Main Beach Shoreline Project

Baseline Understanding Report

Findings of a baseline and literature assessment on the coastal protection structure at Main Beach, Byron Bay

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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 **Baseline Understanding Report** presents the findings of a baseline and literature assessment undertaken in relation to the coastal protection structure at Main Beach, Byron Bay (also known as the Jonson Street Protection Works or JSPW). The report presents understanding of the existing situation including values, opportunities and constraints that need to be considered during the design investigation for the modification of the structure.

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Disclaimer

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INTRODUCTION

General

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, significant public benefit will be gained through improved coastal protection of the town centre, enhancing recreational amenity, improving public safety, improving public access and use of the foreshore and beach.

Community input into the project will be important to ensure how the community use and value the foreshore and their expectations for how foreshore erosion should be managed are incorporated into the design process.

The problem

The existing coastal protection works between the First Sun Holiday Park and the Byron Bay SLSC, were constructed to protect the town centre from the threat of coastal erosion (Figure *1*). The main rock rubble structures were first constructed in the early 1960's 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.

Several investigations into the modification of the JSPW have been undertaken to date. A concept design for the upgrade of the JSPW is presented in WorleyParsons (2014). However, a Council meeting (22 February 2018; Res 18-104) resolved that further modification options shall be canvassed, evaluated and costed. The investigations of further options shall reconsider the available options, undertake a contemporary assessment of the options that considers a range of criteria and refine a preferred concept design that as best as possible meets the project objectives in consultation with the community.

Project objectives

At a meeting held on the 13th December 2018, the following objectives for the MBSP were resolved 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 current and future coastal hazards.
3. To reduce the adverse impacts on coastal processes (e.g. down-drift effects) through reduction of the project footprint.
4. To improve the structural integrity and public safety of the JSPW.
5. To improve public safety around the JSPW.
6. To enhance recreational amenity of the foreshore around the JSPW.

Project outline

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

- Phase 1 – Baseline understanding and review; Report #1 - Baseline Assessment (this Report)
- Phase 2 – Development of concept design options; Memo and Report #2 - Options Development Report;
- Phase 3 – Detailed assessments of design options; Report #3 – Options Assessment Report; and
- Phase 4 – Evaluation of determination of a preferred option; Report #4 – Evaluation Report

This report outlines the present understanding of the existing situation including values, opportunities and constraints that will be considered during the design investigation for the modification of the JSPW.

Project quality assurance / peer-review group

All deliverables produced as part of this project are reviewed by Council and the Department of Planning, Industry and Environment (DPIE). Council has also formed an industry professional peer review group. The group will meet at certain times during the project to discuss and review the key project deliverables.

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

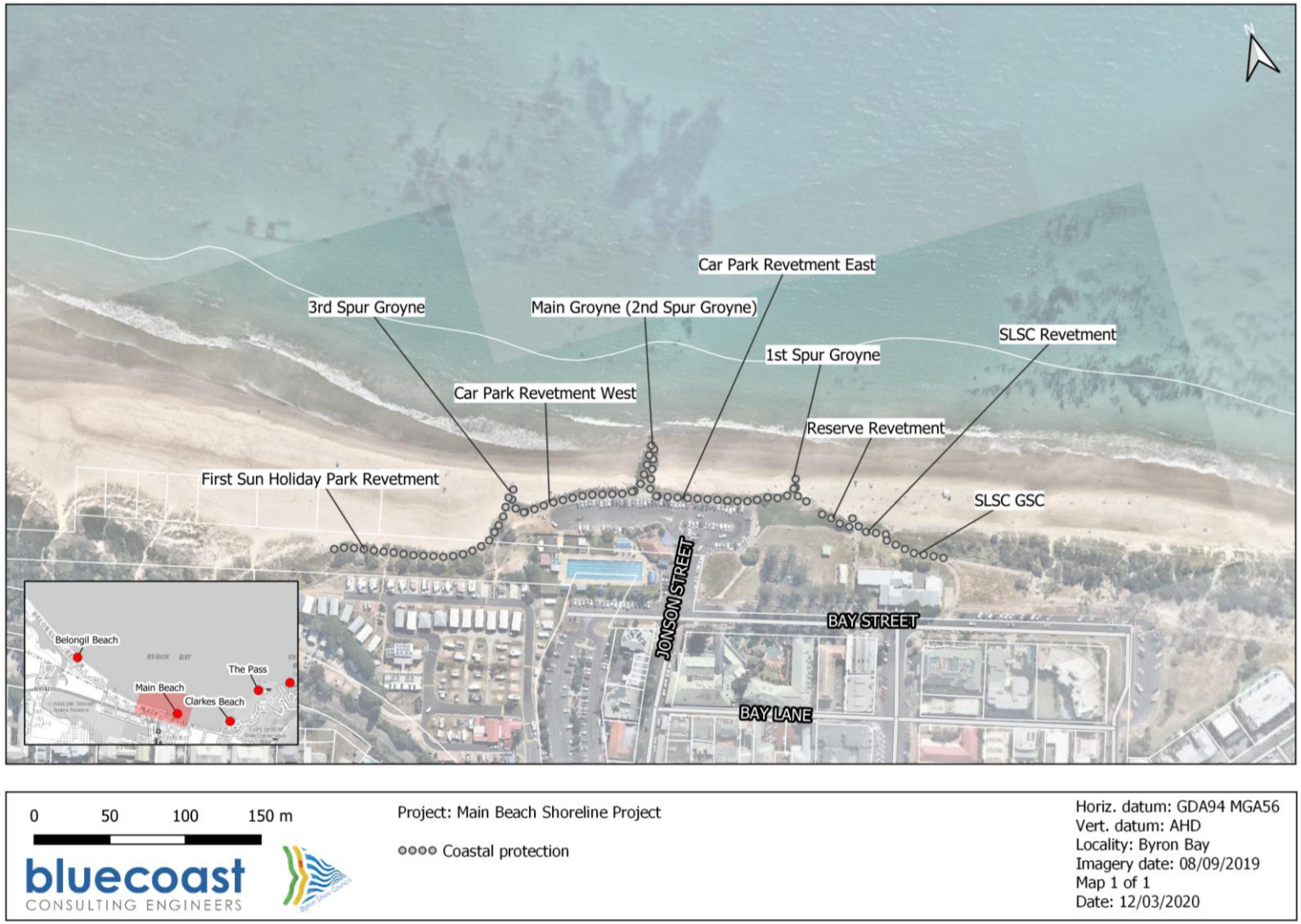


Figure 1: Map showing localities and coastal structure locations.

EXISTING SITUATION

Existing works

History of Jonson Street Protection Works

A history of the development and key events that have transpired in the area of the Jonson Street Protection Works in the last 150 years is provided in this section. A focus is laid on anthropogenic modifications and events that potentially impacted on Byron Bay's shoreline. The dates and information have been informed by various sources of information including PWD (1978), WorleyParsons (2014), Council's website, interview transcripts, historical photographs, the Byron Bay Historical Society (Donald Maughan, pers. comm.) and other sources. The location and historic sequencing of the JSPW and neighbouring coastal structures (since 1964) is shown in Figure 17. A brief historic timeline of key events is also shown in Figure 17 while a more detailed description is provided below:

1870s Discovery of gold in Byron Bay's beach sand and commencement of sand mining.

1888 The Public Works Department (PWD) built a 402-metre-long timber jetty extending from Jonson Street. The jetty had timber wing walls that protected the jetty's landside approaches. 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.

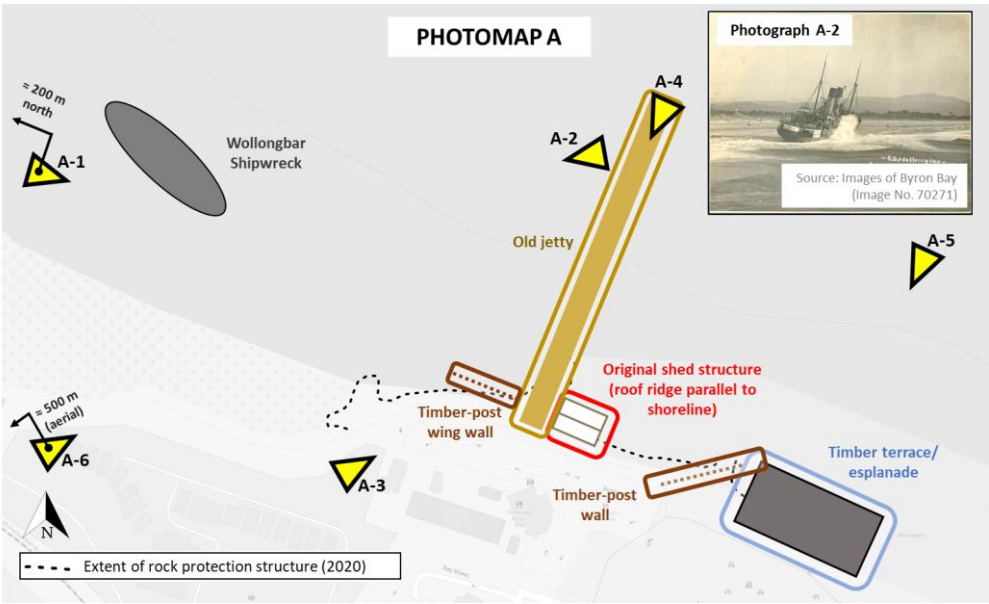
Figure 2: Jetties at Byron Bay: (top) first jetty in 1888 (middle) photograph from 1920s showing first jetty ('Old Jetty'*) and (bottom) view of second jetty ('New Jetty') with remains of first jetty in the foreground (source: Images of Byron Bay).*

1899 Lenore Coltheart's PWD history book "Between Wind and Water" describes: *"The wing walls protecting the approach to the jetty were extended with stone in 1899 to avoid the problem of subsidence in the approaches after heavy seas"* which suggests that beach erosion at the shore connection of the jetty occurred during storm events and rock protection was subsequently added to extend the shore-parallel timber wing walls. The western timber wing wall was built along the same alignment of today's rock protection works and is clearly visible in Figure 2 and Figure 3.

1919 A timber esplanade/ terrace structure was constructed, extending along the beach front from Jonson Street to Fletcher Street. According to newspaper clippings, the wall was built to a height of 6 feet to form the seaward edge of the 'terrace' and a large number of timber piles were driven to form a seawall ('Know What I Miss About Byron Bay?' Facebook Page). The space behind the seawall was filled in and levelled outward from Bay Street to form the esplanade. Today, remnants of the timber piles (cut at low beach level) just east of the current structure are irregularly exposed during erosion events (see Figure 7, Figure 10 and Figure 16).

1921 The 'SS Wollongbar' was driven up on the beach just to the north of Jonson Street during a storm. According to a newspaper article from 1923, there was considerable build-up of sand on the southern side of the wreck.

1923 By 1923 sand was found to encroach on the esplanade structure that had been constructed at the high-water line several years earlier. The newspaper article in 1923 documents the shoreline being "chains" (i.e., a chain equals approx. 20m length) further seaward of the structure than during its construction in 1919 due to sand accumulation in this area.



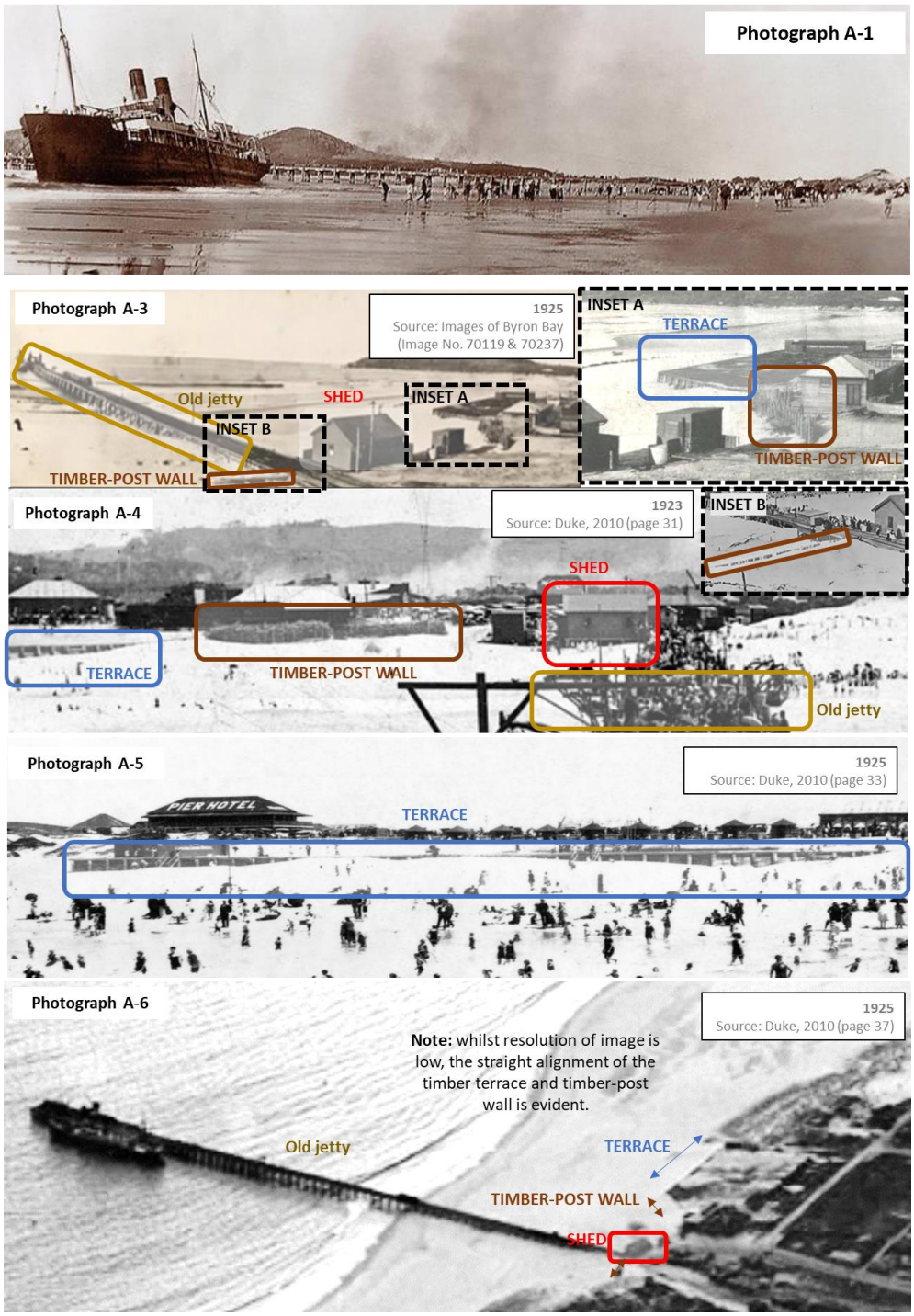


Figure 3: Photomap A and associated photographs showing the structures that existed in the period preceding 1921.

<u>Note:</u> it can be seen from photographs A-4 and A-5 that the piles of the seawall along the seaward edge of the timber terrace are spaced at approximately 2-3 metres. The timber-post wall comprises tightly spaced posts.

1930's Re-commencement of sand mining to extract zircon and rutile undertaken by Zircon Rutile Ltd.

Figure 4: Sand mining for mineral extraction at Main Beach (source: imagesofbyronbay.com.au).

1933-1936 Period of extensive beach erosion. This is evident in subsequent photos of the old jetty. The old jetty was also progressively destroyed/ dismantled over the period of the 1930's.

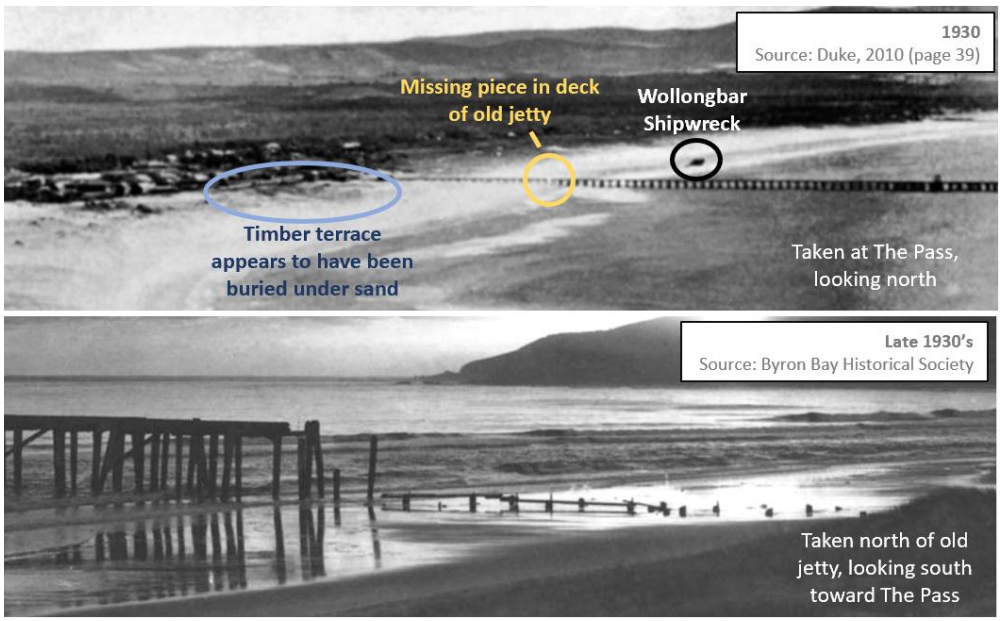


Figure 5: Photographs showing progressive damage/ dismantling of the old jetty, also providing some indication of the beach erosion that occurred during 1930's when considered in succession.

1945 *Tassie III* washed up and sank adjacent to the old Jetty during a storm.

1946 A wide beach fronts the original Byron Bay Surf Life Saving Club building.

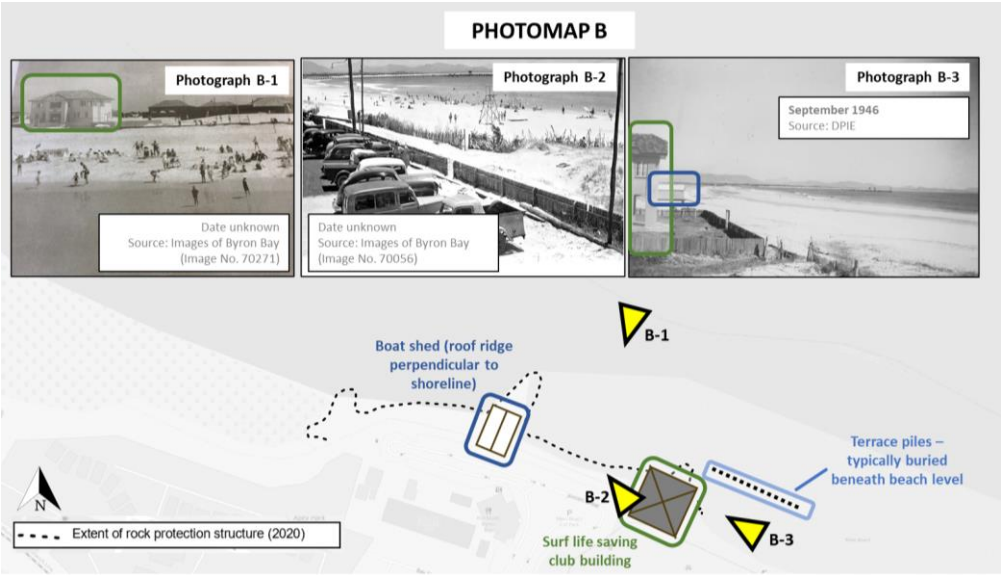


Figure 6: Photomap B and associated photographs showing the structures that existed in the period preceding 1946.
<u>Note:</u> Photographs B-1 and B-2 do not have a date but are inferred to have been taken in the same period (up to 1946*) based on the structures in place (fences etc.) and condition of the beach at the time. Note also that the new 'boat shed' has a roof ridgeline that runs perpendicular to the shoreline (the previous shed had a ridge that ran parallel with the shoreline).*

1955-1956 Period of extensive beach erosion, including a February 1954 tropical cyclone that swept away the outer section of the jetty taking with it all 26 vessels comprising the Byron Bay fishing fleet. The sea broke through and flooded parts of Byron town.

1960 Construction of Brunswick River entrance training walls approximately thirteen kilometres to the north of Jonson Street.

1963 A newspaper article appears in *The Northern Star* on the 29 June 1963 and reports on around 400 feet (122 metres) of rock placed to provide temporary protection against heavy seas and erosion (see Figure 7). The temporary works were only expected to hold for six months to a year and the article discusses plans for implementing more permanent measures. Several photographs are available around this period which also show the terrace piles to the south of the surf life saving club which had become exposed because of the erosion.

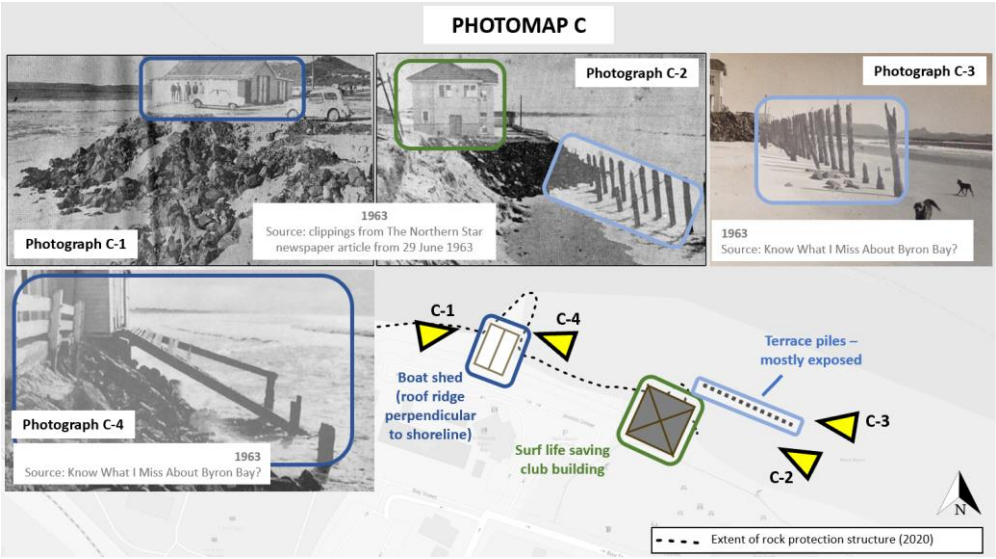


Figure 7: Photomap C and associated photographs showing the structures that existed in the period surrounding 1963.

<u>Note:</u>

- *Photos show placed rock protecting the club's boat shed (western end) and the club house (eastern end). The distance between these two buildings is estimated as approximate 300 feet (91 metres). The photos show erosion at both ends of the rock protection measures.*
- *As seen in C-3, the terrace seawall comprises two rows of the timber piles with a tie-back system that would have been installed during the construction of the terrace in the early 1920's.*

1964

In January 1964, severe tropical cyclone Audrey tracked from the Gulf of Carpentaria overland to cross the coast at Coffs Harbour. The storm caused significant erosion and damage to the foreshore in front of Jonson Street.

Drawings titled *Repairs to cyclone damage to The Esplanade, Byron Bay*, dated 25th March 1964 show the first engineering designs of what later became known as the JSPW. The 1964 drawings show a 900-feet long (274 metres) rock revetment along the alignment of the previous temporary rock protection works and terrace timber seawall. The drawings show that the rock protection works extend from west of the former surf club boat shed and continuing east past the former Byron Bay SLSC (labelled 'Surf Club') to the site of the present day SLSC at Fletcher Street. However, an aerial photograph captured in 1966 (see Figure 8) suggests that the as-constructed rock protection works terminated just east of the former SLSC, which is approximately 250 feet (76m) shorter than shown on the 1964 design. This shorter extent is also shown as existing works on the 1974 'upgrade' drawings presented in Figure 11.

Typical sections show the revetment slopes as 1V:1 ¾H armoured with 4 feet (1.2 metres) of basalt armour rock weighing from 0.1 to 1 tonne. The typical section between structure chainage 250-650 feet (top left in Figure 8) indicate the works

are to be a repair of the existing wall, reusing the existing rock as the armour underlayer with no thickness nominated on the drawings. The existing wall was to be extended on either end, the typical section for structure chainages 0-250 and 650-900 (top right in Figure 8) showing the eroded areas to be filled and compacted before placing three feet (0.9 metres) of quarry run overlaid by armour rock.

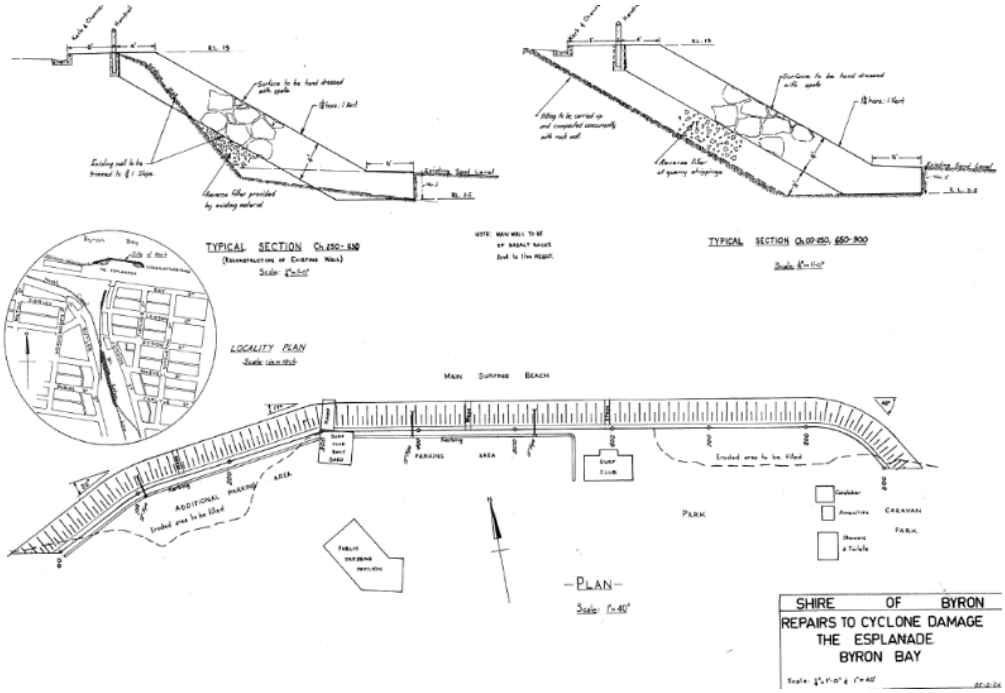


Figure 8: (top) 1964 designs for repairs and extension of the JSPW (WorleyParsons, 2014) and (bottom) 1966 aerial photograph of the constructed rock protection works (source: NSW Government).

1969 The Memorial Pool was constructed at Byron Bay adjacent to the public dressing pavilion, now Fishheads Restaurant.

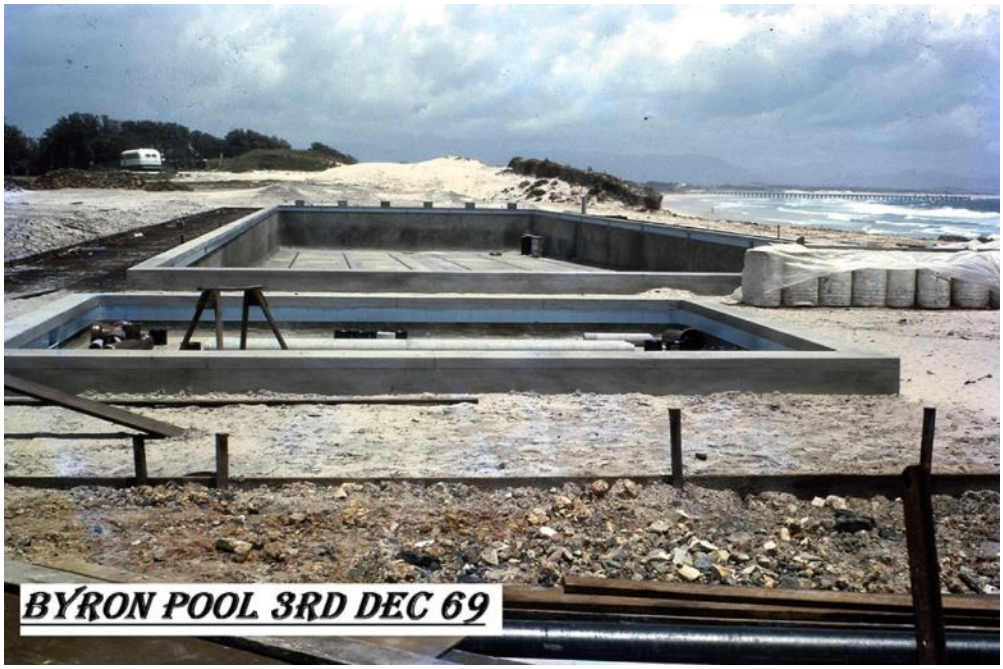


Figure 9: Memorial Pool under construction in 1969 (source: imagesofbyronbay.com.au).

1967-1974 Between 1967 and 1974 seven tropical cyclones impacted NSW (BoM, 2019). These were: Dinah (1967), Barbara (1967), Glenda (1967), Daisy (1972), Wanda (January 1974), Pam (February 1974) and Zoe (March 1974). Large waves and beach erosion claimed houses, roads and public infrastructure. The series of three cyclones in 1974, the most severe being TC Pam in February, caused significant erosion to the dunal system downdrift of the JSPW at Belongil Beach and damage to roads, the JSPW and the surf club.

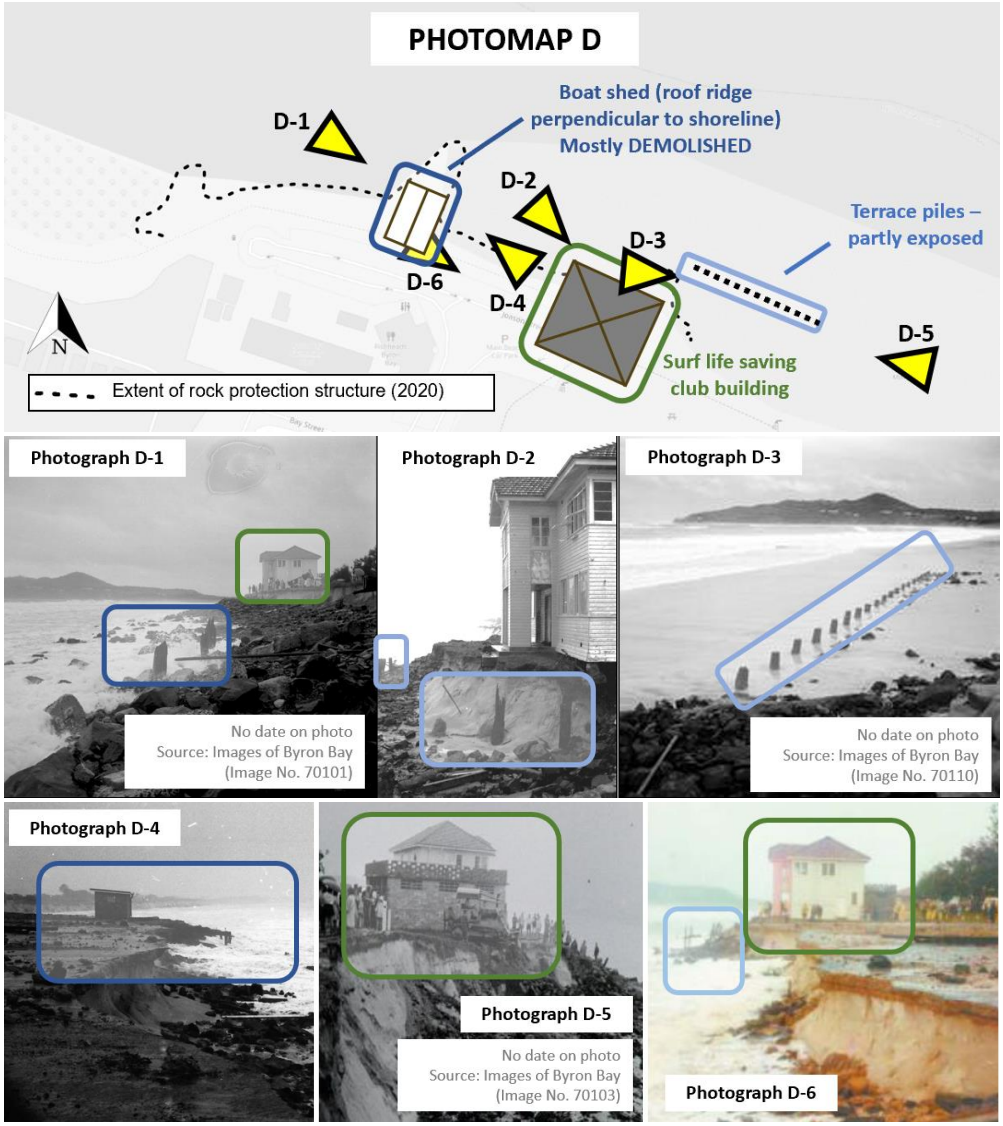


Figure 10: Photomap D and associated photographs showing erosion and damage to JSPW as a result of tropical cyclones between 1967 and 1974.
<u>Note</u>: the protruding piles visible in Photographs D-1 and D-4 are the piles associated with the boat ramp that protruded from the boat shed (see Photograph C-4 in Figure 7).

1970's Mineral extraction became almost non-existent on Byron Bay's beaches.

1975 The JSPW were upgraded with the construction of three groynes and restoration of sections of the pre-existing rock revetment at flatter slopes of 1V:3H along the seaward perimeter of the car park.

Drawings titled *Erosion Protection and Beach Restoration Works, Main Beach Byron Bay*, drawing no. 75-9, show the upgrade included a westward (downdrift) extension of the pre-existing revetment with an approximately 90m of 'heavy' rock revetment and 50m of 'light' rock revetment. The revetment had a design crest level of three metres above the Australian Height Datum (AHD). The main central groyne is shown to extend some 50 metres from the crest of the seawall. A "terra

firma" fabric underlay appears on the drawings. Inclusion of this fabric is likely to have been an important element in stopping the loss of finer material from behind the rock revetment, which may have been one cause of the previous failures.

The drawings indicate that the rock previously placed at a 1V:1 ¾H slope had eroded and/or slumped to form an apron at an approximate 1:10 gradient. The new 'heavier' rock was placed onto this apron to restore the upper sections of the revetment (i.e., the remedial rock was founded on the failed existing rock). This rock apron is often buried. However, review of aerial photography when the beach levels in front the JSPW are low indicate this rock apron is still present and should be considered in any future modification design.

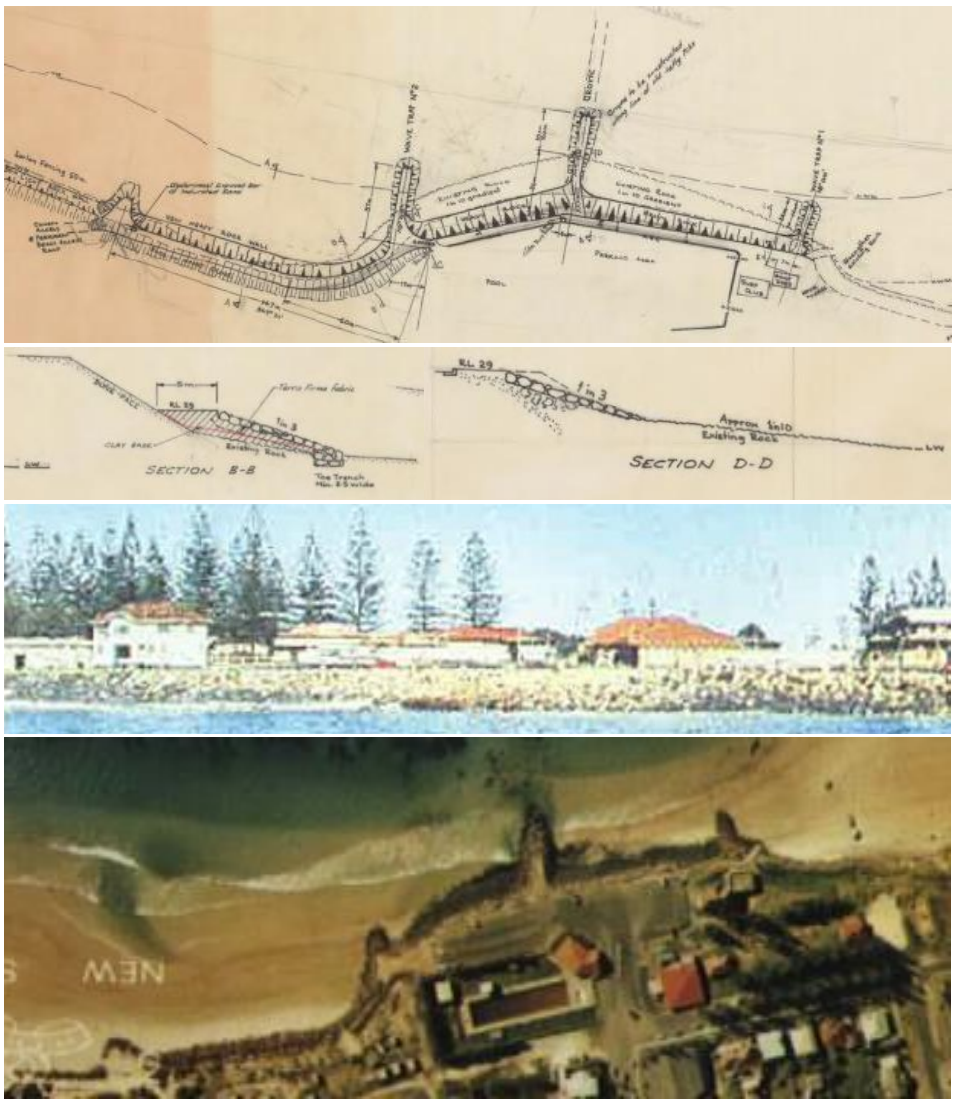


Figure 11: 1975 design of the JSPW upgrade and post-construction photographs (source: BSC; PWD, 1978).

<u>Note:</u> The photograph of the works viewed from the water appears to show newer 'heavy' rock (lighter colour) placed on the upper slope above the pre-existing rock (darker colour). The older rock apron can also be clearly seen in the aerial photograph.

1977 A series of seawalls between the FJ Walker's Meatworks and Manfred Street were constructed in front of properties on Belongil Spit.

1984 Esplanade Road on Belongil Beach lost to the sea due to erosion.

1990's Emergency protection works at Cavanbah Beach comprising of two rows of boulders (median diameter between 500 and 1,000mm) laid at the toe of the embankment at First Sun Holiday Park (3m AHD crest level). Further interim and private protection structures constructed between Border Street and north of Manfred Street, Belongil using geotextile and rock materials.

1996 *Extensive erosion due to East Coast Low.*

Figure 12: Erosion at Belongil Beach in May 1996 (source: BSC).

1999 Extensive erosion from storms and a large swell event.

Figure 13: Photographs showing erosion (left) downdrift and (right) updrift of the JSPW in May 1999 (source: Peter Helman).

2001 Extensive erosion due to East Coast Low.

2002 An interim single-layer geotextile container revetment was constructed by BSC at the Byron SLSC. The structure was built with slopes of 1V:2H and a crest level of 3m AHD. Also constructed by BSC at this time were interim works (geotextile container revetments) at Border St, Don St and Manfred St beach access ways, Belongil Beach.

Figure 14: Photograph showing the construction of the interim geotextile revetment in front of the SLSC in 2002 (source: BSC).

2009 A large East Coast Low arrived at the coast in May 2009 with maximum significant wave heights of 7.4 metres and significant wave heights over 4 metres for four days causing extensive erosion.

2009 BSC reconstruction of interim geotextile container revetment at Border St, Don St and Manfred Street, Belongil (due to large May 2009 storm event).

2013 Tropical cyclone Oswald and successive storms caused extensive erosion.

2015 Replacement of Manfred Street geotextile container revetment with interim rock wall.

2019 Severe erosion at Clarkes Beach in July 2019 caused damage to Reflections Holiday Park and exposure of coffee rock. Emergency protection works were constructed by Reflections immediately at the erosion scarp comprising of single-layer geotextile bags, 4 courses high with slopes of approximately 1V:3H and a crest level of 3m AHD.

Figure 15: Erosion at Clarkes Beach in July 2019 (source: Bluecoast).

2020 Exposure of historic terrace timber piles east of the rock protection works following storm event resulting in low beach levels. Widespread erosion occurred along Clarkes Beach and Main Beach.

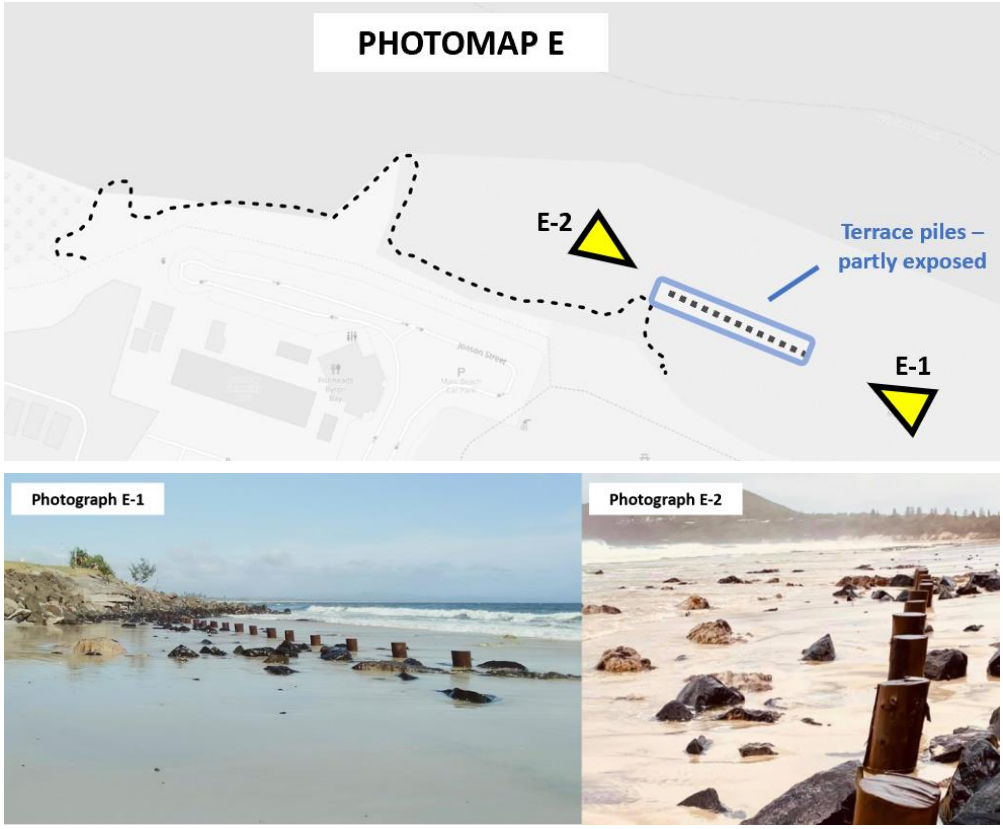


Figure 16: Photomap E – Recent exposure of timber terrace piles following storm event in December 2020.
<u>Note</u>: Timber piles are cut at low beach levels, with the most recent exposure anecdotally understood to be in the 90's.

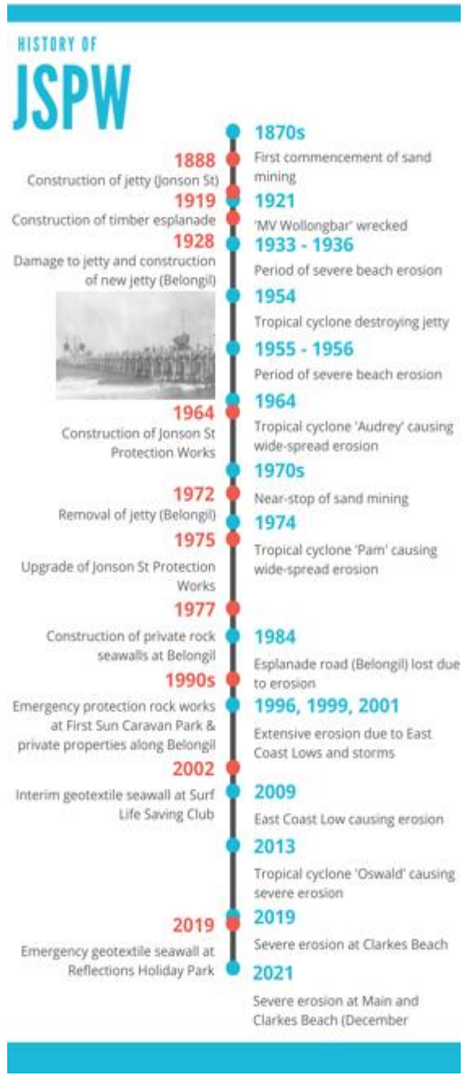


Figure 17: Location and history of the Jonson Street Protection Works (JSPW).

Condition assessment

The visual and drone-based inspection of the JSPW works were undertaken on the 28th October 2019 and used to rate the structural, safety and functional conditions of the JSPW. Overall, the structure condition was rated as **fair** to **poor** and it was found that the structure does not meet contemporary design standards. The most seaward parts of the structure were in the worst conditions. WorleyParsons's (2013) risk assessment used calculations to determine that excessive damage to the structure would be expected during a storm event exceeding 1 to 10-year ARI conditions. Figure 18 presents the overall structural condition rating spatially. All condition assessment results are available via an online database and further details are provided in the Condition Assessment – Technical Report (Bluecoast, 2020a), available on the Council MBSP project webpage under Related Information.

Figure 18: Structural condition rating for JSPW based on visual and drone inspection on 28th October 2019.

Based on the condition assessment, some key considerations to inform the development of redesign options include:

- overall, the armour rock quality was fair but there were isolated areas of poor-quality armour rock with significant degradation;
- in addition to the deterioration of the structure, it is evident that the original construction does not meet contemporary standards for rock revetments;
- various formal and informal accessways have been created over the structure, degrading its function (increased wave run-up risk) and compromising the integrity of the armour layer;

- visual inspection of the structure confirms, as suggested by the construction history, that rock has been progressively added to the JSPW. More recent and larger armour rock on the upper slopes was observed to overlay a darker and much smaller rock. Due to the sand level at the time of the inspection, the toe of the structure was not visible. However, it is suspected that the small darker rock originates from the 1960's revetment construction and now forms a mild sloping rock apron.
- the large total quantity of rock that forms these works needs to be considered in the modification designs, particularly any designs involving landward realignment. It is recommended that:
    i. estimates of the total quantity of the rock in the structure be developed based on, in the first instance, historical photo records; and
    ii. additional inspection be undertaken at the end of summer or after an erosion event when beach levels are lower and more of the structure is exposed; and
    iii. invasive (e.g. peel-back or test pits) and/or non-invasive (e.g. ground penetrating radar or other geophysical methods) investigations be undertaken prior to detailed design where the design incorporates changes to the structure.

Planning framework

Coastal management

The coastal management framework in NSW comprises the following elements:

- the *Coastal Management Act 2016* (the CM Act)
- the State Environmental Planning Policy (Coastal Management) 2018 (CM SEPP) and
- the NSW Coastal Management Manual (OEH, 2018).

The coastal management framework has been established to manage the coastal environment (including beaches and estuaries) in an ecologically sustainable way for the well-being of the NSW community. Council is presently preparing a Coastal Management Program (CMP) for the open coast between Cape Byron and the Shire's northern boundary near South Golden Beach. This portion of coastline experiences the most complex and challenging management issues of the Shire, and therefore a CMP for this area has been prioritised for immediate commencement (BMT WBM 2020). The purpose of the CMP will be to set the long-term strategy for the management of the coastal zone, addressing priority open coast management issues and actions to address the issues, with a focus on achieving the objectives of the CM Act.

Objectives of the CM Act, being:

a) to protect and enhance natural coastal processes and coastal environmental values including natural character, scenic value, biological diversity and ecosystem integrity and resilience, and

b) to support the social and cultural values of the coastal zone and maintain public access, amenity, use and safety, and

c) to acknowledge Aboriginal peoples' (Bundjalung of Byron Bay – Arakwal Bumberlin people) spiritual, social, customary and economic use of the coastal zone, and

d) to recognise the coastal zone as a vital economic zone and to support sustainable coastal economies, and

e) to facilitate ecologically sustainable development in the coastal zone and promote sustainable land use planning decision-making, and

f) to mitigate current and future risks from coastal hazards, taking into account the effects of climate change, and

g) to recognise that the local and regional scale effects of coastal processes, and the inherently ambulatory and dynamic nature of the shoreline, may result in the loss of coastal land to the sea (including estuaries and other arms of the sea), and to manage coastal use and development accordingly, and

h) to promote integrated and co-ordinated coastal planning, management and reporting, and

i) to encourage and promote plans and strategies to improve the resilience of coastal assets to the impacts of an uncertain climate future including impacts of extreme storm events, and

j) to ensure co-ordination of the policies and activities of government and public authorities relating to the coastal zone and to facilitate the proper integration of their management activities, and

k) to support public participation in coastal management and planning and greater public awareness, education and understanding of coastal processes and management actions, and

l) to facilitate the identification of land in the coastal zone for acquisition by public or local authorities in order to promote the protection, enhancement, maintenance and restoration of the environment of the coastal zone, and

m) to support the objects of the Marine Estate Management Act 2014.

Over the preceding years Council has prepared coastal (zone) management plans, however to date no plan has been approved or certified by the Minister. Despite these attempts to formulate an approved plan, Council has implemented strategies to manage the main management issues of the Byron coastline, being coastal hazards. The retention of the JSPW at Main Beach has been a priority

management strategy for Council who have consistently resolved over the preceding years to protect the Byron Bay Town Centre. This design investigation is considered within the processes involved in preparation of the CMP and is part of the overall CMP preparation. The outcomes of the MBSP will be incorporated into the CMP as it progresses. The MBSP is acknowledged in the Stage 1 (Scoping Study) for the (Northern Shire) Cape Byron to South Golden Beach CMP as a study for continuation in Stage 2. The outcomes of the MBSP investigation need to be fully synchronised and incorporated within the overall CMP preparation, hence the evaluation and selection of the preferred modification design should be completed in Stage 3 of the CMP development (CMP Stage 3 – 'Identify and evaluate options'). This provides a holistic and embayment wide approach to coastal management.

Progression of the MBSP into the construction stage of the project is currently dependent on ministerial certification of the CMP. The state government Coastal and Estuary Grants Programs requires a certified CMP in order to fund implementation projects (i.e. construction works). However, alternative funding opportunities may arise, particularly in the event that the works are urgently required prior to a certified CMP and a successful application to the NSW Coastal and Estuary Grant Program being available

Land ownership and management arrangements

The following paragraphs describe the land tenures and the applicable management plans and policies across the JSPW and adjacent areas. Their implications on the proposed JSPW modifications are discussed.

The coastal area of the JSPW falls within a Coastal Land Zone No 7 (f1) under the Byron Local Environmental Plan (1988). The Byron Local Environmental Plan states for development within Zone 7f(1):

- *"The Council, in deciding whether to grant consent to development referred to in subclause (2), shall take into consideration:*
    - *the likelihood of the proposed development adversely affecting, or being adversely affected by, coastal processes,*
    - *the likelihood of the proposed development adversely affecting any dune or beach of the shoreline or foreshore,*
    - *the likelihood of the proposed development adversely affecting the landscape, scenic or environmental quality of the locality of the land, and*
    - *whether adequate safeguards and rehabilitation measures have been, or will be, made to protect the environment."*

Cape Byron State Conservation Area (SCA)

The Cape Byron SCA covers an area of 98.5 hectares extending eastward of Clarkes Beach including the Cape Byron lighthouse. The SCA extends down to the low water mark and forms part of the

NSW National Parks and Wildlife Estate. The Reserve is managed by the Cape Byron Trust and the National Parks and Wildlife Service. The Trust comprises community representatives, local and state government and the Bundjalung of Byron Bay Aboriginal Corporation (Arakwal). The management arrangements are documented in the *Cape Byron Headland Reserve Plan of Management*.

The JSPW are located approximately one kilometre to the west of the SCA boundary at Clarkes Beach. Therefore, no direct impact on the SCA of the JSPW modification is expected.

Cape Byron Marine Park

Cape Byron Marine Park extends from the mean high water mark (MHWM) seaward to the three nautical mile limit of NSW waters from Brunswick Heads to Lennox Head including tidal lands and waters surrounding the JSPW. The marine park is managed in accordance with the provisions of the *Marine Estate Management Act 2014* and its Regulations and management strategies and actions identified in the Cape Byron Marine Park Operational Plan (Marine Parks Authority, 2010).

Tidal lands and tidal waters surrounding the JSPW are within the Belongil Beach, Main Beach and Clarkes Beach Habitat Protection zone while waters in this area which are greater than 100m seaward of the MHWM, are within the Byron Bay Sanctuary Zone. Any development within the Marine Park requires approval under Marine Estate Management legislation.

Crown Land

Crown Land is owned by the State and is managed by the Department of Planning, Industry and Environment (DPIE–Crown Lands) under the *Crown Land Management Act 2016*, commenced in July 2018. The new Act significantly reforms the use and management of Crown Land in NSW. The former structure of reserves, reserve trusts and reserve trust managers has been replaced with a single manager responsible for each reserve. The Crown reserves are owned by the State but generally are managed by DPIE-Crown Lands, Council or NSW Crown Holiday Parks Land Manager t/a Reflections.

The Crown reserves that lie within and adjacent the study area are outlined below:

- Council Managed Crown Land
    - Much of the foreshore area between Main Beach and Clarkes Beach (Reserve 82000), including the location of the JSPW, is classified as 'Crown Land managed by Council' for public recreation. The area (allocated by aqua shading in Figure 17) is managed by Byron Shire Council with a Plan of Management due to be completed by June 2021. *The Crown Lands Management Act 2016* applies which requires the areas to be managed as Community Land while the Crown remains the landowner.
- NSW Crown Holiday Parks Land Manager (trading as Reflections Holiday Park)
    - There is one 'Reflections Holiday Park' located east of the JSPW at Clarkes Beach within a Crown Reserve managed under the *Clarkes Beach Holiday Park Plan of Management (2009).* The area is gazetted for tourist facilities and services as well as for the preservation of native flora and public recreation.

Byron Shire Council 'community land'

Several areas of 'community land' exist in the wider study area which are managed in accordance with the *Local Government Act 1993*. This includes the area south of the Memorial Pool, i.e. Lawson Street North Car Park. This land is set aside for community use and development and use of this land is subject to strict controls set out in the Act.

Some of the 'community land' is classified as 'natural areas' and is managed in accordance with the *Generic Plan of Management for Community Land Categorised as a Natural Area (Byron Shire Council, 2015, #DM599743).* Strict conservation and regeneration objectives apply to these areas.

Byron Shire Council 'operational land'

Areas classified as 'operational land' is land that serves a commercial or operational function, or land that is being retained for commercial or strategic reasons. Around the JSPW, the area including the First Sun Holiday Park and part of the Memorial Pool are classified as 'operational land'. The range of controls that apply to 'community land' do not apply to the use and management of 'operational land'.

Figure 19: Land ownership and management arrangements for the broader area (source: BSC, 2018).Note: The area where the JSPW sits is Crown Land managed by Byron Shire Council.

Indigenous land

Several applications for a Native Title Claim within Byron Shire have been lodged over Crown Land including beaches and coastal waters. The Native Title Claims lodged under the *Aboriginal Land Rights Act 1983 (NSW)* must be considered when actions are proposed on Crown land and any works must comply with the *Native Title Act 1993*.

A Head of Agreement was established in 1998 providing a formal relationship between Native Title Claimants and the Byron Shire Council. The Aboriginal Consultative Committee needs to be consulted for the management and protection of culturally significant places with the study area.

Since 2001, three voluntary Indigenous Land Use Agreements (ILUA) have been registered and apply for the area between Broken Head and Belongil Beach by the Bundjalung People of Byron Bay (Arakwal) People who are recognised as the Traditional Owners of the area. The majority of the footprint of the JSPW lie within land that are deemed 'Surrendered Lands' under this agreement. The western area of the JSPW that lies in front of the First Sun Holiday Park, lies within land where Native Title has been extinguished.

The majority of the JSPW fall within the registered ILUA2 area for Crown Reserve land between the SCA and Tyagarah Nature Reserve (including beach areas and Main Beach car park).

Figure 20: Indigenous Land Use Agreements wihtin the study area (source: BSC, 2020).

Opportunities and constraints

Based on a review of existing information, the opportunities and constraints to be considered in the design investigations have been identified. The following key resources were reviewed:

- Byron Coastline Values Study (BSC, 2000);
- Draft Coastal Zone Management Plan for the Eastern Precincts Byron Bay Embayment (BSC, 2018);
- Draft Coastal Management Program Scoping Study Cape Byron to South Golden Beach (BMT WBM 2020, in prep);

- Byron Bay coastal processes, hazard definition and coastal management studies (e.g. WRL, 2016; BMT WBM, 2013; BMT WBM, 2010; WBM 2000, 2004; PBP, 2006; PWD, 1978);
- Byron Bay Town Centre Masterplan (McGregor Coxall, 2016);
- Byron Shire Council Geographical Information System (GIS) data (e.g. land tenure, cadastre and boundaries);
- Department of Industry website;
- Arakwal People of Byron Bay website; and
- Site observations.

Economic values

A Byron Bay tourism study undertaken by .ID (2018) shows that in 2016/17, tourism and hospitality generated 23 per cent of Byron's jobs (3,500 jobs) and 14 per cent of output/sales ($463M). The flow on impacts of direct tourism and hospitality activities were estimated as 1,600 jobs and $193M in output. The study showed that Byron's accommodation industry is estimated to generate almost $100M each year. Further studies were undertaken by WRL (2016) and BMT WBM (2019) which highlight the importance of the coastal zone (nearshore waters, beaches and foreshores) as a destination driver for tourism. WRL (2016) estimated that beach related tourism expenditure is over $115M annually by assuming that 50 per cent of daily tourism expenditure is spent on beach related activities.

The Byron Bay Masterplan developed an economic development strategy based on the findings of community engagement activities (McGregor Coxall, 2018). The strategy identified some key sites for economic development opportunities including the caravan park site and Sandhill Estate. These sites are neighbouring the JSPW highlighting the need for appropriate land use diversity and recognition of economic value.

Economic revenues for 2018/19* associated with key sites are outlined below:

- Byron Bay Pool $111,977 (note - this does not include the revenue from lease of the Byron Bay Pool Café (Fisheads))
- First Sun Holiday Park $3,622,037
- Pay parking on Crown Reserve $1,093,900

Total revenues from these areas are $4,827,914.

**Revenue information for 2018/19 used as the latest full normal year. Due to COVID19 revenue for 2019/20 is not reflective of normal circumstances.*

Community and cultural values

Results from community engagement activities during the preparation of the Coastal Zone Management Plan are presented in WRL's 2016 report as well as the Byron Bay Masterplan (McGregor Coxall, 2018). The following key community values were highlighted:

- recognition of the history and community support for the Memorial Pool facility;
- recognition of the importance of the car park area as a meeting place for locals and a place to check the surf;
- redevelopment and upgrade of the Surf Life Saving Club into a modern facility and the foreshore to create a more visually appealing space, pedestrian paths/boardwalk to form an east /west connection, amenities and recreational space; and
- sensitive integration of the foreshore and coastal protection works with recreation, nature and pedestrian movement.

These and several other community and cultural values relevant to Byron's coastal areas are described in the following sections. An overview of the key facilities, public amenity and infrastructure within the study area is shown in Figure 21.

Figure 21: Overview of facilities, public amenity and infrastructure within the MBSP study area

Cultural heritage

The Byron Shire coastline has a rich history and large range of cultural heritage values from Aboriginal sites to items of European heritage including shipwrecks and the most significant European cultural item being the Cape Byron Lighthouse (BSC, 2000).

The Bundjalung of Byron Bay – Arakwal Bumberlin people have lived in the coastal landscape around the Byron Bay area for at least 22,000 years. The Arakwal Country extends from Broken Head to the Brunswick River and Indigenous Land Use Agreements are in place with the NSW Government and have been since 2001 (see section above). The Arakwal Aboriginal Corporation is a prescribed body to represent the native titleholders and their rights.

A variety of Aboriginal cultural sites exist in the Byron Bay embayment that include pathways, middens, stone arrangement, stone resource sites, ceremonial sites and burials. Many Aboriginal cultural sites have already been destroyed by previous sand-mining, clearing for agriculture and development. Remaining cultural assets are at risk of loss due to coastal processes (e.g. Aboriginal midden at Clarkes Beach), development pressure, recreational activities and pedestrian/vehicle access (BMT WBM, 2019; BSC, 2000). No geographical location information of the abovementioned Aboriginal cultural sites was available for this study.
European heritage sites exist adjacent to the JSPW. Two shipwrecks remain adjacent to the JSPW, the SS Wollongbar, also known as 'The Wreck', lies immediately to the north of the car park and the Tassie III, sunk in 1945, is located approximately 100m off the beach in front of the JSPW. Both wrecks are popular snorkelling/ diving spots and The Wreck provides excellent surf amenity, as described in the following paragraphs. Two timber jetties existed along Main Beach and Belongil Beach. The original 1888 jetty was located at the main central groyne of the JSPW, while the second jetty was in front of Border Street, Belongil Beach. Today an information sign, as well as the anchor of the SS Wollongbar, are showcased at the public reserve behind Border Street and erosion has partially affected remains of the jetty (WorleyParsons, 2013).

Visual amenity and aspect

The visual amenity and landscape values associated with the Main Beach foreshore area are significant due to the 180 degree views of distinctive landforms and features. While standing at Main Beach, views east to the Cape and Lighthouse, one of the most prominent landscape elements of the Tweed-Byron-Ballina Coast (BSC, 2000), north to Julian Rocks and west to hinterland and Mt Warning (Wollumbin) exist.

The Byron Bay Masterplan (McGregor Coxall, 2018) reported views that are valued by the community included the JSPW foreshore area, as shown in Figure 22.

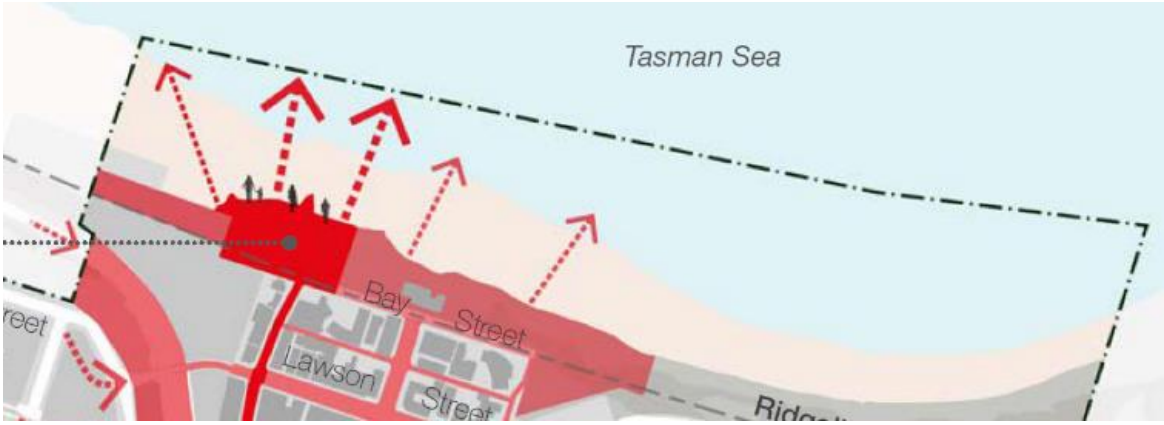


Figure 22: Views (red arrows) across key foreshore spaces at Byron Bay (McGregor Coxall, 2018).

The Masterplan also reported findings from community engagement activities and found that locals highly value the relationship of Byron Bay Town Centre to the natural foreshore setting. The community's main concerns were:

- *"improved management of open spaces;*
- *significant trees in the centre;*
- *retain natural connections to the foreshore and wetlands."*

Foreshore usage and connection

The Main Beach car park is used by the community to gain views of the surf breaks prior to parking and is very popular during sunset with spectacular views of the hinterland. Most evenings, members of the community and tourists gather on the car park and the JSPW to watch the sunset or practice performing art.

Direct access to the beach is provided at numerous formal and informal access ways for pedestrians, allowing passive reactional activities close to the convenience of town. Due to this close proximity to town the Main Beach foreshore area is the most heavily used coastal location within Byron Shire.

The Main Beach foreshore area provides open space but as identified in the Masterplan, the space is without any formal connection between the three main parks (Denning, Peace and Apex, see Figure 23). The Masterplan outlines a key initiative for Main Beach is to establish a continuous foreshore park, catering for large events, spaces for hanging out, picnics, passive and active recreation.

The area is also extremely well used and loved by national and international tourists/visitors. In 2019, 2.21 million people visited Byron Shire with numbers expected to grow by 50% to 75%. By 2030 it is expected that 3.86 million visitors will spend time in Byron Shire (BSC, Sustainable Visitation Strategy, 2020). It is unknown how many people frequent the foreshore area at Main Beach, but it is a prime meeting spot and hanging out spot for sunbaking on the beach, picnicking

on the grassed area with music/entertainment provided most weekends and holidays. The area is extremely important to locals, an integral location for the Byron community.

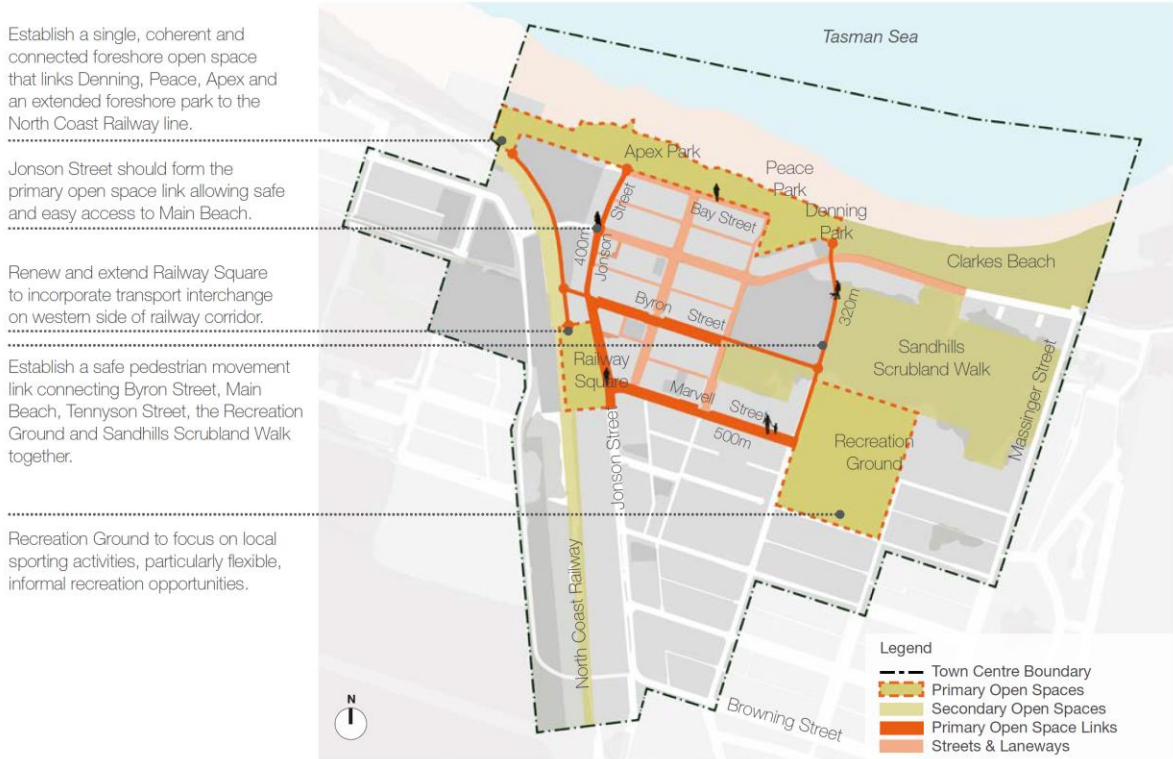


Figure 23: Masterplan recommendations of an 'Open Space Circuit' in the Byron Bay town centre and waterfront (McGregor Coxall, 2018).

Foreshore facilities

Main Beach car park has 95 parking spaces inclusive of five mobility spaces and a four-hour parking limit applies between 9am and 6pm (BSC, 2019). The water-front car park also serves as a surf-check and events space for the community (see previous sections).

Alternative parking spaces are at the below nearby car parks:

- Lawson Street north car park (135 parking spaces including three mobility spaces)
- Lawson Street south car park (74 parking spaces including one mobility space)
- Clarkes Beach car park (90 parking spaces including two mobility spaces)

In 1969, the Memorial Pool was built adjacent to the Main Beach car park. The facility includes a Pavilion incorporating a change room, Fishheads restaurant and fast food outlet.

The Byron Bay Surf Life Saving Club (SLSC), located immediately to the south of the JSPW, is the second oldest club north of Sydney and one of the oldest in Australia having been formed in 1907 (Surf Live Saving Australia, 2019). The club house is used by Surf Live Saving as a base and for

equipment storage and events. An event venue often used for weddings or other parties is in the southern part of the building.

Community engagement activities during the Masterplan study highlighted the coastal areas that are of importance to the community and that should be enhanced. These areas included the Main Beach car park and Memorial Pool as well as the parks and open spaces of the reserve, see Figure 23. The Surf Club was also listed by the community for potential enhancement and beautification. The engagement activities showed that the community has an interest in maintaining or enhancing the cultural offering of the Town Centre, including the foreshore areas.

Surfing and beach amenity

The beaches to the east and west of the JSPW are popular spots for beach goers and swimmers as well as surfers and other water sports, see Figure 24. Periodically, there is also a section of dry beach in front and/or overlying of the rock revetment of the JPSW. There are three beach access points at the southern side of the JSPW, two of which are maintained and suitable for pedestrians (none are compliant disabled access). Informal access to the northern beach is via a narrow track in front of the First Sun Holiday Park.

Beach showers and toilets are located atop the foreshore reserve. The beach to the south of the JSPW 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).

The Wreck (SS Wollongbar) produces consistent, quality waves for all levels of surfers. Both right-hand and left-hand breaking waves in low and high energy wave conditions are found here. Occasionally, during moderate to high wave energy conditions there are also good surfing conditions between The Wreck and the SLSC.

Figure 24: Surfing areas and popular beach access around the JSPW: (left) The Wreck and (right) Main Beach (source: OZBeaches).

Ecological values

The nearshores areas around the JSPW are located within the Cape Byron Marine Park. The areas seaward of the mean high water mark (MHWM) fall within a Habitat Protection Zone while an area

approximately 100 metres seaward of the MHWM to the three nautical mile limit falls within a Sanctuary Zone (see Figure 25). Sanctuary zones provide the highest level of protection for biodiversity and natural and cultural features while Habitat Protection zones protect physical and biological habitats by reducing high impact activities.

The Byron Bay Coastline Management Study (WBM, 2004) stressed that a range of ecological habitats and communities of high value are represented within the wider study area, including:

- ocean and foreshore (including both sandy and rocky shores);
- coastal dunes, littoral rainforest and heathlands; and
- estuaries which include mangroves, saltmarsh and seagrass beds.

The area of the JSPW is predominantly characterised by sandy floors with some shallow nearshore rocky reefs. The rock structures of the JSPW itself provide an artificial intertidal habitat. The nature of the JSPW rock revetment, with many interstitial spaces (or voids) between rocks, has the potential to attract vermin such as rats, whose presences attracts snakes.

An ecology assessment was undertaken by WorleyParsons (2013) including a qualitative marine habitat survey completed on 30 April 2012. The study reports that a number of marine turtles and threatened and protected shorebirds have the potential to occur along the sandy beach stretches east and west of the JSPW, including Belongil Creek. Sightings of loggerhead turtles, green turtles and hawksbill turtles in the Byron Bay area are registered on the Threatened Species Conservation Act online database (WorleyParsons, 2013). The habitat survey found a variety of sessile marine invertebrates including barnacles, limpets, siphon shells, gastropods, tube worms and marine algae including small patches of Ulva (sea lettuce) within the JSPW rock structures. Approximately 200 metres north-east of the JSPW, the shipwreck of the SS Wollongbar emerges from the seafloor and provides habitat to various aquatic species, e.g. see Figure 26.

The dune systems around the JSPW, particularly the undeveloped dunes provide habitat for fauna including invertebrates (e.g., worms, insects and crabs), reptiles (e.g. skinks, snakes and goannas), birds (e.g., shorebirds) and mammals (WorleyParsons, 2013 and DLWC, 2001).

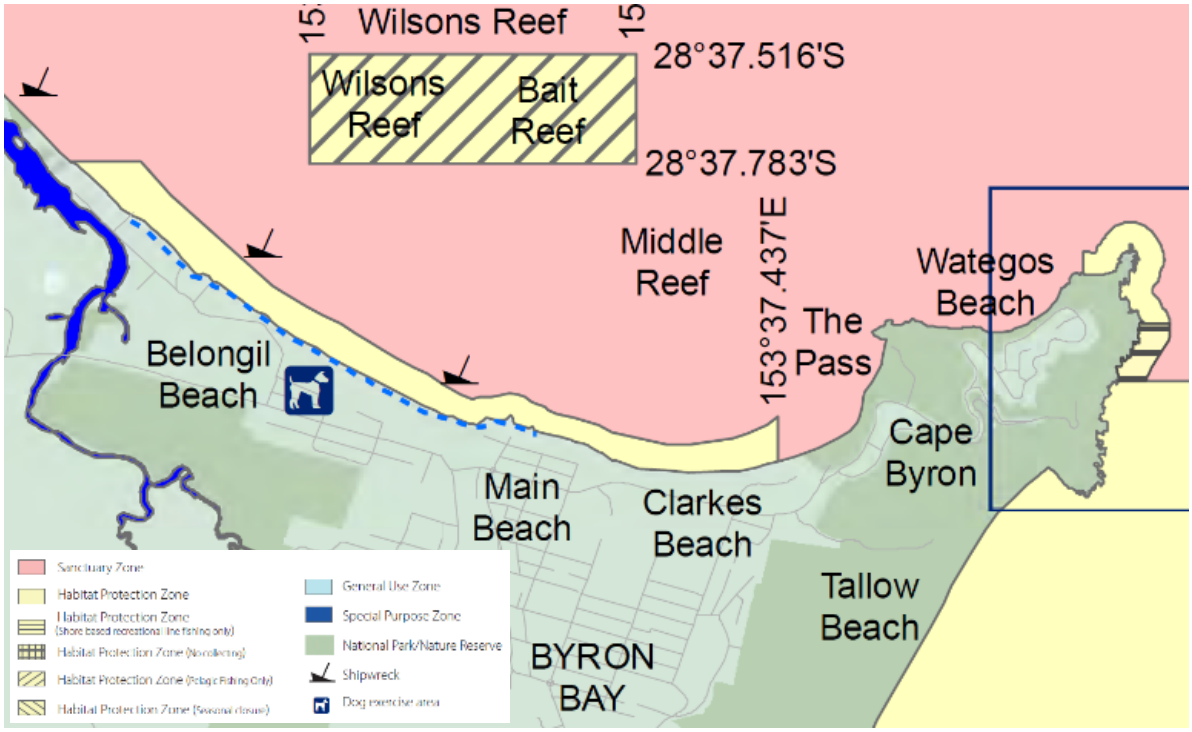


Figure 25: Extract of Cape Byron Marine Park Zoning Map (source: DPI, 2018).

Figure 26: Underwater photograph of the SS Wollongbar shipwreck (source: Pinterest).

Geological and geotechnical conditions

The Byron Bay quaternary geology is depicted in Figure 27. At the JSPW location, the lower beach areas are classified as Holocene sandy beach while the dune and back beach forms part of a Pleistocene coastal barrier with a mix of marine sand and indurated sand. Exposure of beach areas of the indurated sand (or 'coffee rock') occurs frequently following erosion events.

Historic geological analysis indicates that bedrock is generally in excess of 10 metres below the beach in the Byron Bay to Hastings Point region (PWD, 1978). The coastal plain extends around two kilometres from today's shoreline and comprises mainly marine sediment and is highly erodible in the active beach zone. This is underpinned by evidence of underlying long-term recession in this area. However, coffee rock (i.e. indurated sand) has been observed in the eroded dune face and underlying the beach along some parts of Clarkes Beach (Bluecoast, 2020b) and Belongil Beach. Coffee rock is a weak rock that provides some resistance to erosion potentially reducing the extent and rate of beach erosion and longer-term recession where present.

No recent geotechnical site investigations nearby the JSPW have been available for this review to confirm the substrate in this area. The 1975 drawings of the JSPW indicate an isolated patch of indurated sand at the western side of the JSPW. Patches of outcropping indurated sands were also found by seismic surveys reported in PWD (1978) and still evident in aerial photographs. Prior to detailed designs, a geotechnical investigation is recommended to establish the substrata (bedrock and/or coffee rock) levels in the study area.

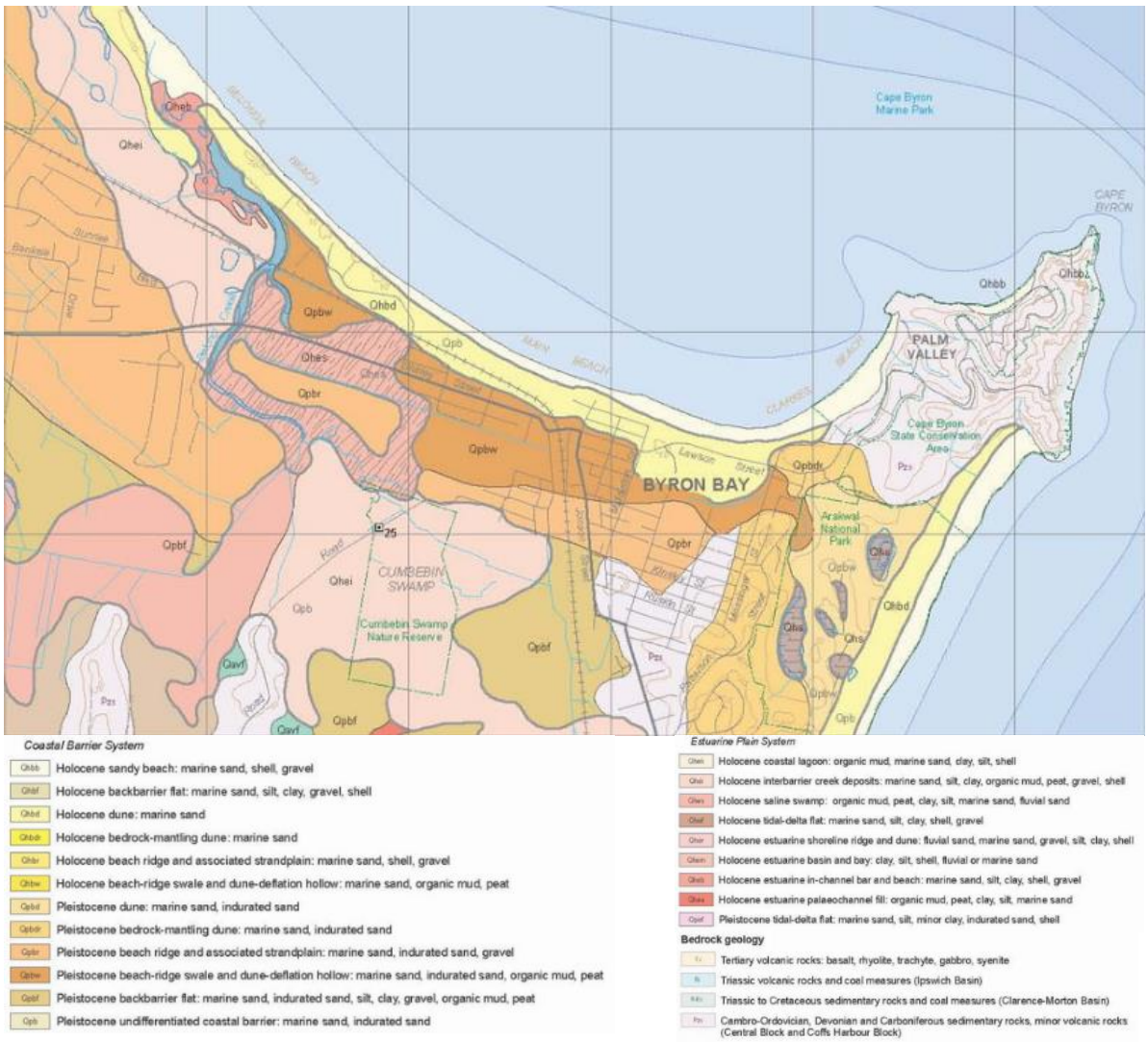


Figure 27: Regional coastal quaternary geology map, 1:25 000 scale (source: NSW DPI, 2007).

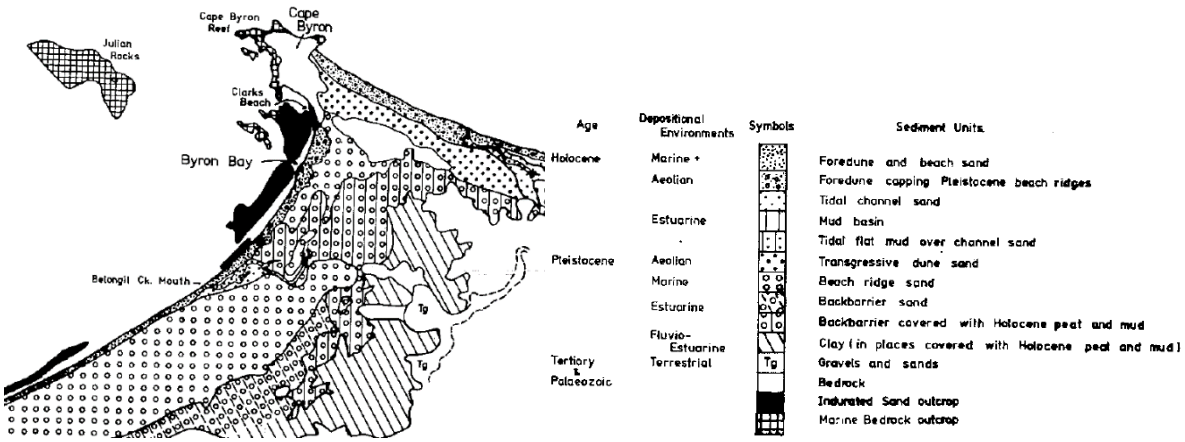


Figure 28: Offshore reefs and onshore sediment distribution (source: PWD, 1987).

Coastal processes and hazards in Byron Bay embayment

Geomorphology and sand characteristics

The JSPW sit within the Point Danger to Cape Byron secondary sediment compartment, see Figure 29. Over thousands of years of sea level changes, sand has moved shoreward from marine sources originating from the continental shelf and formed today's beaches and dunes (PWD, 1978). Recent coastal topography and nearshore bathymetry are shown in Figure 29 along with the secondary sedimentary compartment defined by Geoscience Australia.

PWD (1978) collected and analysed 370 surface samples and drilled 50 boreholes along the beach. Nearshore surface sediment samples were classified into two categories. Inner nearshore sand is light fawn, well to very well sorted, fine-medium grained and composed of well-rounded to sub angular grains of quartz and minor shell. Outer nearshore sand is olive-grey, uniformly well to very well sorted, finer grained than the inner nearshore sand and is composed of sub rounded to sub angular grains of quartz and minor shell.

Patterson Britton (2006) reviewed a limited set of sediment samples in the study area and determined the sand can be classified as 'fine sand' with the following mean grain diameters:

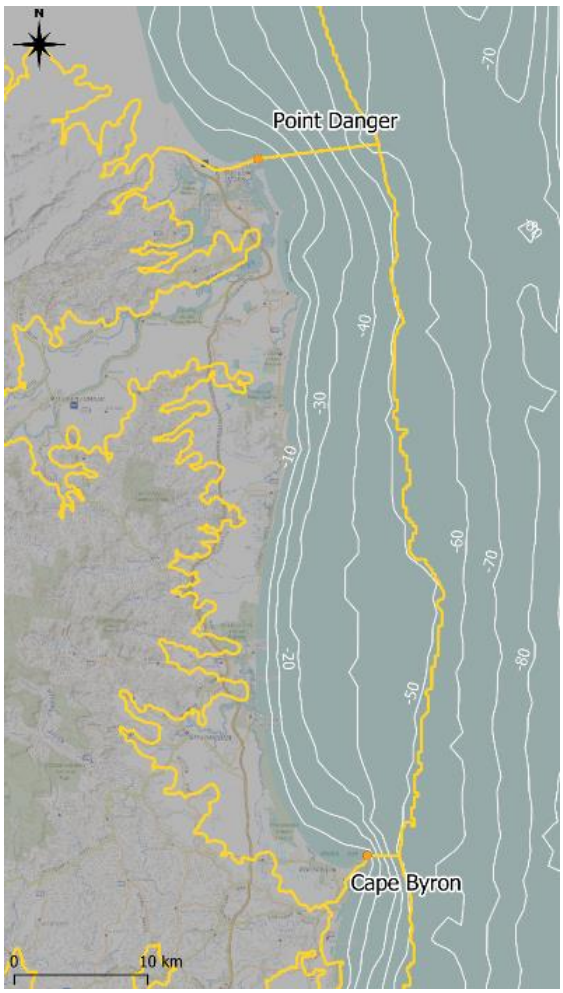


Figure 29: Secondary sediment compartment of Point Danger to Cape Byron and regional bathymetry contours.

- intertidal area – 0.23mm;
- berm – 0.24mm; and
- foredune – 0.24mm

The local bathymetry around the JSPW is shown in Figure 30.

Figure 30: Nearshore bathymetry at the study site.

Regional wave climate

The regional offshore wave climate is characterised with dominant southeast to east swells often ranging between 3 to 4m significant wave height with wave periods between 8 to 15s (BMT WBM, 2013). These low to moderate energy swells are often superimposed by prevailing short-period wind waves with more variable incident directions, mostly from east to southeast.

During the warmer months between November and May, tropical cyclones can bring large storm waves with significant wave heights exceeding 6 to 7m. Between May and July, so-called East Coast Lows, i.e. small, intense storms that form along the NSW coast, are known to generate large waves from south to southeast directions (Short and Trenaman 1992; Short 2007).

A joint frequency analysis of observed wave conditions from the Byron Bay Waverider Buoy (wave buoy) has been undertaken for the period October 1976 to October 2019 (i.e. 43 years). The location of the wave buoy has varied throughout its deployment history between Ballina and Cape Byron, however, its deployment depth has been consistent around 60 to 80m depth. Wave roses of

significant wave height, peak period and peak direction, noting that wave directions have only been recorded since October 1999, are presented in Figure 31.

Extreme wave height statistics have been estimated by various studies using the Byron Bay wave buoy as well as nearby Point Lookout (North Stradbroke Island, QLD). BMT WBM (2013) have summarised these studies, as shown in Table 1. BMT WBM (2013) also notes that these storm waves typically approach from northeast to south-southeast directions. Given the uncertainty of the statistical analysis and the relatively short wave records, BMT WBM (2013) adopted a design deep water wave height of 7.5m with a mean duration in the range 1 to 6 hours.

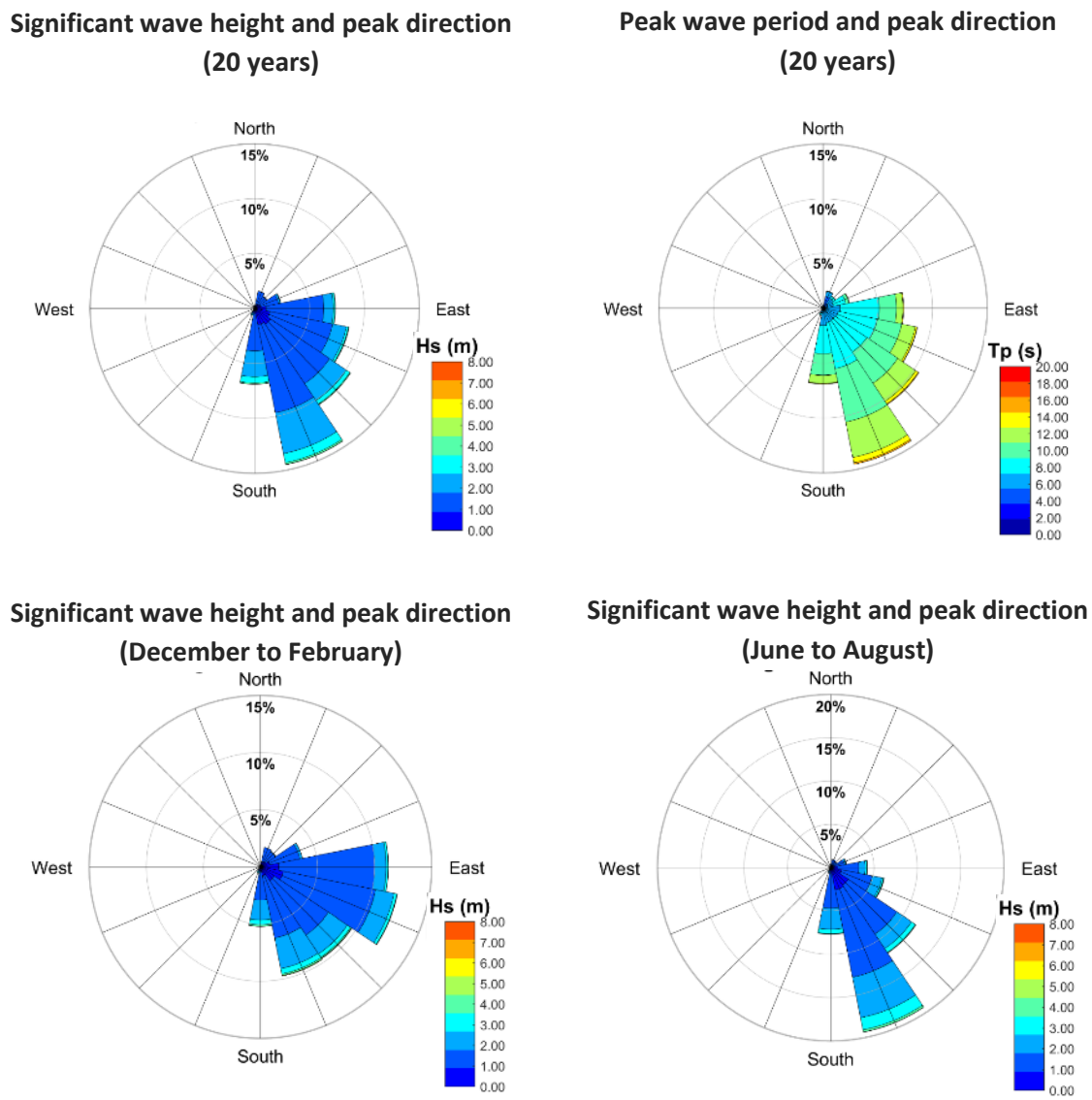


Figure 31: Observed wave conditions at the Byron Bay wave buoy.

Table 1: Summary of extreme wave height statistics at Byron Bay and Point Lookout wave buoys (after BMT WBM, 2013).

Average Reccurence Interval (years)	Significant wave height (m)			
	Byron Bay (1976 to 2004)	Point Lookout (1977 to 1999)	East Coast Lows - Point Lookout (1977 to 1999)	Tropical cyclone - Point Lookout (1977 to 1999)
2	5.40	5.02	4.85	3.89
5	6.00	5.83	5.67	4.60
10	6.30	6.29	6.10	5.20
20	6.70	6.71	6.47	5.83
50	7.30	7.28	6.90	6.73
100	7.60	7.75	7.20	7.46

Currents

Two dominant currents were identified in the wider study area (Patterson Britton, 2006), i.e.:

- surf zone littoral currents; and
- currents associated with the East Australian Current (EAC).

The littoral currents result from waves breaking at an oblique angle to the shoreline. They are the dominant driver of nearshore sand movement in the study area. Predominantly, these currents move south to north due to the offshore wave direction.

At times, the southward directed EAC influences the nearshore currents and can also reverse the dominant south to north littoral currents as it shears against Cape Byron (Patterson Britton, 2006).

Sand movement

To understand shoreline, movements in Byron Bay, and therefore to be able to best assess any proposed changes to the Jonson Street structure, it is convenient to consider them in terms of a combination of three different coastal processes. The first is onshore offshore movements of sand, the second is longshore movements of sand and the third is the effects of headland by-passing. The conceptual sediment transport pathways are depicted in Figure 32, after Patterson Britton (2006).

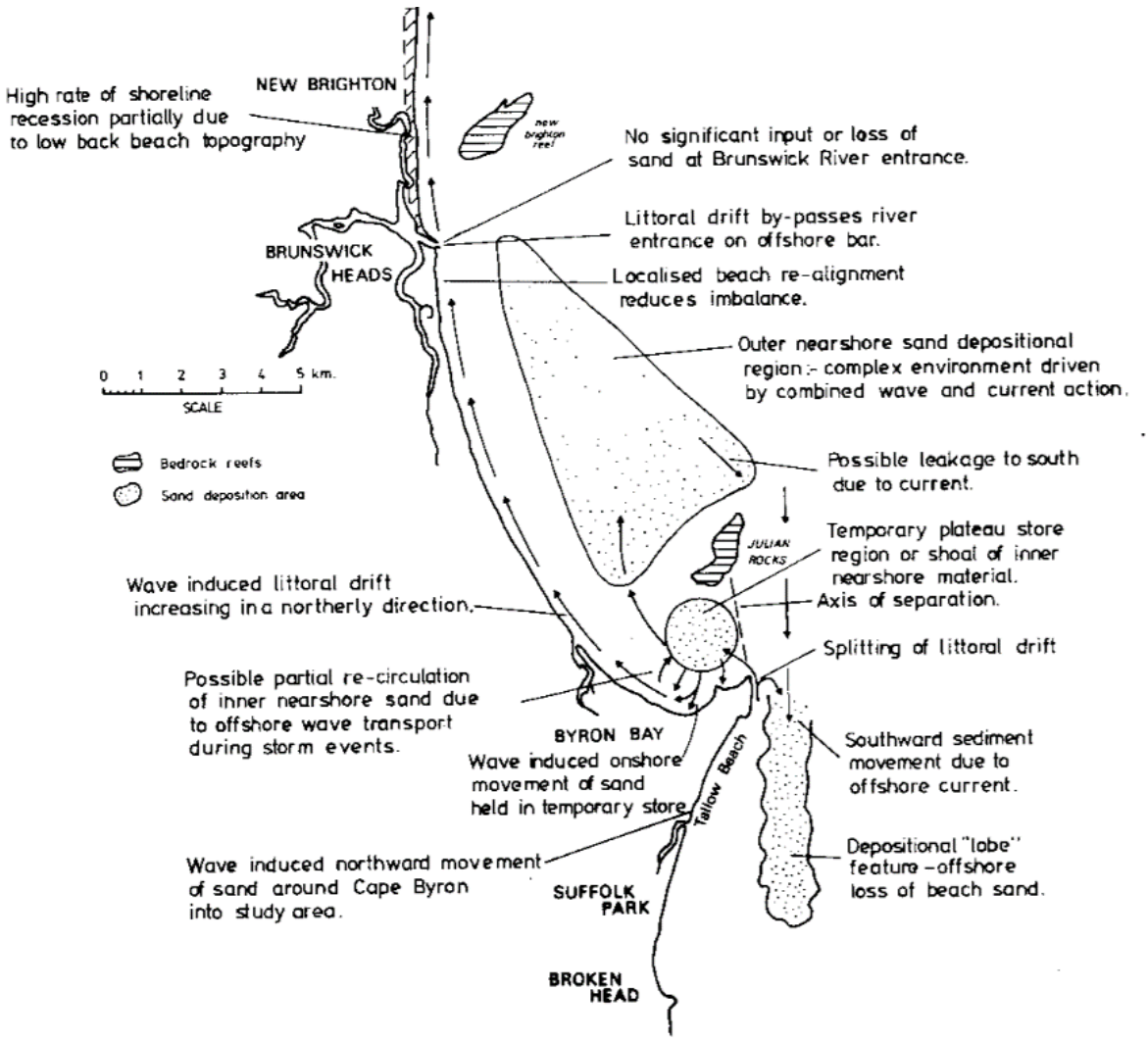


Figure 32: Conceptual model of sand movement at Byron Bay (Patterson Britton, 2006).

Longshore movement

Sand within the active beach zone moves alongshore in response to the wave obliquity at the time. This is referred to as 'gross littoral drift' and is a feature of every beach. At Byron, persistent north-easterly conditions move sand southward (eastward in the Byron embayment) while persistent south-easterly conditions move sand northward (westward in the Byron embayment). This can result in temporary variations in the shoreline position based on the prevailing wave conditions at the time. Net longshore sand transport is defined as the dominant transport direction over longer time periods; hence the net transport direction is south to north. The net littoral sand transport from Tallow Beach to Cape Byron is estimated at 400,000 to 450,000m^3/year (BMT WBM, 2013). While the net northward longshore current within the embayment varies with higher rates at the northern end compared to the more sheltered southern end. This causes an imbalance in the sand supply and transport away from parts of the beach leading to net recession or accretion (BMT WBM, 2013).

Cross-embayment sand transport in water depths up to 10 to 15m may occur from Cape Byron to Belongil Beach at an estimated rate of 200,000m^3/year (BMT WBM, 2013). From The Pass via Main Beach to Belongil Beach the net northward longshore sand transport is estimated at 200,000m^3/year.

The nearshore morphology and shoreline orientation along the northern NSW coast reflect the dominant southeast offshore swell conditions and northward net littoral drift. The crenulate bay shape of Byron Bay is one example of this, being *"more hooked at the southern end and aligned more uniformly and relatively consistently at north-northeast (approx. 20°) at the northern end"* (BMT WBM, 2013).

Headland Bypassing

Headlands, natural or man-made, are potential disruptors to the sand transport system. Their impacts on the net movement of sand can have significant underlying effects on the sand transport processes described herein (Goodwin et al., 2013). Under favourable prevailing weather systems, principally south to south-easterly conditions, sand is moved by wave induced currents from the northern end of Tallow Beach around Cape Byron. However, depending on the strength of the East Australian Current at the Cape some sand is moved offshore and to the south-east into deep water onto what is known as the Cape Byron lobe. This sand is lost to the littoral drift system (Patterson Britton, 2006). If there is prevailing northerly/north-easterly weather the mechanism for sand to move north around the Cape does not exist. Therefore, sand moves around the cape in 'slugs'. That is, at time there is an excess of sand moving around the Cape and at other times there is a deficit.

The 'Cape Byron Sand Lobe' is found to the southeast, east and northeast of the cape, in around 20 to 55m depth, with an estimated sand volume of approximately 370 million cubic metres (Mm^3) (Patterson Britton, 2006).

Onshore/ offshore movement

During large swell and storm conditions, cross-shore sand transport is amplified, and sand moves from the upper beach towards the deeper parts of the profile, forming a storm bar. Occasionally, especially in combination with high tides, this leads to dune erosion and lowering of the upper beach forming an erosion scarp. Conversely, benign wave conditions lead to graduate onshore movement of sand from the deeper profile areas and recovery and widening of the subaerial beach. This natural onshore offshore process within the Byron embayment is modified by both natural and man-made constraints. The constraints include rocky substrata, coffee rock bluffs, outcrops and man-made coastal protection structures that all control the amount of sand available for storm erosion.

In absence of the erosion limiting features described above, the volume of the design 100 year ARI storm erosion (or storm demand) between The Pass and Main Beach car park is estimated at 150 to 200m^3/m and 250m^3/m north of the Main Beach car park (WBM, 2000). The adopted storm demand, long-term shoreline recession and SLR recession (Bruun Rule) for the coastal erosion hazard lines produced by BMT WBM (2013) are presented in Table 2.

Typical storm demand measured on the open coast of NSW during major storm events, at rip heads, range from 200 to 240m^3/m above 0m AHD (NSW Government, 1990). Notably, a quantity of 320m^3/m was measured in the Byron Bay region, immediately downdrift of the JSPW, in the period from 1987 to 1990, which is the maximum for the State (NSW Government, 1990).

Table 2: Estimated storm demand and long-term recession values adopted in the coastal hazard assessment by BMT WBM (2013).

Beach	Storm demand 100-year ARI (m^3/m above AHD)	Long-term recession m/year	SLR recession	
			2050 (m)	2100 (m)
Clarkes Beach	150	0.20	35	73
Main Beach	150	0.09	15	28
North of Main Beach car park	250	0.46	20	72

Sea level and climate change

The regional tides are characterised by a semi-diurnal regime with a spring tidal range of 1.32m. Estimated tidal planes from nearby tidal constituents provided by the Australian National Tide Tables are provided in Table 3.

Table 3: Tidal planes for the Tweed-Byron region derived from tidal constituents (BMT WBM, 2013).

Tidal plane	Level (m AHD)
Highest Astronomical Tide (HAT)	Approx. 1.0 – 1.1
Mean High Water Springs (MHWS)	0.66
Mean High Water Neaps (MHWN)	0.37
Mean Sea Level (MSL)	0.0
Mean Low Water Neaps (MLWN)	-0.37
Mean Low Water Springs (MLWS)	-0.66
Lowest Astronomical Tide (LAT)	-1.0

Council has adopted a set of conservative extreme sea levels (see Table 4) in their Climate Change Planning Policy for a variety of planning periods and processes for flood risk studies in the Byron Shire, 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; and

- 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 4. 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 4: 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)	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 Intergovernmental Panel on Climate Change (IPCC) has released an updated report on global SLR projections (IPCC, 2019). A range of SLR projections above an average sea level between 1986 and 2005 for low and high greenhouse gas emission scenarios are provided in Table 5.

Table 5: Global SLR projections for a range of planning periods and greenhouse gas emission scenarios (source: IPCC, 2019).

	Greenhouse gas emission scenario	
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	0.58
2090 (m)	0.40	0.82
Rate of change at 2100 (mm/yr)	4.0	20.0

Impacts of the JSPW on coastal processes

The JSPW act intermittently as a headland control (WBM BMT, 2013). This has influenced the alignment of updrift beaches as well as downdrift beaches by impacting the northward sand supply. Updrift of the JSPW the beaches initially accreted following the construction in circa 1964 leading to the stabilisation of the foreshore of Main Beach and the development of a dune (WorleyParsons, 2013). In front of the JSPW, the beach width was reduced as the structures encroached on the active beach area. The structures are often exposed to direct wave impacts and partially reflect wave energy seaward (WorleyParsons, 2013), as also evident in the aerial photo shown in Figure 34. 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 (all described above) combined with the effects of the structure itself.

Downdrift of the JSPW the beaches initially eroded following construction of the JSPW, see Figure 33 (WorleyParsons, 2013). While much of this erosion can be attributed to natural processes (i.e. shoreline recession due to net sediment loss), the structure has had an influence as:

- the recession decreases with distance away from the JSPW (WorleyParsons, 2013); and
- more recently the downdrift recession in the area immediately downdrift has reduced suggesting that the initial impact of the JSPW has reduced as the downdrift shoreline has adjusted to the rate of sand bypassing around the structures and that sand loss has become distributed progressively further north (BMT WBM, 2013).

WBM (2000) estimated that approximately 1,000,000m^3 of sand has been lost from the subaerial dune system between the Main Beach car park and Belongil Creek over the 52-year period from 1947 to 1999. Considering the subaqueous nearshore profile to an approximate closure depth of -17m AHD this estimated sand loss would be 3,000,000m^3 (BMT WBM, 2013). WorleyParsons (2013) recognises that some of the downdrift recession may be attributed to natural net loss of sand. Particularly given the beaches downdrift of JSPW are more exposed to the dominant south-easterly swells (i.e. higher littoral drift rates) in comparison to the updrift beaches.

Figure 33: Historical analysis of position of the 4m depth contour downdrift from the JSPW using photogrammetry data (source: WorleyParsons, 2013).

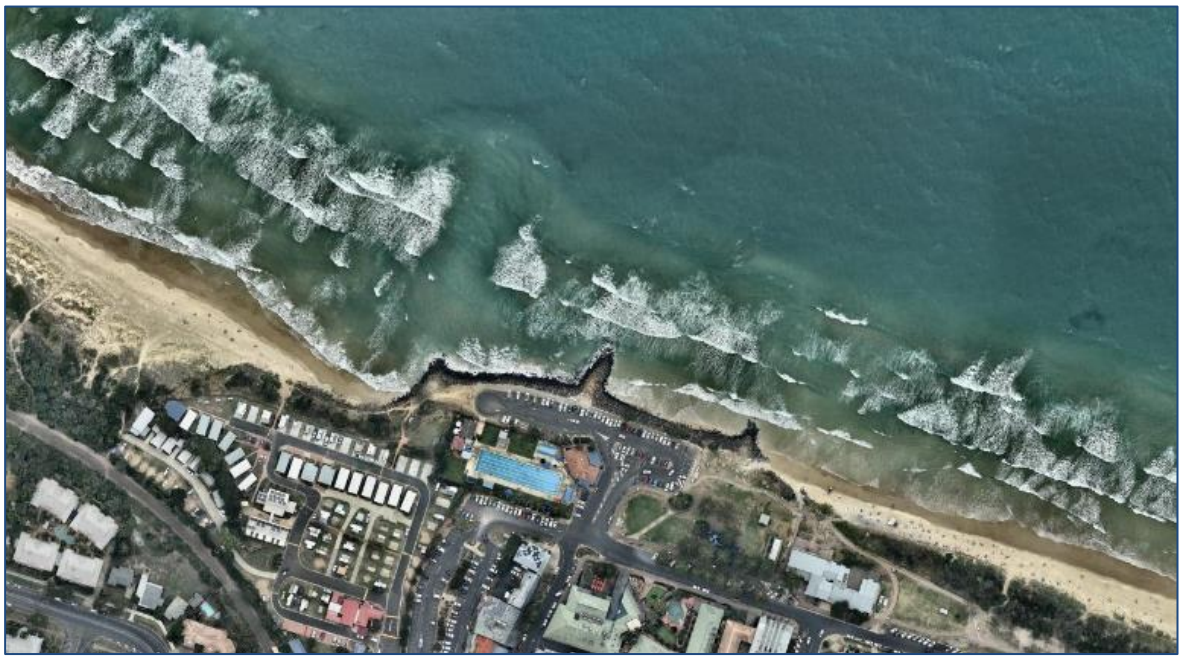


Figure 34: Aerial photo of the JSPW captured in March 2019 during moderate energy wave conditions (source: Nearmaps).

Current and future risks

Immediate and future risk to coastal erosion and long-term recession, including sea level rise induced recession, was assessed in BMT WBM (2013) and WRL (2016). The 'best estimate' coastal

hazard lines for the adjacent areas of the JSPW for immediate, 2050 and 2100 planning horizons are presented in Figure 35 and Figure 36.

The hazard risk assessment assumed that the JSPW would be maintained to provide adequate protection within the adopted planning horizons. Therefore, no projected hazard extents were calculated and drawn landward of the protection works, and hence no significant infrastructure was deemed at risk from coastal erosion in the lee of the protection works. However, the current state of the JSPW comprises of 'undersized' rock and is not deemed hydraulically stable (for events exceeding 1 to 10 year ARI conditions; WorleyParsons, 2013) and the crest-level of the structures is not adequate to prevent wave overtopping in greater than one-year ARI storm events (WorleyParsons, 2014). This suggests that there is an immediate threat to the structural integrity of the JSPW leaving the infrastructure, adjacent land and developments at risk (BSC, 2018).

In accordance with the Coastal Management Act 2016, Byron Shire Council are currently in the process of preparing Coastal Management Programs (CMPs) for the Local Government Area. This includes a CMP for the open coast area between Cape Byron and South Golden Beach, for which the Stage 1 – Scoping Study has been recently completed (BMT, 2020). The scoping study included a first-pass risk assessment that confirmed a number of high risk coastal hazards (e.g. coastal erosion and shoreline recession). Subsequent stages of this CMP are planned to be undertaken concurrent to the Main Beach Shoreline Project and will provide updated coastal hazard and risk assessments for the area.

Figure 35: Coastal erosion hazard lines for areas updrift of the JSPW (source: BMT WBM, 2013).

Figure 36: Coastal erosion hazard lines for areas downdrift of the JSPW (top) under 'Scenario 1' that coastal protection structures are maintained and (bottom) under 'Scenario 2' that coastal protection structures are removed (source: BMT WBM, 2013).

Opportunities associated with the MBSP

The JSPW are an integral part of Main Beach. Based on extensive community consultation, The Byron Bay Town Centre Master Plan outlines short term and long-term priorities for Main Beach noting:

> *"Main Beach should be celebrated as a natural foreshore environment that supports both active and passive recreational uses, strengthening Main Beach's role as Byron Bay's most popular asset"*

The short term (2016 – 2021) and long-term plan for the Main Beach precinct are shown in Figure 37 and Figure 38, respectively. Key projects identified in the Master Plan that are most relevant to opportunities associated with the MBSP are:

- In the short-term Apex Park would be upgraded to establish a pedestrian prioritised shared link from Jonson Street. In the longer-term remaining car parks would make way for more foreshore parklands and pedestrian and cycle access to the rail corridor. The importance of the car park to locals as a meeting point has been expressed through the master plan process. The Master Plan calls for an inclusive community engagement process to be used to redesign the car park.
- Establishing a Main Beach boardwalk along the foreshore to form a generous east to west connection that sensitively integrates coast protection works, recreation, nature and pedestrian movement together.
- In the short-term the Memorial Pool would be upgraded to operate year-round to support pool users as well as offering commercial capacities such as restaurants, cafes and community spaces. In the longer-term either upgrade works to the existing swimming pool will be implemented or an alternate swimming pool location established.
- The Surf Life Saving Club would be upgraded into a modern facility that adequately supports the local lifesaving organisation as well as offering some commercial capacity such as a restaurant, beachside café and community space.

Figure 37: Main Beach precint – short term plan (source: McGregor Coxall, 2016).

Figure 38: Main Beach precint – long term plan (source: McGregor Coxall, 2016).

The alignment of the modification options will be a key consideration when developing options for the JSPW given opportunities associated with a reduced number of car park space, more parklands and an east to west boardwalk. Redesigning the structures footprint landward may increase beach widths in front of the structure and has the potential to offer a reduction in the intermittent headland control (i.e. increase rate of sand bypassing JSPW and landward realignment of updrift shoreline) and beneficial downdrift shoreline realignment. Removal of the groynes may improve swimmer safety in the vicinity of these structures and at times provide a continuous beach. The impacts to surfing amenity near the JSPW will be a particular focus when assessing the alignment options of the JSPW modifications.

In association with improved pedestrian movement through Main Beach parklands, redesigned coastal protection works could greatly improve access to Main Beach to both the east and west and also formal beach access including compliant disabled access. Moreover, by improving the quality of the coastal protection works public safety will be improved such as pedestrian safety around rock walls (slippage), alongshore access and swimming areas. Improved coastal protection works will ensure the structure has the ability to withstand predicted future physical forces under a changing climate to provide adequate protection to the Byron Bay Town Centre.

At present any long-term improvement of the foreshore area and/or linkages between different spaces is dependent on the modification design of the JPSW (primarily alignment of the protection works). This modification investigation has the ability to achieve great amenity outcomes for the community such as:

- increased public access (i.e. access along or over the structure to the beach, suitable disability access, vehicle access for SLSC);
- improved opportunities for use of the structure (i.e. boardwalk/pathways adjacent or on top, integration of seating);
- improved visual aspect, recreational foreshore and beach amenity.

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