Appendix H – Vegetation Survey and Clearing Plans

Vegetation Survey - Pebbly Beach Revetment proposal

Binomial	***Nature Conservation Act***	***Marine Associated***	***Notes***
Melaleuca dealbata	LC		Associated with Myrmecodia beccarii (V) none identified
Corymbia tessellaris	LC		(+/- canopy dominant)
Crotalaria goreensis			Weed
Thespesia populnea			
Stachytarpheta cayennensis			Weed
Megathyrsus maximus			Weed
Mimosa pudica			Weed
Mucuna gigantea	LC		
Colubrina asiatica	LC	X	
Morinda citrifolia	LC		
Hibiscus tiliaceus	LC	X	
Ipomoea pes-caprae	LC	X	
Alyxia spicata	LC		
Terminalia muelleri	LC		
Cocos nucifera	LC	X	
Acacia oraria	LC		
Schefflera actinophylla	-		Exotic
Pandanus tectorius	LC	X	
Stachytarpheta jamaicensis	-		Weed
Cupaniopsis anacardioides	LC		
Acacia polystachya	LC		
Clerodendrum inerme	LC	X	
Melaleuca viridiflora	LC		Associated with Myrmecodia beccarii (V) None identified

Acacia flavescens	LC		
Casuarina equisetifolia	LC	X	
Excoecaria agallocha	LC	X	
Lophostemon suaveolens	LC		
Acrosticum aureum	SL	X	
Ficus microcarpa	LC		
Calophyllum inophyllum	LC	X	
Passiflora suberosa	-	-	Weed
Coelospermum reticulatum	LC		
Stylosanthes humilis	-	-	Weed
Acacia torulosa	LC		
Acacia Celsa	LC		
Praxelis clematidea	-	-	Weed
Lysiana subfalcata	LC		
Jasminum simplicifolium	LC		
Diospyros hebecarpa	LC		
Ganophyllum falcatum	LC		
Chionanthus ramiflorus	LC		
Ficus opposita	LC		
Eucalyptus leptophleba	LC		
Corymbia torelliana	LC		
lumnitzera racemosa	LC	X	
Terminalia catapa	LC		

REV 2
19/11/2024

TMR DRFA 24E
PRIORITY 1 - SITE 6 (52.3km)
MARINE PLANT MAPPING

60730804-064202-SP

Appendix I – Options Assessment and Multi-Criteria Analysis

Geotechnical - Options Assessment

Back to Summary

Road Name : 20A - Captain Cook Highway

Assessment Date: 20-June-2024

Site Reference: 6 Downslope

Start / Finish Chainage: 51.97 - 52.54

Assessment By: AECOM - E. Thompson / D. Freeman

							Option 1			Option 2			Option 3		
							Earth Fill			Rock Fill			Gabion Wall		
Criteria ID	Criteria Title	Criteria Description	Sub Criteria	Total weighting	Criteria Weighting	Scoring Criteria	Score	Weighted Score	Comments	Score	Weighted Score	Comments	Score	Weighted Score	Comments
C1	Comparative cost, including direct (including contractors margins) *These costs are indicative based on rate per m or rate per m2.	• Developed estimate based on similar treatments from previous events. • Proposed treatment allows for standardised procurement (materials). • Proposed treatment allows for market competition (i.e. not an isolated or specialised case).	Comparative Cost	30.0%	30.0%	10 = lowest comparative construction cost 1 = highest comparative construction cost	9.2	2.8	$4,914,132	9.3	2.8	$4,415,587	9.0	2.7	$6,034,239
Co1	Constructability	• Proposed treatment is adapted to the localised site (laydown, access etc.). • Proposed treatment considers site geometry, environmental and cultural heritage impacts. • Proposed treatment to allow flexibility in construction. • Minimise plant size and equipment (e.g. truck movements for quantities of excavation and backfill).	Safety	25.0%	5.0%	10 = highest safety risk work items 1 = lowest safety risk work items	7.0	0.4	Safety High plant work, low manual work Working near water	7.0	0.4	Safety High plant work, low manual work Working near water	2.0	0.1	Safety Fixing crew - hand work Manual work in tidal area - crocodiles
			Lay down & spoil sites		5.0%	10 = highest requirement for laydown area/closest spoil sites 1 = lowest requirement for laydown area / furtherer soil sites	2.0	0.1	Laydown & Site spoil - Delivery of earth fill and rock to site laydown area.	3.0	0.2	Laydowns & Site spoil - Limited laydown area - material trucked to site as needed - highest truck movements - highest spoil removed from site	5.0	0.3	Laydowns & Site spoil - Limited laydown area - material trucked to site as needed - medium truck movements - Medium spoil removed from site
			Ease of construction - Road access vs Access tracks		10.0%	10 = easiest to construct 1 = difficult to construct	6.0	0.6	Ease of construction - This job site and this option would be the easiest to construct by far. Could place earth fill using a backhoe front end loader or grader and do it with a decent productivity. 'Design option pro/con - Earth fill design is simple, however may need some rock at the toe to minimise chance of coastal erosion, - HAT boundary needs to be clarified. - Stringent Environmental controls will be required, including removal of pebbles within works areas for later reinstatement of sites to natural state.	7.0	0.7	Ease of construction - Conventional plant can be used including standard 20 Tonne Excavators, Backhoes, or Front End Loader, Geotextile roll, 'beam' and compaction wheel to place rock, and compact with roller on excavator attachment. Plant & Contractors: VMS boards, TC, portable traffic signals, temporary barriers, tree clearing and mulching, Standard 20T excavator, compaction attachment, geofabric 'beam', tandem tippers, skid steer loader and broom attachment	4.0	0.4	Ease of construction - Road access, working space of 5m on southbound lane. - Optionally gabion baskets could be 'laced' and filled off-site then delivered to site on a flatbed truck and 'craned' into position with a city crane - reduced timeframe on site. Plant & Contractors: VMS boards, TC, portable traffic signals, temporary barriers, tree clearing and mulching, 14T City Crane, Standard 20t excavator, tandem tippers, skid steer loader and broom attachment
			Volume of materials		2.5%	10 = lowest volume of materials 1 = highest volume of materials	2.0	0.1	Volume of materials / storage - Shut down southbound lane traffic lane under contraflow arrangement with portable traffic signals. Conventional plant can be used without having to work on Pebbly Beach. - Earth fill and rock materials quantities will be high but when the material is delivered it can be placed on site quickly and easily.	3.0	0.1	Volume of materials / storage - Large volume of rock but about the same quantity as Option 1 - trucked directly to site when required. There is limited space to store materials on site due to narrow job site. But due to ease of access to site and low height rock can be placed in a timely manner.	4.0	0.1	Volume of materials / storage - Limited space for storage of materials on site due to narrow road width.
			Number of available contractors		2.5%	10 = most available contractors 1 = least available contractors	8.0	0.2	Number of available contractors - Lots of plant and equipment availability for this project and could be done with a number of different types of plant including a standard 20T Excavator, or backhoe, or front end loader of grader.	8.0	0.2	Number of available contractors - Higher availability due to use of conventional plant such as a standard 20Tonne Excavator, Backhoe or Front End Loader that are all readily available in FNQ	6.0	0.2	Number of available contractors - Four contractors that construct Gabion retaining walls in FNQ area.
D1	Timing and sequencing of project delivery	• Contract delivery method to enable early construction procurement. • Construction sequence and methodology accounts for access to stakeholders.	Duration - Procurement & Construction	10.0%	3.3%	10 = shortest time to procure and construct 1 = longest time to procure and construct	8.0	0.3	Lowest duration - procurement contractor. Similar construction duration	7.0	0.2	Lower duration - procurement contractor,. Similar construction duration	5.0	0.2	Similar construction duration, site time could be reduced with off site filling of gabions
			Material Availability / Lead Times		3.3%	10 = highest material availability and least lead time 1 = lowest material availability and highest lead time	8.0	0.3	Lowest risk for material availability - dependent on quarry availability	6.0	0.2	Lower risk for material availability - dependent on quarry availability	5.0	0.2	Medium
			Programming - Combined sites - Nearby with same solution		3.3%	10 = most consistent solution (CCH Package 1) 1 = least consistent solution (CCH Package 1)	5.0	0.2	General embankment - neutral	6.0	0.2	Evidence of rockfill used at nearby sites	5.0	0.2	Solution not consistent with nearby sites
M1	Whole of life consideration (maintenance, operations)	• Similar treatments installed at locations from previous events. • Proposed treatments provide a mitigating measure to protracted maintenance. • Frequency and methodology for District maintenance remains static.	Design life	10.0%	5.0%	10 = highest design life 1 = lowest design life	3.0	0.2	Relatively low design life - salt environment / coastal action	8.0	0.4	Higher design life (100y)	4.0	0.2	Lowest design life (50y) - salt environment
			Maintenance of materials specified		2.0%	10 = least maintenance required 1 = most maintenance required	3.0	0.1	Highest maintenance requirement - unprotected batter for larger events	8.0	0.2	Least maintenance	4.0	0.1	Higher maintenance - gabion baskets (steelwork exposed to ocean)
			Maintenance access		1.0%	10 = easiest to access for maintenance 1 = hardest to access for maintenance	7.0	0.1	Access from road - trafficable slope	5.0	0.1	Access from road	5.0	0.1	Access from road
			Presence of adjacent high risk sites		2.0%	10 = most similar sites nearby 1 = least similar sites nearby	5.0	0.1	Neutral	8.0	0.2	Other sites nearby with same treatment - ease of maintenance	4.0	0.1	Not a common treatment at nearby sites
E1	Environmental / cultural heritage benefits/impacts	• Smallest possible construction footprint which minimises clearing and or demolition. • Visibility of treatment. • Impact on disturbing Cultural sites including marine resources • Noise and vibration from construction methodology • Avoidance of LAT (GBR WHA) in siting of treatment • Avoidance of HAT, MHWS, National Park in siting of treatment	Footprint	12.5%	2.5%	10 = lowest construction footprint 1 = highest construction footprint	3.0	0.1	Footprint Largest footprint	4.0	0.1	Footprint Second largest footprint	5.0	0.1	Footprint Small footprint, comparable with O4, O5 and O6
			Visual Impact		2.5%	10 = lowest visual impact 1 = highest visual impact	6.0	0.2	Visual Impact Similar impact for most options. Vegetation clearing is required for the works.	6.0	0.2	Visual Impact Similar impact for most options. Vegetation clearing is required for the works.	5.0	0.1	Visual Impact Similar impact for most options. Vegetation clearing is required for the works.
			HAT, MHWS, LAT		2.5%	10 = lowest impact to HAT, MHWS, LAT 1 = highest impact to HAT, MHWS, LAT	3.0	0.1	HAT,MHWS,LAT Potentially impacts HAT	5.0	0.1	HAT,MHWS,LAT Close to HAT and MHWS to be confirmed. Unlikely to impact LAT	5.0	0.1	HAT,MHWS,LAT Close to HAT and MHWS to be confirmed. Unlikely to impact LAT
			CH / Ecology		2.5%	10 = lowest to CH / Ecology 1 = highest impact to CH / Ecology	3.0	0.1	CH/Ecology Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing. Potential for vegetation to re-grow on earth fill.	5.0	0.1	CH/Ecology Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing. Potential for vegetation to re-grow on earth fill.	6.0	0.2	CH/Ecology Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing.
			Noise / Vibration		2.5%	10 = least noise / vibration during construction 1 = most noise / vibration during construction	7.0	0.2	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.	5.0	0.1	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.	6.0	0.2	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.
P1	Public interest assessments / stakeholder impacts	• Temporary disruption/delay to traffic flow. • 'Fit for purpose' assessment of remedial works.	Road closure is possible however does required significant detours for some local residents.	12.5%	5.0%	10 = no road closures required 1 = significant detours / road closures	6	0.3	Similar *TMP & Traffic controls as requires to allow single lane flow 'contra flow' 24/7 The northbound traffic lane will need temporary widening to allow the downslope lane work area. May require short stoppages for construction vehicle movements	5.0	0.3	Similar *TMP & Traffic controls as requires to allow single lane flow 'contra flow' 24/7 The northbound traffic lane will need temporary widening to allow the downslope lane work area. May require short stoppages for construction vehicle movements	8.0	0.4	Similar *TMP & Traffic controls as requires to allow single lane flow 'contra flow' 24/7 The northbound traffic lane will need temporary widening to allow the downslope lane work area. May require short stoppages for construction vehicle movements
			Fit for purpose - Post construction public amenity		7.5%	10 = most suitable for public use 1 = leasrt suitable for public use	8	0.6	Similar to current conditions, imitates beach front allows for replanting vegetation Beach front accessible Does not introduce additional safety risk to public	7.0	0.5	Larger boulders present on beach front - similar to current condition Beach front somewhat accessible Increased public safety risk with larger armour rock	3.0	0.2	Introduces near vertical face at beach front - gabion rock wall Does not match surroundings Beach front not accessible Safety risk with near vertical face
					100%	Overall Weighted Score		6.0			6.5			5.7	
						RANK		2			1			4	

Notes:
1. Recommend individual criteria scoring be 0-10. Criteria for scoring to be documented against each criteria above.
2. Recommended scoring of cost criteria as follows:

Cost Score = (1- Option cost / (sum of all option costs))x10

Option	Cost	Score	
1	$4,914,132	9.2	
2	$4,415,587	9.3	
3	$6,034,239	9.0	
4	$6,474,758	8.9	
5	$10,088,465	8.4	
6	$13,732,923	7.8	
7	$15,700,000	7.4	Very high level estimated value - does not impact final ranking

Lowest Option Cost =	$4,415,587

Geotechnical - Options Assessment

Back to Summary

Road Name : 20A - Captain Cook Highway

Assessment Date: 20-June-2024

Site Reference: 6 Downslope

Start / Finish Chainage: 51.97 - 52.54

Assessment By: AECOM - E. Thompson / D. Freeman

Criteria ID	Criteria Title	Criteria Description	Sub Criteria	Total weighting	Criteria Weighting	Scoring Criteria
C1	Comparative cost, including direct (including contractors margins) *These costs are indicative based on rate per m or rate per m2.	• Developed estimate based on similar treatments from previous events. • Proposed treatment allows for standardised procurement (materials). • Proposed treatment allows for market competition (i.e. not an isolated or specialised case).	Comparative Cost	30.0%	30.0%	10 = lowest comparative construction cost 1 = highest comparative construction cost
Co1	Constructability	• Proposed treatment is adapted to the localised site (laydown, access etc.). • Proposed treatment considers site geometry, environmental and cultural heritage impacts. • Proposed treatment to allow flexibility in construction. • Minimise plant size and equipment (e.g. truck movements for quantities of excavation and backfill).	Safety	25.0%	5.0%	10 = highest safety risk work items 1 = lowest safety risk work items
			Lay down & spoil sites		5.0%	10 = highest requirement for laydown area/closest spoil sites 1 = lowest requirement for laydown area / furtherer soil sites
			Ease of construction - Road access vs Access tracks		10.0%	10 = easiest to construct 1 = difficult to construct
			Volume of materials		2.5%	10 = lowest volume of materials 1 = highest volume of materials
			Number of available contractors		2.5%	10 = most available contractors 1 = least available contractors
D1	Timing and sequencing of project delivery	• Contract delivery method to enable early construction procurement. • Construction sequence and methodology accounts for access to stakeholders.	Duration - Procurement & Construction	10.0%	3.3%	10 = shortest time to procure and construct 1 = longest time to procure and construct
			Material Availability / Lead Times		3.3%	10 = highest material availability and least lead time 1 = lowest material availability and highest lead time
			Programming - Combined sites - Nearby with same solution		3.3%	10 = most consistent solution (CCH Package 1) 1 = least consistent solution (CCH Package 1)
M1	Whole of life consideration (maintenance, operations)	• Similar treatments installed at locations from previous events. • Proposed treatments provide a mitigating measure to protracted maintenance. • Frequency and methodology for District maintenance remains static.	Design life	10.0%	5.0%	10 = highest design life 1 = lowest design life
			Maintenance of materials specified		2.0%	10 = least maintenance required 1 = most maintenance required
			Maintenance access		1.0%	10 = easiest to access for maintenance 1 = hardest to access for maintenance
			Presence of adjacent high risk sites		2.0%	10 = most similar sites nearby 1 = least similar sites nearby
E1	Environmental / cultural heritage benefits/impacts	• Smallest possible construction footprint which minimises clearing and or demolition. • Visibility of treatment. • Impact on disturbing Cultural sites including marine resources • Noise and vibration from construction methodology • Avoidance of LAT (GBR WHA) in siting of treatment • Avoidance of HAT, MHWS, National Park in siting of treatment	Footprint	12.5%	2.5%	10 = lowest construction footprint 1 = highest construction footprint
			Visual Impact		2.5%	10 = lowest visual impact 1 = highest visual impact
			HAT, MHWS, LAT		2.5%	10 = lowest impact to HAT, MHWS, LAT 1 = highest impact to HAT, MHWS, LAT
			CH / Ecology		2.5%	10 = lowest to CH / Ecology 1 = highest impact to CH / Ecology
			Noise / Vibration		2.5%	10 = least noise / vibration during construction 1 = most noise / vibration during construction
P1	Public interest assessments / stakeholder impacts	• Temporary disruption/delay to traffic flow. • 'Fit for purpose' assessment of remedial works.	Road closure is possible however does required significant detours for some local residents.	12.5%	5.0%	10 = no road closures required 1 = significant detours / road closures
			Fit for purpose - Post construction public amenity		7.5%	10 = most suitable for public use 1 = leasrt suitable for public use
					100%	Overall Weight

Option 4 – Grib Wall

Sub Criteria	Score	Weighted Score	Comments
Comparative Cost	8.9	2.7	$6,474,758
Safety	2.0	0.1	Safety Fixing crew - hand work Manual work in tidal area - crocodiles
Lay down & spoil sites	5.0	0.3	Laydowns & Site spoil - Limited laydown area - material trucked to site as needed - medium truck movements - Medium spoil removed from site
Ease of construction - Road access vs Access tracks	3.0	0.3	Ease of construction - Road access, working space of 5m on southbound lane. - Crib wall is lightweight and fast to construct. Plant & Contractors: VMS boards, TC, portable traffic signals, temporary barriers, tree clearing and mulching, Standard 20t excavator, tandem tippers, skid steer loader and broom attachment
Volume of materials	4.0	0.1	Volume of materials / storage - Limited space for storage of materials on site due to narrow road width.
Number of available contractors	4.0	0.1	Number of available contractors - Limited availability for contractors that construct crib walls in FNQ area.
Duration - Procurement & Construction	2.0	0.1	Procurement - Grib wall - preorder
Material Availability / Lead Times	2.0	0.1	Material availability - special order - Grib wall - preorder
Programming - Combined sites - Nearby with same solution	2.0	0.1	Solution not consistent with nearby sites (not yet proposed on similar sites or seen on the highway - past repairs)
Design life	5.0	0.3	Medium design life (50y) - salt environment/ coastal action
Maintenance of materials specified	5.0	0.1	Neutral
Maintenance access	5.0	0.1	Access from road
Presence of adjacent high risk sites	3.0	0.1	Not a treatment at nearby sites
Footprint	5.0	0.1	Footprint Smallest footprint, comparable with O3
Visual Impact	4.0	0.1	Visual Impact Similar impact for most options. Vegetation clearing is required for the works.
HAT, MHWS, LAT	5.0	0.1	HAT,MHWS,LAT Close to HAT and MHWS to be confirmed. Unlikely to impact LAT
CH / Ecology	6.0	0.2	CH/Ecology Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing.
Noise / Vibration	6.0	0.2	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.
Road closure	7.0	0.4	Similar *TMP & Traffic controls as requires to allow single lane flow 'contra flow' 24/7 The northbound traffic lane will need temporary widening to allow the downslope lane work area. May require short stoppages for construction vehicle movements
Fit for purpose - Post construction public amenity	4.0	0.3	Introduces near vertical face at beach front - grib wall Does not match surroundings Beach front not accessible Safety risk with near vertical face
Overall Weight		5.2	
		5	

Option 5 – Cantilever retaining wall

Sub Criteria	Score	Weighted Score	Comments
Comparative Cost	8.4	2.5	$10,088,465
Safety	1.0	0.1	Safety Manual work in tidal area - crocodile - longer times than other options
Lay down & spoil sites	3.0	0.2	Laydown & Site spoil - Likely to be expensive to construct as it will need a reinforced concrete structure with formwork and reinforcing steel and it is in a highly corrosive environment on the edge of the ocean.
Ease of construction - Road access vs Access tracks	2.0	0.2	Ease of construction *- This will not be easy to construct as you will need to work around the tides. Lots of materials will required for formwork, reinforcing steel, and concrete will need to be pumped into the retaining wall as well in stages.*
Volume of materials	5.0	0.1	Volume of materials / storage - Limited storage space on site so everything will have to be brought in daily and any spoil removed daily.
Number of available contractors	5.0	0.1	Number of available contractors - Availability of concertos in the Cairns to Port Douglas Areas should be good. - Formwork, Reinforcing steel and concrete should all be readily available from Cairns. - Concrete pumps are readily available form Cairns.
Duration - Procurement & Construction	3.0	0.1	Longer construction duration
Material Availability / Lead Times	3.0	0.1	Retaining wall material procurement
Programming - Combined sites - Nearby with same solution	2.0	0.1	Solution not consistent with nearby sites (not yet proposed on similar sites or seen on the highway - past repairs)
Design life	8.0	0.4	Higher design life (100y)
Maintenance of materials specified	7.0	0.1	Lower maintenance (inspections)
Maintenance access	3.0	0.0	Vertical face, access from beach and road
Presence of adjacent high risk sites	2.0	0.0	Not a treatment at nearby sites
Footprint	5.0	0.1	Footprint Small footprint, comparable with O3, O4 and O6
Visual Impact	4.0	0.1	Visual Impact Similar impact for most options. Vegetation clearing is required for the works.
HAT, MHWS, LAT	5.0	0.1	HAT,MHWS,LAT Close to HAT and MHWS to be confirmed. Unlikely to impact LAT
CH / Ecology	4.0	0.1	CH/Ecology Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing.
Noise / Vibration	2.0	0.1	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.
Road closure	2.0	0.1	Similar *TMP & Traffic controls as requires to allow single lane flow 'contra flow' 24/7 The northbound traffic lane will need temporary widening to allow the downslope lane work area. May require short stoppages for construction vehicle movements
Fit for purpose - Post construction public amenity	1.0	0.1	Introduces vertical face, removes beach front and access Does not match surroundings Beach front not accessible Increased safety risk with vertical face
Overall Weight		4.6	
		6	

Option 6 – Soil nail and shotcrete

Sub Criteria	Score	Weighted Score	Comments
Comparative Cost	7.8	2.3	$13,732,923
Safety	5.0	0.3	Safety Manual work in tidal area - crocodiles - limited compared to options 3 & 4
Lay down & spoil sites	7.0	0.4	Laydowns & Site spoil - Limited laydown area - material trucked to site as needed - lowest truck movements - due to low volume of material - could be stored on site in dead lane - lowest spoil removed from site
Ease of construction - Road access vs Access tracks	6.0	0.6	Ease of construction - Road access, temporary widening of northbound lane to west to enable working space of 5m on slope - pending geotechnical assessment of plant adjacent to hinge Plant & Contractors: VMS boards, TC, portable traffic signals, temporary barriers, tree clearing and mulching, experienced 'fall restraint' rock netting installation crew. Specialist soil nail contractor
Volume of materials	6.0	0.2	Volume of materials / storage 'Low volume of materials for soil nails. Need to have concrete supplied from Cairns but there are a number of suppliers available in FNQ.
Number of available contractors	4.0	0.1	Number of available contractors - Availability of materials - soil nails - Limited Availability of contractors in Cairns - soil nailer - Good availability of concrete pumps and concrete suppliers in Cairns.
Duration - Procurement & Construction	4.0	0.1	Potential longer procurement - Soil nail specialist contractor required. 'Similar construction duration
Material Availability / Lead Times	4.0	0.1	Risk for material lead time - soil nails
Programming - Combined sites - Nearby with same solution	8.0	0.3	Soil nail specialists engaged for nearby sites/similar projects
Design life	8.0	0.4	Higher design life (100y)
Maintenance of materials specified	5.0	0.1	Medium maintenance (soils nails + shotcrete surface)
Maintenance access	5.0	0.1	Access from road
Presence of adjacent high risk sites	8.0	0.2	Other sites nearby with same treatment - ease of maintenance
Footprint	6.0	0.2	Footprint
Visual Impact	2.0	0.1	Visual Impact WTMA prefer alternatives to shotcrete due to visual amenity impacts
HAT, MHWS, LAT	5.0	0.1	HAT,MHWS,LAT Close to HAT and MHWS to be confirmed. Unlikely to impact LAT
CH / Ecology	4.0	0.1	CH/Ecology Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing.
Noise / Vibration	4.0	0.1	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.
Road closure	4.0	0.2	Similar *TMP & Traffic controls as requires to allow single lane flow 'contra flow' 24/7 The northbound traffic lane will need temporary widening to allow the downslope lane work area. May require short stoppages for construction vehicle movements
Fit for purpose - Post construction public amenity	2.0	0.2	Introduces shotcrete face on beach face Does not match surroundings - shotcrete face poor visual amenity Beach front not as accessible Safety risk with shotcrete face and soil nails
Overall Weight		5.7	
		3	

Option 7 – Shift Road Alignment West

Sub Criteria	Score	Weighted Score	Comments
Comparative Cost	7.4	2.2	$15,700,000
Safety	5.0	0.3	Safety High plant work, low manual work Working near water
Lay down & spoil sites	1.0	0.1	Laydown & Site spoil - Largest areas required - full closure
Ease of construction - Road access vs Access tracks	1.0	0.1	Ease of construction - There is a long distance to laydown areas. -
Volume of materials	1.0	0.0	Volume of materials / storage - Very narrow jobsite and need to remove spoil to stockpile off site.
Number of available contractors	6.0	0.2	Number of available contractors - Availability of contractor to do clearing works and road widening for this site would be good.
Duration - Procurement & Construction	1.0	0.0	Longest duration
Material Availability / Lead Times	4.0	0.1	Large material volume incl. soil nail/mesh for western batter
Programming - Combined sites - Nearby with same solution	1.0	0.0	Solution not consistent with nearby sites , significant works
Design life	8.0	0.4	Higher design life (100y), protection to the asset - but pushes the issue down the line if the batter is not protected.
Maintenance of materials specified	7.0	0.1	Lower maintenance
Maintenance access	5.0	0.1	Access from road
Presence of adjacent high risk sites	5.0	0.1	Neutral
Footprint	1.0	0.0	Footprint Highest new impact to west, however less footprint downslope
Visual Impact	1.0	0.0	Visual Impact Similar impact for most options. Vegetation clearing is required for the works.
HAT, MHWS, LAT	7.0	0.2	HAT,MHWS,LAT Close to HAT and MHWS to be confirmed. Unlikely to impact LAT
CH / Ecology	4.0	0.1	CH/Ecology Greater environmental impact with new areas of clearing to widen to the west. Less work occurring downslope with potential to enter the marine park. Adjacent to marine park, GBR WHA. Potential to impact directly and indirectly on marine values. Earth fill would have potential to erode into marine park without rapid stabilisation. Marine plants require clearing.
Noise / Vibration	3.0	0.1	Noise / Vibration Noise and vibration may be a short term impact to sensitive receptors. Similar impact to other options.
Road closure	1.0	0.1	HIGH IMPACT Road closure would be required with detours
Fit for purpose - Post construction public amenity	5.0	0.4	Removes/shifts beach front Fit with current conditions and surroundings Beach front accessible Does not introduce additional safety risk to public
Overall Weight		4.1	
		7	

Notes:
1. Recommend individual criteria scoring be 0-10. Criteria for scoring to be documented against each criteria above.
2. Recommended scoring of cost criteria as follows:

Cost Score = (1- Option cost / (sum of all option costs))x10

Option	Cost	Score	
1	$4,914,132	9.2	
2	$4,415,587	9.3	
3	$6,034,239	9.0	
4	$6,474,758	8.9	
5	$10,088,465	8.4	
6	$13,732,923	7.8	
7	$15,700,000	7.4	Very high level estimated value - does not impact final ranking

Lowest Option Cost =	$4,415,587

Appendix J – Basis of Design Report (Royal HaskoningDHV, 2024b)

Note

Haskoning Australia PTY Ltd.
Water & Maritime

To: AECOM
From: Courtney Wharton
Date: 10 September 2024
Our reference: PA3962
Classification: Internal use only
Subject: Pebbly Beach Revetment BOD

---

1 Management Plans, Guidelines, Standards and Reference Documents

The proposed guideline texts, standards and codes to be used for the detailed design of the works are:

- AS 4997 – Guidelines for design of maritime structures;
- AS 2758.6 – Aggregates and rock for engineering purposes, Part 6: Guidelines for the specification of armour stone;
- AS 4678 – Earth retaining structures;
- Coastal Protection and Management Regulation 2017 (*Coastal Protection and Management Act 1995)*;
- Coastal Engineering Manual prepared by the US Army Corp of Engineers (USACE, 2006);
- The Rock Manual – The use of rock in hydraulic engineering (2nd Edition) (2007) prepared by CIRIA;
- Eurotop Manual – Manual on wave overtopping of sea defences and related structures (EurOtop, 2018);
- The Neural Network for the design of coastal and harbour structures – A Neural Network TOOL for predicting wave reflection, overtopping and transmission (NN, 2016);
- Queensland Tide Tables (Department of Transport and Main Roads, 2024); and,
- Queensland Spatial Catalogue, Queensland Government (QSpatial, 2024).

Project Documents relevant for the investigation are:

- Cairns Region Storm Tide Inundation Study (BMT WBM, 2013).

2 Design Conditions

2.1 Design Life and Design Event

A revetment wall would be classified as Facility Category 3 (equivalent to a standard commercial structure) with a design working life of 50 years, as per AS4997. However, this particular revetment wall is a small component of a much larger project, for which a 100-year design life has been chosen. This extended design life was selected due to the project's proximity to the shoreline.

According to the Queensland Government's Coastal Protection and Management Regulation 2017, Schedule 3 (Prescribed Tidal Works Code), a revetment or seawall must withstand the effects of waves or a combination of waves and water levels resulting from a storm event with a 2% Annual Exceedance Probability (AEP), taking sea level rise into account. Typically, a revetment is designed for a 50-year lifespan, making the 2% AEP appropriate. However, given the 100-year design life of this project, a more stringent 0.5% AEP design event has been selected. This includes a 200-year wave height combined with a 200-year water level. Although this approach is conservative, as the likelihood of a 200-year wave coinciding with a 200-year water level is very low, it ensures robust protection.

The rock structure is designed to sustain up to 5% damage in a 200-year ARI event, balancing stability with cost-effectiveness. It is also capable of withstanding a 20-year ARI event with no damage.

2.2 Toe Level

After reviewing the provided cross-sections of the existing surface and aerial imagery, it has been determined that the toe will be positioned between 0.4m AHD and 0m AHD on a rock bed. Since this rock bed is a non-erodible surface, no specific toe design is required for this section. Although it appears that the rock bed extends across the entire length of Pebbly Beach, this is not fully confirmed.

The toe elevation has been designed at 0.35m AHD but may extend as low as 0m AHD. This variation has been addressed by applying a conservative sea-level rise (SLR) allowance. However, if the toe extends significantly below 0m AHD, the design would need to be reassessed.

2.3 Desing Water Levels

The design water levels from the various studies are presented in Table 1.

Table 1: Design storm tide surge levels (including wave setup) for Oak Beach (BMT WBM, 2013)

Location	1% AEP 100 yr ARI	0.5% AEP 200 yr ARI	0.2% AEP 500 yr ARI	0.1% AEP 1,000 yr ARI	0.01% AEP 10,000 yr ARI
Storm Surge (excluding wave setup + runup)	1.29 m AHD	1.60 m AHD	2.01 m AHD	2.31 m AHD	3.13 m AHD
Storm Tide (excluding wave setup + runup)	1.84 m AHD	2.09 m AHD	2.40 m AHD	2.66 m AHD	3.30 m AHD
Storm Tide (including wave setup + runup)	2.96 m AHD	3.26 m AHD	3.61 m AHD	3.88 m AHD	4.55 m AHD

Based on a 100-year design life and a 200-year ARI storm event, the design storm tide is 2.09m. Note that the storm tide design used for rock rise calculation excludes wave setup and runup.

Sea level rise is the projected increase in sea level caused by global warming due to climate change. A sea level rise of 0.8m has been allowed for in this design to coincide with a 100-year design life. This level is based on the IPPC Sixth Assessment report considering the SSP2-4.5 scenario (Figure 1), which is the most likely scenario to occur based on the changes to the climate to date (2024). It should be noted that the Queensland government (Department of State Development, Infrastructure, Local Government and Planning, 2022) adopt the SSP5-8.5 scenario and adopt a 0.8m increase by 2100.

The design water level adopted is 2.89m AHD (2.09 + 0.80).

	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP5-8.5 *Low Confidence*
Thermal expansion	0.12 (0.09–0.15)	0.14 (0.11–0.18)	0.20 (0.16–0.24)	0.25 (0.21–0.30)	0.30 (0.24–0.36)	0.30 (0.24–0.36)
Greenland	0.05 (0.00–0.09)	0.06 (0.01–0.10)	0.08 (0.04–0.13)	0.11 (0.07–0.16)	0.13 (0.09–0.18)	0.18 (0.09–0.59)
Antarctica	0.10 (0.03–0.25)	0.11 (0.03–0.27)	0.11 (0.03–0.29)	0.11 (0.03–0.31)	0.12 (0.03–0.34)	0.19 (0.02–0.56)
Glaciers	0.08 (0.06–0.10)	0.09 (0.07–0.11)	0.12 (0.10–0.15)	0.16 (0.13–0.18)	0.18 (0.15–0.21)	0.17 (0.11–0.21)
Land-water Storage	0.03 (0.01–0.04)	0.03 (0.01–0.04)	0.03 (0.01–0.04)	0.03 (0.02–0.04)	0.03 (0.01–0.04)	0.03 (0.01–0.04)
Total (2030)	0.09 (0.08–0.12)	0.09 (0.08–0.12)	0.09 (0.08–0.12)	0.10 (0.08–0.12)	0.10 (0.09–0.12)	0.10 (0.09–0.15)
Total (2050)	0.18 (0.15–0.23)	0.19 (0.16–0.25)	0.20 (0.17–0.26)	0.22 (0.18–0.27)	0.23 (0.20–0.29)	0.24 (0.20–0.40)
Total (2090)	0.35 (0.26–0.49)	0.39 (0.30–0.54)	0.48 (0.38–0.65)	0.56 (0.46–0.74)	0.63 (0.52–0.83)	0.71 (0.52–1.30)
Total (2100)	**0.38 (0.28–0.55)**	**0.44 (0.32–0.62)**	**0.56 (0.44–0.76)**	**0.68 (0.55–0.90)**	**0.77 (0.63–1.01)**	**0.88 (0.63–1.60)**
Total (2150)	0.57 (0.37–0.86)	0.68 (0.46–0.99)	0.92 (0.66–1.33)	1.19 (0.89–1.65)	1.32 (0.98–1.88)	1.98 (0.98–4.82)
Rate (2040–2060)	4.1 (2.8–6.0)	4.8 (3.5–6.8)	5.8 (4.4–8.0)	6.4 (5.0–8.7)	7.2 (5.6–9.7)	7.9 (5.6–16.1)
Rate (2080–2100)	4.2 (2.4–6.6)	5.2 (3.2–8.0)	7.7 (5.2–11.6)	10.4 (7.4–14.8)	12.1 (8.6–17.6)	15.8 (8.6–30.1)

Figure 1: SLR projections (Source: IPCC,2021)

2.4 Design Wave Conditions

2.4.1 Offshore Design Wave Conditions

Table 2 presents the significant wave height and peak wave period for various Average Recurrence Interval (ARI) events, with wave heights provided by BMT WBM (2013) and wave periods based on the observed wave climate during tropical cyclones. The 200-year ARI event will be used as the design condition in accordance with the Queensland Prescribed Tidal Works Code. A significant offshore wave height of 2.8 meters and a period of 6.2 seconds have been selected for this event. It is important to note that this wave height was determined at a depth of approximately 10 meters and will require transformation to obtain the design wave height and period at the structure's toe.

Table 2: Offshore Significant Wave Height and wave periods

Parameter	5% AEP 20 yr ARI*	2% AEP 50 yr ARI*	1% AEP 100 yr ARI	0.5% AEP 200 yr ARI	0.2% AEP 500 yr ARI	0.1% AEP 1,000 yr ARI	0.01% AEP 10,000 yr ARI
Hs (m)	2.66	2.71	2.74	2.80	2.85	2.87	2.92
Tp (seconds)	2.2	2.7	6.0	6.2	6.5	6.7	7.0

**Note: The study (BMT WMB, 2013) only provided data for 100 to 10,00 year ARI events. Therefore, interpolation was used to obtain the 20 and 50 year ARI design wave heights.*

2.4.2 Wave Conditions at the Structure

The nearshore height is the minimum of the shoaled wave height and the depth limited wave height, which are calculated below.

Shoaled Wave Height

The shoaled height of the wave at the structure toe as defined by (USACE, 2006):

$$H_1 = H_0 K_s K_r$$

Where:

H_0= Deepwater wave height

K_s = coefficient of wave shoaling for straight and parallel contours
K_r = coefficient of wave refraction for straight and parallel contours

Wave refraction is the bending of waves caused by a change in bed level. The shoaling coefficient on a coast with straight, parallel depth-contours is given by (USACE, 2008):

$$K_r = \left(\frac{1 - sin^2\theta_0}{1 - sin^2\theta_1}\right)$$

Where:

K_r = coefficient of wave refraction for straight and parallel contours
θ_0 = deepwater wave angle
θ_1 = wave angle in shallow water

The shallow water wave angle is given by (USACE, 2008):

$$\sin\ \theta_1 = \frac{C_1 \sin\theta_0}{C_o}$$

Where:

C_1 = shallow water wave celerity
C_0 = deep water wave celerity
θ_0 = deepwater wave angle
θ_1 = wave angle in shallow water

The deepwater group velocity is given by (USACE,2006):

$$C_o = \frac{gT}{2\pi}$$

Where:

T = wave period
g = acceleration due to gravity 9.81m/s^2

The shallow water group velocity is given by (USACE, 2008):

$$C_1 = \sqrt{gh}$$

Where:

h = water depth at the location of the shallow water wave height
g = acceleration due to gravity 9.81m/s^2

For this study it is assumed the waves moves perpendicular to the shoreline, therefore the offshore angle is 0 and the K_r is equal to 1 (no wave refraction).

Wave shoaling is the effect by which surface waves entering shallower water change in wave height. The shoaling coefficient on a coast with straight, parallel depth-contours is given by (USACE, 2008):

$$k_s = \left(\frac{C_{g0}}{C_{g1}}\right)^{\frac{1}{2}}$$

Where:

K_s = coefficient of wave shoaling for straight and parallel contours
C_{g0} = group velocity in deep water
C_{g1} = group velocity in shallow water

The group velocity in deepwater is given by (USACE, 2008):

$$C_{go} = \frac{gT}{4\pi}$$

Where:

T = wave period

g = acceleration due to gravity 9.81m/s^2

In shallow water the group velocity is calculated using the same equation as the shallow water wave celerity.

The shoaling coefficient is provided in Table 3 and the shoaled wave height at the structure toe is provided in Table 4 (2.97m wave height).

Table 3: Shoaling coefficient.

ARI (years)	T (s)	d (m MSL)	C_{go} (m/s^2)	C_{g1} (m/s^2)	K_s
100	9.20	5.30	7.18	6.30	1.07

Table 4: Wave height and period at structure toe

ARI (years)	Deepwater wave height (H_0) (m)	Depth at structure toe (m)	Refraction coefficient (K_r)	Shoaling coefficient (K_s)	Wave height at structure (H_1) (m)	Wave Period Shallow (sec)
100	2.80	2.54	1.00	1.06	2.97	7.23

Depth Limited Wave Breaking

EurOtop (2018) and CIRIA (2007) indicates that the nearshore breaking wave height (H_{mo}) can be determined from the breaker index, which is dependent on nearshore beach slope and the relative water depth determined from the breaker water depth at structure toe (h) and deepwater wave length (Lo). Based on a typical average slope of 1V:100H, a suitably conservative breaker index can be derived from the graphical fitted curve in Figure 2 where:

$S_{op} = H_{mo\ deep}/L_{op}$

H_{mo} = depth limited significant wave height at toe of structure

$H_{mo\ deep}$= depth limited significant wave height in deep water

L_{op} = peak wave length in deep water

h = water depth at toe of structure

For $H_{mo\ deep}$ = 2.80m (calculated in Section 2.4.1) and L_{op} = 60 (6.2 second period) in deep water, S_{op} ~ 0.04. Assuming a water depth at the toe of the structure of 2.54m and L_{op} = 60, h/L_{op} =0.04. With a foreshore slope of 1:100, H_{mo}/h ~0.54m (Figure 2).

It should be noted that breaker height is dependent on wave period, water depth near the structure and beach slope and it is independent of the offshore wave height. Therefore, a storm event with a lower offshore wave height and similar wave period would result in the same breaker height, unless of course the transmitted nearshore wave height is too low. Conversely, a storm that lacks the energy to generate a sufficient amount of scour would result in a lower depth limited wave height near the structure.

The depth-limited wave height at the structure toe is provided in Table 5. The depth-limited breaking wave height is 1.37m for rock size. This is the maximum wave height that can occur in a water depth of 2.54m. As the depth-limited wave breaking height is smaller than the 100 year ARI shoaled wave height calculated above the depth limited wave height was chosen as the design wave height.

Table 5: Depth-limited wave height at structure (EurOtop, 2018)

ARI (years)	Slope	h_b/L_0	h/Lop	Hmo/h	h (m)	H_b (m)
200	100	0.04	0.04	0.54	2.54	1.37

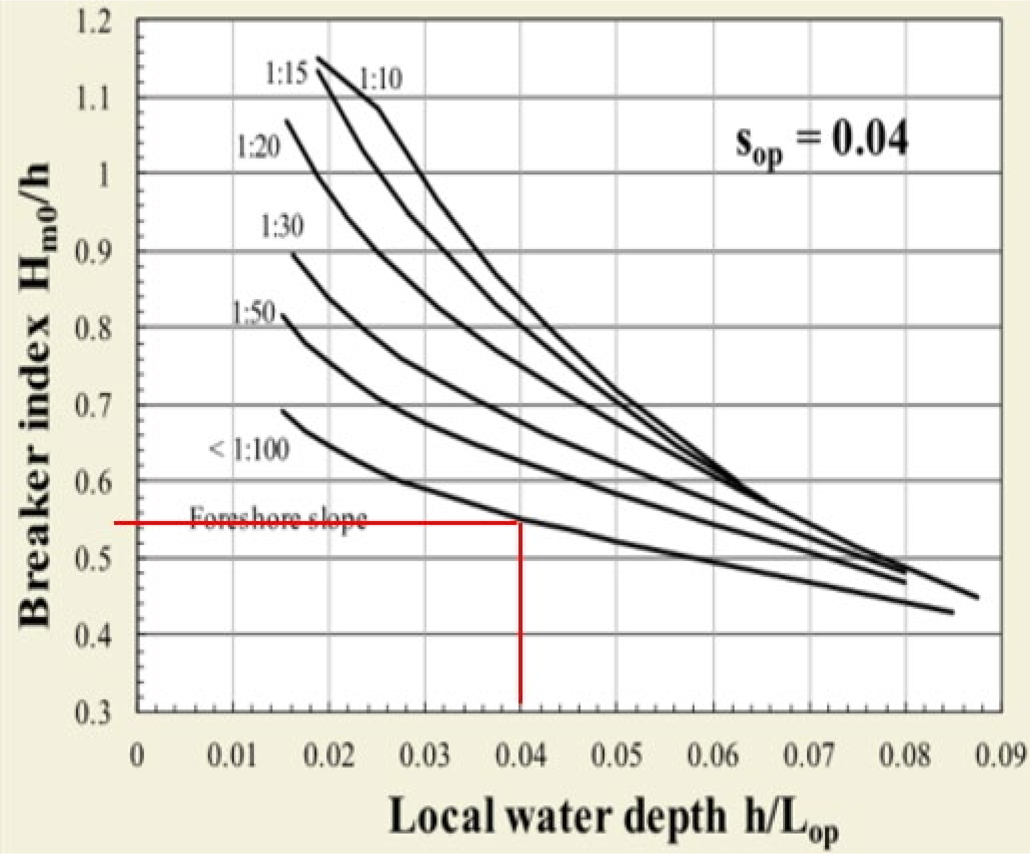

Figure 2: Depth-limited significant wave heights for uniform foreshore slopes (Figure 2.4, EurOtop 2018).

2.4.3 Rock Sizing

A rock revetment has been proposed comprising relatively uniform rock armour. The revetment would comprise 2 layers of primary armour rock and 2 layers of secondary armour rock with a narrow grading of the average between:

- $0.80*D_{50}$ to $1.2*D_{50}$
- $0.75*M_{50}$ to $1.25*M_{50}$

As a check to ensure narrow grading the ratios in Figure 3 are applied.

Grading width	D_{85}/D_{15}	M_{85}/M_{15}
Narrow or *single-sized* gradation	Less than 1.5	1.7–2.7
Wide gradation	1.5–2.5	2.7–16
Very wide or *quarry run* gradation	2.5–5.0	16–125+

Figure 3 Armour stone grading width related to the uniformity (source: Table 3.4 The Rock Manual CIRIA, 2007)

The rock armour would be required to achieve material acceptance requirements for use in a marine environment.

Design parameters are provided in Table 6. Underlayers would satisfy filter rule requirements, particularly; internal stability, permeability and retention criteria. The cross-section below (Figure 4) shows the typical revetment wall design.

The sourced rock will need to achieve the requirements in Table 7 (compliant with AS2758.6).

Table 6: Rock revetment design parameters

<table>
<tr><th colspan="2">Design Parameters</th><th>Value</th><th>Comments</th></tr>
<tr><td colspan="2">Significant Wave Height and Peak Period</td><td>H_s = 1.37m
$H_{1/10}$ = 1.62m
$H_{2\%}$ = 1.72m
T_p = 7.23 seconds</td><td>Wave statistics determined in accordance with CIRIA Box 4.4</td></tr>
<tr><td colspan="2">Slope (V:H)</td><td>1:1.5</td><td></td></tr>
<tr><td colspan="2">Toe depth</td><td>~0.35m - 0m AHD</td><td>0.35-0m AHD or non erodible surface</td></tr>
<tr><td colspan="2">Toe width</td><td>0m</td><td>No toe design, tie into existing non erodible surface</td></tr>
<tr><td colspan="2">Crest height</td><td>4m – 3.5m</td><td>Meets over topping requirements</td></tr>
<tr><td colspan="2">Minimum Design Rock Dry Density</td><td>2.6 t/m^3</td><td>Higher density would result in lower rock mass.</td></tr>
<tr><td rowspan="2">Primary Rock</td><td>Median Rock Mass</td><td>600kg (slope 1V:1.5H)
range: 350kg to 900kg</td><td rowspan="2">Determined in accordance with Van Der Meer (modified by Van Gent) and Eldrup and Lykke Anderson shallow water equations.</td></tr>
<tr><td>Median Rock Diameter (D_{50})</td><td>0.6m (slope 1V:1.5H)
0.5m to 0.7m</td></tr>
<tr><td rowspan="2">Secondary Rock</td><td>Median Rock Mass</td><td>50kg (slope 1V:1.5H)
range: 20kg to 100kg</td><td></td></tr>
<tr><td>Median Rock Diameter (D_{50})</td><td>0.27m (slope 1V:1.5H)
0.20m to 0.35m</td><td></td></tr>
</table>

Table 7: Rock property criteria and requirements

Criteria	Requirement
Petrography (AS1141.26)	Igneous or high-grade thermal metamorphic
Specific gravity (as1141.6.1)	≥ 2.6
Absorption	≤ 1.5%
Sulphate soundness (as1141.24)	≤ 9%
Los Angeles abrasion loss (as1141.21)	≤ 25%
Wet/dry strength variation	≤ 25%
Aggregate crushing strength	≥ 150kN
Field drop test (ciria 2007 rock manual or en13383)	Breakage rate ≤ 10% Mass loss ≤ 5%
Field visual	Rough angular rock free of seems or major distinctions that is compliant with the size and petrography criteria.
Shape	≤ 5% by number have length to thickness ratio greater than 3

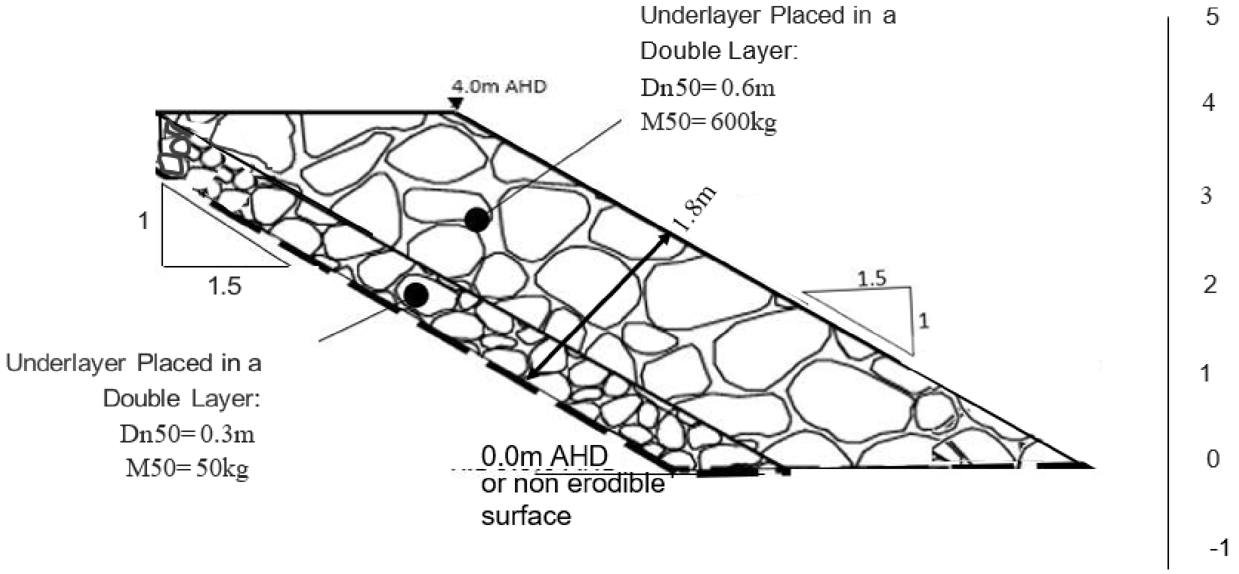

Figure 4: Typical revetment wall design cross-section

2.4.4 Wave Overtopping

Overtopping of a rock structure along a shallow foreshore can be determined using the Neural Network for the design of coastal and harbour structures online tool (NN, 2016). Figure 5 details all the inputs that can be used to calculate overtopping. Multiple crest heights and crest widths were assessed. The results are presented in Table 8. A 4m crest height with a crest width of 1.8m (~3 rocks wide) could produce an overtopping rate of 12.3 L/s/m, where a crest height of 3.5m with a crest width of 1.8m will produce an overtopping rate of 56.3 L/s/m. This will decrease as the crest width increases. For a crest width of 2.5m the overtopping rate decreases to 25.6 L/s/m.

In accordance with EuroTop (2018), unsafe mean overtopping for cars on a seawall/ dike crest, or railway close behind crest is defined as (Figure 6):

- Hmo=3m, less than 5 L/s/m
- Hmo=2m, between 10 – 20 L/s/m
- Hmo=1m, less than 75 L/s/m

For the design wave height at the structure of 1.37m (Table 5), the acceptable overtopping rate is approximately 34 L/s/m (interpolated for a Hmo of 1.37m).

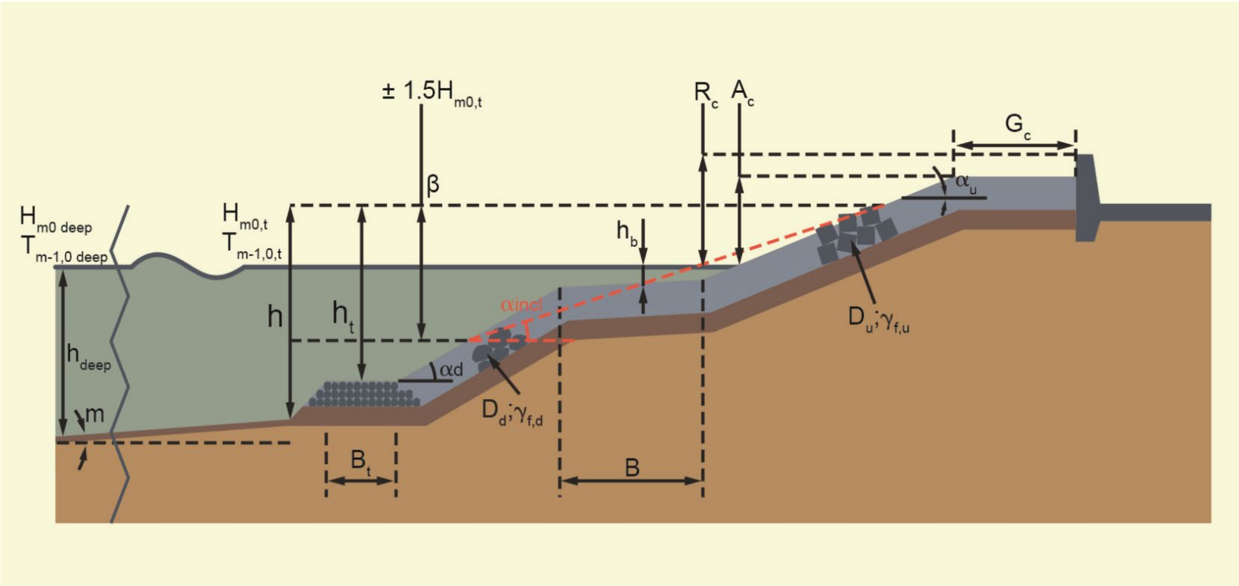

Figure 5: Schematisation of the structure, including the parameters required to run the NN tool (Figure 4.16, EurOtop 2018)

Table 8: Overtopping calculations

Revetment Slope (cotα)	Berm	Water Level (m AHD)	Crest Height (m)	Crest width (m)	Toe width (m)	Wave Overtopping (L/s/m)
1.5	No	2.54	5	2.5	0	0.4
1.5	No	2.54	5	1.8	0	0.85
1.5	No	2.54	4	2.5	0	5.5
1.5	No	2.54	4	1.8	0	12.3
1.5	No	2.54	3.5	2.5	0	25.6
1.5	No	2.54	3.5	1.8	0	56.30

Hazard type and reason	Mean discharge q (l/s per m)
People at structures with possible violent overtopping, mostly vertical structures	No access for any predicted overtopping
People at seawall / dike crest. Clear view of the sea.	
H_{m0} = 3 m	0.3
H_{m0} = 2 m	1
H_{m0} = 1 m	10-20
H_{m0} < 0.5 m	No limit
Cars on seawall / dike crest, or railway close behind crest	
H_{m0} = 3 m	<5
H_{m0} = 2 m	10-20
H_{m0} = 1 m	<75
Highways and roads, fast traffic	Close before debris in spray becomes dangerous

Figure 6: Limits for overtopping for people and vehicles (Source: Table 3.3 EurOtop Manual, 2018)

Royal HaskoningDHV is an independent consultancy which integrates 140 years of engineering expertise with digital technologies and software solutions. As consulting engineers, we care deeply about our people, our clients and society at large. Through our mission Enhancing Society Together, we take responsibility for having a positive impact on the world. We constantly challenge ourselves and others to develop sustainable solutions to local and global issues related to the built environment and the industry.

Change is happening. And it's happening fast – from climate and digital transformation to customer demands and hybrid working. The speed and extent of these changes create complex challenges which cannot be addressed in isolation. New perspectives are needed to accommodate the broader societal and technological picture and meet the needs of our ever-changing world.

Backed by the expertise of over 6,000 colleagues working from offices in more than 20 countries across the world, we are helping organisations to turn these challenges into opportunities and make the transition to smart and sustainable operations. We do this by seamlessly integrating engineering and design knowledge, consulting skills, software and technology to deliver more added value for our clients and their asset lifecycle.

We act with integrity and transparency, holding ourselves to the highest standards of environmental and social governance. We are diverse and inclusive. We will not compromise the safety or well-being of our team or communities – no matter the circumstances.

We actively collaborate with clients from public and private sectors, partners and stakeholders in projects and initiatives. Our actions, big and small, are driving the positive change the world needs, and are enhancing society now and for the future.

Our head office is in the Netherlands, and we have offices across Europe, Asia, Africa, Australia and the Americas.

euroCompliance certification ISO 37001

euroCompliance certification ISO 37301

royalhaskoningdhv.com

Royal HaskoningDHV
Enhancing Society Together