# Main Beach Shoreline Project

## Concept Design Development - Report

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bluecoast
CONSULTING ENGINEERS

Byron Shire Council

**Readers Note:**

This report is a Technical Report in a series of reports for the Main Beach Shoreline Project (MBSP), 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 **Concept Design Development Report** presents a summary of the projects critical factors and preliminary basis of design to guide the development of concept options for the modification of the Jonson Street Protection Works (JSPW). This Report will be updated and added to once broader community engagement on the options presented in this Report have been undertaken along with key stakeholder consultation.

### Document History

| Version | Date | Author(s) | Reviewer(s) | Status | Signature |
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### Disclaimer

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

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# INTRODUCTION

## Background

Byron Shire Council (Council) have engaged Bluecoast Consulting Engineers (Bluecoast) to deliver the first stage of the Main Beach Shoreline Project (MBSP). The project's first stage is focused on finding the solution for modification of the coastal protection works (also known as the Jonson Street Protection Works or JSPW) that will give the best possible outcomes for Main Beach, Byron Bay and adjacent areas.

The JSPW are a public asset that provides a significant role in protecting the Byron Bay town centre from the First Sun Holiday Park to the Byron Bay Surf Life Saving Club (SLSC) from coastal erosion and inundation. The MBSP is an important project for the community of Byron Shire, with the intent to improve the current situation. Through modification of the works, large public benefit will be gained enhancing recreational amenity, improving public safety, improving public access and use of the foreshore and beach.

## The problem

The JSPW were constructed to protect the town centre from the threat of coastal erosion and no longer provide adequate protection. The older and more exposed sections of the structure are in a poor condition and require modification works to be brought up to contemporary engineering standards. The works also don't provide suitable public amenity and aesthetics, public safety and access.

## Project objectives

At a meeting held on the 13th December 2018 the following objectives for the MBSP were agreed on by Council (Res 18-839):

1. To provide adequate protection to the Byron Bay town centre against current and future coastal hazards.
2. To mitigate adverse current and future risks from coastal hazards, taking into account the effects of climate change.
3. To mitigate impacts on coastal processes (e.g. down-drift effects) through reduction of the project footprint.
4. To improve the structural integrity of the JSPW.
5. To improve public safety around the JSPW.
6. To enhance recreational amenity, public access and use of the foreshore around the JSPW.

## Special conditions

This project is being partly funded by the NSW Government through the Coastal and Estuary Grants Program. Two special conditions apply to Council's funding agreement ensuring the investigation considers all contemporary options for the modification of the structure including realignment of the structure landward. The conditions are outlined below and have been considered in the concept design development.

*The Jonson Street Protection Works upgrade options assessment should include an assessment of all potentially feasible options, including those that seek to reduce any impacts of the structure on coastal processes, public amenity and safety. Upgrade options should include consideration of, but may not be limited to:*

- *Reducing the plan footprint of the structure*
- *Realignment of the structure further landward*

## Project outline

The MBSP comprises a four-phase approach to the investigation of the modification design for the JSPW, including:

- Phase 1 – Baseline understanding; Report #1 – Baseline Report
- Phase 2a – Development of concept design options; (**this Report**)
- Phase 2b – Detailed assessments of concept design options
- Phase 3 – Recommendation of preferred option; and
- Phase 4 – Evaluation of determination of a preferred option.

This report provides a summary of the project's critical design success factors, development of key performance indicators (KPIs) and provides a preliminary basis of design to guide the development of seven concept design options considered feasible for the modification of the JSPW. Previous design investigations for the JSPW have been criticised for not consulting with the community early in the process (i.e. after a lot of technical work had already been completed). The purpose of the option development phase is to generate options that vary across key design elements so that community feedback can be sort. As such broader community engagement on the options presented in this Report will be undertaken along with key stakeholder consultation. Once community/stakeholder feedback is received, three options will be selected by Council for progression of the project to the next phase for further refinement and detailed technical assessment.

## Project quality assurance / peer-review group

Bluecoast have appointed Tom Shand and Richard Reinen-Hamill from Tonkin & Taylor as technical reviewers for the duration of the project.

All deliverables produced as part of this project are reviewed by Council and the Department of Planning, Industry and Environment (DPIE). Council have also formed an industry professional peer review group. This group will meet at certain times during the project to discuss and review the key project deliverables. Review of this Memo is the first deliverable of the Peer Review Group and minutes/feedback will be reported back to Council.

## Key Performance Indicators

In addition to the project objectives, critical design success factors have been developed by Council (as per project brief) as follows:

- **Community/cultural values** – such as community use of assets (Memorial Pool, SLSC and carpark) adjacent the JSPW, priorities of the Byron Masterplan which include sensitive integration of the foreshore and works with recreation, nature and pedestrian movement, Indigenous values, tourism, and surfing amenity.
- **Public recreational amenity and public safety** – such as pedestrian safety around rock walls (slippage), alongshore access, swimming areas that are consistent with other nearby beaches/surf zones and beach amenity, including consideration of the Byron Masterplan.
- **Visual amenity and aspect** – such as the visual impact of the works on the area in the presence of the works, including the view from land adjacent the JSPW towards the sea, the ranges to the west, and Cape Byron to the east, including consideration of the Byron Masterplan.
- **Economic factors** – including construction costs, maintenance costs, and indirect costs such as loss of carpark revenue (for re-alignment options), indirect cost of disruption to the community during construction works, or indirect costs associated with changes to the recreational space
- **Ecological impacts on marine and terrestrial habitats** – such as loss or gain of intertidal areas, loss or gain of vegetation and degradation of materials into the marine environment
- **Coastal processes, beach profile and planform** – predicted impacts to shoreline alignment, beach profile, sediment transport, and wave breaking patterns.
- **Climate change and sea level rise** – resilience of the structure under projected climate change impacts including sea level rise, storm intensity increase, etc. The ability to adapt the structure to withstand predicted future physical forces.

To focus the concept design investigations on the project outcomes, the project objectives and above mentioned success factors have been reviewed and are presented as key performance indicators (KPIs) in Table 1. The KPIs provide the means for comparing and evaluating the design options as they evolve towards a detailed concept design solution. The KPI’s cover mandatory project requirements including adequate protection of the town centre, minimisation of impact on coastal processes and improved public safety. The KPIs will be reviewed and adjusted as needed as the project moves forward. In particular, the KPIs will be reviewed in-light of the community feedback and targeted key stakeholder interviews that will be collected in November/December 2020.

Table 1: Criteria design success factor and KPIs for the Main Beach Shoreline Project.

| Result area | Critical design success factor | KPI | Priority |
|---|---|---|---|
| **Coastal protection** | Provide adequate protection to the Byron Bay town centre over the project life. | Withstand 100-year ARI wave conditions. | High |
| | | Acceptable rate of wave overtopping. | High |
| | Adaptability to withstand future physical forces under a changing climate. | Estimated future adaption costs. | Medium |
| **Shoreline impact** | Minimise downdrift impacts, while maintaining an acceptable shoreline for Main Beach (updrift). | No reduction of pre-project littoral drift supply rates to downdrift areas. | High |
| **Safety** | Improve public safety of the structure. | Minimise hazards (voids in rocks can attract detritus, vermin and snakes). | Low |
| | | Minimise safety risk such as trips, slips and rock fall. | High |
| | | For swimmer safety, rip currents generated near the structure should not exceed pre-project levels. | High |
| **Beach and foreshore amenity** | Beach amenity is maintained or enhanced. | Pedestrian access along the beach seaward of the structure based on the beach width in front of the structure. | Medium |
| | | Enhance beach access. | High |
| | | Length and extent of temporary disruption to the beach and foreshore area during construction. | Medium |
| | Enhance recreational amenity of the foreshore around the structure. | Minimise impacts on community and cultural values. | Medium |
| | | Enhance pedestrian movement. | Medium |
| | Maintain visual amenity and aspect. | Maintain views from land towards the sea, ranges to the west and Cape Byron to the east. | Medium |
| **Surfing amenity** | Maintain the surfing amenity around the structure. | The number of surfable waves in front of the structure. | Medium |
| | | Level of impact on surfing | Medium |

| Result area | Critical design success factor | KPI | Priority |
|---|---|---|---|
| | | conditions updrift or downdrift of the structure. | |
| **Environment** | Ecological value of the foreshore area. | Minimise potential attraction of pests and hazardous fauna. | Low |
| | Protect physical and biological habitats. | Maintain or replicate existing ecological habitats. | Medium |
| **Economic factors** | Capital costs. | Cost (including contingency) for the construction of the modification of the structure. | High |
| | Maintenance costs. | Minimise maintenance costs. | Medium |
| | Indirect impacts (e.g. carpark revenue, shops). | Minimise potential indirect costs and adverse impacts on businesses. | Low |

## KPI metrics

To facilitate evaluation of design options, metrics and targets for each KPI will be developed. These will be informed by community and stakeholder feedback. Wherever possible the performance of each option will be measured against the status quo (or base case). Useful metric(s) and attainable targets also need to consider the project's technical assessment and what measures can be reasonably obtained as these investigations progress.

A selection of potential metrics has been discussed below. One important element of the KPIs are the units of measurement and range for any metrics. It is recommended that baseline values for project metrics be determined prior to the assessment process where they do not already exist.

**Wave overtopping KPI:**
The metric for this KPI is wave overtopping volume in litres per seconds per metre (l/s/m). The target is defined as safe average overtopping volumes during extreme events. An extreme event is defined as a wave event equal or greater than a one-year average recurrence interval. Safe overtopping volumes are defined based on EurOtop (2018), see Figure 1.

| Hazard type and reason | Mean discharge q (l/s per m) | Max volume $V_{max}$ (l per m) |
|---|---|---|
| People at structures with possible violent overtopping, mostly vertical structures | No access for any predicted overtopping | No access for any predicted overtopping |
| People at seawall / dike crest. Clear view of the sea. | | |
| $H_{m0}$ = 3 m | 0.3 | 600 |
| $H_{m0}$ = 2 m | 1 | 600 |
| $H_{m0}$ = 1 m | 10-20 | 600 |
| $H_{m0}$ < 0.5 m | No limit | No limit |
| Cars on seawall / dike crest, or railway close behind crest | | |
| $H_{m0}$ = 3 m | <5 | 2000 |
| $H_{m0}$ = 2 m | 10-20 | 2000 |
| $H_{m0}$ = 1 m | <75 | 2000 |

| Hazard type and reason | Mean discharge q (l/s per m) | Max volume $V_{max}$ (l per m) |
|---|---|---|
| Rubble mound breakwaters; $H_{m0}$ > 5 m; no damage | 1 | 2,000-3,000 |
| Rubble mound breakwaters; $H_{m0}$ > 5 m; rear side designed for wave overtopping | 5-10 | 10,000-20,000 |

Figure 1: Overview of safe wave overtopping volumes (EurOtop, 2018) – (top) for people and cars and (bottom) structural damage to coastal protection structures.

**Shoreline impacts KPI:** The metric used for the KPI is beach erosion volume change or shoreline change. The target for the design investigations is that the predicted envelope of shoreline impacts falls within acceptable limits or the pre-project envelope of shoreline position and volumes. Importantly, it is noted that the shoreline position and beach widths adjacent to the JSPW are largely controlled by the natural sand movement processes of onshore/offshore transport, headland bypassing and longshore transport (see Bluecoast, 2020a) combined with the effects of the structure itself. This requires careful consideration when assessing each option's performance and requires further investigation during the detailed concept design development.

While the beach updrift and downdrift has adjusted to the rate of sand bypassing around the existing structures (BMT WBM, 2013) it is required to assess the option's performance against the recent (e.g. since 2000) envelope of beach volumes and shoreline positions. For example, the Coastal Management Act defines a 'beach fluctuation zone' which is the location of the 'shoreline' as the erosion escarpment following the 100-year ARI erosion event. This describes *"the range of natural locations a beach profile occupies from its fully accreted condition to its fully eroded condition"* and helps determine the likely impacts on assets and/or their vulnerability both now and into the planning horizon (including sensitivity to climate change) for each option.

Consideration of natural impacts on the beaches due to storm events, long-term recession and climate change should be considered. Therefore, performance should be assessed on shoreline impacts attributable to the structure modification and not to natural variability. Also, the modification of the structure has the potential to alter wave, hydrodynamic and sediment transport processes, changing the equilibrium of the immediately adjacent beaches. An adjustment period should be considered when measuring the shoreline impacts post construction (number of years to be determined).

It is also noted that these targets will be reviewed based on the modelling proposed as part of the concept design investigations.

**Beach amenity KPI:** Usable beach width is the metric used for the beach amenity KPI. Beach erosion results in reduced amenity due to the reduced usable beach width and is well recognised by community stakeholders. The project is required to maintain or improve beach widths that facilitate beach amenity. While it has not been completed here, a definition of usable beach width ideally based on beach transect data would aid the interpretation of this KPI. Like the shoreline impact KPI, pre-project and post-project levels can be established with reference to beach transect surveys. As with beach volumes, analysis of beach width needs to account for natural fluctuations.

**Swimmer safety KPI:** The metric for this KPI is RSIFR (or similar). Historical records for other comparable settings or site-specific pre-project conditions would be required to establish a baseline for this metric. The beach to the south of the structure is patrolled by Surf Live Saving Australia and the Surf Lifesavers average nine rescues a year at Main Beach (beachsafe.org.au – accessed Oct 2019). An alternative (or additional measure) would be to undertake a monitoring campaign to measure wave driven rip currents in the area in front of the structure.

**Surfable waves KPI:** The metric used for the KPI is surfable waves. A surfable wave is defined as a breaking wave that can be surfed using a variety of surf craft.

This KPI has been given a medium priority as maintaining regular surfable waves is an important factor communicated by the surfing community. For this metric, it is recommended that a baseline *surfability* value for waves in the vicinity of the structure be determined.

For the purposes of the concept design, predictions of this KPI will be based on output from the detailed SWASH wave and flow model. Once calibrated, this model will be able to accurately predict wave breaking patterns in front of the structure as well as immediate updrift/downdrift areas for pre-project and modified structure conditions. The numerical modelling assessment will be undertaken for a series of bathymetries that were identified to provide good surfing conditions. The model will be able to determine if options produce increased reflections or change currents patterns through the surf zone affecting surf amenity.

The predictive modelling completed as part of the concept design will also consider the quality of the surfable waves (e.g. length of ride, wave height, peel angle, peel velocity etc.). Post-project observations should also assess wave quality in-line with the expected performance outcomes from the detailed concept design.

**Marine ecology KPI:** The metric for this KPI is to compare the ecological communities around the structure to those found on the existing structure. Following construction, it would take some time for marine life to colonise the new habitat and the ecology would evolve as a succession of different organisms/groups colonise the area. To establish the basis for comparisons it would be necessary to:

- Undertake a baseline marine ecology survey of the area around the structure (this could be based on the findings in WorleyParsons, 2013).
- Undertake regular ecological surveys following construction for a period long enough to determine the nature of the new ecosystem. Consider, documenting the change in marine ecology since construction in a seasonally varying environment.

**Foreshore amenity KPI:**

Community engagement activities during the Masterplan study highlighted the coastal areas that are of importance to the community and that should be enhanced compared to the present conditions. These areas included the Main Beach car park and Memorial Pool as well as the parks and open spaces of the reserve. Visual amenity and aspect of the foreshore area are difficult to quantify. However, the following draft metrics are suggested, these would be refined based on community engagement outcomes:

- Maintain or increase existing areas (metres squared) of open space, vegetation and pedestrian area.
- Unhindered views towards the sea, the ranges to the west, and Cape Byron to the east. This would be adopted as a yes/no target for the design modification options.

**Capital cost KPI:** The metric for this KPI is the construction costs in dollars. Construction costs have been defined as being the target outturn cost (TOC) or similar.

# CONCEPT DESIGN DEVELOPMENT

## Basis of design

This preliminary Basis of Design (BoD) has been developed to inform the concept design development of the JSPW modification. The purpose of the BoD is to provide a frame within which to progress the development of the concepts. The BoD brings together baseline information obtained through the Task 1 review process, the project objectives and key performance indicators as well as recently gathered site data. The preliminary BoD will be further refined as the project progresses with the final Basis of Design proposed to be completed as part of Task 5.

## Design life

Design life is defined as the period for which a structure or a structural element remains fit for use for its intended purpose with appropriate maintenance. The design life of the JSPW will be confirmed during the detailed design (Task 5) and will be cognisant of projected climate change impacts.

The Australian Standard Guidelines for the design of maritime structures (AS 4997-2005) specifically excludes the design of “coastal engineering structures such as rock armoured walls, groynes, etc.” The *Investigating the Re-design of the Jonson Street Protection Works - Options Assessment and Concept Design Report* (WorleyParsons, 2014) suggested a 50-year planning period to estimate total maintenance and construction costs in considering the different spans of design life and frequency of maintenance for the various options. At this preliminary design stage, a 50-year design life has also been adopted.

## Design event

Conventional coastal engineering practice in Australia is to allocate a design Average Recurrence Interval (ARI) storm event[1] ranging from the design life of the project (50-years) up to that suggested in AS 4997-2005. WorleyParsons (2014) suggested the rock revetment structures proposed within their options assessment be designed to withstand a 100-year ARI design storm event. The same 100-year ARI value will also be adopted for the stability of the rock structures examined as part of this concept design development. The presented KPI for pedestrian access is defined as safe average overtopping volumes during extreme events. The recurrence of the return event for the overtopping design is yet to be defined but could, for example, be a one-year average recurrence interval.

Table 2 provides the defined 100-year ARI design storm events as listed in the *Options for Upgrading Jonson Street Protection Technical Report* (WRL, 2009), those provided in the WorleyParsons (2014) report and those adopted for this preliminary BoD.

[1] An average recurrence interval (ARI) is the average time between events such as extreme storm waves, elevated water levels or cyclones. It is a statistical measurement typically based on historic data over an extended period and is used for the analysis of risks.

Table 2: Comparison of 100-year ARI design water level and wave events from WRL (2009), WorleyParsons (2014) and those adopted for the preliminary BoD.

| Variable | WRL 2009 | WorleyParsons 2014 | Adopted for preliminary BoD |
|---|---|---|---|
| Still water level (tide + wind + wave setup) | 2.2m AHD | 2.2m AHD | 2.2m AHD |
| Offshore significant wave height[2] (Hs) | 9m | 7.2m[3] | 7.5m[4] |
| Nearshore significant wave height (Hs) | 4.4m[5] | 3.7m | 4.4m |
| Spectral peak wave period, (Tp) | 12sec | 12sec | 12sec |

## Maintenance

Structures which are designed for smaller (more frequent) ARI events, or have exceeded their design life will incur costs through maintenance, repairs, or upgrade. Structures which are designed for higher ARI events will have lower future costs (past construction) but will involve higher initial capital outlay. Kite (1988) examined the relationship between risk (ARI frequency), maintenance and capital which can be seen in Figure 2.

Trade-offs between capital and maintenance costs have not been the focused on in the development of the initial options. The project objectives and importance of protecting landward assets suggests a low maintenance design philosophy. By setting the design event at or higher than the design life, then a lower likelihood (e.g. 40% in this case) of needing any maintenance over the design life can be achieved. A 40% chance of significant damage or failure may be considered too high. But as wave height at the toe and minimum stable rock sizes will be affected by sea level rise, it is likely that the design event cannot happen until close to the design life (i.e. only occurs under future higher sea levels). Meaning the design may be more like a 1,000 event at present day sea levels. Regardless, of the approach the interplay between wave height and water depths at the toe suggests the need to understand the joint probability of these parameters, as is proposed to inform further design development.

[2] Refers to the significant wave height, or the mean of the highest third of the waves in a wave group, computed on the basis of a spectrum.
[3] Maximum of 100year ARI directional wave heights scaled based on ratios between non-directional 1,10 and 100year ARI 6-hour significant wave heights for Coffs Harbour Waverider Buoy taken from WRL (2014)
[4] This value is based on the offshore significant wave height value used for calculations in BSC (2018).
[5] Depth limited nearshore breaking wave height in 4.2m of water (CEM 2002 Fig II-4-2)

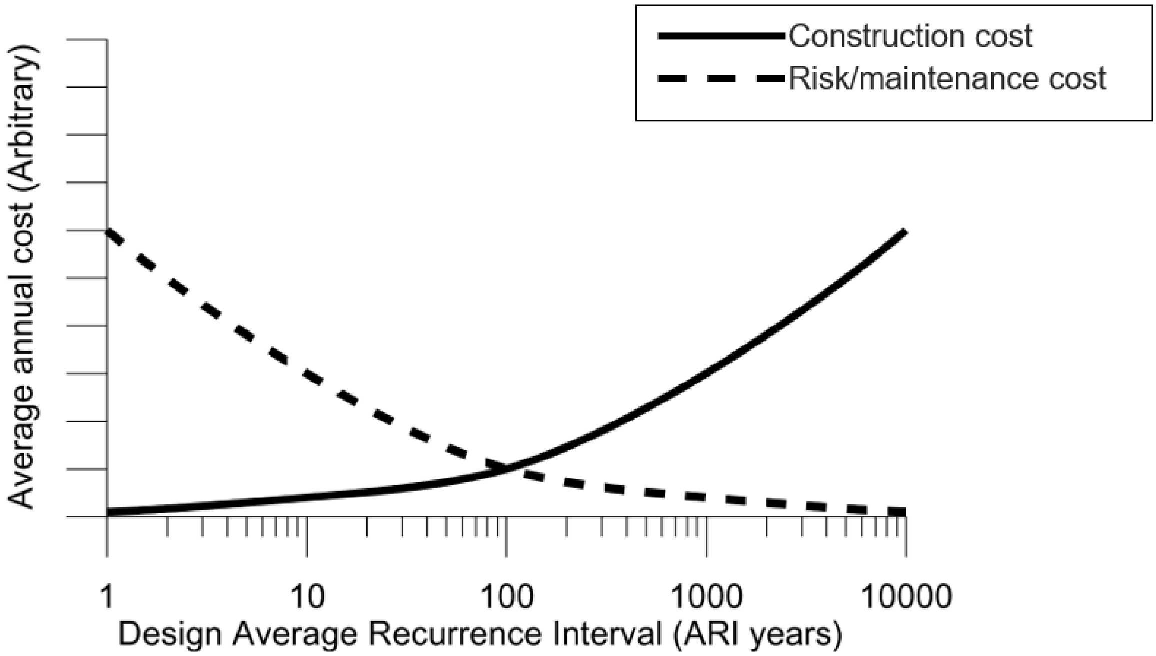



Figure 2: Balance between risk, maintenance and capital cost (based on Kite, 1988).

## Climate change and sea level rise

WorleyParsons (2014) listed the main aspects of climate change affecting the JSPW:

- Sea level rise will result in future higher wave runup onto the structures and greater volumes of wave overtopping
- Erosion of the beach in front of the seawall due to reduced onshore sand supply caused by sea level rise
- Higher waves able to reach the structure caused by deepening of the nearshore profile
- Potential for higher offshore water levels, increased cyclone activity and higher offshore wave heights.

A schematic showing possible impacts of sea level rise on the JSPW is provided in Figure 3, and will be used to inform the development of the concept designs.

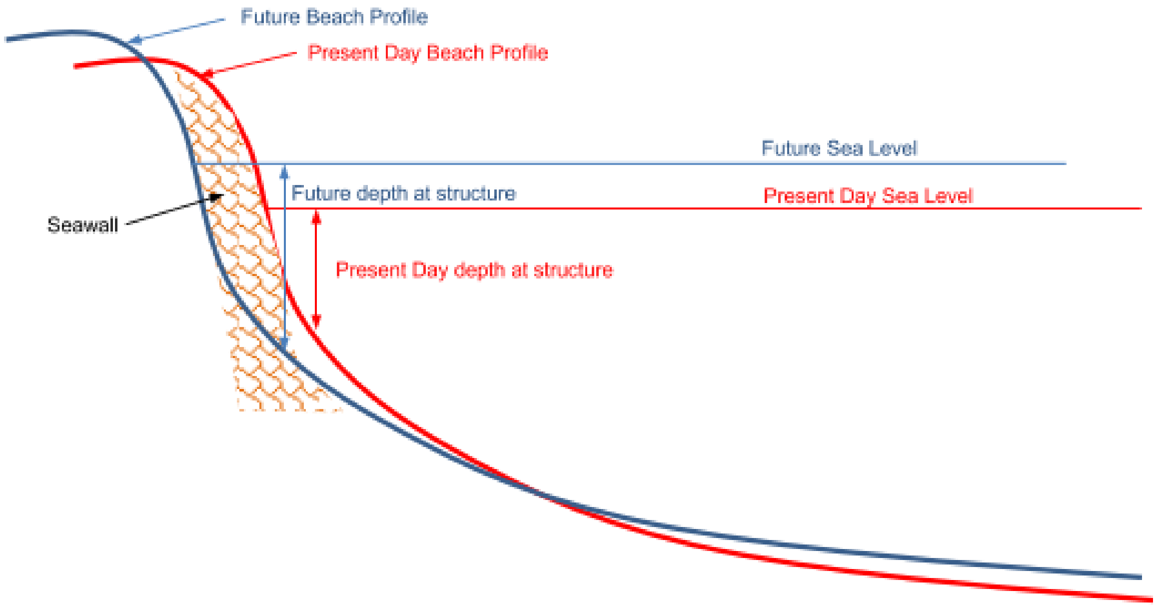



Figure 3: Effect of sea level rise on water depth in front of Jonson Street Protection Works (Source: WorleyParsons, 2014).

Council has adopted a set of conservative extreme sea levels (see Table 3) for a variety of planning periods and processes for flood risk studies in the Byron Shire document #908785 adopted 12th November 2009 by resolution No. 09-968, which include:

- A provision for storm surge of 0.9m, 1.1m and 1.2m for present day, 2050 and 2100, respectively, to account for increased cyclone intensity.
- A high tide level of 0.94m above AHD as an average spring high tide.
- Wave setup of 0.45m based on 6% of the 100-year ARI significant wave height of one-hour duration.
- Sea level rise (SLR) projections as 0.4m and 0.9m by 2050 and 2100 respectively as discussed in the following paragraphs.

In addition, a series of wave run-up levels for a 100-year ARI design event at the JSPW are provided in BSC (2018), see Table 3. A storm tide level of 1.94m above AHD and offshore significant wave height of 7.5m (direction just north of east) was adopted for the run-up calculations.

Council's Climate Change Strategic Planning Policy (BSC, 2014) presents the following projected sea level rise (SLR) scenarios for planning purposes in the Byron Shire (also provided are WRL, 2016 levels above 2010 mean sea level):

- present day – 0m above 1990 mean sea level;
- year 2050 – 0.4m above 1990 mean sea level (or 0.34m above 2010 levels); and
- year 2100 – 0.9m above 1990 mean sea level (or 0.84m above 2010 levels).

Table 3: Council's adopted conservative design sea levels and wave-run up for inundation studies (BSC, 2018).

| Date | 100-year ARI sea level (m above AHD) | Incident significant wave height (m) at toe | Seabed level seaward of rock structures (m AHD) | Run-up component (m) | Run-up level on storm tide (m) |
|---|---|---|---|---|---|
| **2010** | 2.29 | 3.0 | -2.0 | 3.1 | 4.94 |
| **2050** | 2.89 | 3.0 | -2.0 | N/A* | 5.3 |
| **2100** | 3.49 | 3.0 | -2.0 | N/A* | 5.8 |

*Not provided in BSC (2018)

While the adopted SLR estimates provide a convenient planning tool for the design of the modification of the JSPW, it is also required to understand the sensitivity and uncertainty of these values. The latest advice from IPCC (2019) on sea level rise calls for increases to the allowances in previous documents. A range of SLR projections above an average sea level between 1986 and 2005 are provided in Table 4.

Table 4: Global SLR projections for a range of planning periods and greenhouse gas emission scenarios (adopted from IPCC, 2019).

| Date (unit) | Very low (RCP2.6) | Very high (RCP8.5) |
|---|---|---|
| **2030 (m)** | 0.15 | 0.23 |
| **2050 (m)** | 0.24 | 0.38 |
| **2070 (m)** | 0.32 | 0.56 |
| **2100 (m)** | 0.43 | 1.1 |
| **Rate of change at 2100 (mm/yr)** | 4.0 | 20.0 |

### Crest Level

WRL (2009) undertook preliminary calculations for the design of an upgraded seawall in the same location as the existing JSPW, noting a crest level of the structure (in the car park) of approximately 4.5 to 5m AHD. The empirical calculations showed that for a new (stepped) concrete or rock armour seawall if the crest level of the new structure is kept like the present one, major overtopping would occur during large storm wave events. Using numerical models (ACES, SBEACH), WorleyParsons (2014) similarly showed that overtopping of the crest of the existing seawall would occur during the design 100yr ARI wave event. The report made the following recommendations regarding crest design to eliminate (or significantly reduce) overtopping:

- Increase crest level above the calculated runup levels (4.7-5.9m AHD) including an appropriate allowance for freeboard and future sea level rise due to climate change.
- Increase crest width – a wider crest can absorb wave overtopping back into the revetment armour.

- Provide a wave return structure at the crest of the revetment to reduce the volume of overtopping.

Council's Draft Coastal Zone Management Plan (BSC, 2018) provides conservative design sea levels and wave-run up to be adopted for inundation studies, these levels have been provided in Table 3. Prior to the completion of the inundation modelling, these values will be used to inform the concept design development.

### Scour level

One of the key design parameters informing the structural stability (and longevity) of the proposed structure will be confirmation of the design scour level. WRL (2019) initially used the NSW design guidelines and historical photography to estimate the design scour level as -2m AHD. WorleyParsons (2014) used photogrammetry techniques to place the lowest observed scour levels in front of the JSPW at -1m AHD. The report also provided details of SBEACH modelling used to determine scour potential, showing that if the beach is in an eroded state, the scour level in front of the JSPW would reach a level of around -2 m AHD for 100 year ARI event.

The condition assessment and data review undertaken in Task 1 provided evidence of an 'apron' of rock that has slumped from a previous iteration of the seawall. Historical as-constructed drawings of the seawall remediation in 1975 show that the upgraded rock work was placed atop and founded on the failed rock apron. Aerial photography shows that the rock apron is buried for most of the year until beach levels fronting the JSPW are reduced. This rock apron will provide a hard, non-erodible substrate minimising the scour potential in front of the structure. For use in the concept design development, an approximate conservative level of -2m AHD will be assumed as the design scour level until detailed investigations (geotechnical/physical) are undertaken to determine the depth and extent of the rock apron.

### Alignment

The alignment of the concept design will be developed based on the advantages and disadvantages presented in Table 5 and carefully weighed against the constraints and opportunities presented in the Baseline Report (Bluecoast, 2020a) with respect to:

- Land ownership and management arrangements
- Economic values
- Community and cultural values
- Ecological values

WorleyParsons (2014) noted that the unprotected beach profile on either side of JSPW would be expected to recede with sea level rise (Figure 3). In this scenario, the JSPW would extend further seaward compared to the adjacent beach areas, out into the future active beach profile. As such the impact of JSPW on longshore sediment transport would also increase into the future as the structures would extend further into the active zone of littoral sand transport. The report offered three main options with respect to structure alignment:

1. **Maintain** the current structure alignment.
2. **Removal** of the spur groynes, whilst retaining (or upgrading) the rest of the JSPW.
3. **Realignment** of the structure. It is generally accepted that this would be landward of its current position.

WorleyParsons (2014) also provided a detailed list of advantages and disadvantages of each structural alignment option which have been summarised and expanded on in Table 5.

Table 5: Jonson Street Protection Works alignment options (adapted from WorleyParsons, 2014).

| JSPW alignment option | Advantages | Disadvantages |
|---|---|---|
| **Maintain the current structure alignment** | Maintain the Jonson Street carpark and reserve in their current location and configuration.<br><br>Excavation costs would be reduced when compared with options which involve re-alignment of the structure.<br><br>The upgrade work could be done in stages, working on a section at a time, with minimal disruption to the community when compared with the option of re-aligning the structure. | Compartmentalisation of the beach, with continued interruption of sediment transport from east to west.<br><br>Difficult to maintain usable beach in front of structure.<br><br>Wave overtopping and incident wave height would continue to increase over time with sea level rise and future erosion of the adjacent shoreline.<br><br>Decrease in recreational amenity over time as ability to maintain a usable beach on the seaward side of the carpark would decrease. |
| **Removal of the spur groynes** | Improve sand bypassing past structure.<br><br>Maintain the Jonson Street carpark and reserve in their current location and configuration.<br><br>Initial increase in beach berm width in front of the First Sun Holiday Park.<br><br>May allow pedestrian access around the JSPW at times when there is | Could result in shoreline retreat at Main Beach (east) due to increased efficiency of sand bypassing around the JSPW.<br><br>Likely results in narrowing of the width of the beach berm in front of the JSPW.<br><br>Wave overtopping and incident wave height would continue to increase over time with sea level rise and future erosion of the adjacent shoreline.<br>Decrease in recreational amenity over |

| JSPW alignment option | Advantages | Disadvantages |
|---|---|---|
| | enough sand on the beach.<br><br>Materials from the spur groynes could be re-used in the upgrade of the works.<br><br>Excavation costs would be reduced when compared with options which involve re-alignment of the structure.<br><br>Staged construction would reduce disruption to the community. | time as ability to maintain a usable beach on the seaward side of the carpark would decrease.<br><br>Could increase the incident wave energy onto the eastern end of the structure.<br><br>Potential impacts on the surfing amenity in the area around JSPW. |
| **Realign the structure (landward)** | Restore a more natural beach planform, like what existed prior to construction of JSPW.<br><br>Reduced impact on adjacent coastal processes.<br><br>Improved sand bypassing at the structure through the intertidal zone.<br><br>Subject to lower design wave heights and scour levels than structures in the existing location if sand buffer in front of the JSPW can be maintained.<br><br>Opportunity to maintain a usable beach in front of the structure for longer. | Require excavation of around 30,000 $m^3$ of material (including rock, fill, asphalt, as well as existing utilities).<br><br>Likely to result in shoreline retreat at Main Beach (east) due to increased efficiency of sand bypassing around the JSPW.<br><br>Major disruption to the community.<br><br>Major change in the character of the area - permanent loss or relocation of seaside community recreational space.<br><br>May affect local Byron Bay CBD businesses.<br><br>Long timeframe of construction affecting businesses and community.<br><br>Potential impacts on the surfing amenity in the area around JSPW. |

### Longshore extent of structure

The coastline directly adjacent to the JSPW is described as high value land, which includes the assets of the Surf Club to the east and First Sun Holiday Park to the west and recreational foreshore area (parks). Design decisions regarding the alignment of the structure, be they; removal, realignment, or maintenance need to consider possible impacts to either of these facilities. The longshore extent of rigid and semi-rigid coastal structures in the active zone will invariably influence the adjacent coastline. WRL (2009) used the desktop-based approach of Komar and McDougal (1988) to determine the downdrift impacts of the current JSPW on the downdrift (western) beach. The empirical calculations showed an erosional effect of the current seawall (ignoring the small spur groyne) of approximately 250m.

Currently both the Byron Bay SLSC and the First Sun Holiday Park have insufficient protection from a large storm event (WorleyParsons, 2014). As such, design considerations for a possible westward or eastward (or both) extension of the JSPW will be undertaken during concept development to incorporate these high-value assets into the project footprint.

### Structure footprint (including spur groynes)

The Baseline Assessment Report (Bluecoast, 2020a) describes the value of the area around the JSPW. In addition to the significant economic value of the site, the report describes the important social, cultural, and ecological value of the area. Although linked intrinsically with the alignment and extent of the structure design, the size of the proposed structure footprint should be kept to a minimum where possible, to preserve these values.

### Material selection

Depending on the type of structure or coastal protection mode adopted, selection of an appropriate construction material will be a key factor in meeting the project objectives of the MBSP. Selection of a suitable material should be project-specific and based on the following design parameters; structural, ecological and visual amenity. Table 6 provides advantages and disadvantages for different coastal protection structures as well as possible material types.

Table 6: Material suitability for the Main Beach Shoreline Project.

| Material | Structure/ protection type | Suitability for MBSP |
|---|---|---|
| **Beach sand** | Nourishment | Externally sourced sediment would need to be tested to ensure it matched the attributers (particle size distribution/PSD) and colour as that of Main and Belongil beaches to ensure the longevity of the placement as well as for visual amenity. Desirably sand would be sourced within the embayment or from the entrance to Belongil Creek. |
| **Geotextile sand containers (GSC)** | Flexible sloping sandbag revetments | Generally, GSCs are used for temporary coastal protection works and would require maintenance to meet the design life specified for the MBSP. Visual amenity is generally compromised when |

| Material | Structure/ protection type | Suitability for MBSP |
|---|---|---|
| | | GSC units are exposed (not buried), especially within the marine environment (by marine growth) or if there is deformation to the units. |
| **Gabion baskets** | Flexible sloping rock rubble revetments<br><br>Flexible sloping rock mattress revetments | Degradation of basket material is usually less than the design life specified above. The 'constructed' look of gabions creates an urban landscape. Small rock in the baskets creates voids that provide habitat in the marine environment; above ground these voids can attract spiders and lizards. |
| **Vinyl and fibre reinforced plastic** | Bulkhead walls | Limited maintenance is required for this material and can be custom-made to match local environment (colour and texture). |
| **Steel** | Bulkhead walls<br><br>Gravity structures | Limited maintenance is required with steel structures generally having a design life like that provided above ensuring suitable cathodic protection is applied (and regularly replaced). Steel structures affect visual amenity, creating an industrial/urban impression, especially when surface begins to rust. Degradation of structures at the design life can create public safety hazards and ecological impacts. |
| **Concrete** | Gravity structures<br><br>Semi-rigid sloping pattern-placed unit revetments (tetrapod, X-Blocs, Seabees, etc.) | Requires limited maintenance if protective coating (silane, etc) are applied. Concrete can be used in place of rock if supply is compromised. Concrete structures may affect visual amenity, creating an urban landscape. Large concrete units create voids that provide habitat in the marine environment. Above ground these voids can attract vermin and snakes. |
| **Rock** | Flexible sloping rock rubble revetments<br><br>Flexible sloping rock mattress revetments | Higher density rock (e.g. basalt, granite) reduces rock size for same stability requirements. Rocks with higher abrasion threshold should also be selected. Choosing local rock will also blend in visually and compliment visual aesthetic of the beach. Large rocks create voids that provide habitat in the marine environment. Above ground these voids can attract vermin and snakes. |

### Appraisal of generic options

A wide range of generic coastal protection design options are available for consideration for the modification of the JSPW. The following section provides an overview of these options and provides commentary as to their suitability for the MBSP. Within each of these design options there may be several possible layout configurations, extents and materials that could be incorporated in the design. These have been listed in the preliminary BoD section (above) and as such will not be revisited in this section. Following an appraisal of the generic design options a preliminary suite of the seven most suitable designs have been selected for consideration. It should be noted that any option or design element that did not meet the mandatory project requirements was not considered further.

The project area is a high value beach and foreshore public space. When this is combined with the poor condition of the existing coastal protection structure, it is understood that non-works options such as 'do nothing' or complete removal of the structure are not acceptable to Council, DPIE of the local community. As such, these options have not been considered further.

### Seawalls

Given the intent of providing terminal protection against beach erosion, seawalls or rock revetments are given primary consideration. Constructing a new seawall on a natural beach requires consideration of both the cross-shore location and the longshore alignment of the structure. These need to be considered from both structural and coastal process viewpoints i.e. the effect of hydrodynamics and coastal processes on structural integrity and the effect of the structure on beach processes. The cross-shore positioning of a seawall influences the interaction of the natural beach system and seawall structure. To minimise disrupting coastal processes, seawalls are ideally positioned as far landward as possible.

The preliminary basis of design details physical parameters affecting the design of the seawall such as building material, the scour level (this will define toe level and founding method), crest level (to reduce overtopping) as well as the general alignment and extent of the structure. In addition, the following key design parameters need to be considered when designing a seawall:

- <u>Slope</u>: vertical seawalls reflect wave energy and can increase the scour level in front of the structure and may affect nearby surf breaks. Sloped seawalls increase design volume and structure footprint.
- <u>Hydraulic roughness</u>: is linked to material selection and plays an important role in the amount of wave energy dissipation, reflection and run-up on the structure.
- <u>Unit size</u>: individual units must be large enough to be hydraulically stable to meet the design wave event however not so large as to be prohibitive for construction. Shape of the units and interlocking of individual units will affect the hydraulic stability and the amount of wave energy dissipation, reflection and run-up on the structure.
- <u>Filtration design</u>: this is important for semi-rigid and flexible structure design to absorb wave energy as it 'passes through' the interstices of the structure. Appropriate filtration design will ensure the soundness of the structure is maintained through its design life.
- <u>Crest design</u>: in addition to height of the crest, the width of the crest and crest type are key design considerations that need to be made. This is usually dictated by the value placed on the infrastructure backing the seawall, in this case pedestrian safety in areas backing the

wall as dictated in the project KPIs. Seawalls may be topped by wave deflectors, crown walls or public infrastructure, however, this is unlikely to be acceptable from a visual amenity perspective in this location. Drainage may be incorporated landward of the crest if there is an allowable level of overtopping.

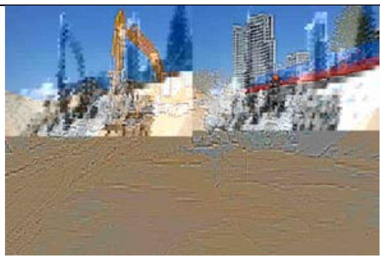
- Toe design: A suitable foundation of the structure needs to be designed to minimise failure. This may be undertaken by excavating to the design scour level or providing an artificial substrate distributing the load. Of importance at this site is the presence of an apron of failed rock that is believed to provide an informal foundation for the existing structure (Bluecoast, 2020a).

The JSPW have been in place in one form or another since the 1960's. The structure has modified the natural beach processes and resulted in the realignment of the adjacent shorelines. Given the period the structure has been in its present form, the adaptation of the adjacent shoreline and the community's acceptance of some sort of seawall protection on this section of the coast, a seawall structure is considered a suitable design option.

Table 7: Suitability and examples of seawalls.

| Seawall type | Suitability | Examples |
|---|---|---|
| **Vertical seawalls**<br><br>Timber wall<br><br>Concrete wall<br><br>Sheet piles<br><br>Rigid gravity structures<br><br>Bulkheads<br><br>Large masonry units<br><br>Buried terminal protection seawalls | Vertical seawalls are 100% reflective and are not considered suitable for this exposed location unless set back from the current alignment.<br><br>Vertical seawalls on landward alignments (i.e. buried terminal protection seawalls) are also not considered suitable because:<br>(i) they are not in-line with the Master Plan<br>(ii) managed retreat would be required in the area between the current alignment and the terminal structure creating a high degree of uncertainty in the use of this highly valued foreshore area<br>(iii) under future climate change scenarios and shoreline recession the structure would not remain buried and the vertical structure would have a high risk of wave overtopping, waves reflections and scour of the beach and<br>(iv) construction difficulties as discussed below. | <br>Bondi Beach seawall (source: Waverley Council)<br><br><br>PVC bulkhead seawall (source: WorleyParsons, 2014) |

| Seawall type | Suitability | Examples |
|---|---|---|
| | Installation of sheet piles through hard buried material is highly problematic. The existing buried rock that forms the JSPW would need to be completely removed prior to piling works commencing.<br><br>Stabilising the tie-back mechanism (dead anchor, etc) would need to be designed at a suitable inland distance from the wall, requiring further excavation and increasing construction footprint.<br><br>Beach access is restricted and can become dangerous when beach levels in front of the structure are reduced.<br><br>Large armour units are usually used in the absence of suitably sized rock sources. These units create a more urban/industrialised vista and depending on their design can also create large vertical faces causing more reflections. As there are sources for suitably sized rock, masonry units are not deemed necessary. | <br>Large concrete unit breakwater (source: Alamy.com) |
| **Stepped seawalls**<br><br>Concrete<br><br>Gabion units<br><br>Masonry units | High vertical faces of each step may be completely reflective. Smaller steps increase surface roughness, reducing the wave run-up height.<br><br>Steps may provide public amenity and a place to socialise and provide a hub that connects the beach to foreshore parks, promenades, surf clubs and other amenities.<br><br>Relatively expensive protection measure. | <br>Stepped concrete seawall (source: WorleyParsons, 2014) |

| Seawall type | Suitability | Examples |
|---|---|---|
| | Gabion units are sometimes used in instances where suitably sized rock is not available. A key constraint with gabion units relates to the longevity of the mesh material used for the containment of the rock. Exposure to the marine environment and UV reduces the life of the mesh compromising the integrity of the units. Once the unit has failed, the undersized rock is then dispersed throughout the structure. There are also safety issues with sharp wire exposed on the beach. Gabions are therefore not considered suitable. |  Gabion stepped seawall (source: Maccaferi.com)  Masonry unit stepped seawall (source: engineeringcivil.org) |
| **Sloping revetments**<br><br>Rock<br><br>Pattern-placed units<br><br>Geotextile sand containers | Deemed the most suitable for the location as it will be an upgrade to current 'accepted' design.<br><br>It is recommended to decrease the slope of the existing seawall to assist with stability, increase hydraulic roughness and to reduce the amount of wave reflection, runup and overtopping.<br><br>Pattern placed units such as Seabee may not be suitable given the desire to retain a natural aesthetic to the foreshore. They may also be questioned on safety issues for public access.<br><br>Geotextile sand containers of sufficient size to meet stability requirements (estimated to be up to $5m^3$) are susceptible to catastrophic (total unit) failure should the material become damaged. Damage of a single unit has the propensity to compromise the structure. Smaller |  Sloping rock revetment construction, Gold Coast (source: Knobel Construction, 2020)  Pattern placed 'Seabee' seawall construction, Nth Cronulla (source: The Leader, 2017)  |

| Seawall type | Suitability | Examples |
|---|---|---|
| | units (2.5 m$^3$) are used for wave climates with Hs less than 2.0 m (Coghlan et al. 2009) and therefore would not be suitable for this site. | Geotextile sand container sloping seawall (Source: tessilbrenta.com) |

### Shore normal structures

Shore normal structures are rigid and semi-rigid structures constructed approximately perpendicular to the shoreline, extend across the beach and the nearshore surf zone. Their function is to trap sand moving along the shoreline under longshore transport processes to build up and stabilise the alignment of the beach on the updrift side. By necessity they affect sand supply to the shoreline on the downdrift side, causing erosion there until such time as sand bypassing around the structure occurs, restoring longshore sand transport to the downdrift side.

Table 8: Suitability and examples of shore normal structures.

| Structure type | Suitability | Examples |
|---|---|---|
| **Groynes** | There is much contention surrounding the 'groyne-effect' of the JSPW and the perceived detriment downdrift. An additional groyne would exacerbate this further and place immediate risk to the First Sun Holiday Park. Extension of the existing groynes or additional groynes are not deemed suitable for the MBSP. |  Shore normal rock groyne, Palm Beach (source: City of Gold Coast, 2020) |
| **Artificial headland** | The JSPW as it stands is acting as a quasi-artificial headland due to its seaward protrusion. Re-design of the planform of the structure to resemble a more natural rounded headland shape would assist in a more constant east-west flow of sediment around the structure.<br><br>The central to northern east coastline of Australia has numerous natural rocky headlands that could be used as templates for planform design which are subject to the net northerly drift along this coastline. Subsequent shoreline response would be predictable. |  Artificial headland design, Townsville (source: coastengsol.com.au, 2020) |

| Structure type | Suitability | Examples |
|---|---|---|
| **Jetty or pier** | In 1888 at the site of the JSPW the Public Works Department (PWD) built a 402-metre-long timber jetty extending from Jonson Street. The jetty became unserviceable and was replaced with a new 610-metre-long jetty in 1928 at Belongil Beach. This new jetty was damaged in 1954 and finally removed in 1972.<br><br>While Byron Bay is partially protected from southerly swells, cyclonic waves, from time to time can cause damage to the beaches and maritime structures. Given the unfavourable history of jetties in this area, reconstruction of another jetty has not been considered further. | <br>Jonson Street jetty (source: imagesofbyronbay.com.au) |

## Offshore structures

Offshore structures protect the shoreline by reducing the wave energy arriving at the shore and rotating incoming wave crests. On a sandy coast, this can reduce longshore drift gradients and encourage sand deposition in the lee of the structure. Offshore structures may be emergent, partially emergent, or submerged. Submerged and semi-submerged structures act by breaking or refracting the waves rather than absorbing or reflecting them to dissipate energy. While less visually intrusive, they are less effective than emergent structures, particularly during high water level and wave conditions that can result in beach erosion due to wave focussing.

Table 9: Suitability and examples of offshore structures.

| Structure type | Suitability | Examples |
|---|---|---|
| **Artificial submerged reefs** | Submerged structures may be multi-purpose, meeting coastal protection, ecological and recreational amenity objectives.<br><br>Submerged structures do not hinder visual amenity.<br><br>Relatively expensive to construct.<br><br>Less predictable shoreline response. | <br>Artificial reef construction, Palm Beach (source: City of Gold Coast, 2020) |
| **Detached breakwater** | Emergent structure used to block wave energy from reaching the shore.<br><br>They have a greater visual impact, creating | |

| Structure type | Suitability | Examples |
|---|---|---|
| | a built environment landscape.<br><br>May create dangerous currents adjacent to the structure.<br><br>Shoreline recession would be experienced at both the eastern and western shore of the structure. | <br>Detached breakwater, Albany (source: Nearmaps, 2019) |

## Beach nourishment

Beach nourishment is the provision of additional beach sand to provide a buffer against large waves and elevated water levels. The sand can be placed by excavator on the upper beach, via pipelines along the beach through back/bypassing or via dredge either 'rainbowed' into the nearshore or pumped ashore and onto the upper beach. The placed nourishment will eventually be redistributed by coastal processes. As such beach nourishment is often considered a temporary solution that would require ongoing campaigns at some sites. The speed of the redistribution will be dictated by the amount of wave and current energy available to mobilise the sediment.

Table 10: Suitability and examples of beach nourishment methods.

| Nourishment type | Suitability | Examples |
|---|---|---|
| **Sand bypassing** | Sand bypassing of Cape Byron by pipelining sand from Tallows Beach into the embayment would be well beyond the budget of this project and is anticipated to be met with strong community opposition.<br><br>Sand bypass systems have high ongoing power costs and would change the nature of the project and the embayment. The net northerly transport through the bay does not warrant such a large capital expenditure.<br><br>Small-scale sand bypassing over short distances with smaller quantities to augment natural bypassing of the JSPW, on the other hand, is considered feasible. | <br>Sand bypass system, Southport (source: City of Gold Coast, 2020) |

| Nourishment type | Suitability | Examples |
|---|---|---|
| **Sand backpassing** | Sand sourced for a potential backpassing operation would need to be located further west than Belongil Creek. This would mean infrastructure required to pipe the sand to the project site would make this option too expensive.<br><br>Sand backpass operations have high ongoing power costs and would change the nature of the project and the embayment. | <br>Sand backpass system, Noosa (source: Slurry Systems Marine, 2020) |
| **Mass nourishment** | Mass or over-nourishment of the beach is placing volumes larger than the annual sediment budget of the beach into the active zone to create a buffer during storm events.<br><br>This is a temporary solution on alongshore drift coastlines but is viewed as a softer engineering approach. Nourishment campaigns can also be designed to improve surf amenity. | <br>Mass nourishment, Gold Coast (source: City of Gold Coast, 2020) |

## CONCEPT DESIGN OPTIONS

### Background

Seven discrete design options have been developed that are considered appropriate for further consideration. Each design option involves a combination of the **key design elements**:

1. alignment
2. structure or material type; and
3. configuration of groynes.

A key objective in developing these seven discrete options has therefore been to present a range of key design elements, i.e. range of alignments, range of materials, range of groyne treatments. The next step in the design process is to gather broader community and key stakeholder/agency feedback through engagement activities and consultation aiming to understand how they use and value the foreshore, their expectations for how the foreshore should be managed, and to test what peoples preferences are (i.e. ranking of the seven options). All the options for the structural modifications of the JSPW should be considered in combination with other softer management measures. Council is currently in the process of developing a Coastal Management Program (CMP) for Byron Bay which will consider a range of management measures that could be considered to complement the modified JSPW, for example: dune rehabilitation or maintenance, beach scraping, beach nourishment, planning controls, managed retreat and landscaping.

Information gathered from the consultation process will be used to refine the seven discrete options down to three options. Feedback from this process may mean the three discrete options taken forward are a modified combination of the key design elements presented herein.

Each of the seven design options are discussed further below and listed as:

- Option 1 – rock revetment and stepped concrete seawall
- Option 2 – berm rock revetment and pathway
- Option 3 – detached groyne
- Option 4 – artificial headland with sand bypassing
- Option 5 – protective structure moved landward by 10m
- Option 6 – protective structure moved landward by up to 30m
- Option 7 – existing structure upgraded to contemporary standards

The key design elements specific to each of the seven options are presented in Table 11. Table 12 presents a preliminary comparison of the assets that are protected by the various alignment options. Construction costs are an important differentiator between the key design elements. Construction cost estimates will be developed in later project stages, however, based on experience the relative construction costs for the key design elements are summarised as:

- **Alignment:** Maintaining the current alignment will be the cheapest cost alignment, followed by the 10m landward alignment. The up to 30m landward alignment and the seaward alignment (i.e. artificial headland) will be the more expensive options.
- **Material / structure types:** the linearly metre cost of the stepped concrete seawall is around 1.5 times the cost of a rock revetment.
- **Groynes:** Removal of groynes is likely to have marginally lower cost than repairing them. The additional costs associated with excavation of the groynes would be offset by re-use of the material deemed suitable in the reconstruction and extension of the main structure.

It is noted that the complex shoreline behaviour in response to any modification of the existing JSPW is difficult to predict based on available information. As a first-pass assessment, engineering judgement and previous preliminary numerical modelling of the predicted shoreline response presented in WorleyParson (2014) was considered herein. This modelling was highly simplified and does not account for the interplay of complex coastal processes within the Byron Bay embayment. The next stage of this investigation involves a detailed review of the performance in all result areas of up to three discrete design options.

Table 11: Summary of the key design elements in each option.

| Design option | Alignment | Material / structure type | Groynes |
|---|---|---|---|
| **Option 1** | Current alignment retained | Predominately rock revetment with inclusion of stepped concrete seawall | All spur groynes removed |
| **Option 2** | Current alignment retained | Predominately rock revetment with inclusion of shared path on lower level (berm) | All spur groynes removed |
| **Option 3** | Current alignment retained | Predominately rock revetment | Spur groynes removed, keep modified (detached) centre groyne |
| **Option 4** | Seaward alignment (25m) within footprint of main (centre) groyne | Predominately rock revetment with inclusion of artificial headland | Spur groynes removed, replace main (centre) groyne with artificial headland |
| **Option 5** | Landward alignment (10m) | Not specified (one of above) | All spur groynes removed |
| **Option 6** | Landward alignment (up to 30m) | Not specified (one of above) | All spur groynes removed |
| **Option 7** | Current alignment | Rock revetment | All spur groynes retained |

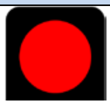
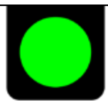
Table 12: Assets landward of considered alignment options.

| Alignment option/ Asset | Current alignment retained | Landward alignment (10m) | Landward alignment (up to 30m) | Seaward alignment (25m) – artificial headland |
|---|---|---|---|---|
| **Car park** | 100% of paved area. All 95 car parks. Footpath width 2.5m. | 88% of paved area. 55 car parks. Footpath width 3m (relocated). | 31% of paved area. 10 car parks. Footpath width 3m (relocated). | 100% of paved area. All 95 car parks. Footpath width 2.5m. |
| **Apex Park** | 100% of grassed area. Showers retained. | 82% of grassed area. Showers retained. | 80% of grassed area. Showers retained. | 124% of grassed area (increase). Showers retained. |
| **Council buildings (Fishheads)** | Fully retained. | Fully retained. | Fully removed or relocated. | Fully retained. |

| | | | | |
|---|---|---|---|---|
| **Memorial Swimming pool** | Fully retained. | Fully retained. | Pool footprint is fully retained. Partial removal of the pool complex. | Fully retained. |
| **First Sun Holiday Park** | Fully retained. | Fully retained. | Fully retained. | Fully retained. |

A traffic light system has been adopted to rate each option across the key results areas, with green, yellow and red indicating, improvement, no change or worsening of the structure's performance, respectively (as outlined in further in Table 13).

Table 13: Traffic light assessment criteria used for concept design options

| Traffic light colour | Design element suitability |
|---|---|
|  Red | Design element does not meet project objectives or KPI |
|  Yellow | Design element partially meets project objectives or KPI |
|  Green | Design element fully meets project objectives or KPI |

## Suite of preliminary design options

### Option 1 – rock revetment and stepped seawall

Figure 4 presents a plan view, images and overview of Option 1. This option broadly consists of:

- Removal of the spur groynes.
- Reconstruct and extension of the rock revetment along the current alignment to contemporary engineering standards.
- Inclusion of stepped concrete seawalls in popular section to provide enhanced amenity of the structure footprint.
- Formal beach access (including disabled ramp).

<u>Rationale</u>

This option is largely based on the preferred option that emerged from the 2014 Worley Parsons investigation and the concept that was resolved by Council for inclusion in the previous (draft) *Coastal Zone Management Plan (CZMP) for the Byron Bay Embayment* (BSC, 2016). The WorleyParsons (2014) investigation considered four structure types (near vertical seawall, stepped seawall, sloping pattern-placed revetment and rock revetment) on three separate alignments (maintain current alignment, remove spur groynes or move landward). An assessment was undertaken based on economic, social and environmental factors. Each factor considered was scored and weighted at a workshop with Council and NSW Government stakeholders (Cape Byron Marine Park, Office of Environment and Heritage and Crown Lands). The rock revetment structure type was ranked the highest followed by the stepped seawall. Of the alignment options, removal of the spur groynes was ranked marginally higher than maintaining the current alignment, with a landward realignment ranked lower largely due to the additional costs and the disruption to the community during construction.

The inclusion of the stepped concrete seawall is targeted at obtaining feedback on these structure types, with the location to be refined based on community feedback.

Preliminary performance assessment

A preliminary assessment of the performance of Option 1 is presented in Table 14. This assessment is based on available information and engineering judgement. The next stage of this investigation involves a detailed review of the performance of up to three discrete design options.

Table 14: Summary of the anticipated performance of Option 1.

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. Option 1 retains the current alignment and there would be expected to be an increase in the level of coastal protection for all existing assets compared to the base case (of retaining the existing structure). Removing the groynes is likely to lower the beach on the eastern side (Main Beach) and require additional toe protection/deeper foundations/piles. | Green |
| | If existing levels are retained, the introduction of the stepped seawall(s) would expect to result in an increase in overtopping above the base case (Modra et al., 2016). Likewise, the removal of the groynes would also be expected to marginally increase overtopping. | Yellow |
| **Shoreline impacts** | The removal of the spur groynes would be expected to increase the supply of littoral sand to downdrift areas. Preliminary shoreline modelling by WorleyParsons (2014) indicated some accretion downdrift along with some erosion on the updrift side. The structure would still be in the active beach zone (landward of the embayment wide erosion scarps/run-up levels) and would still interact with littoral transport. | Yellow |
| **Amenity (beach, foreshore** | Removal of the groynes will improve the pedestrian connectivity along the beaches. If a high value is assigned to improved pedestrian connectively via the dry beach, then on balance beach amenity is | Yellow |

| Result area | Anticipated performance | Rank |
|---|---|---|
| **and surfing)** | expected to be improved above the base case. Future shoreline recession would be expected to reduce any gain in dry beach width in front of the structure.<br><br>Largely retaining the car park, Apex Park, Memorial Pool, Fishheads restaurant this option would retain the high foreshore amenity value of the existing area. The stepped seawall(s) would improve the usage of the structure footprint due to its location in a popular area. Landscaping, wider footpaths additional/improved showers would all lead to amenity improvements above the base case.<br><br>The groynes are perceived to have a positive influence on the surf amenity value of the area. Removing the groynes was raised as a key concern by the local surfing community following the completion of WorleyParsons (2014) recommended concept design. It is currently not clear what leads to any improved surf conditions nearby the structure (i.e. is it the influence of the groyne/structure on creation of a semi-permanent rip or modified shoreline/nearshore morphology or is it pre-conditioning by offshore reefs or the like that is independent of the groynes?). Any potential impact of removing the groynes on the SS Wollongbar wreck, a high surf amenity and ecological value area, needs to be considered. | Green<br><br>Yellow |
| **Public safety** | Stepped seawalls would reduce the extent of rock revetment, thereby reducing the interstitial spaces (or voids) and risk of dangerous snakes interacting with the public as well as trips, slips and rock falls. However, this structure type would also increase the frequency and volume of overtopping if existing crest levels are maintained.<br><br>Removal of the groynes is likely to reduce the occurrence of rip currents nearby the structure. | Green |
| **Cost** | The removal of the spur groynes and sections of the existing structure would be costly and would need to be staged so as not to disrupt traffic, beach access and patrons of the pool and Fishheads Café. The largest costs for this option would come through the excavation of the toe of the structure to a suitable scour level as there is a significant amount of remnant rock to be removed along the existing footprint. Further site investigations and design would be required to define the required toe excavation and a conservative allowance has been made herein.<br><br>However, the removal of the groynes and re-use of suitable material, | $$$ |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | would reduce the structure footprint with material savings to be made.<br><br>Additional costs are associated with the construction (and maintenance) of the stepped concrete seawall in comparison to a rock revetment. | |

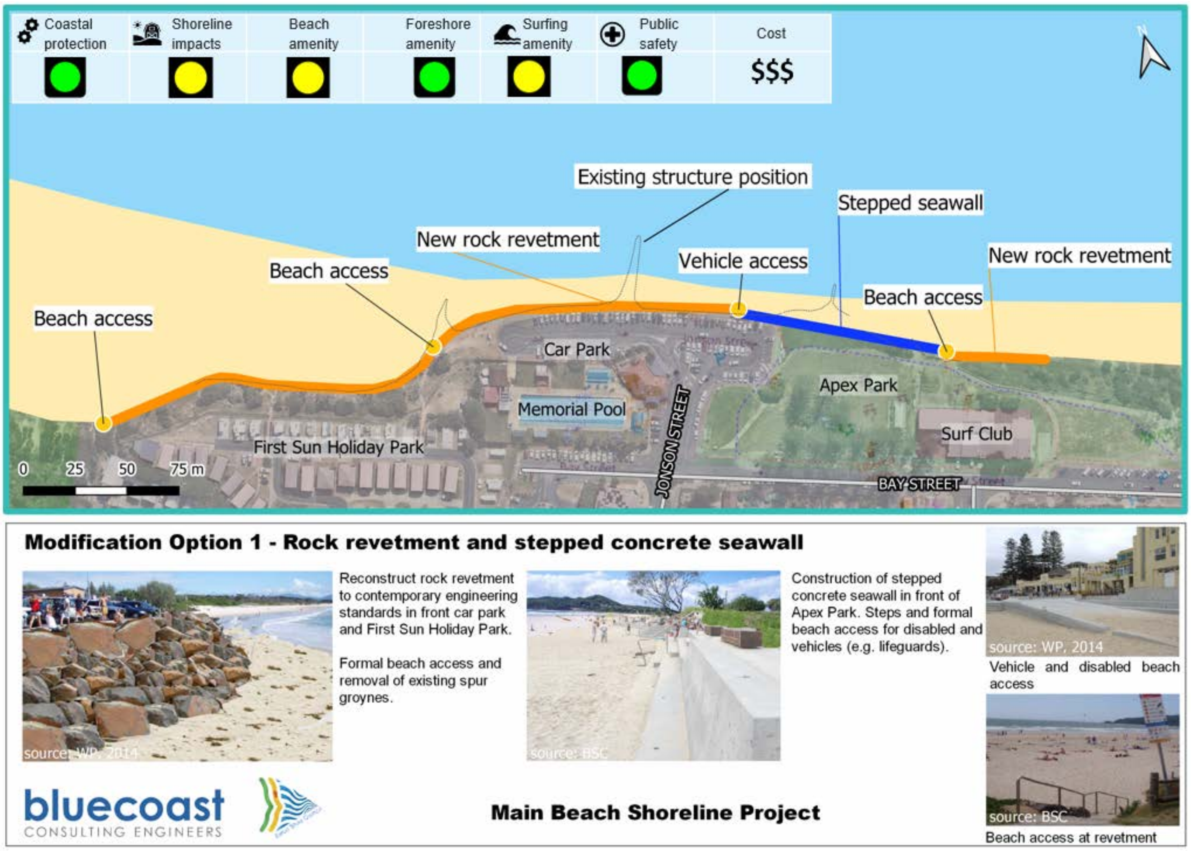



Figure 4: Modification option 1 – Rock revetment and stepped concrete seawall.

## Option 2 – berm rock revetment

Figure 5 presents a plan view, images and overview of Option 2. This option broadly consists of:

- Removal of the spur groynes.
- Construction of a berm rock revetment along the current alignment to contemporary engineering standards. The berm would create a terrace at a lower level (i.e. closer to water edge) with a shared pathway based by a second seawall which could be vertical or stepped to reduce the footprint of the structure.
- Reconstruct and extend the rock revetment, to contemporary engineering standards, in front of First Sun Holiday Park, Apex Park and the Surf Club.

- Formal beach access (including disabled ramp).

<u>Rationale</u>

This option is aimed at providing improved east-west connection, both via the beach and via a terraced lower level boardwalk in line with the Byron Town Master Plan. In relation to the foreshore area within the Main Beach Precinct, the Masterplan states:

*"A new Main Beach boardwalk along the foreshore should form a generous east to west connection that sensitively integrates the hybrid coast protection works, recreation, nature and pedestrian movement together."*

The current footpath is 2.5m and located immediately landward of the crest. The lower revetment is envisaged to have a shallower slope, but the top revetment or vertical wall could be steeper. Combined this would be a similar footprint to the current structure and the footpath would be simply relocated to the berm. If wider, the structure would cut into the car park and reduce the number of car spaces.

<u>Preliminary performance assessment</u>

A preliminary assessment of the performance of Option 2 is presented in Table 15. As with Option 1, this assessment is based on available information and engineering judgement and subject to further investigation in the next stage.

Table 15: Summary of the anticipated performance of Option 2.

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. Option 2 retains the current alignment and there would be expected to be an increase in the level of coastal protection for all existing assets compared to the base case. Removing the groyne is likely to lower the beach on the eastern side (Main Beach) and requires additional toe protection/deeper foundations/piles.<br><br>The introduction of a berm structure would be expected to result in reduced overtopping landward of the full structure. However, the lower terraced section where a shared pathway is proposed would be subject to more frequent overtopping and inundation. Public safety concerns would need to be considered in the design and levels of the lower berm with a need to cope with a yet to be defined frequency and magnitude of overtopping. | Green<br><br>Green |
| **Shoreline impacts** | The shoreline impacts would be expected to be equivalent to Option 1 with removal on the groynes increasing sand bypassing, some accretion downdrift along with some erosion on the updrift side. The structure would still be in the active beach zone (landward of the embayment | Yellow |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | wide erosion scarps/run-up levels) and would still interact with littoral transport. | |
| **Amenity (beach, foreshore and surfing)** | Removal of the groynes will connect the beaches and the lower level terrace pathway within the berm structure would enhance the east to west connectivity and is expected to improve beach, foreshore and visual amenity above the base case. As with Option 1, future shoreline recession would be expected to reduce any gain in dry beach width in front of the structure.<br><br>Largely retaining the car park and Apex Park, Memorial Pool, Fishheads restaurant this option would retain the high foreshore amenity value of the existing area. By integrating the pathway, the berm structure would improve the usage of the structure footprint and could be further enhanced by sections of stepped seawall(s) in popular areas. Landscaping, wider footpaths additional/improved showers would all lead to amenity improvements above the base case.<br><br>As with Option 1, removal of the groynes will need to be considered in relation to concerns by the local surfing community of impacts to the surf conditions nearby the structure. Any potential impact of removing the groynes on the SS Wollongbar wreck, a high surf amenity and ecological value area, needs to be assessed. | Green<br><br>Yellow<br><br>Yellow |
| **Public safety** | The berm revetment will have a lower level pathway that will be overtopped and inundated more frequently. A safety management plan, signage warning of the dangers and/or closure of the pathway in storm wave and high-water level conditions would need be considered. However, landward of the full structure height this type of structure would be expected to perform well in reducing the frequency and volume of overtopping.<br><br>Removal of the groynes is likely to reduce the occurrence of rip currents nearby the structure. | Green<br><br>Green |
| **Cost** | As with Option 1 the removal of the existing structure, toe excavation and disruptions due to construction costly. The reconstruction of a berm type revetment may offer marginally cost efficiencies when compared to a standard rock revetment. However, if a section of stepped concrete seawall were included the construction costs would be expected to be in the same range as Option 1. | $$ |


Figure 5: Modification option 2 – berm rock revetment.

## Option 3 – detached groyne

Figure 6 presents a plan view, images and overview of Option 3. This option broadly consists of:

- Removal of the two short groynes and the initial portion of the main (centre) spur groyne to create a detached groyne.
- Reconstruct and extension of the rock revetment along the current alignment to contemporary engineering standards in front of First Sun Holiday Park, Apex Park and the Surf Club.

<u>Rationale</u>

This option attempts to retain the surf amenity benefits derived from the large groyne, as is perceived by members of the community, while also allowing for a reduction in the structures footprint and more sand bypassing along the upper beach (between the revetment and the detached groyne).

Stepped seawalls, as per Option 1, could also be incorporated into the design. However, feedback is initially sought on the detached groyne as the differential feature of the design.

Preliminary performance assessment

A preliminary assessment of the performance of Option 3 is presented in Table 14. As with the other options this assessment is based on available information and engineering judgement and subject to further investigations in the next stage.

Table 16: Summary of the anticipated performance of Option 3.

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. Like Option 1 and 2, Option 3 retains the current alignment and there would be expected to be an increase in the level of coastal protection for all existing assets compared to the base case. By providing a gap for swash zone sand bypassing of the structure there is likely to be a moderate lowering of the beach on the eastern side (Main Beach).<br><br>By retaining the offshore section of the main spur groyne no significant increase in wave overtopping would be expected in the case existing crest levels are retained. | Green<br><br>Green |
| **Shoreline impacts** | Through the removal of the two small spur groynes and creation of a gap in the main spur groyne an increased supply of littoral sand to downdrift areas would be expected. The preliminary modelling by WorleyParsons (2014) did not consider this scenario but it did consider the complete removal of the spur groynes. If this option is progressed, shoreline modelling to quantify this option would be undertaken. By retaining the existing alignment, the main structure would still be in the active beach zone (landward of the embayment wide erosion scarps/run-up levels) and would still interact with littoral transport. | Yellow |
| **Amenity (beach, foreshore and surfing)** | Removal of the two small groynes and creation of a gap in the main groyne at the shoreline will improve the connectiveness along the beaches. The gap will be designed to, where conditions permit, support improved pedestrian access via the dry beach. On balance beach amenity is expected to be improved above the base case. While future shoreline recession would be expected to reduce any gain in dry beach width in front of the structure, the presence of the detached groyne is expected to assist in retaining sand in this area.<br><br>Largely retaining the car park, Apex Park, Memorial Pool and Fishheads restaurant this option would retain the high foreshore amenity value of the existing area. Inclusion of the stepped seawall(s) would improve the usage of the structure footprint. Careful landscaping, wider footpaths additional/improved showers will all lead to amenity improvements | Green<br><br>Yellow |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | above the base case.<br><br>The central groyne is perceived to have a positive influence on the surf amenity of the area. Removing the groyne was raised as a key concern by the local surfing community following the completion of WorleyParsons (2014) recommended concept design. While there remains uncertainty regarding the influence of the structure on nearby surf conditions, by incorporating a detached groyne this option is likely to provide no change to surfing amenity and be more acceptable than complete removal. Any potential impact of changing the groynes on the SS Wollongbar wreck, a high surf amenity and ecological value area, needs to be considered. | Green |
| **Public safety** | Largely retaining the plan outline of the existing structure no significant change in the frequency and volume of overtopping would be expected if existing levels are maintained. | Green |
| **Cost** | As with Option 1 and Option 2 the removal of the existing structure, toe excavation and disruptions due to construction would be costly. Material from the two spur groynes and the initial section of the main groyne could be re-used and represents material savings. If a section of stepped concrete seawall were included the construction costs would increase and be similar to Option 1 and Option 2. | $$ |


Figure 6: Option 3 – detached groyne.

## Option 4 – artificial headland with sand bypassing

Figure 8 presents a plan view, images and overview of Option 4. This option broadly consists of:

- Replace the main central groyne with an artificial headland. The artificial headland would be designed as a multifunctional infrastructure offering benefits in high-value public domain space, coastal protection, enhanced foreshore amenity and potentially enhanced surf amenity.
- Add a small-scale sand bypassing pump to increase sand bypassing from east to west with the pipeline infrastructure built-in to the headland.
- Reconstruction and extension of the rock revetment in front of First Sun Holiday Park and the Surf Club along the current alignment to contemporary engineering standards.
- Formal beach access (including disabled ramp).

A small-scale sand bypassing system is proposed as a stand-alone jet pump (see Figure 7) that is supplied by a motive water pump and discharges sand/seawater without any further pumps, screens or slurry tanks. Initial calculations show a single jet pump can deliver about 100 tonnes (approx. 62m$^3$) of sand per hour over a 300m length (typically over a 10-hour pumping shift). Increased production could be achieved by running the water pump at higher pressure or increasing the size of the jet pump and associated pipework. The supply costs of the jet pump

shown in Figure 7 is around $45,000 but the full cost of the small-scale system has not yet been estimated.
It has been assumed that the sand bypassing system would be included in the design to ensure that the objective to reduce adverse impacts on coastal processes is met (refer Project objectives #3). However, it may be that natural sand bypassing would be enough (i.e. the shape and extent of the headland alone would enhance bypassing above base case), and mechanical sand bypassing would not be required.

Figure 7: Photo of a jet pump being installed at Jimmys Beach.

Rationale

The Main Beach foreshore is an iconic coastal location and Byron Bay's most popular asset (McGregor Coxall, 2016). According to the Byron Bay Town Masterplan it "should be celebrated as a natural foreshore environment that supports both active and passive recreational uses". Space is at a premium with open space, car parking, the swimming pool and surf club all popular assets with a long history of community support. The artificial headland concept seeks to both accommodate the existing uses and provide space to improve the foreshore public space domain experience. The headland can be designed to have a natural feel and its position will enhance the iconic views towards Byron Bay's hinterland and preserve the vistas from the Main Beach area. Through a well-designed headland shape and the potential inclusion of assisted mechanical sand transfer, the objective of reducing the adverse impacts on coastal processes can also be achieved.

While costs have not been a focus of the preliminary design development, Option 4 is likely to have higher capital and on-going costs when compared to Options 1, 2 and 3. However, the social and economic benefits derived from the Main Beach foreshore, not only for the local area but for the state of NSW and Australian tourism should not be understated.

Preliminary performance assessment

A preliminary assessment of the performance of Option 4 is presented in Table 17. As with the other options this assessment is based on available information and engineering judgement and subject to further investigations in the next stage.

Table 17: Summary of the anticipated performance of Option 4.

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. As the artificial headland extends further seaward it is expected to provide an increase in the level of coastal protection all existing assets compared to the base case. Beach levels on the updrift side would be expected to be similar or slightly lower than the base case.<br><br>Wave overtopping around the headland would need to be considered in the design but ultimately the headland would act to reduce the coastal inundation hazard to the town centre. | Green<br><br>Green |
| **Shoreline impacts** | The preliminary modelling by WorleyParsons 2014 did not consider this scenario and further investigations on the natural sand bypassing rates around the headland are required. However, through the inclusion of the mechanical sand bypassing the beaches updrift and downdrift can be managed in response to changing conditions and future climate change scenarios. | Green |
| **Amenity (beach, foreshore and surfing)** | Creation of the headland with a similar offshore extent as the central groyne is expected to offer similar levels of connectiveness along the beaches as the base case (i.e. possible at low tide when beach levels are high). Future shoreline recession would be expected to reduce the dry beach width in front of the structure. However, improved pedestrian connectivity could be incorporated into the headland design.<br><br>This option retains the car park, Apex Park, Memorial Pool, Fishheads restaurant but also provides additional public domain space to enhance the high foreshore amenity value of the existing area. The stepped seawall(s) or berm revetment could be incorporated into the headland design to improve the usage of the structure footprint in located in two popular areas. Landscaping, wider footpaths additional/improved showers would all lead to amenity improvements above the base case.<br><br>The groynes are perceived to have a positive influence on the surf | Yellow<br><br>Green |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | amenity value of the area. Removing the groyne was raised as a key concern by the local surfing community following the completion of WorleyParsons (2014) recommended concept design. The headland design would need to consider opportunities to enhance the surf amenity, potentially offering an “inside rock break” on small days, breaking along the edge of the headland and promoting sand/rip formation similar to that perceived by the local community as offering enhance surf amenity offshore of the existing structure. In addition, the outlet of the sand bypassing system, if positioned sub-aqueous, has the potential to provide a positive influence on sand bank formation for surfing. Any potential impact of the design on the SS Wollongbar wreck, a high surf amenity and ecological value area, needs to be considered. | Yellow |
| **Public safety** | Overtopping around the headland would need to be considered in relation to public safety on or near the crest. Likewise rip currents around the structure will need to be assessed. | Green |
| **Cost** | This option has the largest structure footprint and will incur greater cost for materials. The construction of the revetment along an alignment seaward of the existing and the small-scale bypassing system would also incur additional costs. Ongoing costs will be associated with the operation and maintenance of the sand bypass system.<br><br>As noted above this option would derive a range of additional social and economic benefits when compared to other options. These benefits would be expected to offset the additional costs. An evaluation of which would require a cost-benefit analysis to be undertaken as is proposed in later project stages. | $$$$ |

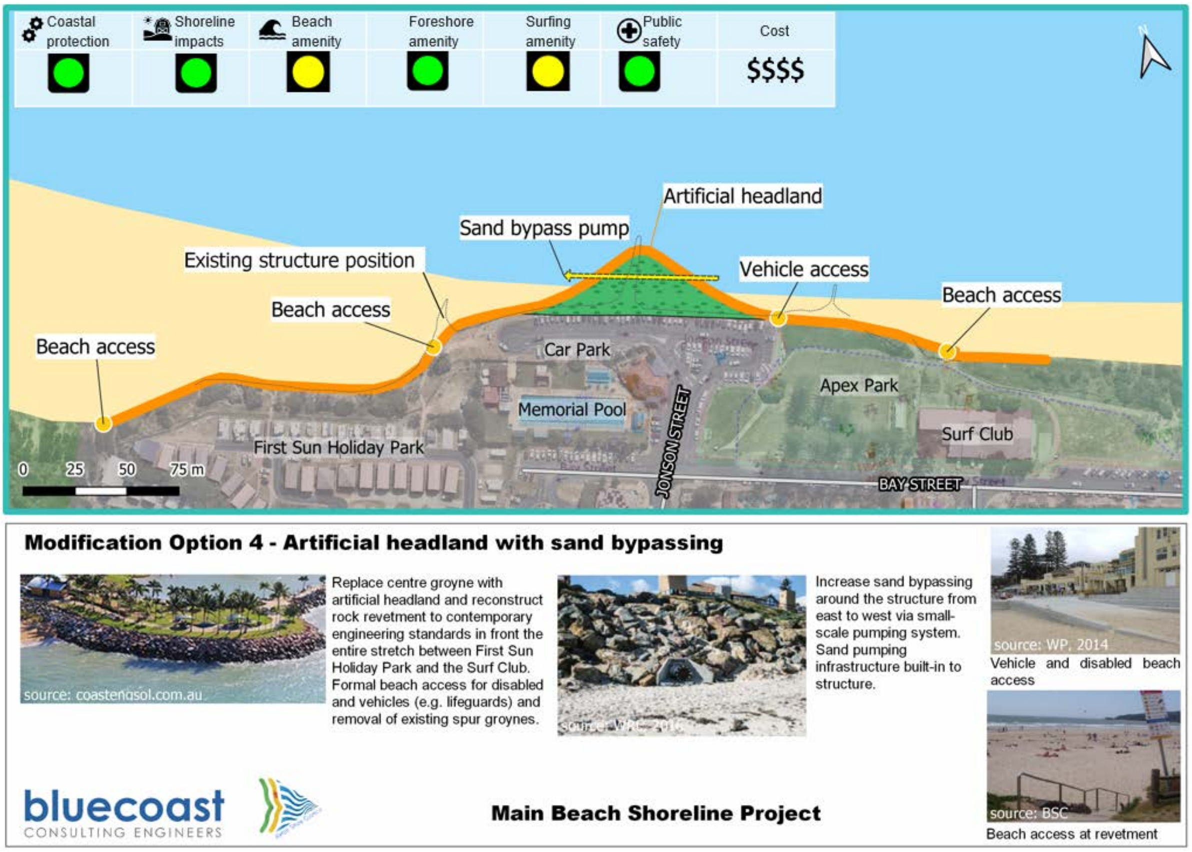


Figure 8: Option 4 – artificial headland with sand bypassing.

## Option 5 – protective structures moved landward by 10m

Figure 9 presents a plan view, images and overview of Option 5. This option broadly consists of:

- Removal of the spur groynes.
- Removal of the existing revetment fronting the car park and Apex Park and reconstructing the physical infrastructure landward and to contemporary engineering standards.
- Reconstruct and extension of the rock revetment to contemporary engineering standards in front of First Sun Holiday Park and the Surf Club.
- Formal beach access (including disabled ramp).

It is noted that sacrificial infrastructure (e.g. boardwalk) could be placed seaward of the protection structure to provide additional recreational foreshore space.

Rationale

Project objective number three as agreed on by Council in 2018 is a key project objective. Moreover, this objective is linked to the requirement of DPIE's project funding (refer Special conditions). It states that upgrade options must seek to reduce the impacts of the structure on coastal processes, public amenity and safety. Specifically, options that realign the structure landward and reduce the planned footprint of the structure should be considered. Option 5 and Option 6 consider two landward realignments that could apply to any of the presented options.

Option 5 is based on a 10m landward shift, a shift that would still allow a single row of car parking as well as a shared pathway corridor while protecting the entire Memorial Pool site.
Options for the structure types would be further explored once feedback on the alignment and key design elements are received from the community. However, it is envisaged that a vertical seawall (e.g. secant piled structure with a rock toe) would offer the advantage of a reduced plan footprint. A secant piled seawall can be constructed without the need for excavation which can be costly (due to groundwater) and high risk due to the exposure to wave action. Further geotechnical investigations would be required, particularly considering the history of the existing Jonson Street rock revetment, previous damage and the extent of the rock apron that underlies the structure (i.e. piling through hard buried material is highly problematic). A vertical structure type would, however, be expected to increase reflected wave energy, being subject to greater rates of overtopping (when compare to a rock revetment), reduce visual amenity and potentially impact nearby surf amenity.

Reconfiguring the car park and shared pathway under this realignment option would require further consideration. The numbers presented in Table 12 are indicative.

While costs have not been a focus of this report, it is noted that both realignment options (i.e. Option 5 and Option 6) are likely to be two of the more expensive options presented herein due to the additional construction time associated with the cost of removal of assets and excavation of material. WorleyParsons (2014) noted an additional capital cost of at least $2.5 M (for excavation or rock and soil, removal of concrete and bitumen paving, disposal of excavated concrete and fill for estimated material quantities for a 30m landward realignment). Unlike Option 4, the additional costs association with realignment options are unlikely to be matched by social and economic benefits.

Preliminary performance assessment

A preliminary assessment of the performance of Option 5 is presented in Table 18. As with the other options this assessment is based on available information and engineering judgement and subject to further investigations in the next stage.

Table 18: Summary of the anticipated performance of Option 5

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. Option 5, however, is located landward of the current alignment. Table 12 provides a summary of the assets that are expected to be affected. By setting the structure further back on the active beach profile some design parameters could be relaxed (e.g. scour depth) as per WorleyParsons (2014).<br><br>The form of the structure will consider overtopping including under sea level rise scenarios. However, setting the structures back will have a beneficial effect on overtopping in the short term. Future shoreline | Yellow<br><br>Yellow |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | recession and sea level rise will lead to more interaction with the structure, lowering of the beach levels and increased overtopping, particularly in the case of a vertical structure. | |
| **Shoreline impacts** | The preliminary shoreline modelling undertaken as part of the 2014 WorleyParsons investigations considered a 30m landward realignment with no groynes. A marked increase in the sand bypassing around the structure with considerable accretion on the downdrift (western) side and associated updrift (eastern side) recession was found. Changes to the updrift shoreline alignment have not been assessed in detail, however a considerable landward movement would be expected. | Green |
| **Amenity (beach, foreshore and surfing)** | Removal of the groynes and realignment of the structure landward will markedly improve the connectiveness along the beaches. Future shoreline recession will eventually reduce any gains in dry beach width in front of the structure.<br><br>With a reduction in the number of car spaces, the east to west connectivity along the foreshore would be expected to be like the base case. As the size of the car park and Apex Park would be reduced a component of the high foreshore amenity value of the existing area would be lost. Landscaping, wider footpaths additional/improved showers could all still be incorporated into the works and lead to amenity improvements.<br><br>As with Option 1, removal of the groynes will need to be considered in relation to concerns by the local surfing community of impacts to the surf conditions nearby the structure. Moreover, the potential impact of removing the groynes and realigning landward on the SS Wollongbar wreck, a high surf amenity and ecological value area, needs to be considered. | Green<br><br>Yellow<br><br>Yellow |
| **Public safety** | A structure realigned landward will reduce the frequency and volume of overtopping. However, the structure type would need to also consider shoreline recession and sea level rise regarding future public safety atop the crest.<br><br>Removal of the groynes and realignment landward is likely to reduce the occurrence of semi-permanent rip currents nearby the structure and return the area to a more natural beach state. | Green |
| **Cost** | The excavation and removal of the existing structure, carparks, footpaths, services and foreshore park would be costly. It would be more disruptive to traffic, beach access and patrons of the pool and Fishheads Café when compared to other options. Reconstructing the | $$$ |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | structure to conventional standards along the new landward realignment may prove to offer some benefits in the ease of excavation to the required toe depths but further site investigations would be required to quantify construction costs more accurately. | |


Figure 9: Option 5 – protective structures moved landward by 10m.

## Option 6 – protective structures moved landward by 30m

Figure 10 presents a plan view, images and overview of Option 6. This option broadly consists of:

- Removal of the spur groynes.
- Removal of the existing revetment fronting the car park, Apex Park and the First Sun Holiday Park and reconstructing the physical infrastructure landward to contemporary engineering standards.
- Reconstruct and extension of the rock revetment to contemporary engineering standards in front of the First Sun Holiday Park and the Surf Club.
- Formal beach access (including disabled ramp).

It is noted that sacrificial infrastructure (e.g. boardwalk) could be placed seaward of the protection structure to provide additional recreational foreshore space.

Rationale

As discussed in design rationale of Option 5, options that realigned the structure landward and reduced the plan footprint of the structure are to be considered. Option 6 considers a more significant shift landward of up to 30m in places. It is not based on retaining existing assets but rather based on an embayment wide alignment for any future protective works under the notion of a consistent and co-ordinated approach to the Byron Bay shoreline. In the absence of an agreed alignment this landward shift is based around the 1913 erosion scarp reported in WBM (2000). If this alignment is to be considered for the Main Beach Shoreline Project, the embayment-wide alignment would be expected to be developed and agreed on as part of a Coastal Management Program.

As with Option 5, the structure type(s) would be further explored once feedback on the alignments are received from the community. As outlined in Table 12, this option would result in the removal and/or relocation of all or parts of a number of significant assets (i.e. the car park, Memorial Pool and portions of Apex Park). It would require a significant reconfiguring of the Main Beach foreshore area and potentially revisiting the Byron Bay Town Master Plan.

Preliminary performance assessment

A preliminary assessment of the performance of Option 6 is presented in Table 19. As with the other options this assessment is based on available information and engineering judgement and subject to further investigations in the next stage.

Table 19: Summary of the anticipated performance of Option 6

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. Option 6, however, is located landward of the current alignment. Table 12 provides a summary of the assets that are expected to be affected. By setting the structure further back on the active beach profile some design parameters (e.g. scour depth) may be relaxed as per WorleyParsons (2014). | Yellow |
| | The form of the structure will consider overtopping including under sea level rise scenarios. However, setting the structures back will have a beneficial effect on overtopping in the medium term. Future shoreline recession and sea level rise will eventually lead to more interaction with the structure, a lowering of the beach levels and increased overtopping. | Green |

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Shoreline impacts** | The preliminary shoreline modelling undertaken as part of the 2014 WorleyParsons investigations considered a 30m landward realignment with no groynes. A marked increase in the sand bypassing around the structure with considerable accretion on the downdrift (western) side and an associated updrift (eastern side) recession was found. Accordingly, a readjustment of the shoreline with an initially increase in littoral transport would be expected. As with Option 5, a considerable landward shift of the updrift (eastern side) shoreline position would be expected. | Green |
| **Amenity (beach, foreshore and surfing)** | Removal of the groynes and realignment of the structure landward will markedly improve the beach widths and connectiveness along the beaches. Given the planform of this section would be consistent with an embayment wide shoreline, any shoreline recession and beach erosion would be expected to affect the dry beach in front of the structure to a similar extent as adjacent beaches. The revetment protection in front of the Surf Club may act as a control point under future landward shorelines.<br><br>The size and character of the iconic Main Beach foreshore area would be permanently changed. The car park as well as a significant proportion of Apex Park would be removed, and the high foreshore amenity value of the existing area would be lost or relocated. Given the removal of assets and excavation required, this option would have an extended construction period at additional costs. An economic assessment of the costs and benefits would be required to assess the potential losses to public and private revenue, loss of foreshore amenity and compare this to the additional beach amenity gained. Careful planning, landscaping design and extensive community consultation required (i.e. the Masterplan would need to be revisited). A permanent change to the character of the location would arise which may be perceived as either positive or negative by different sectors of the community.<br><br>The impact on surf amenity at the SS Wollongbar wreck, a high surf amenity and ecological value area, needs careful consideration. | Green<br><br>Red<br><br>Yellow |
| **Public safety** | The significant landward realignment will reduce the public safety risk of overtopping. Public safety would also be improved due to the increase in beach width.<br><br>Removal of the groynes and realignment landward is likely to reduce the occurrence of semi-permanent rip currents nearby the structure | Green |

| Result area | Anticipated performance | Rank |
|---|---|---|
| | and return the area to a more natural beach state. | |
| **Cost** | As with Option 5 the excavation and removal of the existing structure and landward areas would be costly. If a suitable re-use could not be found the costs associated with the disposal of the larger volumes of material under this option would be significant. Higher costs would also be incurred from road realignment and reconfiguration of other assets as well as the higher levels of disruptions to traffic, beach access and patrons of the pool and Fishheads Café.<br><br>Unlike Option 4, the additional costs are unlikely to be offset by additional benefits. | $$$$ |

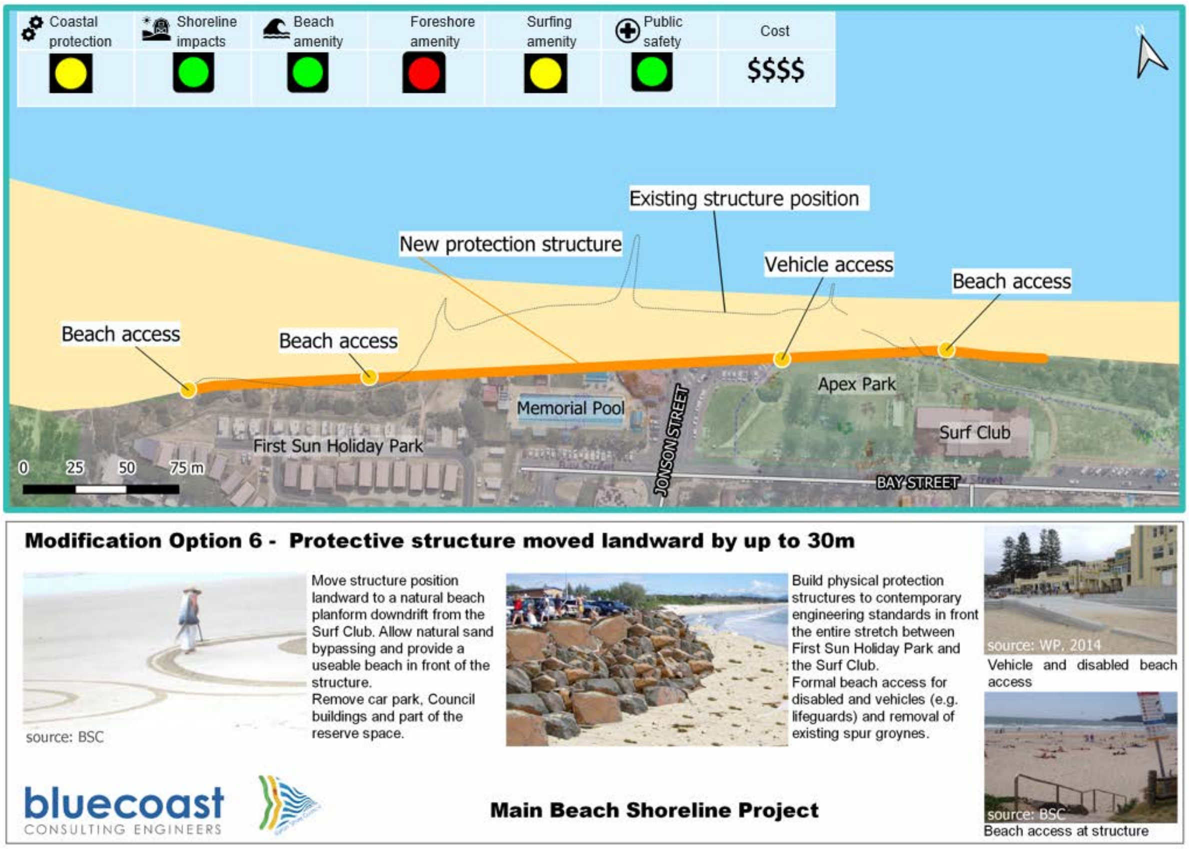



Figure 10: Option 6 – protective structures moved landward by 30m.

### Option 7 – existing structure upgraded to contemporary standards

Figure 11 presents a plan view, images and overview of Option 7. This option broadly consists of:

- Reconstruct the rock revetment to contemporary engineering standards between the First Sun Holiday Park and the Surf Club.
- Retention of current structure alignment including the spur groynes and main groyne.
- Removal of the front (seaward) row of car parking spaces with landscaping of this area for use as public open space.
- Upgrade of the existing formal beach accesses (including disabled ramp).

Rationale

This option retains the existing alignment to preserve community sentiment about the current structure and to retain any perceived surf amenity afforded by the status quo. An increased buffer would be created through the removal of the front (seaward) row of car parking spaces (approximately 20% reduction) to increase recreational foreshore area/park for connectivity, amenity and visual improvement.

The structure type(s) would be further explored once feedback on the alignments is received from the community.

Preliminary performance assessment

A preliminary assessment of the performance of Option 7 is presented in Table 20. As with the other options this assessment is based on available information and engineering judgement and subject to further investigations in the next stage.

Table 20: Summary of the anticipated performance of Option 7

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Coastal protection** | All options will be designed to withstand 100-year ARI design conditions and are expected to offer similar levels of erosion protection of landward assets. Table 12 provides a summary of the assets that are expected to be affected. | Green |
| | The form of the structure will consider overtopping including under sea level rise scenarios, this would most likely include a raising and/or widening of the revetment crest. Future shoreline recession and sea level rise will eventually lead to more interaction with the structure, a lowering of the beach levels and increased overtopping. | Yellow |

| Result area | Anticipated performance | Rank |
|---|---|---|
| **Shoreline impacts** | Upgrading the works in front of these areas would not be expected to impact on sediment transport rates and coastal processes, provided that the structure footprint does not extend further seaward than that of the existing protection (WorleyParsons, 2014). The structure would continue to interrupt sediment transport from east to west along Belongil Beach as is the case at present and rising sea levels would exacerbate the issue. | Yellow |
| **Amenity (beach, foreshore and surfing)** | The recreational amenity of the beach would decrease over time as sea level rises and potential for recession increases. The instances of there being a usable beach on the seaward side of the carpark would decrease.<br><br>The size of the iconic Main Beach foreshore area would remain the same. If the revetment design crest is raised the foreshore park will now be bordered by (hard) engineering structures rather than a vista that continues from the town centre, through the park and onto a sandy beach. The removal of the front (seaward) row of carparks would provide an area that could now be converted for recreation through increased parkland, widened footpath and/or viewing structure.<br><br>The surf amenity at the SS Wollongbar wreck, a high surf amenity and ecological value area and adjacent areas would remain the same. | Yellow<br><br>Yellow<br><br>Green |
| **Public safety** | The removal of the front (seaward) row of carparks and upgrade of the revetment structure to contemporary standards will reduce the public safety risk of overtopping.<br><br>The semi-permanent rip currents nearby the structure would be expected to be unchanged. | Green |
| **Cost** | The removal of the existing structure and front row of carparks is quite a straightforward endeavour but would need to be staged so as not to disrupt traffic, beach access and patrons of the pool and Fishheads Café. The largest costs for this option would come through the excavation of the toe of the structure to a suitable scour level as there is a significant amount of remnant rock to be removed along the existing footprint. | $$ |

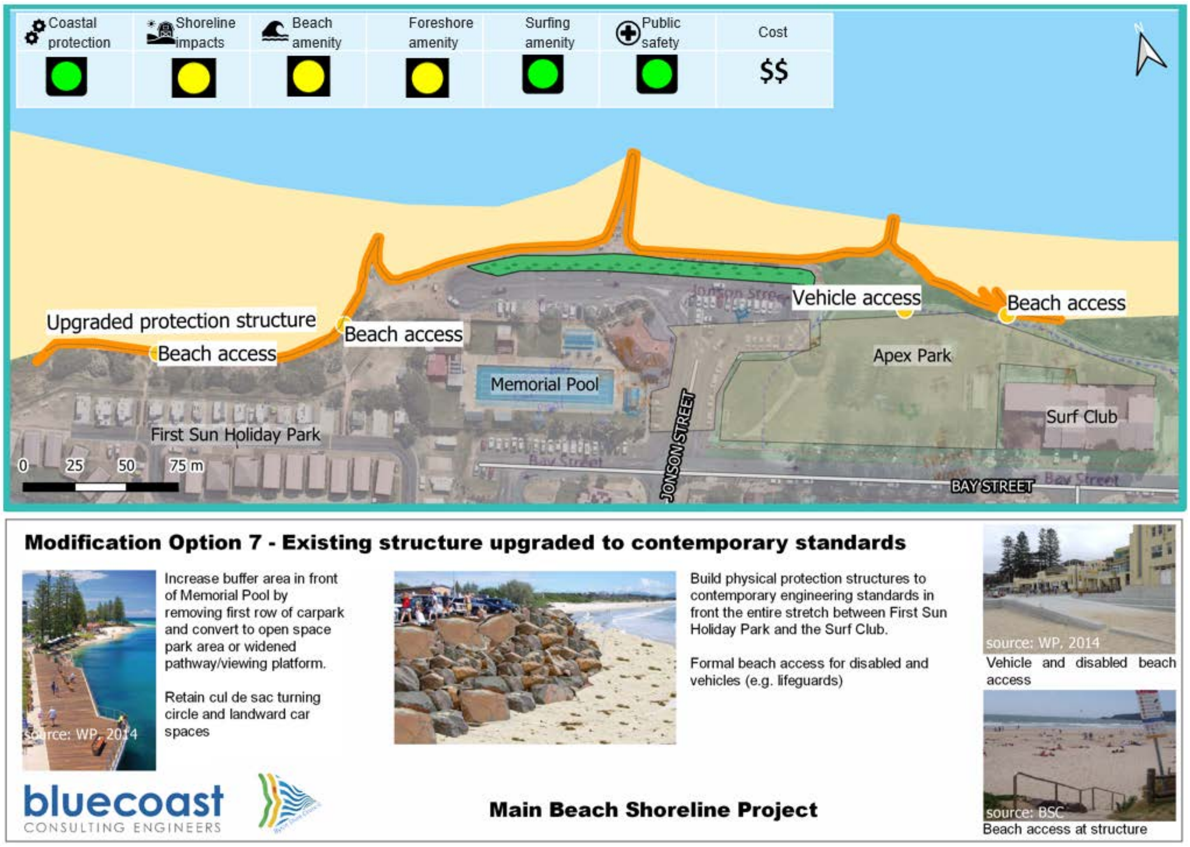



Figure 11: Option 7 – Existing structure upgraded to contemporary standards and removal of seaward car paking spaces.

## Summary of options

Table 21 provides a summary of the seven concept options and their corresponding assessment against project objectives.

Table 21: Summary of the anticipated performance of all options

| Option | Anticipated performance | | | | | | |
|---|---|---|---|---|---|---|---|
| | Coastal protection | Shoreline impacts | Beach amenity | Foreshore amenity | Surf amenity | Public safety | Cost |
| **Option 1** – rock revetment and stepped concrete seawall | 🟢 | 🟡 | 🟡 | 🟢 | 🟡 | 🟢 | $$$ |
| **Option 2** – berm rock revetment and pathway | 🟢 | 🟡 | 🟢 | 🟡 | 🟡 | 🟢 | $$ |
| **Option 3** – detached groyne | 🟢 | 🟡 | 🟢 | 🟡 | 🟢 | 🟢 | $$ |
| **Option 4** – artificial headland with sand bypassing | 🟢 | 🟢 | 🟡 | 🟢 | 🟡 | 🟢 | $$$$ |
| **Option 5** – protective structure moved landward by 10m | 🟡 | 🟢 | 🟢 | 🟡 | 🟡 | 🟢 | $$$ |
| **Option 6** – protective structure moved landward by up to 30m | 🟡 | 🟢 | 🟢 | 🔴 | 🟡 | 🟢 | $$$$ |
| **Option 7** – existing structure upgraded | 🟢 | 🟡 | 🟡 | 🟡 | 🟢 | 🟢 | $$ |

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