South Thomson Bay Barge Development

Coastal Processes Assessment

26 February 2025 | 14029.101.R1.Rev2

Innovation Engineered.

baird.com

South Thomson Bay Barge Development

Coastal Processes Assessment

Prepared for:

Rottnest Island Authority
1 Mews Road
Fremantle WA 6160

Prepared by:

Baird Australia Pty Ltd as Trustee for the Baird Australia Unit Trust
ACN 161 683 889 | ABN 92 798 128 010

For further information, please contact
Rhian Wardley at +61 8 6255 5080
rwardley@baird.com
www.baird.com

14029.101.R1.Rev2

Z:\Shared With Me\QMS\2025\Reports_2025\14029.101.R1.Rev2_SouthThomsonBargeDevelopment_CoastalProcessesAssessment.docx

Revision	Date	Status	Comments	Prepared	Reviewed	Approved
RevA	18/12/2023	Draft	For Client Review	RW	JC	JC
Rev0	2/2/2024	Final	Issued Final	RW	JC	JC
Rev1	14/2/2024	Final	Issued following client comment	RW	JC	JC
Rev2	26/2/2025	Re-Issue	Re-issue to incorporate Peer Review comments	RW	JC	JC

This document was prepared by Baird Australia Pty Ltd as Trustee for the Baird Australia Unit Trust for Rottnest Island Authority. The outputs from this document are designated only for application to the intended purpose, as specified in the document, and should not be used for any other site or project. The material in it reflects the judgment of Baird in light of the information available to them at the time of preparation. Any use that a Third Party makes of this document, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Baird accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this document.

Executive Summary

We acknowledge the Traditional Custodians of this Island, the Whadjuk people of the Noongar Nation, their ancestors and their Elders past, present and emerging. We acknowledge and respect their continuing culture and the contribution they make to the life of this Island and this region.

Wadjemup (Rottnest Island) is an A-class nature reserve of ecological, cultural, and social significance, with the island currently supplied with bulk cargo via the roll-on-roll-off vessel which docks at the barge ramp located near the base of the Main Ferry Wharf. Following identification in the Rottnest Island Master Plan – 20 Year Vision (RIA 2019) of the need to improve the functionality and efficiency of transporting bulk cargo to and from Wadjemup, investigations and studies have been undertaken to determine a design and method to convert the former Army Jetty (currently Army Groyne) site in South Thomson Bay into a barge landing development to move these activities away from the Main Ferry Wharf site.

A range of concept designs have been formulated and investigated since, with the concept developed by AECOM in their Value Engineering of Concept Design reporting (AECOM 2020) to be assessed in this Coastal Processes Assessment report. Assessment has been made here of the impact of the proposed barge development on the coastal processes acting within South Thomson Bay, including wave conditions, sediment transport pathways, wrack dynamics and the impact of wave penetration within the proposed harbour basin of the barge development.

To assess the impacts of waves on the proposed South Thomson Bay Barge Development, review was undertaken of the modelling that was performed in MRA's 2019 coastal processes assessment, with further wave modelling undertaken for the option evaluated in this assessment subsequently carried out. Data from a four-year modelled hindcast was used to determine representative swell and sea conditions to be used in the comparison of wave climate with and without the proposed barge ramp structure at the Army Groyne. The greatest influence on wave climate post-construction is seen for waves that approach the proposed site from the north, due the extension of the breakwater into Thomson Bay. For shorelines on the east of the groyne that are in the lee of the breakwater there is lower wave penetration to the shoreline. For the majority of wave hindcast conditions, the difference in wave climate post-construction at the shoreline in the lee is less than 0.15m. For northerly wave conditions the differences are up to 0.4m. Whilst these differences in wave height are small, the location has a low-energy wave climate hence the comparative reduction in wave energy for the shoreline on the east of the groyne is of note.

The impact on wave conditions outside of the proposed barge facility breakwater structure is minimal, with decreases in wave height being the main observation across each of the cases. While no detrimental increase in wave height caused by reflections from the breakwater structure is seen at the moorings managed by RIA in these model results, further investigation of this should be undertaken in the detailed design phase using a wave phase resolving model, as a model of this kind is more suitable for investigating the complexity of reflected wave interactions as well as resolving wave diffraction in the lee of the structures.

An assessment of the sediment transport pathways that make up the sediment budget of the coastal compartment along South Thomson Bay is important for determining the impact that a coastal structure may have on these pathways, and therefore the overall function of this sediment compartment. Assessment was made of the cross-shore sediment transport pathways, the longshore sediment transport pathways, the aeolian sediment transport pathways, as well as the overall sediment budget expected when considering each of these pathways. Finally, an assessment of the impact of climate change on the sediment dynamics was carried out, along with the impact that the proposed barge development may have on the sediment dynamics of South Thomson Bay.

It is considered unlikely that the barge development would have a significant impact on the sediment dynamics along the western side of the development in South Thomson Bay as the existing Army Groyne has posed a barrier to sediment transport in this region since it's construction. In the lee of the structures the shoreline is predicted to accumulate sediment once the development breakwater is established. Presently, longshore transport of sediment to this section of the shoreline occurs in summer months and is naturally cleared from the eastern side of the Army Groyne in early winter by storms. There is the strong potential for the sediment transport pathway that moves sediment away from the Army Groyne in early winter months to be interrupted by the breakwater and for sediment in this area to continue to accumulate if not managed by the RIA.

An assessment of the expected impacts of wrack accumulation on the proposed design layout was required to determine any negative effects that may be experienced through the interruption of regular wrack dynamics and movement along the beach in South Thomson Bay. It is considered that the proposed development of the South Thomson Barge Landing will not have a significant impact on the timing or volume of wrack accumulation across the beaches on the western side of the development in Thomson Bay, further than the impact that the Army Groyne already has on the dynamics in South Thomson Bay. However, the impact of the structures on wrack dynamics in the lee of the structure and the shoreline to the east of the development presented in Baird (2025) shows there is a strong potential for the wrack to become trapped in this region post construction. The process to manage buildup of wrack within the footprint of the breakwater structure is discussed further in the site specific CHRMAP report (Baird 2025).

An assessment of wave penetration into the harbour basin has been undertaken based on the diffraction curves of Goda (2010). Waves approach the South Thomson Bay site from the north for approximately 50% of the year, and the analysis of diffracted wave conditions at the barge ramp indicate the barge landing location is well sheltered from swell wave conditions that arrive from the north. The breakwater reduces waves at the barge ramp by approximately 40%, with the diffracted swell wave arriving at the stern of the vessel. Wind sea waves arrive at the site from the northeast for approximately 30% of the year. The diffraction curves show the breakwater reduces these incident waves by approximately 30%, with waves arriving at the vessel stern. Wave conditions from the east represent a small proportion of the annual seastate (~2%). The configuration of the breakwater in the design layout does not provide protection from this direction and it is assumed these conditions would reach the barge ramp unchanged. The waves will approach the barge ramp approximately in line with the vessel stern at 0.44 to 0.5m significant wave height.

This analysis of wave penetration indicates the wave conditions are reduced by the structures for approach directions from the N and the NE which are the dominant wave conditions at the location. An understanding of the limiting conditions of the barge vessel would allow for further analysis of potential downtime at the barge ramp. The wave conditions at the landing are approximately in line with the barge ramp alignment, and it is expected that the vessel would manage these types of conditions when at the ramp. As the vessels manoeuvre into or away from the facility within the turning circle, the waves would be more 'beam on' to the barge (i.e., 90 degrees to the vessel) and this would be more problematic. This analysis does not consider reflection of waves from the structures or bi-modal seastates that can occur in the area during winter when swell waves from the north are coupled with sea waves from the east. Further assessment of these conditions as part of more detailed wave penetration modelling in the detailed design phase is recommended.

Table of Contents

Tables

Figures

1. Introduction

Wadjemup (Rottnest Island) is an A-class nature reserve of ecological, cultural, and social significance. The island is currently supplied with bulk cargo via the roll-on-roll-off vessel which docks at the barge ramp located near the base of the Main Ferry Jetty. Following identification in the Rottnest Island Master Plan – 20 Year Vision (RIA 2019) of the need to improve the functionality and efficiency of transporting bulk cargo to and from Wadjemup, to reduce noise levels for residents, and to improve safety and amenities for visitors arriving at the island, investigations and studies have been undertaken at the Army Groyne. This includes studies to determine a design and method to convert the former Army Jetty (currently Army Groyne) site in South Thomson Bay into a barge landing, freight handling and associated storage area to aid in reducing heavy vehicle traffic around Wadjemup's main jetty in the Main Settlement area.

Initial concept designs prepared by Wallbridge Gilbert Aztec (WGA) in late 2018 were used by MP Rogers and Associates (MRA) in their South Thomson Bay Coastal Processes Assessment (MRA 2019), with further development of the first option being undertaken by BMT in 2020. Following these assessments, AECOM were engaged by the Rottnest Island Authority (RIA) to undertake a high-level value engineering assessment of this concept design, aiming to identify opportunities to reduce capital costs, while maintaining the key functional/user requirements achieved by the initial concept design.

The concept developed by AECOM in their Value Engineering of Concept Design reporting (AECOM 2020) is the concept that will be used in this updated Coastal Processes Assessment report.

1.1 Study Site

Wadjemup is located approximately 20 kilometres west of the port of Fremantle in Western Australia. The island is a remnant of the Pleistocene dune ridges and is surrounded by large quantities of coral reefs and rock formations. It is a popular tourist attraction with over 780,000 visitors to the Island annually enjoying short stay accommodation and recreational activities including snorkelling, bike riding and site seeing (WA Govt 2019). Tourists enter Wadjemup via ferry services disembarking on the island's Main Ferry Wharf located in Thomson Bay. Thomson Bay is located on the north east side of the island, spanning a distance of approximately 2.5 km and sheltered from the prevailing south westerly swell conditions (Figure 1.1).

Sediment cells, spatially discrete sections of coastline that include the intersection of both marine and land-based structures that connect through the exchange of sediment (Stul et al 2015), are important to consider in any coastal processes assessment as they allow for the identification of the spatial context most relevant to the coastal evaluation being undertaken. Stul et al (2015) presents a hierarchy of sediment cells for the Vlamingh coast, covering the Western Australian coastline between Cape Naturaliste to the south and Moore River to the north, to be used in the planning, management, engineering, science and governance of this coastline, including when making decisions around management of coastal infrastructure such as the Army Groyne.

Sediment cells are mapped by Stul et al for three spatio-temporal scales along the Vlamingh coast:

- Primary Cells – These relate to large landforms and consider potential changes to the coastline over timescales of more than 50 years.
- Secondary Cells – These incorporate contemporary sediment movement on the shoreline and potential landform responses to inter-decadal changes in coastal processes.
- Tertiary Cells – These are defined by the reworking and movement of sediment in the nearshore and are relevant for seasonal and inter-annual changes to the beach face.

The sediment cell most relevant to the proposed facility at South Thomson Bay is the R14b tertiary cell extending from Bathurst Point to Philip Point, with due consideration made to its position within the R14

Secondary cell between North Point and Philip Point and the R06D Primary cell extending from Fremantle to Safety Bay and out to Wadjemup along the Garden Island Ridge.

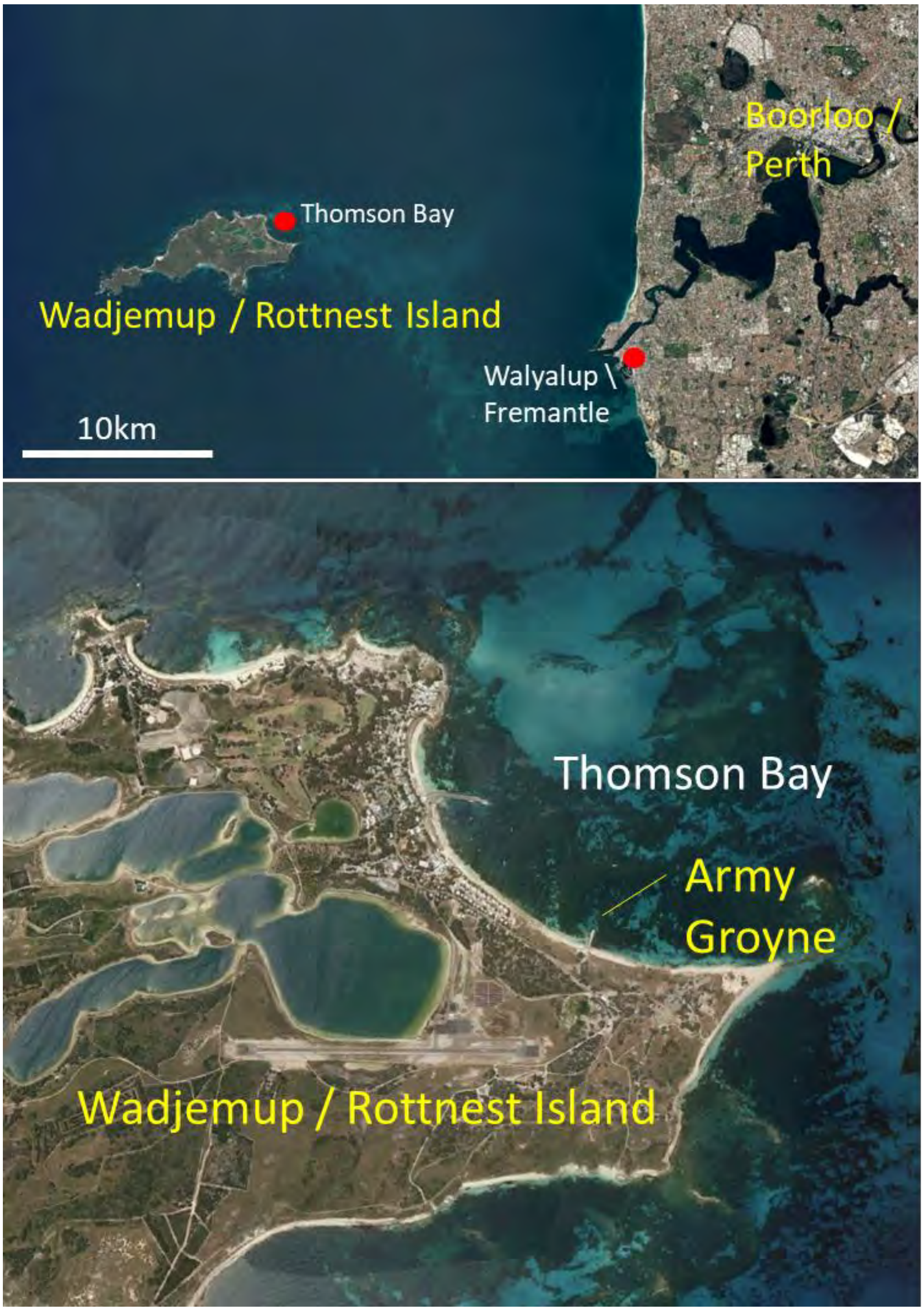


Figure 1.1: Site location showing Wadjemup and the location of Thomson Bay on the Northeast side of the Island

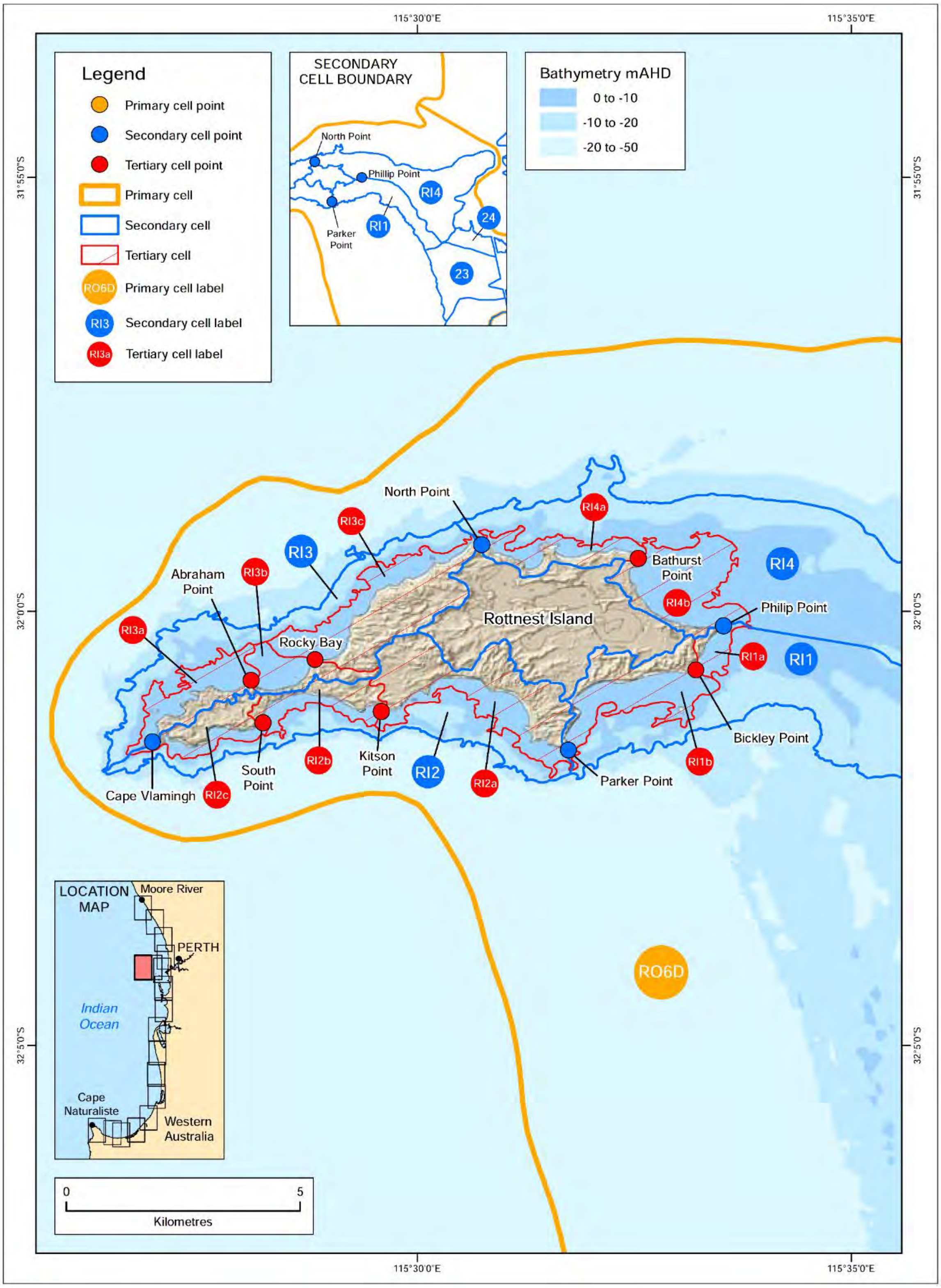


Figure 1.2: Secondary and Tertiary Sediment Cells within the R06D Primary Sediment Cell around Wadjemup / Rottnest Island (Stul et al 2015)

1.2 Concept Designs

Initial concept designs were developed by WGA in 2018, with the two identified options at that stage shown below for Option 1 (Figure 1.3) and Option 2 (Figure 1.4). These designs were used by MRA in their initial Coastal Processes Assessment reporting in 2019.

Figure 1.3: Concept Option 1 (WGA 2018) used by MRA in their 2019 Coastal Processes Assessment

Figure 1.4: Concept Option 2 (WGA 2018) used by MRA in their 2019 Coastal Processes Assessment

The development of Option 1 from WGAs concept level designs that was undertaken by BMT in 2019, as shown in Figure 1.5.

Figure 1.5: Development of Concept Design Option 1 by BMT (RIA 1716-02-01 RevF, 2019), referred to in AECOM design report as the BMT base case.

This design was then used as a reference by AECOM when RIA requested that they undertake a value engineering assessment of the BMT concept design. The development of the Value Engineering Concept 1 by AECOM undertaken in 2020 is shown in Figure 1.6. This concept is the layout that this updated coastal assessment will be based upon.

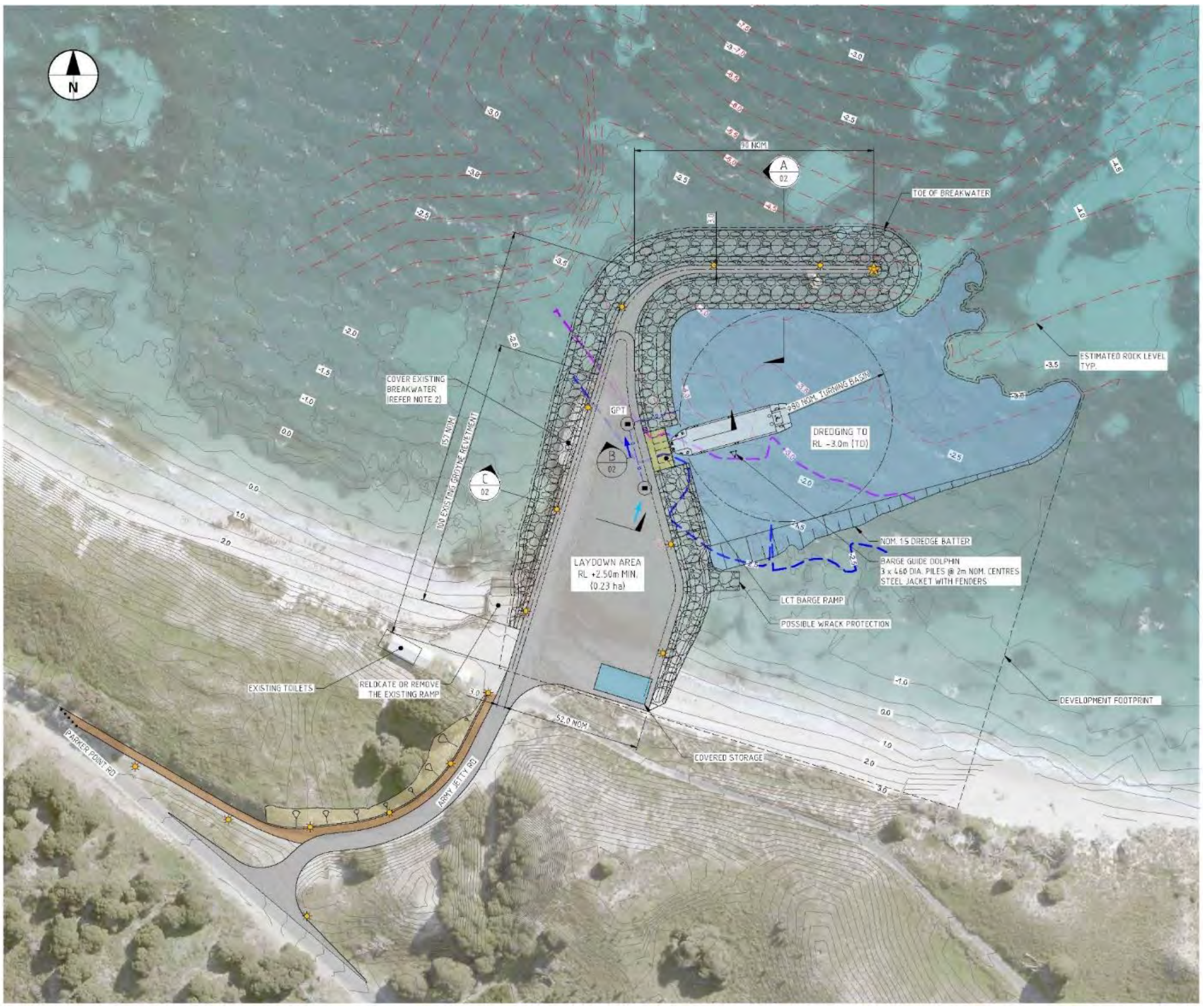


Figure 1.6: Value Engineering Concept 1 General Arrangement (AECOM 2020, RIA-2520-19180-MAR-01 RevE)

2. Local Setting

Analysis of the measured data from around Thomson Bay and Wadjemup is presented in this section and used to inform the understanding of the metocean conditions at the Thomson Bay Army Groyne and the basis for establishing the wave model.

2.1 General Wave Climate

The wave conditions in Thomson Bay are generated by two principal sources:

1. Long period swell waves (>8 seconds) that are generated in the Southern Ocean and which travel around the north side and south side of the Island by diffraction and refraction to enter Thomson Bay as low amplitude swell.
2. Short period (<8 seconds) wind sea waves approach the bay from an easterly direction. These short period waves are generated by easterly winds acting over the fetch between the Perth coastline and Wadjemup.

A general overview of wave processes in Thomson Bay is shown in Figure 2.1 from Seashore (2020):

The swell and wind sea wave conditions can occur simultaneously resulting in a bi-modal seastate in Thomson Bay, where low amplitude swell waves approach from the north at the same time as short period wind sea waves approach generally from the east sector.

Both wave modes are affected by the natural reef and rock structures surrounding the island. As waves travel over the reef structures, they lose wave energy through wave breaking and bed roughness reducing the amplitude of the waves. The natural wave protection offered by reef and the island’s topography results in a relatively benign wave climate within Thomson Bay.

2.2 Bathymetry and Reefs

There is a very good description of the bathymetry from around the Island, with bathymetric data captured in high resolution by the Department of Transport (DoT) from the shoreline out to approximately 30m depth (Figure 2.2). There are high resolution local bathymetric surveys in Thomson Bay around the Army Groyne captured in 2017 and 2020 which provide an excellent description of the seabed for the study (Figure 2.2).

2.3 Local Datum

The Rottnest tidal planes and charts are based on Rottnest Sounding Datum which in this report is referred to as Chart Datum (CD). CD is the lowest low water recorded at Rottnest (Wadjemup) in 1978.

The bathymetry captured by the DoT in Thomson Bay used for this project is at CD with a vertical datum stated as ‘Rottnest Island, Low Water Mark 1978, 3.628m below benchmark PWD AW A728. 0.72m below Australian Height Datum (AHD)’.

In the current report the vertical datum of CD has been adopted.

- To convert CD to mean sea level (MSL) an adjustment of -0.68m is applied.
- To convert CD to AHD an adjustment of -0.72m is applied.

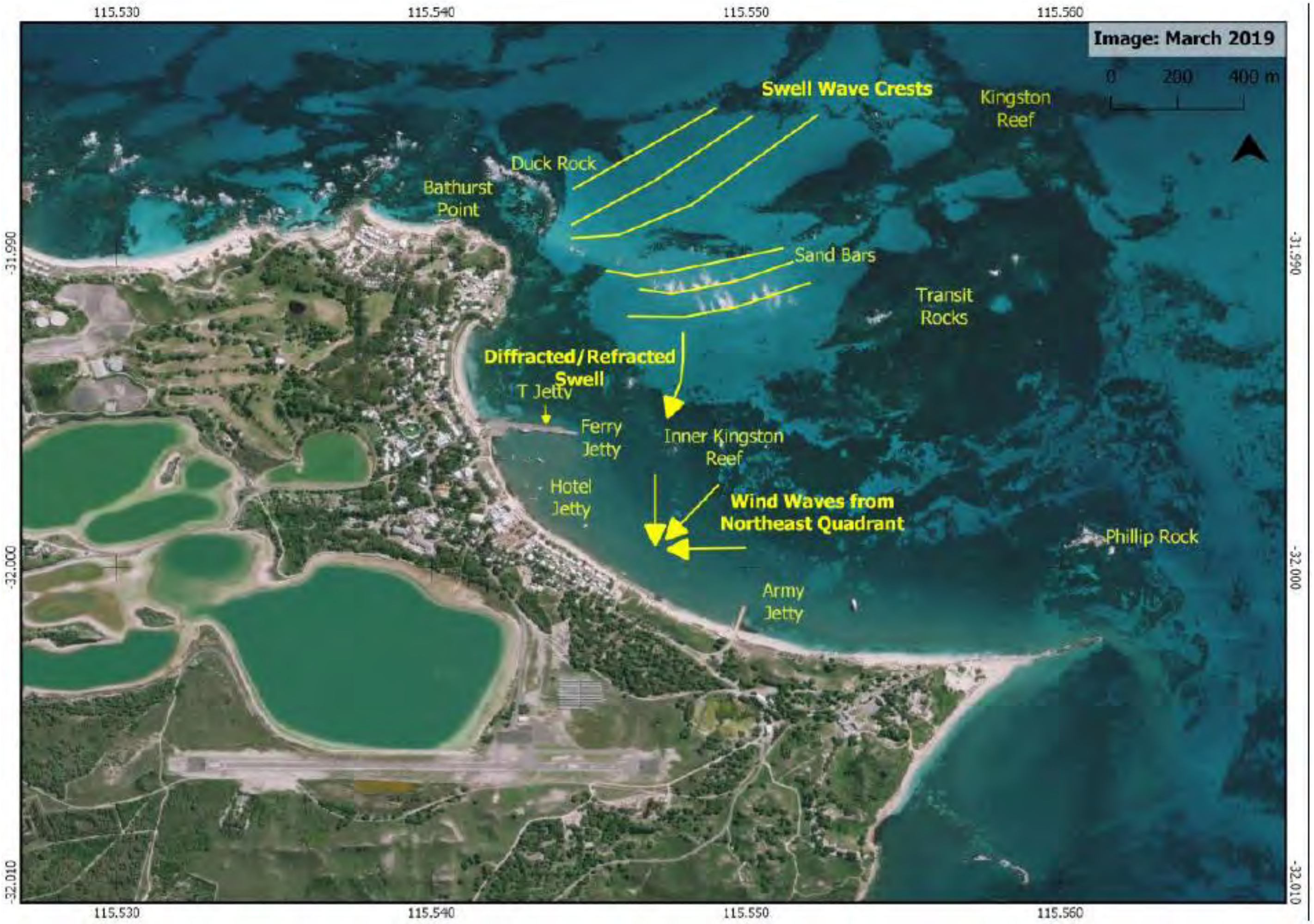


Figure 2.1: Passage of waves into Thomson Bay (Seashore 2020)

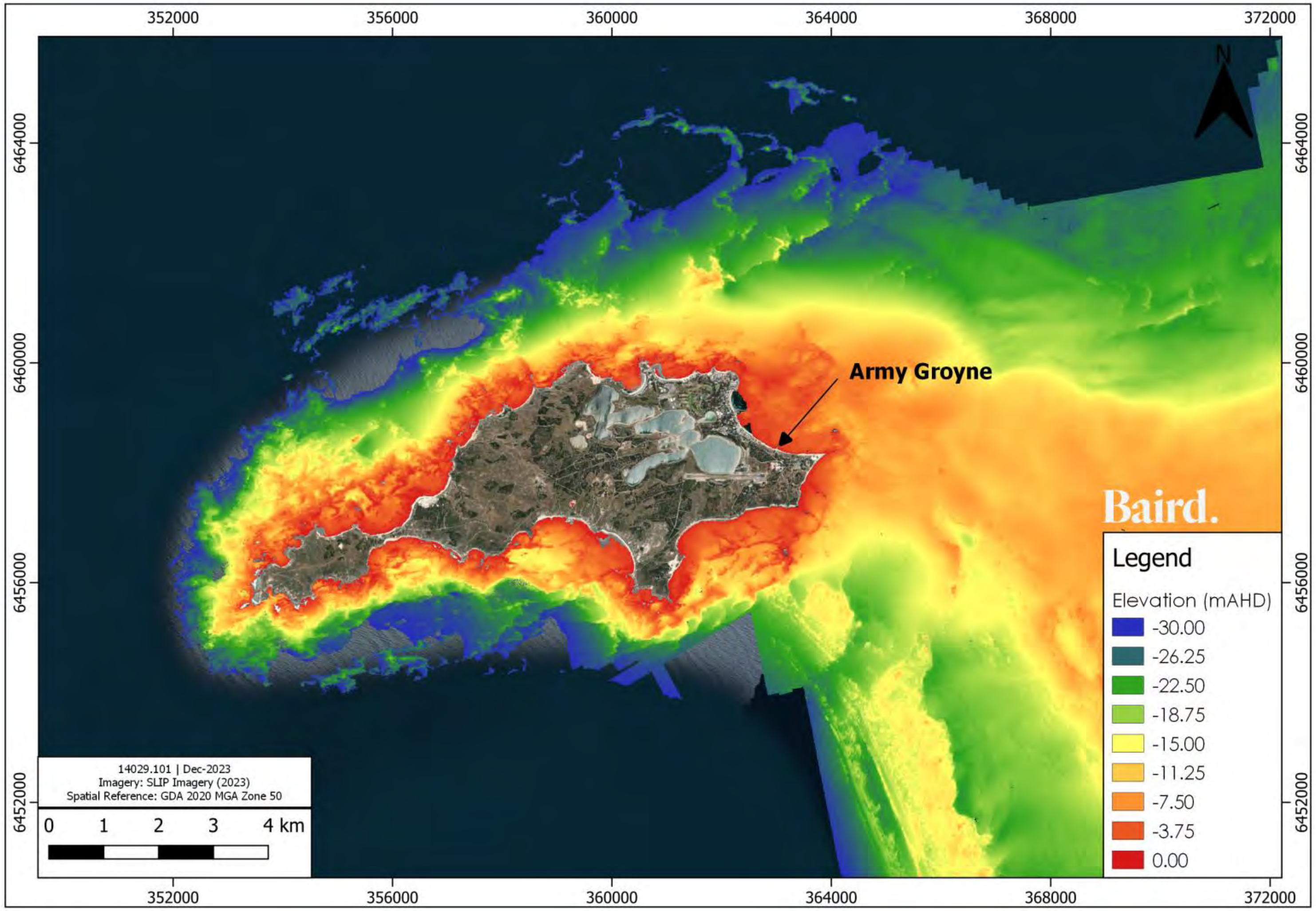


Figure 2.2: High resolution multibeam bathymetry captured by DoT around Wadjemup

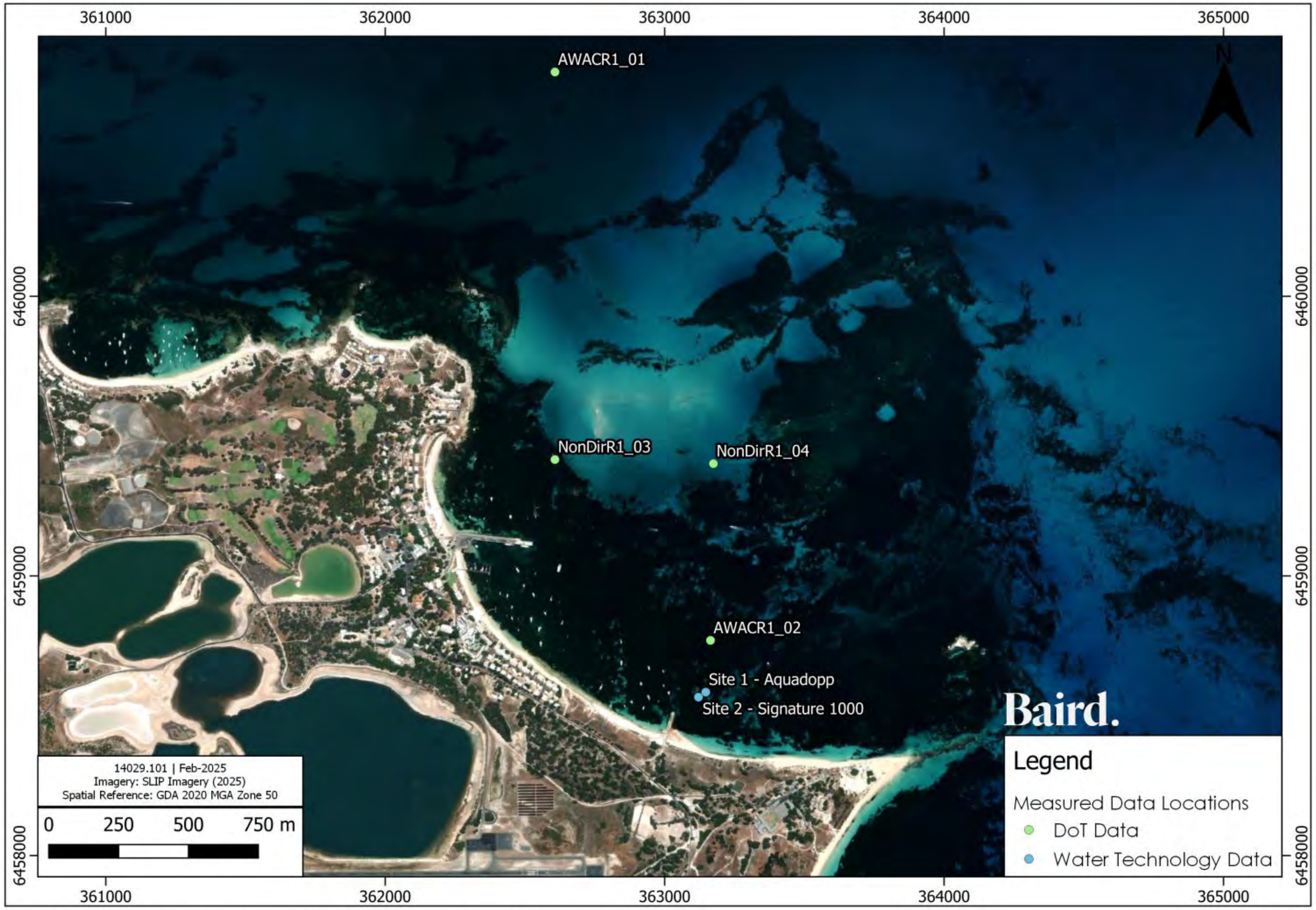
2.4 Measured Data Summary

A summary of the measured data available around Wadjemup and locally adjacent the site in Thomson Bay is presented in Table 2.1. The locations are shown for sites around Rottnest Island in Figure 2.3 and for locations within Thomson Bay in Figure 2.4.

Table 2.1: Measured Metocean Data from around Wadjemup and Thomson Bay

Instrument	Date Available	Depth (m CD)	Data
Fremantle Tide Gauge	1986 - 2022	2	Water level
Rottnest Island Wind	1983 - 2022	+43m	Wind Speed/Direction
Swanbourne Wind	1985 - 2022	+41m	Wind Speed/Direction
Rottnest Buoy DWR	2004 - 2022	48m	Wave (Hs, Tp, Dir)
Cottesloe Buoy DWR	1999 - 2022	17m	Wave (Hs, Tp, Dir)
Signature1000_Site1	5th November 2020 – 9th February 2021	3m	Wave (Hs, Tp, Dir, Spread)
Aquadopp_Site2	Two Periods: 25th June 2020 – 13th October 2020 9th February 2021 – 6th August 2021	3m	Water Level, Currents
AWAC_R1_01	8th August – 3rd Oct 2012	13.3m	Wave (Hs, Tp, Dir)
AWAC_R1_02	8th August – 3rd Oct 2012	3.3m	Wave (Hs, Tp, Dir)
PressureSensor_R1_03	8th August – 3rd Oct 2012	2.7m	Waves (Non-Dir)
PressureSensor _R1_04	8th August – 3rd Oct 2012	4.7m	Waves (Non-Dir)

Figure 2.3: Locations of Measured Data around the Wadjemup Site



N:\Projects\14029.101_RottnestCoastalProcesses\09_GIS\9 QGIS\Figures\RottnestMeasuredData_IslandZoom_v2.png

Figure 2.4: Locations of Measured Data in Thomson Bay around the Army Groyne Site

2.5 Water Level

2.5.1 Tidal Planes

The tidal planes for Thomson Bay have been taken from the nautical chart for Rottnest Island WA412 (DoT 2011) and are shown in Table 2.2. The vertical datum is to the Rottnest Island Sounding Datum which in this report is referred to as CD (refer Section 2.2.3). It is noted that the LAT level has not been established for Thomson Bay.

The tides at Wadjemup are mainly diurnal with a spring tide range of approximately 0.7m and neap tide range of 0.5m. The water level peaks during the June solstice (Eliot 2020).

There is no tide gauge on Wadjemup with the nearest measured data location being the tide gauge at the Fremantle boat harbour, which is considered generally representative of the tidal regime on Wadjemup in Thomson Bay. Tidal planes are summarised in Table 2.2 from the Fremantle Boat Harbour location to the Fremantle Chart Datum (m CD).

Table 2.2: Tidal Planes for Fremantle Boat Harbour (DoT 2016) and Thomson Bay (DoT 2011)

	Fremantle[1]	**Thomson Bay**[2]
Tidal Plane	Level (m CD)	Level (m CD)
HAT	1.40	1.42
MHHW	1.15	1.03
MLHW	1.04	0.93
MSL	0.81	0.68
MHLW	0.57	0.43
MLLW	0.47	0.33
LAT	0.26	
CD	0.00	0.00

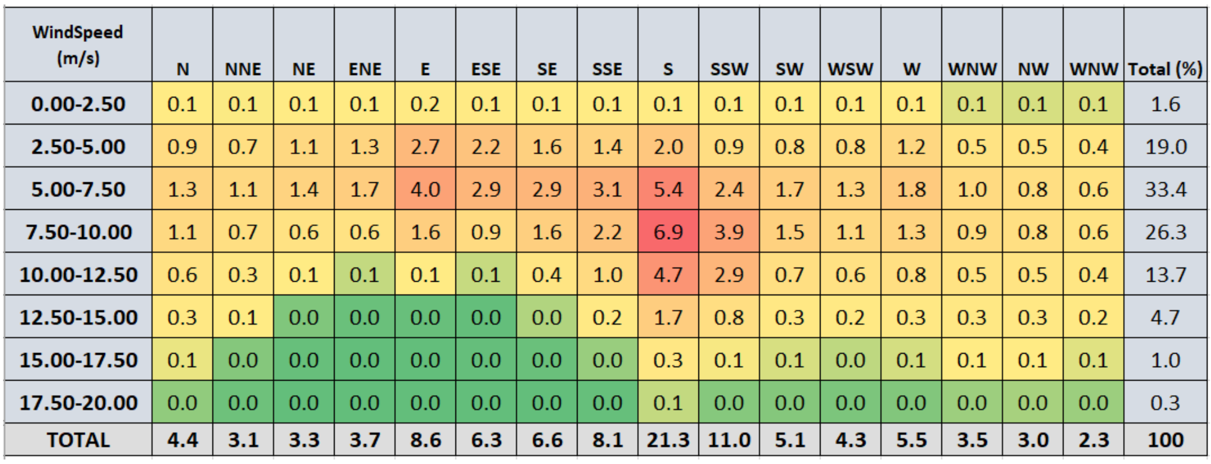
Source:

1. Submergence curve for Fremantle Boat Harbour Tide gauge (DoT 2016).
2. Nautical Chart WA412 Rottnest Island (DoT 2011).

2.6 Wind Conditions

The measured wind record from the Bureau of Meteorology (BoM) site on Rottnest Island (BOM Site 9193) was analysed over the period 1983 to 2020 to produce a joint frequency table and wind rose plot of the wind speed and wind direction shown in Table 2.3 and Figure 2.5.

Table 2.3: Joint Frequency Table of measured wind speed and direction. Analysis of the Rottnest Island BOM0009193 station data 1983 - 2022



WindSpeed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	WNW	Total (%)
0.00-2.50	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.6
2.50-5.00	0.9	0.7	1.1	1.3	2.7	2.2	1.6	1.4	2.0	0.9	0.8	0.8	1.2	0.5	0.5	0.4	19.0
5.00-7.50	1.3	1.1	1.4	1.7	4.0	2.9	2.9	3.1	5.4	2.4	1.7	1.3	1.8	1.0	0.8	0.6	33.4
7.50-10.00	1.1	0.7	0.6	0.6	1.6	0.9	1.6	2.2	6.9	3.9	1.5	1.1	1.3	0.9	0.8	0.6	26.3
10.00-12.50	0.6	0.3	0.1	0.1	0.1	0.1	0.4	1.0	4.7	2.9	0.7	0.6	0.8	0.5	0.5	0.4	13.7
12.50-15.00	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2	1.7	0.8	0.3	0.2	0.3	0.3	0.3	0.2	4.7
15.00-17.50	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.0
17.50-20.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
TOTAL	**4.4**	**3.1**	**3.3**	**3.7**	**8.6**	**6.3**	**6.6**	**8.1**	**21.3**	**11.0**	**5.1**	**4.3**	**5.5**	**3.5**	**3.0**	**2.3**	**100**

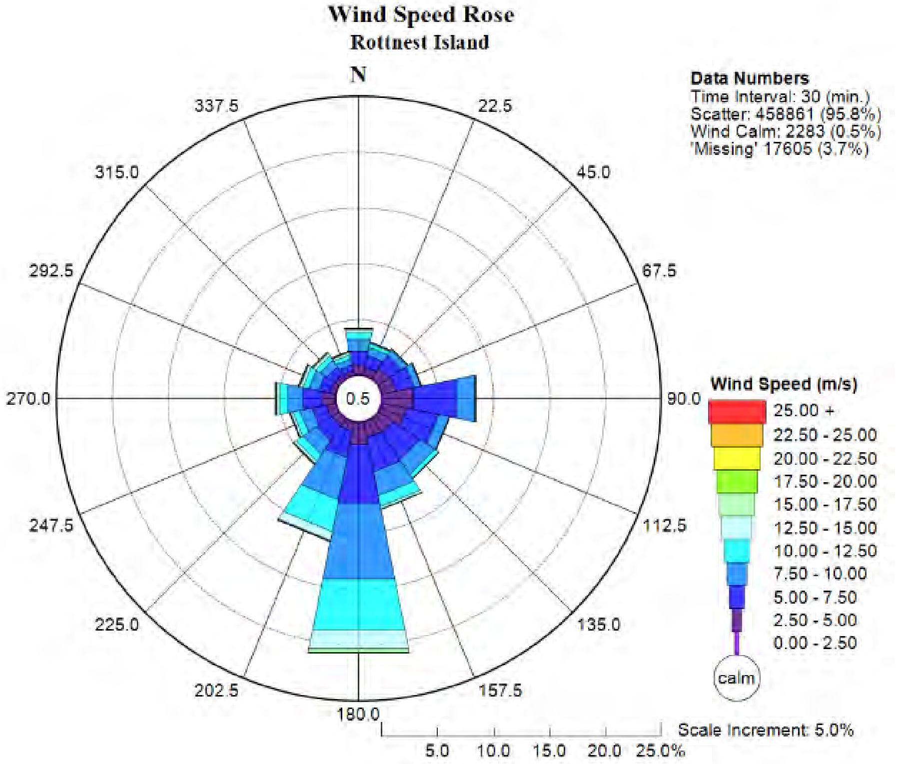
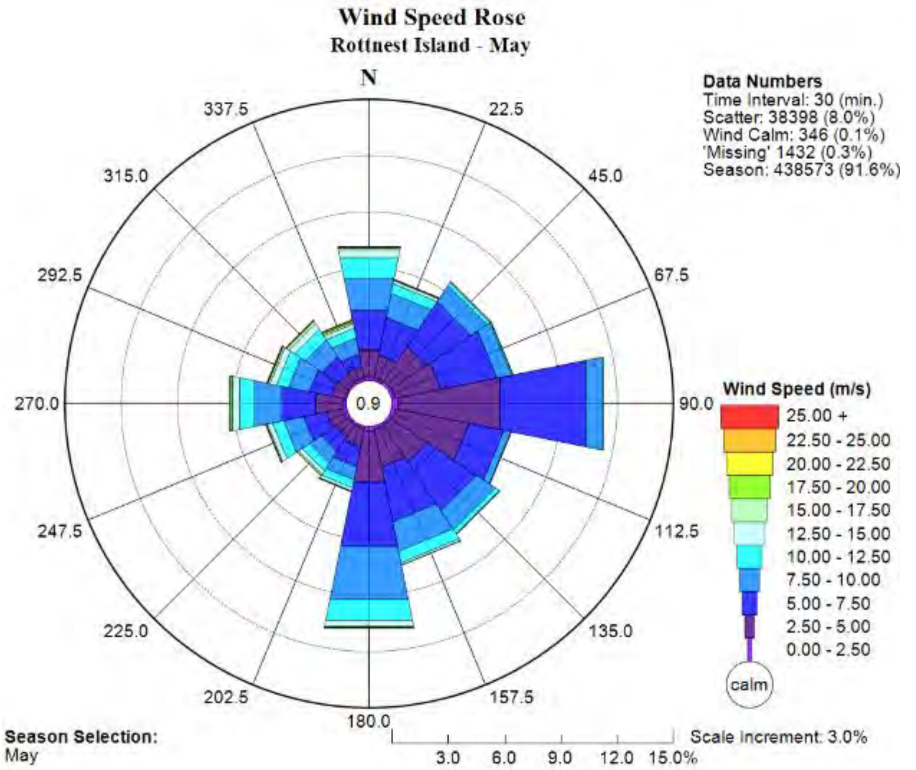


Figure 2.5: Wind Rose plot of annual wind speed and direction - measured data from Rottnest Island BOM site 9193 over the period 1983 to 2022.

The wind rose in Figure 2.5 show the winds approach from all directions with winds from the southerly sector dominant in the annual record and representing almost 40% of the data record.

The easterly approach sector is of key importance for the Thomson Bay Main Jetty as this generates wind sea waves that approach Thomson Bay (refer Figure 2.1). The easterly sector winds are well represented in the annual record in Figure 2.5 with the Army Groyne exposed to wind directions from NNE clockwise through SE. The easterly winds are most prevalent in the late autumn and early winter months with the wind roses for the months of May and June shown in Figure 2.6 from the full measured data record.



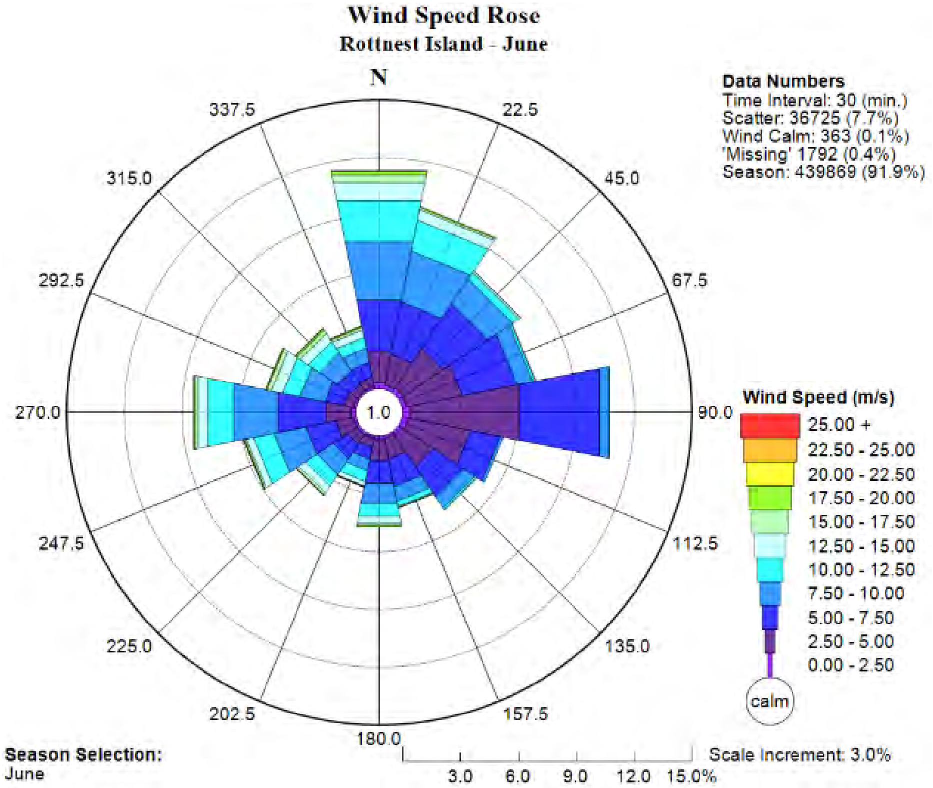


Figure 2.6: Wind Rose plot of annual wind speed and direction - measured data from Rottnest Island BOM site 9193 for the month of May (upper) and June (lower) over the entire measured data period 1983 to 2022. The influence of the winds from the easterly sector is clear during these months.

2.7 Wave Conditions

Wave conditions at the site have been assessed using both the long-term dataset available from the Rottnest Wave Rider Buoy when considering the regional wave climate offshore of Wadjemup (Rottnest Island) and the yearlong deployment by Water Technology from 25th June 2020 – 6th August 2021 when considering the local wave climate within South Thomson Bay.

2.7.1 Rottnest Directional Wave Rider Dataset

The measured wave record from the Rottnest Wave Rider Buoy (Rottnest DWR in Figure 2.4) was used to assess the wave climate offshore of Wadjemup (in approximately 50m depth). The Rottnest DWR dataset for the period 2004 to 2020 comprised 16-years of hourly wave conditions for significant wave height, peak period and direction. The data is provided as individual sea and swell components and as a combined total of sea and swell.

The measured wave record was analysed over the period 2004 to 2020 to produce a joint frequency table and wave rose plot of the wave height and wave direction offshore of Wadjemup over this period, shown in

Table 2.4: Joint Frequency Table of measured wave height and direction. Analysis of the Rottnest Island Directional Wave Rider Buoy Data 2004 - 2022

Wave Height (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total (%)
0.0-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	**0.03**
0.5-1.0	0.05	0.01	0.04	0.16	0.22	0.11	0.06	0.06	0.15	0.27	1.68	0.69	0.13	0.04	0.08	0.08	**3.83**
1.0-1.5	0.32	0.10	0.21	0.72	0.86	0.70	0.22	0.15	0.48	1.86	8.37	4.56	0.75	0.24	0.33	0.47	**20.32**
1.5-2.0	0.36	0.08	0.16	0.40	0.46	0.60	0.20	0.12	0.39	3.71	11.01	8.04	1.21	0.30	0.47	0.63	**28.15**
2.0-2.5	0.14	0.02	0.04	0.10	0.13	0.15	0.07	0.05	0.19	2.76	7.58	7.39	1.29	0.28	0.41	0.46	**21.05**
2.5-3.0	0.04	0.00	0.00	0.02	0.03	0.03	0.01	0.01	0.05	1.03	3.40	4.98	1.20	0.32	0.31	0.20	**11.63**
3.0-3.5	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.02	0.25	1.40	3.42	1.08	0.22	0.21	0.09	**6.72**
3.5-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.52	1.89	0.79	0.21	0.13	0.03	**3.63**
4.0-4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.25	1.07	0.61	0.15	0.07	0.02	**2.18**
4.5-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.56	0.40	0.09	0.02	0.00	**1.20**
5.0-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.29	0.26	0.05	0.01	0.00	**0.65**
5.5-6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.12	0.04	0.00	0.00	**0.32**
6.0+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.10	0.14	0.02	0.00	0.00	**0.29**
Total	**0.92**	**0.23**	**0.44**	**1.40**	**1.71**	**1.59**	**0.55**	**0.40**	**1.29**	**9.96**	**34.42**	**33.13**	**7.98**	**1.96**	**2.04**	**1.97**	**100.00**

.

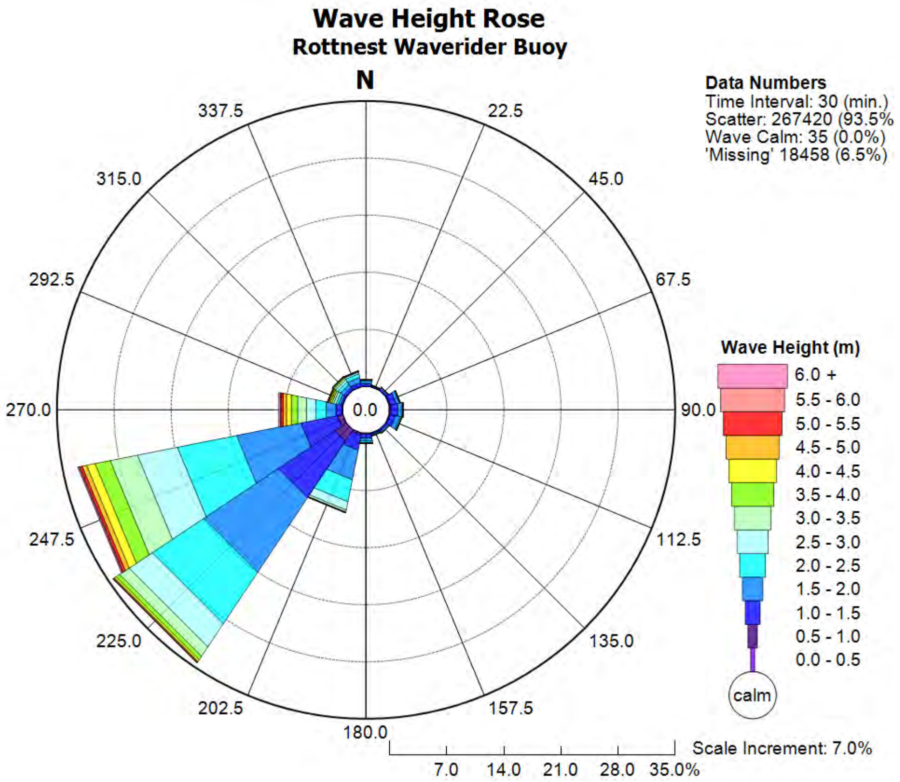


Figure 2.7: Wave Rose plot of annual wave height and direction - measured data from the Rottnest Island Directional Wave Rider Buoy Data 2004 - 2022

Table 2.4: Joint Frequency Table of measured wave height and direction. Analysis of the Rottnest Island Directional Wave Rider Buoy Data 2004 - 2022

Wave Height (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total (%)
0.0-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	**0.03**
0.5-1.0	0.05	0.01	0.04	0.16	0.22	0.11	0.06	0.06	0.15	0.27	1.68	0.69	0.13	0.04	0.08	0.08	**3.83**
1.0-1.5	0.32	0.10	0.21	0.72	0.86	0.70	0.22	0.15	0.48	1.86	8.37	4.56	0.75	0.24	0.33	0.47	**20.32**
1.5-2.0	0.36	0.08	0.16	0.40	0.46	0.60	0.20	0.12	0.39	3.71	11.01	8.04	1.21	0.30	0.47	0.63	**28.15**
2.0-2.5	0.14	0.02	0.04	0.10	0.13	0.15	0.07	0.05	0.19	2.76	7.58	7.39	1.29	0.28	0.41	0.46	**21.05**
2.5-3.0	0.04	0.00	0.00	0.02	0.03	0.03	0.01	0.01	0.05	1.03	3.40	4.98	1.20	0.32	0.31	0.20	**11.63**
3.0-3.5	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.02	0.25	1.40	3.42	1.08	0.22	0.21	0.09	**6.72**
3.5-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.52	1.89	0.79	0.21	0.13	0.03	**3.63**
4.0-4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.25	1.07	0.61	0.15	0.07	0.02	**2.18**
4.5-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.56	0.40	0.09	0.02	0.00	**1.20**
5.0-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.29	0.26	0.05	0.01	0.00	**0.65**
5.5-6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.12	0.04	0.00	0.00	**0.32**
6.0+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.10	0.14	0.02	0.00	0.00	**0.29**
Total	**0.92**	**0.23**	**0.44**	**1.40**	**1.71**	**1.59**	**0.55**	**0.40**	**1.29**	**9.96**	**34.42**	**33.13**	**7.98**	**1.96**	**2.04**	**1.97**	**100.00**

ehe top 15 events based on peak H_s from the Rottnest DWR data set occurring offshore, are summarised in Table 2.5 with the following noted:

- the majority of the extreme events in Table 2.5 are generated by winter storms.
- the largest event on record, an 8.9m offshore significant wave height (Hs) was measured in July 2009 associated with the passage of a severe winter storm.
- The fourth ranked event (25 May 2020) corresponds to Tropical Cyclone Mangga.

This analysis, as well as comparison of the overall wave climate during summer and winter months at the Wave Rottnest DWR (Figure 2.8) show that the greatest impact (i.e., the time when the largest waves are occurring) on facilities built on Wadjemup will be during winter months.

Table 2.5: Summary of Top 15 Events Measured by Hs from Measured Wave Record at Rottnest Directional Wave Rider Buoy (DWR)

Rank	Date	Peak Hs (m)
1.	21/07/2009 5:10	8.9
2.	2/08/2022 4:39	8.7
3.	25/05/2018 23:20	8.5
4.	25/05/2020 20:09	8.5
5.	22/07/2018 23:20	8.1
6.	6/05/2020 7:09	7.8
7.	28/11/2012 22:46	7.8
8.	10/08/2021 13:55	7.8
9.	7/08/2006 23:05	7.6
10.	4/09/2012 18:16	7.5
11.	27/07/2021 6:55	7.5
12.	24/05/2022 0:39	7.5
13.	23/09/2013 5:28	7.4
14.	7/07/2014 15:41	7.4
15.	19/07/2017 22:29	7.4

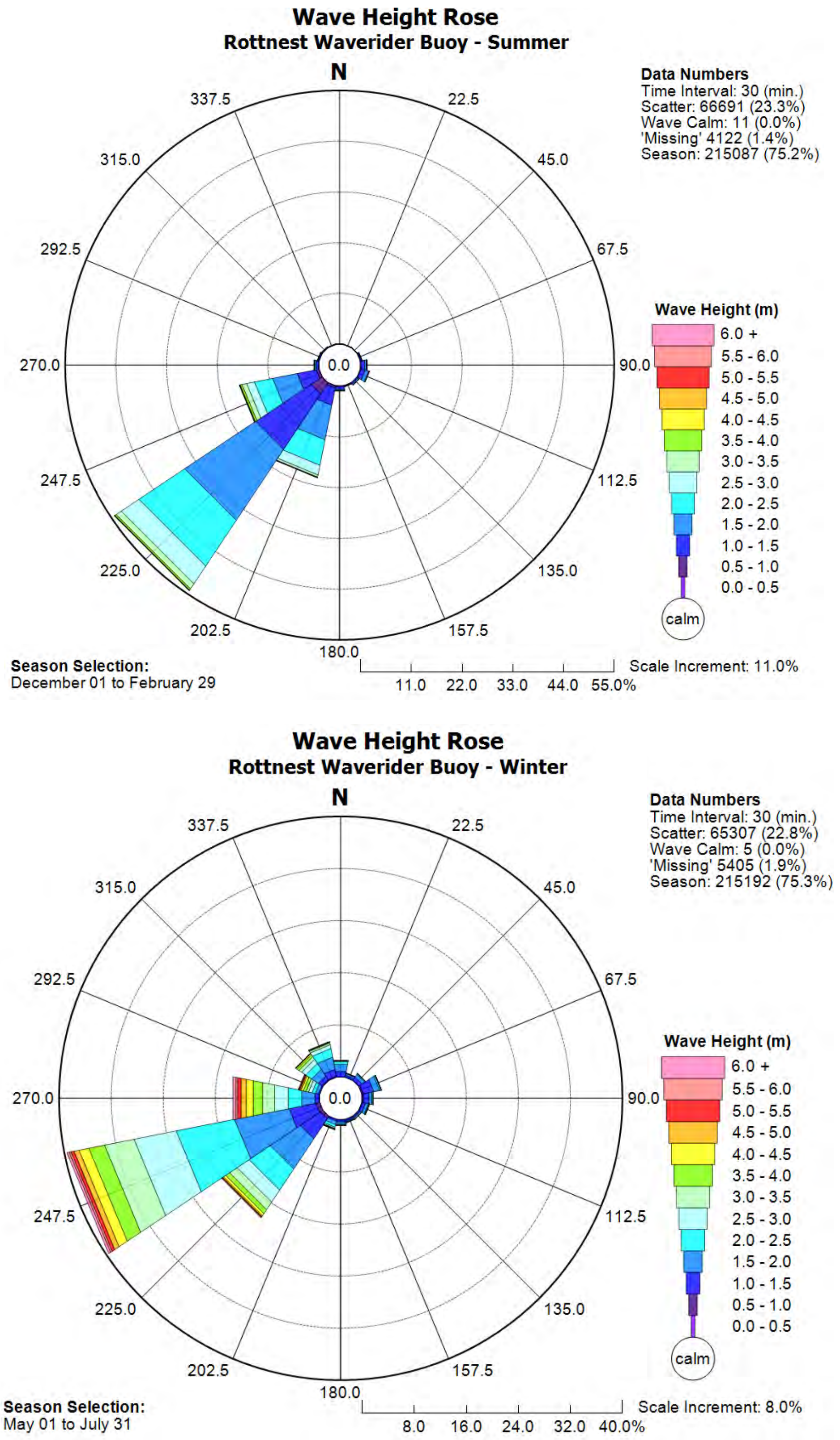


Figure 2.8: Wave Rose plots of Summer wave height and direction (upper) and Winter wave height and direction (lower) - measured data from the Rottnest Island Directional Wave Rider Buoy (Data period 2004 – 2022).

2.7.2 Thomson Bay Wave Measurements

Water Technology were engaged by RIA to undertake a wave and current data collection campaign in 2020, with data collected from two ADCP instruments in close proximity to the proposed development site as shown in Figure 2.4.

These deployments together produced a near continuous dataset with each individual instrument covering different time periods:

- Site 1 (Aquadopp):
    - 25th June 2020 – 13th October 2020
    - 9th February 2021 – 6th August 2021
- Site 2 (ADCP, Signature 1000)
    - 5th November 2020 – 9th February 2021

Taken separately, the Aquadopp deployment largely covers winter and transitional months where wave heights within South Thomson Bay are greater, whereas the Signature 1000 deployment covers summer months when wave heights within South Thomson Bay are lower.

The wave rose plots for the two instruments are presented in Figure 2.9. The directional approach of waves at the measurement locations remains within the NNW to ENE bracket across the measured data signal.

Joint frequency tables (JFT's) of the measured data from Thomson Bay is presented based on the analysis in Water Technology (2021). The joint frequency table for wave height and direction is presented in Table 2.6 and the JFT for wave height and peak period is presented in Table 2.7. The JFT's confirm the majority of waves at these sites arrive from directions between NNW to ENE and also show that more than 50% of the waves arriving at these sites across the measurement year fell within the 12-16s wavelength range (i.e., swell waves).

This aligns with the general wave climate described in Section 2.1 with a combination of swell waves generated offshore of Wadjemup in the Indian Ocean arriving at the site following refraction around Bathurst Point and Duck rock and refraction across the sand bars of Thomson Bay and Inner Kingston Reef, as well as wind waves generated from winds blowing across Thomson Bay from the easterly sector, predominantly in winter months (Figure 2.6).

Table 2.6: Joint Frequency Table Wave Height-Direction. Analysis of the Aquadopp and ADCP data - June 2020 and August 2021 (WaterTech 2021)

		Mean Wave Direction (oN)																
Hs (m)	**blank**	**N - NNE**	**NNE - NE**	**NE - ENE**	**ENE - E**	**E - ESE**	**ESE - SE**	**SE - SSE**	**SSE - S**	**S - SSW**	**SSW - SW**	**SW - WSW**	**WSW - W**	**W - WNW**	**WNW - NW**	**NW - NNW**	**NNW - N**	**Total**
<0 or (blank)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
0-0.1	0.0	0.8	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	**2.2**
0.1-0.2	0.0	8.9	5.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.2	5.3	**21.7**
0.2-0.3	0.1	8.7	6.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	6.1	**24.0**
0.3-0.4	0.0	5.1	2.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	9.2	**20.1**
0.4-0.5	0.0	3.7	1.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	9.8	**16.6**
0.5-0.6	0.0	2.9	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.2	**9.0**
0.6-0.7	0.0	1.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	**4.2**
0.7-0.8	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	**1.3**
0.8-0.9	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.7**
0.9-1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
Total	**0.1**	**33.3**	**18.8**	**4.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**4.8**	**38.5**	**100.0**

Table 2.7: Joint Frequency Table Wave Height – Peak period. Analysis of the Aquadopp and ADCP data June 2020 and August 2021 (WaterTech 2021)

	Tp(s)								
Hs(m)	**<0 or (blank)**	**0-4**	**4-8**	**8-12**	**12-16**	**16-20**	**20-24**	**24-28**	**Total**
<0 or (blank)	0	0	0	0	0	0	0	0	**0**
0-0.1	0	0.2	0.1	0.9	0.9	0.1	0	0	**2.2**
0.1-0.2	0	1.9	0.1	5.7	13.3	0.7	0.1	0	**21.7**
0.2-0.3	0.1	5.9	0.1	1.5	14.1	2	0.3	0	**24**
0.3-0.4	0	2.7	0.3	0.6	14.2	2.3	0	0	**20.1**
0.4-0.5	0	2.2	0.5	0.3	10	3.7	0	0	**16.6**
0.5-0.6	0	1.1	0.5	0.5	4.5	2.5	0	0	**9**
0.6-0.7	0	0.3	1	0.7	1.7	0.5	0	0	**4.2**
0.7-0.8	0	0.1	0.2	0.4	0.6	0	0	0	**1.3**
0.8-0.9	0	0	0.4	0.2	0.1	0	0	0	**0.7**
0.9-1	0	0	0.1	0	0	0	0	0	**0.2**
Total	**0.2**	**14.3**	**3.1**	**10.9**	**59.3**	**11.8**	**0.4**	**0**	**100**

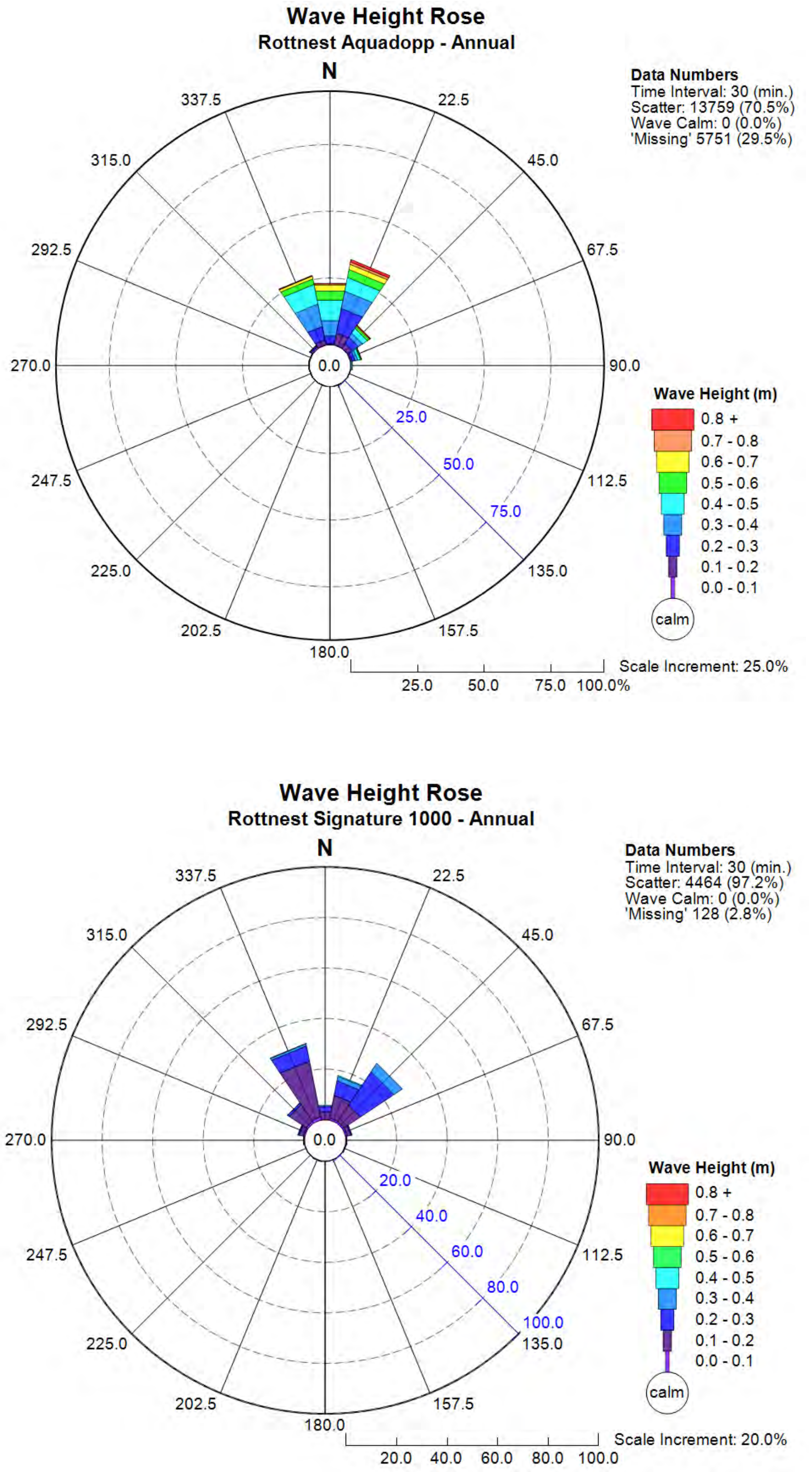


Figure 2.9: Wave rose plots of wave heights and direction at the Aquadopp (upper) and Signature 1000 ADCP (lower).

Table 2.6: Joint Frequency Table Wave Height-Direction. Analysis of the Aquadopp and ADCP data - June 2020 and August 2021 (WaterTech 2021)

		Mean Wave Direction (oN)															
Hs (m)	**blank**	**N - NNE**	**NNE - NE**	**NE - ENE**	**ENE - E**	**E - ESE**	**ESE - SE**	**SE - SSE**	**SSE - S**	**S - SSW**	**SSW - SW**	**SW - WSW**	**WSW - W**	**W - WNW**	**WNW - NW**	**NW - NNW**	**NNW - N**	**Total**
<0 or (blank)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
0-0.1	0.0	0.8	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	**2.2**
0.1-0.2	0.0	8.9	5.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.2	5.3	**21.7**
0.2-0.3	0.1	8.7	6.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	6.1	**24.0**
0.3-0.4	0.0	5.1	2.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	9.2	**20.1**
0.4-0.5	0.0	3.7	1.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	9.8	**16.6**
0.5-0.6	0.0	2.9	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.2	**9.0**
0.6-0.7	0.0	1.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	**4.2**
0.7-0.8	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	**1.3**
0.8-0.9	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.7**
0.9-1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
Total	**0.1**	**33.3**	**18.8**	**4.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**4.8**	**38.5**	**100.0**

Table 2.7: Joint Frequency Table Wave Height – Peak period. Analysis of the Aquadopp and ADCP data June 2020 and August 2021 (WaterTech 2021)

	Tp(s)								
Hs(m)	**<0 or (blank)**	**0-4**	**4-8**	**8-12**	**12-16**	**16-20**	**20-24**	**24-28**	**Total**
<0 or (blank)	0	0	0	0	0	0	0	0	**0**
0-0.1	0	0.2	0.1	0.9	0.9	0.1	0	0	**2.2**
0.1-0.2	0	1.9	0.1	5.7	13.3	0.7	0.1	0	**21.7**
0.2-0.3	0.1	5.9	0.1	1.5	14.1	2	0.3	0	**24**
0.3-0.4	0	2.7	0.3	0.6	14.2	2.3	0	0	**20.1**
0.4-0.5	0	2.2	0.5	0.3	10	3.7	0	0	**16.6**
0.5-0.6	0	1.1	0.5	0.5	4.5	2.5	0	0	**9**
0.6-0.7	0	0.3	1	0.7	1.7	0.5	0	0	**4.2**
0.7-0.8	0	0.1	0.2	0.4	0.6	0	0	0	**1.3**
0.8-0.9	0	0	0.4	0.2	0.1	0	0	0	**0.7**
0.9-1	0	0	0.1	0	0	0	0	0	**0.2**
Total	**0.2**	**14.3**	**3.1**	**10.9**	**59.3**	**11.8**	**0.4**	**0**	**100**

2.8 Current Conditions

Current conditions within South Thomson Bay have been assessed using the deployment by Water Technology from 25th June 2020 – 6th August 2021, with the same measurement periods available at each of the two instruments for the current data as for the wave data referenced in Section 2.7.2.

With the different months of the year that each instrument measured the predominant current directions experienced by each instrument are shown in current rose plots:

- in Figure 2.10 for the winter and transitional months (Aquadopp)
- in Figure 2.11 and summer months (Signature 1000 ADCP)

The pattern between instruments shows a stronger and more directional signal during the winter and transitional months of the measurement period, with currents of up to 0.3m/s predominantly coming from the ESE direction, and a weaker, more bi-directional signal during summer, with top current magnitudes of approximately 0.2m/s changing direction between east and west across that summer period.

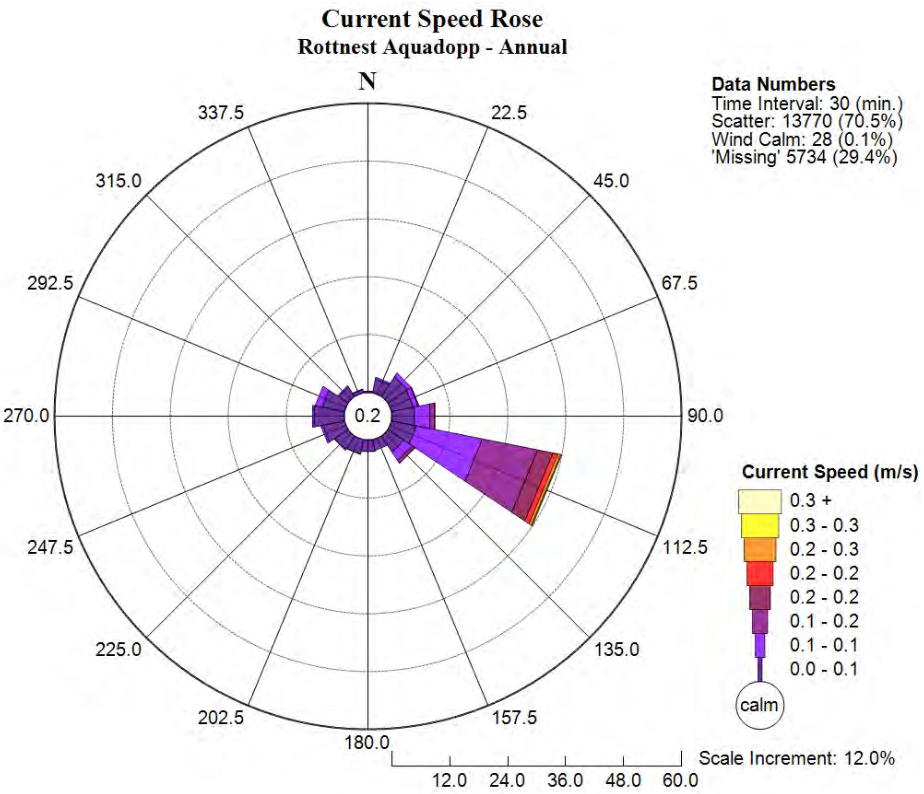


Figure 2.10: Current rose plots of current speed and direction during winter and transitional months (measured by the Aquadopp).

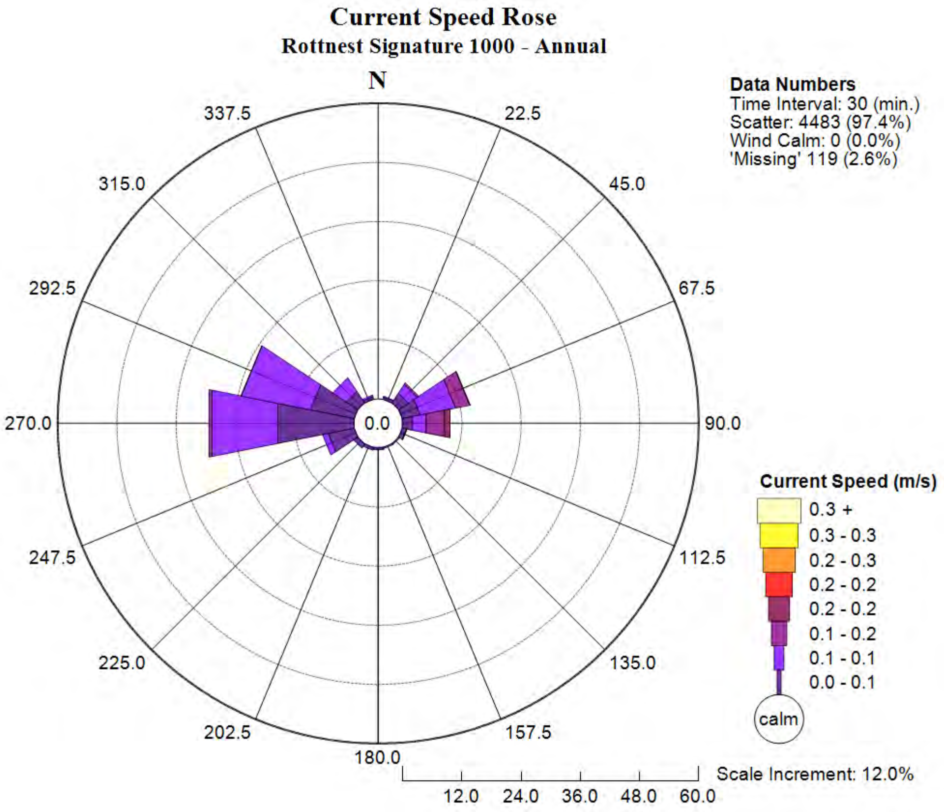


Figure 2.11: Current rose plots of current speed and direction for the summer period (measured by the Signature 1000 ADCP).

2.9 Shoreline Characteristics and Existing Coastal Structures

The shoreline of Thomson Bay follows an arcuate shape between Bathurst Point and Philip Point, truncated in places by the construction of impermeable land attached structures including the Main Passenger Ferry Jetty and the Army Groyne (see arcuate shape in Figure 2.12). The shoreline consists mainly of sandy perched beaches, with much of the beach sitting on top of rock platforms or pavements (Seashore Engineering 2019) and interspersed with rocky outcrops and limestone cliffs (Short 2005) (see Figure 2.15).

The dunes to the east of the Army Groyne are well vegetated and sit between approx 5m and 10m high (Figure 2.16), with the dunes to the west at a similar height immediately landward of the Army Groyne (Figure 2.14) and decreasing in height along the beach towards the Main Jetty (Figure 2.12).

Figure 2.12: View of Thomson Bay to the west of the Army Groyne structure

Figure 2.13: View of the dunes backing the beach east of the Army Groyne structure.

Figure 2.14: View towards the Army Groyne structure, showing dune height east and west of the structure

Figure 2.15: Rock pavement/platform supporting the perched beaches of Thomson Bay, as seen in front of the South Thomson Bay seawall.

Over approximately the last century a range of man-made/engineered structures have been built along the Thomson Bay shoreline, including the Main Ferry Wharf structure that still acts as the main point of travel to the island with several commercial ferry operators running services that dock at this wharf on a daily basis. This structure, as well as the Army Groyne structure consist of rock structures that create largely impermeable barriers to sediment movement along Thomson Bay, creating a relatively significant impact upon the coastal processes in the bay compared to other piled structures that allow coastal processes to continue largely uninterrupted (e.g., Town Jetty, Hotel Jetty).

Historic dredging of the channel that services the ferries docking at the Main Ferry Wharf has also had an impact on the coastal processes influencing Thomson Bay, with dredged material used for land reclamation or for placement along the beach (DPI 2009). A summary of the major engineered interventions that have occurred along Thomson Bay have been included in Figure 2.16, with information included from DPI (2009), MRA (2019), along with details of recent works undertaken at the Main Ferry Wharf and South Thomson Bay.

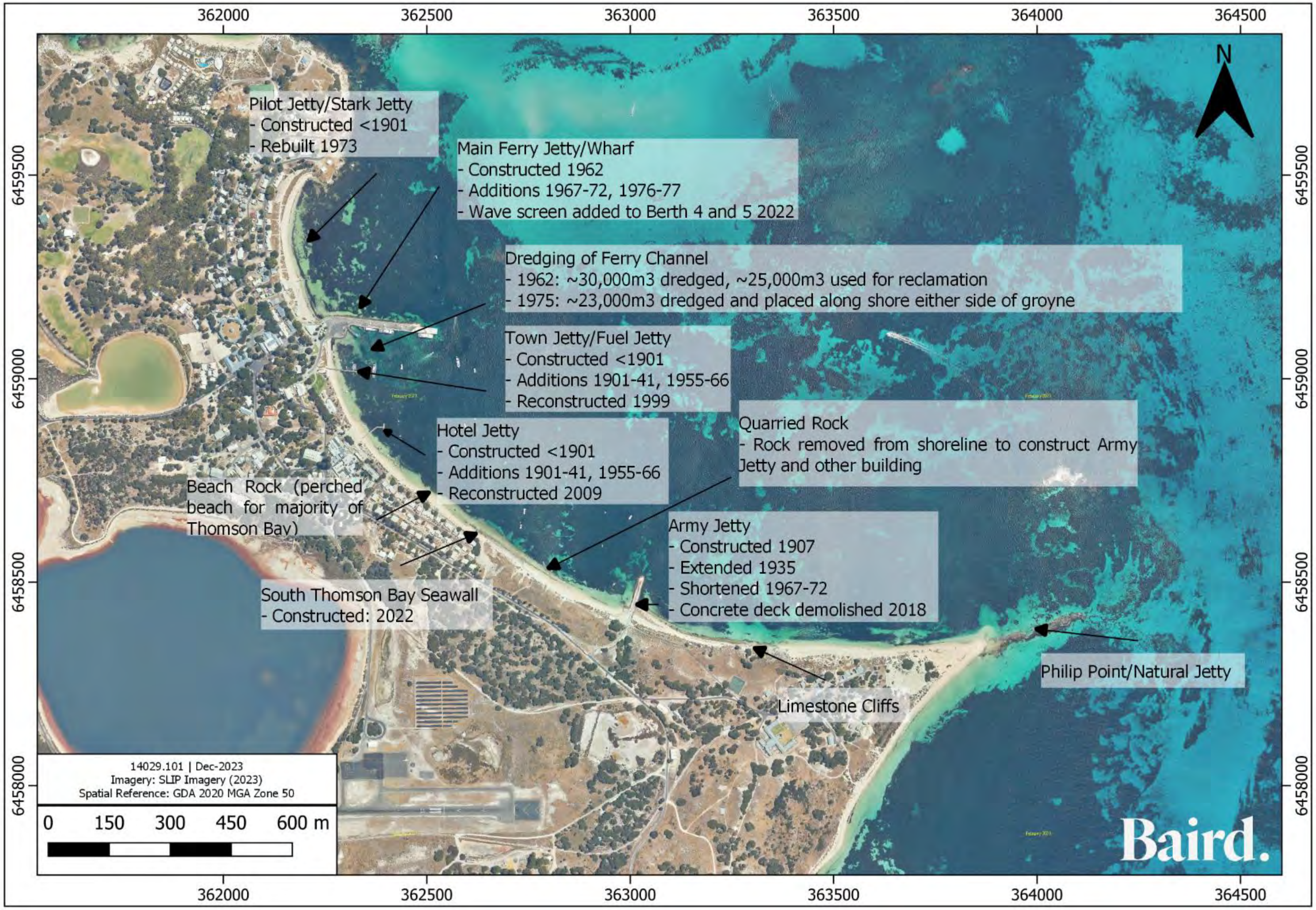


Figure 2.16: Shoreline characteristics and engineered modifications in Thomson Bay (modified from MRA 2019)

3. Wave Assessment

To assess the impacts of waves on the proposed South Thomson Bay Barge Development, review was undertaken of the modelling that was performed in MRA’s 2019 coastal processes assessment, with further wave modelling undertaken for the option evaluated in this assessment (Figure 1.6) subsequently carried out.

3.1 Wave Modelling

3.1.1 Model Description

The wave modelling was completed using SWAN, an industry standard spectral wave model which computes wave propagation, wave generation by wind, non-linear wave-wave interactions and dissipation, for a given bottom topography, wind field and water level (Deltares, 2024). The SWAN model accounts for propagation due to current and depth and represents the processes of wave generation by wind, dissipation due to white capping, bottom friction and depth-induced wave breaking and non-linear wave-wave interactions (both quadruplets and triads) explicitly with state-of-the-art formulations.

3.1.2 Model Domains

The wave modelling was completed using two model domains:

1. A large scale hindcast wave model domain that extends from Rottnest Island across the Perth coastline over an area 50km by 80km, which was used to develop hindcast wave conditions within South Thomson Bay (Figure 3.1).
2. A local scale high-resolution model domain at the project site in South Thomson Bay of approximately 500m x 500m which is used to propagate selected wave conditions to the shoreline and determine the influence of the structures on the wave conditions at the facility and the adjacent shoreline (Figure 3.4).

3.2 Hindcast Model

The hindcast wave model utilised here was developed for the Rottnest Wave Screen project in Baird (2021). The hindcast period covers 4 years from 2017 to 2020.

The hindcast model grids consisted of 5 grids increasing in resolution approaching Thomson Bay.

- The outer model grid is at a resolution of 500m x 500m and extends from Alkimos in the North to Secret Harbour in the South.
- Successive nested model grids at 200m, 50m over Rottnest Island and a 10m resolution grid for Thomson Bay were used to downscale waves into the Bay (Figure 3.1).

The model forcing consists of:

- Wave conditions at the boundary that are applied from the measured waves of the Rottnest DWR (Hs, Tp, wave direction).
- Varying water level based on the measured data from the Fremantle tide gauge.
- Winds over the model domain applied as a grid based on the measured winds at Swanbourne and Rottnest Island BoM stations, and these develop local seas inside the model domain.

Figure 3.1: Left:Model domain for the hindcast SWAN wave model (Baird (2021) .Right: Thomson Bay measured data locations for the calibration.

The calibration of the model is reported in Baird (2021) and is reproduced here for reference, with key validation plots presented in Appendix A. The calibration involved the following:

1. The model calibration period was selected over the period where measured data was available at the time of the Baird (2021) study. This was the 13 August to 3 October 2012.
2. The measured wave conditions from 4 instruments in Thomson Bay (Figure 3.1) collected over the 2012 winter period were used for the purpose of calibration
    - AWACR1_01 – directional wave data in the northern approach to Thomson Bay.
    - R1_03 and R1_04 - two non-directional measurement locations In Thomson Bay northeast of the Main Passenger Ferry jetty.
    - AWACR1_02 – directional wave data south of Thomson Bay
3. The wave breaking and bed friction in the SWAN model were adjusted as part of the calibration process to account for reef structures around Wadjemup and inside Thomson Bay, to ensure the model could closely represent the measured data.
4. Time series plots of the wave conditions from the model vs measured data over the approximate 2-month period is presented in Appendix A.

Overall, the model showed good agreement with the measured wave data for significant wave height, period and direction at the four measured data locations in Thomson Bay (Appendix A).

- The modelled wave conditions at the northern approach to Thomson Bay (AWACR1_01) show good agreement to the measured wave height, with high model skill (0.94) and low bias (-0.05m). The model peak period and direction align well with the measured data.
- For the two non-directional measurement locations in the middle of Thomson Bay adjacent the Main Passenger Ferry jetty (R1_03 and R1_04) the significant wave height was found to be in good agreement with the measured data (0.71 to 0.90 model skill) albeit the wave height was biased high in the location closest the jetty on the north side (R1_03). The model peak period is a reasonable match to the measured peak period, with the range of period values between 8s to 16s indicating swell waves dominate the data.
- At the location in the south of Thomson Bay (AWAC R1_02), the significant wave height is reproduced well by the model with a reasonable skill (0.76). The wave heights in the model are marginally higher than the measure data with a positive bias of 0.07m in the statistics In Appendix A. The model peak period is a reasonable match to the measured peak period, with the range of period values over the range 8s to 16s in the model, indicating swell waves dominate the data. The measured direction is typically from the North quadrant, with periods of NNW and NE. The model direction is largely within the N sector with some NNW and follows to the NE direction at the time of the measured data.

Based on the outcomes of the model validation plots in Appendix A, the model system is considered to reproduce the wave conditions reasonably well in Thomson Bay well at the four reporting locations.

The southern Thomson Bay measured data location AWAC R1_02 is of key importance as this location has been used in the present report as the location for a hindcast of wave conditions in the next section.

3.2.1 Hindcast Analysis

Using the hindcast model, a hindcast of waves was produced over the period 1 January 2017 to 31 December 2020. The four years of hindcast data from the AWAC R1_02 location in Thomson Bay was analysed to develop wave conditions for further application in the local scale model.

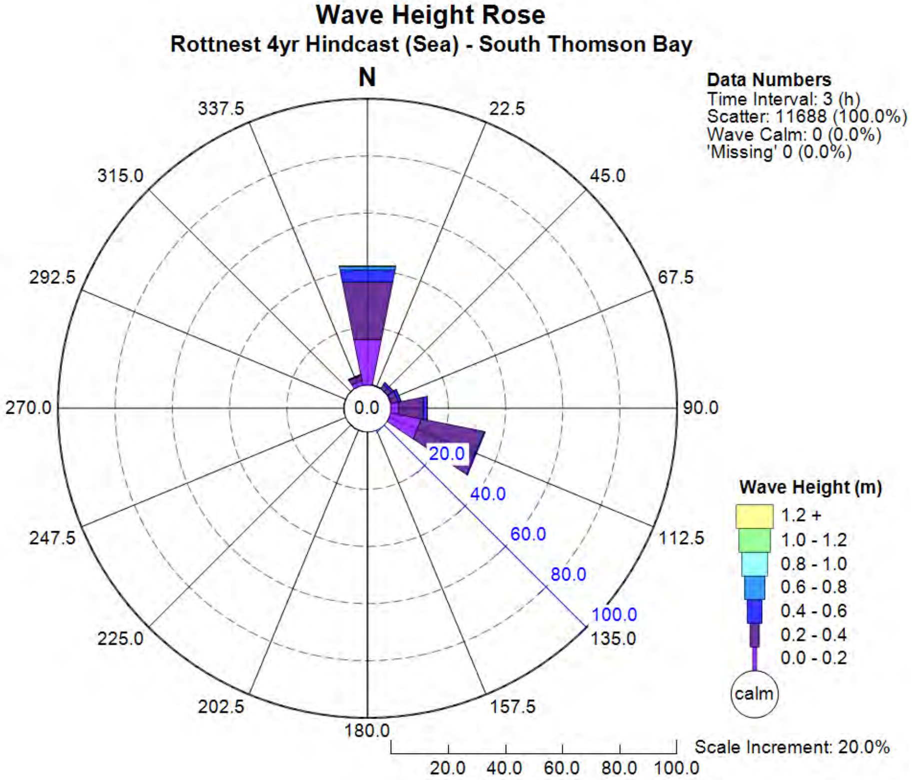
Wave roses and joint frequency tables across the four year hindcast dataset for this location are shown for swell conditions in Table 3.1and in Figure 3.3 (lower plot). The windsea conditions are shown in Table 3.2 and in Figure 3.3 (upper plot).

This analysis shows that swell waves are consistently arriving at the site from the N direction, with a very small scattering of swell waves from the NNW and E sector. Sea waves approach the site from a wider range of directions, predominantly from the northern to the eastern sector.

It is noted the four year hindcast period was chosen as it was an existing dataset that could be leveraged for the work to readily provide representative wave conditions that could be assessed for the South Thomson Bay location where the barge development is planned. Baird acknowledge that the range of wave conditions that may occur at the site over the 50-year life of the structure are influenced by variability at annual to decadal time scales. The 4-year hindcast period is used in lieu of a longer-term 10 to 20-year hindcast which is outside of the scope.

The hindcast model analysis was used to find a range of representative conditions at the site that could be used to compare conditions with and without the barge development structures in place (Section 3.3.3). The approach focusses on comparable impact across pre and post development scenarios, rather than the absolute impact of expected wave conditions.

Figure 3.2: Location of hindcast analysis point in the vicinity of the proposed barge ramp facilities, as well as the nearby moorings managed by the Rottnest Island Authority.



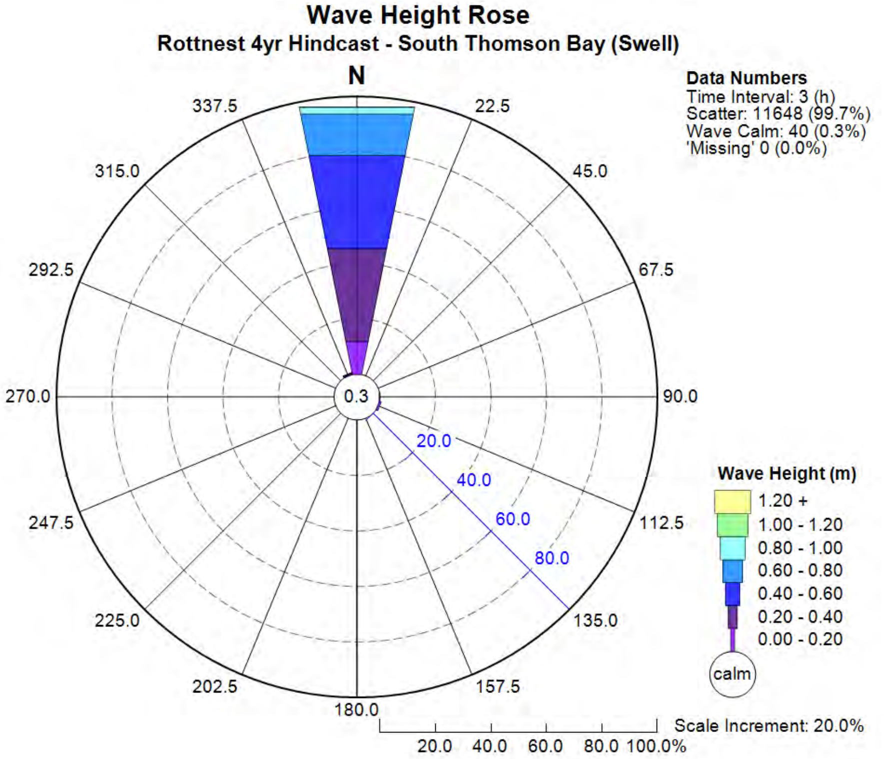


Figure 3.3: Wave roses of 2017-2020 hindcast dataset, showing sea conditions (upper) and swell conditions (lower).

Table 3.1: Wave Height and Direction Joint Frequency Tables – 2017-2020 Hindcast Swell Conditions

Direction Hs (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total (%)
0.0-0.2	12.09	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	12.98
0.2-0.4	34.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	34.60
0.4-0.6	34.38	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	34.52
0.6-0.8	15.34	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	15.45
0.8-1.0	2.37	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40
1.0-1.2	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
1.2+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	98.50	0.00	0.00	0.00	0.14	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	100.00

Table 3.2: Wave Height and Direction Joint Frequency Tables – 2017-2020 Hindcast Sea Conditions

Direction Hs (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total (%)
0.0-0.2	16.26	0.01	0.05	0.36	2.76	10.92	0.00	0.00	0.00	0.00	0.01	0.00	0.14	0.01	0.05	1.64	32.21
0.2-0.4	20.52	0.18	1.75	2.40	8.87	22.46	0.00	0.00	0.00	0.09	0.02	0.00	0.03	0.00	0.01	1.81	58.14
0.4-0.6	4.31	0.00	0.75	0.92	1.38	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	7.99
0.6-0.8	1.16	0.00	0.06	0.09	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	1.41
0.8-1.0	0.22	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24
1.0-1.2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1.2+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	42.48	0.19	2.63	3.77	13.08	33.71	0.00	0.00	0.00	0.09	0.03	0.00	0.16	0.01	0.06	3.79	100.00

3.3 Local Scale Model – South Thomson Bay

3.3.1 Model Setup

A high resolution (2m x 2m) SWAN wave model was established over the study area of South Thomson Bay and extending across the project site. Wave conditions were applied on the boundary for select cases representative of swell and sea conditions and wind was applied over the domain.

The SWAN model simulations were used to determine the difference in impact of a set of typical swell and sea conditions in the vicinity of the proposed barge facility, with and without the structures. The model grid setups without the proposed structures (i.e., to reflect existing conditions) is shown in Figure 3.4, with the grid setup with the proposed structures shown in Figure 3.5.

Boundary conditions were applied to the boundary of both model grids for each of the representative swell and sea cases determined from the 4-year hindcast data. The results of each model were then compared to determine the changes in wave conditions that were experienced in the vicinity of the proposed structures when compared to the wave conditions that would be experienced presently under the existing conditions at the Army Groyne – this is a 'like-for-like' comparison of the changes that would result in the wave field following construction of the barge development structure.

The SWAN model cases were run with the inclusion of the influence of reflections on the structures. Reflection in the SWAN model was represented as a sheet structure at the crest of the breakwater that produces diffuse reflections (scattering of reflections will be caused by a rubble mound structure, Boshek 2009) with a reflection coefficient of 0.85 (Pratola et al 2021).

The model simulations were executed without wave diffraction active in the simulations. Wave diffraction is a process that is most relevant for swell wave penetration. It is considered that the use of the spectral wave model provides a reasonable description of the wave conditions at the location pre and post-construction and is a useful tool for assessing changes to the general wave conditions at the site for this report. RIA may consider refining the analysis through the use of a phase resolving model (eg MIKE21BW) in future phases of the project (eg detailed design). A phase resolving model is more suited to resolving complex wave conditions such as wave diffraction, wave reflection and wave-wave interactions when compared to a spectral model.

3.3.2 Selected Wave Conditions for Assessment in Local Model

The analysis of the hindcast data at the location AWAC R1_02 was undertaken to determine one swell case and three wind-sea cases for analysis in the local model as summarised in Table 3.3.

Table 3.3: Wave Conditions for Assessment of the Barge Development

Case	Hs	Tp	Direction	Wind Spd	Wind Dir
North Swell	0.5m	14s	0°N	None	None
North Sea	0.6m	3s	0°N	10m/s	20°N
North Northeast Sea	0.4m	3s	45°N	7.5m/s	45°N
East Sea	0.45m	5s	80°N	7.5m/s	90°N

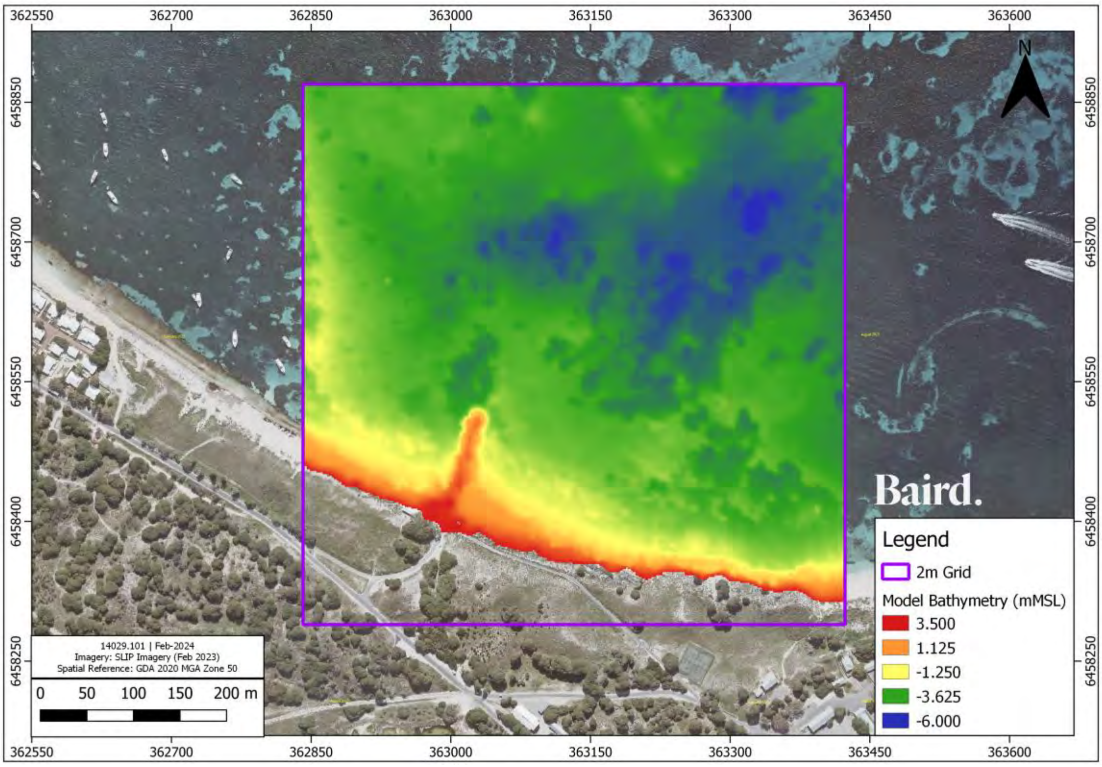


Figure 3.4: 2m resolution wave grid with model bathymetry reflecting existing conditions.

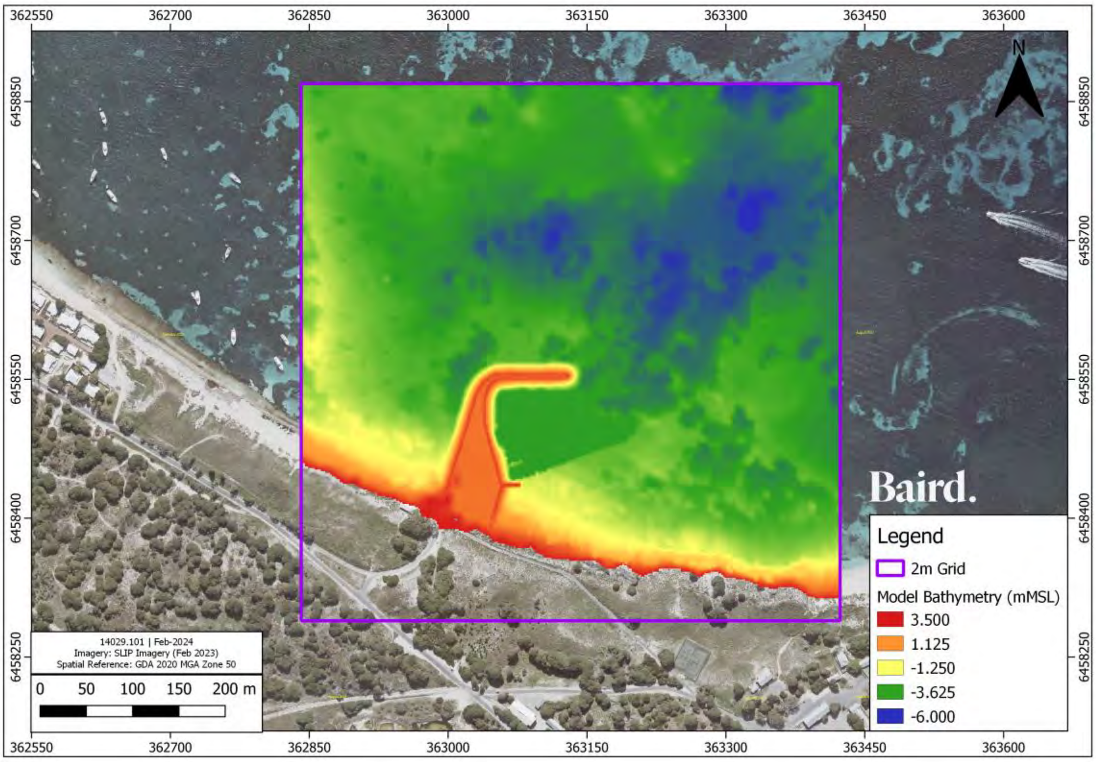


Figure 3.5: 2m resolution wave grid with model bathymetry reflecting the proposed structures and required dredged depth.

3.3.3 Modelled wave conditions and analysis

The results of the SWAN model simulations for the four selected sea and swell cases are presented here.

The wave height and direction maps from the model cases with and without structures are shown for the:

- Swell event (Figure 3.6):
- Northern windsea event (Figure 3.8):
- Northeastern windsea event (Figure 3.10):
- Eastern windsea event (Figure 3.12):

Difference plots showing the change in the wave conditions with and without the structures are presented for the:

- swell event in Figure 3.7,
- northern windsea event in Figure 3.9,
- northeastern windsea event in Figure 3.11,
- eastern windsea event in Figure 3.13.

The following observations of changes to the wave impacts with and without the structures in place have been made:

- The wave shadowing seen at the shoreline on the western side of the breakwater is minimal, with a difference of <0.1m in each wave case when compared to the existing condition. This is due to the impact that the existing Army Groyne structure has on waves on its western side when arriving at the structure from the predominant directions experienced at this location (i.e., from the northern to eastern sector).
- While the greatest reduction in wave height when compared to the existing conditions is seen within the harbour basin area, some reduction in wave height along the shoreline on the eastern side of the breakwater is also evident, with wave shadowing increasing up to 0.4m a short distance to the east from the breakwater structure. This is most prominent, and has the greatest spatial impact, in the northerly wave cases.
- This reduction in wave height and its impact on the sediment transport pathways within South Thomson Bay are discussed further in Section 4.
- The wave shadowing seen within the harbour structure (most prominent with the northerly wave condition cases) create a reduction between 0.1m and 0.4m across the cases, with the expectation that some wave direction conditions could produce a reduction in wave climate of up to 0.4m within the harbour basin. Further discussion on the impact this may have on sediment dynamics and the transport of wrack in and around the harbour are discussed further in Section 4 and Section 5.

It is reiterated here that the SWAN model is a spectral wave model and is not describing reflection from the structures. In addition, the diffraction process is not activated in the model and the process of wave diffraction is likely under-represented by the model for the swell case. The SWAN comparisons represent an indication of changes in wave conditions between the pre and post-construction scenarios, presenting the like-for-like changes with and without the development structures. The use of phase resolving models to further resolve the wave conditions in and around the development should be considered as part of detailed design.

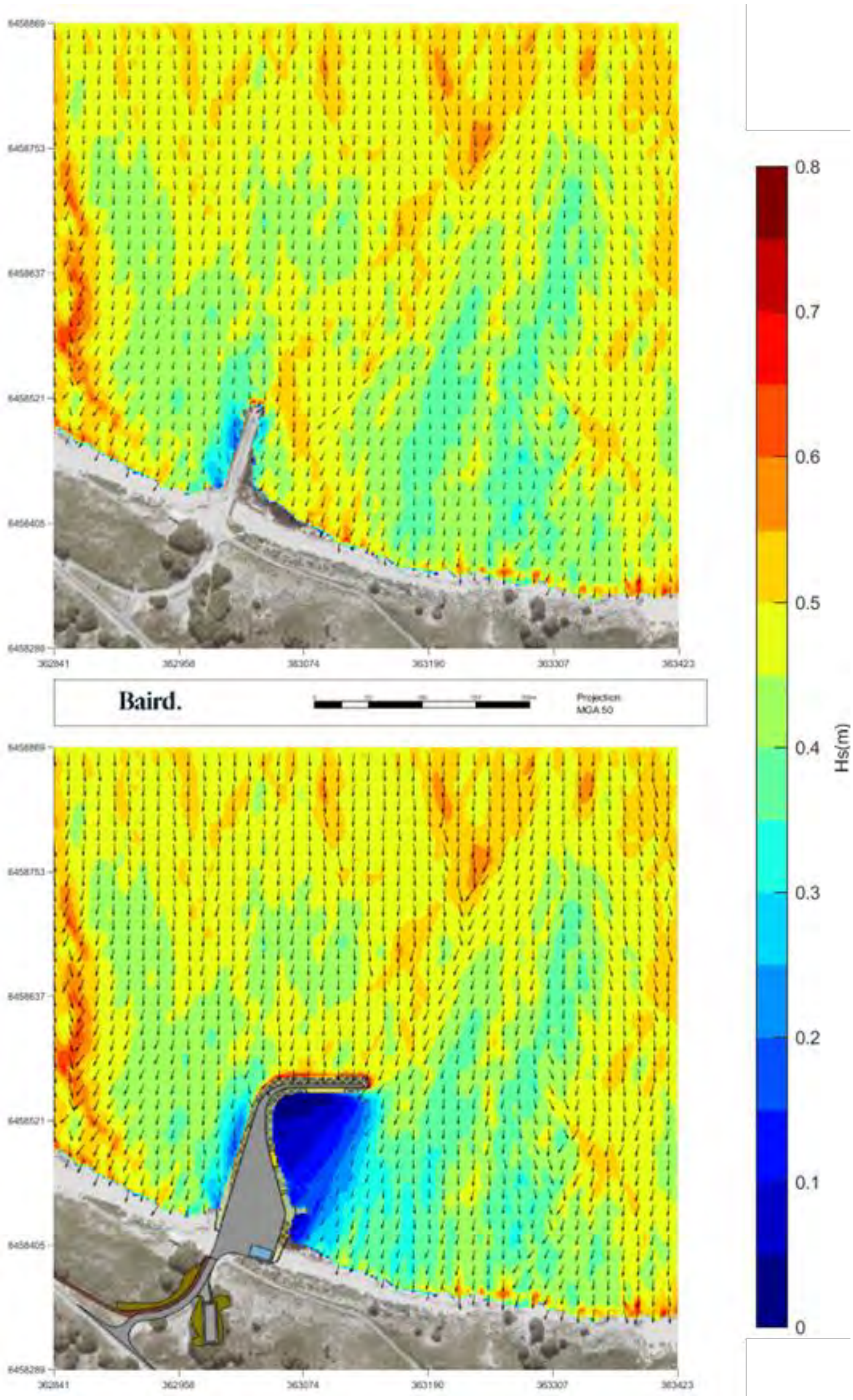


Figure 3.6: Northern swell event wave plots showing wave conditions at the Army Groyne (top) and at the proposed barge landing facility (bottom)

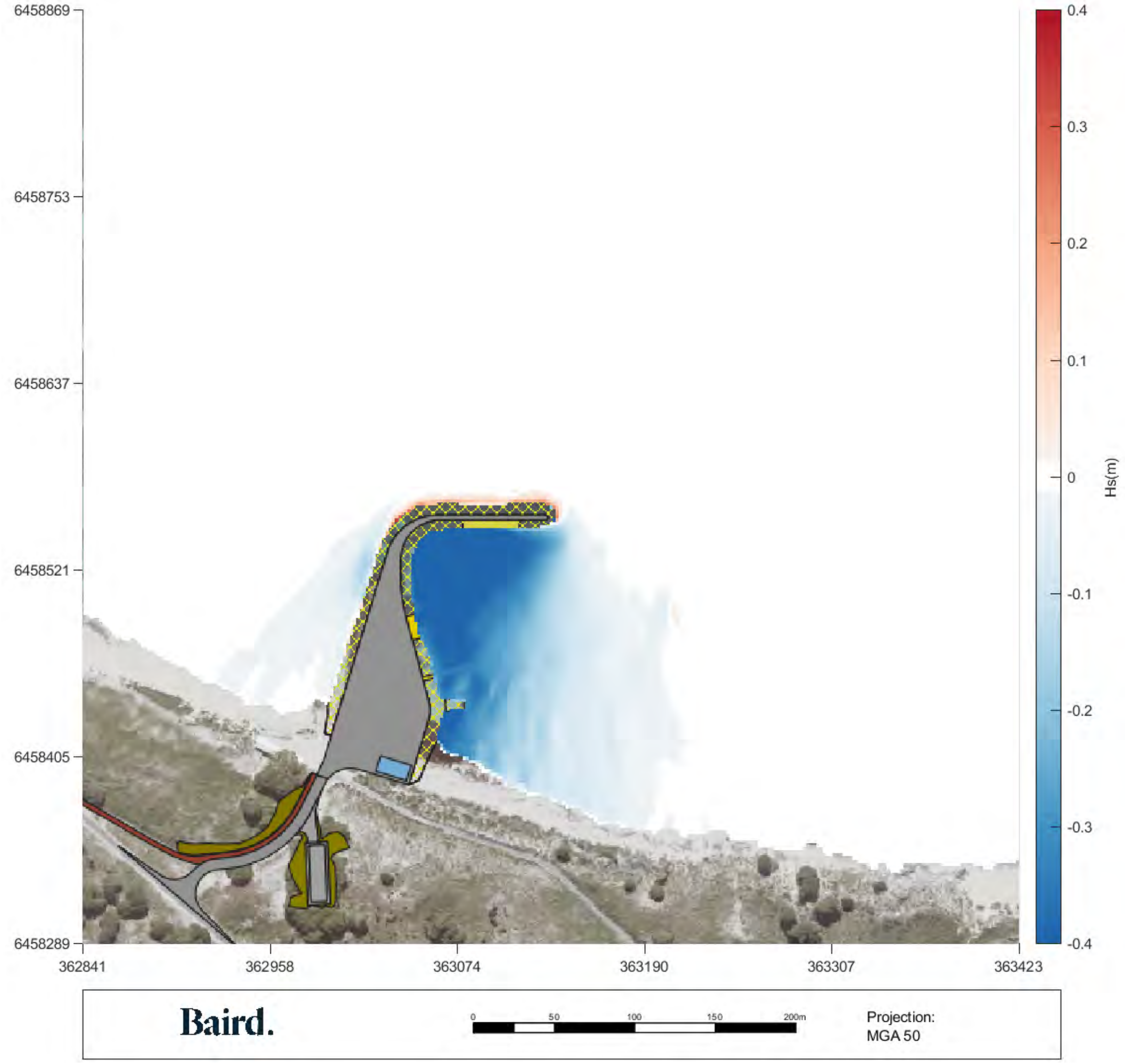


Figure 3.7: Northern swell event wave plot showing the difference between incident waves with and without the proposed structures

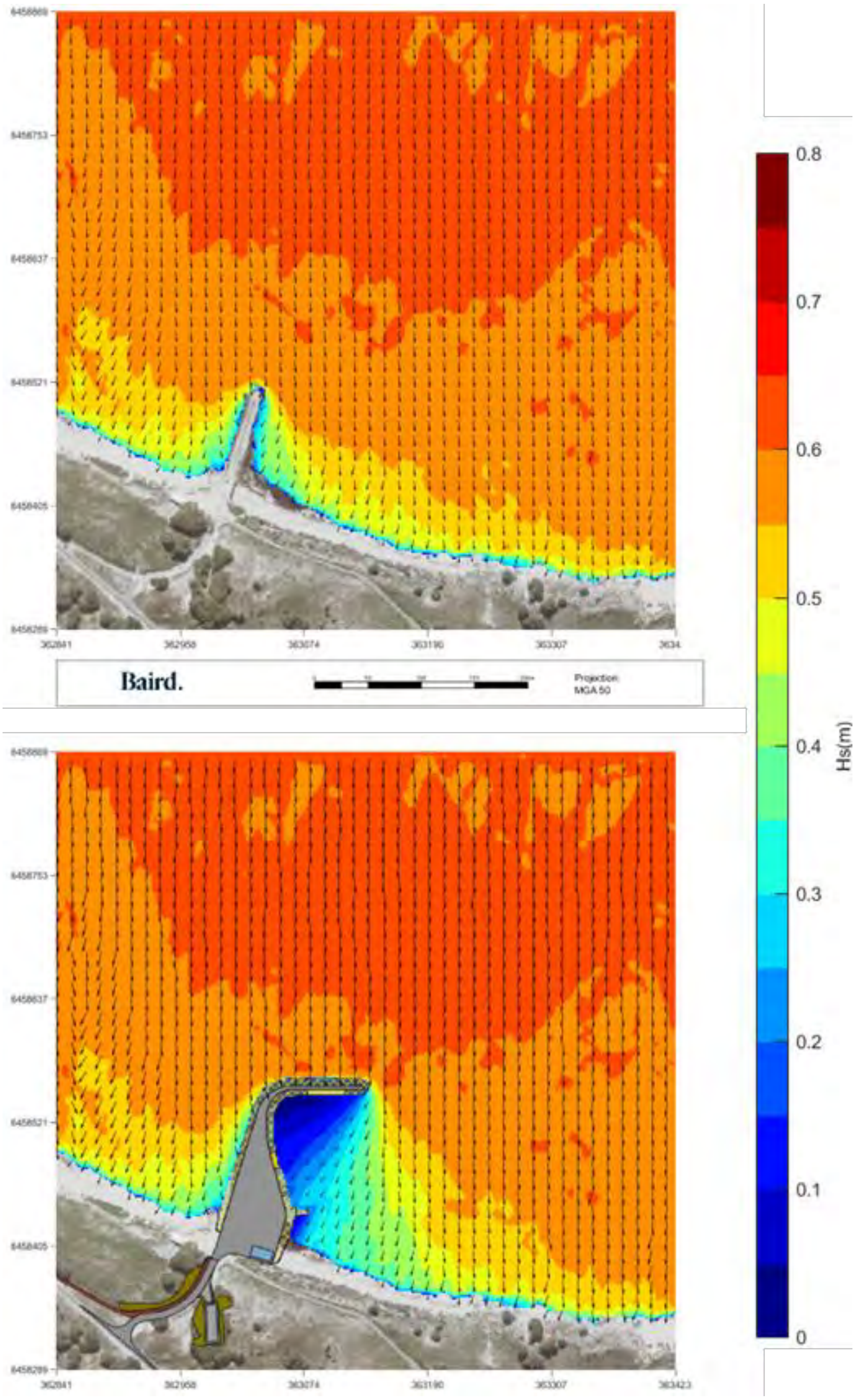


Figure 3.8: Northern windsea event wave plots showing wave conditions at the Army Groyne (top) and at the proposed barge landing facility (bottom)

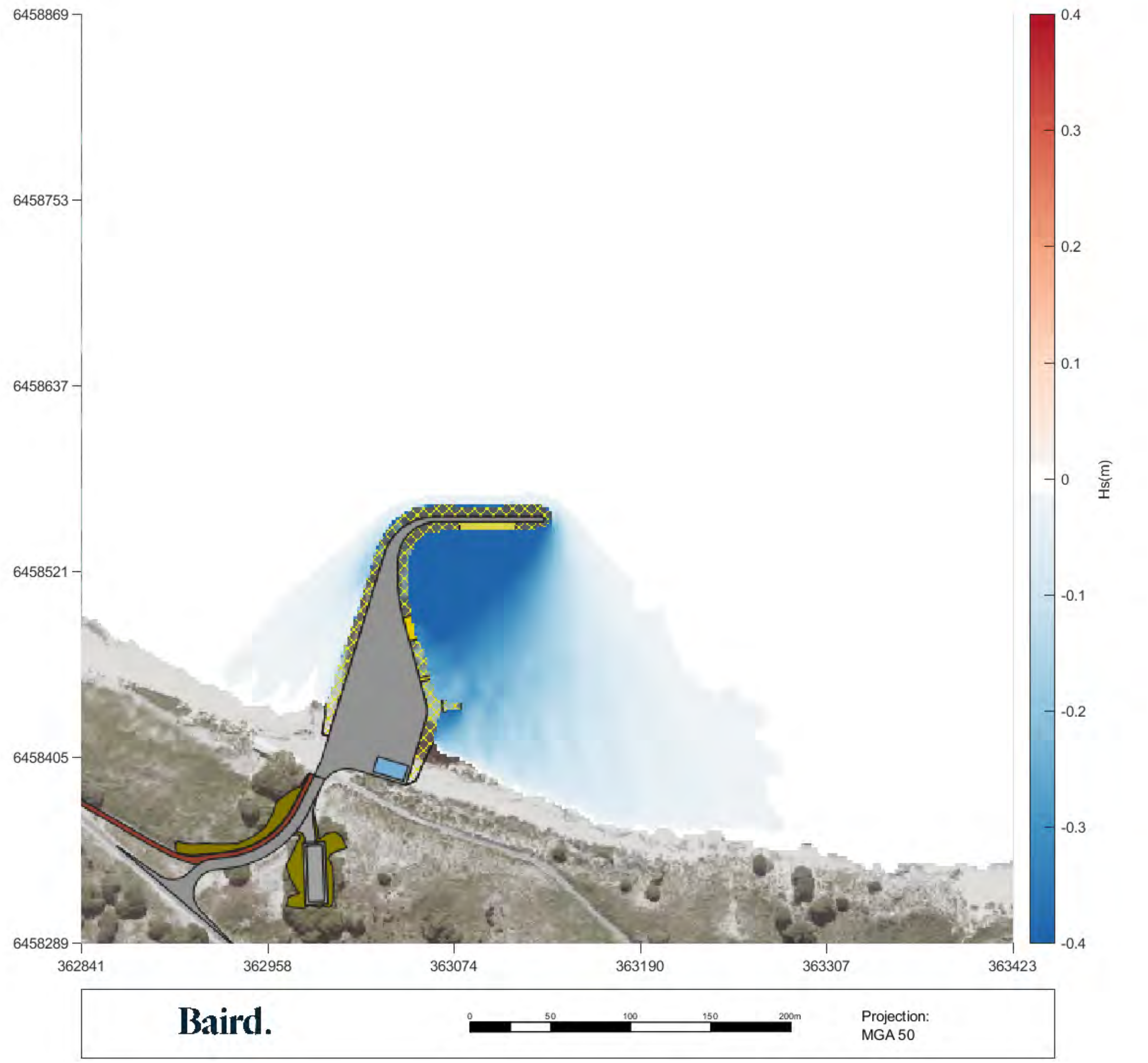


Figure 3.9: Northern windsea event wave plot showing the difference between incident waves with and without the proposed structures

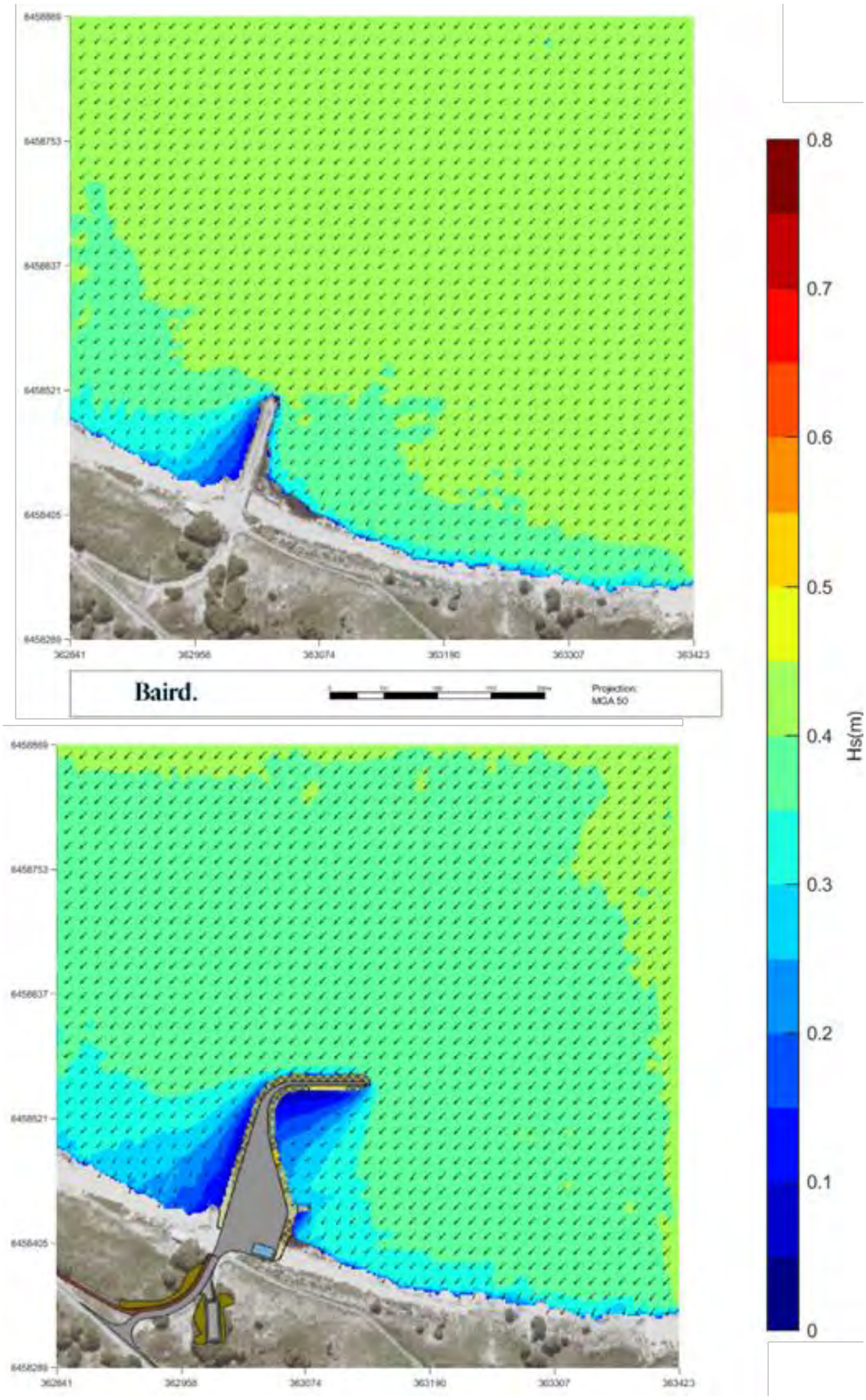


Figure 3.10: Northeastern windsea event wave plots showing wave conditions at the Army Groyne (top) and at the proposed barge landing facility (bottom)

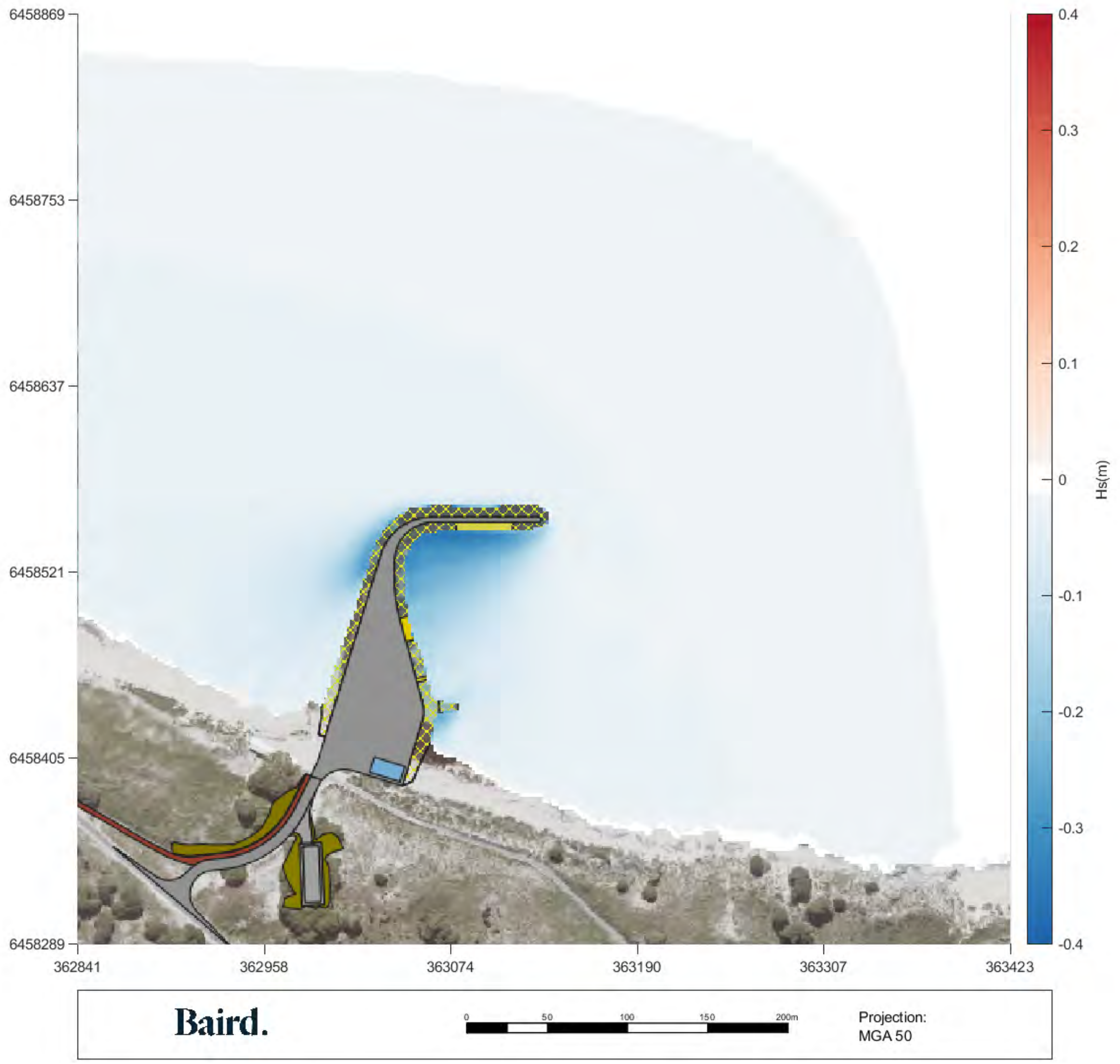


Figure 3.11: Northeastern windsea event wave plot showing the difference between incident waves with and without the proposed structures (bottom)

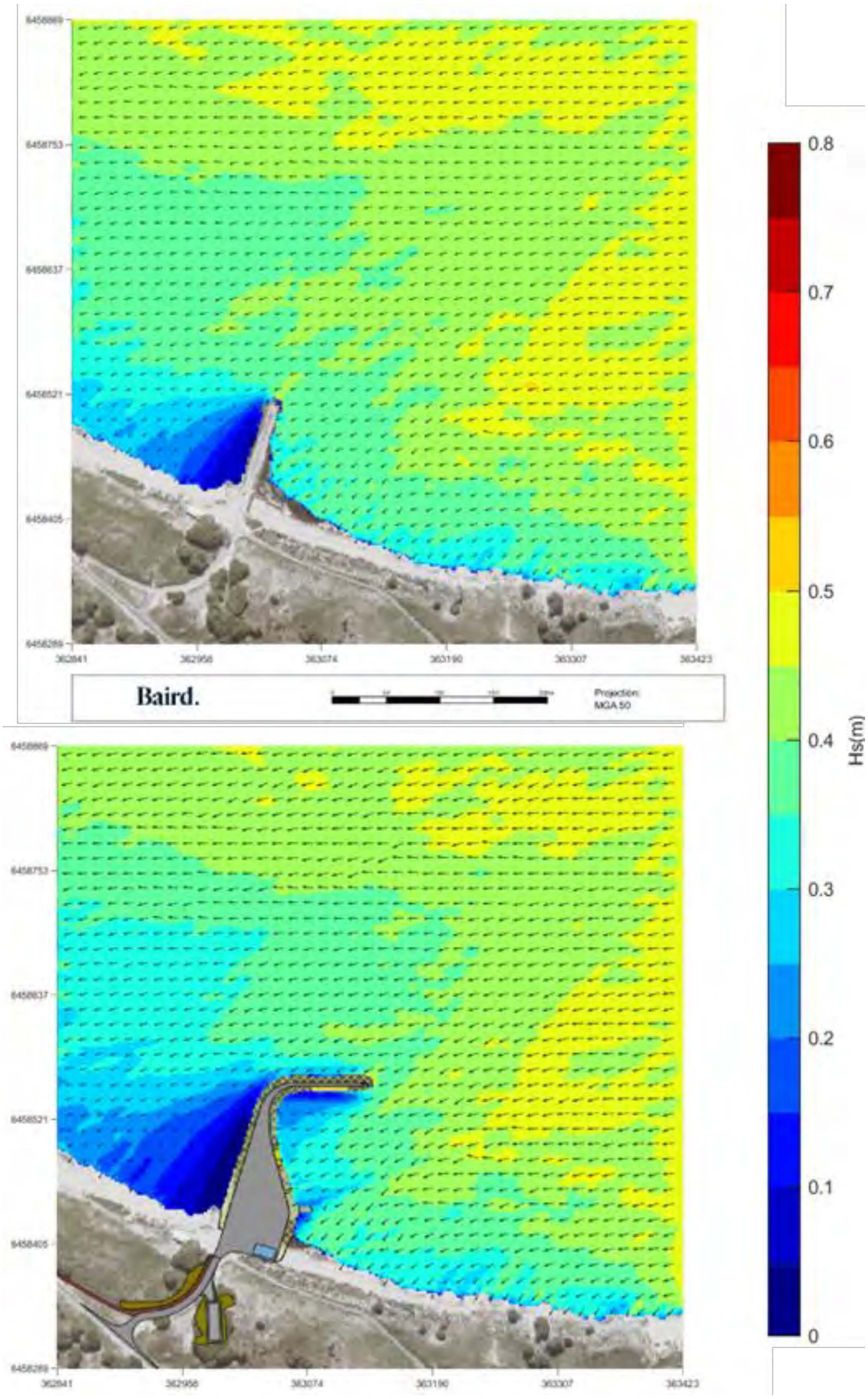


Figure 3.12: Eastern windsea event wave plots showing wave conditions at the Army Groyne (top) and at the proposed barge landing facility (top right,

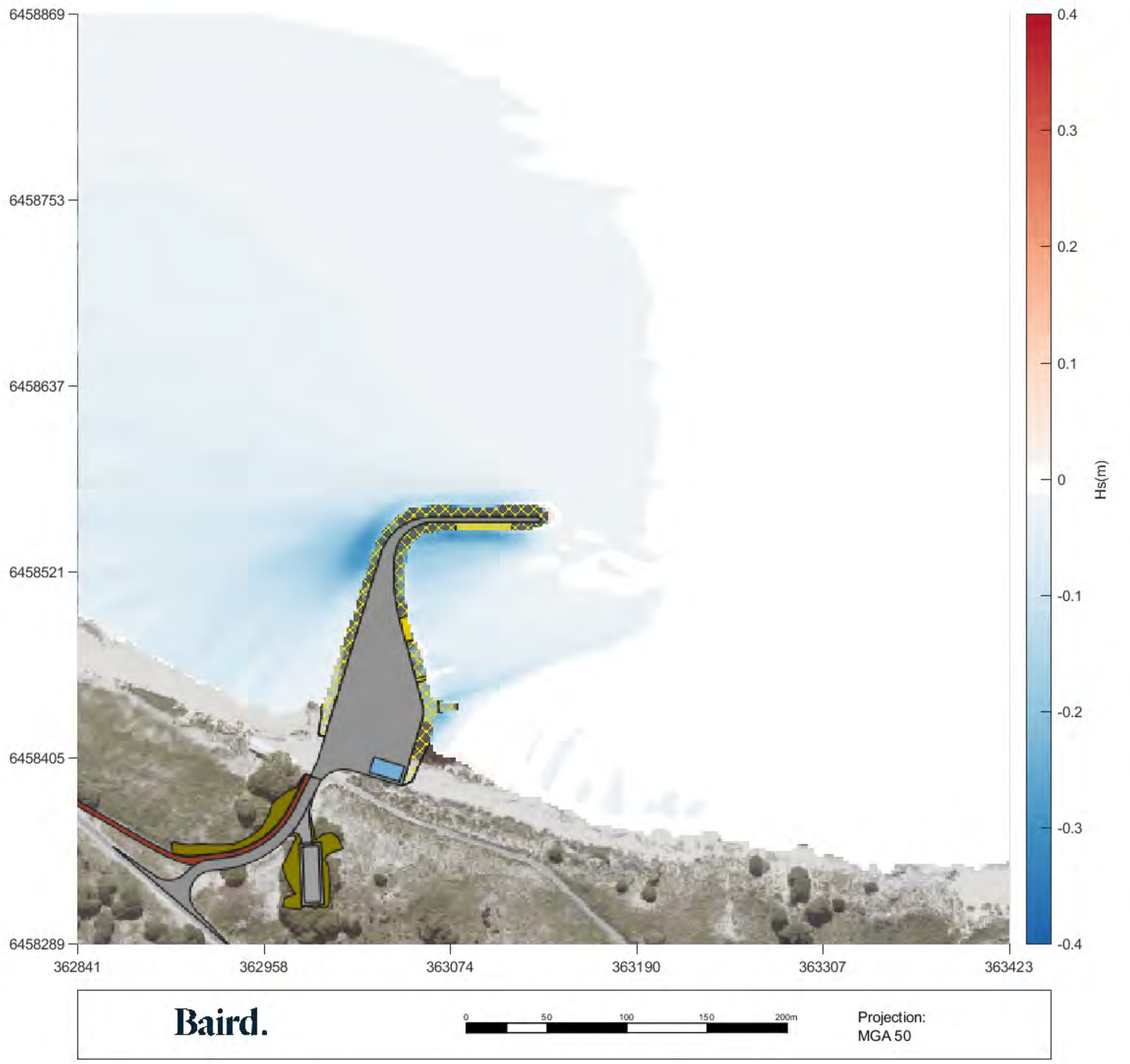


Figure 3.13: Eastern windsea event wave plot showing the difference between incident waves with and without the proposed structures (bottom)

3.3.4 Impact on RIA Managed Moorings

The modelled wave conditions presented as comparison plots from Figure 3.6 to Figure 3.13 indicate the impact on wave conditions outside of the proposed barge facility breakwater structure is minimal. For the RIA moorings on the northwest of the development (Figure 3.2) decreases in wave height are the principal observation across each of the cases.

While no detrimental increase in wave height caused by reflections from the breakwater structure is seen at the moorings managed by RIA in these model results (the proximity of these moorings to the proposed structure is shown in Figure 3.2), further investigation of this should be undertaken in the detailed design phase using a wave phase resolving model, as a model of this kind is more suitable for investigating the complexity of reflected wave interactions.

4. Sediment Assessment

An assessment of the sediment transport pathways that make up the sediment budget of the coastal compartment along South Thomson Bay is important for determining the impact that a coastal structure may have on these pathways, and therefore the overall function of this sediment compartment.

4.1 Sediment Transport Pathways

There are three typically important sediment transport mechanisms that contribute to an overall coastal sediment budget (Figure 4.1), each of which will be described for South Thomson Bay in this section:

- Cross-shore Sediment Transport
- Longshore Sediment Transport
- Aeolian (wind-blown) Sediment Transport

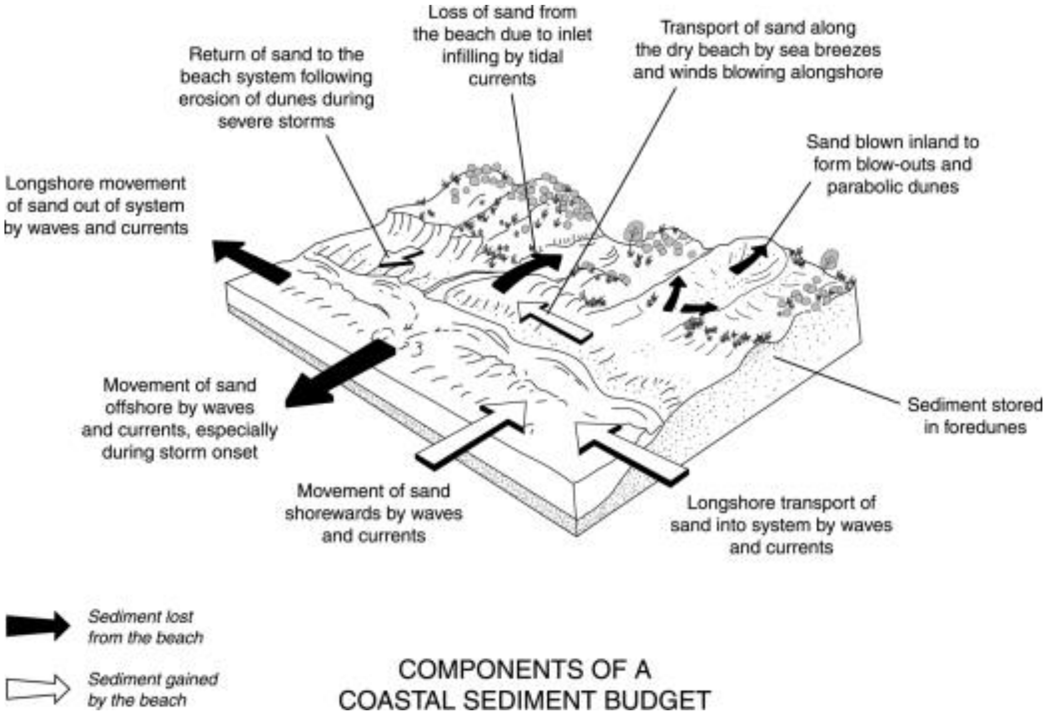


Figure 4.1: Components of a coastal sediment budget (WAPC 2013a)

4.2 Cross-shore Sediment Transport

The cross-shore movement of sediment within a coastal compartment, or sediment cell, has a significant contribution to the overall sediment budget within that compartment, as seen in Figure 4.1. Movement of sediment offshore by waves and currents during a storm reduces the volume of sediment in the dune system backing the beach (profile B and profile C in Figure 4.2), often forming offshore sand bars that can act as wave attenuators that cause waves to break further offshore and decreasing the wave energy that can reach the beach and dune system (CERC 1984). This erosion is typically followed by the return of sediment to the beach system following the passage of the storm through the onshore movement of sediment by waves and currents during calmer conditions.

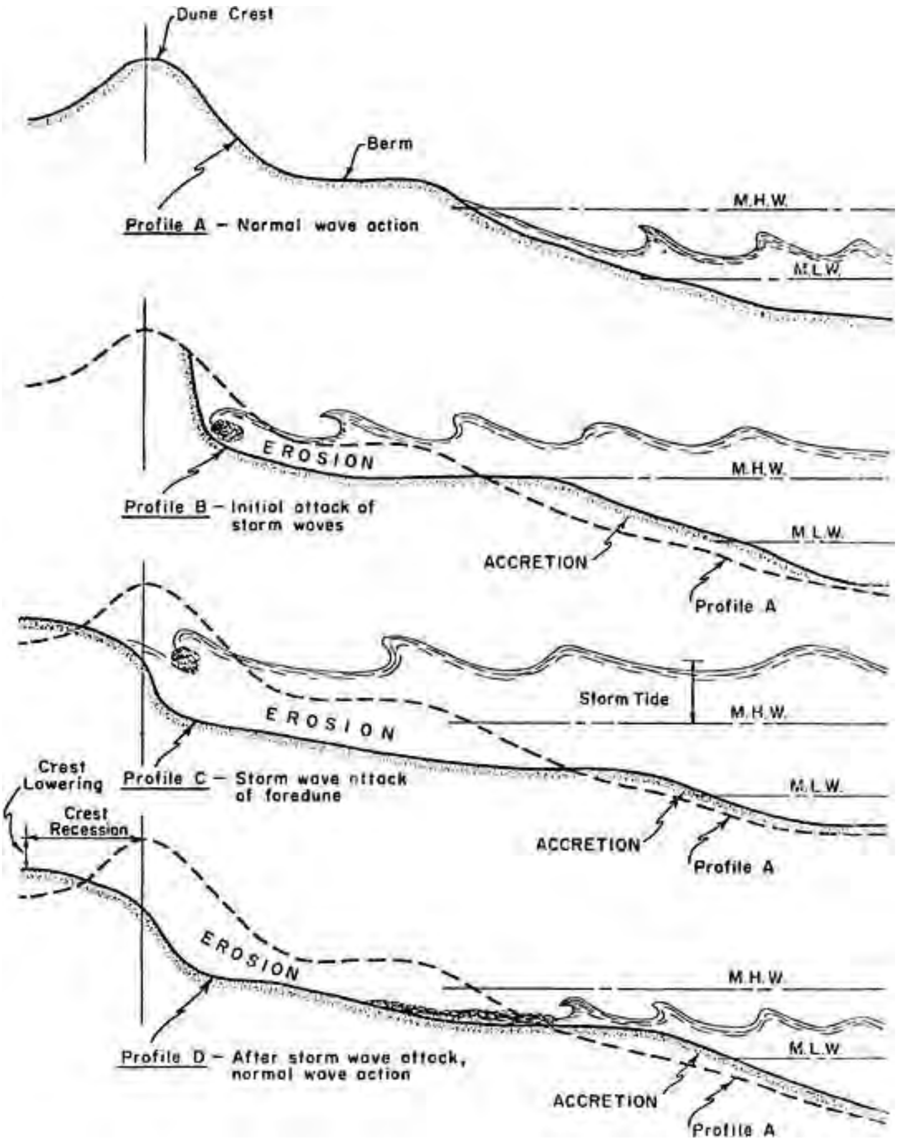


Figure 4.2: Stages of cross-shore sediment movement prior to, during and following the passage of storm waves on a sandy shoreline (Herbich et al., 1982)

Cross-shore sediment transport assessments used to determine the potential for the loss of sediment from the beach and dune system have recently been conducted for South Thomson Bay by MRA in their 2019 South Thomson Bay Coastal Processes Assessment, and by Cardno in their 2022 Coastal Hazard Risk Management and Adaptation Plan for Rottnest Island. An overview of Cardno's assessment is included here due to the more recent nature of the assessment, with due consideration and comparison to the assessment undertaken by MRA in 2019.

As recommended in the State Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6) (WAPC 2013b), the CHRMAP assessment investigated the impacts of short-term acute (storm-induced) erosion on various sites around Wadjemup (Rottnest Island), including within South Thomson Bay. The full set of transects included in the CHRAMP study are shown in Figure 4.3, with the inset at the top left-hand corner showing the transects of interest within South Thomson Bay; Transect 24 and Transect 25 on either side of the existing Army Groyne.

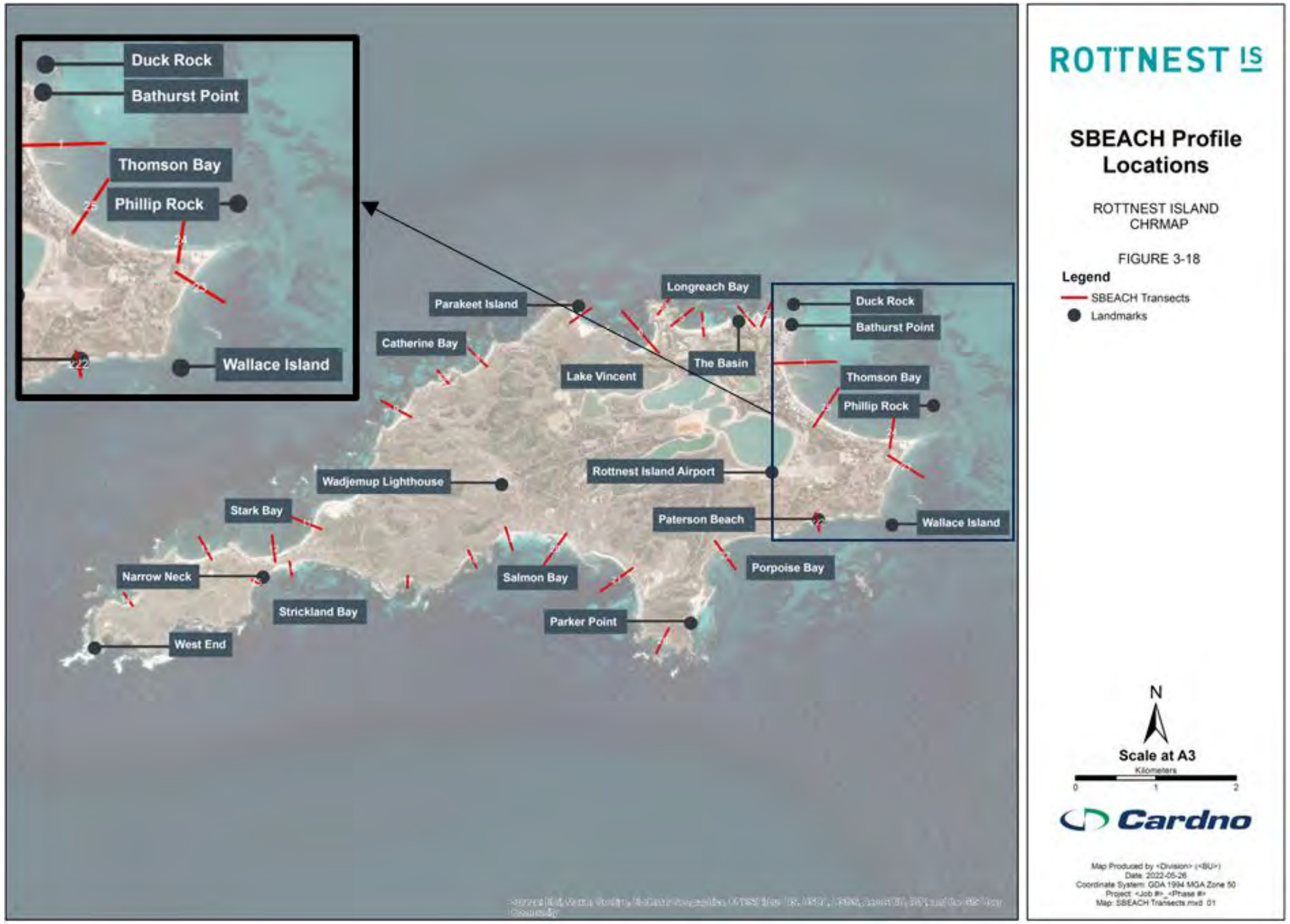


Figure 4.3: SBEACH profile locations from Cardno (2022)

SBEACH modelling was undertaken by Cardno based on a scaled design storm event defined in DoT's synthetic storm database (MRA 2018) at the Rottnest DWR, comprising of a large south westerly swell, coinciding with strong south-westerly through to north-westerly winds and a water level below that of the 1-year ARI at the Fremantle tide gauge. Due to the highly variable aspect of the beaches around Wadjemup, and most of the storms within the design storm event database being derived for Perth's western facing beach aspects, Cardno undertook subsequent wave modelling to derive more representative storm parameters for each of the transects included in the CHRMAP. The parameters that were derived from this modelling were used to scale the storm to be appropriate for use at South Thomson Bay, with these scaled H_s, T_p, and Peak Storm Dir defined for Transect 24 (T024) and Transect 25 (T025) shown in Table 4.1. The median sediment diameter (D_{50}) that was used as an input to the SBEACH modelling for the two transects in this region was based on sediment sampling undertaken by Cardno as part of the CHRMAP scope (Cardno 2022), shown in Table 4.1, with the timeseries applied in the SBEACH modelling shown in Figure 4.4.

Table 4.1: Wave conditions and sediment sizing adopted for SBEACH modelling in South Thomson Bay (adapted from Cardno 2022)

Transect	H_s (m)	T_p (s)	Peak Storm Dir	D_{50} (mm)
T024	1.68	7.4	N	0.39
T025	1.61	7.4	N	0.26

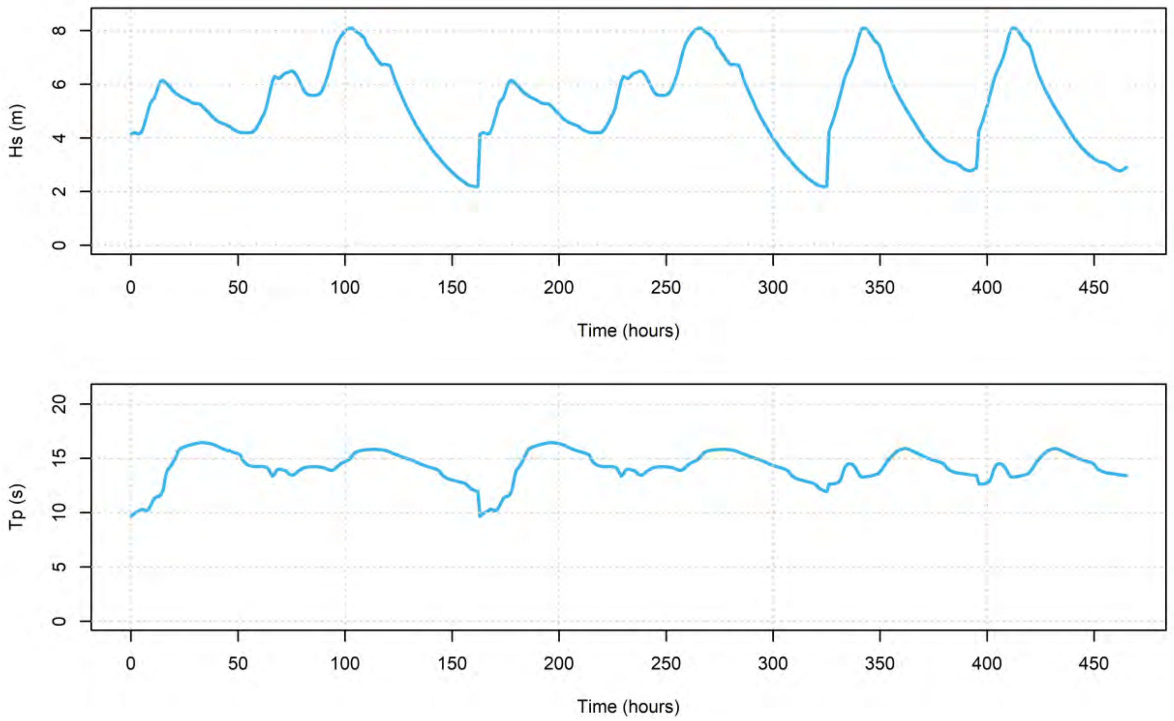


Figure 4.4: Timeseries of Hs and Tp during the synthetic design storm event at the Rottnest DWR, taken from MRA 2018 to be used in the Rottnest Island CHRMAP (Cardno 2022)

The results of the cross-shore erosion assessment using the SBEACH method outlined above are presented for Transect 24 in Figure 4.5 and for Transect 25 in Figure 4.6. These results show that there can be expected to be between 5m and 10m cross-shore erosion during the 100-year ARI design erosion event in South Thomson Bay, which is in line with the 5-10m expected erosion extent predicted by MRA in their 2019 assessment.

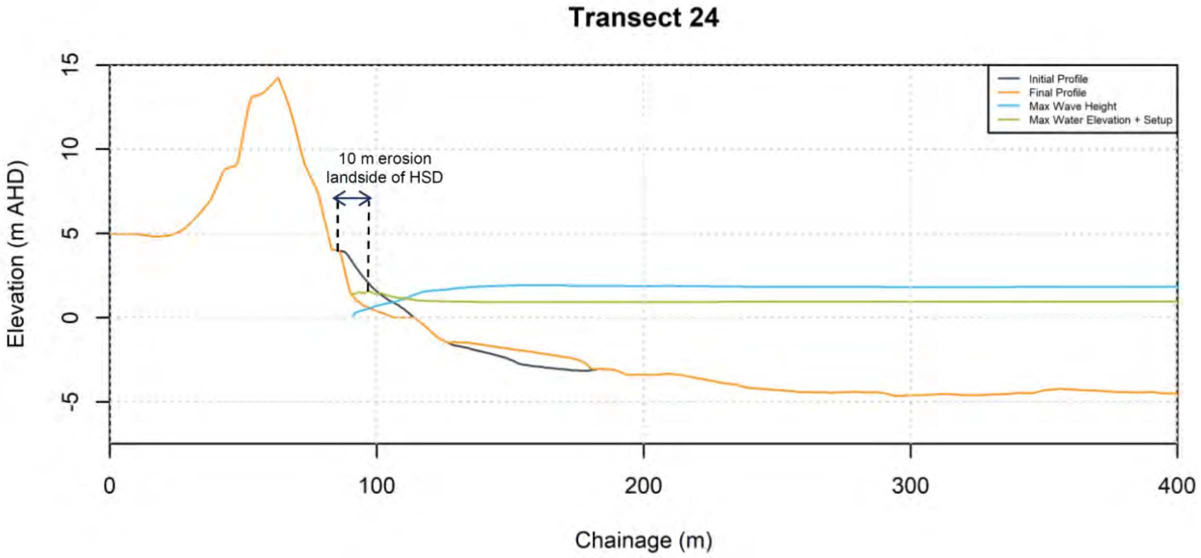


Figure 4.5: SBEACH Profiles derived from the scaled synthetic storm at Transect 24 within South Thomson Bay

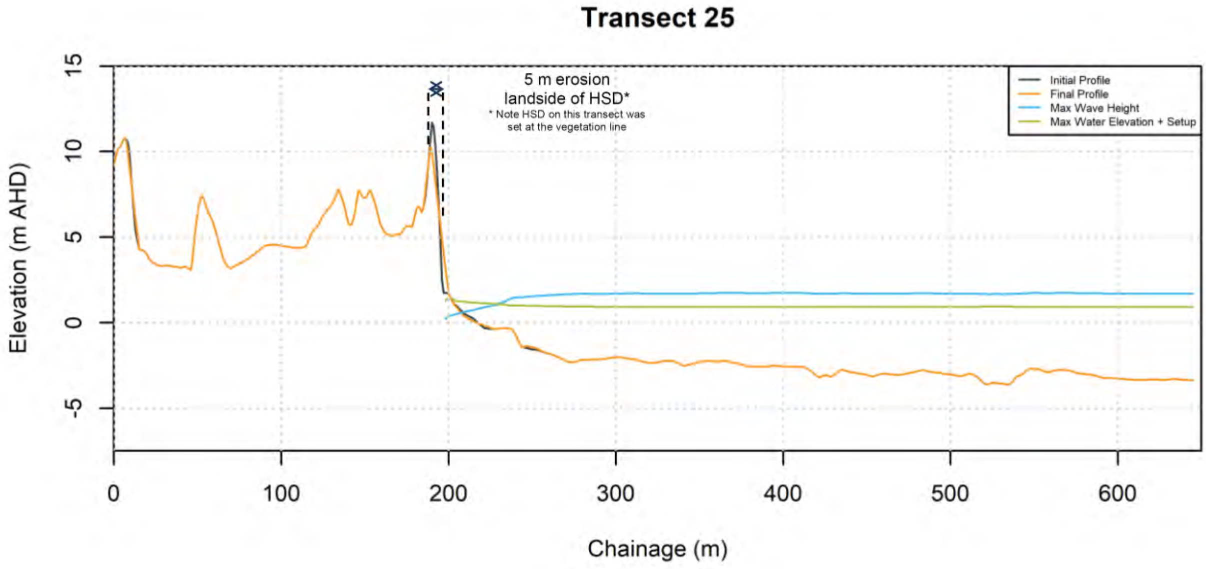


Figure 4.6: SBEACH Profiles derived from the scaled synthetic storm at Transect 25 within South Thomson Bay

4.3 Longshore Sediment Transport

Longshore sediment transport results from the agitation of sediments through wave and/or current action at the beachface and the subsequent movement of sediment along the shoreline via the component of the wave energy that is acting along the shoreline (as opposed to the cross-shore compenent of that energy) and the longshore current that is produced by this wave action (CERC 1984). A simplified diagram of the dynamics of longshore sediment transport is shown in Figure 4.7.

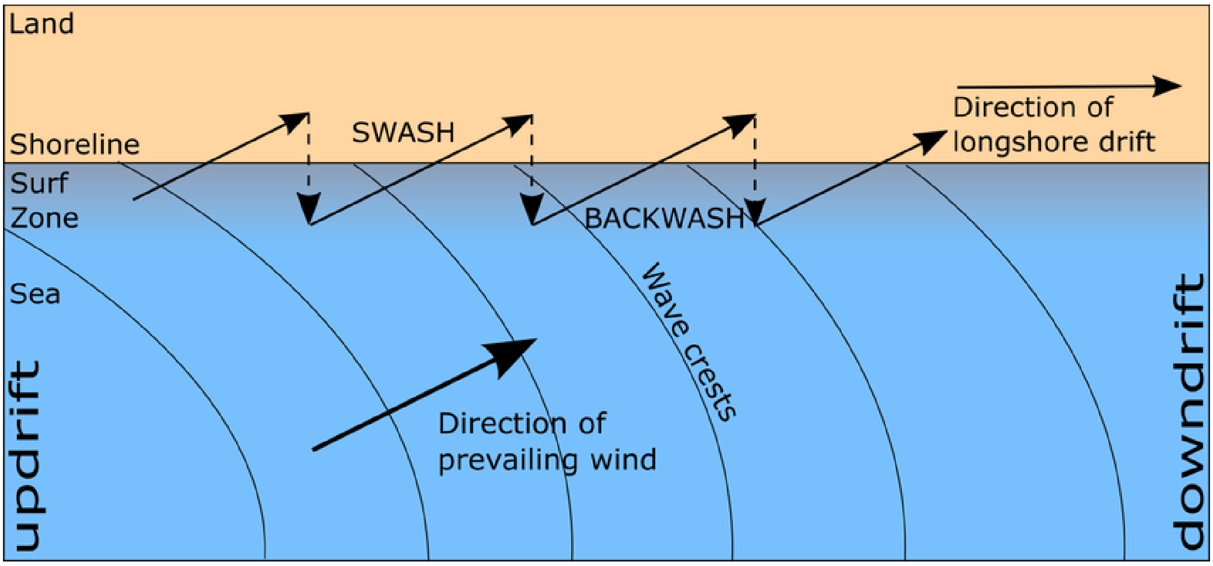


Figure 4.7: Simplified diagram of longshore drift on sandy beaches (van Zyl 2018)

There are a range of measurements and observational methods that are useful when looking to determine the rate of longshore sediment transport, including:

- Analysis of historical aerial imagery
- Analysis of changes to survey data
- Analysis of shoreline movements over time, noting that this estimate will also take into account cross-shore movements of sediment and so is an overall proxy for longterm shoreline movement rather than solely for the estimation of longshore sediment transport

4.3.1 Historical Aerial Image Analysis

Aerial imagery at approximate 10 year intervals dating back from 2023 (2001 is earliest aerial imagery available via the WA Government's SLIP database) at Thomson Bay (Figure 4.8) show that there has been little to no erosion in the vicinity of the Army Groyne since 2001. A version of this image comparison zoomed into close proximity to the Army Groyne (Figure 4.9) further shows that there is very little movement in the vegetation line to the west of the Army Groyne (minimal accretion in the dune is apparent), with greater evidence of accretion and vegetation growth to the east of the Army Groyne.

Seasonal accretion against the eastern side of the Army Groyne structure is evident, with each of the images from 2001, 2003, and 2023 taken in the period from December to February showing an accummulation of sediment. This is in contrast to the beach width seen on the eastern side of the Army Groyne structure in the 2013 image (also taken in February), with the beach shape during that year (i.e., narrow at the groyne and wider with distance east from the groyne) potentially explained by the preceding La Niña cycles from 2010-11 and 2011-12 producing greater positive sea level anomalies in the season's immediately prior to this image (CSIRO 2015).

Figure 4.8: Historical aerial images from 2001 to 2023 in South Thomson Bay overlaid with the 2023 shoreline (proxied by the 2023 vegetation line)

Figure 4.9: Historical aerial images from 2001 to 2023 adjacent the Army Groyne overlaid with the 2023 shoreline (proxied by the 2023 vegetation line)

Comparison of aerials from 2001 to 2023 was also undertaken for the area in the vicinity of Bickley Point due to the relative variability in the shoreline in this region since 1964 (see historic shoreline analysis in Section 4.3.2 below) and the influence this may have on the availability of sediment in South Thomson Bay.

Figure 4.10 indicates that the overall shoreline position around Phillip Point has experienced little fluctuation since 2001, with the shoreline within Bickley Bay experiencing an erosion event followed by recovery of the dune in this area evidenced by the sparser vegetation along this length of shoreline in 2023. Figure 4.11, zoomed in closer to the detail of Phillip Point, shows that the spit linking to the Natural Jetty at this location experiences periods of elongation and truncation, but with the overall position of the point held in place by the Natural Jetty. Evidence of potential future destabilisation of this area is seen through the growth of the dune blowout, progressing each decade up to 2023.

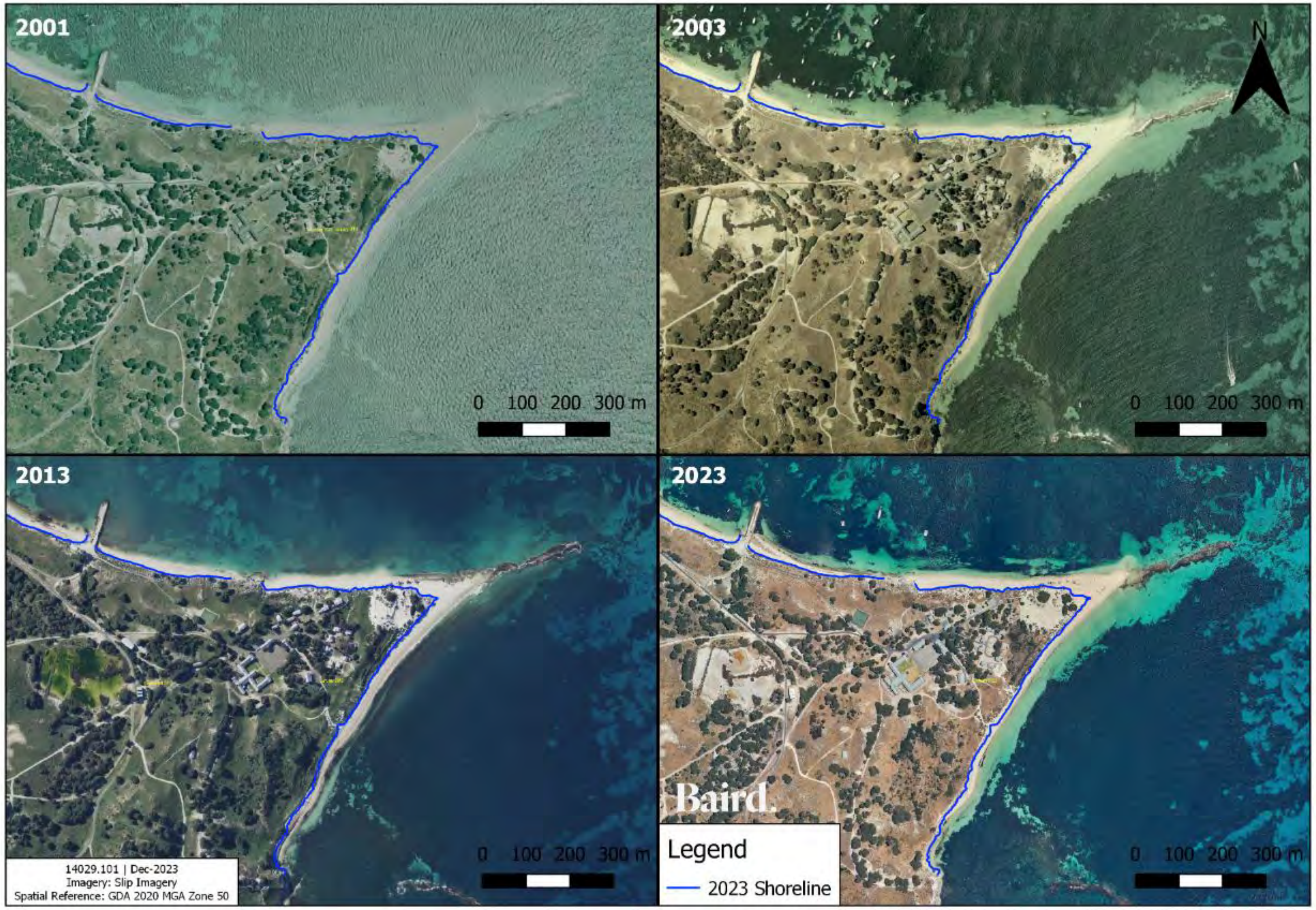


Figure 4.10: Historical aerial images from 2001 to 2023 at Point Phillip overlaid with the 2023 shoreline (proxied by the 2023 vegetation line).

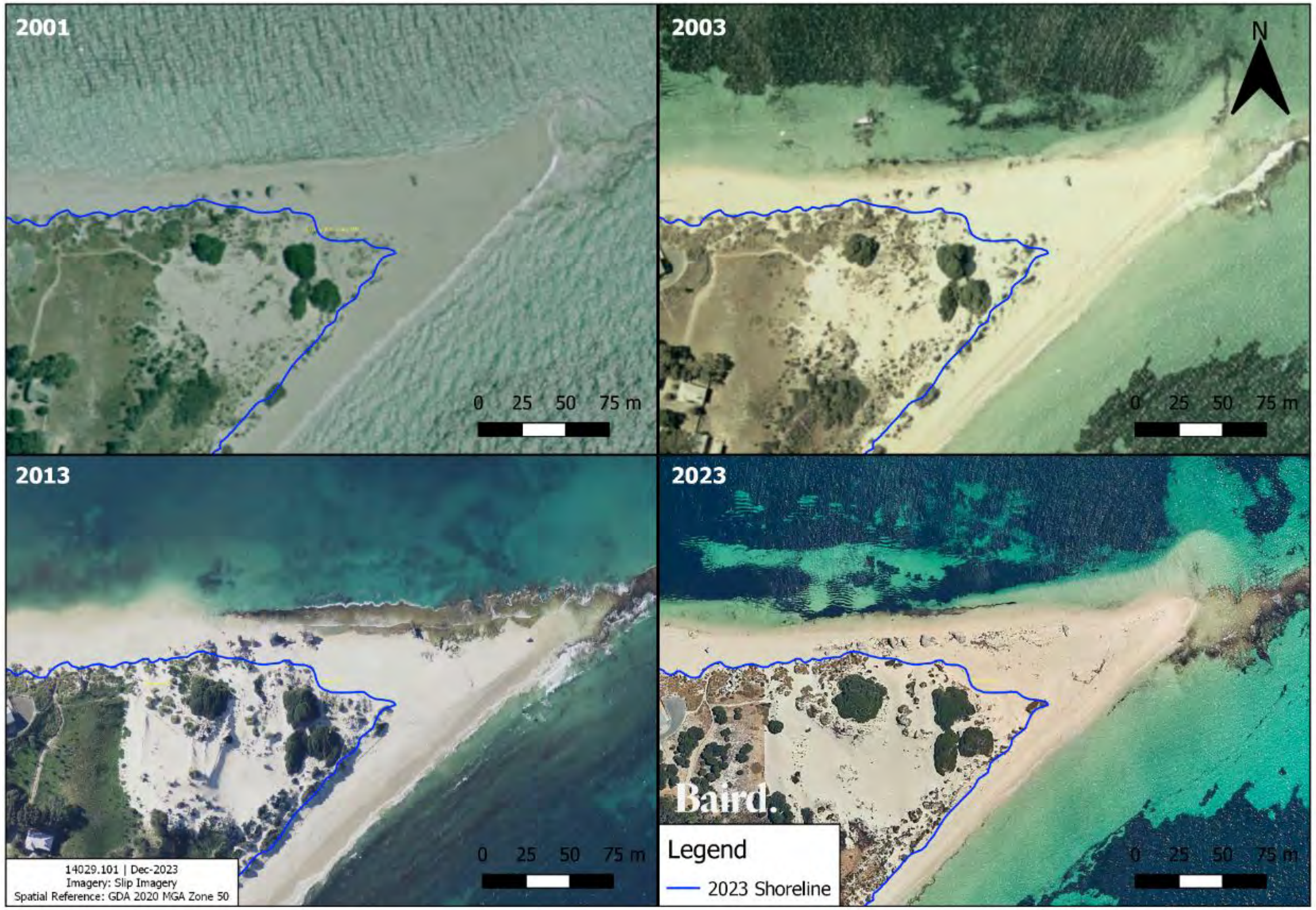


Figure 4.11: Historical aerial images from 2001 to 2023 at Point Phillip overlaid with the 2023 shoreline (proxied by the 2023 vegetation line), zoomed into close proximity to the Point.

4.3.2 Shoreline Movement Plotting

Analysis of historical shoreline positions has been undertaken in previous investigations by MRA (2019) and Cardno (2022), with each of these assessments showing that the shoreline in the vicinity of the Barge Landing development site at the Army Groyne is experiencing some of the smallest fluctuations seen around Thomson Bay. The historic vegetation lines and chainages used by MRA in their assessment of historic shoreline movement in their 2019 coastal processes assessment are shown in Figure 4.12, with the plot of shoreline position at each chainage relative to the 1964 baseline year shown in Figure 4.13.

The largest movement seen around Thomson Bay by MRA is the accretionary pattern evident to the north towards Bathurst Point, and the erosion pattern seen south of Phillip Point in Bickley Bay, with the 2016 shoreline position at the Army Groyne either in line with the 1964 position (west of the Army Groyne) or further seaward of the 1964 position (east of the Army Groyne) indicating accretion.

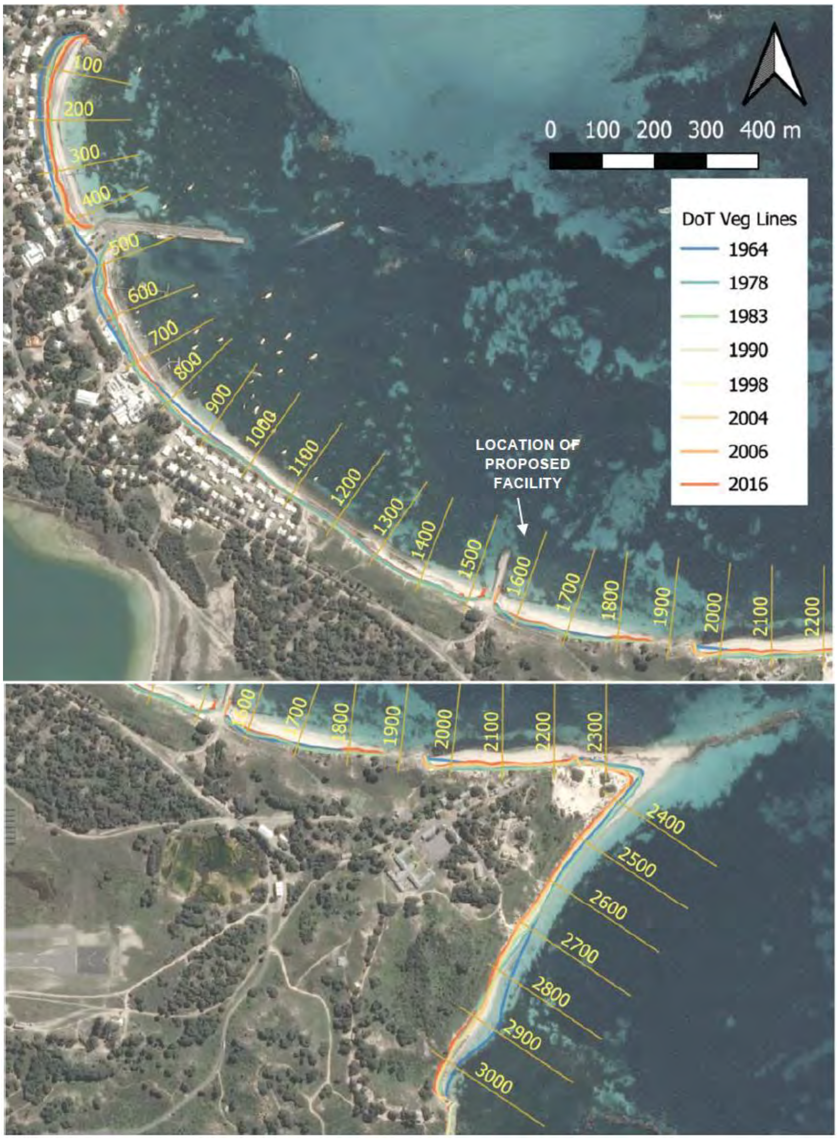


Figure 4.12: Detail of the historic vegetation lines and chainages for Thomson Bay and Bickley Bay used by MRA in their assessment of historic shoreline movement in their 2019 assessment (MRA 2019)

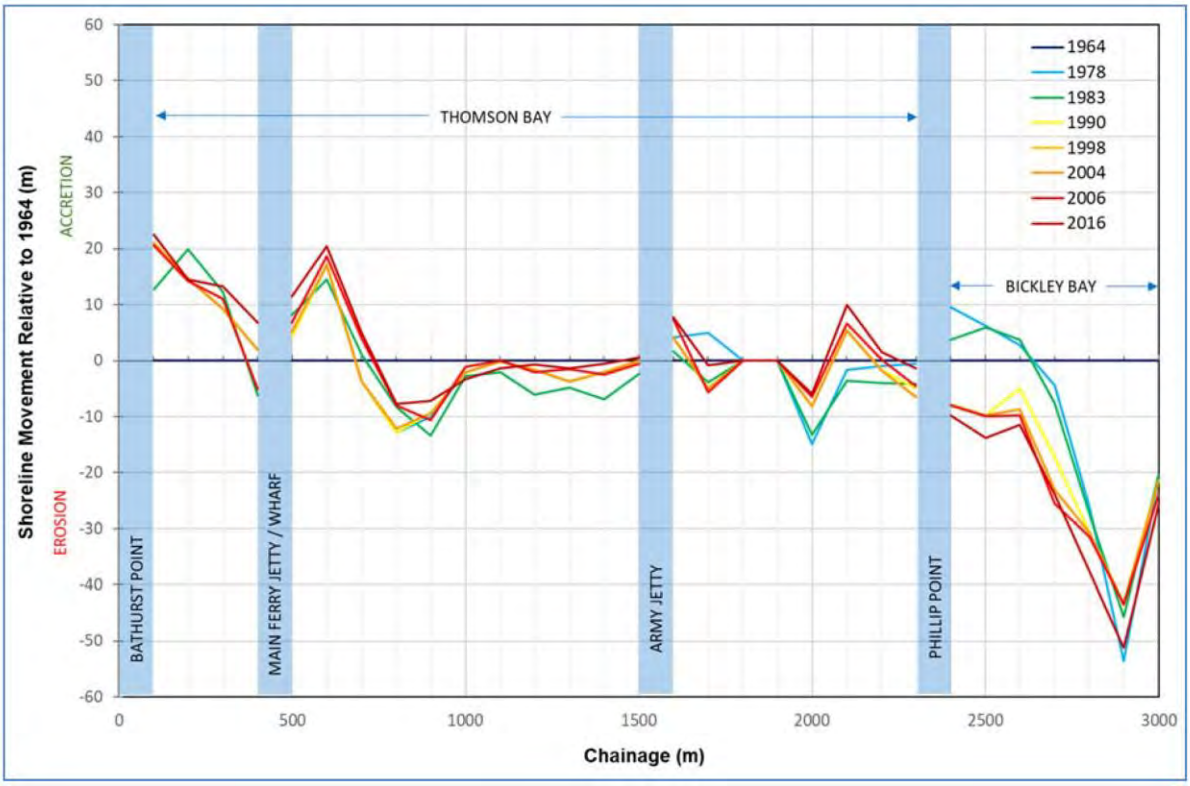


Figure 4.13: Shoreline movement trends relative to the 1964 baseline (MRA 2019)

A similiar assessment was carried out in Cardno (2022, with the chainages used within Thomson Bay shown in Figure 4.14 and the outcome of the shoreline movement analysis shown in Figure 4.15. The chainages closest to the Army Groyne in South Thomson Bay are between 120 and 122, showing an erosion/accretion pattern between 2005 and 2021 of ±5m, also indicating that the shorelines in this area are experiencing only small fluctuations in position across the timeframes investigated.

Update to the shoreline movement analysis has been undertaken here to determine if the trends identified by MRA (2019) and Cardno (2022) have continued into 2023, with Figure 4.16 showing shoreline position for 2016, 2019 and 2023 at the Army Groyne location in South Thomson Bay. This analysis shows that the shoreline position is largely unchanged between 2016 and 2023, with the largest region of erosion seen to the west of the Army Groyne at approx. 4m, and the largest region of accretion seen to the east of the Army Groyne at approx. 3m.

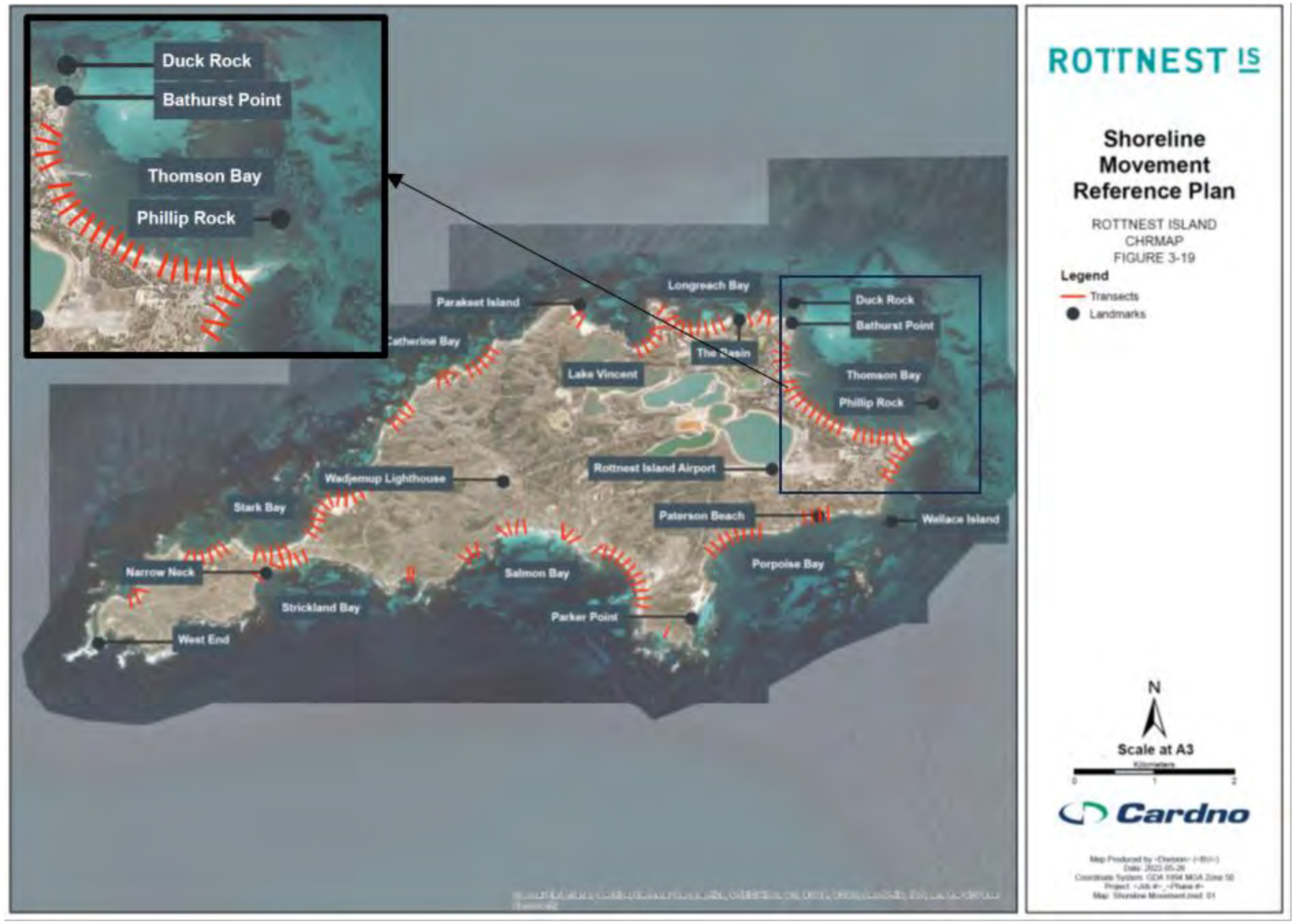


Figure 4.14: Chainages used by Cardno in their assessment of historic shoreline movement in their 2023 CHRMAP, with the inset showing the chainages used within Thomson Bay and Bickley Bay (Cardno 2022)

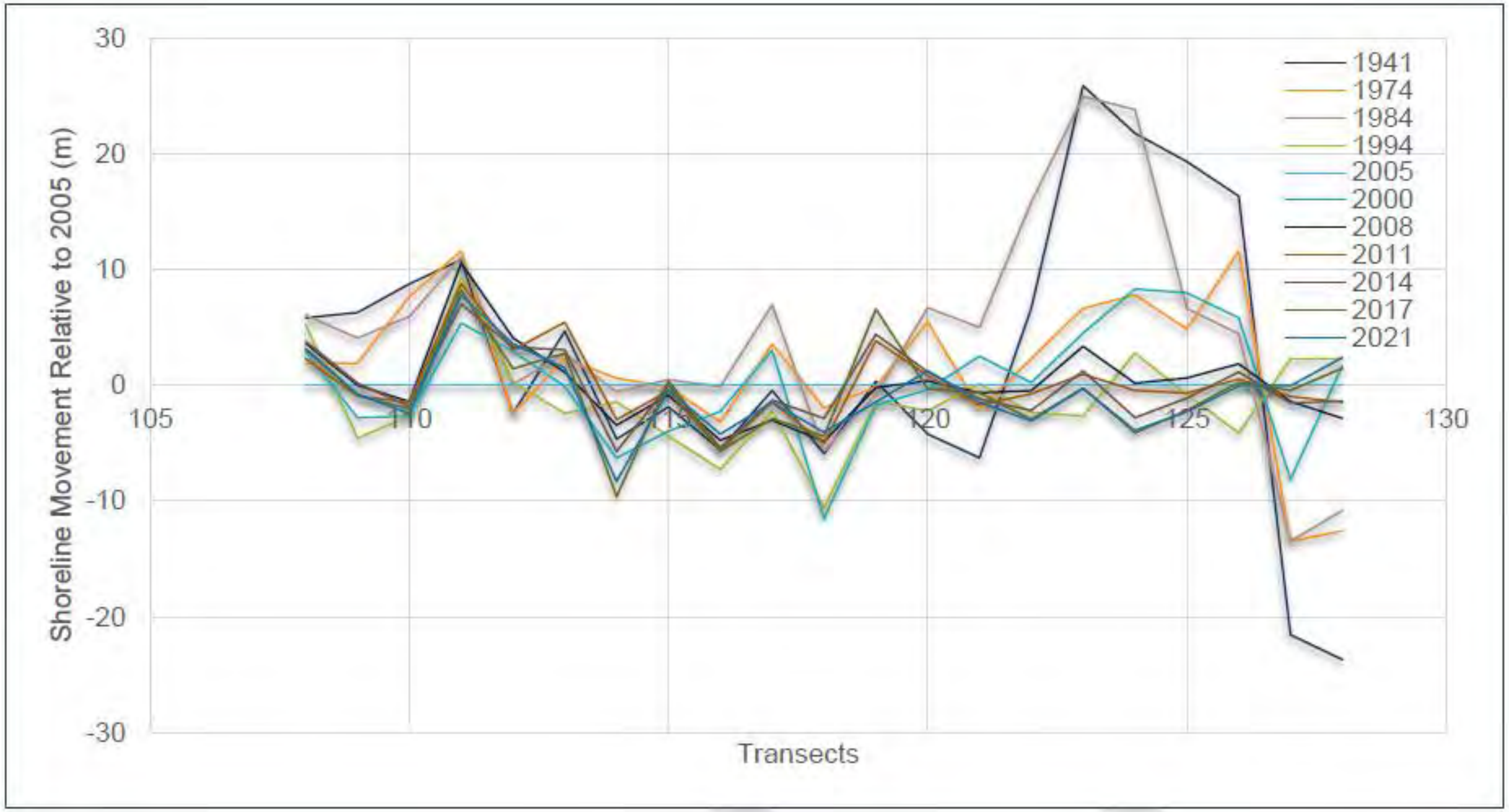


Figure 4.15: Shoreline movement plot relative to a 2005 baseline for Thomson Bay (Cardno 2022)

Figure 4.16: Overview of the latest shoreline movements, showing the 2019 and 2023 shorelines aligned to the 2016 shoreline

4.4 Aeolian Sediment Transport

Evidence of the movement of sediment through aeolian (wind-blown) transport is seen in the progression of blowouts, mostly minor, across the shoreline of South Thomson Bay. This is seen through the minor dune blowout progression between 2016 and 2023 in Figure 4.18 and the larger dune blowout progression between 2001 and 2023 at Point Phillip in Figure 4.11. Human access to the dunes also plays a part in the progression of this blowout, with children observed playing in this area due to the close proximity to popular tourist accommodation in South Thomson Bay.

A calculation of the potential for windblown sand volumes along this section of the coast was undertaken based on the Hsu (1986) equation for windblown sand transport as summarised in the Coastal Engineering Manual (USACE, 2008). The calculation of transport potential was completed adopting a range of sediment sizes from measured data reported in Cardno (2022). The sediment sizes were D_{50}=0.39mm for the beach west of the Army Groyne, a D_{50}=0.26mm for the beach east of the Army Groyne, and a D_{50}=0.4mm for the beach south of Phillip Point. The analysis was completed using three-hourly data from Rottnest Airport for 2021.

Calculations were carried out to determine the potential for aeolian transport east and west along South Thomson Bay, as well as north across Phillip Point from Bickley Bay to South Thomson Bay due to the evidence of sediment moving through this pathway via the blowout in this area. As noted by MRA in their 2019 assessment, the strong seabreezes experienced from the south on Wadjemup (see the overall wind pattern with strong winds from the south in Figure 2.5 and the breakdown of the 9am and 3pm wind roses of data from 1984 to 2023 showing the strong southerly component of the afternoon seabreeze) are likely to be contributing to the windblown transport of sediment from the south to the north of Phillip Point.

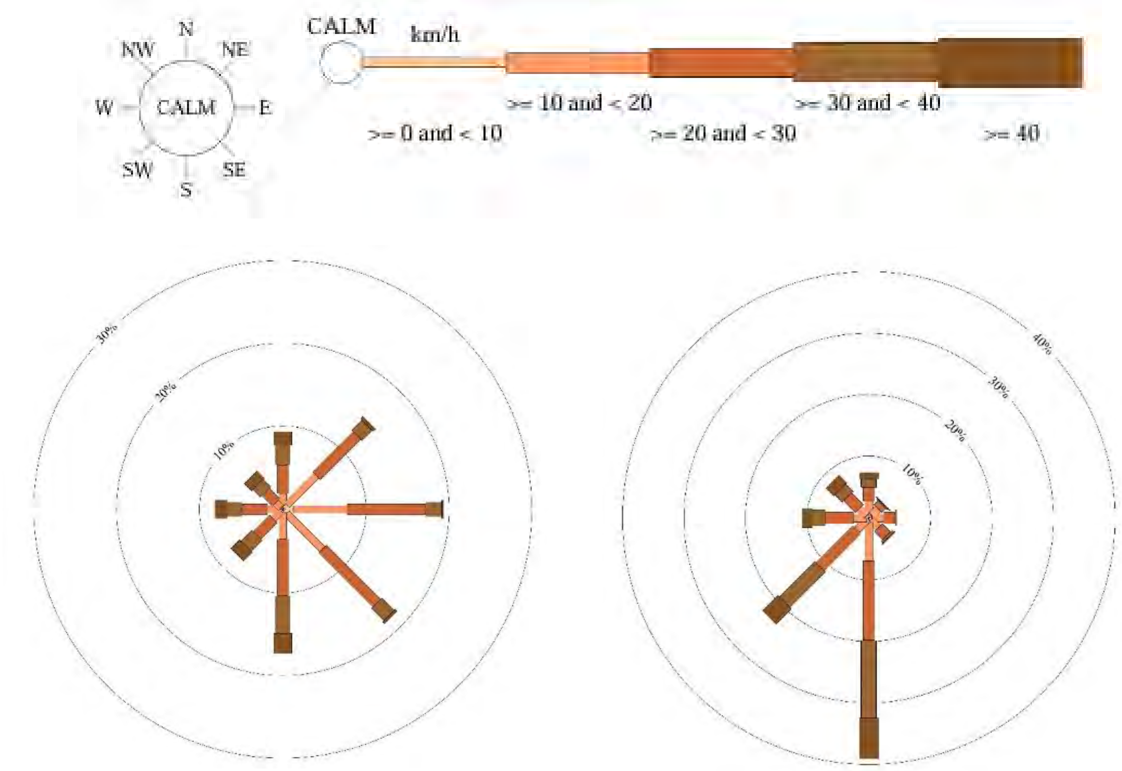


Figure 4.17: 9am and 3pm wind roses covering data from 1984 to 2023 at Rottnest Island (site no. 009193) (BOM 2023)

Annual transport rates in cubic meters per unit meter width are summarised in Table 4.2, showing the potential for sediment to be transported around South Thomson Bay, noting that these potential rates are subject to the availability of sediment to be transported.

Table 4.2: Annual Transport Per Meter Shoreline

	(m^3/m)
North-bound Transport	64
West-bound Transport	25
East-bound Transport	37

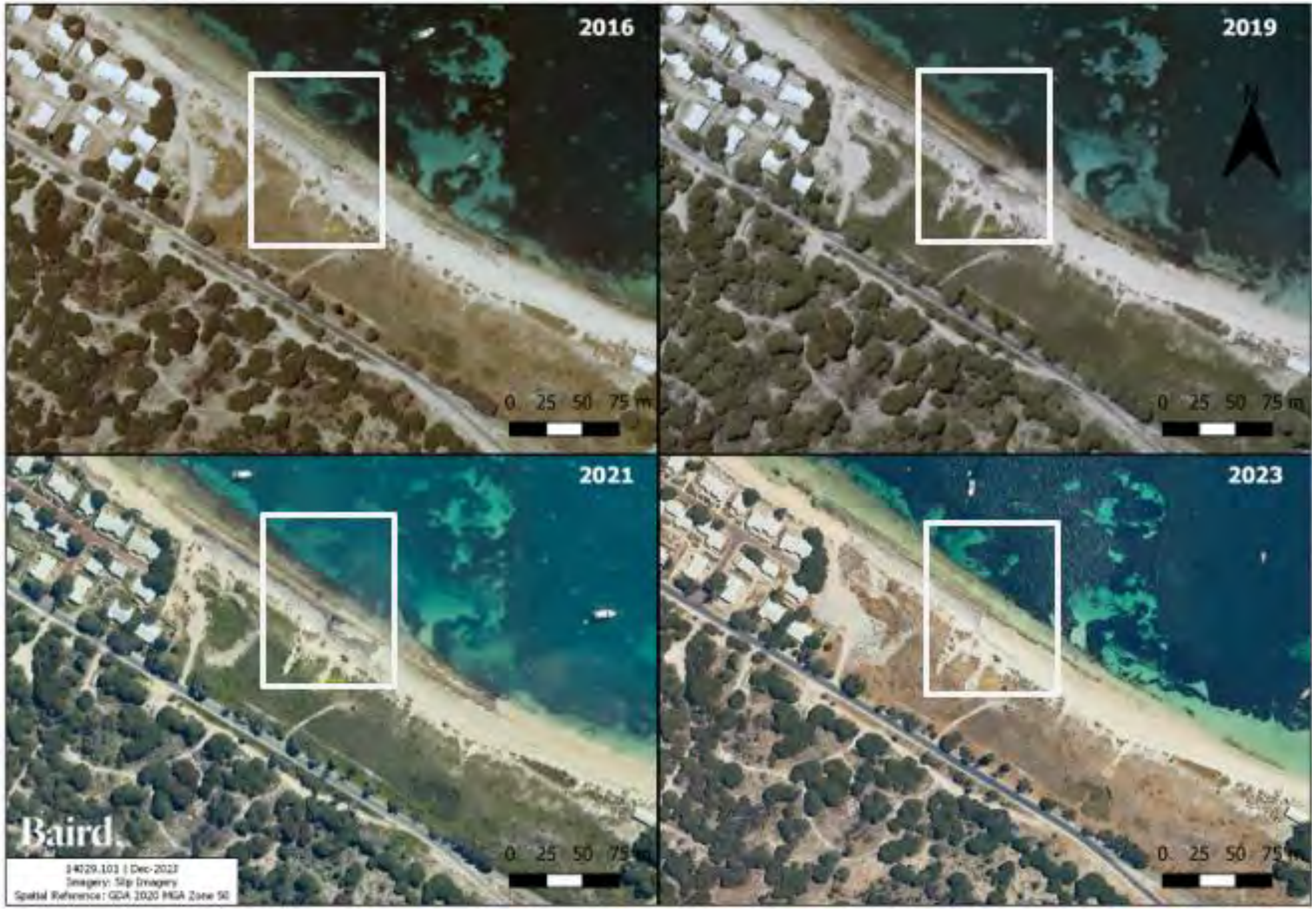


Figure 4.18: Progression of a minor dune blowout in South Thomson Bay, west of the Army Groyne, between 2016 and 2019

4.5 Sediment Budget

Based on the above updated analysis of the shoreline movements and the cross-shore and longshore sediment transport patterns, the sediment budget for Thomson Bay compiled in MRA (2019) has been updated to reflect more recent observations. This updated sediment budget provides the estimated annual sediment movement across the tertiary sediment cell covering Thomson Bay, the R14b Bathurst Point to Philip Point sediment cell.

Acknowledgement is given to the MRA (2019) analysis that the sediment budget should take into account the dredging of the channel that occurred adjacent to the Main Ferry Jetty in the 1960s and 1970s and the significant impact that these works had on the northern section of Thomson Bay, therefore the updates to the sediment budget provided here are based on the sediment budget provided from 1978 to 2018 in MRA (2019).

Updated observations that have contributed to differences between this sediment budget (1978 to 2023) and the sediment budget for 1978 to 2016 estimated by MRA in their 2019 assessment include:

- Observations of the growth of the dune blowout at Philip Point and quantification of the potential for wind-blown sand in the northward direction along Bickley Bay has led to differences in the estimated sediment fluxes along the Bickley Bay sector. It should be noted that the estimated annual loss of sediment in this area has remained the same due to the minimal change in shoreline position between 2016 and 2023 along this section of coast.
- Observation of the minimal change to shoreline position in the northern segment of the South Thomson sector has led to the update of the annual sediment volume change to ~0m^3/yr (rather than a negative volume)
- It is noted that the South Thomson Bay seawall has been constructed since MRA's 2019 assessment, and so shoreline recession in this area can be expected to be ~0 m^3/yr over the lifetime of that structure. Sediment flux along the beach fronting the seawall is still included in the sediment budget, allowing for the movement of sediment past the structure on an annual basis.

The boxes show the quantity of material estimated lost (shown in red) or gained (shown in green) in each compartment of the study site. The estimated annual sediment budget for the period from 1978 to 2016 is provided in Figure 4.19.

Figure 4.19: Conceptual Sediment Budget (1978-2023, adapted and updated from MRA (2019))

4.6 Impact of Climate Change on Sediment Dynamics

The sediment dynamics within South Thomson Bay will be impacted by climate change both through mean sea level rise and the intensification and change in frequency of storms. Further study is required to determine a quantified impact of the intensification of storm events on the Western Australian coastline, with the design storm outlined in Section 4.2 used to determine storm impacts in this assessment.

Consideration should also be given to the impact of raised sea levels resulting in the increased ability of waves to pass over the nearshore reefs within Thomson Bay (e.g., Kingston Reef), leading to more wave energy passing over these reefs and impacting on the shoreline. Some vertical reef growth may be expected to occur over the period of sea level rise, with current data showing that many reefs around the world have the capacity to grow with the current rates of sea level rise. However, it has also been seen that many reefs do not have the capacity to track with the projected rates of sea level rise expected over the next 100 years (Perry et al 2018).

The potential impacts of sea level rise on the sediment dynamics presented above will be discussed here.

Following the Department of Transport (DoT)'s publication on the application of sea level change to coastal planning in Western Australia (2010), which incorporated projections of sea level rise based on the upper bound of the global average projections from the IPCC's Fourth Assessment Report (2007), a Sixth Assessment Report has been released by the IPCC in 2021 with updated projections derived from their Shared Economic Pathways analysis. This places the expected amount of sea level rise over the next 100 years at approximately 0.94m when estimated from SSP5 in IPCC (2021) (Figure 4.20).

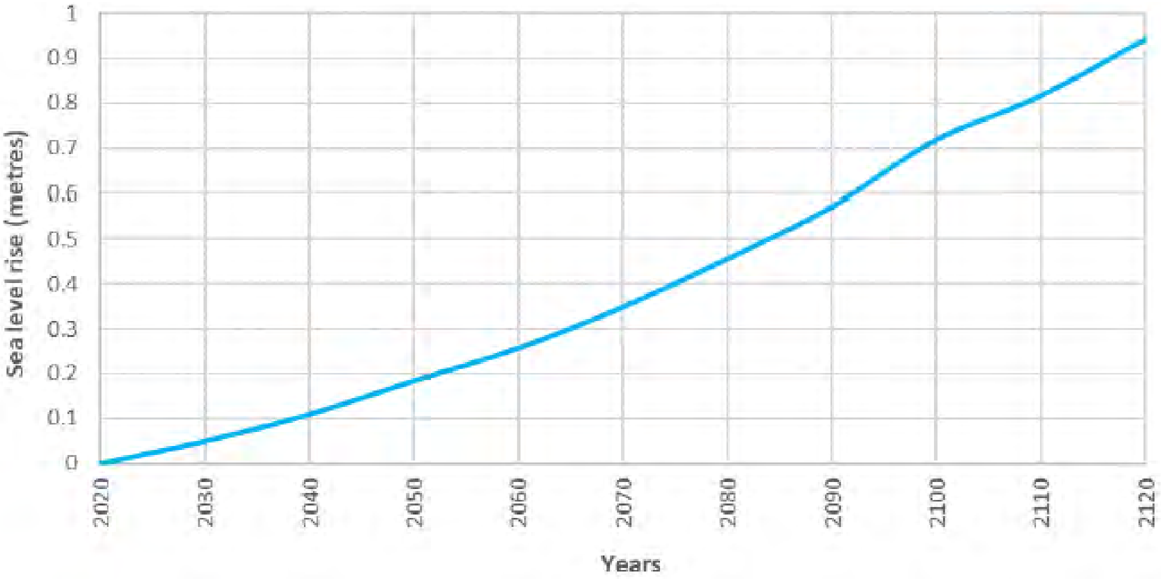


Figure 4.20: Projected sea level rise for the Western Australian coastline (IPCC 2021)

According to the guidelines and policy of the Western Australian Government (SPP2.6, WAPC 2013b), this rise in sea level can be expected to cause shoreline recession along the sandy shoreline of South Thomson Bay of up to 100 times the magnitude of sea level rise experienced, as based on the Bruun rule (Bruun 1962). In line with this rule, a 1cm rise if sea level can loosely be expected to cause a 1m landward recession of the average shoreline position of a sandy coast, as demonstrated through Figure 4.21). It is acknowledged that this rule is generally considered to be a conservative relationship between sea level rise and sandy shoreline recession (Rosati et al, 2013), but is adopted as a standard across Western Australia to date.

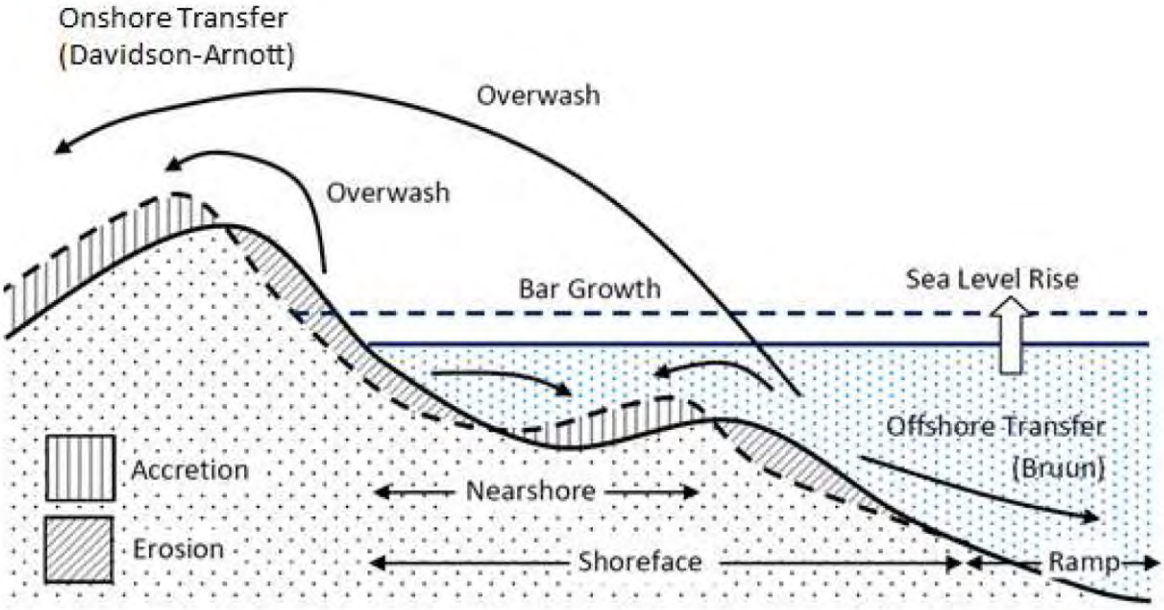


Figure 4.21: Typical sandy shoreline cross shore response to sea level rise, adapted from Dubois (1992) (Seashore 2021).

This assumption is incorporated into CHRMAP assessments via the S3 component of the assessment, the allowance for erosion caused by future sea level rise and has been calculated by Cardno in their 2022 CHRMAP assessment for Rottnest Island. A value for this expected shoreline erosion of 94m in 100 years was adopted for the whole of Rottnest Island in this assessment (Cardno 2022), with interim values adopted according to the timeframes of the intermediate assessments utilised in the study.

4.7 Impact of Proposed Facility on Sediment Dynamics

4.7.1 Thomson Bay Shoreline West of the Development

Considering the above analyses, it is unlikely that the proposed barge development would have a significant impact on the sediment dynamics on the western side of the development structures along South Thomson Bay. As the existing Army Groyne has posed a barrier to sediment transport in this region since it’s construction, and subsequent extension and shortening (Figure 2.16), since 1904, the shoreline in this region has had a significant amount of time to adjust to the impacts of an impermeable structure and therefore the addition of the proposed facility creating a similar barrier in the same location is expected to have minimal impact.

4.7.2 Thomson Bay Shoreline East of the Development and in the Lee of the Structures

The presence of the breakwater structures results in modification of the shoreline processes in the lee of the structures, the shoreline connection point and the Thomson Bay shoreline on the eastern side.

In the lee of the structures, for the shoreline on the eastern side, there is expected to be changes to the existing coastal processes. This shoreline is presently supplied with sediment in the summer months with notable volume of sediment building up on the east side of the groyne through the November to March period due to wind driven longshore transport. During the autumn to winter period (April through July) storms direct wave conditions through Thomson Bay with waves from the North and North-Northeast, which serve to naturally clear the sediment buildup on the east side of the groyne and move it offshore and back along the beaches to the east. This mechanism will be inhibited once the groyne structures are in place, with wave shadowing presented in (Figure 3.6 and Figure 3.7) clearly indicating the reduction in wave energy for northern storms with the extended breakwater in place.

To understand the coastal processes in the lee in more detail, analysis of the shoreline position (nominally representing mean sea level) on the east of the groyne for 25 aerial images taken at various times of the year was undertaken in Baird (2025). An estimation of the shoreline position in each respective aerial along four transects shown in Figure 4.22 was undertaken with a summary graph that shows the change over the months of the year. The shoreline position is presented relative to the shoreline position in July 2013.

The coastal processes can be inferred from the analysis of shoreline changes observed in aerial imagery on the shoreline east of the groyne as follows:

- shoreline accretion is most active through Summer months (Dec – Mar).
- erosion of the shoreline occurs in the late autumn / early winter storms (April – June / July).
- the shoreline is eroded back to its minimum position on transects through winter months (June – Sep).
- Transect 1 and Transect 2 exhibit significant shoreline changes (up to +40m), with accretion rate reducing at Transect 3 (+20m). The changes in shoreline position at Transect 4 are much less significant with this representing a largely stable profile over the analysis (+/- 10m).
- Transect 4 is located at a distance 140m east of the present Army Groyne. If this range of influence is adopted as the potential shoreline that will experience accretion post-construction this would extend almost to the limestone rock outcrop on the eastern shoreline identified in Cardno (2022), that is assumed to be ‘rocky shoreline’.

The volume of material moving east along the beach between winter and summer has been estimated based on analysis along the transects using survey elevation data from 2017. An estimate of the average sediment volume above the mean sea level that is moving to the area between the transects on the east side of the groyne from winter to summer peak is 800m^3. Note this represents the volume above mean sea level and there would be additional volume below this offshore.

In summary, the coastal processes for the shoreline east of the barge development are summarised as:

- sediment moving west under the long shore transport mechanism (approximately 800m^3) in summer months that will accrete on the shoreline along the eastern edge of the breakwater structure post-construction.
- The developed case breakwaters reduce wave energy at the shore. The present mechanism for the sediment to be naturally cleared from the eastern side of the developed structure in the autumn months by N and NE wind driven storm waves and long-shore transport will be reduced or potentially not occur at all post-construction.
- This is expected to result in continual build-up of sediment on the east side groyne in subsequent summers if no management action is undertaken.

A site specific CHRMAP report has been prepared for the barge development site in Baird (2025) which provides recommendation for coastal erosion hazard distances for the site based on SPP2.6. The CHRMAP provides mapping for coastal erosion setback in future planning periods based on the coastal processes understanding presented in this section. Coastal management approaches and monitoring recommendations are also provided for the barge development site in Baird (2025).

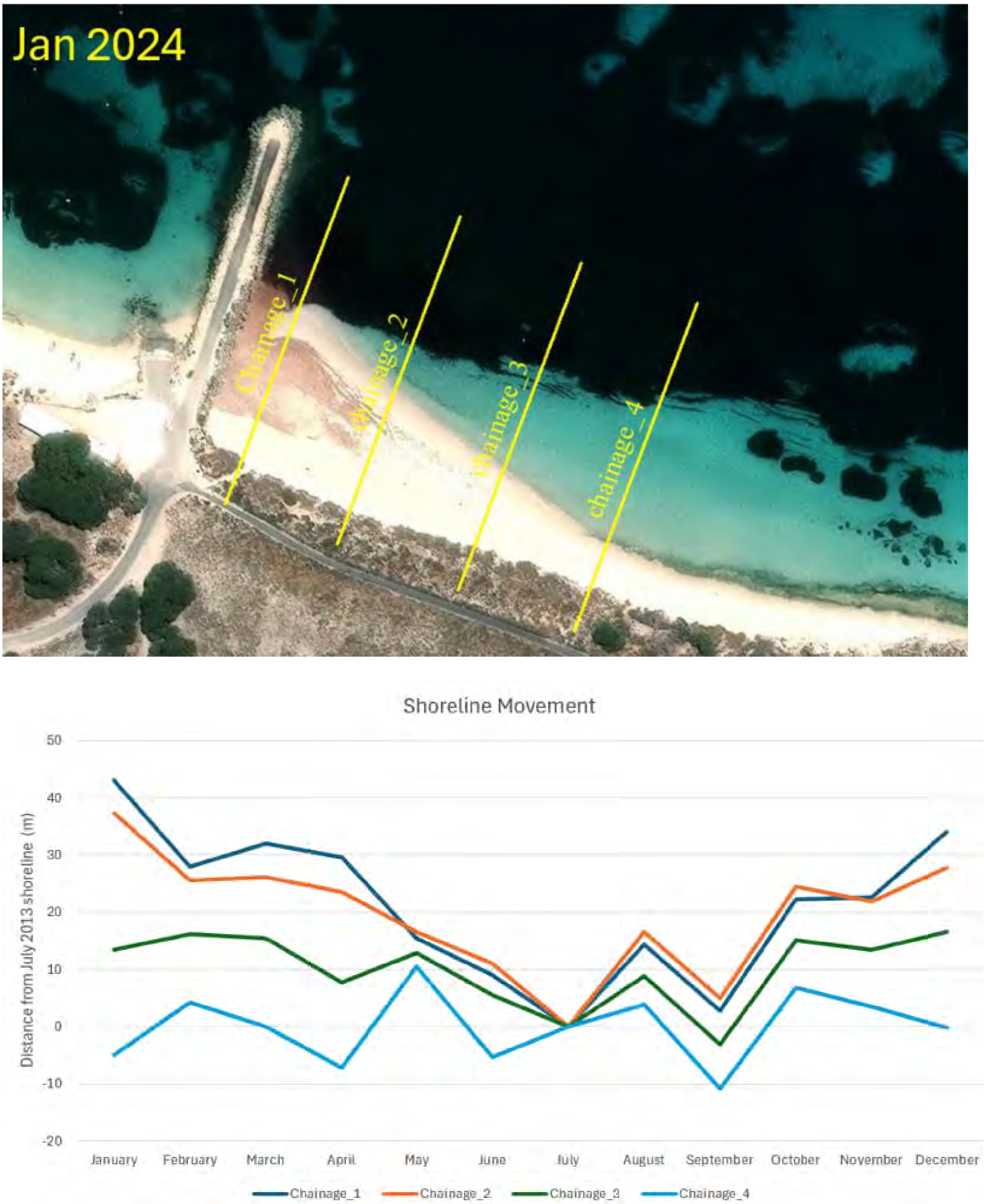


Figure 4.22: Analysis of shoreline movement in shoreline east of the Army Groyne (aerial image shown is January 2023).

5. Wrack Accumulation

An assessment of the expected impacts of wrack accumulation on the proposed design layout (Figure 1.6) is required to determine any negative effects that may be experienced through the interruption of regular wrack dynamics and movement along the beach in South Thomson Bay. Due to the prevalence of seagrass meadows off the coast of Western Australia, with 27 of the 60 known seagrass species found across Western Australia's 20,000 km^2 of seagrass meadows (Department of Fisheries 2011), consideration of wrack accumulation on Western Australian beaches has long been a requirement of coastal management assessments. Historic issues with wrack accumulation in the vicinity of coastal structures, including notable examples at Two Rocks and Port Geographe, have included odour, reduced water quality, reduced navigability and reduced access to beaches. Seagrass wrack, which may also include algae and kelp, has been known to present the issue of building up and decomposing within harbours and, in conjunction with low energy conditions (low tides and incident swell energy), contributing to low dissolved oxygen levels that may lead to fish kills in the vicinity (DPIRD 2023).

5.1 Wrack Generation and Transport

Seagrass wrack can be made up of a mixture of seagrass and macrophytes (largely macroalgae) that have been disconnected from the seabed and transported to the surf zone or beach to accumulate (Kirman and Kendrick 1997, Hansen 1984).

The MRA (2019) assessment of the coastal processes within South Thomson Bay cited the generalised lifecycle of seagrass that ends up in wrack accumulations on beaches and around coastal structures from Oldham et al (2010) that includes:

- The generation of seagrass and macrophyte wrack in offshore seagrass meadows from the ongoing shedding of leaves and stems that accumulate in the meadows and unvegetated zones due to the greater density of the wrack than seawater. This process occurs during calmer metocean conditions, up until autumn.
- The distribution of seagrass wrack through the water column during the first winter storms, where:
  - Some of the wrack becomes buoyant and accumulates at the surface of the water column.
  - Some of the wrack remains dense and remains near the seabed.
- The transportation of wrack towards shore, following this distribution throughout the water column where, generally, seagrass wrack is deposited on beaches during storm events with high water levels.
- The potential for wrack to be repeatedly washed (and transported) onto, across, or off the beaches depending on local metocean conditions. Seagrass wrack deposits high on the beach may become incorporated into the beach sand, compacted and difficult to remobilise into the water during subsequent storm events.
- The drying of seagrass wrack when it is stuck on beaches, leading it to become more buoyant and gain the potential to remobilise from the beach to the nearshore waters where it may be transported off the beach.

The presence of coastal structures or other formations may interrupt the remobilisation and natural clearing of seagrass wrack from beaches where those structure interrupt the natural transport pathway of the seagrass, as is the case in the notable locations mentioned above where seagrass is trapped on the western side of Port Geographe (Oldham et al 2010) and the southern side of the Two Rocks marina (MRA 2000).

An analysis of the benthic habitat surrounding Wadjemup was carried out in 2004, with a map of the prevalent species found presented in Figure 5.1 (Harvey 2009) showing a relatively high coverage of seagrass within Thomson Bay. This creates a plentiful source of seagrass to contribute to potential wrack accumulation along the beach in this area.

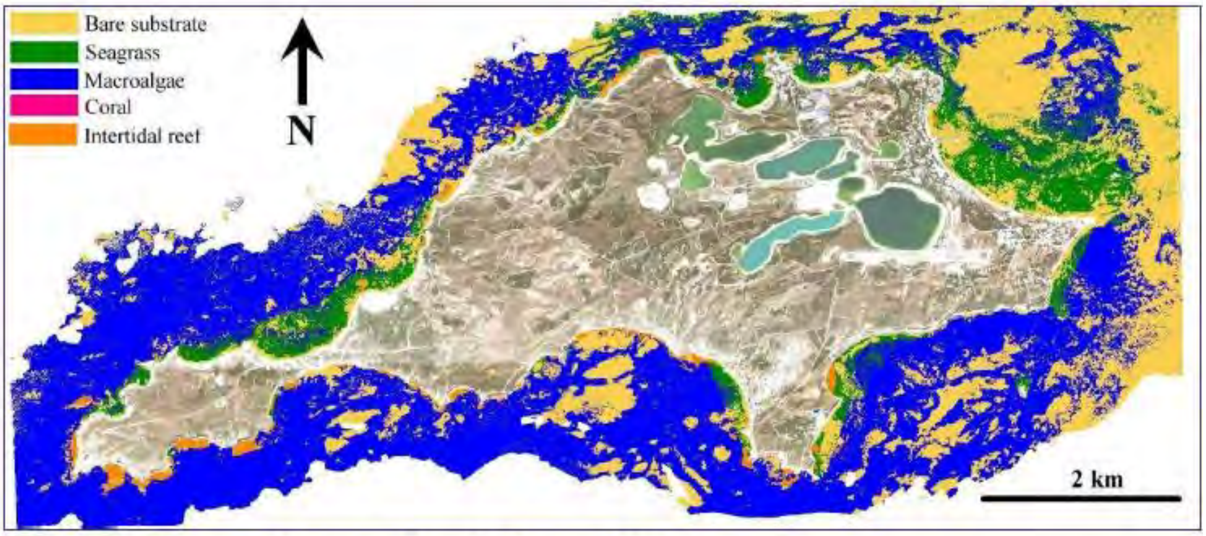


Figure 5.1: Habitat map of the waters surrounding Wadjemup (from Harvey 2009)

Assessment undertaken by RPS subsequent to this mapping showed the potential for discrepancies between the mapping undertaken by Harvey in 2009 and more recent benthic habitat surveys undertaken via aerial image analysis (RPS 2019). Following this, RPS undertook further assessment in Thomson Bay to allow for ground truthing of the aerial imagery-based habitat mapping, to enable more accurate assessment of impacts to benthic habitat due to the proposed development.

The combined assessment found the relative cover of the different habitat types identified by RPS to be that reported in Table 5.1, with a map of these habitat types overlaid with the proposed development footprint shown in Figure 5.2. These data sources provide an updated estimate of the prevalence of seagrass and macroalgae available to contribute to seagrass wrack along South Thomson Bay.

Table 5.1: Habitat type at each field survey site in RPS (2023)

Habitat Type	# of sites	Percent of total coverage
Amphibolis dominated	8	5%
Halophila dominated	1	1%
Limestone reef/pavement	3	2%
Macroalgae dominated	17	11%
Mixed algae/seagrass	6	4%
Mixed seagrass	4	3%
Posidonia dominated	75	49%
Sand	23	15%
Sand with seagrass	8	5%
Sand with wrack	8	5%

Habitat Type	# of sites	Percent of total coverage
Grand Total	**153**	**100%**

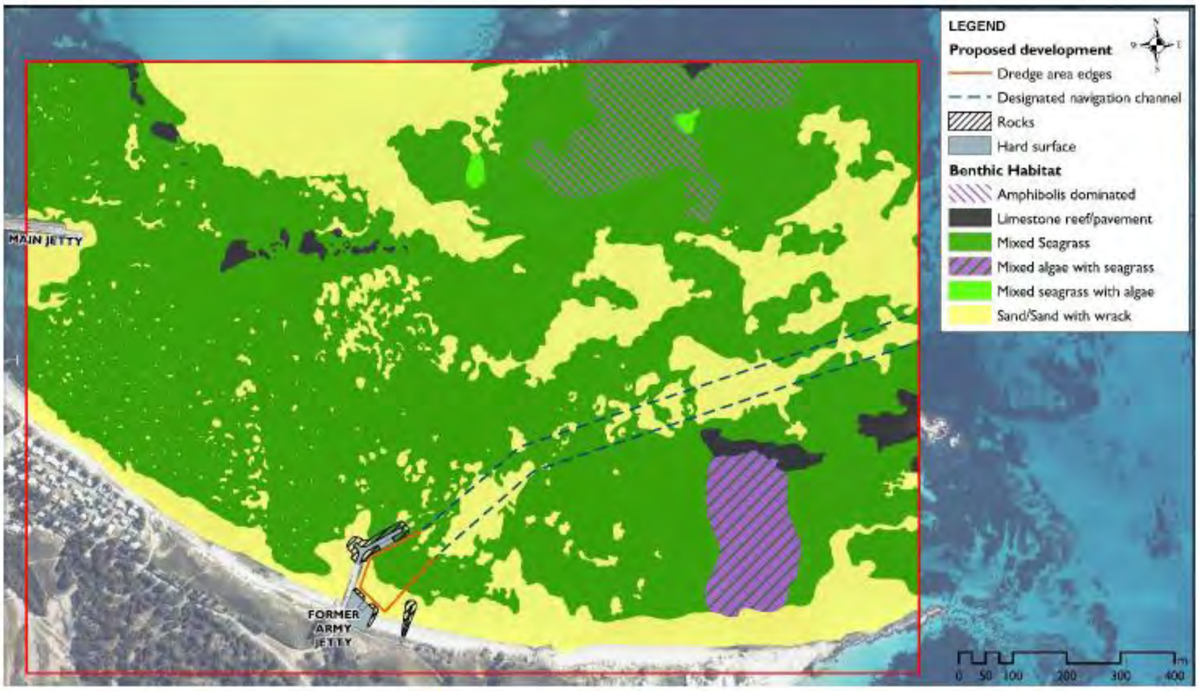


Figure 5.2: South Thomson Bay benthic habitat map with the proposed development footprint of WGA's Option 1 overlaid.

5.2 Historical Wrack Accumulation

Historic wrack accumulation along South Thomson Bay can be assessed through observations made through site photos and through historic aerial images. As presented in MRA (2019) :

- Wrack is shown to accumulate along a majority of the Thomson Bay shoreline at a range of intervals across an average year.
- It is most prominent on the eastern side of the Army Groyne and often collects up against the structure, while the western side of the structure is typically clear of wrack.
- Collection of wrack on the beach is usually during the summer months, while during the winter months it tends to clear from the beach naturally.
- Quantities of wrack on the beach within Thomson Bay at any one time are estimated to be in the range of 500 m^3 to 1,000 m^3.

Aerial imagery covering 2014 to 2023 shown in Figure 5.3 demonstrate these observations, with further images from recent and more historic site visits showing different aspects of accumulation along Thomson Bay in Figure 5.4 to Figure 5.7.

Figure 5.3: Aerial photography indicating the buildup of seagrass wrack between 2014 and 2023, largely on the eastern side of the Army Groyne (adapted from MRA 2019)

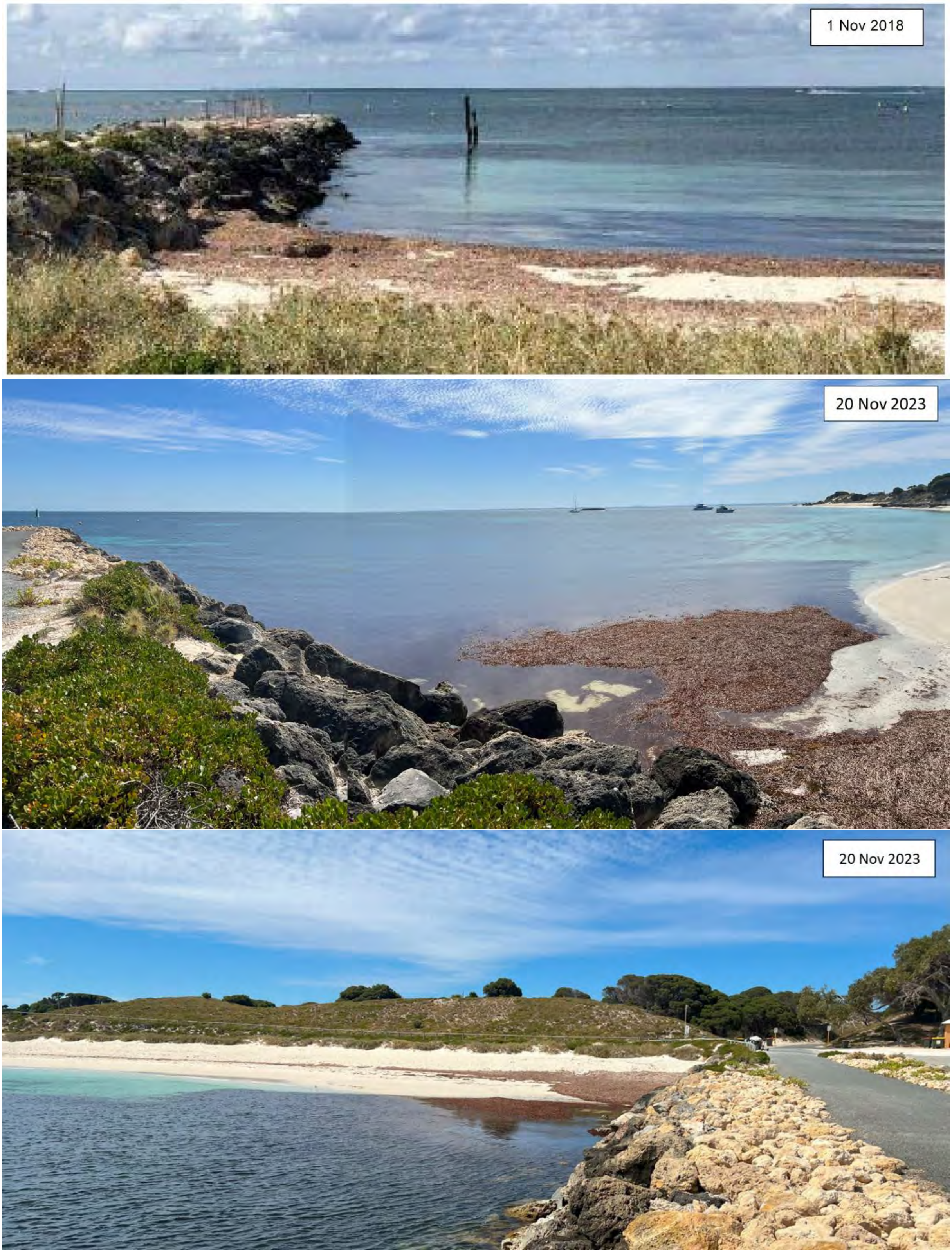


Figure 5.4: Wrack accumulation on the eastern side of the Army Groyne looking seaward (top, mid) and looking landward (bottom)

Figure 5.5: Wrack accumulation along South Thomson Bay on May 2nd 2019 (MRA 2019)

Figure 5.6: Wrack accumulation along South Thomson Bay on November 20th 2023

Figure 5.7: Minimal accumulation of wrack on western side of Army Groyne on November 20th 2023

5.3 Impact of Proposed Facility on Wrack Dynamics

5.3.1 Shorelines West of the Breakwater Structure

Similarly, to the analysis outlined in MRA (2019), it is considered that the development structures will not have a significant impact on the timing or volume of wrack accumulation across the beaches of Thomson Bay, further than the impact that the Army Groyne already has on the dynamics in South Thomson Bay.

5.3.2 In the Lee of the Structures and shorelines East of the Development

The requirement to consider the impact the structures may have on the ability for wrack to be cleared from the structures following being trapped remains. Elevated levels of accumulated seagrass wrack may be experienced in this area in summer due to the westward movement of seagrass along the shoreline being interrupted by the proposed development structure. Coupled with this is the wave shadowing caused by the extension of the breakwater from the current footprint of the Army Groyne reducing the ability for seagrass to be cleared through the dynamics currently acting along the eastern side of the Army Groyne structure. These two processes have the potential to cause elevated accumulation of seagrass on the eastern side of the proposed development structure, which may lead to ingress of seagrass to the harbour footprint. These potential seagrass dynamics are shown in Figure 5.8.

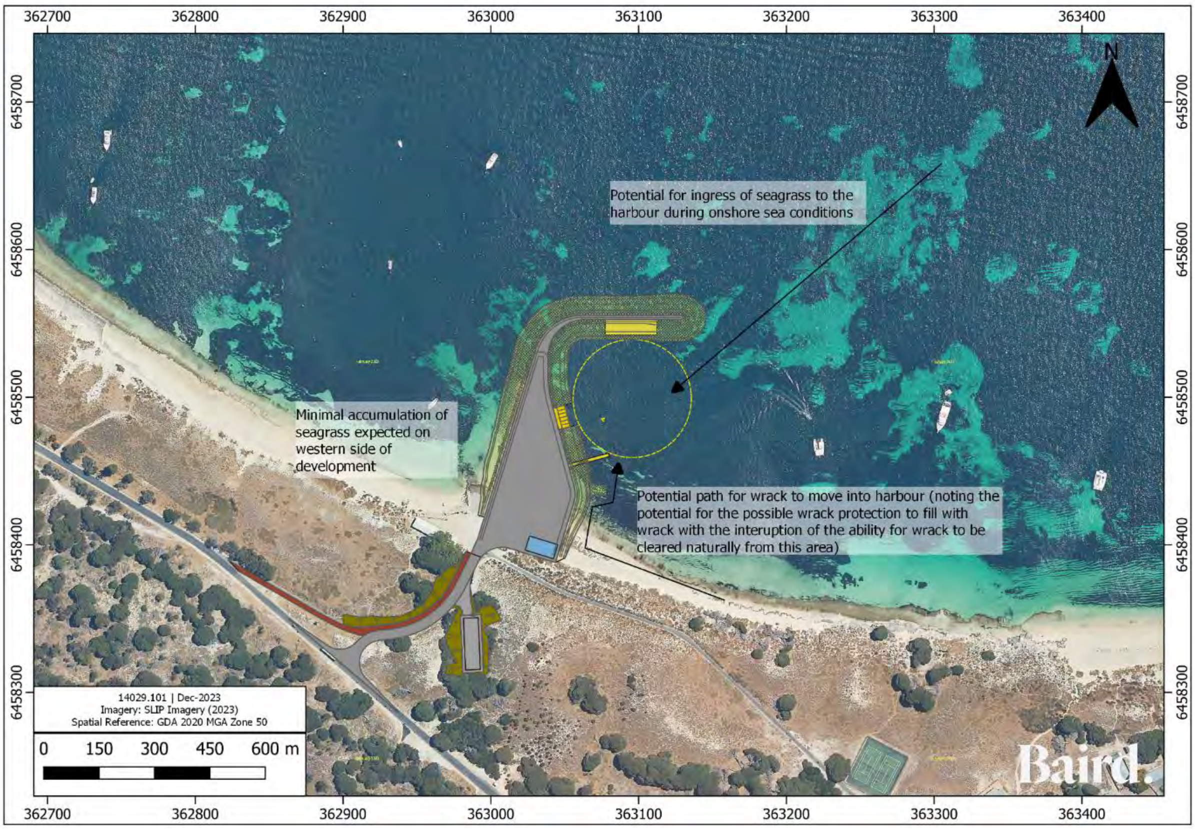


Figure 5.8: Proposed development structure layout with potential wrack dynamic descriptions

Based on analysis presented in Baird (2025) the average annual volume of wrack accumulation to the west of the Army Groyne currently is about 1,000m^3. This is largely concentrated near the eastern side of the groyne and nearshore region and peaks in late summer.

The present length of the Army groyne extends around 100m from the shoreline into Thomson Bay. Under the proposed developed case the breakwaters will project out into Thomson Bay approximately 160m. If the estimated volume of wrack for the Army groyne is increased by 60%, to account for this additional catchment potential from the extended breakwater structures the volume of wrack that would be present on the eastern side inside the project footprint is 1,600 m^3.

It is noted the present mechanism for the wrack to be naturally cleared from the eastern side of the developed structure in the autumn months by N and NE wind driven storm waves with long-shore transport will be reduced due to the extent of the breakwater structure (Baird 2025). A volume of up to 1,600m^3 of seagrass wrack is estimated as needing to be managed by RIA on an annual basis.

Management of the seagrass wrack is discussed in Baird (2025) with the following recommended:

- Ongoing monitoring of shoreline accretion and seagrass accumulating on the eastern side of the development during the summer period will be required post construction.

- Depending on the accumulation volume of wrack and the reshaping of the shoreline towards the protection nib on the eastern side of the groyne, maintenance activities (ie manual removal by excavator) may need to be actioned.
- The RIA may also be required to carry out periodic maintenance activities to remove seagrass that directly enters the harbour during onshore sea conditions from the north-east.

6. Concept Design Review

6.1 Wave Penetration Assessment

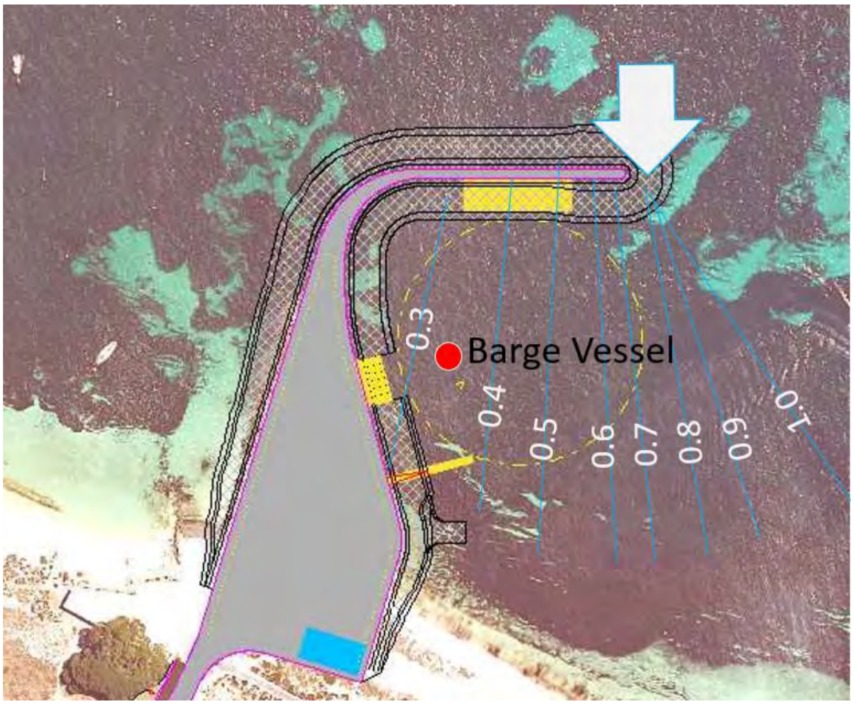
An assessment of wave penetration into the harbour basin has been undertaken based on the diffraction curves of Goda (2010). The analytical solutions from Goda (2010) are based on random waves and provide an estimate of the diffracted wave energy in the lee of the breakwater structure.

The measured wave conditions captured from the site (Section 2.7) were analysed to determine representative wave conditions for a swell and wind sea scenarios, as summarised in Table 6.1. Wave conditions at the barge ramp are presented in Table 6.1 for each case.

The respective diffraction curves have been selected based on assumed directional spreading for swell (long period waves of approximately 15s) and wind sea (short period waves typically less than 5s). The diffraction curves are shown overlaid on the concept in Figure 6.1.

Table 6.1: Wave conditions examined for wave penetration.

Wave Scenario	Wave Condition at entrance	Representative Condition	Wave Condition at Barge Ramp
Swell Case 1	H_s: 0.46m T_p: 15s Direction: N (from)	80th Percentile value for the northern sector, approximately 38 days per year	H_s: 0.18m T_p: 15s Direction: NE (from)
Swell Case 2	H_s: 0.59m T_p: 15s Direction: N (from)	95th Percentile value for the northern sector, approximately 9 days per year	H_s: 0.24m T_p: 15s Direction: NE (from)
Wind sea Case 1	H_s: 0.34m T_p: 4s Direction: NE (from)	80th Percentile value for the northeastern sector, approximately 23 days per year	H_s: 0.24 m T_p: 4s Direction: NE (from)
Wind Sea Case 2	H_s: 0.51m T_p: 4s Direction: NE (from)	95th Percentile value for the northeastern sector, approximately 6 days per year	H_s: 0.31 m T_p: 4s Direction: NE (from)
Wind sea Case 3	H_s: 0.44m T_p: 4s Direction: E (from)	80th Percentile value for the eastern sector, approximately 2 days per year	H_s: 0.44 m T_p: 4s Direction: E (from)
Wind Sea Case 4	H_s: 0.50m T_p: 4s Direction: E (from)	95th Percentile value for the eastern sector, approximately 0.5 days per year	H_s: 0.50 m T_p: 4s Direction: E (from)



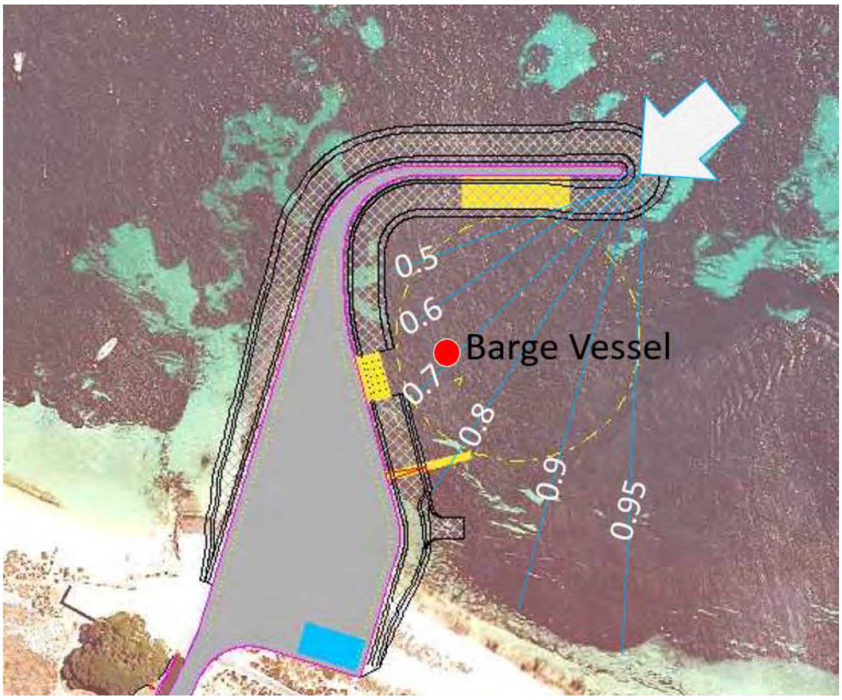


Figure 6.1: Estimated diffraction coefficient for incident waves for northerly swell case (upper) and wind sea from the Northeast case (lower).

6.2 Summary Recommendations

From the measured data at the site, waves approach the South Thomson Bay site from the northerly sector for approximately 50% of the year. The analysis of diffracted wave conditions at the barge ramp in Table 6.1 indicate the barge landing location is well sheltered from swell wave conditions that arrive from the north. The breakwater is effective at reducing the wave conditions at the barge ramp to approximately

40% of the incoming wave conditions, with the diffracted swell wave arriving at the stern of the vessel. For the 80th percentile wave height from the northern sector, the wave height at the breakwater is 0.46m, whilst the diffracted wave at the stern of the vessel is 0.18m. For the 95th percentile wave height from the northern sector, the wave height at the breakwater is 0.59m, with the diffracted wave at the stern of the vessel at 0.24m.

From the measured data at the site, wind sea conditions arrive at the site from the northeast quadrant for approximately 30% of the year. These wave conditions cover waves that have wave periods of typically less than 4s and are generated by local wind conditions. The diffraction curves (Figure 6.1) show the breakwater reduces the incident waves by approximately 30%. For the 80th percentile wave height from the northeast sector, the wave height at the breakwater is 0.34m whilst the diffracted wave at the stern of the vessel is 0.24m. For the 95th percentile wave height from the northern sector, the wave height at the breakwater is 0.51m whilst the diffracted wave at the stern of the vessel is 0.31m.

Eastern sector wave conditions present in the measured data record represent a small proportion of the annual seastate, at approximately 2% of the yearly record. The configuration of the breakwater in the design layout does not provide protection from this direction and it is assumed these conditions would reach the barge ramp unchanged. The waves will approach the barge ramp approximately in line with the vessel stern at 0.44 to 0.5m significant wave height. It is noted these conditions are infrequent over the course of the annual record in the measured data and are concentrated in the winter months.

This analysis of wave penetration indicates the wave conditions are reduced by the structures for approach directions from the N and the NE which are the dominant wave conditions at the location.

An understanding of the limiting conditions of the barge vessel would allow for further analysis of potential downtime at the barge ramp. The wave conditions at the landing are approximately in line with the barge ramp alignment, and it is expected that the vessel would manage these types of conditions when at the ramp. As the vessels manoeuvre into or away from the facility within the turning circle, the waves would be more ‘beam on’ to the barge (i.e., 90 degrees to the vessel) and this would be more problematic, potentially warranting further investigation.

This analysis does not consider reflection of waves from the structures or bi-modal seastates that can occur in the area during winter when swell waves from the north are coupled with sea waves from the east. Further assessment of these conditions as part of more detailed wave penetration modelling in the detailed design phase is recommended. This analysis should include use of a phase resolving wave model which can accurately account for the processes of diffraction and reflection in the lee of the breakwater. Assessment of the transformed wave conditions at the barge ramp for the typical barge vessel sizes and berthing operations can be undertaken to provide a detailed analysis of the overall availability of the ramp. This would provide a projected estimate of the downtime at the new ramp location i.e. the amount of time during the year where the wave conditions may preclude use of the barge ramp. As part of this assessment, mitigation measures could be examined (if required).

As a general comparison the sea wave conditions at the South Thomson Bay barge facility (which arrive from the east and northeast) would be expected to be consistent with the conditions experienced at the present location of the barge ramp adjacent the main passenger ferry jetty. The swell wave conditions whilst attenuated by the breakwater would likely be marginally higher at the new facility compared with the existing location. As noted above, this may not be an issue due to the orientation of the barge vessels. However, further examination to confirm this assumption is warranted as part of the detailed design process.

7. References

AECOM (2020), South Thomson Bay Barge Facility; Value Engineering of Concept Design. Doc. No. 606370980-MA-REP-0001 Rev 0.

Baird (2021). Rottnest Island Wave Screen Study, Wave Modelling Report. Prepared for WGA, 13533.101.R1.Rev0

Baird (2025). South Thomson Bay Barge Development, Coastal Hazard Risk Management and Adaptation Plan. Prepared for RIA. 26 February 2025 | 14029.200.R1.Rev0

Bruun, P. (1962). Sea level rise as a cause of shore erosion, Journal Waterways and Harbours Division, American Society of Civil Engineers. WWI, 88, pp. 117-130

Boshek, MR. (2009). Reflection and Diffraction Around Breakwaters. Thesis prepared for the faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands. June 2009.

Cardno (WA) Pty Ltd (2022). Rottnest Island Coastal Hazard Risk Management and Adaptation Plan. Prepared for Rottnest Island Authority. CW1198700.

CSIRO, BoM, (2015). Climate Change in Australia, Technical Report: Projections for Australia 's NRM Regions. Australian Government Department of Environment, Australia.

CSIRO, BoM, (2015b). Climate Change in Australia: Projections for Selected Australian Cities. Australian Government Department of Environment, Australia.

Department of Transport (DoT), (2010). Sea Level Change in Western Australia – Application to Coastal Planning, Coastal Infrastructure, Coastal Engineering Group.

Department of Planning & Infrastructure (DPI), 2009. Shoreline Movement Study, Thompson Bay, Rottnest Island. Draft. Reference Paper. December 2009.

Department of Primary Industries and Regional Development (2023). Update on Lancelin fish kill investigation. Media Release, 31st January 2023, https://www.wa.gov.au/government/announcements/update-lancelin-fish-kill-investigation.

Goda, Y. (2010). Random Seas and Design of Maritime Structures. 3rd Edition. Advanced Series on Ocean Engineering – Volume 33. World Scientific.

Hansen, J. A. (1984). Accumulations of macrophyte wrack along sandy beaches in Western Australia: Biomass, decomposition rates and significance in supporting nearshore production. PhD thesis, Department of Botany, University of Western Australia, Perth, Australia.

Harvey, M.J., (2009). Development of techniques to classify marine benthic habitats using hyperspectral imagery in oligotrophic, temperate waters. PhD Thesis, Murdoch University, Australia.

Herbich, J.B., Haney, J.P. (1982). Coastal erosion . In: Beaches and Coastal Geology. Encyclopedia of Earth Sciences Series. Springer, New York, NY. https://doi.org/10.1007/0-387-30843-1_115

IPCC, (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

IPCC (2021) Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Kirkman, H. & Kendrick, G. A. (1997). "Ecological significance and commercial harvesting of drifting and beach-cast macro-algae and seagrasses in Australia: a review." Journal of Applied Phycology 9: 311-326.

M P Rogers & Associates Pty Ltd (MRA) (2000). Two Rocks – Seagrass Wrack Management, R096 Rev 0. Prepared for the City of Wanneroo.

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

M P Rogers & Associates Pty Ltd (MRA), (2019). South Thomson Bay – Barge Ramp Facility Coastal Processes Assessment, Reference: K1655, Report R1203 Rev 0203 Rev 0.

Oldham C, Lavery PS, McMahon K, Pattiaratchi C & Chiffings T 2010. Seagrass wrack dynamics in Geographe Bay, Western Australia. Prepared for the Department of Transport & Shire of Busselton.

Perry, C.T., Alvarez-Filip, L., Graham, N.A.J. *et al.* (2018). Loss of coral reef growth capacity to track future increases in sea level. *Nature* **558**, 396–400. https://doi.org/10.1038/s41586-018-0194-z

Pratola, Luigi, Antonio Rinaldi, Matteo Gianluca Molfetta, Maria Francesca Bruno, Davide Pasquali, Fabio Dentale, and Michele Mossa. (2021). Investigation on the Reflection Coefficient for Seawalls Protected by a Rubble Mound Structure. Journal of Marine Science and Engineering 9, no. 9: 937. https://doi.org/10.3390/jmse9090937

RIA (2020a) Rottnest Island Management Plan 2020 - 2024

RIA (2020b) Rottnest Island Authority Strategic Plan 2020 – 2024

Rosati, Julie & Dean, R.G. & Walton, T.L. (2013). The modified Bruun Rule extended for landward transport. Marine Geology. 340. 71-81. 10.1016/j.margeo.2013.04.018.

RPS (2019). South Thomson Bay Barge and Cargo Facility. Assessment of Benthic Habitats. EEN19032.002.

RPS. (2019b). Environmental Advisory Report: Repair and Extension of Former Army Jetty, Rottnest Island. RPS Australia West Pty Ltd.

Seashore Engineering (2019). Assessment of Coastal Erosion Hotspots in Western Australia. Report SE052-01-Rev1. Prepared for the Department of Transport and Department of Planning, Lands and Heritage.

Seashore Engineering (2018). Design Storms for Western Australian Coastal Planning: Tropical Cyclones. Document prepared for Department of Transport Seashore Engineering Report No. SE015-01-RevB

Seashore Engineering (2020), South Thomson Bay Coastal Erosion Management Plan, Seashore Engineering June 2020 Report SE095-02-02

Short, A., (2005). Beaches of the Western Australian Coast: Eucla to Roebuck Bay – A guide to their nature, characteristics, surf and safety. University of Sydney and Surf Life Saving Australia Ltd.

Stul T, Gozzard JR, Eliot IG and Eliot MJ (2015) Coastal Sediment Cells for the Vlamingh Region between Cape Naturaliste and Moore River, Western Australia. Report prepared by Seashore Engineering Pty Ltd and Geological Survey of Western Australia for the Western Australian Department of Transport, Fremantle. Western Australian Planning Commission (WAPC) 2013. State Planning Policy 2.6 – State Coastal Planning Policy. Government of Western Australia, Perth.

van Zyl FW (2018). Geological mapping of the inner shelf off Cape Town’s Atlantic Seaboard, South Africa. University of Cape Town.

WAPC (2013a). Coastal Planning and Management Manual. A community guide for protecting and conserving the Western Australian coast.

WAPC (2013b) State Planning Policy No. 2.6: State Coastal Planning Policy. Published by the Western Australian Planning Commission, Perth, Western Australia.

WAPC (2013c) State Coastal Planning Policy Guidelines. Published by the Western Australian Planning Commission, Perth, Western Australia.

Water Technology (2021), Rottnest Island Wave & Current Monitoring, Data Report. Report prepared for Rottnest Island Authority, 31 August 2021

Appendix A

Wave Model Validation Plots

2021 Hindcast Model - SWAN

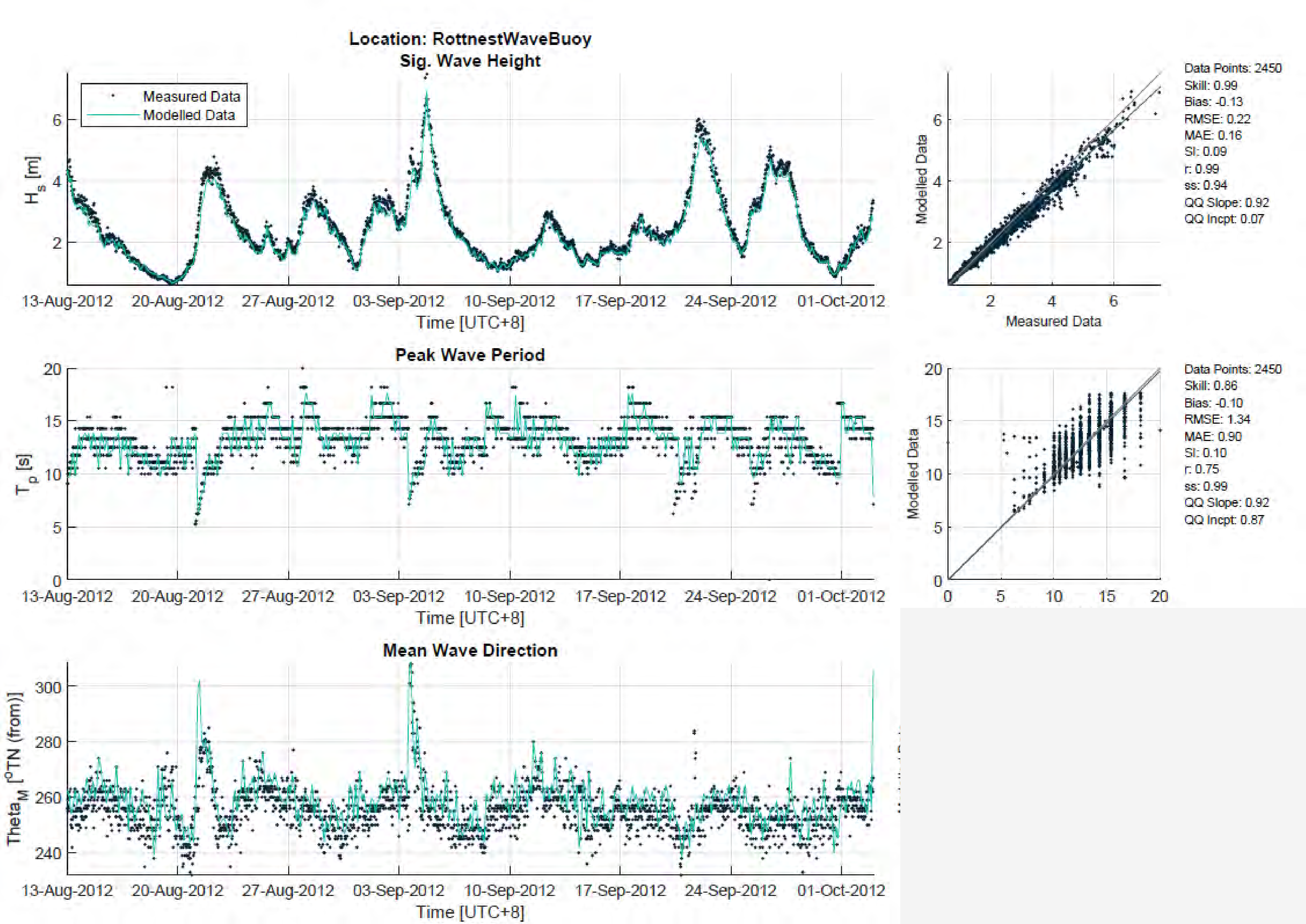
- 4 Nested Grid Model of increasing resolution to the site
- Time varying winds over the grids
- Waves from Rottnest DWR on West and South Boundary
- Water levels from Fremantle tide gauge, timestep 3 hourly
- Reef structures described by varying roughness in model

Model Calibration / Validation

- Model run for ~2 months in winter (13 Aug – 5 Oct 2012).
- Roughness used to calibrate model to measured data at 4 locations in Thomson Bay
  - AWACR1_01
  - AWACR1_02
  - NonDirR1_03
  - NonDirR1_04
- Measured vs Model Plots

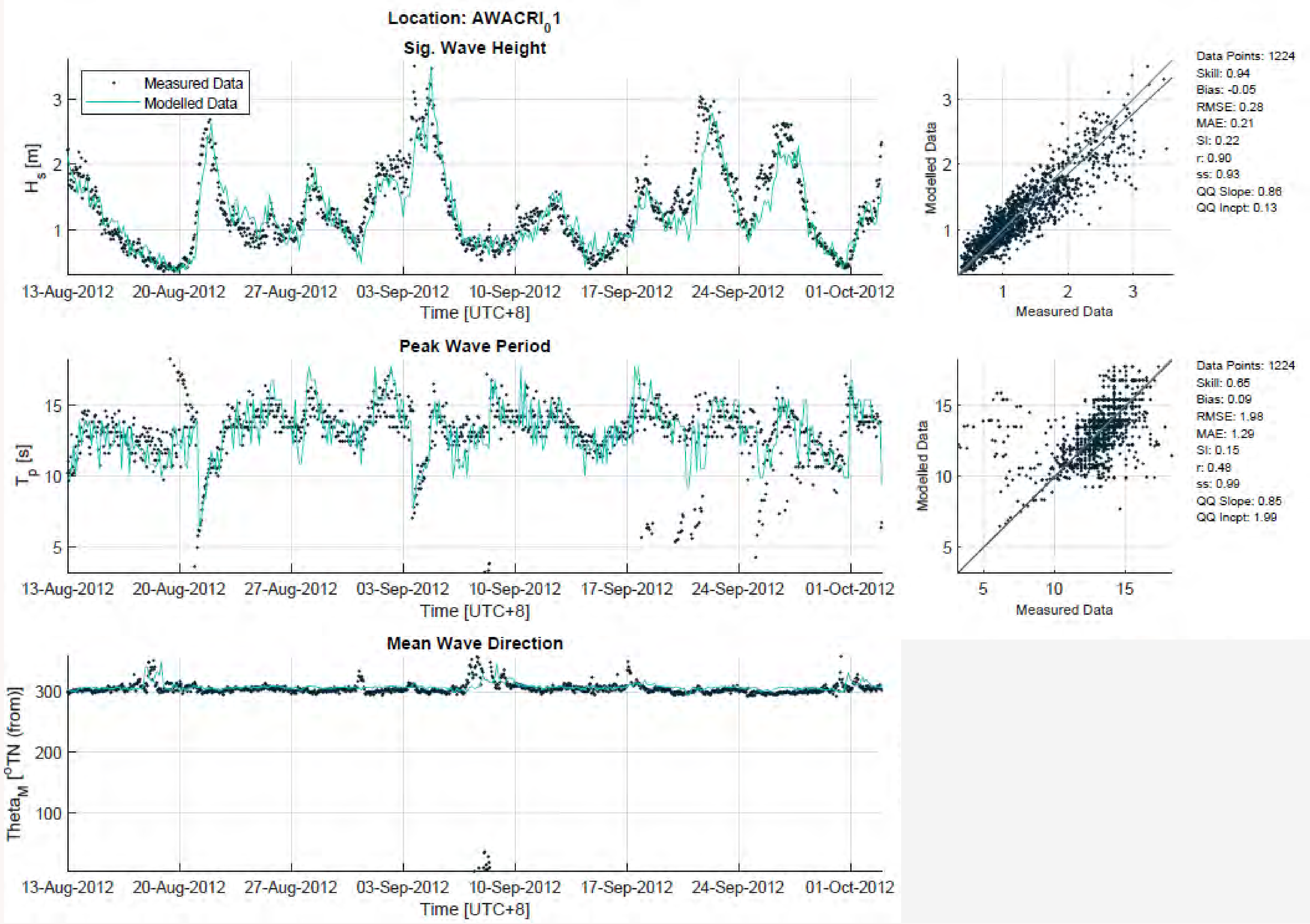
Model Calibration

- Rottnest DWR
- Hs - Skill 0.99



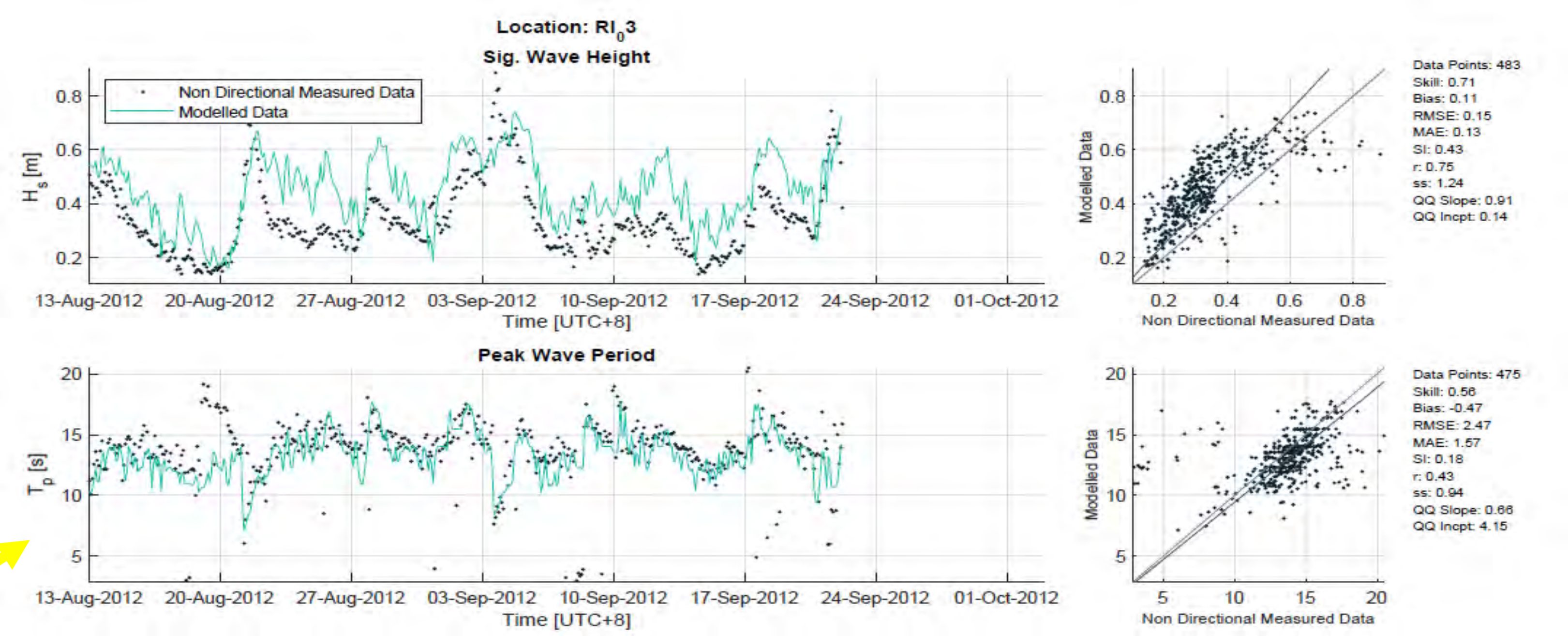
Model Calibration

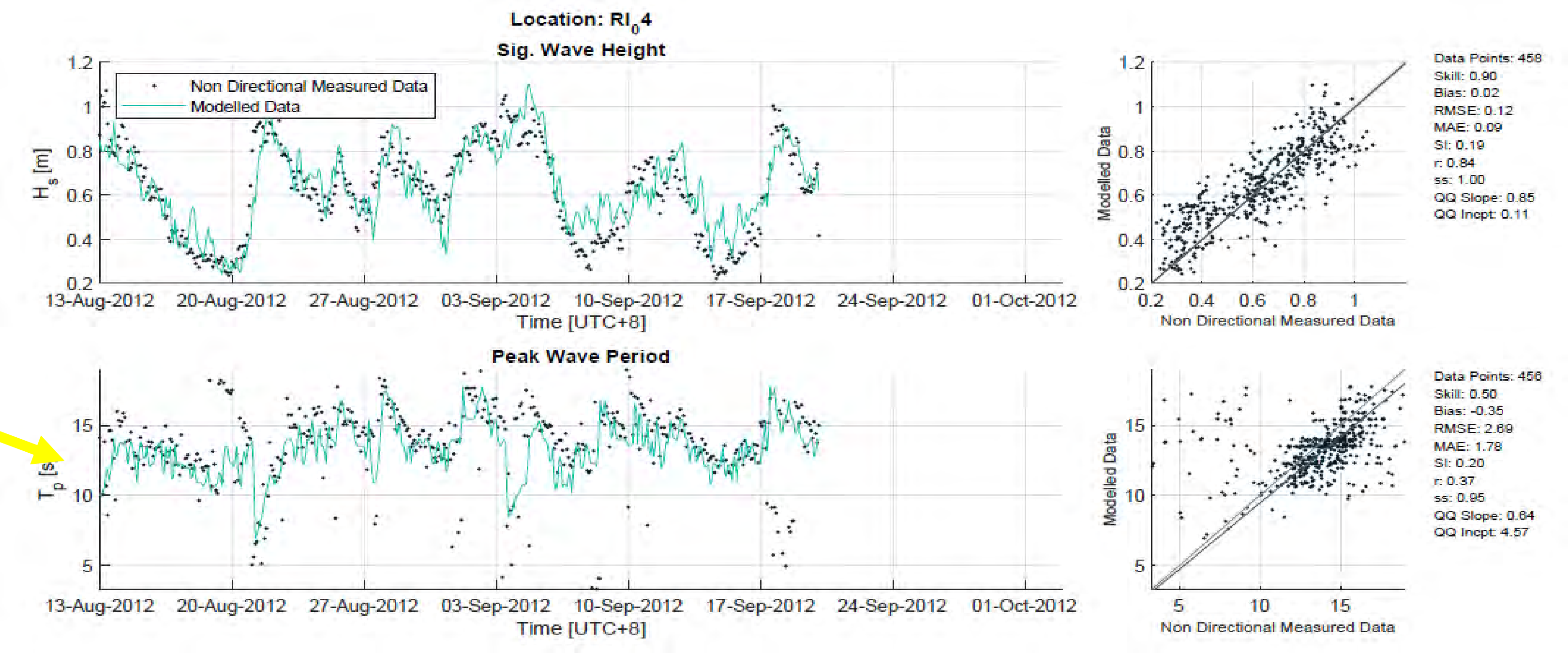
- AWAC R1_01 Thomson Bay North
- Hs - Skill 0.94



Model Calibration

- Non-Directional R1_03 and R1_04
- Thomson Bay Mid
- Skill 0.71 – 0.90





Model Calibration

- AWAC R1_02 Thomson Bay South
- Hs - Skill 0.76