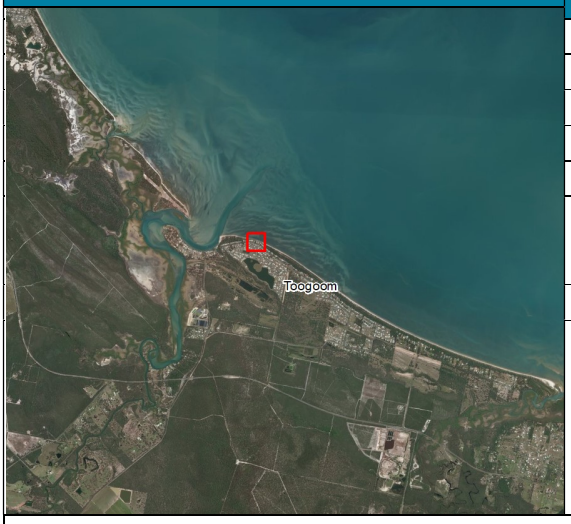
COASTAL ASSET CONDITION SURVEY REPORT

1. General information

Location Plan:	Kingfisher Parade Seawall	
	Date:	30 November 2017
	Engineer:	Gildas Colleter
	DEHP Coastal Segment:	FRC047
	Start coordinates	152.671764232, -25.2449565559
	End coordinates	152.675724521, -25.2458581927
	Tide	Low during inspection (3 hours on-site)
	Asset Certification	Yes, RPEQ
	Other associated assets	Stair access Beach accesses Fence Signs Private properties

NOTE: This document has been prepared as an Asset Condition Survey Report for Fraser Coast Regional Council. JBP accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

1.1. Structure information

Structure type:	Rock armour revetment		
Approx. defence length (m):	375m		
Approx. co-ordinates from:	152.672570672, 25.2450582158	to:	152.67518283, 25.2455802775
As built drawing available:	Yes		
Infrastructure protected:	Private property and public land		

1.2. Access considerations

Third party/adjacent landowner permissions:	Council Contact: Rosalyn Acworth
Local guidance:	Park along kingfisher parade and access beach via staircase TGM20. Access via beach access west of seawall 48 kingfisher parade - TGM21 recommended at low tide to inspect the progression of the erosion scarp to the west of the structure.
Equipment required for access and examinations:	Necessary PPE following Safety Assessment – iPad (GPS, Camera, notes), tape, etc.

2. Representative photographs and background information

2.1. Photograph

West	 **The seawall meets the dune. The dune is eroding. The toe is visible at low tide – Location Reference 6**	 **seawall capping stones and trunk are being uncovered by erosion – Location Reference 21**

Mid-section	 **Looking west - seawall trunk is exposed and the toe is burried – Location Reference 2**	 **Looking East - seawall trunk is exposed and the toe is burried – Location Reference 2**

East	 **The seawall toe and trunk sections are buried – Location Reference 20**	 **Looking towards the west - the seawall merges into the beach – Location Refence – "Inspection End"**

2.2. Background information

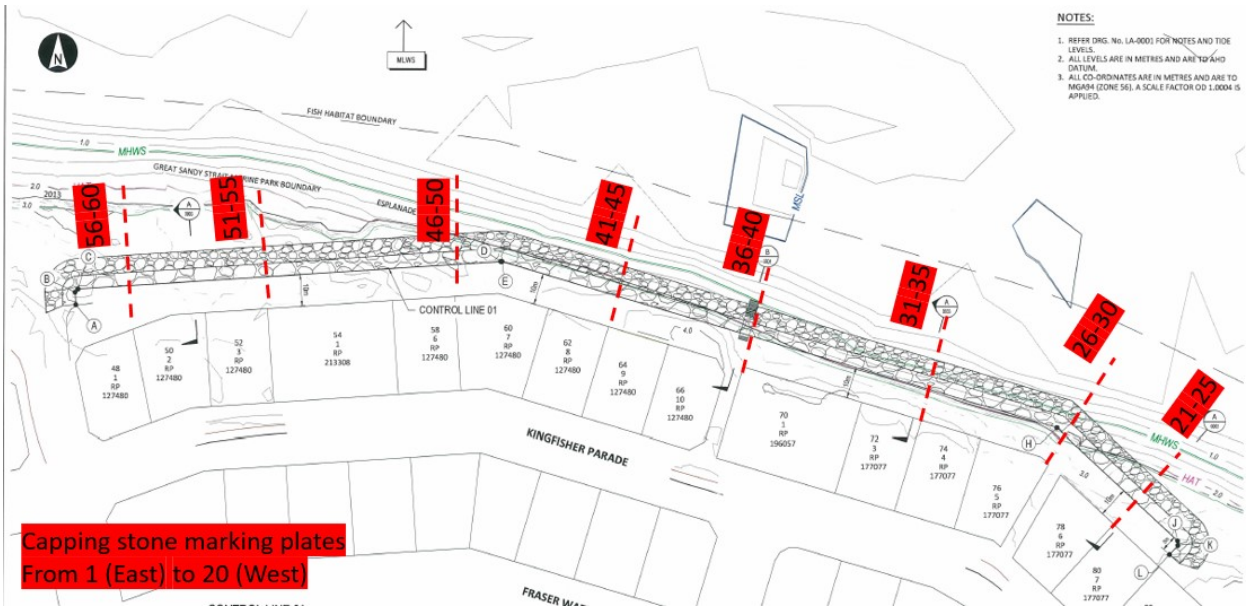
Function	The Kingfisher Parade Seawall is an erosion protection structure. It is not a coastal flooding control structure such as a coastal levee or a dyke. State design guideline were adopted for the design of the seawall in particular the Department of Environment and Heritage Protection (EHP) "Building and engineering standards for tidal works". As such, the seawall has a 50-year design life (including monitoring and maintenance) and allows for a Sea Level Rise (SLR) of 0.3m. The local area is classified as a significant to high flood and storm tide hazard inundation zones. During future major storm event the seawall may be overtopped by waves (refer Aurecon Design Report).
Background	Ex tropical cyclone Oswald (January 2013) eroded the Kingfisher Parade foreshore up to many beachside property fences. This event followed decades of documented on-going and storm-induced beach erosion along the Toogoom Foreshore. State, Local and Resident consultations followed while emergency sand push ups were carried in the interim. A more permanent solution was sought to manage erosion along properties 48 to 80 Kingfisher Parade. The consultation led to testing and designing a rock armour seawall. The seawall consisted of a trunk armourstone revetment with pattern-placed capping stones at the crest and a wide toe scour apron. The seawall alignment was offset 10m from the properties boundaries and is approximately 375m long.
Design summary	The design investigation included hydraulic testing at 1:30 scale at the University of New South Wales Water Research Laboratory. Armour stability and wave overtopping were investigated to establish the seawall performance in relation to EHP guideline. The hydraulic testing demonstrated that for a 50-year storm event (including SLR): • 1t rock armourstones are stable on the seawall trunk • 3t rock pattern-placed capping stones are stable at the crest
Construction	The seawall was constructed from December 2013 to November 2014 (Bulk of the armouring works were completed in May 2014) with Council-appointed construction contractor and on-site supervision. The armourstones placed on the structure are oversized by 50% on the trunk (~1.5t placed) and 33% at the crest (>4.0t placed). This oversizing was designed to account for long-term dilapidation of stones from Dundorwan and Maryborough quarries and recognition that trunk armourstones are typically more exposed to dilapidation than capping stones. The constructed seawall "as built" survey included excavations across each property boundaries to survey the toe and to install (60x) marking plates. As-con survey analysis demonstrates that the seawall geometry and armouring functional requirements were met as confirmed by RPEQ.
Past-performance	Since construction, major storm events such as ex-tropical cyclone Debbie (February 2017) and ex-tropical cyclone Marcia (March 2015) have continued to erode the shoreline to the west of the seawall. The seawall has stabilised the shoreline southward position, reducing significantly the coastal erosion hazard along the protected properties from 48 to 80 Kingfisher Parade.

2.3 Seawall Inspection Methodology

Three types of inspections have been carried and are outlined in this survey report.
1 Marking plate inspection
2 Test panel inspection, for each property along Kingfisher Parade
3 Armourstone dilapidation inspection

2.3.1 Marking plate inspection

The Kingfisher Parade Seawall has been equipped with 60x marking plates in November 2014. 20x marking plates were placed on the capping stones from East to West (ID 1 – ID20). Marking plates ID21 to ID60 were placed across the properties boundaries from the crest of the seawall down to the toe of the seawall by cluster of 5 plates for each cross sections (8x cross-sections).



A list of visible marking plates was made during the inspection. The condition of each armourstone has been recorded. This allows to do a rapid evaluation of change to the seawall armourstone. Missing plates may be due to burial under the sand (particularly toe stones), detached plates and overturned/displaced armourstones.

A photographic record of marking plates and armourstones has also been made during the site inspection. The photographic record can be used to compare overtime the surface of the stone for signs of weathering.

2.3.2 Test panel inspection

The test panel inspection consists of a physical inspection of a group of armourstones along the seawall. The test panel is a random sample of a cluster of approximately 30 contiguous armour stones visible. Each stone is visually inspected for defect such as spalling, cracking and physical signs of wear and tear as well as damage. All armourstone inspected (N) and damaged armourstones (D) are reported.

The Criteria for damaged armourstone applies to armourstones which have been reduced in mass beyond wave stability mass criteria. Physical testing demonstrated that, for the Kingfisher Parade seawall, an armourstone median mass of 1t in the trunk and of 3t for the capping stones meet the wave stability mass criteria. An armourstone below 750kg on the trunk of the seawall would be too small to meet the typical grading criteria for armourstone (+- 25% of median mass).

Visual comparison of stone size to neighbouring non-defective stone size allows a quick assessment of the mass of an individual stones. A more detailed estimate of armourstone mass can be carried-out using the sum of girth method (see below) or a calibrated test-scale.

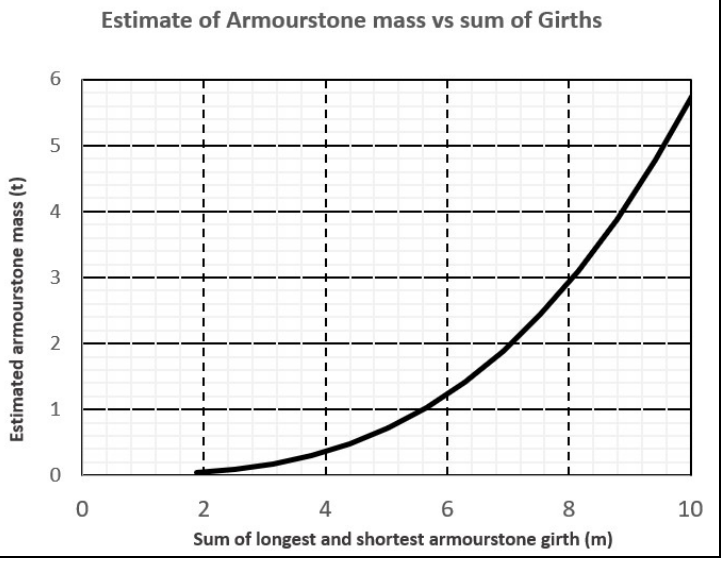
Estimating armourstone mass using the "Sum of Girth" method

The direct in-situ measurement of the sum of girths of an armourstone with a measuring tape can provide an reasonably accurate estimate of armourstone mass using the graph to the right.

Method:

1. The tape is used to measure the armour stone longest perimeter (girth 1)
2. The tape is used to measure the smallest perimeter (girth 2)
3. These two dimensions are added and form the sum of girth (in metre)
4. The graph is used for estimating the Armourstone mass

The graph is valid for stone density installed on the Kingfisher Parade Seawall. The method accuracy performs best on blocky armour-stones.



2.3.3 Dilapidation survey

During the inspected all damaged stones found during the survey were reported, located and photographed.

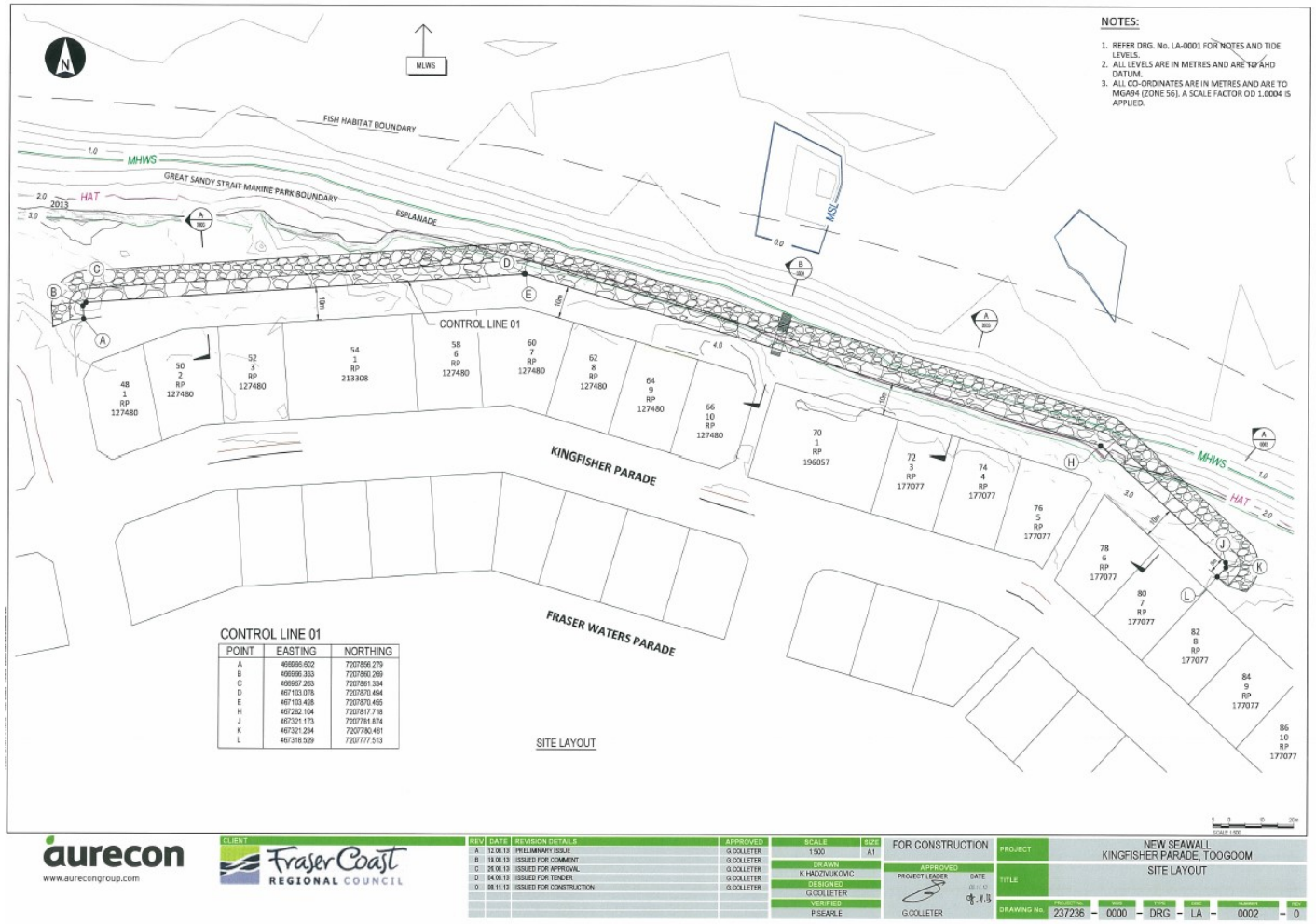
At Kingfisher Parade, an estimate of the quantity of armourstone visible during an inspection can be done by multiplying the length of visible seawall by the height of the seawall. There is approximately 300m of seawall visible and on average there are 7x armourstone visible across the structure. The total number of stones visible during the inspection was around 7x300=2,100 armourstones. There are approximately 250 capping stones along the crest.

All stones found damaged during the seawall inspection and were photographs and have been presented in the armourstone damage list. Some of the defective stones have also been reported to illustrate the typical failure modes:

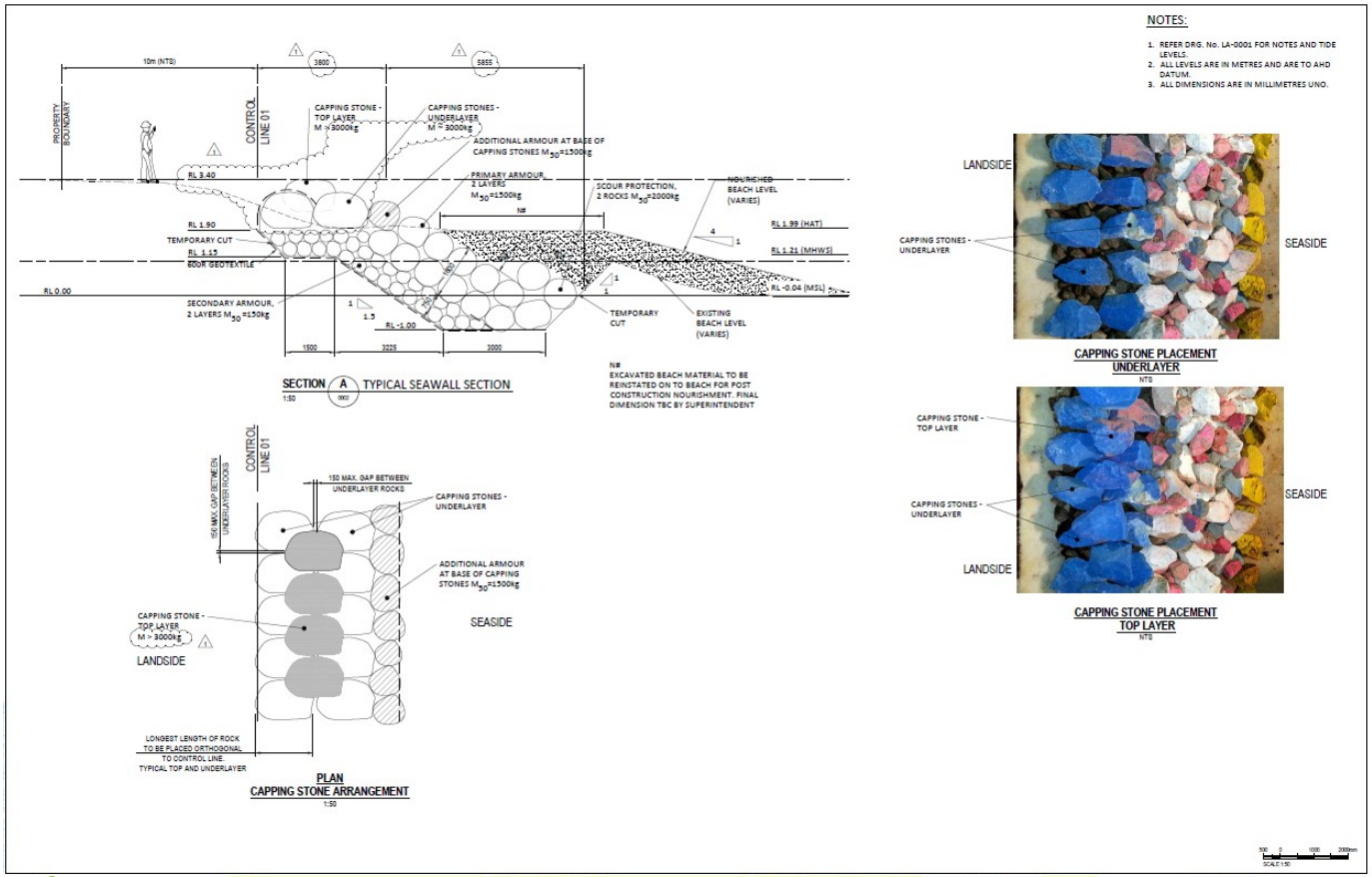
- Rock spalling or onion-peeling of the armourstones along localised weaknesses such as smectite veins and microfracture planes
- Mechanical impacts, due to stone movements
- Rock erosion and abrasion

3. Asset sketches

Plan



Cross section



4. Visual Condition Survey
4.1 Indicative location of photographs

Inspection Extent - QGlobe® (2017)

Crest	Emergent			Part. buried	
Trunk	Buried	Partially buried	Emergent	Buried	
Toe	Buried	Partially Buried	Buried		

4.2 Asset condition grade

Reference Asset Condition grade scale from 1 to 5

Grade	Description of condition	Extent of defects
1	Very good	Cosmetic defects that will have no effect on performance
2	Good	Minor defects that will not reduce overall performance of asset
3	Fair	Defects that could reduce performance of asset
4	Poor	Defects that would significantly reduce performance of asset
5	Very poor	Severe defects resulting in complete performance failure

Source: UK Environment Agency, Condition Assessment Manual, 166-03-SD01, 2006

Asset condition grade summary

	Section A
Target condition grade	N/A
Overall surveyed condition grade	2(*)

General: The seawall is generally in very good condition with a few minor defects to armouring, such as localised loose packing and voids, causing downgrading from 1 to 2(*). Minor dilapidation of individual armourstone on trunk (damage estimate to be 1.5% since construction) that will not reduce overall functional performance of the asset. Capping stone dilapidation is negligible. Safety sign and fence installed. Some fence damage and fence continuation along western side of the seawall is missing.

Specific description: Angular stone thorough, generally well packed and stable. Alignment retained at crest and toe. Constant slope on trunk section with only minor defects due to individual armourstone movement/dilapidation. Vegetation well established at crest which aids into binding the blocks and preventing washout of sand through crest.

Key features: Minor settlement of sand into capping stones at crest but no significant cave-ins and no movement or damage to capping stone. No missing elements (sign or fence), no loss of material visible on beach (negligible presence of cobbles and gravels) and no bulging or undermining of the toe. No animal burrowing or foreign objects present into the structure.

(*) The asset condition grade may be restored back to 1 following rectification of minor defects outlined in Section 10.1.

5. Identification of monitoring points, defects and recommendations – Crest and trunk only (Defects are indicated as D#)

Ref No.	Type	Lat	Long	Condition Grade	Monitoring point description or defect Description	Recommendations	Defect Priority / Monitoring frequency
P1	Beach Access TGM20	-25.2449684532	152.671830857	1	Erosion and tree debris	Monitor	N/A
P2	Beach stair access TGM21	-25.2452776788	152.674149723	2	Minor unpacking of armourstones each side of stair (refer to **D6**	Loose armourstones to be re-packed in armour	N/A
P3-P20	General armour maintenance	-25.2455802775	152.675182830	2	**D5** rock spalls accessible from the beach to be placed between capping stones **D6** Lower than average armourstone interlocking in few discrete areas along the wall.	Re-pack individual armourstones. Place rock spalls into the armour voids, particularly into the crest voids	Band B - Urgent
P3	Dune erosion to West	-25.2450582158	152.672570672	2	**D4** Dune scraping in front of properties 50 and 52 Eroded apron, tree debris, 1.5m scarp, rock covered by 1m to 500mm thick sand with hollowed sections	Fence dune access and install sign Monitor closely safety and vegetation	Monthly monitoring of scarp
P4	Property 54 – Test Panel	-25.2450736526	152.672747733	1	Trunk armourstone appears through the dune scarp. **D6:** some minor unpacking	Monitor erosion progression as the seawall is uncovered	Monthly monitoring of scarp
P5	Property 54 – marking plate	-25.2450689294	152.672869741	1	**D8** Trunk Armourstone visible through the dune and toe stone visible on beach surface. 2x marking plates missing (glue visible)	Monitor erosion progression as the seawall is uncovered	Band D – Long-Term Replace marking plate Monthly monitoring of scarp
P6	Property 58 – seawall	-25.2450451347	152.673088652	1	Very good condition	Long-term monitoring	Monitor – 6 months unless event

Ref No.	Type	Lat	Long	Condition Grade	Monitoring point description or defect Description	Recommendations	Defect Priority / Monitoring frequency
P7	Property 60 – seawall	-25.2450736883	152.673388464	1	Very good condition, except for one damaged stone found during dilapidation survey. **D5** rock spalls to be placed in localised voids	Long-term monitoring	Band B - Urgent Monitor – 6 months unless event
P8	Property 62 – seawall	-25.2451252506	152.673645294	1	Very good condition. One damaged stone found.	Long-term monitoring	Monitor – 6 months unless event
P9	Property 64– seawall	-25.2451728398	152.673845169	1	Very good condition, except for one damaged stone. **D6** minor armour unpacking	Long-term monitoring	Band B - Urgent Monitor – 6 months unless event
P10	Property 66– seawall	-25.2452274465	152.673995286	1	Very good condition.	Long-term monitoring	Monitor – 6 months unless event
P11	Property 70– seawall	-25.2453168747	152.674342687	1	Very good condition, except for one damaged stone.	Long-term monitoring	Monitor – 6 months unless event
P12	Property 72– seawall	-25.2454067058	152.674618107	1	Very good condition.	Long-term monitoring	Monitor – 6 months unless event
P12	Property 72 - Void at crest due to localised crest slumping	-25.2454067058	152.674618107	2	**D2** Sand is seeping through the capping stones at the crest	Voids in crest to be reduced by relocating trunk armourstone rock spalls into voids	Band B – Urgent
P12	Property 72 – Fence wire missing	-25.2450656113	152.672639543	N/A	**D3** Fence top-wire is loose	Replace and refit disconnected wire.	Band A - Emergency
P13	Property 74 – seawall	-25.2454700634	152.674806875	1	Very good condition. **D6** minor armour unpacking	Long-term monitoring	Monitor – 6 months unless event

Ref No.	Type	Lat	Long	Condition Grade	Monitoring point description or defect Description	Recommendations	Defect Priority / Monitoring frequency
P14	Property 76– seawall	-25.2455139381	152.675032268	1	Very good condition of armourstones. **D5** Minor rock spalls, **D6** minor armour unpacking.	Long-term monitoring	Monitor – 6 months unless event
P15	Property 78– seawall	-25.2456548842	152.675300937	1	Very good condition	Long-term monitoring	Monitor – 6 months unless event
P16	Property 80 seawall	-25.2457891967	152.675470812	1*	Very good condition of capping stone. (+) condition grade assumed to be very good - the seawall has been buried since construction	Long-term monitoring	Monitor – 6 months unless event
P17	Property 52 – seawall	-25.2450589199	152.672498259	1(+)	(+) condition grade assumed to be very good - the seawall has been buried since construction	Monthly monitoring of scarp	Monthly monitoring of scarp
P18	Property 50 – seawall	-25.2450348580	152.672289153	1(+)	(+) condition grade assumed to be very good - the seawall has been buried since construction **D7** Assess vegetation which may be threatened by erosion	Assess vegetation in erosion area Monthly monitoring of scarp	Band C – Short-Term Assess vegetation in erosion area Monthly monitoring of scarp
P19	Property 48 – seawall	-25.2450048849	152.672057714	1(+)	(+) condition grade assumed to be very good - the seawall has been buried since construction	Monthly monitoring of scarp	Monthly monitoring of scarp
P20	Dune accretion to East	-25.2455802775	152.675182830	N/A	East-end of wall covered by beach Vegetation cover “goat foot”. Shoreline is eroding towards the east of the seawall (exposed tree roots).	Long-term monitoring	Monitor – 6 months unless event
P20	Property 76 - Entrapment void	-25.2455802775	152.675182830	2	**D1** Large void in trunk	Void to be closed-out with smaller rocks and rock spalls	Band A- Emergency

Ref No.	Type	Lat	Long	Condition Grade	Monitoring point description or defect Description	Recommendations	Defect Priority / Monitoring frequency
P21	Western fence missing	-25.2450656113	152.672639543	N/A	**D4** Fence to be continued toward the fence, include sign identifying the beach scarp	Fence dune access and install sign Band A – Emergency	Band A - Emergency

Photos of reference points with damages and defects

Beach Access TGM20
Ref No: P1

Beach Access TGM20
Ref No: P1

Access stair TGM20
Ref No: P2

Access stair TGM20
Ref No: P2

Dune erosion to west – exposed trunk section
Ref No: P3

Dune erosion to west – capping stones-
Ref No: P3

Photos of reference points with damages and defects	
 **Kingfisher parade Seawall** **Ref No: P3**	 **Beach access** **Ref No: P2**
 **Beach access** **Ref No: P2**	 **Property 54** **Ref No: P5**

Photos of reference points with damages and defects

Property 56
Ref No: P6

Property 58
Ref No: P7

Property 60
Ref No: P8

Property 62
Ref No: P9

Photos of reference points with damages and defects

Property 64
Ref No: P10

Property 66
Ref No: P11

Property 70
Ref No: P12

Property 72
Ref No: P13

Photos of reference points with damages and defects

Property 74
Ref No: P14

Property 76
Ref No: P15

Property 78
Ref No: P16

Property 78
Ref No: P16

Photos of reference points with damages and defects

Property 80
Ref No: P17

Property 52
Ref No: P18

Property 50
Ref No: P19

Property 48
Ref No: P20

Photos of reference points with damages and defects	
 **Access stair TGM20** **Ref No: P2**	 **Dune towards the West** **Ref No: P16**
 **Dune towards the West** **Ref No: P16**	 **Defect D1: Entrapment void** **Ref No: P20**

Photos of reference points with damages and defects	
 **Defect D2: Void at crest due to localised sand slumping** **Ref No: P12**	 **Defect D3: Interruption of western fence** **Ref No: P21**
 **Defect D4: Fence wire disconnected** **Ref No: P12**	

6. Marking Plate Survey

During the inspection 28 marking plates were found, one damaged armourstone (Plate ID 48) and no defective armourstones amongst the 28 armourstone sample. 7x marking plates (33, 34, 37, 45, 46, 53 and 54) appear to be missing and should be re-instated on the seawall.

The November 2015 found 26 marking plates and one damaged armourstone (Plate ID 48).

Marking Plate ID	Photograph / Notes
ID1	Not found, may be buried since Nov. 2015
ID2	Not found in Nov. 2017. This plate was found in Nov. 2015
ID3	Not found, may be buried since Nov. 2015
ID4	Not found, may be buried since Nov. 2015
ID5	Not found, may be buried since Nov. 2015
ID6	Not found, may be buried since Nov. 2015
ID7	 Found in Nov. 2015
8	 Found in Nov. 2015
ID9	 Found in Nov. 2015

Marking Plate ID	Photograph / Notes
ID10	 Found in Nov. 2015
ID11	 Found in Nov. 2015
ID12	  Found in Nov. 2015

Marking Plate ID	Photograph / Notes
ID13	  Found in Nov. 2015
ID14	  Found in Nov. 2015
ID15	  Found in Nov. 2015

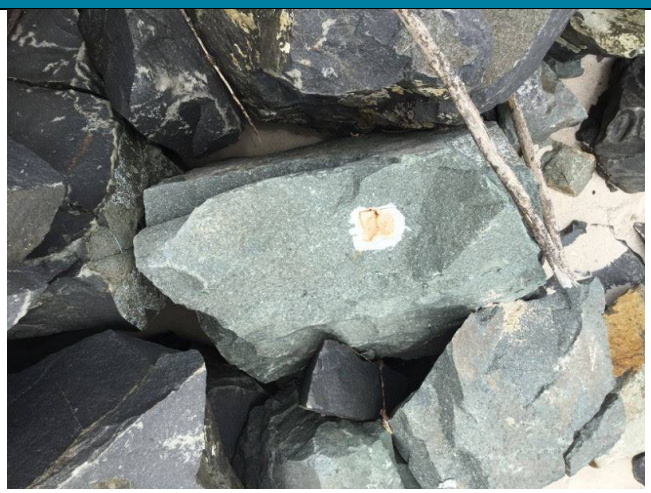
Marking Plate ID	Photograph / Notes
ID16	  Found in Nov. 2015
ID17	  Buried in Nov. 2015
ID18	  Buried in Nov. 2015

Marking Plate ID	Photograph / Notes
ID19	Buried in Nov. 2015  
ID20	Buried in Nov. 2015  
ID21	Not found, may be buried since Nov. 2015
ID22	Not found, may be buried since Nov. 2015
ID23	Not found, may be buried since Nov. 2015
ID24	Not found, may be buried since Nov. 2015
ID25	Not found, may be buried since Nov. 2015

Marking Plate ID	Photograph / Notes
ID26	Was not found in Nov. 2015  
ID27	Not found, may be buried since Nov. 2015
ID28	Not found, may be buried since Nov. 2015
ID29	Not found, may be buried since Nov. 2015
ID30	Not found, may be buried since Nov. 2015
ID31	Not found, may be buried since Nov. 2015
ID32	Found in Nov. 2015  
ID33	Not found, may be buried since Nov. 2015 or this could also be a missing plate
ID34	Not found, may be buried since Nov. 2015 or this also be a missing plate

Marking Plate ID	Photograph / Notes
ID35	 This plate was not found in Nov. 2015
36	 Found in Nov. 2015
ID37	Not found in Nov. 2017. This plate was found in Nov. 2015.This could be a missing plate.
ID38	Not found, may be buried since Nov. 2015
ID39	Not found, may be buried since Nov. 2015
ID40	Not found, may be buried since Nov. 2015
ID41	  Found in Nov. 2015
ID42	 Found in Nov. 2015

Marking Plate ID	Photograph / Notes
ID43	Found in Nov. 2015 
ID44	Found in Nov. 2015 
ID45	Not found, may be buried since Nov. 2015 or this could be a missing plate
ID46	This plate was not found in Nov. 2017. It was found in Nov. 2015. This plate may be missing.
ID47	Found in Nov. 2015  

Marking Plate ID	Photograph / Notes
ID48	 Damaged since November 2015. The armourstone seems not to be originating from Dundorwan Quarry
ID49	 Found in Nov. 2015
ID50	This plate was not found in November 2017. It was found in Nov. 2015..
ID51	Not found, may be buried since Nov. 2015
ID52	This plate was buried in Nov. 2015  

Marking Plate ID	Photograph / Notes
ID53	 This plate was buried in Nov. 2015, Glue visible only. Stainless steel Plate ID 53 is missing
ID54	 This plate was buried in Nov. 2015, Glue visible only. Stainless steel Plate ID 54 is missing
ID55	Not found, may be buried since Nov. 2015
ID56	Not found, may be buried since Nov. 2015
ID57	Not found, may be buried since Nov. 2015
ID58	Not found, may be buried since Nov. 2015
ID59	Not found, may be buried since Nov. 2015
ID60	Not found, may be buried since Nov. 2015

7. Test panels inspections

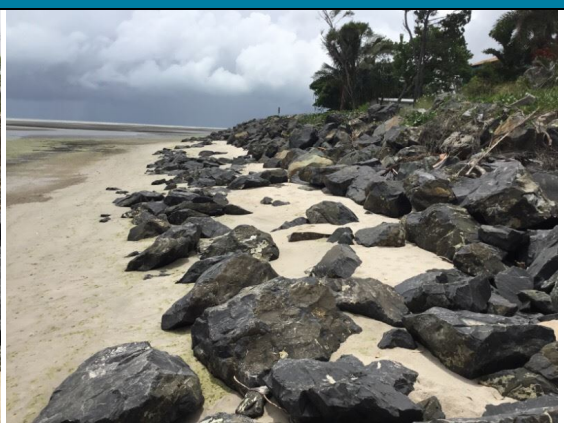
7.1. Test panel photographs

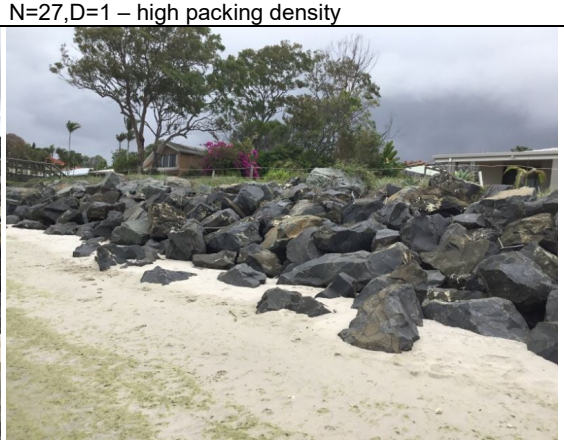
Pictures of seawall test panels, for each property along Kingfisher Parade, are provided below along with the measurement of:

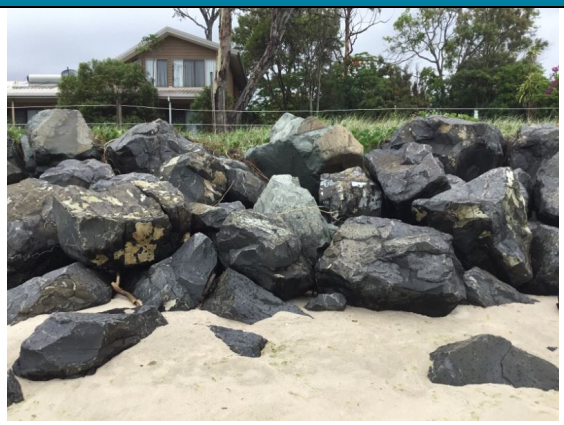
- N: number of stone counted in the photograph
- D: number of damaged armourstones (estimated armourstone mass below 750kg)

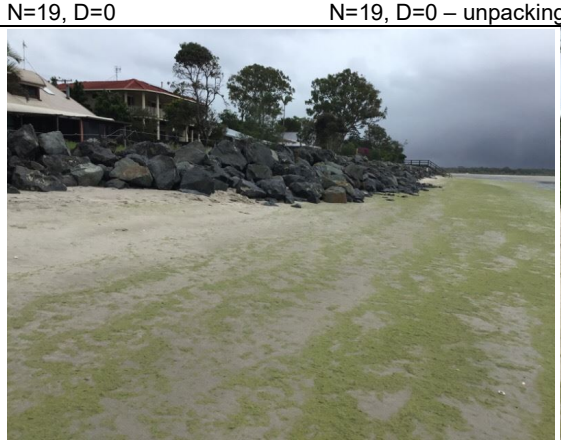
Each damaged armourstones have been located with red arrows.

Property Number	Picture, comments and armourstone count (N) and damage (D) quantification
#48	  Seawall is buried – No damage on capping stones N=0, D=0
#50	  Approximately 1 armourstone height visible along the dune - N=8,D=0
#52	  2-3 height armourstones visible (trunk). Large trees noted in the dune erosion footprint. Minor unpacking, TBC N=21,D=0 N=16, D=0

Property Number	Picture, comments and armourstone count (N) and damage (D) quantification
#54	  Top of toe is visible at low tide, start of transition to trunk full exposure, 2-3 armourstone unpacking N=28, D=0 N=7, D=0
#58	  N=23, D=0 N=30, D=0
#60	  N=32, D=0 N=28, D=1 – minor rock spalls present

Property Number	Picture, comments and armourstone count (N) and damage (D) quantification	
#62		
	N=27, D=0	N=27,D=1 – high packing density
#64		
	N=24, D=1	N=18, D=0 – Unpacking of 1 armourstone, some spalls
#66		
	N=16, D=0	N=16, D=0 – high packing density

Property Number	Picture, comments and armourstone count (N) and damage (D) quantification	
#70		
	N=19, D=0	N=25, D=1 – good packing density
#72		
	N=14, D=0	N=30, D=0 – good packing density
#74		
	N=12, D=0	N=18, D=0 – unpacking of 1 or 2 armourstones, some spalls present

Property Number	Picture, comments and armourstone count (N) and damage (D) quantification
#76	  N=19, D=0 N=19, D=0 – unpacking of 2-3 armourstones, some rock spalls present
#78	  N=8, D=0
#80	  Capping stone visible only

7.2. Test Panel results

A total of N=485 armourstones can be inspected from these pictures of sections of seawall from crest and toe. This is a significant proportion (485/2100=23%) of an estimated 2,100 stones visible on the structure.

Only four armourstones were found to be damaged (D=4) over a total of N=485 stones. This is a 0.82% dilapidation (4/485 = 0.82%).

8. Armourstone dilapidation survey

8.1. Photographic record

All damaged armourstone found during the inspection (over 3 hours on site) were photographed during the inspection and are included below. Not all defective stone were photographed, however a sample of defect have been included to assist future inspections.

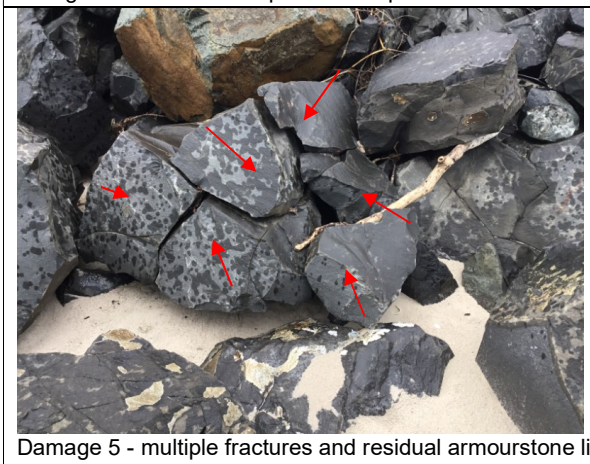
Damaged armourstone pictures (all armourstones)

Damage 1 on Marking Plate 48- multiple fractures and residual armourstone likely 750kg or less - Damaged since November 2015. The armourstone seems not to be originating from Dundorwan Quarry - #58. Appears to be a mechanical fracture

Damage 2 - multiple fractures and residual armourstone likely 750kg or less - #60

Damage 3 - multiple fractures and residual armourstone likely 750kg or less - #62. Multiple fracture planes

Damage 4 – Residual armourstone likely 750kg or less - #62



Damage 5 - multiple fractures and residual armourstone likely 400kg or less - #64. Multiple fracture planes

Damage 6 - multiple fractures and residual armourstone likely 750kg or less - #64

Damage 7 - multiple fractures and residual armourstone likely 750kg or less - #70

Damage 8 – 3x fractures main armourstone likely ~ 750kg or less #70

Damage 9 - multiple fractures planes and residual armourstone likely 400kg or less - #72

Damage 10 - multiple fractures plane and residual armourstone likely 100kg or less - #76

Sample of Defective Stones

Defect - Spalling, armourstone likely >>1t mass - #50

Defect- Spalling with main armourstone likely >1t - #78

Defect – Rock spalls, could be relocated in armour voids #70

Defect- spalling with main armourstone likely >>1t - #70

Defect- spalling with main armourstone likely >1t - #74

Defect- spalling with main armourstone likely >1t - #74

Defect- spalling with main armourstone likely >1t - #72

Defect- Spalling with main armourstone likely >>1t - #76

8.2. Dilapidation survey results

At the time of inspection, 10 primary armourstones have loss median mass beyond stability requirements (mass below 750kg).

It is important to consider that not all damaged stones may have been found. The test panel inspection were not continuous all along the seawall. The damage estimate has therefore been augmented for armourstone found outside of the test panels to provide a conservative estimate of damage A factor or 2100/485=4.3 has been applied for these stones outside of the test panels.

The estimated total damage is 4+6*4.3=30 armourstones.

The armourstone dilapidation over the period from May 2014 to November 2017 is therefore:

- Capping stone damage: 0/250 (0%)
- Trunk armourstone damage: ~30/2100 stones (~ 1.5%)
- Toe stone damage: small surficial sample is too small to make an assessment

A conservative estimate of armour stone damage is therefore around 0.5% per year, which is significantly less than the 2% per year rate considered for the oversizing of armourstones (50% oversizing over 50 years = 2% dilapidation per year). At the rate of 0.5% loss per year, the seawall is likely to maintain its design functionality well beyond 2064 without major maintenance or renewal works.

On-going monitoring and minor maintenance must be continued to achieve a good overall seawall appearance and to manage safety around the structure. As such, the seawall and beach may benefit from cleaning and local repacking from time to time, particularly after the seawall is exposed by erosion or severe wave actions. Also, as time is progressing the dilapidation maybe affected by various external considerations such as the changing environment.

9. Other minor defects

9.1. Interlocking and packing, D6

Some localised individual armourstones have moved since construction. This generate some localised low packing density along the structure. This defect, D6, maybe more prevalent where the seawall is being uncovered by dune erosion.

It is recommended to increase local interlocking and packing density where armourstones are isolated, particularly on the trunk of the seawall. The photograph below shows individual stones isolated from the armour which should be re-interlocked tightly into the trunk of the seawall. It was not possible to make an exhaustive record of the number of stone to be re-packed onto the structure. A ball-park estimate of 40 to 60 armourstones is likely sufficient to regain a very good packing density overall.

Property #76

Property #60

Property #74

Property #64

Property #54

Property #54

9.2. Trees and vegetation and access along erosion scarp, D7

There may be a few larger trees near the erosions scarp. The position of large trees in relation to the seawall crest should be ascertained to trigger lopping or removal of tree if required.

The scarp is unstable and could collapse, therefore access should be restricted (fencing) and the erosion scarp hazard should be indicated along the crest (erosion scarp >1m).

Property #52

Property #50

10. Asset assessment

10.1. Recommended works

Refer to Table in Section 5, Page 12-15 for further details on the defect location and classification.

Band A: Emergency works

Defect posing an immediate safety hazard. Immediate action required.

Representative photograph	Defect Recommendation	Defect #	Property
	Fill void in armourstones	D1	76
	Close void in between capping stones at the crest with rock spalls	D2	72,
	Re-instate sagging fence wire	D3	72
	Fence continuation along the west of the seawall crest is interrupted. Prolong crest and add safety sign warning of high dune erosion scarp	D4	50 to 54

Band B: Urgent Works
Defect posing a potential safety hazard. Work recommended within 12 months period.

Representative photograph	Defect Recommendation	Defect #	Property
	Rock spalls to be placed into the seawall crest to increase packing density in between armourstones, particularly near crest - voids between capping stones to be filled with rock spalls – Refer to 10.3 defect remediation sketches for defect D5	D5	54 - 76
	Localised armour unpacking and/or localised low interlocking – increase armourstone density by partial stone relocation to re-instate an even armour slope – Refer to 10.3 defect remediation sketches for defect D6	D6	57-76

Band C: Short-term remedial works
Defect posing a potential safety hazard. Work recommended within 12 to 30 months period.

Representative photograph	Defect Recommendation	Defect #	
	Assess trees and vegetation in the erosion area	D7	50

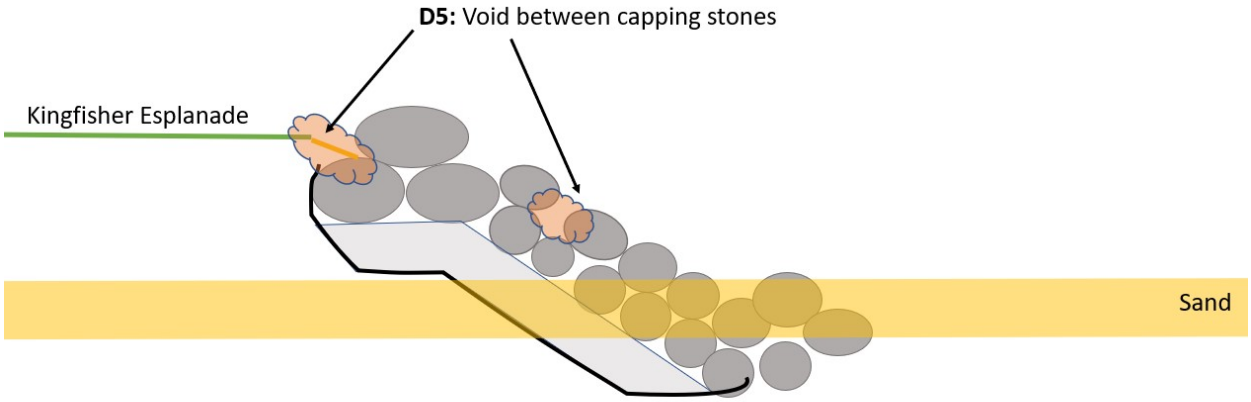
Band D: Long-term maintenance works
Defect resulting in long-term deterioration of structure or affecting performance. Work recommended within 30 to 48 months period.

Representative photograph	Defect Recommendation	Defect #	
	7 marking plates (ID33, ID34, ID37, ID45, ID46, ID53 and ID54) are missing and should be re-instated on the seawall.	D8	54,60, 70, 72

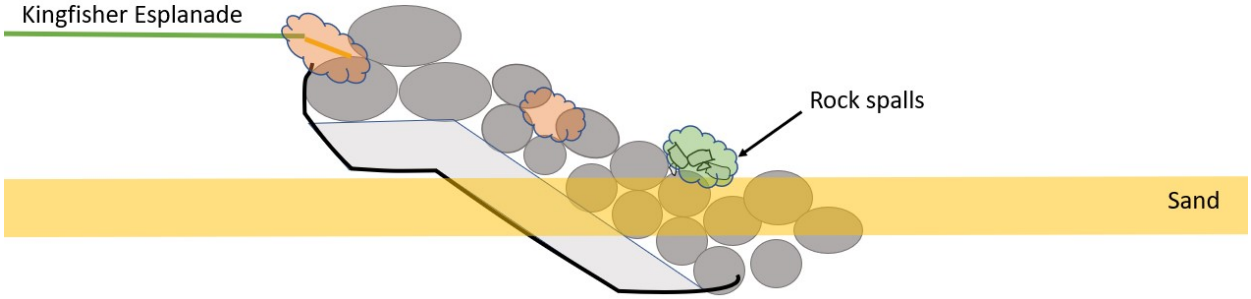
10.2. Recommended works locations

10.3. Proposed step-by-step instruction to remediate to defects D5 and D6

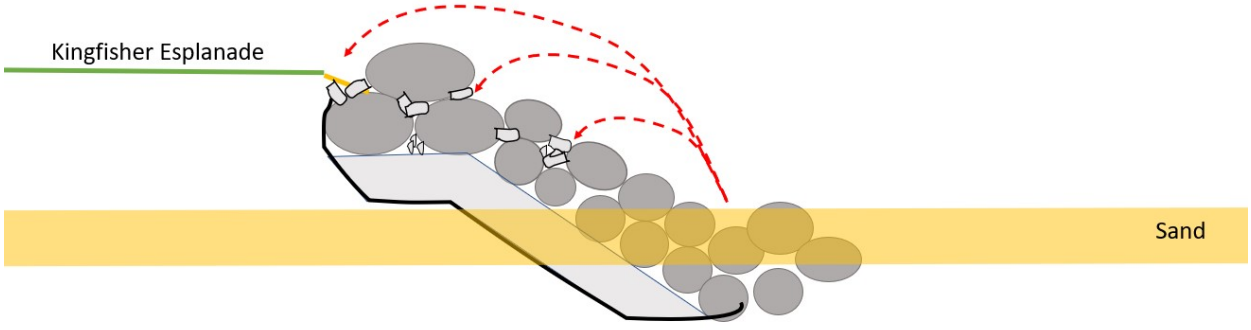
The following remediation is proposed for defects **D5** void between capping stones by using rock spalls collected from the seawall and onto the beach.



Step 1: Identify largest voids in armourstone which lead to Localised void near geotextile at the crest
and/or Localised steep sand slope/void at crest
and/or Deep voids between capping stones
and/or Lower armour packing in armour trunk

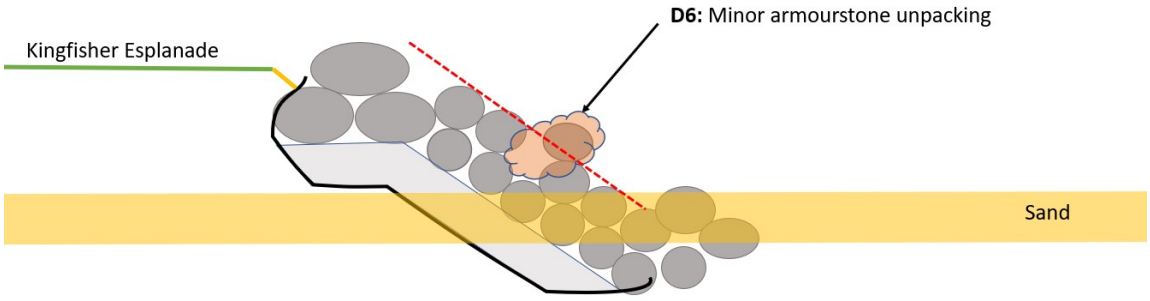


Step 2: Collect rock spalls from the seawall

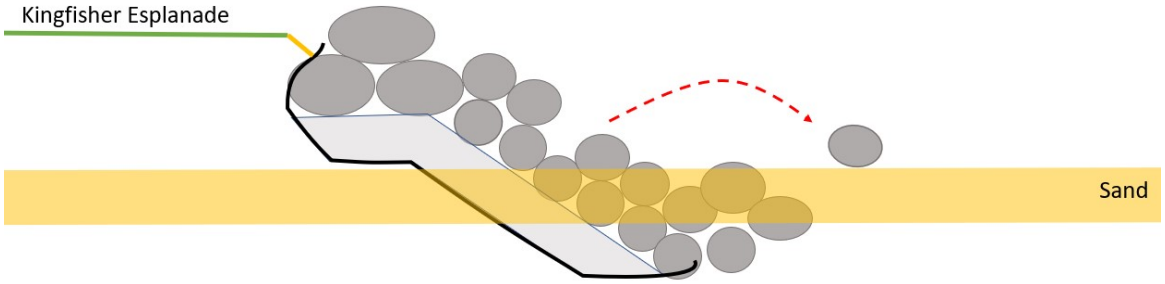


Step 3: Wedge rock spalls into voids

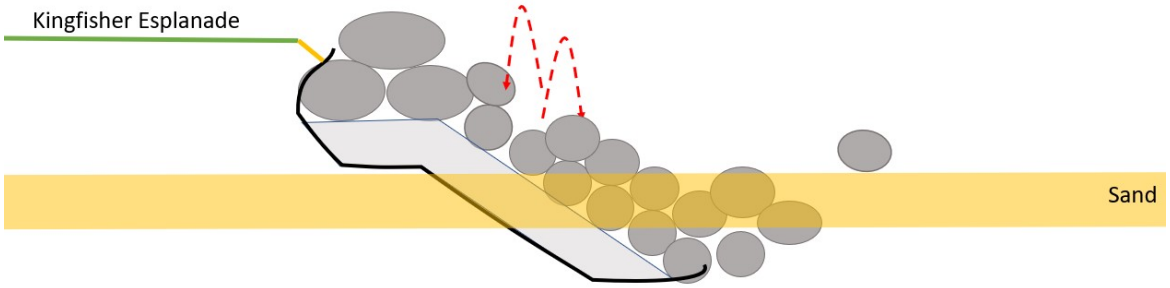
The following remediation is proposed for **D6** minor armourstone unpacking and/or low localised armourstone interlocking and/or lower armourstone packing density.



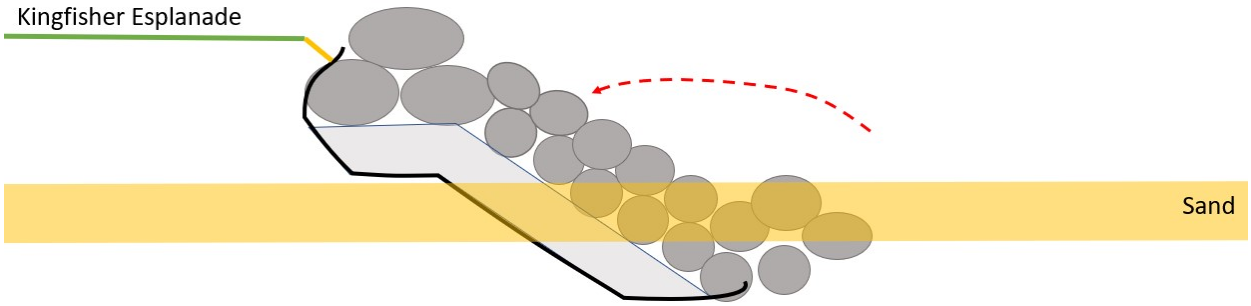
Step 1: Identify poorly interlocked armourstone which have wedged in armour with 3 points of contact or less
and/or isolated on seawall
and/or located out of slope grade
and/or located near a localised void in armour



Step 2: Remove poorly interlocked armourstone



Step 3: Wedge armourstones / increase seawall packing density locally



Step 4: Re-insert the armourstone into the seawall

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