Main Beach Shoreline Project

Technical Report: Condition Assessment
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Readers Note:

This report is a Technical Report in a series of reports for the Main Beach Shoreline Project, prepared by Bluecoast Consulting Engineers for Byron Shire Council.
The Main Beach Shoreline Project is a design investigation using multiple lines of evidence to investigate options and solutions for modification of the coastal protection works at Main Beach, Byron Bay.

This Technical Report presents the findings of a coastal engineering condition assessment undertaken on the coastal protection structure at Main Beach, Byron Bay (also known as the Jonson Street Protection Works or JSPW).

Document History

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Introduction

This technical note presents the findings of a coastal engineering condition assessment undertaken on the coastal protection structure at Main Beach, Byron Bay (also known as the Jonson Street Protection Works or JSPW). This assessment has been undertaken by Bluecoast Consulting Engineers as part of the Main Beach Shoreline Project (MBSP). Byron Shire Council is undertaking a design investigation into the modification of this structure and information of the current condition is required to inform concept design options. The objective of this coastal engineering condition assessment is to define the current structural characteristics of the structure through visual inspection complimented with reference to previous engineering reports.

Background

The JSPW fronts the town centre of Byron Bay and consist of 420 metres of predominantly rock revetment shoreline protection with three short groynes. The JSPW were first constructed in the early 1960's and have been subject to various restoration and extension efforts since that time, including major remedial works in 1975. A short section of geotextile sand containers (GSC) was added in front of the Byron Bay Surf Life Saving Club (SLSC) in 2002. Maintenance records are not available, but it is understood outside of major remedial works maintenance has been minor and infrequent. A full estimated history of the construction of the JSPW is provided in the Baseline Understanding Report for the MBSP (Bluecoast, 2019a).

In 2013 WorleyParsons undertook a condition assessment of the JSPW and their findings have been referenced here where relevant.

Methodology

Following review of previous literature and historical information relating to the JSPW, the approach used for the condition assessment of the current state of the structure involved:

- visual inspection; and
- drone survey and photography.

Assessment criteria and ratings

Three criteria were assessed:

1. Structural condition;
2. Safety risk; and
3. Functional performance.

A one to five rating scale was adopted for each category as outlined in Table 1. This scale is similar to four ratings scaled used by WorleyParsons (2013) but the 'excellent' category is also defined.

Table 1: *Condition assessment rating scale.*

Rating	Assessment criteria		
	Structural	**Safety risk**	**Function performance**
5 (Excellent)	None or very little damage	None	No loss of function
4 (Good)	Minor damage	Minor	Minor loss of function
3 (Fair)	Moderate damage	Moderate	Moderate loss of function
2 (Poor)	High level of damage	High	Major loss of function
1 (Failed)	Very high level of damage.	Very high	Complete loss of function

Based on guidelines provided in the CIRIA Rock Manual (CIRIA, 2007) and Oliver et al. (1998) the following defect categories were considered for the detailed assessment of structural condition:

- loss of crest elevation, which is primarily due to settlement of the revetment or groyne or its foundation;
- core exposure/loss, which occurs when underlayer or core is removed from the structure by waves passing through openings in the armour layer;
- armour displacement, typically occurs as a result of damage by large waves (i.e. erosion of the armour rocks) a sign of undersized units;
- armour settling, which may occur along or transverse to the armour slope due to the consolidation or settlement of underlayer, core or foundation soils;
- bridging, which is a form of armour loss that may apply to the side slopes or crest and occurs when the underlayers settle but the top armour layer remains in position;
- loss of interlocking, means armour is more susceptible to movement and can be unstable;
- drifters, which is a single piece of armour dislodged from the structure;
- slope steepening, which occurs when the slope of a structure settles on soft ground; and
- slope sliding, which is due to settlement or scour at the toe that can cause the armour layer to move downwards.

Visual inspection

The visual inspection of the JSPW was undertaken on the 28th October 2019 by two coastal engineers. Prior to the inspection the structure was divided into nine segments based on the structure type and construction history. A chainage system was also developed along the structures crest, see Figure 1. Example photos from the inspections are shown in Figure 2 and additional photos are included in **Appendix A** (see Figure 7 to Figure 14).

Using a field tablet, scores for the relevant structural defect categories across each of the predefined segments were entered directly into an online database. The overall structural condition rating for each segment was then rounded down to the average of the individual defect ratings.

Safety and functional rating were based on a single score assessed by the inspecting coastal engineer's visual inspection and the assumed design intent of the structure to serve as coastal protection against coastal erosion and inundation/overtopping.

In addition, the length and height of ten randomly selected armour rocks across each structure segment were collected and used to determine an approximate rock diameter. Defects and other observations made during the inspection were noted and photos were gathered by segment.

The rock quality was assessed in accordance with the CIRIA Rock Manual (2007). This assesses the quality of and damage to individual armour rocks and reflects how much damage or deterioration has occurred.

Drone survey

Concurrent to the on-ground condition assessment a drone survey was undertaken, the details of which are provided in Bluecoast's technical note (Bluecoast, 2019b). Using the results of the drone survey the crest level and revetment slope for each section was calculated. Aerial photographs captured using the drone were also reviewed to assist in defining defects and condition ratings.

Figure 1: Structure segments and crest chainage system defined for the existing structure.

Figure 2: Fieldwork photographs.

Previous studies

In 2013, Worley Parsons completed a comprehensive risk assessment for coastal protection structures within Byron Bay including JSPW. The assessment included risks in relation to public safety, the integrity of the structures and the impacts to the surrounding environment (Worley Parsons, 2013). In April and May 2012, visual inspection and condition ratings were completed but importantly the risk assessment extended the condition ratings using calculations of the wave and water level climate at the toe of the structure, hydraulic stability of the rock revetments, overtopping and scour potential and geotechnical stability.

Using these calculations each segment of the JSPW was assigned an average recurrence interval (ARI) for the storm event that was expected to result in greater than 30-40% damage to the structure's armour layer assuming the beach was in an eroded state. The ARI estimates by Worley Parsons (2013) have been adopted in this technical note. They describe the design standard to which the existing structure segments are in accordance with.

Contemporary design standards

There are no engineering design standards or codes that define the minimal acceptable design event for rock revetments in NSW (Coastal Environments, 2013). The Australian Standard AS4997-2005 *"Guidelines for the design of maritime structures"* does not cover the design of coastal engineering structures, however, it nominates a 50-year design life for a "normal commercial structure" and is often referred to. For the purposes of this assessment, minimum contemporary design standards have been defined based on generally acceptable industry practice for 'flexible' rock structures (Royal HaskoningDHV, 2016) as:

- 50-year ARI event with no greater than 5% damage to armour.

It is noted that other similar structures, including the rock revetment seawall constructed at Kingscliff in 2017, adopted a 100-year ARI event with no greater than 5% damage to armour rock (Coghlan, Carley, & Cox, 2016).

Results

The scores for the condition assessment have been placed on an interactive online database accessible via this link:

View the Condition Assessment for the JSPW

Each scoring category can be viewed individually, as well as the final score. In addition, observations made during the inspection are presented as 'points of interest' which contains photos of each segment against relevant modes of failure. Figure 3 presents the overall structural condition rating spatially. All scores are available in the online database.

The aerial image and digital surface model derived from the drone survey are provided in Figure 4. Table 2 presents a summary of the structural characteristics based on the condition assessment results. Table 3 presents the criteria ratings, structural, safety and functional, along with a description of each segment as identified from the inspection and the design standard assigned by Worley Parsons (2013). Overall comments are provided in the summary below with some additional information shown in Figure 5 and Figure 6.

Figure 3: Structural condition rating for structure based on visual and drone inspection on 28th October 2019.

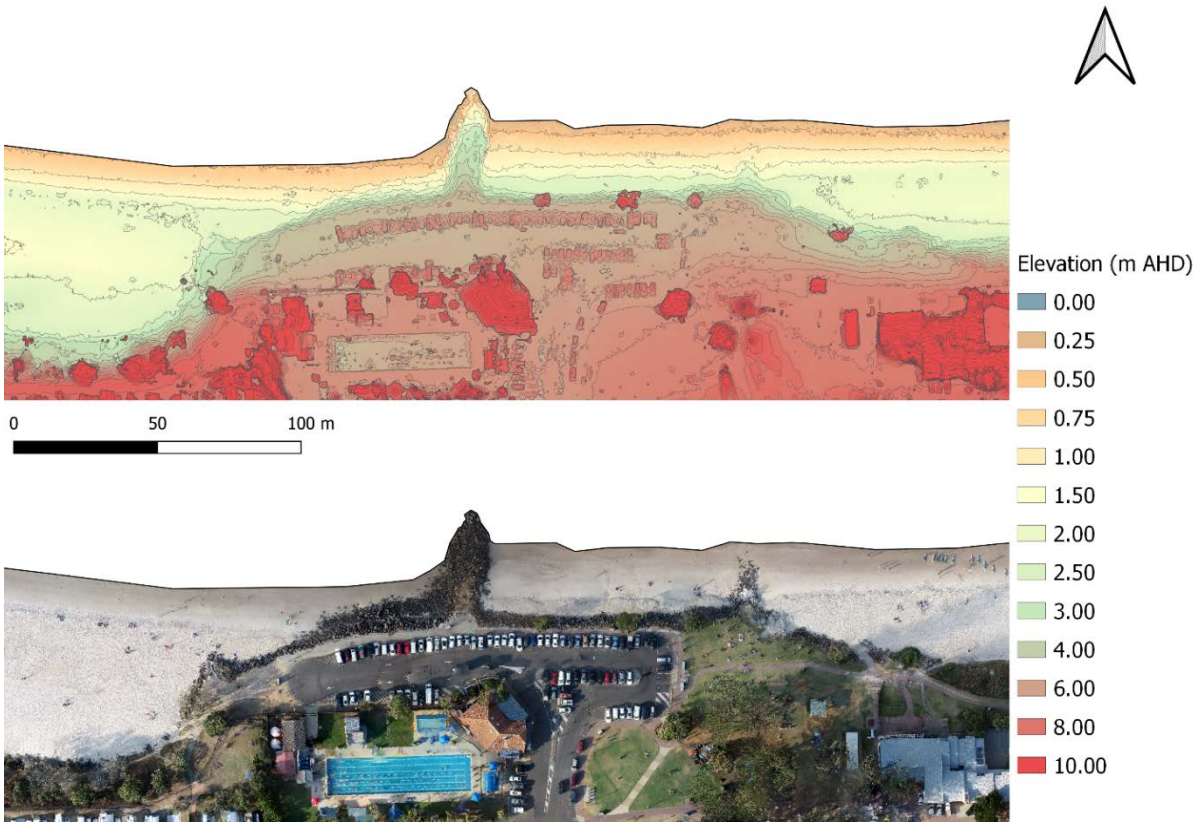

Figure 4: Digital surface model (top) and aerial photograph (bottom) derived from the drone survey on 28th October 2019.

Table 2: Structural characteristic of JSPW based on condition assessment results. Colours indicate the conditions rating as per Table 3.

Segment ID	Name	Chainage	Material	Crest elevation (m AHD)	Slope	Armour grading (D50 in mm)
1.1	SLSC GSC	0 - 41	GSC	3	1V:2H	NA
1.2	Reserve revetment	41 - 67	Rock	3.5	1V:2.5H	790
1.3	SLSC revetment	67 - 90	Rock	4	1V:2.5H	680
1.4	1st spur groyne	100 - 118	Rock	3	1V:1.5H	485
1.5	Car park revetment east	118 - 199	Rock	5	1V:1.5H	900
1.6	Main groyne	199 - 215	Rock	3.5	1V:2H	840
1.7	Car park revetment west	215 - 288	Rock	4 (east) to 3 (west)	1V:2H	840
1.8	3rd spur groyne	288 - 302	Rock	2	1V:4H	530
1.9	First Sun Caravan Park revetment	302 - 426	Rock toe	2.8	1V:2.5H	790

Table 3: *Overview of JSPW condition assessment results.*

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Description and design standard
	Structural	Safety	Functional	
1.1 SLSC GSC Chainage: 0 to 41m	N/A	N/A	N/A	These interim protection works were not visible as they were buried by sand and a fenced, vegetated dune. Assumed to be in good condition as they are not regularly exposed. WorleyParsons (2013) estimated the GSC containers to become unstable in storm events equal or greater than 1-year Annual Recurrence Interval (ARI).
1.2 SLSC revetment Chainage: 41 to 67m	3	4	2	Located further from the average shoreline this segment is less exposed and displays sand ingress and vegetation over the structure, suggesting that the seawall has not been exposed to waves for some time. Photos of this segment are provided in Figure 7. Two types of armour rock are evident. A lighter and more rounded stone and a darker and more angular stone. While the armour appears in fair condition, several platy and/or rectangular units were observed. During the inspection a large brown snake was observed to be patrolling segment 1.2 and 1.4 of the structure as well as the beach and grassed area above the structure (see Figure 7). Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'fair' condition rating and used a detailed risk assessment to assign a design standard of 10-year ARI. The

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Description and design standard
				condition rating assigned here is also 'fair'. This segment does not meet contemporary design standards for coastal protection structures.
1.3 Reserve revetment Chainage: 67 to 90m	3	2	3	Poured concrete ramp acting as an informal beach access has caused the rock slope to slide and steepen adjacent to the ramp. Concrete filled voids adjacent to ramp where there is a small section of the upper slope with no armour. The ramp reduced the structure's effectiveness against wave run-up. Photos of this segment are provided in Figure 8. In general, the armour layer is in fair condition but some wave damage (erosion) and overtopping is evident. No filter layer was visible. Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'fair' condition rating and used a detailed risk assessment to assign a design standard of approximately 10-year ARI. The condition rating assigned here is also 'fair'. This segment does not meet contemporary design standards for coastal protection structures.
1.4 1st spur groyne Chainage: 100 to 118m	1	2	2	The 1st spur groyne appears to have been poorly constructed and has been subsequently badly damaged. The crest level of the groyne is only 2.6m AHD and significantly less than that shown on the 1975 design drawings. It appears that settlement, scour and wave damage have dislodged armour and core (noting the 1975 drawings show no existing rock apron under this groyne) and scattered and flattened the structure with almost complete loss of interlocking. Sand infills the low structure and there was very little effect on the beach at the time of the inspection. Photos of this segment are provided in Figure 9. West of the 1st spur groyne there is a short section of revetment built from the same, significantly undersized armour and armour of poor quality with cracking, fracturing, spalling and rounding all observed. The core is exposed in the corner under small pandanus tree. Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'poor' condition rating and used a detailed risk assessment to assign a design standard of less than 1-year ARI. The condition rating assigned here is 'failed'. This segment does not meet contemporary design standards for coastal protection structures.
1.5 Car park revetment east Chainage: 118 to 199m	2	2	3	This segment shows significantly different construction with larger armour rocks (lighter in colour and less angular) overlaying older smaller and darker rocks that have been rounded by wave action, see Figure 5. Informal access at the eastern end of the car park has resulted in loss of armour layer integrity. Photos of this segment are provided in Figure 10. Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'fair' condition rating and used a detailed risk assessment to assign a design standard of approximately 1-year ARI. The condition rating assigned here is 'poor'. This segment does not meet contemporary design standards for coastal protection structures.
1.6 Main groyne Chainage:	2	1	3	The main groyne shows a wide grading of rock sizes with a predominant fraction of larger rock. Some steepening of the eastern slope at the shore connection with the adjacent revetment was evident. The western side showed greater damage with some sections of core exposed and evidence of

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Description and design standard
199 to 215m				some fractured armour rocks. Several drifters were visible several metres away from the groyne on it seaward end. A large section of its western shore connection slumped and with evidence of old concrete stormwater outlet rubble. Photos of this segment are provided in Figure 11. The beach level of the western side of the groyne (downdrift) appeared significantly lower at the time of inspection, exposing greater extents of the toe apron. Two exposed remains of the piling of the old timber jetty were noted at the seaward end of the groyne suggesting that more remains may be buried under the groyne. Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'fair' (eastern side) and 'poor' (western side) condition ratings and used a detailed risk assessment to assign a design standard of approximately 1-year ARI. The condition rating assigned here is 'poor'. This segment does not meet contemporary design standards for coastal protection structures.
1.7 Car park revetment west Chainage: 215 to 288m	2	2	3	This segment showed a similar build to the Main Groyne with a wide armour rock grading and a sloping crest level of 4m AHD along the eastern extent sloping to 3m AHD on its western end. In the corner closest to the Main Groyne, the eastern end of this segment had slumped, resulting in a steepened face. Several concrete slabs are mixed in with the rock armour layer in this area. Photos of this segment are provided in Figure 12. The upper face of the revetment has steepened as armour rocks were displaced to the lower faces. The crest of the revetment has been concrete capped with some evidence of degradation and cracking of the concrete layer. Clear evidence of sand infill at approximately mid face was noted. Older, more rounded and darker rock was visible on the lower slope of the revetment extending away from the upper revetment at a milder slope (refer Figure 6). Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'poor' condition rating and used a detailed risk assessment to assign a design standard of approximately 1-year ARI. The condition rating assigned here is 'poor'. This segment does not meet contemporary design standards for coastal protection structures.
1.8 3rd Spur Groyne Chainage: 288 to 302m	2	3	1	This 3rd spur groyne appears to be predominately buried while also many of the armour units were displaced by wave action. The armour rocks are significantly undersized and the structure has very low crest elevation of approximately 2m AHD. The eastern connection to the adjacent revetment has steepened due to displaced armour rocks. Photos of this segment are provided in Figure 13. Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'poor' condition rating and used a detailed risk assessment to assign a design standard of approximately 1-year ARI. The condition rating assigned here is 'poor'. This segment does not meet contemporary design standards for coastal protection structures.
1.9 First Sun Holiday Park	3	3	3	This structure comprises toe rock only with several access paths throughout structure and multiple displaced armour rocks. Several drifters were identified 2-3 metres seaward from the toe rock structure. A relatively densely vegetated dune system extends on the shoreward side of this structure. This suggests

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Description and design standard
revetment Chainage: 302 to 426m				that it currently provides some protection from wave impacts. Some dune erosion behind one of the access paths through the structure was evident at one of the access paths. Photos of this segment are provided in Figure 14. Based on visual inspection in 2012, Worley Parsons (2013) assigned this segment a 'poor' condition rating and used a detailed risk assessment to assign a design standard of approximately 1-year ARI. The condition rating assigned here is 'poor'. This segment does not meet contemporary design standards for coastal protection structures.

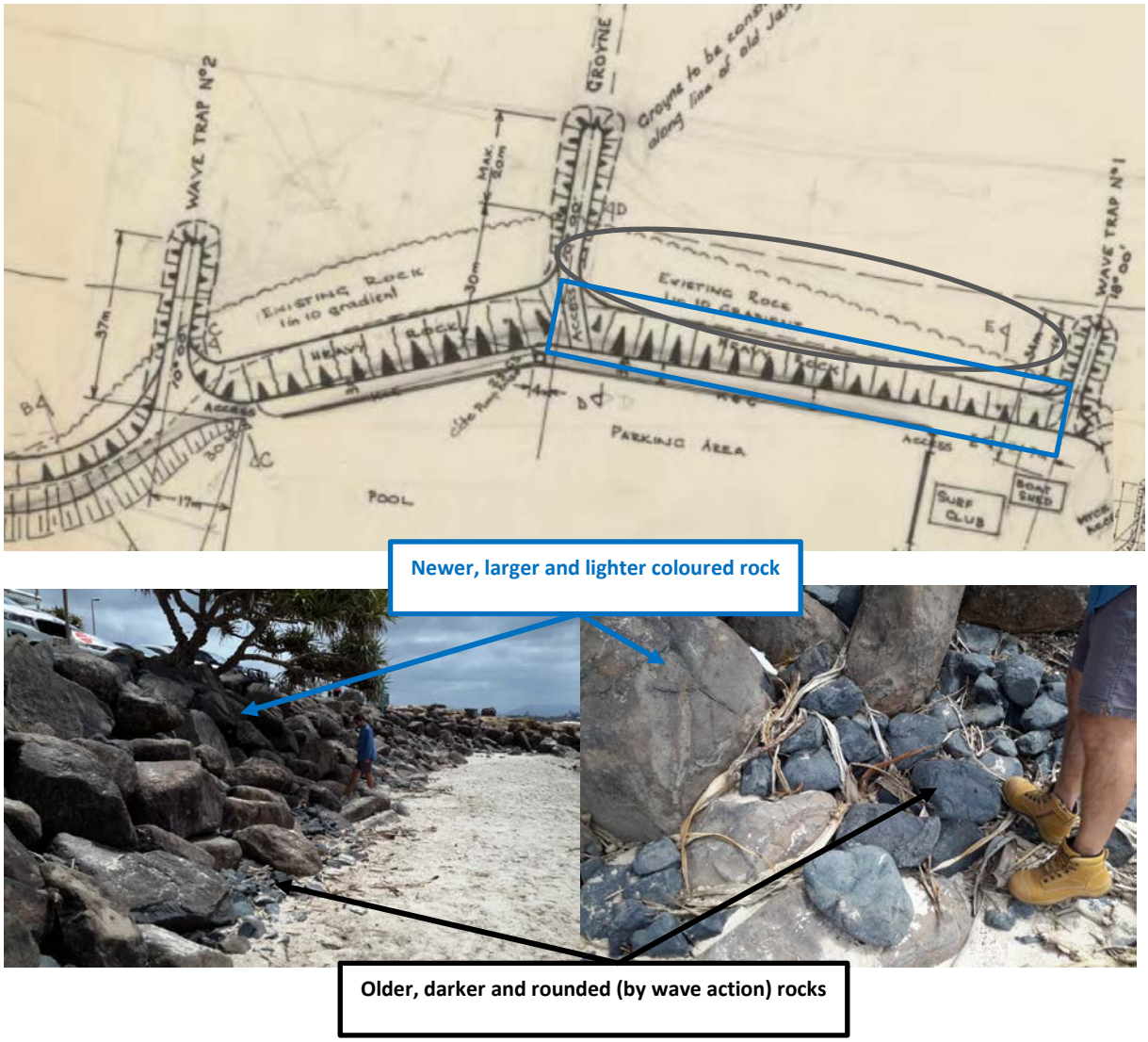

Figure 5: 1975 design drawings showing apron of older failed rocks forming a gentle gradient in front of the planner 'heavy rock' placements.

Note: *The flatter 'existing' rock is believed to be remnants of the structure that failed in the 1974 tropical cyclone Pam event. This rock was placed as armour and underlayer in 1963 and 1964. During design wave conditions this older and smaller rock would be mobile and the structure was likely to have been undermined by scour. Having been redistributed by wave action and shaken down to close to the scour level, this rock now forms an apron that founds the main revetments.*

Figure 6 provides a cross-section of the structure within segment 1.7 which highlights the existence of this older rock being lower down on the revetment and at a milder slope. The slopes in each of the coloured sections on the figure are:

- upper revetment (larger armour): 1V:2H
- lower revetment (smaller darker rocks): 1V:5H
- beach: 1V:17H

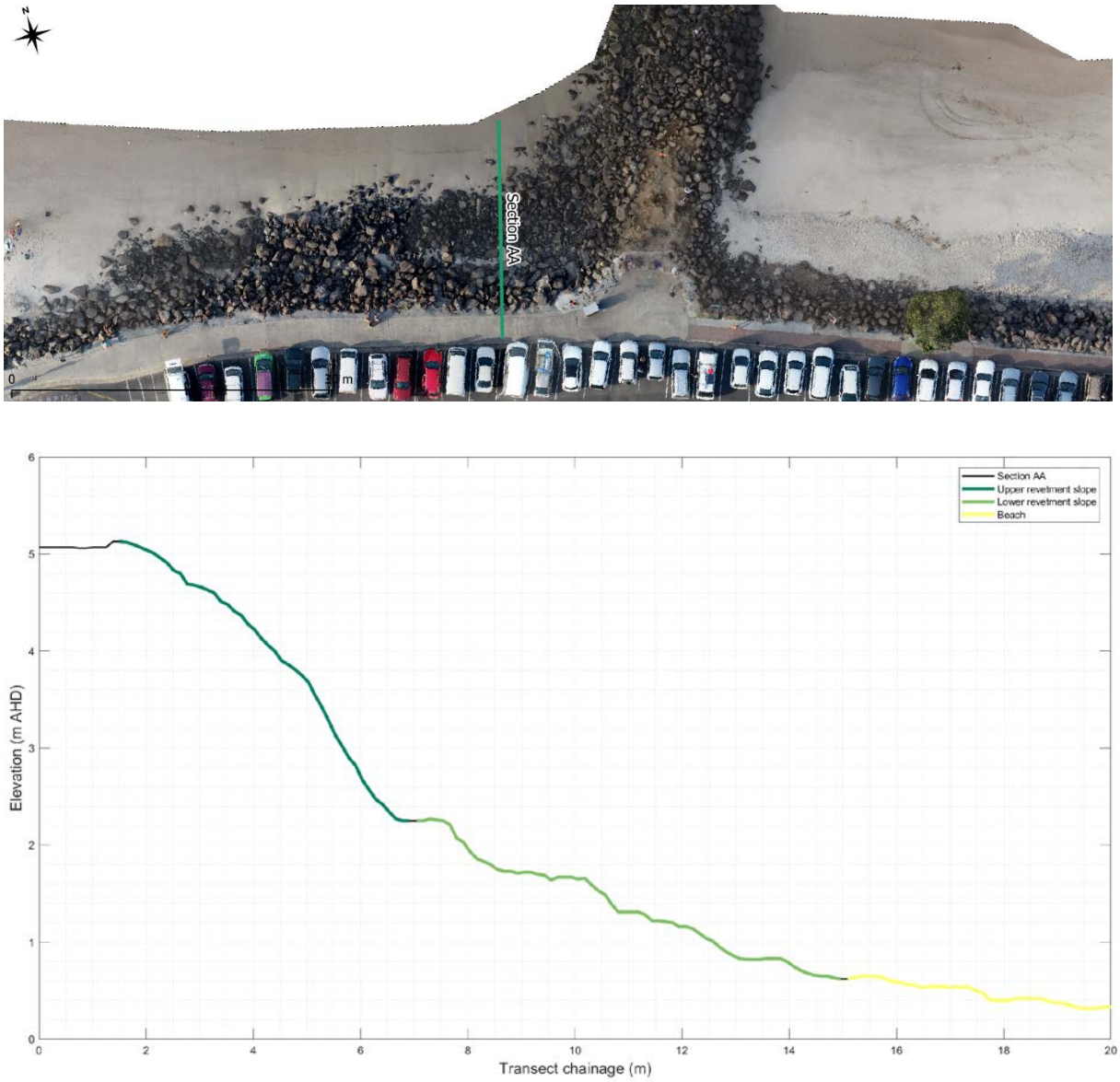

Figure 6: Section AA location and aerial photograph (top) and structure cross-section derived from drone survey on 28th October 2019.

Summary

The visual and drone-based inspection of the JSPW works were undertaken on the 28th October 2019 and used to rate the structural, safety and functional conditions of the JSPW. Overall the structure was rated as **fair** to **poor**. The most seaward parts of the structure were in the worst conditions. Worley Parsons's 2013 risk assessment used calculations to determine that excessive damage to the structure would be expected during a storm event exceeding 1 to 10-year ARI conditions. Based on the assessment complete herein, Bluecoast consulting engineers is of the opinion that the structure does not meet contemporary design standards.

At present, maintenance works are not planned for the structure, so priority zones have not been documented. The key findings of this investigation and further considerations to inform the development of design options and modifications for the structure are as follows:

- overall, the armour rock quality was fair but there were isolated areas of poor-quality armour rock with significant degradation;
- in addition to the deterioration of the structure, it is evident that the original construction does not meet contemporary standards for rock revetments;
- various formal and informal accessways have been created over the structure, degrading its function (increased wave run-up risk) and compromising the integrity of the armour layer;
- visual inspection of the structure confirms, as suggested by the construction history, that rock has been progressively added to the JSPW. More recent and larger armour rock on the upper slopes was observed to overlay a darker and much smaller rock. Due to the sand level at the time of the inspection, the toe of the structure was not visible. However, it is suspected that the small darker rock originates from the 1960's revetment construction and now forms a mild sloping rock apron.
- the large total quantity of rock that forms these works needs to be considered in the modification designs, particularly any designs involving landward realignment. It is recommended that:

    (i) estimates of the total quantity of the rock in the structure be developed based on, in the first instance, historical photo records; and

    (ii) additional inspection be undertaken at the end of summer or after an erosion event when beach levels are lower and more of the structure is exposed; and

    (iii) invasive (e.g. peel-back or test pits) and/or non-invasive (e.g. ground penetrating radar or other geophysical methods) investigations be undertaken prior to detailed design where the design incorporates changes to the structure.

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Appendix A – Additional field photos

Figure 7: Fieldwork photos of segment 1.2 and brown snake

Note: Brown snake in rock structure in the photo on lower-right and then again on beach nearby segment 1.3 in the photo on lower-left.

Figure 8: Fieldwork photos of segment 1.3

Figure 9: Fieldwork photos of segment 1.4

Figure 10: Fieldwork photos of segment 1.5

Figure 11: Fieldwork photos of segment 1.6

Figure 12: Fieldwork photos of segment 1.7

Figure 13: Fieldwork photos of segment 1.8

Figure 14: Fieldwork photos of segment