pig face or similar to sprawl over edge as existing elsewhere. Alternatively, can consider a salt marsh berm in the riprap design. Add formal access point.

NOTE: At CH 0 established mangroves are to be protected as they are offering protection to the bank and allowing the accumulation of sediment.

Figure 4-1 Shoreline Protection Area A Extending from Chainage 0 to 100 m



3. Grouted rock wall approximately 1m high. Necking of timber groyne piles - repair with a concrete filler collar (FRP collar that wraps around the pile and filled with appropriate mortar mix) or similar.

4. Mixture of small rubble and larger rock. Staircase experiencing settlement and cracking. Large gum and light pole at top of stairs. Crest level approximately 3m AHD. Rebuild staircase on stable foundation or on piles. Rebuild revetment (retaining tree as bank stabilisation) with rock rip rap to an adequate scour depth. Vegetate with sprawling pigs face, alternatively a salt marsh berm can be incorporated. Retain light pole and shower if possible, alternatively replace with solar light and move landward.

5. Deteriorated concrete storm water pipe with exposed reinforcement. Displaced and cracking concrete mattress. Washout of bank behind mattress.
Remove concrete scour matting and construct revetment as in point 4.

6. Rock wall approximately 2 stones high. Rock diameter approximately 600mm. Areas at the crest of the wall where geotextile is exposed and minor scour however generally in good condition. Stairs at CH150 experiencing settlement of concrete base.
Consider incorporating rock scour protection infront of wall, or steeping top course of blocks back to slope the bank. Consider incorporating alternate access with a ramp for passive craft.

Figure 4-2 Shoreline Protection Area B Extending from Chainage 100 to 150m.

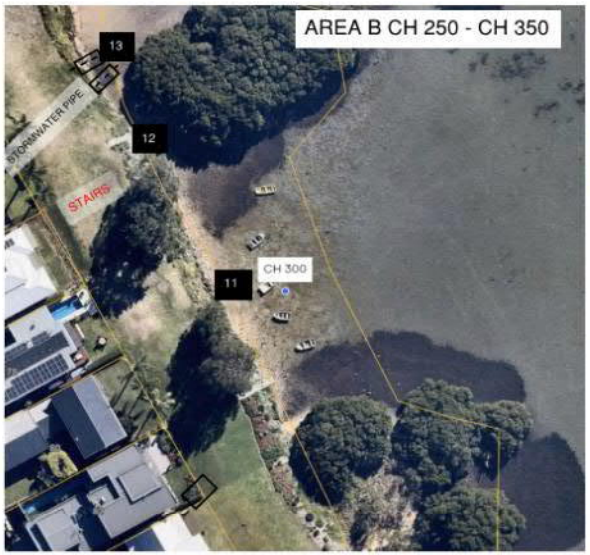
8. Well vegetated rock wall in excellent condition due to protection offered by mangroves.

9. Concrete stairs in good condition. Add rock scour protection around base of stairs or piles.

7. Rock wall with mix of large (~600mm diameter) and smaller rock. Scour along crest of wall. Areas of exposed concrete matting and geotextile. Slumping in some sections. Grout has been applied along the crest in some areas. Increase height of wall or add additional scour protection along crest. Rebuild/recycle existing rock. Install rock scour protection along toe to prevent future slumping/overturning

10. Slumping of rock wall adjacent to stairs. Rebuild rock revetment, two stones high on an angle (not vertical face) and add toe scour protection.

Figure 4-3 Shoreline Protection Area B Extending from Chainage 150 to 250m.



12. Concrete stairs experiencing minor settlement.
Rebuild lower section of stairs on piles.

11. Vegetated rock wall in excellent condition.
Consider adding scour protection along toe.

13. Two reinforced concrete storm water pipes. Gabion scour protection. Gabion baskets have been repaired and some are in need of repair.
Consider replacing gabions with stone blocks in the future.

Figure 4-4 Shoreline Protection Area B Extending from Chainage 250 to 350m.

Area C chainages 350 to 700m comprises the following and is shown in Figure 4-5 and Figure 4-6.

- Vegetated sections of natural bank performing well and sand accumulation in areas protected by mangroves.
- Concrete access ramp (~CH 380) exposed at toe and experiencing washout from underneath.
- Slumping of bank in areas with no rock protection/no mangroves in front.
- Minor displacement of concrete stairs (~CH 450).
- Two reinforced concrete stormwater pipes with gabion protection (CH 500).
- Erosion scarp approximately 2 m high next to stormwater pipe where there is no rock bank protection.
- Areas where the height of the rock wall needs to be increased to mitigate against scour occurring behind wall.

14. Concrete ramp exposed at toe and experiencing washout underneath. Erosion occurring along the downstream bank. Cutoff ramp above HWM and replace with FRP mesh on piles at end.

15. Slumping of bank adjacent to rock protection. Continue rock protection all the way along bank to ramp.

16. Rock wall approximately two stones high, well vegetated and in good condition from CH 400 to CH 500. Concrete stairs showing signs of displacement.
Consider toe scour protection along extent of rock wall.

17. Two reinforced concrete storm water pipes with gabion scour protection.
Slumping occurring next to the pipe at approximate CH 510, continue rock wall in this area.
Repair displacement and cracking of storm water pipes. Add rock scour protection.

Figure 4-5 Shoreline Protection Area C Extending from Chainage 350 to 550m.

18. Concrete stairs currently in good condition. Displacement may start to occur in sections were material is being washed out from underneath. Fill under concrete stairs with concrete. Add rock scour protection at toe or alternatively place on piles.

19. Minor settlement of stairs occurring. Grout has been used on the stair landing aimed at minimising further settlement. Rocks placed either side of stairs as scour protection. Material appears to be being washed out from under stairs. Replace lower portion of stairs and place on piles.

20. Erosion occurring along crest of wall. Wall height needs to be increased. Displaced rocks along extent of wall - better placement required. Rebuild wall (approx two stones high) and rock scour protection along toe.

21. Concrete ramp with lower portion made from FRP. In good condition. Displacement of rocks either side of ramp and minor slumping - increase height of wall crest.

Figure 4-6 Shoreline Protection Area C Extending from Chainage 550 to 700m.

4.2 Ranking of Remediation Areas

A consequence category based on Table 4-1 and risk matrix (Table 4-2) were used to rank and prioritise those areas requiring remediation.

Table 4-1 Consequence Category

Criteria	Consequence Category				
	Insignificant	Minor	Moderate	Major	Catastrophic
Erosion/Condition	Insignificant erosion	Minor erosion observed	Moderate level of erosion observed	Major erosion observed	Catastrophic erosion with impact on safety and amenity
Access	Insignificant - no access issues	Minor access concerns	Moderate issues associated with access to the foreshore	Major access deterioration	Catastrophic impact on access to the foreshore
Visual Impact	Low impact to the surrounding environment	Minor impact to the visual amenity of the site	Moderate impact to the visual amenity of the site	Major impact to the visual amenity of the site	Catastrophic impact to the visual amenity of the site
Safety	Insignificant safety issues	Minor impact to public safety	Moderate impact to safety	Major impact to safety	Catastrophic impact to safety

Table 4-2 Risk Matrix

	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	**High**	**High**	**Extreme**	**Extreme**	**Extreme**
Likely	**Moderate**	**High**	**High**	**Extreme**	**Extreme**
Moderate	**Low**	**Moderate**	**High**	**Extreme**	**Extreme**
Unlikely	**Low**	**Low**	**Moderate**	**High**	**Extreme**
Rare	**Low**	**Low**	**Moderate**	**High**	**High**

The criteria, rating and consequence are shown in Table 4-3.

Table 4-3 Criteria and Rating of Remediation Areas

Criteria	Comment	Consequence Category	Rating
Area A – Chainage 0 -100			
Erosion/Condition	Erosion scarp approximately 0.5 – 1.0 m high	Moderate	Moderate
Access	Access via erosion scarp and informal stone steps	Minor	Low
Visual Impact	The beach area could be made more visually appealing	Minor	Low
Safety	Minimal safety issues	Minor	Low
	OVERALL RATING	Minor	Low
Area B - Chainage 100 - 350			
CH 100 - 105			
Erosion/Condition	Rubble wall adjacent to steps adequate	Minor	Low
Access	Settlement of steps and scour at toe	Minor	Low
Visual Impact	This small section could be made more visually appealing	Minor	Low
Safety	Minimal safety issues	Minor	Low
	OVERALL RATING	Minor	Low
CH 105 – 130			
Erosion/Condition	Very deteriorated concrete matting Washout behind matting potentially leading to significant slope instability	Major	High
Access	No access in this section	-	-
Visual Impact	High visual impact, unsightly concrete matting and deterioration of the stormwater pipe	Major	High
Safety	Potential safety issues with exposed and deteriorated matting as well as slope instability	Major	High
	OVERALL RATING	Major	High
CH 130 – 200			
Erosion/Condition	Rock wall performing well, increase crest height by adding additional rock where scour occurring	Minor	Low
Access	One access point at CH150 – lower portion of stairs requires replacement	Moderate	Moderate
Visual Impact	No visual impact		

Criteria	Comment	Consequence Category	Rating
Safety	Access point potential safety concern	Moderate	Moderate
	OVERALL RATING	Moderate	Moderate
CH 200 – 300			
Erosion/Condition	Rock wall collapsing in sections, rebuild as per existing using available material. Increase crest height by adding additional rock where scour occurring	Minor	Low
Access	Stairs at CH240 and 280 in good condition – minor settlement consider rebuilding lower portion on piles or adding additional scour protection around base	Minor	Low
Visual Impact	No visual impact	Minor	Low
Safety	No safety concerns	Insignificant	Low
	OVERALL RATING	Minor	Low
CH 300 – 350			
No works required			
Area C - Chainage 350 - 700			
CH 350 - 500			
Erosion/Condition	Large rock size, displacement of rock and erosion occurring either side of access ramp where there is no shoreline protection. Adopt concept C	Moderate	Moderate
Access	Washout occurring under concrete access ramp – replace lower portion	Moderate	Moderate
Visual Impact	Stormwater pipes and gabions not visually appealing	Moderate	Moderate
Safety	Exposed gabion mattresses and very large rock potential safety hazard	Moderate	Moderate
	OVERALL RATING	Moderate	Moderate
CH 500 - 550			
Erosion/Condition	Large erosion scarp adjacent to stormwater pipe - adopt concept C protection	Major	High
Access	Stair access in good condition	Minor	Low
Visual Impact	Stormwater and erosion scarp visually unappealing	Major	High
Safety	Safety concerns with large scarp height and exposed gabions	Major	High
	OVERALL RATING	Moderate	High

Criteria	Comment	Consequence Category	Rating
CH 550 – 600			
Excellent condition, maintain mangrove vegetation			
CH 600 - 700			
Erosion/Condition	Scour occurring along crest of wall, rebuild and increase crest height	Minor	Low
Access	Access points in good condition – gradually replace out when required	Minor	Low
Visual Impact	Displaced rock	Minor	Low
Safety	Minimal safety issues	Minor	Low
	OVERALL RATING	Minor	Low

The overall ranking of treatment areas is detailed below.

Table 4-4 Ranking of Areas for Remediation

Chainage	Consequence Cateogry	Rating
CH 105 - 130	Major	High
CH 500 - 550	Moderate	High
CH 130 – 200	Moderate	Moderate
CH 350 - 500	Moderate	Moderate
CH 0 -100	Minor	Low
CH 100 - 105	Minor	Low
CH 200 - 300	Minor	Low
CH 600 - 700	Minor	Low
CH 300- 350	No Works	
CH 550 - 600	No Works	

5 Concept Design

5.1 Failure Modes of Revetment Designs

Failure modes of revetments for the foreshore stabilisations works were considered in the design. A structure is deemed to have failed if damage has occurred that results in structure performance and functionality below the minimum anticipated design (USACE, 2006). Failure may occur for one or more of the following reasons (USACE, 2006):

- Design failure: when the structure as a whole, or individual structure components cannot withstand load conditions within the design criteria.
- Load exceedance failure: when anticipated design load conditions are exceeded.
- Construction Failure: due to incorrect or poor construction or material.
- Deterioration failure: from structure deterioration and/or poor maintenance.

Possible failure modes for revetment design are summarised in Figure 5-1 to Figure 5-4. These failure modes have been considered as part of the design process for this project, as described in Table 5-1.

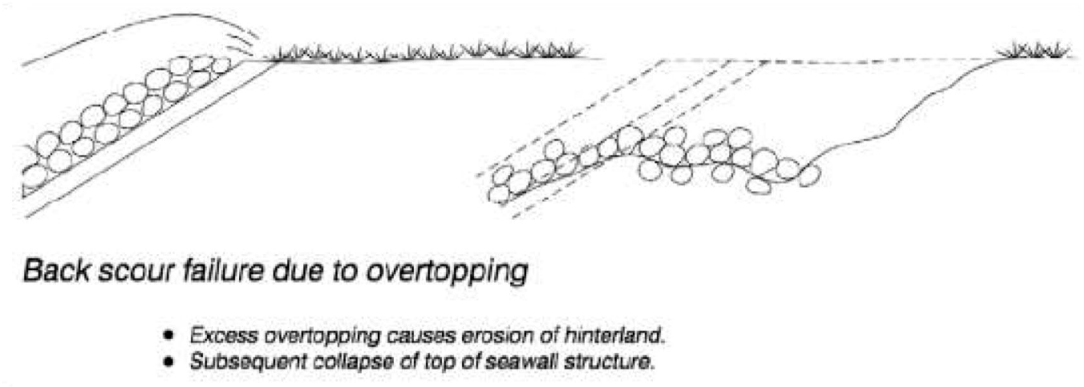


Figure 5-1 Scour Due to Overtopping (USACE, 2006)

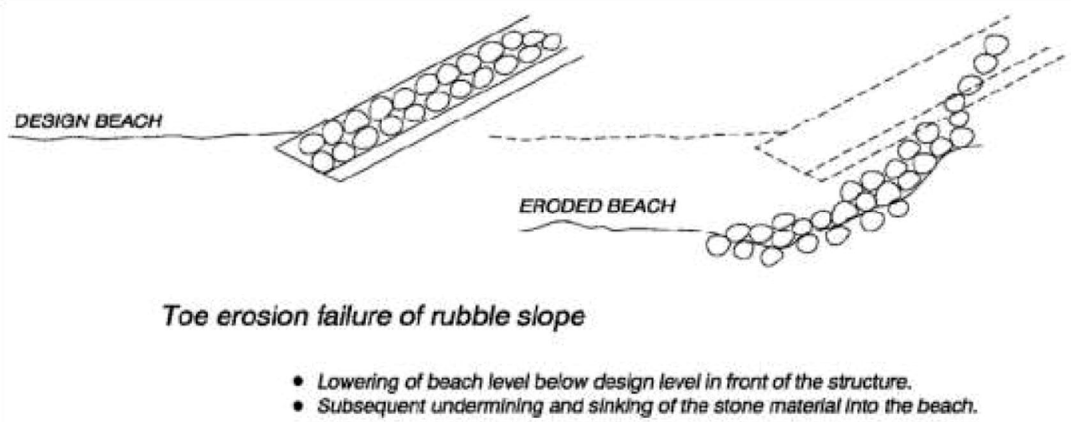


Figure 5-2 Toe Erosion Failure of Rubble Slope (USACE, 2006)

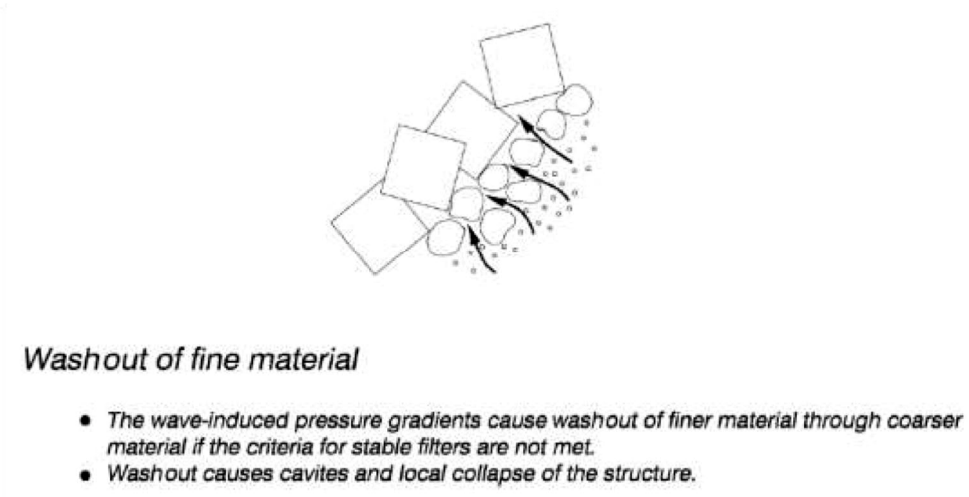


Figure 5-3 Washout of Underlying Material (USACE, 2006)

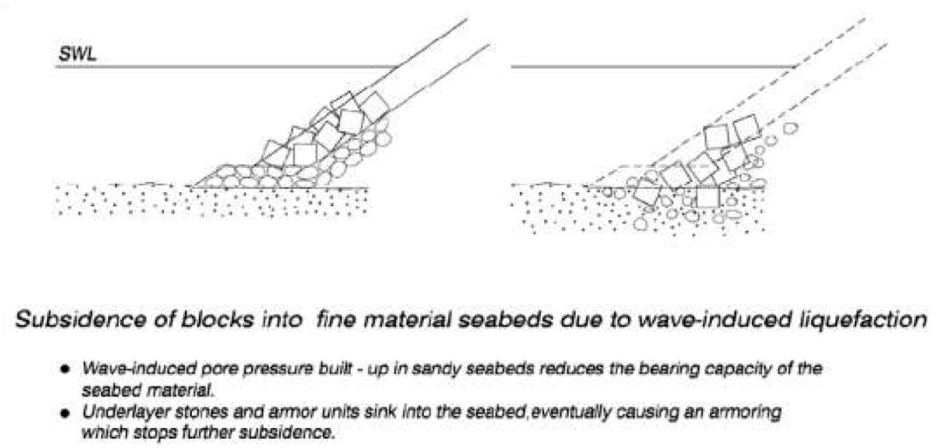


Figure 5-4 Block Subsidence Due to Liquefaction (USACE, 2006)

Table 5-1 Design Features Addressing Possible Failure Modes

Possible Failure Mode	Design Feature to Address Failure Mode
Scour due to overtopping	High crest level relative to prevailing wave climate and water levels such that overtopping would be limited to rare water level or wave events.
Toe erosion failure of rubble slope	Construct toe to design scour level. Alternatively adopt a layer of large rock placed at the toe of the seawall to provide additional protection against scour if toe erosion were to occur. This rock layer could settle to a level below the MLWS level of -0.364m AHD without compromising structural integrity of the wall.
Washout of underlayer material	Incorporate a gravel layer or suitable geotextile between the bed and revetment to minimise washout of fine material.
Block subsidence due to liquefaction	Gravel between the bed and revetment and/or possibly a geotextile filter would minimise wave-induced pore pressures in the seabed, which in would be low because of the mild wave climate at the site.

5.2 Concept Design Options

The concept designs have been developed in accordance with the Basis of Design in Section 3 and informed by the walkover assessment in collaboration with Council, DPIE and the site investigators. The concept designs are presented as a series of design sketches provided in the following section.

The concept designs recommended consist of:

- Riprap - Riprap is used for shore and bank protection structures that are not exposed to high waves or strong currents. The wider size distribution of riprap provides a less uniform armor layer that is more susceptible to damage by strong waves and currents. Riprap is less expensive than uniform stone, and placement on the slope is usually less precise (e.g., dumping from trucks). Riprap has been nominated as a concept remediation option in Area A and in sections of Area B as detailed in the concepts below.
- Rockpool Treatment
- Sand Nourishment
- Rock Treatment
- Mangrove Treatment (discussion only) protect existing established mangroves
- Stair Treatment
- Stormwater Pipe Treatment

The site is restrained to a narrow Council reserve with stands of Casuarinas on the existing embankment and near property boundaries. Due to these constraints, design options that reduce the width of the reserve were not recommended. In addition, adopting mangrove treatment along the full length of the foreshore has not been proposed due to the potential complications with residents and hindered view corridors. Where stands of mangroves exist, they are performing well, and it is recommended to protect to allow for expansion and signage aimed at highlighting the benefits of mangroves as a form of erosion management.

The concept designs are discussed in more detail below:

<u>Concept A – Riprap (Area A Chainage 0 -100)</u>

- Minimum two layers of riprap protection at a slope of 1V:5H. A steeper slope of up to 1V:2H can be adopted if preferred
- Founded on suitably prepared subgrade
- Buried rock toe protection
- Geotextile to extend under the underlayer
- Mix of native vegetation to be planted along the crest of treatment
- Grasses expected to partially grow over crest of treatment

<u>Concept A Alternative – Rock Pool (Area A Chainage 0 -100)</u>

- Rock bedding
- Rocks and larger boulders spaced to provide rock pool habitat
- Grasses and planting expected to grow over crest treatment

Concept A Alternative – Beach Nourishment (Area A Chainage 0 -100)

- Rebuild foreshore lost due to gradual erosion through placement of sand from the adjacent sand spit
- Allow for average scarp height of 1m along full length of CH 0 – 100
- Sand placement to be benched to match existing foreshore height represented by edge of existing vegetation then sloped down to water no steeper than 1:5

Concept B – Riprap (Area B Chainage 105-130)

- Demolition existing bank protection and potentially reuse material.
- Minimum two layers of riprap protection at a slope of 1V:1.5H for the primary layer and 1V:3H for the underlayer. The riprap will extend out past the existing bank alignment.
- Subgrade
- Geotextile to prevent migration of fines
- Buried toe protection
- Option – incorporate a rock berm approximately 1m wide

Concept C – Existing (Remainder of site Ch 130 – 700)

- Add additional rock at crest to minimise scour behind
- Offset second level rock to remove vertical face
- Incorporate buried rock toe protection

In those locations where there are concrete stairs it is recommended to consider incorporating piled foundations for the base of the stairs (Figure 5-18) and scour protection to minimise further settlement and scour. Rock bedding should be added under stormwater pipes to provide support and minimise further damage and scour (Figure 5-20).

GENERAL
1. INCORPORATE TOE SCOUR PROTECTION ALONG FULL EXTENT OF SEAWALL.
2. STAIRS *TYPICAL* - BASE OF STAIRS TO BE REINSTATED ON PILES OR PROTECTED WITH ROCK SCOUR PROTECTION.
3. INCREASE CREST HEIGHT IN ALL AREAS EXPERIENCING SCOUR AT CREST.
4. TIMBER GROYNE PILES *TYPICAL* - REPAIR NECKING OF TIMBER PILES WITH CONCRETE FILLER COLLAR OR SIMILAR

Figure 5-5 Study Area and Types of Remediation

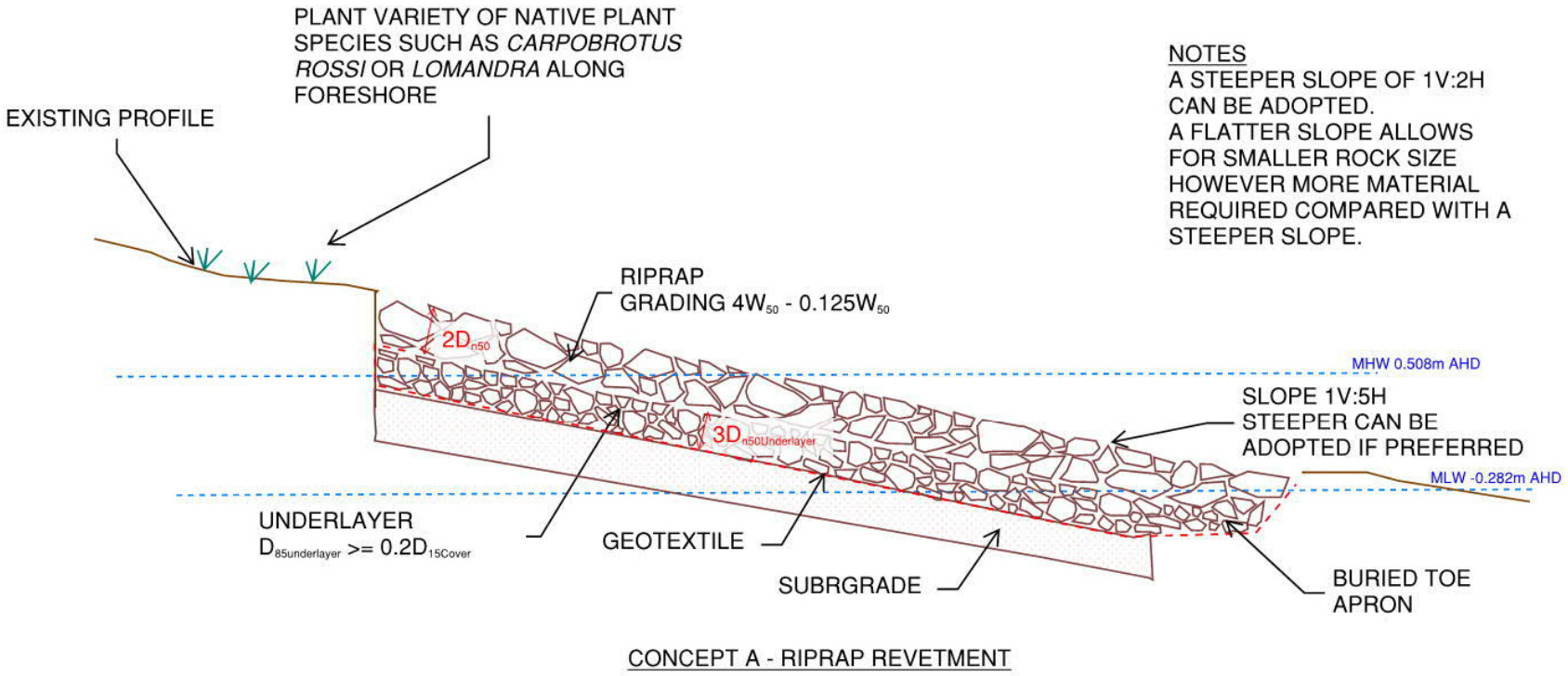


Figure 5-6 Concept A – Riprap Foreshore Protection

Figure 5-7 Examples of Riprap Shoreline Protection

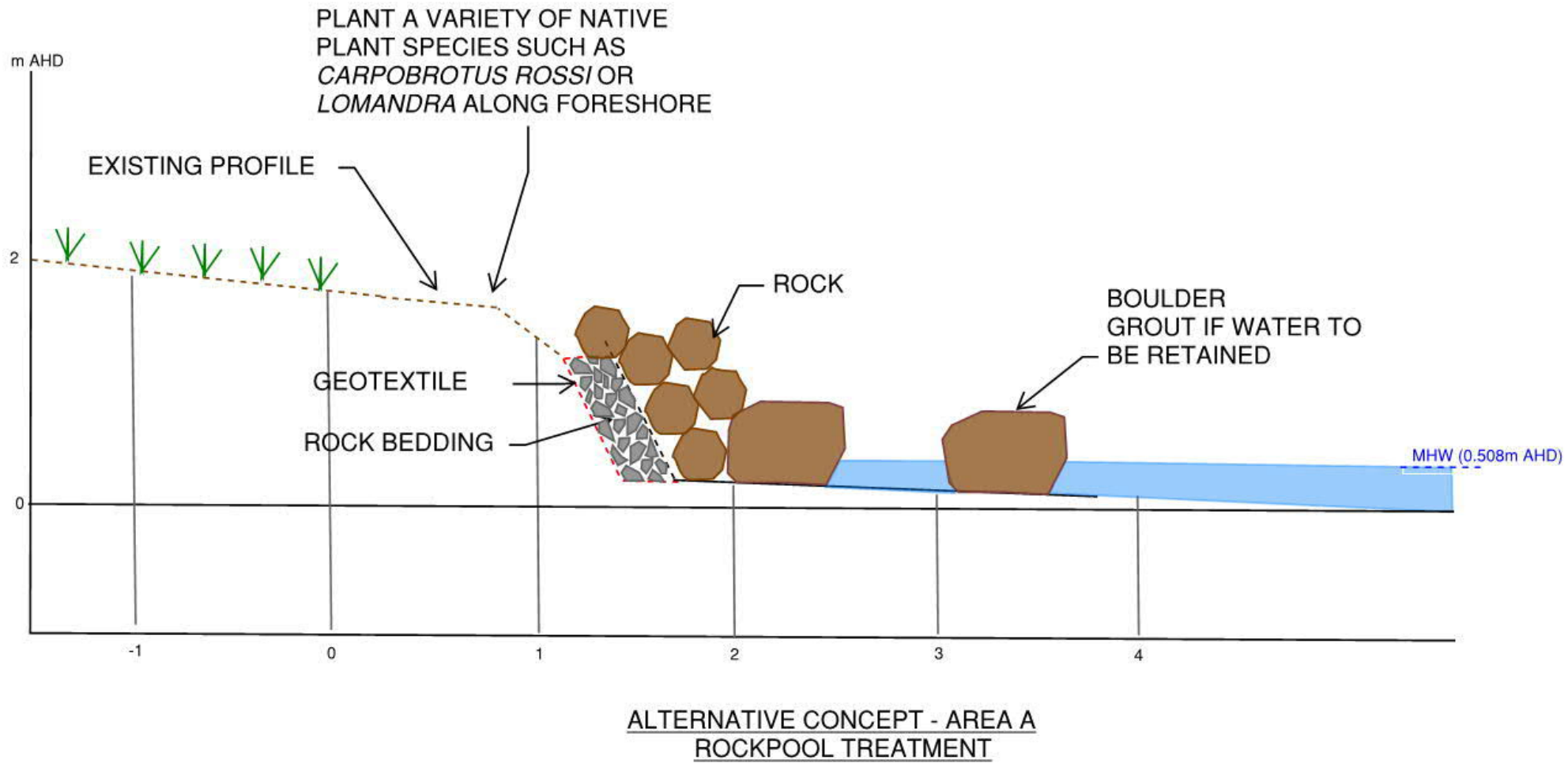
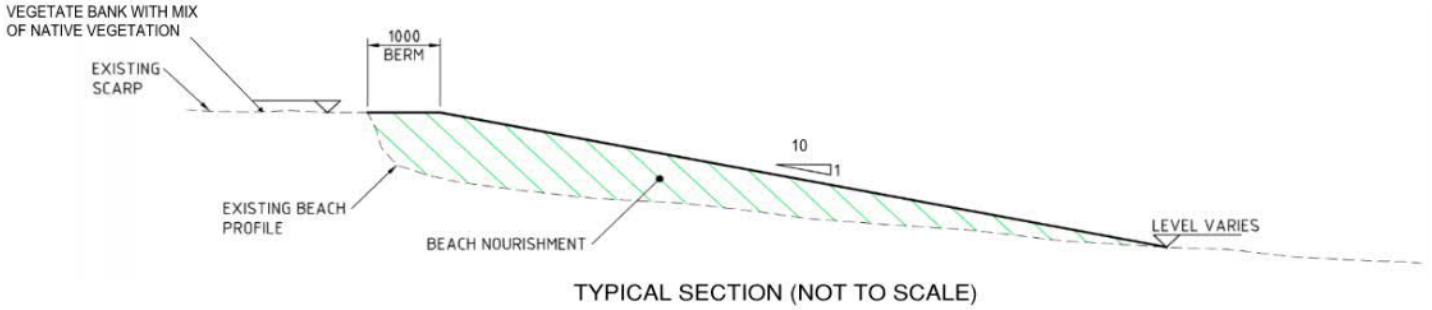


Figure 5-8 Alternative Concept A – Rockpool Foreshore Protection

Figure 5-9 Example of Rockpool Treatment

SAND SOURCE AND PLACEMENT PLAN



TYPICAL SECTION (NOT TO SCALE)

Figure 5-10 Alternative Concept A – Beach Nourishment

Figure 5-11 Example of Small Micro Dredger for Sand Nourishment

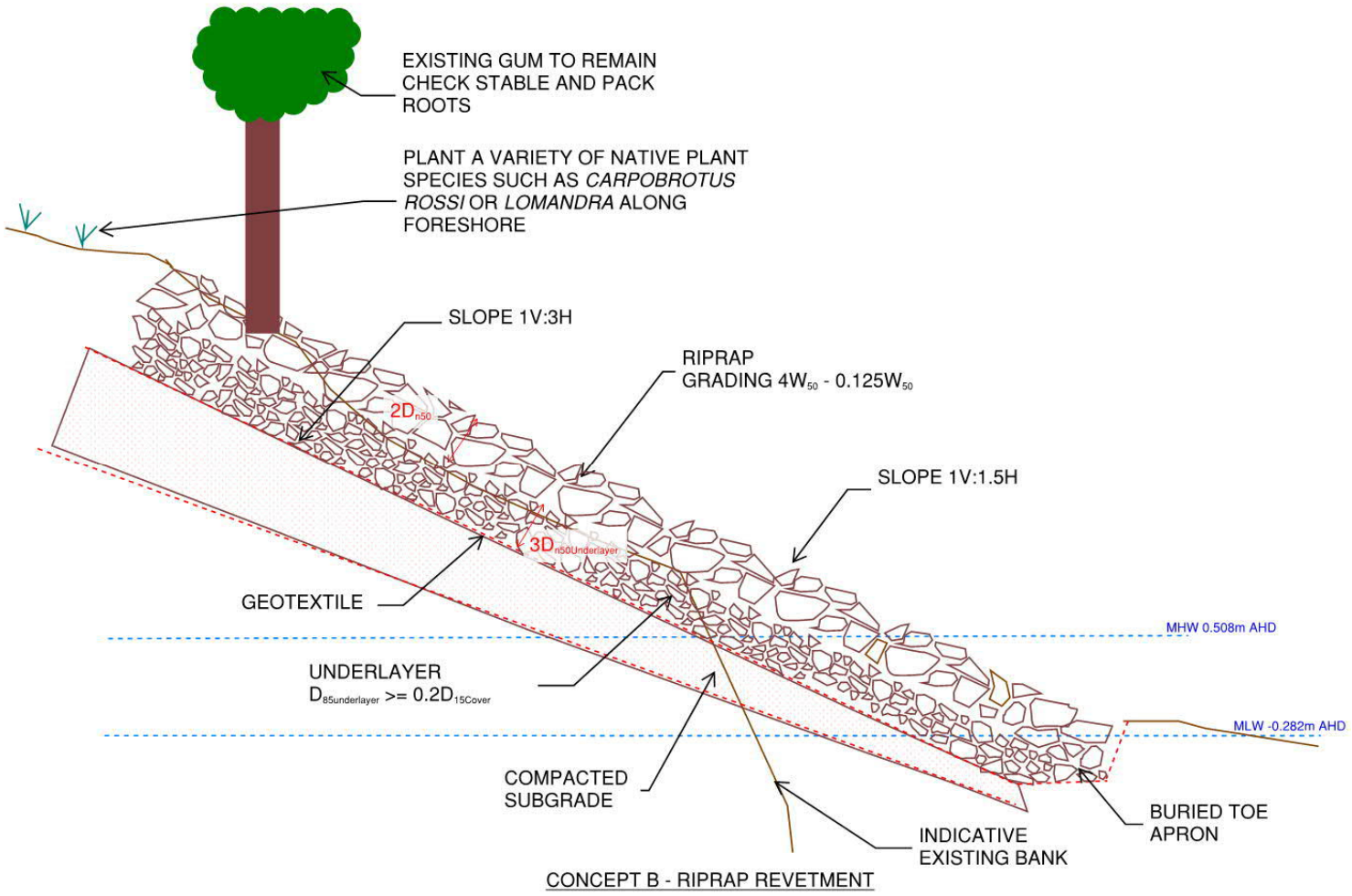


Figure 5-12 Concept B – Riprap Protection Slope of 1V:1.5H

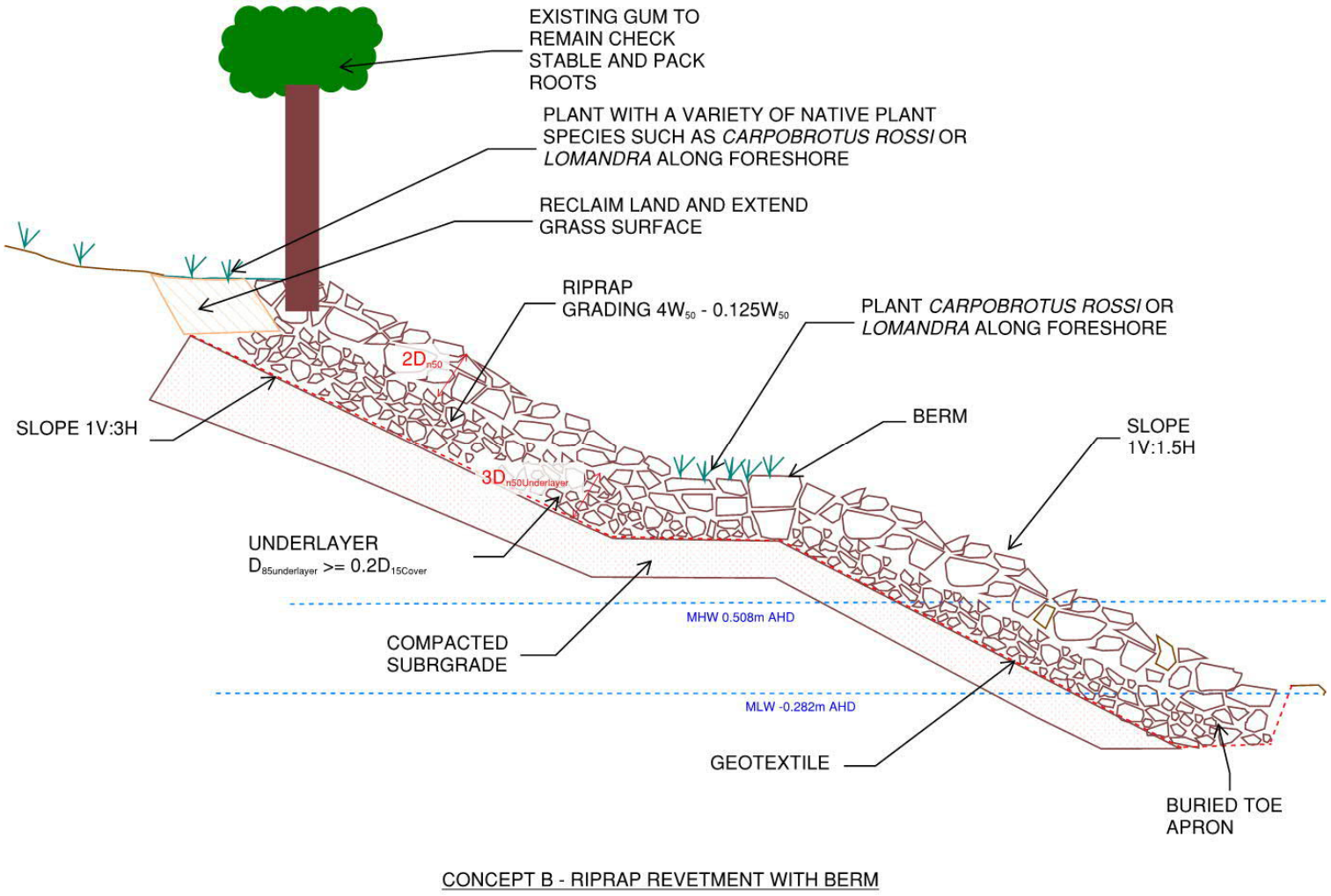


Figure 5-13 Concept B – Riprap Protection with Berm (Berm Planted with Native Vegetation)

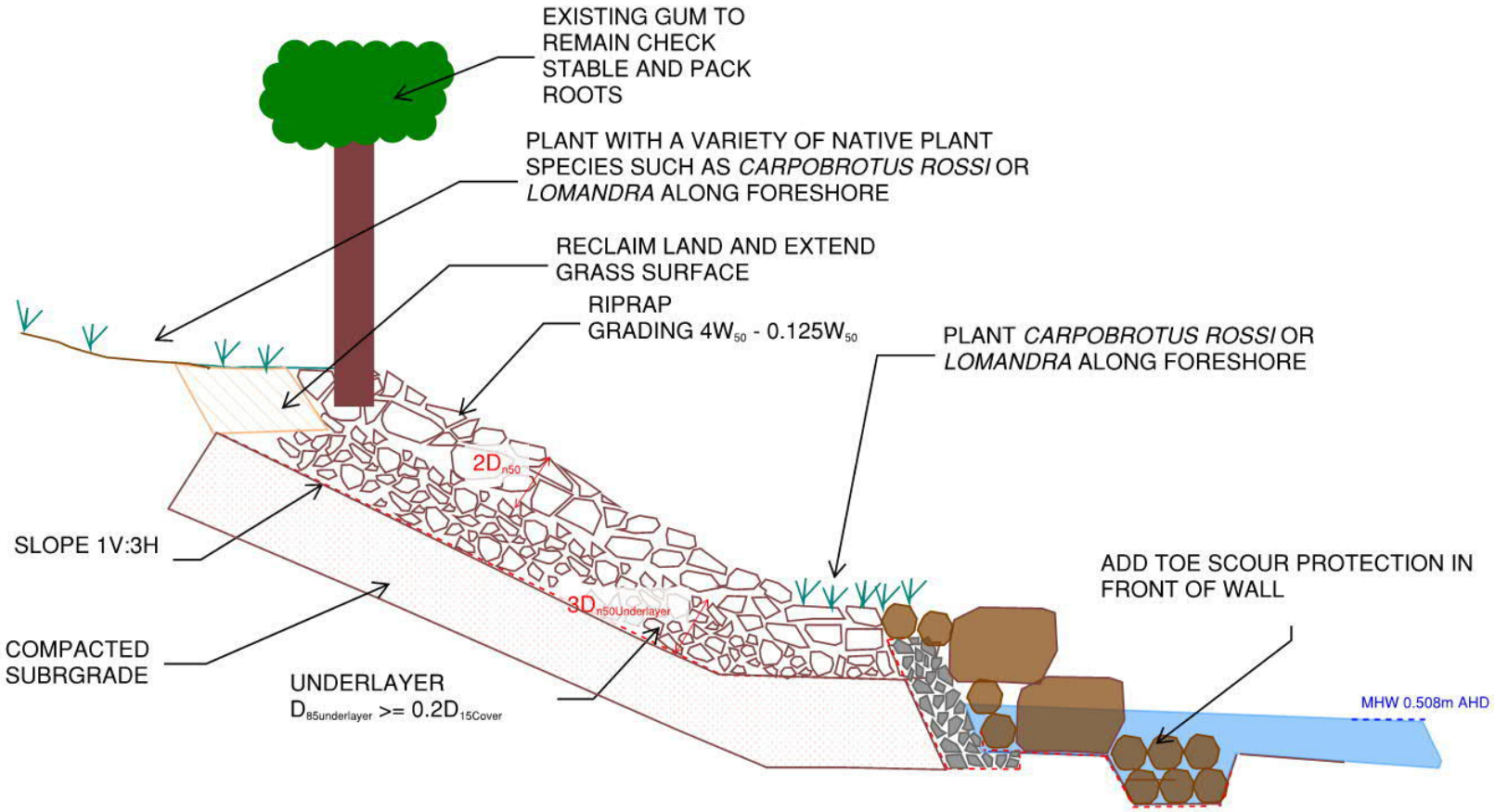


Figure 5-14 Concept B Alternative to Match in With Adjacent Wall

Figure 5-15 Example of Rock Protection with Vegetated Berm and Crest

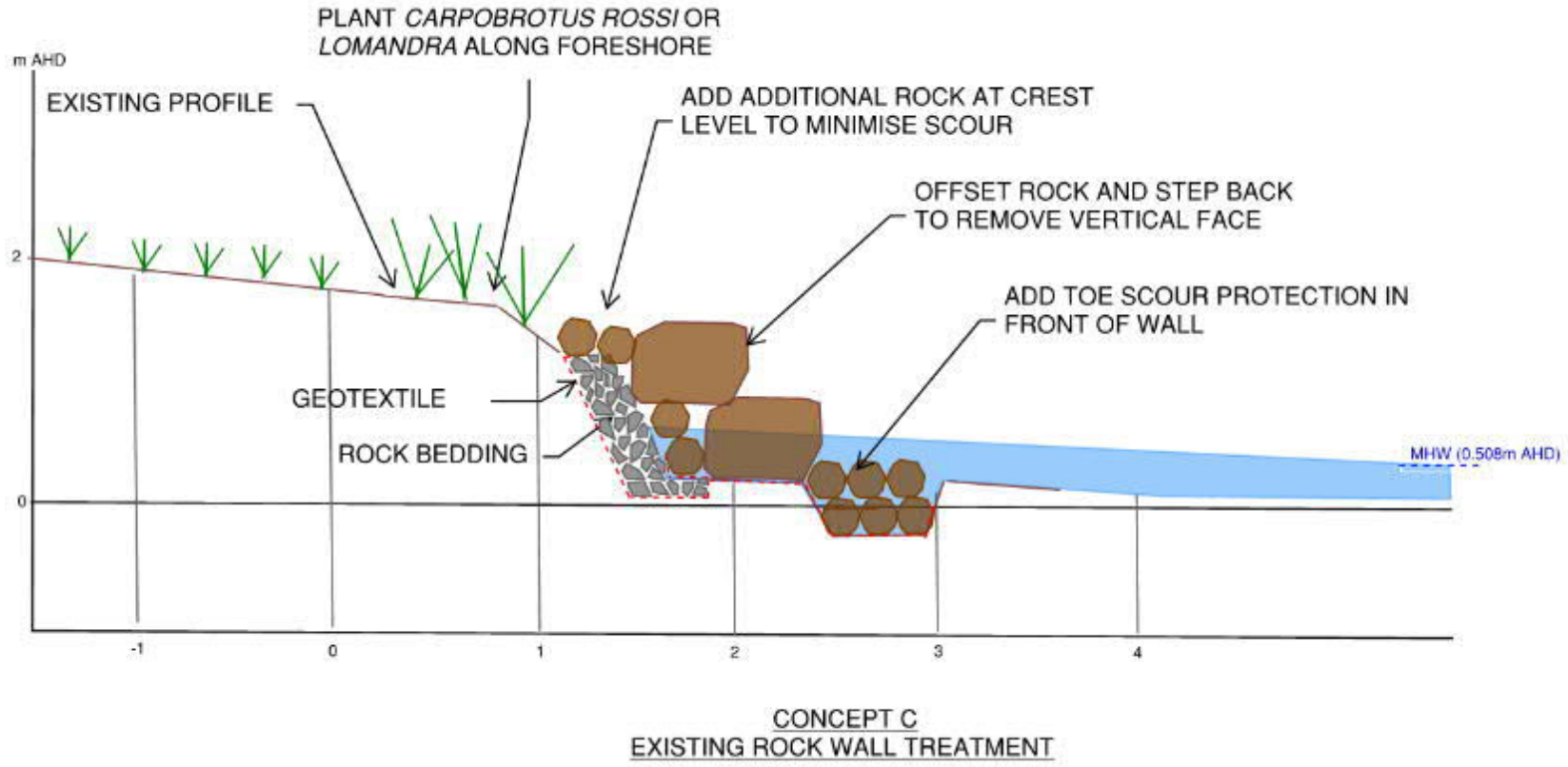


Figure 5-16 Concept C – Existing Rock Wall Treatment

Figure 5-17 Example of Existing Rock Wall Treatment (Note no scour protection shown– to be incorporated)

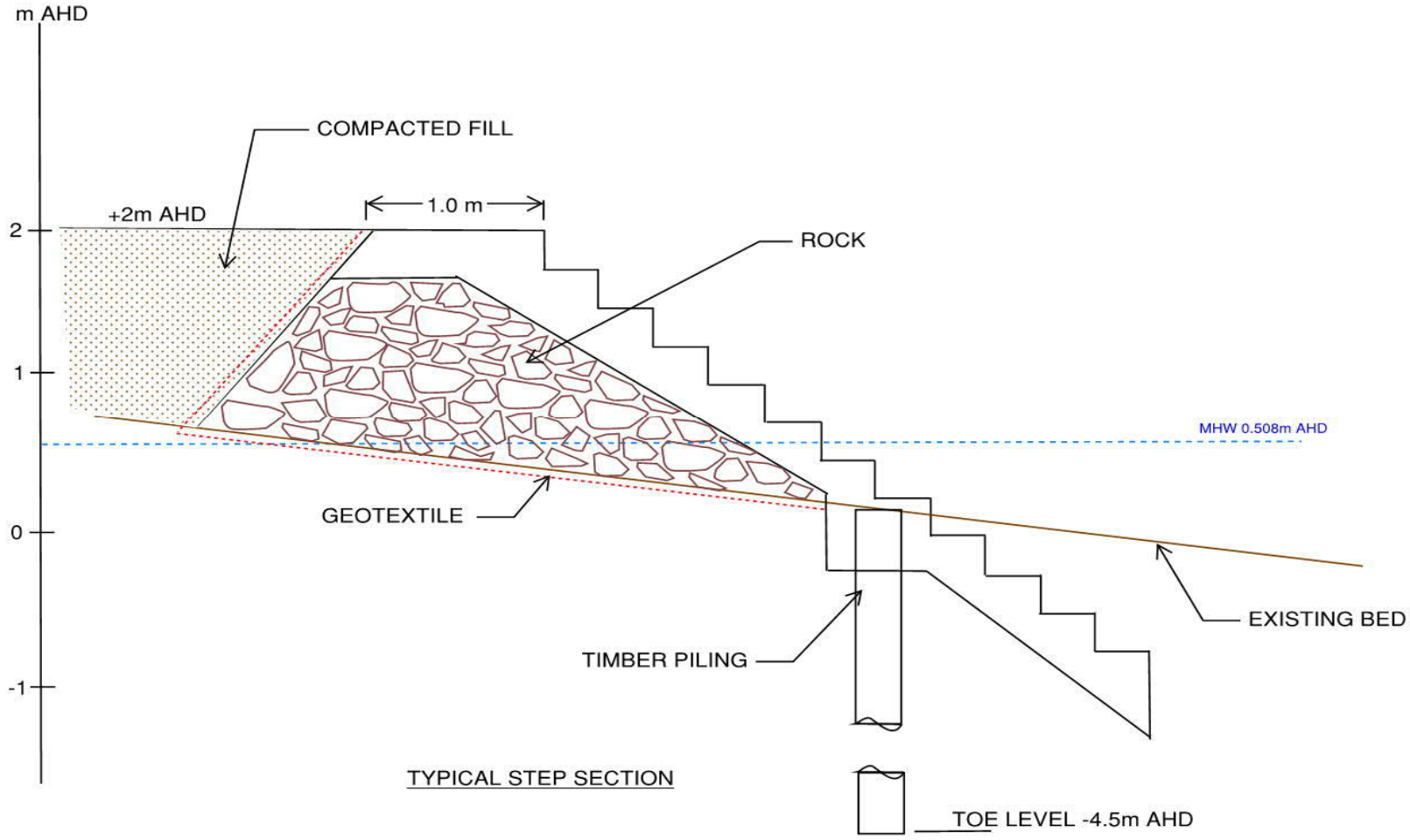


Figure 5-18 Typical Stair on Pile Treatment

Figure 5-19 Example of FRP Mesh Beach Access Steps as an Alternative to Concrete

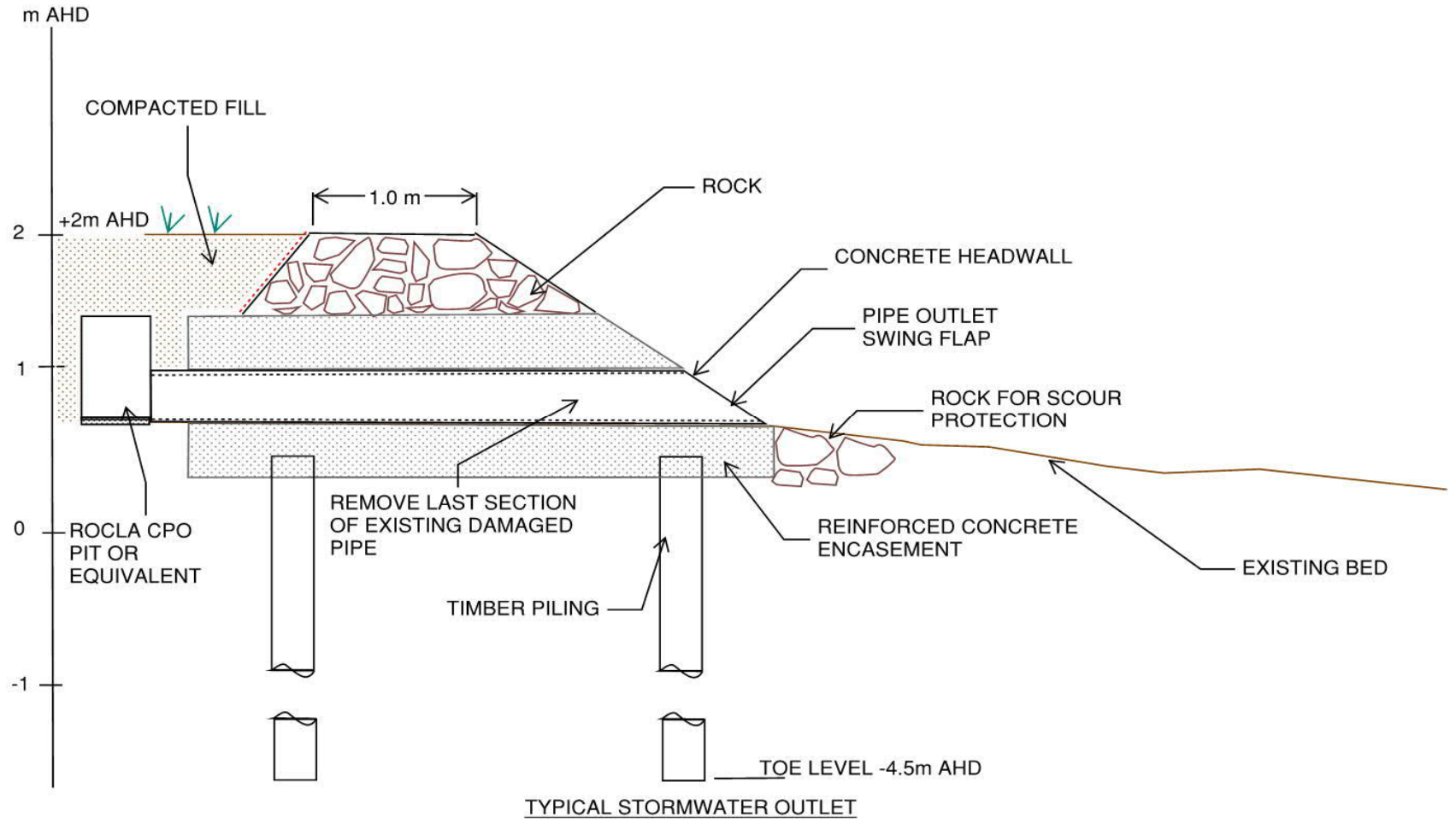


Figure 5-20 Typical Stormwater Pipe Treatment

6 Cost Estimates and Timing of Remediation Works

Indicative cost estimate for each of the concept options have been prepared. As the options are concept, cost estimates are within ±50% accuracy and contain a 25% contingency in accordance with Advisian's cost estimate guidelines. Approximate dimensions have been adopted due to limited survey data.

6.1 Cost Breakdown

Table 6-1 Cost Estimate of Concept Options

Item	Description	Quantity	Unit	Rate($)	Cost ($)
1	Site Establishment	-	Item	LS	$7,000
2	Survey				
2.1	Preconstruction survey	-	Item	LS	$4,200
2.2	Setting out construction works	-	Item	LS	$1,800
2.3	Post-construction survey	-	Item	LS	$4,200
3	Installation/Maintenance of Environmental Control Provisions	-	Item	LS	$6,000
4	Concept A – Riprap Rock Treatment (CH 0 -100)				
4.1	Earth works (excavation/onsite reuse)	100	m^3	24	$2,400
4.2	Geotextile (supply and place)	500	m^2	$10	$5,000
4.3	Subgrade (supply and place)	100	m^3	$120	$12,000
4.4	Underlayer (supply and place)	198	t	$120	$23,760
4.5	Primary armour layer	264	t	$150	$39,600
4.6	Planting	100	m^2	$20	$2,000
				Total	$107,960
				+Contingency (25%)	$134,950
				/m	$1,349
5	Concept A Alternative – Rock Pool (CH 0 – 100)				
5.1	Earth works (excavation/onsite reuse)	100	m^3	$24	$2,400
5.2	Geotextile (supply and place)	150	m^2	$10	$1,500
5.3	Rock Bedding (supply and place)	49.5	t	$100	$5,940
5.4	Rock (supply and place)	8	t	$120	$933

Item	Description	Quantity	Unit	Rate($)	Cost ($)
5.5	Boulders (supply and place)	264	t	$150	$39,600
5.6	Planting	100	m^2	$20	$2,000
				Total	$75,573
				+Contingency (25%)	$94,466
				/m	$945
6	Concept A* Alternative – Beach Nourishment (CH 0 – 100)				
6.1	Mobilisation/Demobilisation	-	Item	$50,000	$50,000
6.2	Dredging Operation (Dredging and Nourishment)	-	Item	$36,000	$36,000
6.3	Planting	100	m^2	$20	$2,000
				Total	$88,000
				+Contingency (25%)	$110,000
				/m	$1,100
7	Concept B – Riprap Rock Treatment (CH 105 – 130)				
7.1	Demolition	-	Item	$12,000	$12,000
7.2	Earth works (excavation/onsite reuse)	120	m^3	$24	$2,880
7.3	Geotextile (supply and place)	150	m^2	$10	$1,500
7.4	Subgrade (supply and place)	120	m^3	$100	$14,400
7.5	Underlayer (supply and place)	238	t	$120	$28,512
7.6	Primary armour layer	317	t	$150	$47,520
7.7	Planting	30	m^2	$20	$600
				Total	$130,612
				+Contingency (25%)	$163,265
				/m	$6,531
8	Concept B – Riprap Rock Treatment with Concept C (CH 105 – 130)				
8.1	Demolition	-	Item	$12,000	$12,000
8.2	Earth works (excavation/onsite reuse)	120	m^3	$24	$2,880
8.3	Geotextile (supply and place)	150	m^2	$10	$1,500
8.4	Subgrade (supply and place)	120	m^3	$100	$14,400

Item	Description	Quantity	Unit	Rate($)	Cost ($)
8.5	Underlayer (supply and place)	118	t	$120	$14,256
8.6	Primary armour layer	158	t	$150	$23,760
8.7	Rock	37	t	$150	$5,544
8.8	Planting	30	m^2	$20	$600
				Total	$98,140
				+Contingency (25%)	$122,675
				/m	$4,907
9	Concept C* – Existing Rock Treatment (Assuming 300m in Total)				
9.1	Earth works (excavation/onsite reuse)	300	m^3	$24	$7,200
9.2	Geotextile (supply and place)	900	m^2	$10	$9,000
9.3	Subgrade (supply and place)	90	m^3	$100	$9,000
9.4	Rock	370	t	$150	$55,440
9.5	Planting	300	m^2	$20	$6,000
				Total	$109,840
				+Contingency (25%)	$137,300
				/m	$458
10	Stair Concept				
10.1	Stairs (Does not Include Mob/Demob) price per staircase	-	LS	$20,000	$20,000
11	Stormwater				
11.1	Stormwater (Does not Include Mob/Demob) price per stormwater pipe assuming pits, piles and replacement of existing pipe)	-	LS	$50,000	$50,000
11.2	Stormwater (Fixing end of pipe only)	-	LS	$20,000	$20,000

**Qualifications:*

- *Beach Nourishment Concept A does not include for environmental investigations/permits*
- *Concept C cost estimate is calculated based on new rock being supplied, no reuse of existing rock on site has been assumed*

6.2 Type, Cost and Timing of Remediation Works

Table 6-2 provides details of the location of works, timing and indicative total cost.

Table 6-2 Location, Type and Timing of Shoreline Remediation Works

Chainage	Option to be Adopted	Total Length	Indicative Cost ($)	Timing	Work Type
Foreshore Works					
CH 0 – 100	Concept A Riprap	100	$134,950	Low Priority	New Concept
CH 0 - 100	Concept A Alternative Rockpool	100	$94,466	Low Priority	New Concept
CH 0 - 100	Concept A Alternative Beach Nourishment	100	$110,000	Low Priority	New Concept
CH 105 – 130	Concept B Riprap	25	$163,265	High Priority	Restructure/New Concept
CH105 – 130	Concept B and C combined	25	$122,675	High Priority	Restructure/New Concept
CH 130 - 200	Concept C Maintain – Increase crest height and vegetate	70	$32,060	Moderate Priority	Maintenance
CH 200 - 230	Maintain mangrove vegetation	30	Labour	Low Priority	Maintenance
CH 230 - 280	Concept C and maintain mangrove vegetation in front of foreshore	50	$22,900	Low Priority	Maintenance
CH 280 - 350	No works	70	-	-	-
Ch 350 - 450	Concept C either side of access ramp	50	$22,900	Moderate Priority	Continuation of existing structure - Maintenance
Ch 450 - 500	No works		-	-	-
Ch 500 - 550	Concept C	50	$22,900	High Priority	Continuation of existing structure - Maintenance
Ch 550 - 600	Maintain mangrove vegetation	50	Labour	-	Maintenance
Ch 600 - 700	Concept C	100	$45,800	Low Priority	Continuation of existing structure - Maintenance

Chainage	Option to be Adopted	Total Length	Indicative Cost ($)	Timing	Work Type
Stairs					
Ch 105	Stair on Pile Concept		$20,000	High Priority	Replacement 'like for like'
CH 150, 230, 280, 340, 460, 540 and 620	Stair on Pile Concept	-	-	Low Priority	Replacement 'like for like'
Stormwater					
CH 105	Stormwater Concept	-	$50,000/pipe	High Priority	Replacement 'like for like'
CH 350	Stormwater Concept (NB these two pipes could initially just have scour protection and pipe support to mitigate future cracking and existing gabions removed)	-	$20,000/pipe	Low Priority	Replacement 'like for like'
CH 520	Stormwater Concept	-	$50,000/pipe Alternatively, $20,000/pipe if end of pipe only	High Priority	

7 Bibliography

Panayotou, K. (2004). *Geomorphology of the Minnamurra River Estuary* .

Patterson Britton and Partners. (1995). *Minnamurra River Estuary Management Study.* Kiama Municipal Council.

Reinfelds, I. B. (1999). *Stormwater Management Plan Final Report.*

Whitehead and Associates. (2014). *South Coast Regional Sea Level Rise Policy and Planning Framework.*