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R2093 Rev 1

October 2025

Smiths 2014 Pty Ltd

Smiths Beach
Coastal Processes Report

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Limitations of this Document

Table of Contents

Table of Figures

Table of Tables

1. Introduction

Smiths 2014 Pty Ltd (the Proponent) is looking to create a vibrant coastal tourist node through the development of Lot 4131 Smiths Beach Road, Yallingup (the Site) and the associated foreshore. The Proponent has assembled a team of planners, architects, environmental consultants, civil engineers, geotechnical specialists and coastal engineers to help plan the development.

The proposed development will consist of:

- Tourist development comprising hotel accommodation, restaurant and wellness centre;
- Campground;
- Community Hub comprising café, reception hall, surf lifesaving club;
- Cape to Cape Welcome Centre and general store/bakery; and
- Holiday homes.

The site master plan developed by the Proponent and its team is presented in the figure below.

Figure 1.1 Smiths Beach Development – Site Master Plan

Given the coastal nature of the development, the Proponent engaged specialist coastal and port engineers M P Rogers & Associates Pty Ltd (MRA) to provide assistance with the coastal planning and management components of the development.

1.1 The Site

Smiths Beach is located near the town of Yallingup on the South West coast of Western Australia. The beach is very popular amongst tourists and locals. It is used for swimming, fishing, surfing, exercising and general recreation. The location of the Site, Lot 4131, is shown in the figure below.

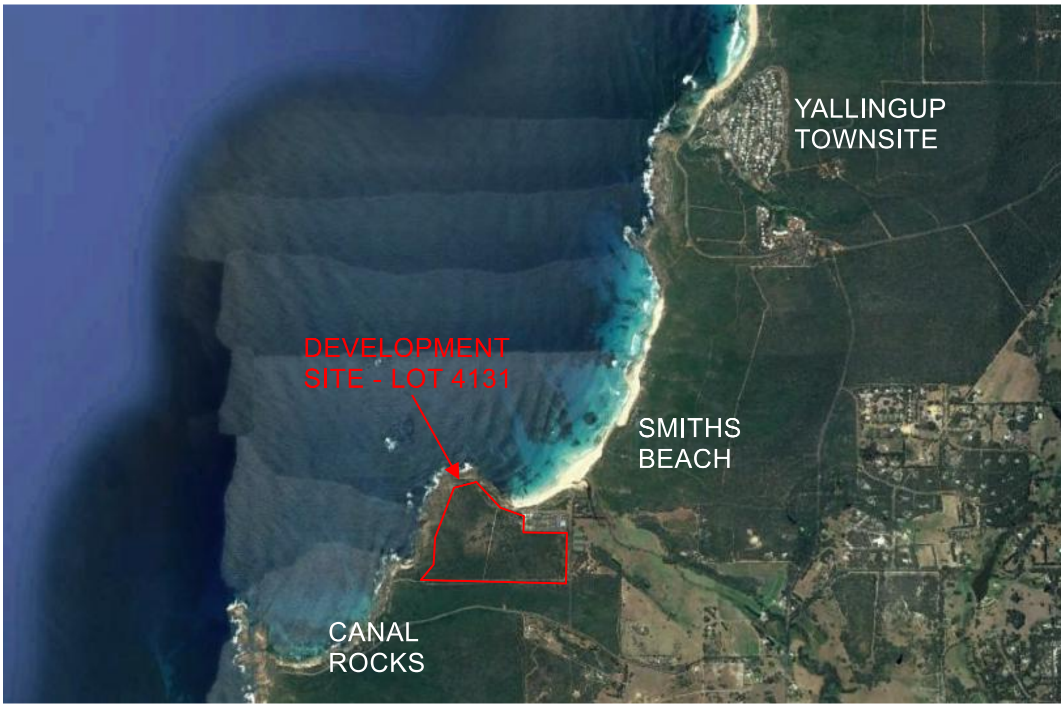

Figure 1.2 Site Location

Smiths Beach comprises sandy beaches to the east and a rocky coast and headland to the west. The rocky coast offers much of the site natural protection from erosion.

Figure 1.3 Smiths Beach Looking East

1.2 Purpose & Scope

The environmental approval process for the development requires completion of a Public Environmental Review. As part of this process, MRA were engaged to provide specialist assistance to the project team on the coastal aspects of the project. Details of the coastal aspects of the project that need to be considered were outlined within the Environmental Scoping Document (ESD) for the project as well as within the Coastal Processes Environmental Factor Guideline (EPA 2016). The ESD contained a section specifically regarding coastal processes.

Many aspects of the work required under the coastal processes section of the ESD have been completed and presented in other reports. The purpose of this report is to address the requirement to characterise the current coastal processes, including the coastal morphology, and to describe the potential for any adverse impacts to coastal processes or adjacent areas as a result of implementation of the proposal.

This report addresses these requirements and identifies that the implementation of the proposal will not adversely impact the natural coastal processes occurring at Smiths Beach.

2. Coastal Aspects of the Proposal

2.1 Coastal Hazards

Within Western Australia, State Planning Policy 2.6: State Coastal Planning Policy (SPP2.6; WAPC 2013) provides guidance for land use and development decision-making within the coastal zone, including the establishment of coastal foreshore reserves to protect, conserve and enhance coastal values. SPP2.6 also provides guidance on the assessment and management of coastal hazard risks for assets located in close proximity to the coast.

The objectives of SPP2.6 are wide ranging; however, a key component of the policy is the identification of appropriate areas for the sustainable use of the coast. This includes use for recreational, tourism and commercial purposes.

Guidance on the assessment of coastal hazard risk and development of appropriate management and adaptation plans is provided within SPP2.6.

The identification of areas that are potentially vulnerable to coastal erosion hazards is made using the recommendations of SPP2.6. Specifically, SPP2.6 recommends that appropriate allowances be determined for the following factors to demarcate the extent of coastal areas that could be impacted by erosion.

- Allowance for the current risk of storm erosion – termed the S1 Allowance.
- Allowance for historic shoreline movement trends – termed the S2 Allowance.
- Allowance for erosion caused by future sea level rise – termed the S3 Allowance.

Each of the allowances identified above are then summed, together with a 0.2 m/year allowance for uncertainty, to provide an indication of the potential coastal erosion hazard area. An understanding of the coastal hazards and subsequent risks is critical for the determination of management and adaptation actions.

Numerous assessments of appropriate coastal erosion hazard areas have been completed for Smiths Beach over the past decades. However, to ensure consistency with current planning documentation the results of the assessment completed as part of the City of Busselton's (City's) Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) have been adopted for the development of Lot 4131.

The potential extent of coastal erosion hazard impact on the coastline fronting the development, as determined within the City's CHRMAP, is presented in Figure 2.1.

Figure 2.1 Coastal Erosion Hazard Lines (City 2022)

These coastal erosion hazard lines present the potential extent of coastal erosion impact over the various planning horizons. It must be understood that these coastal hazard lines are not predictions of future shoreline location, but rather are the outcome of risk based assessments that provide an indication of the potential future extent of erosion over these respective timeframes. Furthermore, it should be noted that geotechnical assessment for the area fronting Lot 4131 (as further discussed in subsequent sections of this report) identified competent hard rock in the area. This means that these coastal hazard lines are expected to include a higher level of conservatism than normal. Nevertheless, the coastal hazard lines have been adopted for development planning of Lot 4131.

Assessment of potential coastal inundation hazards was also completed within the City's CHRMAP. This shows that the Site is well above the potential inundation levels and therefore there is no risk posed from coastal inundation.

2.2 Regional Planning Context

SPP2.6 states that coastal hazard adaption measures should include consideration of the following coastal hazard risk management and adaption planning hierarchy on a sequential and preferential basis.

- Avoid
- Planned or Managed Retreat
- Accommodation
- Protection

The City completed a Multi-Criteria Analysis (MCA) for each of the management units considered within the CHRMAP by assessing each adaption measure against an acceptability criteria, feasibility criteria and financial criteria. The outcome of the MCA concluded that a protection option is the most appropriate for Smiths Beach. Significantly, protection is noted in the CHRMAP as a requirement across all timeframes, including "current – 2043", "2043 – 2073" and "2073 – 2123".

For the "current – 2043" timeframe, the City's CHRMAP proposes the following coastal management response:

> *"1. To protect the beach, beach amenity, fore dune, infrastructure and buildings, maintain existing fore dune and beach as much as possible, and install coastal protection structures, such as seawalls or groynes, as necessary.*
>
> *2. Supplement the infrastructure described above with beach nourishment."*

Consistent commentary is provided throughout the described actions for the other planning horizons, with the stated intention being to construct a seawall to protect existing infrastructure and the Site.

It was noted within the City's CHRMAP that the seawall should be buried and should extend from the western end of the beach, eastwards to a point between the most eastern beach access path and Gunyulgup Brook.

Whilst an image showing the extent of the proposed seawall was not provided, it is interpreted that the proposed extent of the seawall should be as shown in Figure 2.2, as the CHRMAP states that the requirement is to "*construct a buried seawall from the western end of the beach to a point between the most eastward beach access path and Gunyulgup Brook* ". It should be noted that the extent shown in Figure 2.2 is not intended to be interpreted as a potential alignment for the seawall.

Figure 2.2 Extent of Seawall Described in the City's CHRMAP

From a coastal engineering perspective, the extent of the seawall described in the City's CHRMAP appears sound to provide protection to the existing infrastructure and the Smiths Beach project. Fundamentally, the two elements of the seawall extent that are most critical to the success of the structure are (1) the connection of the seawall to the existing rock at the western end, and (2) ensuring that the seawall extends an adequate distance past the areas intended to be protected (at the eastern end) to ensure that flanking erosion around the seawall termination does not impact the areas intended to be protected.

Focusing on the western end, an important consideration is to ensure that the seawall is adequately tied in with the natural rock to provide a continuous level of protection. If a gap was to be left between the natural rock and the seawall this area would potentially be prone to flanking erosion that could compromise the integrity of the protection and impact any adjacent development. In the case that the revetment was not tied in with the natural rock, the seawall would need to be extended in a landward direction to appropriately protect against potential flanking erosion around the end of the structure. On review, tying in with the existing natural rock would provide a more consistent level of protection.

2.3 Proposed Coastal Structure

The recommended protection approach outlined within the City's CHRMAP would provide protection to the proposed development as well as any foreshore areas that were landward of the seawall. However, it is important to note that there is a balance that must be considered when locating the seawall within this area.

The location of the seawall needs to balance:

- the ability to tie in with the protection for the existing development (including Smiths Beach Road, Canal Rocks Beachfront Apartments and the Smiths Beach Resort);
- retention of a sandy beach in front of the seawall for as long as possible (i.e. being as far away from the coast as possible); and
- the provision of adequate foreshore width behind the seawall after the shoreline erodes such that there is useable foreshore space available for public.

Several possible alignments were considered for the seawall, however, upon review of the options, it was concluded that the alignment which provided the best outcome would involve the construction of the seawall within Lot 4131. A more detailed view of the proposal is shown in Figure 2.3.

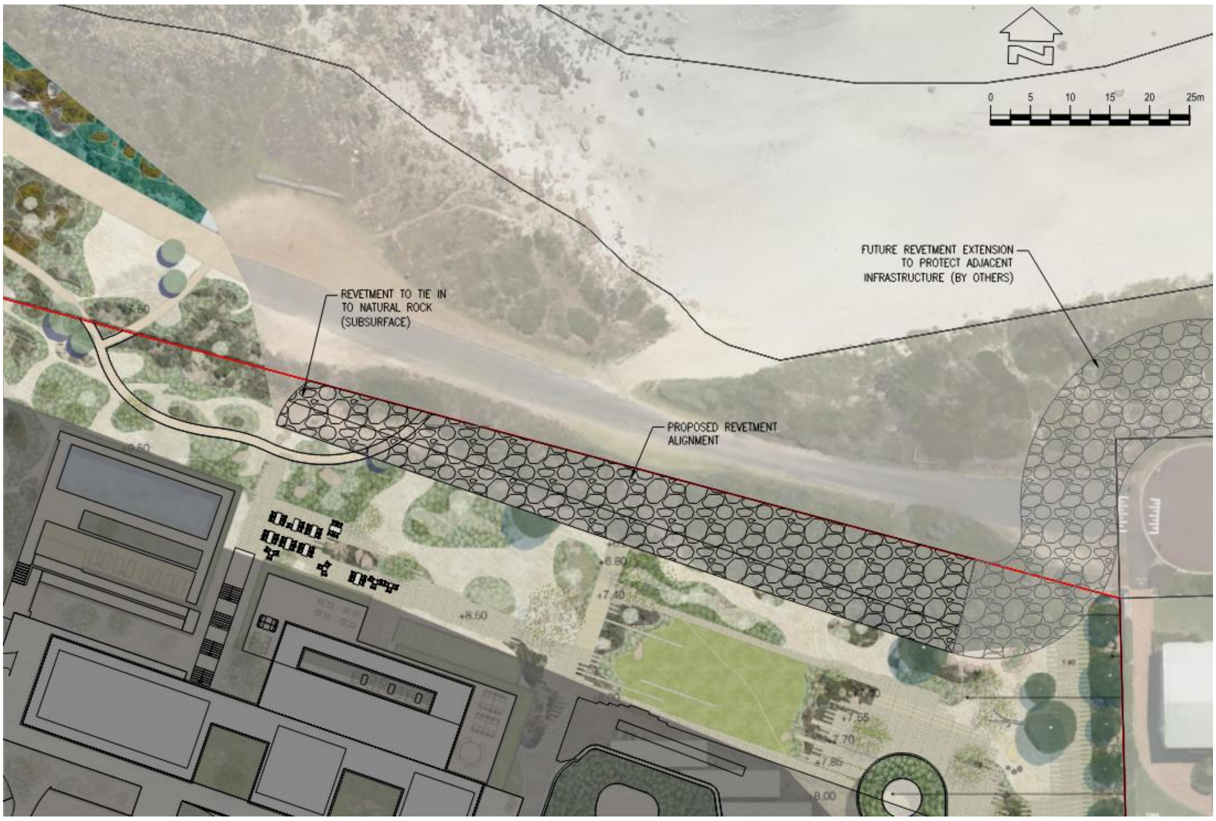

Figure 2.3 Proposed Alignment for the Construction of the Seawall

The intention with the construction of this seawall would be that the seawall would initially be buried, in line with the recommendations of the City's CHRMAP. This would enable the entire foreshore area to remain available for public use. Thereafter, at the point when/if the shoreline erodes back to the alignment of the seawall then this structure would ultimately provide the protection to the remaining foreshore area. As shown in Figure 2.3 this would retain a public foreshore reserve in the order of 20 m wide to accommodate foreshore uses.

With respect to the timing for the construction of the seawall, the City's CHRMAP identifies that construction of the seawall is expected to be required within the immediate planning timeframe from "current – 2043". However, discussions with the City have identified that they currently do not have funding to complete the construction of this seawall.

As identified by the vulnerability assessment, in the absence of this seawall, the risk posed to the proposed development within the 100 year planning timeframe is too high. Therefore, based on precedence from other developments in Western Australia, it is incumbent on the Proponent to ensure that adequate protection is in place prior to construction. The responsibility for the construction of the seawall fronting the proposed development site will therefore fall to the Proponent.

Construction of the initial section of the seawall by the Proponent will therefore allow the City to continue the protection in front of the existing infrastructure (including Smiths Beach Road, Canal Rocks Beachfront Apartments and the Smiths Beach Resort) when required. The design and construction of the seawall within Lot 4131 would be cognisant of this requirement and would ensure that the future tie in would be well planned and detailed.

The potential impacts associated with the construction of this seawall on the local coastal processes will be investigated within this report.

3. Site Setting

3.1 Geology & Geomorphology

Smiths Beach is a headland-bounded, embayed pocket beach located on the southwest coast of Western Australia. It is enclosed by resistant rocky headlands and fronted by nearshore limestone reef (refer Figure 3.1), which together exert strong control over the beach's planform and limit alongshore sediment exchanges with adjacent coasts (Short, 2006; Dean & Dalrymple, 2002). Short (2005) describes that the Smiths Beach embayment is comprised of three sections, each separated by intertidal calcarenite reef, more commonly known as beach rock. The Gunyulgup Brook also drains across the shoreline approximately 450 m from the southern rock headland.

Smiths Beach lies on the western margin of the Leeuwin–Naturaliste Ridge, a prominent geomorphic feature extending between Cape Naturaliste and Cape Leeuwin in the far southwest of Western Australia. The ridge is underlain predominantly by Tamala Limestone, a Pleistocene aeolianite formed from wind-blown calcareous sands that have been lithified over time (Short, 2006). This unit is part of the Spearwood Dune System of the Swan Coastal Plain, and in the Smiths Beach area it forms steep coastal bluffs, headlands, and nearshore platforms (Playford et al., 1976; Semeniuk, 1997).

The nearshore zone is characterised by discontinuous limestone reef platforms and shore-parallel ridges, remnants of the Tamala Limestone bedrock (refer Figure 3.2). These features exert a strong control on wave transformation, sediment transport, and shoreline morphology. The reefs create zones of wave attenuation and focusing, influencing the distribution of erosion and accretion along the beach (Short, 2006; Eliot et al., 2011). These features also heavily influence seasonal changes in the beach planform, which are discussed in latter sections of this report.

Geomorphologically, Smiths Beach is a headland-bounded embayment. The rocky promontories at either end of the bay act as fixed boundaries, limiting alongshore sediment exchange with adjacent coasts and creating a closed sediment compartment. The beach planform reflects an equilibrium between wave climate, sediment availability, and the geological framework (Hsu & Evans, 1989).

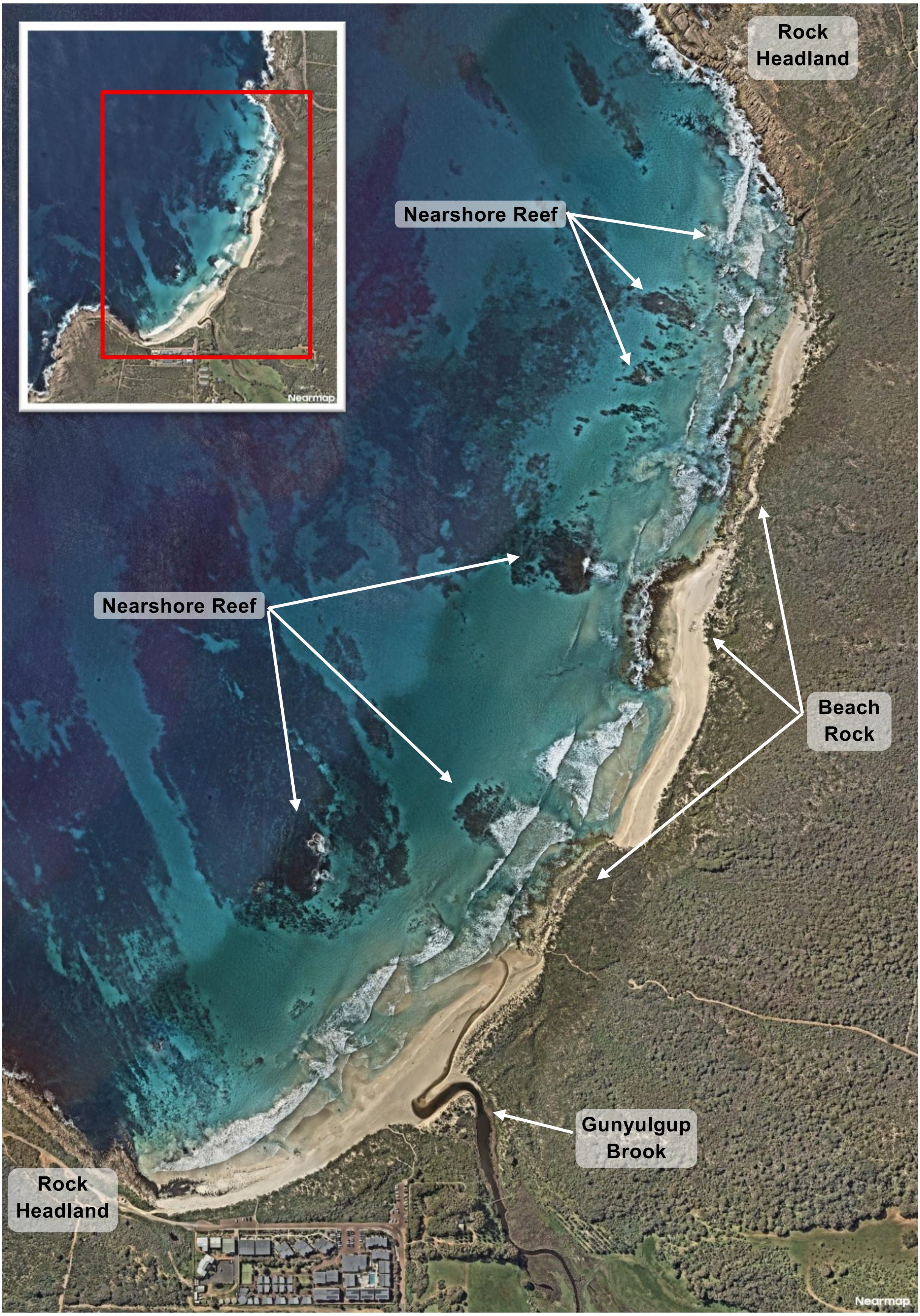

Figure 3.1 Key Geological & Geomorphological Features of Smiths Beach

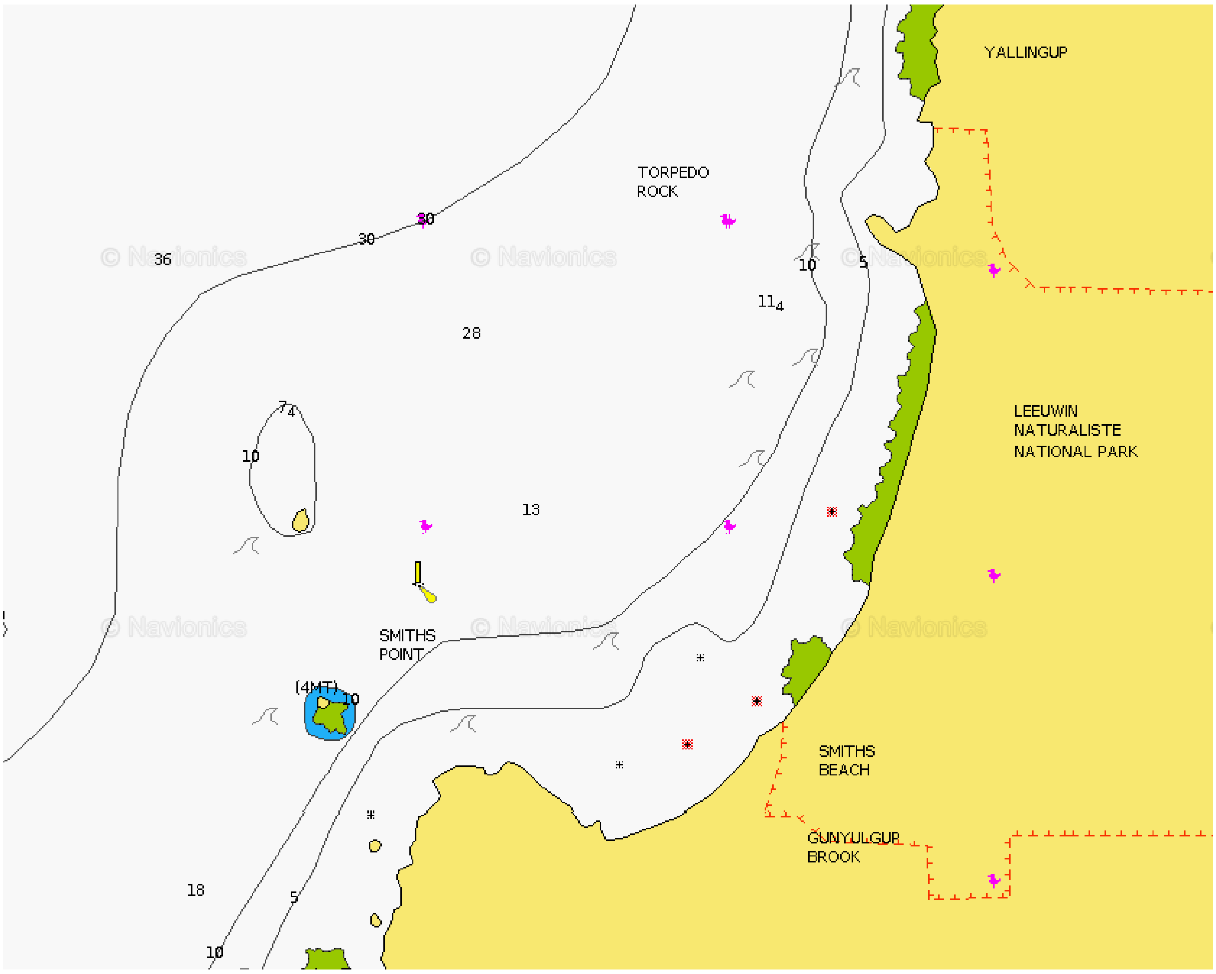

Figure 3.2 Extract from the Local Nautical Chart Showing Local Bathymetry Around Smiths Beach (Source: Navionics)

3.1.1 Geotechnical Investigations

Golder Associates (Golder) carried out a geotechnical investigation around the proposed development site at Smiths Beach. The objectives of the investigation included the following.

- Assess surface and subsurface conditions, subsurface soil layer thickness, strength and other geotechnical characteristics.
- Assess the preliminary site for the development.
- Assess the surface level of rock near the coastline that is considered to have sufficient durability to withstand the action of the ocean in the coming century.

The field work was completed between 10 December 2020 and March 2021 and included drilling of hand auger boreholes, Perth sand penetrometer (PSP) and dynamic cone penetrometer (DCP) testing, diamond core boreholes, in situ permeability testing and the collection of samples for geotechnical laboratory testing (Golder, 2021). Of most relevance to the assessment of coastal processes is the boreholes completed along the shoreline fronting the proposed development area. The locations of these boreholes are shown in Figure 3.3.

The investigation found that high strength gneiss rock sits below the surface, though the elevations of the rock vary. The inferred subsurface sections prepared by Golder are presented in Figures 3.4 and 3.5 and reference the section locations shown on Figure 3.3. A spatial plot showing the inferred rock elevations is also included in Figure 3.6.

These results show that, across the areas where drilling was completed, the elevation of the rock reduces with increasing distance from the exposed rock shoreline. However, it is clear that there is rock present across the majority of the area.

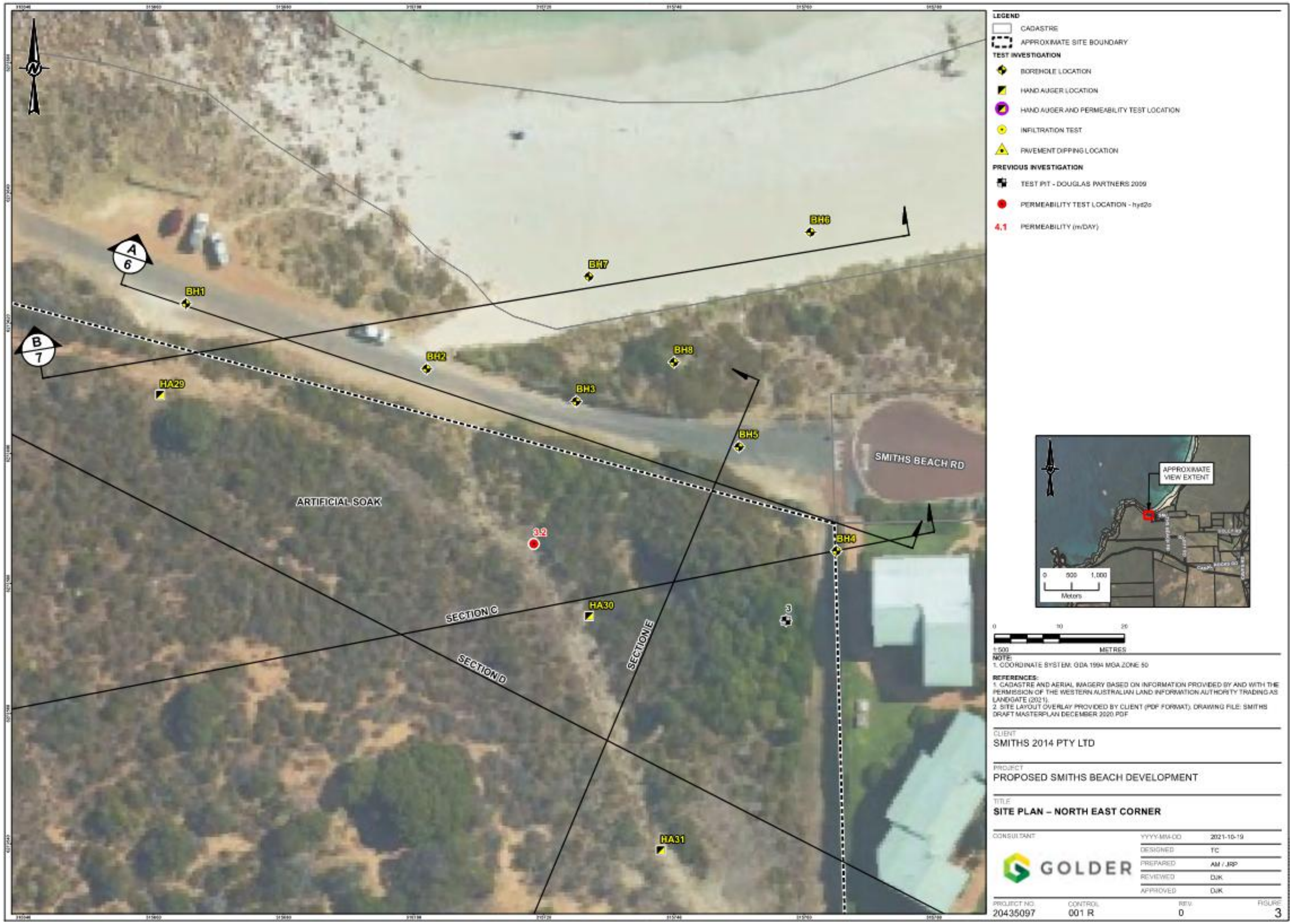

Figure 3.3 Locations of Boreholes Completed Adjacent along the Coastal Margin of the Site (Golders, 2021)

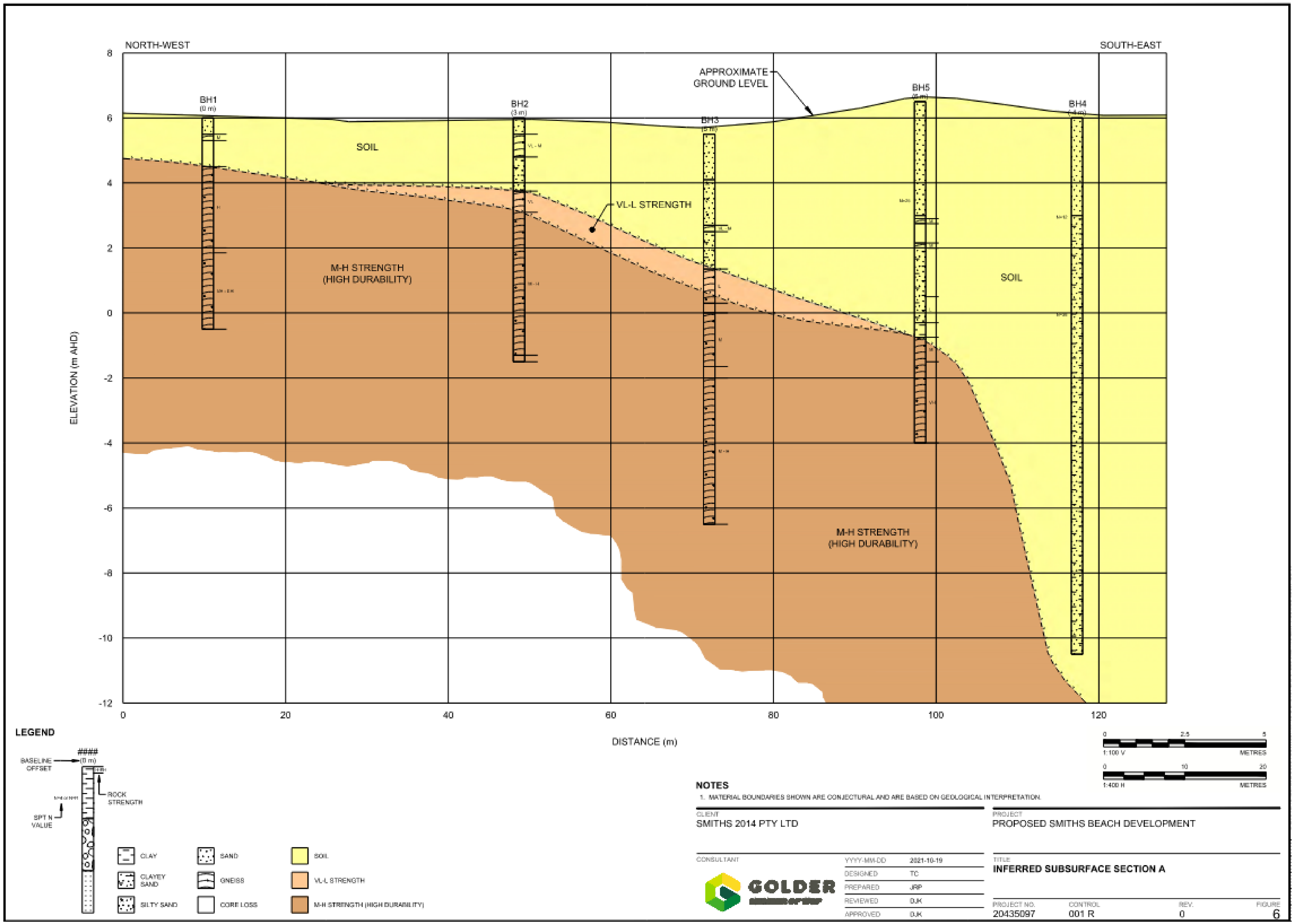

Figure 3.4 Inferred Rock Surface Elevation – Section A (Golders, 2021)

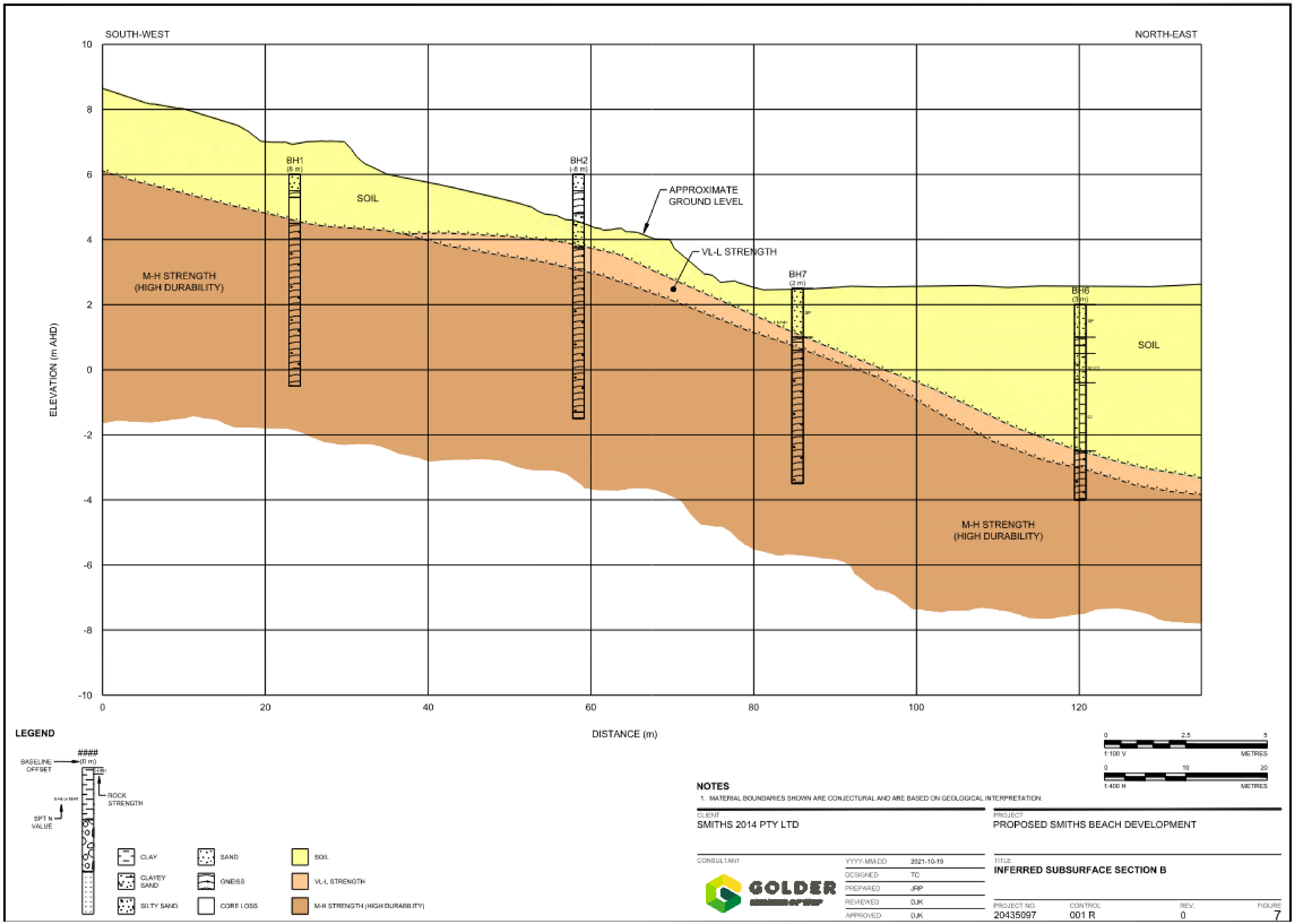

Figure 3.5 Inferred Rock Surface Elevation – Section B (Golders, 2021)

Figure 3.6 Spatial View Showing Elevations of Rock Observed in Boreholes

3.2 Metocean Conditions

3.2.1 Wind Regime

The seasonal weather patterns at Smiths Beach are largely controlled by the position of the Subtropical High Pressure Belt. This is a series of discrete anticyclones that encircle the earth at the mid-latitudes (latitudes of 20 degrees to 40 degrees). Throughout the year, these high pressure cells are continuously moving from west to east across the southern portion of the Australian continent. A notional line joining the centres of these cells is known as the High Pressure Ridge.

In winter this ridge lies across Australia typically between 25 to 30 degrees south and is to the north of Smiths Beach at 33 degrees 39 minutes south. Consequently, the migrating low pressure systems which exist to the south of the High Pressure Ridge, are located sufficiently northward to bring a westerly wind regime to the southwest of Western Australia and the adjacent waters. Cold fronts associated with these low pressure systems pass over the Smiths Beach region. These can bring storm force winds with directions from northwest, through west, to southwest.

During summer, the High Pressure Ridge moves south of Smiths Beach and lies between 35 and 40 degrees south. Under these circumstances, the Smiths Beach region comes under the influence of the high pressure cells of the High Pressure Ridge. These cells cause anti-cyclonic winds that rotate anti-clockwise in the Southern Hemisphere. At Smiths Beach , these winds arrive from the southeast to east as the high pressure cell approaches from the west. The winds then rotate through northeast to north as the high pressure cell passes to the Great Australian Bight.

In addition to these synoptic scale effects which cause seasonal variations, the meso-scale phenomenon of a land / sea-breeze system is commonly experienced during summer at Smiths Beach and adjacent coastal regions. This causes variations on a daily time scale, and breezes come from the land in the morning and swing around to come from the sea in the afternoon.

The Bureau of Meteorology has recorded wind data at Cape Leeuwin since 1907 and has prepared wind roses to show seasonal differences in wind patterns. The wind roses for summer and winter are presented in Figure 3.7 and 3.8 respectively.

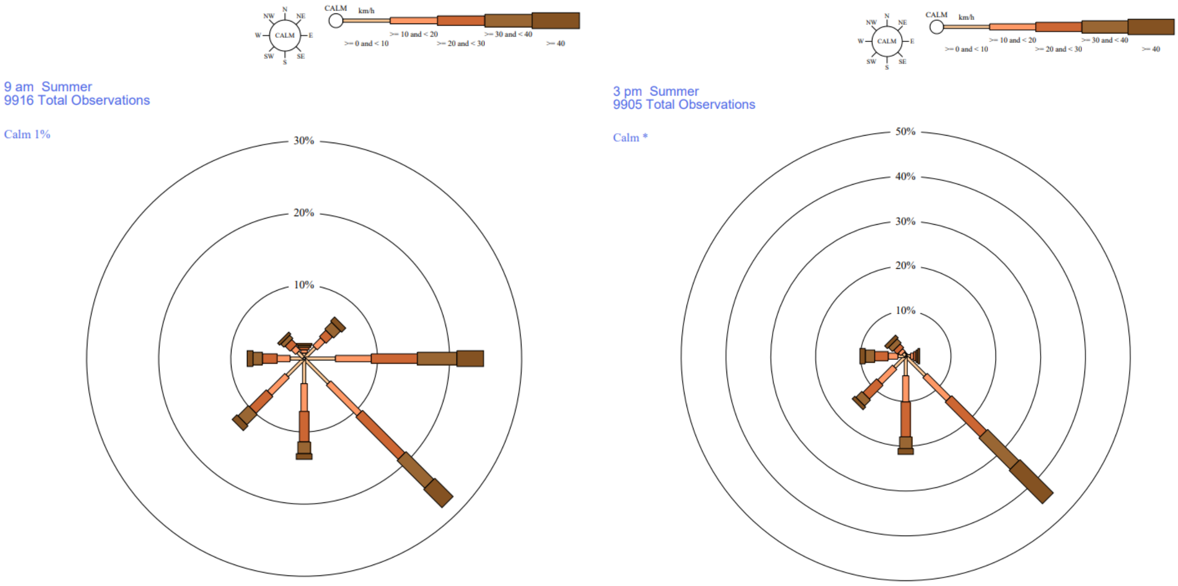

Figure 3.7 Summer Wind Roses for Cape Leeuwin for 9am (left) & 3pm (right)

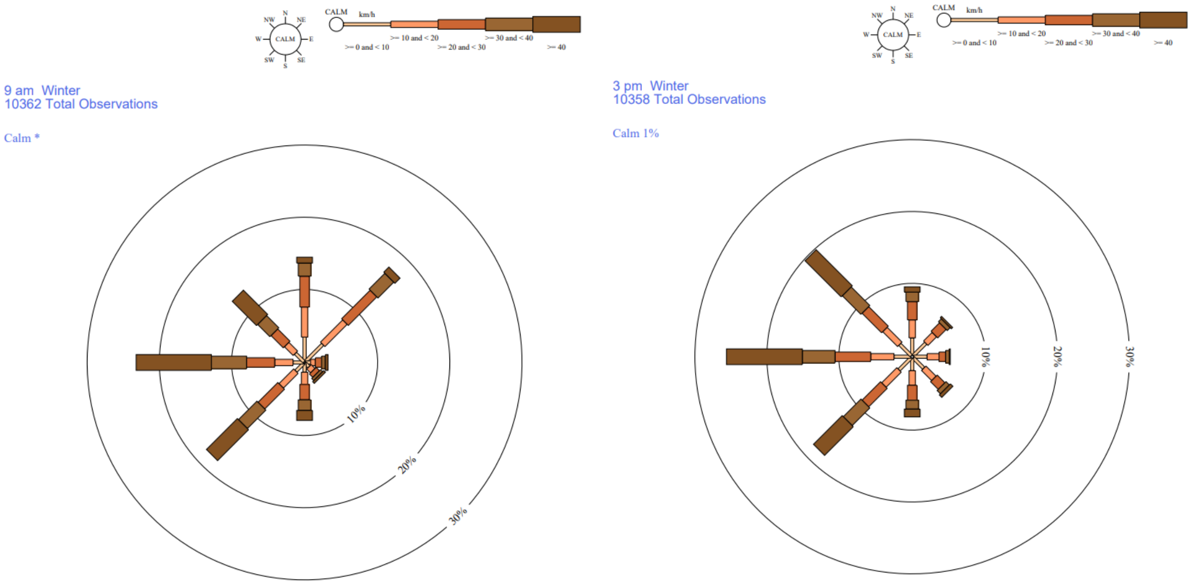

Figure 3.8 Winter Wind Roses for Cape Leeuwin for 9am (left) & 3pm (right)

The wind roses demonstrate the extent of seasonal differences in wind directions, with winds having a strong easterly component in summer and westerly component in winter. Significantly, the wind roses also show that there is a high prevalence of strong winds throughout the year.

3.2.2 Wave Climate

Wave measurements and observations taken in deep water off Cape Naturaliste indicate that the area offshore from Cape Naturaliste experiences reasonably high wave energy (MRA, 2018). Figure 3.9 shows monthly wave climate statistics for the Cape Naturaliste recordings.

The main elements of the offshore wave climate are as follows.

- Average significant wave heights (H_s) are greater than 2 m throughout the year. This average wave height consists mainly of swell wave energy that varies between 1.7 to 2.8 m on average throughout the year. Heights of average sea waves vary between approximately 1.3 to 1.6 m throughout the year.

- Average peak wave periods (Tp) throughout the year predominately correspond to the average peak period of the swell waves, with values of 12 and 13.5 s. Average peak periods for sea waves are typically between 6.5 and 7 s.

- The incident direction (dir) of swell waves is very consistent throughout the year, with directions varying between 233 and 243 degrees. The direction of seas varies between 197 and 253 degrees, with directions being more southerly over the summer months.

As these waves were recorded in a water depth of approximately 50 m, there is the potential for them to be modified by a range of physical processes as they travel from the deep offshore waters towards the shore. However, the high energy nature of the coastal environment around Smiths Beach and the relatively deep waters in the nearshore area, mean that the amount of wave energy arriving at the shoreline is relatively high. This high degree of wave energy is a significant factor in the consideration of local coastal processes.

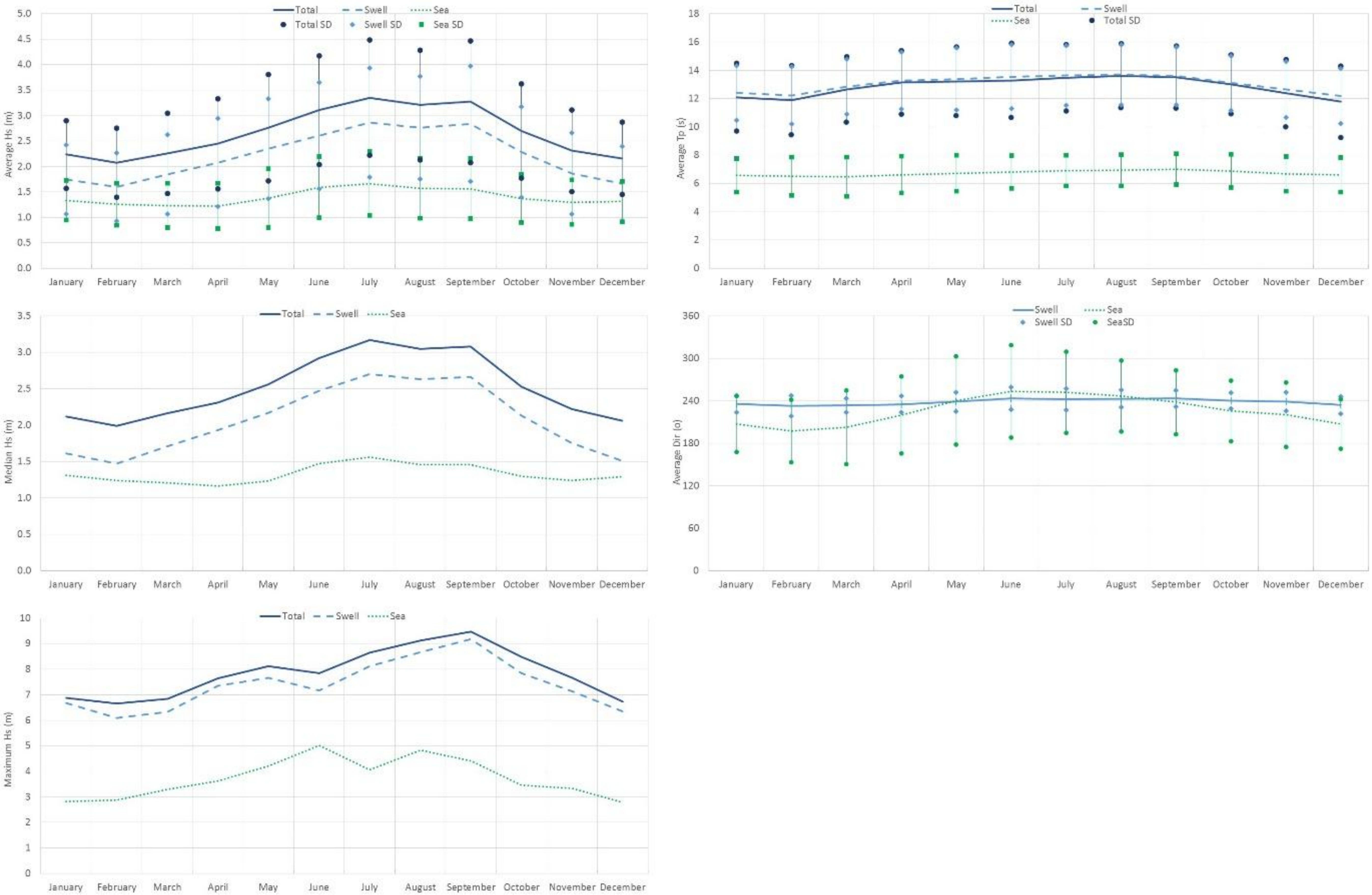

Figure 3.9 Monthly Wave Climate Statistics for Cape Naturaliste Wave Recordings

3.2.3 Tides & Storm Surge

The astronomical tides at Smiths Beach are predominantly diurnal (one tidal cycle each day) and relatively limited in range. The daily range is typically about 0.7 metres during spring tides and about 0.3 metres during neap tides. The spring / neap tidal cycle occur each fortnight.

The following are the main tidal characteristics for Smiths Beach compared to Lowest Astronomical Tide (LAT):

- Highest Astronomical Tide (HAT) = 1.2 m above LAT
- Mean High High Water (MHHW) = 0.9 m above LAT
- Mean Sea Level (MSL) = 0.6 m above LAT
- Mean Low Low Water (MLLW) = 0.2 m above LAT

Seasonal shifts in the sea level occur due to meteorological effects. Typically, the mean sea level at Smiths Beach rises 0.1 metre during winter and falls 0.1 metre during summer. Interannual variations in the Leeuwin Current can cause variations in the mean sea level of a similar magnitude.

During storm events, barometric and wind effects can cause significant storm surges. In typical winter storms, the surge is often about 0.4 metres above the astronomical tide level. The storm surge can be in the order of 1 metre during more severe storms.

4. Coastal Processes

4.1 Characterisation of Existing Shoreline Change

Smiths Beach is a headland-bounded, embayed pocket beach. It is enclosed by resistant rocky headlands and in some sections is fronted by nearshore limestone reef, which together exert strong control over the beach's planform and limit alongshore sediment exchanges with adjacent coasts (Short, 2006; Dean & Dalrymple, 2002). The embayment is effectively a closed sediment compartment, with no significant external sand supply or loss pathways. Consequently, changes to shoreline position are driven primarily by cross-shore processes and the redistribution of sand within the bay itself (Dean & Dalrymple, 2002; Masselink & Short, 1993).

Under the current wave climate, Smiths Beach is exposed predominantly to high-energy southwest to west-southwest swells (Short, 2006). The embayed planform is maintained by the equilibrium between incident wave energy, sediment availability, and the geological controls of the headlands and nearshore reef (Hsu & Evans, 1989; Bowyer & Hsu, 1989). However, seasonal cross-shore sediment cycling is extremely evident along the coastline. This seasonal sediment cycling creates short-term variability in the shoreline position and is generally driven by erosion of the berm and dune toe during storm events which transport sand offshore into subtidal bars, while calmer periods promote the return of sediment landward and the rebuilding of the beach profile (Dean & Dalrymple, 2002; Masselink & Short, 1993).

Evidence of this seasonal sediment cycling is observed on review of available aerial imagery such as that shown in Figure 4.1. This figure presents aerial photographs from February and September 2024. These photographs essentially show the general characteristics of the beach at the end of summer and the end or winter respectively.

The February image, which is approximately the end of summer and is therefore representative of a summer beach profile, shows wide sandy beaches with few obvious offshore bars. The shoreline shape is clearly related to the direction of the incident swell, with clear accumulations in the lee of offshore reefs where refractive and diffractive processes result in a focusing of wave energy.

In contrast, the September image shows narrower beaches with obvious bar and rip formation in the immediate nearshore area. The shape of the shoreline is heavily influenced by the nearshore reef systems, as well as the exposed beach rock, as discussed in Short (2005). Despite these significant changes in position of the waterline (changes up to 40 to 50 m are common), the beach alignment still closely matches the alignment of the incident swell.

The consistency of these seasonal trends is highlighted further in Figure 4.2, which shows images from different years. Whilst there are some differences in the shoreline positions within these images (noting that some of these differences could be accounted for by different months of some of the photos) the general trends remain the same.

Based on these aerial images, there does not appear to be any significant rotation or seasonal transport of sediment along the shoreline within the embayment. This is on the basis that there is no discernible increase in beach width at one end of the embayment accompanied by a corresponding decrease at the other end that would suggest sediment is being transported from one end to the other. Instead, it appears that the beach generally recedes in a reasonably uniform manner, though it is noted that the formation of rips as well as the outflow from Gunyulgup Brook does cause local differences in beach shape, particularly along the southern portion of the embayment.

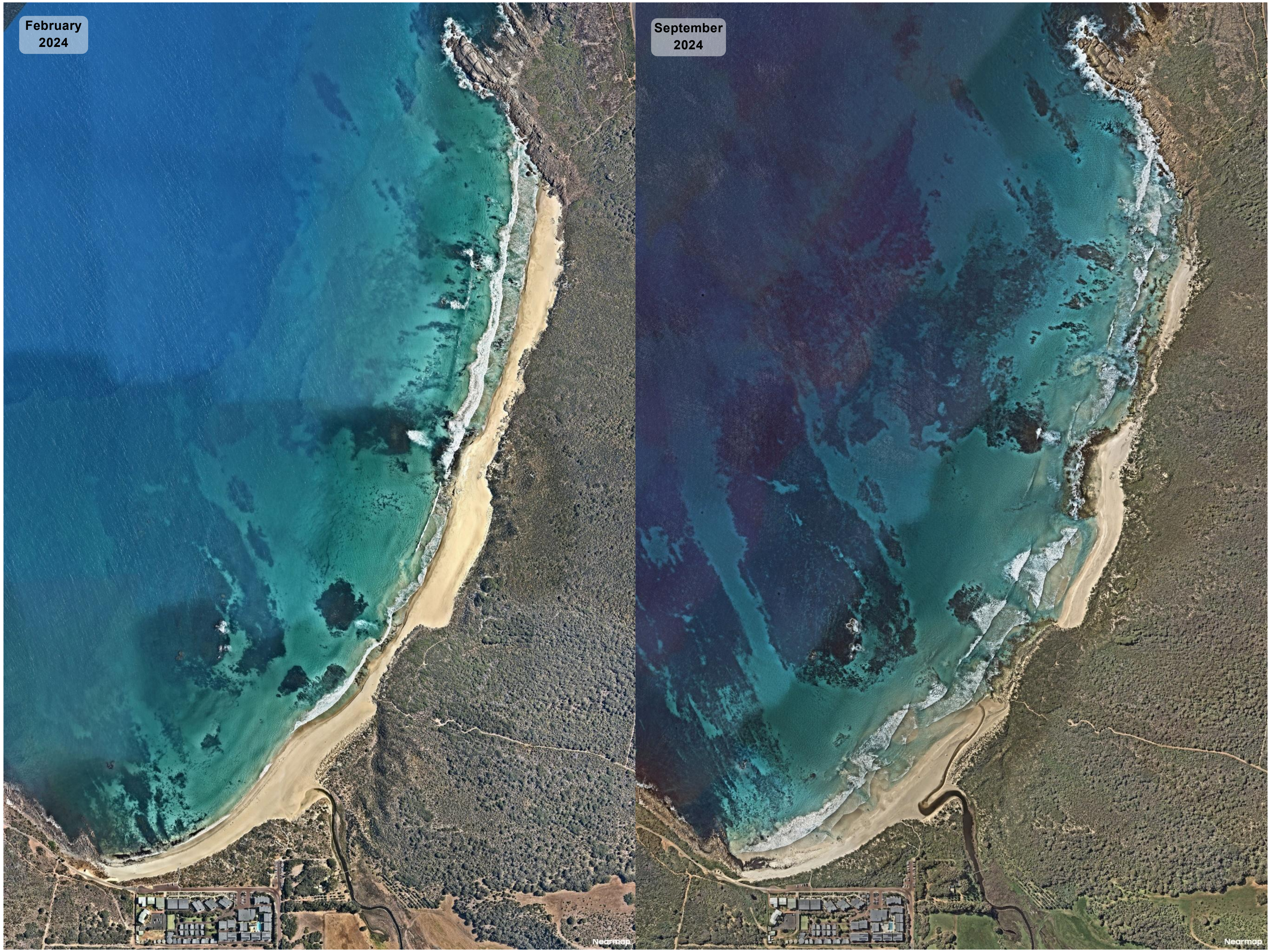

Figure 4.1 Aerial Images Showing Seasonal Differences in Beach Form (Source: Nearmap)

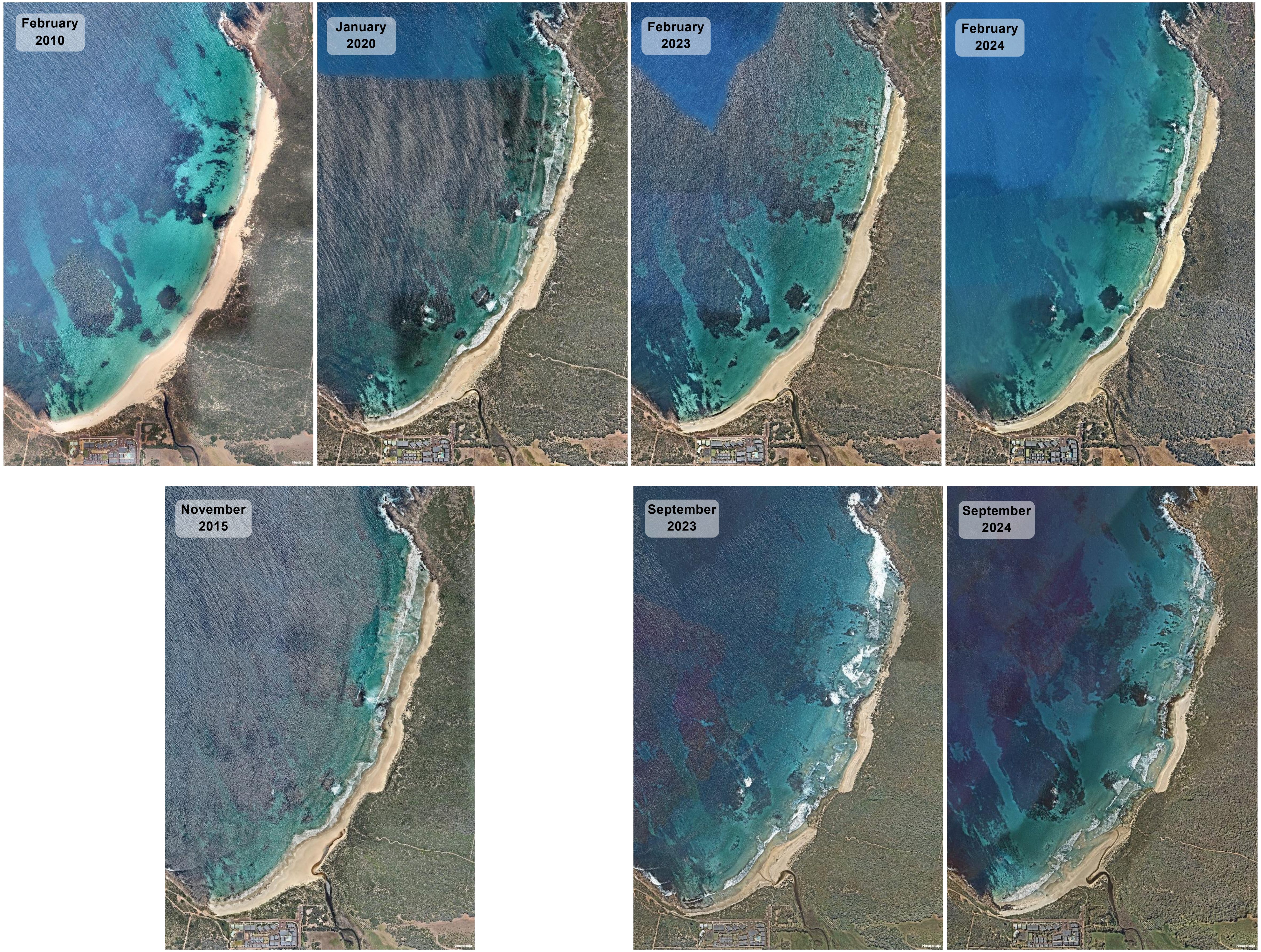

Figure 4.2 Historical Aerial Images Showing Seasonal Variations in Beach Widths (Source: Nearmap)

The relatively uniform seasonal recession of the water line is generally reflective of the dominance that the local swell conditions exert on the Smiths Beach embayment. As shown previously, the Capes coastline is exposed to large swell throughout the year, with reasonably long swell wave periods (average over 12 seconds) and reasonably consistent incident directions. This means that the offshore wave approach is relatively consistent. As these long period swells propagate into the nearshore zone, they interact with the nearshore bathymetry. This bathymetric control induces progressive wave refraction, bending the wave crests to align more closely with the shoreline.

The combination of consistent offshore wave direction, long swell periods, and the refractive influence of the nearshore bathymetry results in waves arriving at the beach at a relatively uniform angle throughout the year. This uniformity in wave approach minimises variability in alongshore sediment transport and reduces the likelihood of significant planform rotation. Consequently, the beach alignment remains close to its equilibrium form, bounded by the headlands at either end of the embayment. This stability is a key factor in maintaining the characteristic planform of Smiths Beach under present conditions, with changes in alignment occurring only under atypical storm or directional wave events (Hsu & Evans, 1989; Short, 2006), with any modifications to the alignment being short lived as a result of the swell dominance.

As noted previously, these cross shore changes result in exposure of rock along the coastline. Whilst the exposed beach rock is more obvious along the northern portions of the embayment, rock is also exposed along the southern extent of the shoreline adjacent to the rock headland. This exposed rock is shown in Figure 4.3. The presence of this rock is consistent with the outcomes of the geotechnical investigations fronting Lot 4131, although the aerial image shows that the rock extends a significant distance along the beach. This rock, like other rock along the shoreline, will exhibit shoreline control and contribute to shoreline stability when the shoreline is in its eroded state.

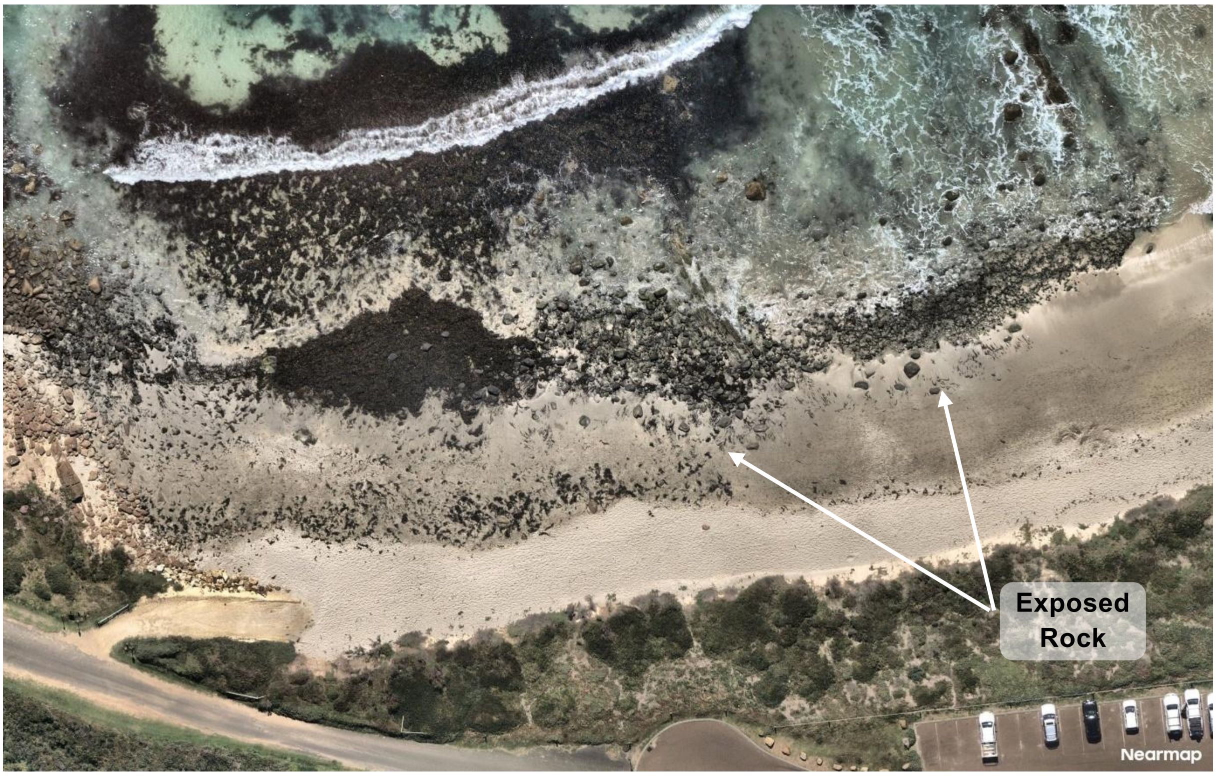

Figure 4.3 September 2023 Aerial Image Showing Exposed Beach Rock Adjacent to the Southern Headland (Source: Nearmap)

Whilst the aerial imagery does not provide any clear indication of seasonal beach rotations, the extent of any potential long term changes also need to be considered. Bishop-Taylor et al (2021) developed a means to assess the extent of historical shoreline changes through detailed interrogation of satellite imagery and computer aided shoreline tracking. The approach by Bishop-Taylor et al maps the median position of the mean sea level (MSL) shoreline for each year. This approach helps suppress short-term shoreline variability and accurately tracks the dominant position of the shoreline annually over the period between 1988 and 2024.

The results of the assessment methodology developed by Bishop-Taylor et al for this section of coastline are shown in Figure 4.4. This figure shows the location of the annual median position of the MSL shoreline for each year. It is clear from this figure that there are fluctuations in the median MSL shoreline position from year to year, however there does not appear to be any obvious trends in shoreline movement that would indicate long term changes. To better interrogate whether any long term changes have been experienced, a series of time history plots have been prepared that show the changes in median MSL position over time. To help interrogate whether these changes have been different across the different sections of the beach, the average median MSL change has been presented for 6 different sections of the embayment. The locations of these sections are shown in Figure 4.5, with the shoreline movement time history plots presented in Figure 4.6.

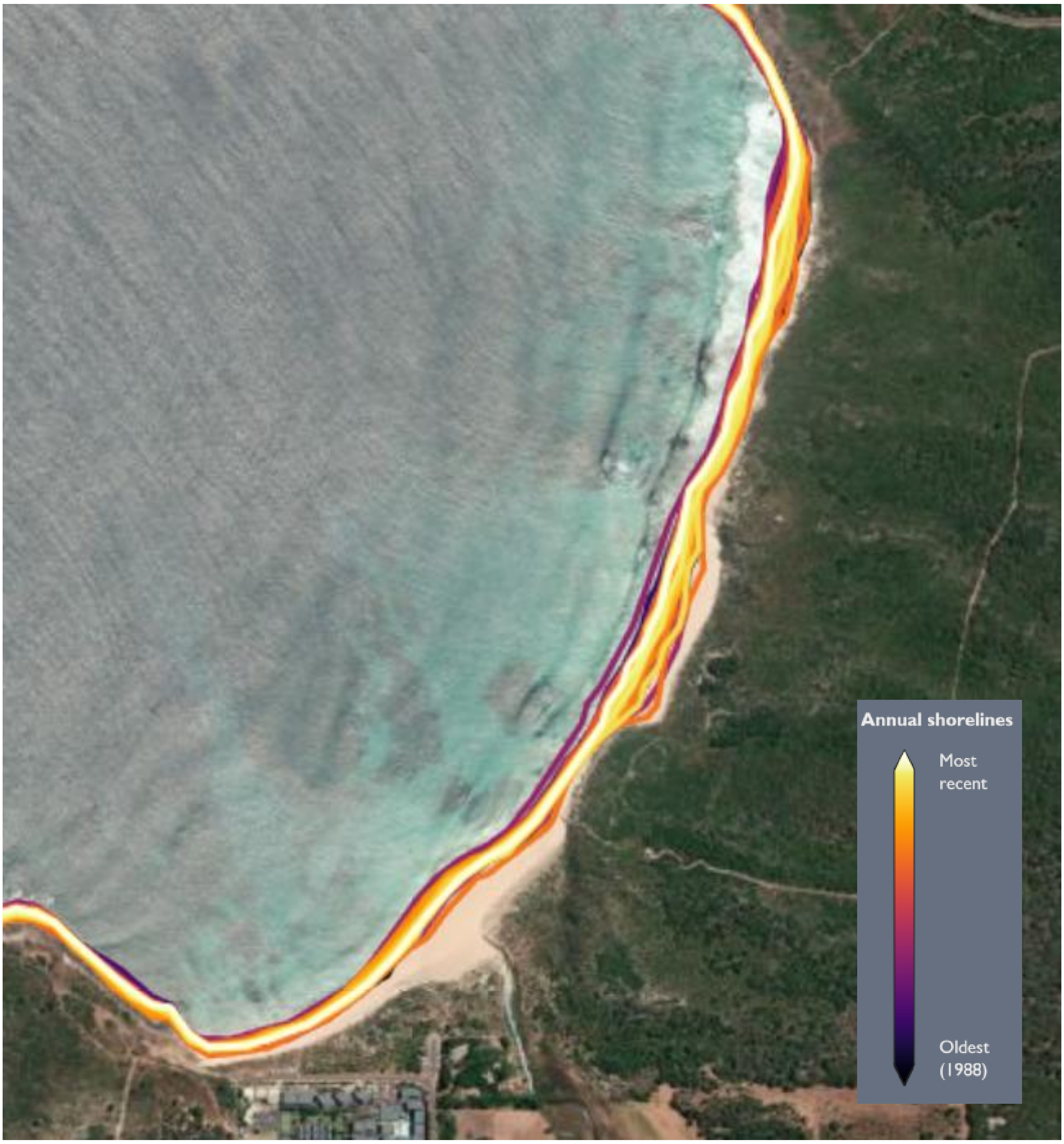

Figure 4.4 Annual Mean Sea Level Contours (Bishop-Taylor et al, 2021)

Figure 4.5 Shoreline Sections used for Time History Plots

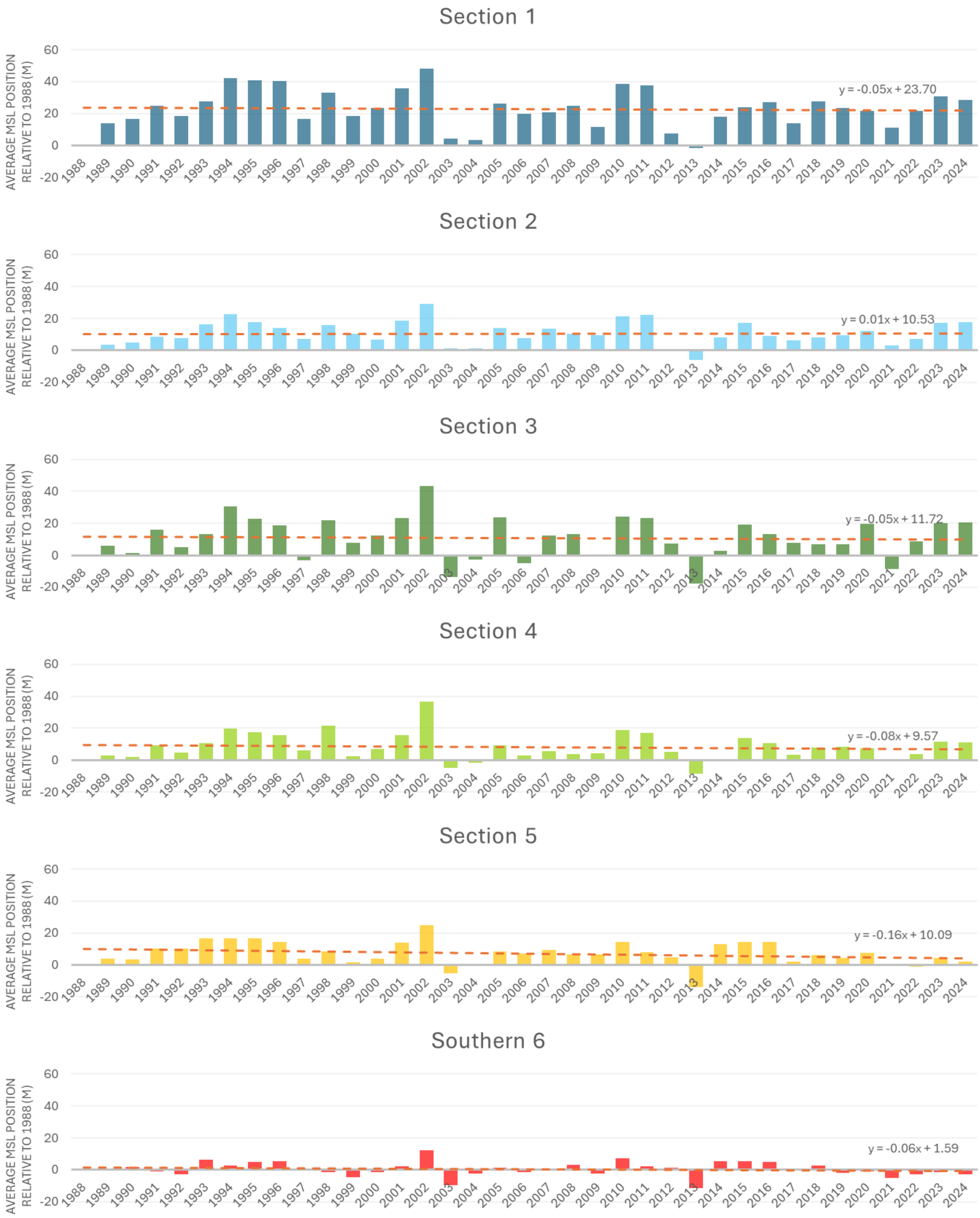

Figure 4.6 Time History of Average Median MSL Shoreline Movement for each Shoreline Section

The time history plots show that there have been significant fluctuations in the median MSL positions from year to year. However the trends of these changes appear to be reasonably consistent across the different sections of the beach. The extent of the changes is also within the range of changes to beach width that were observed in the aerial imagery (up to around 40 to 50 m). There are several potential reasons for this, including differences in storminess from year to year leading to changes in the median MSL position, or potential differences in the number of available photographs over the summer to winter periods resulting in a biasing of the median shoreline position. Regardless of the actual reason, it is not expected that the biases are weighted in one particular direction (towards a narrower or wider beach profile) and therefore the assessment of longer term changes in shoreline position using this data is still appropriate.

To assist in the review of longer term changes, a trendline has been added to each plot. This trendline helps to show the extent of any change to the median MSL position over time. Additionally, an equation for the trendline has also been plotted.

To determine whether the observed changes in shoreline position represent a statistically significant long-term trend or are simply the result of natural variability, a linear regression analysis was undertaken for each monitoring section. The approach compared year to year measurements of shoreline position against time, versus the fitted trendline.

The slope of this line indicates the average rate of change in shoreline position over the monitoring period (metres per year), with positive slopes reflecting accretion and negative slopes reflecting erosion. The figures show that the slopes of the trendlines are relatively flat, indicating that any long term changes have likely been very small. However, as the slope of the trendlines is so slight, a statistical significance test was applied to the slope to assess whether it was meaningfully different from zero. This test considers:

- the magnitude of the slope relative to the short-term variability in the dataset; and
- the number of years of data available (degrees of freedom), which affects the confidence in the result.

A two-tailed probability value (p-value) was calculated (refer to Table 4.1). This p-value represents the likelihood of observing a slope as large as the one calculated, purely by chance, if there were in fact no real underlying trend. Lower p-values indicate a greater likelihood that the observed trend is genuine rather than random noise.

For a 90% confidence level, trends were considered statistically significant when the p-value was less than 0.10. This approach ensures that both the magnitude of change and the inherent variability of the dataset are taken into account, providing a transparent and repeatable basis for distinguishing genuine shoreline movement trends from background fluctuations.

The results show that there is very low confidence that the majority of the trends were actually reflective of real shoreline movement. The highest confidence was from Section 5, for which there is around 85% confidence that the observed trend is real. This suggests that, to an 85% level of confidence the observed erosion rate in this section of coastline is real. The results also suggest that there is around a 60% level of confidence that the slight shoreline erosion observed in Section 6 is real.

Table 4.1 Assessment of Probability that Observed Shoreline Movement Trends are Real

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Trendline Slope (m/year)	-0.048	0.007	-0.047	-0.078	-0.158	-0.063
Slope Standard Error	0.188	0.115	0.198	0.132	0.110	0.069
P-Value	0.801	0.953	0.813	0.558	0.158	0.370

As there is limited evidence of longshore transport of sediment within the embayment, it follows that sediment losses could potentially be caused by an offshore transport of sediment within the embayment itself. Whilst this may seem counterintuitive given the observed persistent impact of swell pushing sediment back onto the shoreline during calmer periods, one possibility is that the impacts of sea level rise could be contributing to the migration of the profile in response to increased water levels.

BoM (2024) presents details regarding observed sea level rise, noting that globally there has been over 22 cm in sea level rise since 1900, with half of this increase occurring since 1970. In the south-west of Western Australia, long term tide gauge and satellite altimetry records show a clear upward trend in sea level consistent with global patterns, though with regional variability. Since 1993, satellite altimetry data (refer Figure 4.7) indicates mean sea level offshore from Smiths Beach has risen at about 2.5 cm per decade, or 2.5 mm per year.

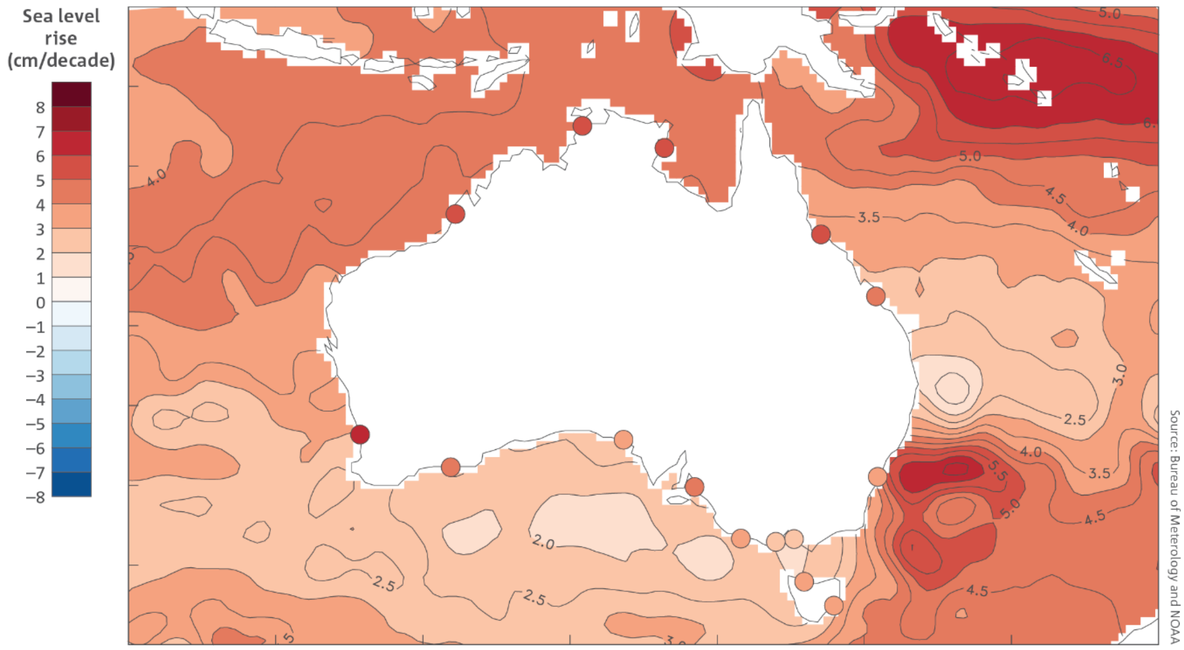

Figure 4.7 Rate of Sea Level Rise Around Australia Measured from Satellite Altimetry between 1993 and 2023 (BoM, 2024)

For embayed shorelines such as Smiths Beach first order estimates of landward shoreline translation under sea level rise commonly adopt the Bruun Rule profile translation concept, while recognising its limitations and the constraining role of local geology in embayments (Dean & Dalrymple, 2002; Ranasinghe, 2016).

The Bruun Rule relates the recession of the shoreline to the sea level rise and slope of the nearshore sediment bed:

$$R = \frac{1}{tan(\theta)}S$$

where: R = recession of the shore.

θ = average slope of the nearshore sediment bed.

S = sea level rise.

The basic notion behind the Bruun Rule is that a sea level rise would cause erosion of the upper beach, and transference of sand from the beach to the adjacent sea floor would, in due course, restore the previous transverse profile in relation to the higher sea level (Bird 2000; Komar 1998). As a result, Bruun Rule analyses are often presented in terms of ratios between the increase in sea level and the corresponding retreat of the shoreline.

Nevertheless, it is expected that recession would not be spatially uniform across the bay. Where the active profile is pinned by headland controls or shallow nearshore rock, the capacity for upward and landward profile translation is reduced, and shoreline change tends to manifest as concentrated dune toe erosion and intermittent exposure of rock rather than uniform retreat. Conversely, in the more mobile central sector of the bay where the active profile is wider and less constrained, greater landward translation is expected. Accordingly, a reasonable spatialised expectation for sea level rise at Smiths Beach would be for lesser recession adjacent to headlands or areas where beach rock influences the profile, and greater recession in the central embayment, with local departures where reef focuses or dissipates wave energy (Short, 2006; Dean & Dalrymple, 2002; Woodroffe et al., 2022). These patterns reflect the closed sediment budget of the pocket beach (i.e., no external nourishment from alongshore drift) and the well documented influence of geological constraints on embayed shoreline response, rather than any assumed change in planform due to wave direction shifts (Short, 2006; Woodroffe et al., 2022; Ranasinghe, 2016).

The above description explains the variability in observed shoreline behaviour for each of the different shoreline sections within the Smiths Beach embayment, with:

- limited confirmed changes across shoreline sections 1 to 4, potentially due to the increased presence of beach rock;
- a higher certainty of retreat in shoreline section 5 due to the shoreline being relatively central within the embayment and predominately sandy with no observed presence of extensive beach rock; and
- a moderate level of certainty that a slight rate of erosion has been experienced within shoreline section 6 – an area that has observed rock below the beach and is also close to the adjacent headland.

Using the results from BoM (2024) (assuming a 2.5 mm per year increase in sea levels) the potential erosion rates of 0.158 and 0.063 m per year for shoreline sections 5 and 6, respectively, result in potential ratios of sea level rise to shoreline retreat of approximately 1:63 for shoreline section 5 and 1:25 for shoreline section 6. By way of comparison, these ratios are far lower than the ratio of 1:100 adopted within SPP2.6.

In addition to the longer term (chronic) shoreline change, which is plausibly largely related to the influence of sea level rise, the impact of severe storm erosion can also affect the position of the shoreline. MRA (2021) completed modelling of the potential impact of a 100 year average recurrence interval event on the shoreline. The modelling indicated that erosion of approximately 10 m of the dune system could be experienced during such an event. Although such erosion can temporarily alter the position of the shoreline in the period immediately following a storm event, the prevailing coastal processes ensure that sediment removed from the beach face and dune and deposited in the adjacent subtidal bar remains within the active system. During calmer swell conditions, this material is typically re-mobilised and transported landward, contributing to natural beach recovery. Over time, this would reform the beach face and dune, although the timescale for dune repair often spans many years.

4.2 Expectations of Future Coastal Change

Through characterisation of the existing shoreline change, the following key outcomes from the previous section can be used to detail how the shoreline can be expected to change in the future.

- Smiths Beach is a headland-bounded, embayed pocket beach with no significant alongshore sediment exchange. It is a closed sediment compartment.
- Geological controls (rocky headlands, nearshore limestone reefs, exposed beach rock) strongly influence beach planform and limit profile mobility near boundaries.
- The wave climate is dominated by high-energy swells with long periods (> 12 s) and consistent approach angles, reinforced by refraction over nearshore bathymetry meaning that the alignment of swell at the shoreline is very consistent.
- Seasonal cross-shore sediment cycling is very pronounced, with storm events moving sand offshore into bars and calmer conditions driving onshore return and natural profile recovery.
- Aerial imagery and shoreline tracking show uniform seasonal recession with no persistent planform rotation; annual shoreline position fluctuations up to 40–50 m are common.
- Statistical analysis of shoreline data from 1988 to 2024 indicates minimal long-term trend, with only shoreline sections 5 and 6 showing moderate confidence in a small erosion signal.
- Based on available satellite altimetry data, the apparent ratio of sea level rise to coastal recession could be in the order of 1:25 for the shoreline close to the southern headland, increasing to 1:63 for sandy shorelines closer to the middle of the embayment. Statistically significant recession has not been noted along the northern sections of the embayment where rock is present.
- Storm bite modelling for a 100-year ARI event suggests that around 10 m of dune erosion could occur, but sediment would remain in the system and is would generally be reworked back onshore over time.

Based on these key findings it is expected that future shoreline change at Smiths Beach will occur primarily through parallel landward translation of the existing beach alignment in response to chronic drivers such as sea-level rise, interspersed with acute storm driven erosion and recovery cycles.

The dominant control on future alignment will remain the consistent swell regime and the refractive influence of the nearshore bathymetry and reef structures, which act to stabilise wave approach and minimise longshore variability. Consequently, planform stability will persist, with erosion expected to result in a largely parallel movement of the shoreline rather than exhibiting significant rotational change. Nevertheless, some degree of spatial variability in future erosion magnitude is possible due to differences in geological exposure:

- Central embayment (e.g. Section 5): Predominantly sandy with limited rock control; likely to experience the greatest recession under projected sea-level rise scenarios.
- Southern sector adjacent to headland (e.g. Section 6): Expected to undergo less erosion than central areas due to combined sheltering from the headland, reduced wave energy exposure, and the stabilising influence of underlying and intermittently exposed beach rock.
- Northern sector: Similar moderating influence where beach rock is present, though exposure to prevailing swell may result in localised variability.

In summary, the long-term evolution of Smiths Beach under projected sea-level rise, which is considered the dominant driver for future change, is expected to be characterised by a shore-parallel recession of the existing equilibrium alignment, with erosion magnitude modulated by localised geological and hydrodynamic sheltering effects. These patterns, combined with the embayment's closed sediment budget, will continue to shape its adaptive response, with central sandy areas receding most and rock-influenced sectors receding least.

4.3 Impacts of Proposal on Shoreline & Local Coastal Processes

Establishment of the fact that current and future coastal change is likely to see a shore-parallel recession of the existing equilibrium alignment is a key factor in determining the potential impact of the proposal on the shoreline and the local coastal processes. Based on the findings of this assessment, the following changes are expected.

- The southern shoreline within the Smiths Beach embayment will recede as sea level rises. The extent of this recession is likely to be higher along the shoreline slightly further north (shoreline section 5) than it is along the southern section of shoreline fronting Lot 4131 (shoreline section 6). The smaller recession of the shoreline fronting Lot 4131 is due to:
  - the extra protection provided by the rock headland;
  - the presence of beach rock fronting the site (that is observed during times of narrow beach widths during winter months); and
  - the confirmed presence of rock determined as part of the geotechnical assessment for Lot 4131.
- The recession of the shoreline fronting Lot 4131 will continue until such time that the existing natural rock or the proposed seawall is exposed. This is significant, as the presence of natural rock in the area directly fronting the majority of the seawall (particularly

at the western end of the proposed seawall but tapering away towards the east) would mean that a sandy shoreline would likely not exist in this area regardless of whether a seawall was constructed (as evidenced by the beach rock observed during periods of narrow beach widths over winter, as well as from the results of the geotechnical assessment).

- Given the shore-parallel nature of the shoreline recession, the exposure of the seawall would not be expected to have any significant impact on the adjacent shoreline alignment (i.e. the sections of shoreline to the north east of the seawall), nor would it be expected to cause any downdrift erosion impact, as it has been established that there is limited observable longshore sediment transport along the coastline.
- If the shoreline was to continue to recede following exposure of the seawall, then the areas immediately adjacent to the seawall would continue to erode and this could lead to erosion around the edge of the seawall, however it is noted that if this was to occur then adjacent infrastructure, including Smiths Beach Road, the Canal Rocks Beachfront Apartments and the Smiths Beach Resort would all be impacted.

The key uncertainty with respect to the changes outlined above, is the extent of shoreline recession that could occur. The coastal erosion hazard allowances determined using the assessment methodology outlined in SPP2.6 provide a conservative estimate of future change. These coastal hazard allowances were presented in Figure 2.1.

These allowances could be considered to be the “worst case” scenario for shoreline retreat given the deliberately conservative allowance adopted within the policy (to support coastal planning). However, as demonstrated previously, the actual rates of recession expected for the area fronting the development are potentially much lower. The main component of this difference is the fact that the assessment of shoreline movement for the existing coastline estimated a ratio of sea level rise to shoreline recession of 1:25 for the area fronting Lot 4131. This is significantly less than the 1:100 multiplier adopted within SPP2.6. The ratio of 1:25 also fits very well with the assessed slope of the beach over the active profile zone with is approximately 1V:23H. On this basis, the use of the calculated shoreline recession ratio would provide an indication of the “more likely” shoreline movement. Details of the extent of “more likely” shoreline movement are provided in Table 4.2.

Table 4.2 More Likely Shoreline Movement Allowances within Shoreline Section 6

	Storm Erosion Allowance (m)	Allowance for Long Term Trends (m)	Allowance for Sea Level Rise (m)	Allowance for Uncertainty (m)	Total Allowance (m)
2043	10	0	3	4	17
2073	10	0	10	10	30
2123	10	0	25	20	55

It should be noted that the values in Table 4.2:

- include the allowance for storm erosion modelled by MRA (2021) for the shoreline fronting Lot 4131;
- don't include an allowance for long term trends as there is no evidence of long term trends across the shoreline, only evidence of potential response to sea level rise;
- include allowances for sea level rise based on increases in sea level of 0.11 m, 0.38 m and 0.97 m across the respective timeframes; and
- includes a 0.2 m per year allowance of uncertainty to account for additional shoreline changes that may not be covered by the above allowances.

Using the allowances in Table 4.2 combined with the outcomes from the City's CHRMAP, it is possible to plot the potential shoreline alignments associated with the "worst case" and "most likely" shoreline positions. Note that the potential positions of the shoreline have been estimated based on the potential rock levels adjacent to the headland and the expected protection provided by the seawall constructed within Lot 4131. These alignments are intended to be indicative of the future shoreline positions. These shoreline positions are plotted in Figure 4.8.

Figure 4.8 shows a significant increase in the potential exposure of the shoreline associated with the SPP2.6 "worst case" scenario. Under this scenario it is expected that significant erosion would impact the existing infrastructure beyond 2043, at which stage the seawall would be at risk of flanking erosion. Beyond this time, increasingly significant loss of all infrastructure would be expected, though it is noted that this is not consistent with the approach outlined in the City's CHRAMP.

Reviewing the impacts from the "more likely" scenario, it is anticipated that the seawall would provide protection to the development on Lot 4131 through to 2073. Beyond this time there would be increasing likelihood of impacts to adjacent development with some impact to the foreshore area within Lot 4131, though it is unlikely that any significant infrastructure within Lot 4131 would be exposed.

Nevertheless, it is important to reiterate that if there was to be loss of some of the foreshore within Lot 4131 then there would also be complete loss of the foreshore in the areas fronting the adjacent development, as well as loss of some of the adjacent development, including Smiths Beach Road. The complete loss of foreshore fronting existing development and the loss of actual development itself is expected to be a disproportionately larger impact than a small loss of foreshore area within Lot 4131. This finding is consistent with the outcomes of the City's Council-endorsed CHRMAP which considered the coastal hazard risks and completed a review of potential adaptation actions before determining that a seawall should be built in this location to protect existing assets.

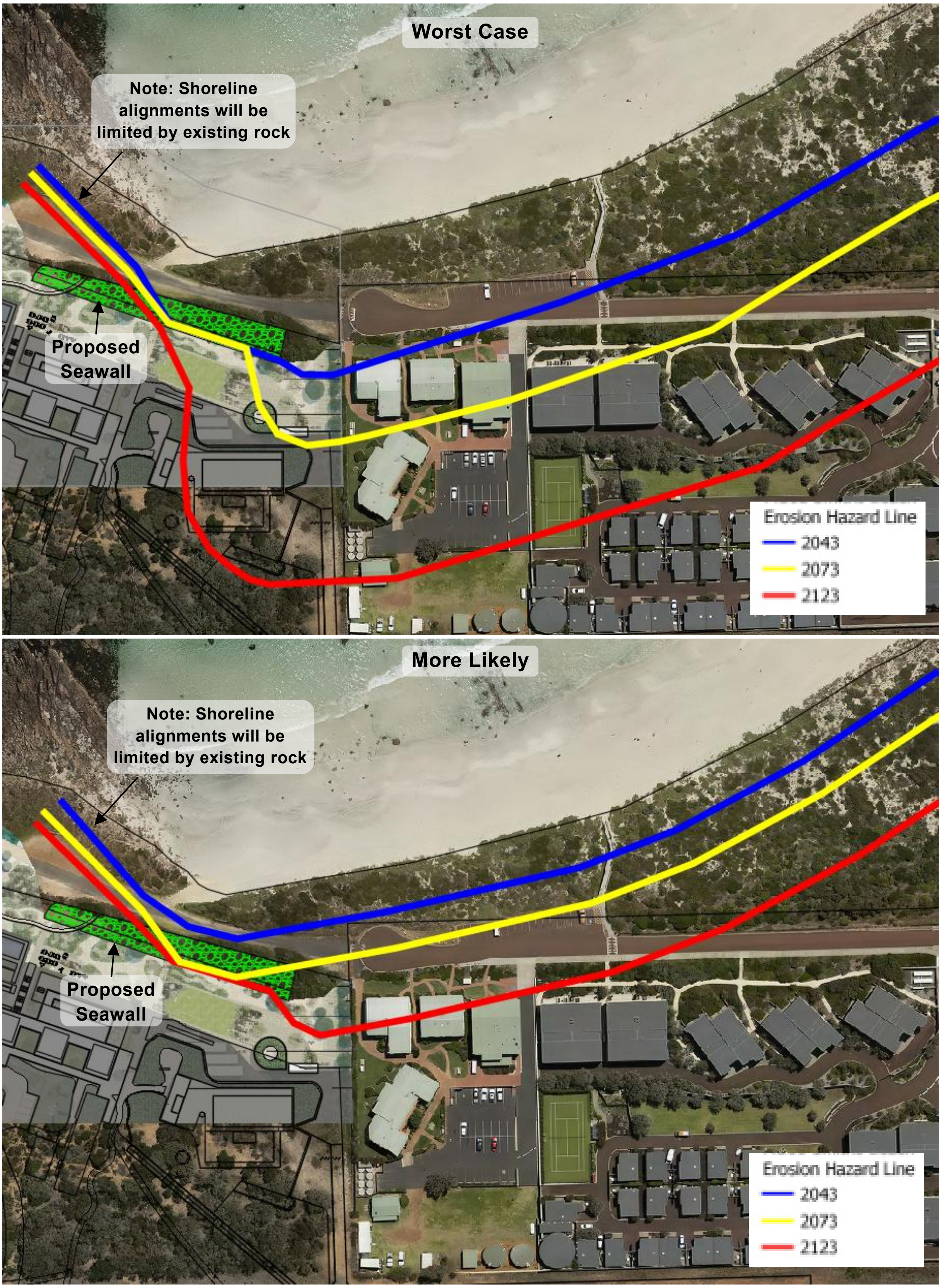

Figure 4.8 "Worst Case" & "More Likely" Shoreline Alignments fronting Lot 4131

In summary, the proposal seeks to construct a buried seawall within the boundary of Lot 4131. This seawall would be located approximately 20 m from the active beach area at its closest point and would have absolutely no impact on the current coastal processes whilst it remains buried.

At some point in the future the buried seawall would become exposed, however even when this occurs:

- it is likely that the majority of the shoreline fronting the seawall would be rocky, as evidenced by the visible beach rock during periods of reduced beach width in winter and from the results of the geotechnical investigation, and

- the seawall would not have any significant impact on the coastal processes within the Smiths Beach embayment.

The only potential adverse impact would be flanking erosion around the eastern end of the seawall if the seawall had not been extended to protect the adjacent infrastructure. However, the assumption that the seawall would not be extended seems highly unlikely, given the requirements of SPP2.6 and the City's CHRMAP which considered a range of different adaptation strategies for the area and ultimately determined that the construction of a seawall to protect the existing private and public assets was the preferred option.

5. Conclusion

The coastal processes assessment confirms that the proposed development, including the construction of a buried seawall within Lot 4131, will not result in any adverse impacts to the natural coastal dynamics of Smiths Beach. The site's geomorphic setting, limited longshore sediment transport, and the protective influence of existing rock formations ensure that shoreline changes will continue to occur in a predictable, shore-parallel manner, independent of the proposal. While the seawall will remain buried for the foreseeable future, even its eventual exposure will not alter adjacent shoreline alignment (i.e. the alignment of shorelines to the north east of the seawall) or cause downdrift erosion. Furthermore, the shoreline directly fronting the seawall is likely to be rocky following the occurrence of shoreline recession so any loss of sandy beach as a result of the seawall construction is expected to be minimal. The proposal is therefore fully compatible with the ongoing stability and function of the local coastal system.

6. References

Bishop-Taylor, R., Nanson, R., Sagar, S., Lymburner, L., 2021. *Mapping Australia's dynamic coastline at mean sea level using three decades of Landsat imagery*. Remote Sensing of Environment, 267, 112734.

Bowyer, R. & Hsu, J.R.C. (1989). Parabolic bay shapes and applications to coastal engineering. Journal of Waterway, Port, Coastal, and Ocean Engineering, 115(5), 556–570.

Bureau of Meteorology (2024). State of the Climate 2024. https://www.bom.gov.au/state-of-the-climate/oceans.shtml accessed 25/08/2025.

Dean, R.G. & Dalrymple, R.A. (2002). Coastal Processes with Engineering Applications. Cambridge University Press.

Eliot, I., Short, A.D., & Branson, P. (2011). Geomorphology and coastal management of Western Australian beaches. Journal of Coastal Research, SI(64), 55–69.

Environmental Protection Authority (2016). *Environmental Factor Guidelines: Coastal Processes*. Government of Western Australia, Perth.

Golder Associates, 2021. *Smiths Beach Development – Preliminary Geotechnical and Pavement Investigation.* Prepared for Smiths 2014 Pty Ltd.

Harley, M.D., Turner, I.L., Short, A.D., & Ranasinghe, R. (2011). A re-evaluation of coastal embayment rotation: The dominance of cross-shore versus alongshore processes. Journal of Geophysical Research: Oceans, 116(C7).

Hsu, J.R.C. & Evans, C. (1989). Parabolic bay shapes and applications. Proceedings of the Institution of Civil Engineers, Part 2.

IPCC (2021). Climate Change 2021: The Physical Science Basis. Cambridge University Press.

Masselink, G. & Short, A.D. (1993). The effect of tide range on beach morphodynamics and morphology: A conceptual beach model. Journal of Coastal Research, 9(3), 785–800.

M P Rogers & Associates Pty Ltd (MRA), 2018. *Design Event Selection for Erosion Hazard Assessments – West & South Coasts of WA R1004 Rev 2*. Prepared for Department of Transport.

Playford, P.E., Cockbain, A.E., & Low, G.H. (1976). Geology of the Perth Basin, Western Australia. Geological Survey of Western Australia Bulletin 124.

Ranasinghe, R. (2016). Assessing climate change impacts on open sandy coasts: A review. Earth-Science Reviews, 160, 320–332.

Semeniuk, V. (1997). The Quindalup Dunes: the regional system, physical framework and vegetation habitats. Journal of the Royal Society of Western Australia, 80, 67–88.

Short, A.D. (2005). *Beaches of the Western Australian Coast: Eucla to Roebuck Bay.* Sydney University Press.

Short, A.D. (2006). Australian beach systems—nature and distribution. Journal of Coastal Research, 22(1), 11–27.

WAPC 2013. *Statement of Planning Policy No. 2.6 – State Coastal Planning Policy*. Western Australian State Government, Perth.

Woodroffe, C.D., Carvalho, R.C., Oliver, T.S.N., & Thom, B.G. (2022). Sediment dynamics at different timescales on an embayed coast in southeastern Australia. Journal of Coastal Conservation, 26, 21.

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