Seashore Engineering

Koombana Bay Marine Structures SPER
Coastal Processes
Peer Review

Seashore Engineering Pty Ltd
February 2022

Report SE048-04

Introduction

This document has been prepared to summarise a peer review process undertaken for the Koombana Bay Marine Structures (KBMS) Strategic Public Environmental Review (SPER), specifically a review of the Coastal Processes assessment that is intended to support the Strategic Public Environmental Review (SPER). The Coastal Processes assessment is comprised of a Coastal Processes Impact Assessment, CPIA (GHD 2021a) and a Coastal Processes Management Plan, CPMP (GHD 2021b).

The SPER is being prepared by RPS Australia, under the direction of the Southwest Development Commission (SWDC) and on behalf of stakeholders involved in a set of projects within Koombana Bay. The SPER is intended to address Environmental Scoping Documents (ESD) established for the project, including a Coastal Processes ESD, which outlined a set of Key Environmental Factors (KEF). The Coastal Processes assessment has been developed by GHD Pty Ltd (GHD), with peer review feedback being provided at stages of the assessment delivery. The present version was submitted by GHD after five rounds of peer review meetings and commentary.

The present assessment (GHD 2021a,b):

- Meets the scope agreed between SWDC and GHD
- Provides information to address targeted aspects of the Coastal Processes Environmental Scoping Document
- Provides a limited framework for identification and ongoing management of coastal processes impact
- Provides limited guidance to refine design of Koombana Bay Marine Structures.

It is noted the assessment refers to Koombana Bay CHRMAP (GHD 2019), which is intended to provide a framework for adaptation of coastal management practices to long-term term changes, particularly the longer-term erosion trend anticipated due to projected sea level rise.

Basis for Peer Review

This peer review has been conducted based on our previous experience with submission of SPER and PER documents. The primary focus of the review is consequently typical for EIA:

> *Demonstrate that expected impacts are tolerable, and that risks can be managed*

The peer review has been undertaken with three questions in mind:

1. How does the document address broad SPER objectives?
2. How does the document address the ESD?
3. Does the document support implementation of the derived proposals (i.e. beyond a SPER)?

The EIA framework acknowledges that there is limited certainty in the projection of environmental hazards, and consequently supporting documents typically combine evaluation of hazards with an associated management plan. The plan should be capable of identifying and managing unpredicted changes. The management plan should identify monitoring, triggers, actions and responsible agencies. There is typically a trade-off between *scientific defensibility* of the impact assessment and how *robust* the management plan needs to be.

The peer review also considered aspects of *clarity* and *consistency*, as in our experience, these substantially assist with OEPA comprehension of the assessment.

There has been limited consideration of the *assessment scope*, as this is determined by an agreement between GHD and SWDC. However, we consider that this attribute is crucial to OEPA review of the SPER, and therefore we have provided additional comment in a separate section.

It is recognised that there is an array of techniques for undertaking coastal assessments, and that there are practicalities of project budget and time frames. Consequently, it is understood there may be assessment attributes which differ from the expectations of the peer reviewers (or ultimately the OEPA). For this reason, it was not expected that all comments raised during the peer review would be fully resolved.

Overall Comment

The CPIA (GHD 2021a) provides a limited evaluation of coastal processes for Koombana Bay, addressing selected requirements of the ESD. Consequently, the CPMP provides a key role for managing risks to coastal processes that may be introduced by the proposed works. The CPMP is a preliminary document, requiring liaison with stakeholders and further requirement to enable it to be effectively implemented.

It is considered a marginal risk to SWDC and project stakeholders to carry the existing documents through to SPER submission, with anticipated outcomes being requirement for:

1. Submission of detailed local coastal impact statements associated with each of the derived proposals; and
2. Refinement of the preliminary Coastal Processes Management Plan (CPMP) to incorporate auditable performance measures and quantified, functional management triggers.

A risk associated with the existing assessment is that it confirms positions and characteristics of the derived proposal structures, without considering how they may need to vary. This 'locks in' the preliminary designs and provides limited capacity for optimisation or refinement. This could limit future detailed design options. For example, absence of modelling any coastal structures at the Dolphin Discovery Centre means that should a jetty or ramp be designed in the future it will either require separate approvals or must be designed to avoid the impact on coastal processes (i.e. wholly piled, with an abutment which integrates with the recently built walling). This risk has been identified to stakeholders and they have accepted the design and approval implications.

The approach used for assessment has been comparative analysis, where modelling of the final case is compared against modelling of a baseline case for the same set of scenarios. As the ultimate conclusion of GHD (2021a) was that there would be minimal change to the dynamics of Koombana Beach, any perceptible deviation from historic behaviour may be considered outside the range of predictions, requiring remedial action. Implicitly, this means that performance measures for the CPMP should be derived from historic behaviour. Although the CPMP provides indicative performance measures, these have not been evaluated and tested. Potential limitations of the triggers are suggested by the review of coastal observations (Attachment 2).

Observed patterns of coastal change and seagrass dynamics have not been used as a basis to establish the modelling framework or to provide validation of model performance, except in a qualitative and undocumented fashion. As a consequence, there is considered to be high opportunity for outcomes to deviate from the behaviour suggested by the modelling. For this reason, there is a need to treat modelling as one tool, amongst several, that supports management of Koombana Bay coast. This increases relative importance of the CPMP, which therefore must be suitably robust to identify and manage changes that have not been predicted. The CPMP presented, to date, is an initial framework, requiring stakeholder liaison and further refinement.

GHD Document Scope

The scope of GHD (2021a,b) is determined by a contract between GHD and SWDC. However, overall requirements for the SPER are determined by the Coastal Processes ESD. For this reason, the peer review has undertaken an evaluation relative to the KEFs, which is included as Attachment 1. The choice of whether to address discrepancies between the GHD scope and ESD requirements was made by SWDC and SPER stakeholders.

Modelling Framework

The coastal processes assessment framework is based almost solely upon numerical modelling, using global models of wind and wave conditions. There is weak calibration of the hydrodynamic and wave models based on field observations, with qualitative or anecdotal validation of sediment transport, cross-shore erosion, longshore transport and wrack transport models. Overall, despite the very large amount of effort and time required, this represents a limited modelling framework for simulation of coastal processes within Koombana Bay (Table 1).

Dependence of the modelling system on global models is substantial. While it is acknowledged that these can provide a cost-effective means of modelling, they are known to be biased, which can limit how well they describe local conditions. The nature of these biases is not clearly presented in GHD (2021a), with reported description of conditions (winds and waves) mainly based upon observational datasets, which are not included in the modelling system. Comparison of observed meteorological and oceanographic data and model outcomes includes:

- Comparison of currents and water levels for winter and summer calibration periods
- Comparison waves for the winter calibration period.

Identified limitations of modelling outcomes include:

- Section 3 outlines the methodology and provides time series plots and summary statistics to demonstrate wave and current model verification. Figures 3-4, 3-5, 3-7, 3-8, 3-9 and 3-11 do not show good model validation and appear to be missing diurnal variation.
- The scale of Fig 3-10 prevents clear evaluation of direction. However, the index of agreement value of 0.54 and mean absolute error of 8$_o$ at Beacon 3 are potentially substantial, given the importance of wave diffraction within the Bay. Model bias appears low (more southerly), which will underestimate the wave climate into Koombana Bay
- The absence of directional wave verification inside Koombana Bay significantly constrains confidence in modelled nearshore wave conditions along Koombana Beach;
- Sediment transport modelling and wrack modelling do not attempt to replicate observed coastal dynamics. Instead, the approach has been taken to model baseline and developed scenarios and compare differences. This is a basic technique, with a key limitation that it can only demonstrate processes that are incorporated into the model and gives limited attention to the relative scale of different processes. This is illustrated by outcomes shown in Figure 4.11, which suggest a massive onshore delivery of sediment to the beach north of the Inner Harbour as well as strong nearshore transfer (beach steepening), neither of which are demonstrated from observed behaviour (see Attachment 2).

In this case, the major coastal process finding from the modelling is that swell wave propagation to Koombana Beach has not been affected by the proposed breakwaters. This considered a reasonable outcome, particularly as alignment in the direction of swell was one of the design criteria for KSCM breakwater. Other model findings principally relate to water body separation and wave sheltering provided by the breakwaters.

Table 1: Summary of Modelling Framework

Component	Description	Inputs	Calibration / Validation	Rating
Hydrodynamic Model	MIKE 21 FM (2D mode, nested)	DHI Global Tide Model CFSv2 Winds HYCOM	Moderate calibration to measurements	Fair
Wave Model	MIKE 21 SW (nested)	Wavewatch III CFSv2 Winds	Moderate calibration to measured wave height	Fair
Sediment Transport Model	MIKE 21 ST (Fixed grain size, 'flat' bed)	Hydrodynamic + Wave Models	Anecdotal	Limited
Cross-shore Erosion Model	SBEACH (*quasi-empirical*) (5 profiles)	Wave Model	Anecdotal	Limited
Longshore Transport Model	Kamphuis (*empirical*) (5 profiles)	Wave Model	Net direction of transport matches observations	Very Limited
Wrack Transport Model	GHD *	Hydrodynamic + Wave Models	Anecdotal	Uncontrolled

The basis for using the hydrodynamic model effectively in 2D mode has not been presented, and may have implications for sediment transport. However, this is a relatively common simplification and deemed reasonable.

Known biases of the Wavewatch III offshore wave hindcast set include overstating the wave height (by a factor of 1.05-1.2) and under-representing the directional range. It is also understood that the Wavewatch III offshore wave hindcast used does not provide directional spread of wave energy, which can be a key parameter when evaluating a sheltered site subject to wave diffraction.

The GHD assessment framework represents a hydrodynamic-focused view of coastal processes, which has limited consideration of geomorphology, particularly for inshore. This view is reflected in comments regarding the unimportance of inshore wave direction variability, a crucial parameter affecting alongshore sediment transport. Based on previous installation of structures within Koombana Bay, the majority of observed change has been confined to the inshore region, resulting in beach rotation, with slow accretion on the west and erosion to the east.

The modelling approach to describe this 'typical' change is basic, interpreting longshore transport from three profiles using Kamphuis empirical equation, including the effect of an apparently misaligned profile (profile 3). There is limited consideration of how the proposed structures may affect the equilibrium assumption intrinsic to longshore transport calculation. There is no acknowledgement of the narrowed range of inshore wave directions developed by the modelling approach, or calculation of potential changes to 'zero-transport' beach orientation along the beach due to wave sheltering.

The modelling approach for offshore sediment transport principally assumes that circulation and wave conditions are the only variables. This does not take into account bed or sediment variability.

The objective of modelling cross-shore erosion and determining coastal setback allowances based on present-day profiles is unclear. Continuation of existing alongshore transport patterns is anticipated to alter the structure of Koombana Beach. How these changes occur, and the dependent variation of coastal vulnerability, are expected to influence the appropriate form of hazard mitigation on Koombana Beach. Specifically, this could support identification of whether defence, sediment back- passing or renourishment from external supply is likely to be most appropriate.

Wrack transport modelling appears to have had substantial effort involved in its derivation. However, the basis for development of the model elements is not reported, and there is no validation of its performance presented. Consequently, it is an uncontrolled model, and should be considered indicative, at best. Substantial findings from the wrack modelling, which include wrack trapping in the shipping channel and release of stranded wrack with 30 days cannot be relied upon.

Limitations of the sediment and wrack transport modelling have been catered for through development of the CPMP.

Scenario Selection

The approach of choosing one year as a 'representative' year and two storms as 'strong' and 'directionally anomalistic' is a simplified means of addressing the ESD requirement to consider variability. However, the method to demonstrate the appropriateness of these events is limited. For example, the July 2007 storm was selected as one of several strong westerly storms which included a northerly component of wave energy, rather than identifying a set of northerly storm events. Incidentally, the strongest recorded northerly winds were from a storm of June 2007, which caused sustained high water levels.

It is noted that on some previous occasions, OEPA have required that the appropriateness of these selected scenarios be demonstrated, through use of one or more climate indices.

Development Scenario and Study Area

GHD (2021a) provides an assessment of the impacts of the breakwaters associated with Casuarina Boat Harbour (CBHD) and Koombana Sailing Club Marina (KBSC). This consequently does not address impacts from the Dolphin Discovery Centre proposal – except to conditionally require that the development is wholly permeable to alongshore sediment transport.

Assessment of impacts based upon modelling has been limited to Koombana Beach. Anticipated impacts to other beaches (Ski Beach, CBHD beach and KSCM beach) have been interpreted based upon engineering judgement, including consideration of processes (wave reflection and channelling) that have not been modelled.

Impact Assessment

The impact assessment presents a summary of the results of the modelling, supplemented by interpretation based upon engineering judgement.

The modelling and assessment framework applied by GHD has limited capacity to identify impacts to coastal processes caused by the proposed works. The methodology is capable of:

- Resolving changes to bay-scale circulation (hydrodynamic) patterns
- Resolving large-scale changes to swell wave climate within the bay (e.g. areas sheltered by the proposed breakwaters).

Modelling demonstrated that the bay-scale circulation was modified by the proposed breakwaters, and that there would be limited modification of the swell wave climate outside the boat harbour and marina precincts. This is considered a reasonable and justified conclusion.

Evaluation of sediment transport was undertaken by:

- Modelling of seabed sediment transport, incorporating currents and waves, which indicated small change to bay-scale sediment transport
- Empirical assessment of longshore transport rates; and
- 1-D modelling of profile response to storm events.

The latter two assessments, which are largely determined by swell waves, showed negligible change. These assessments provide a limited basis for understanding of Koombana Bay coast and anticipated response to the proposed structures, requiring development and implementation of an adaptive coastal management plan.

Outcomes from sediment transport modelling gave results which are inconsistent with observed behaviour (Seashore Engineering 2013, 2019), including overestimating rates of sediment transport and a reversed direction of net transport along western Koombana Beach. It is plausible that this is a result of an incorrect profile alignment (for profile 3). The results suggest a change in drift direction between profiles 3 (west) and 4 (central) for both the baseline and developed cases. This has been misinterpreted as a switch in transport direction following development. Combined with a possible impact of mach-stem waves along the KSCM breakwater, this has been interpreted as causing erosion on western Koombana Beach. This is opposite to 'typical' behaviour, where the combined effect of net westward sediment drift and wave shadow development would be expected to increase deposition rates at the western end of the beach.

Modelling results were supplemented by engineering interpretation (otherwise unsupported) to provide conclusions regarding changes to currents (Table 5.1), changes to waves (Table 5.2) and changes to morphology (Table 5.3). The absence of evidence to support these conclusions increases the requirement for a sound coastal management framework, which is the basis for development of the CPMP (GHD 2021b).

Although modelling results generally suggest negligible substantive change to coastal processes, neither impacts nor model uncertainty are quantified. This constrains ongoing auditing of KBMS performance to comparison of future coastal dynamics with historic behaviour. Any deviation in behaviour could be deemed (rightly or wrongly) an unpredicted consequence of the KBMS structures, requiring mitigation by the proponents, or (less reasonably and quite unlikely) could be considered a failure to meet environmental compliance, with the prospect of fines or order for removal of structures.

As part of the transition from SPER to project environmental commitments, it is appropriate to establish a set of coastal process performance criteria which can be audited. These should be capable of distinguishing between unforeseen impacts from the KBMS structures, effects of variable weather conditions and response to projected sea level rise.

Exclusion of local effects such as scour and accretion adjacent to structures may substantially understate the impact of the proposed structures on coastal processes. Based on historic observations, these effects are the most likely impact to occur, and consequently require monitoring and management.

Coastal Processes Management Plan

GHD (2021b) provides a preliminary framework for management of Koombana Bay coast. Ideally, the plan requires refinement of targets, monitoring, management triggers, actions and responsible agencies. Although monitoring, responsible agencies and potential use of dredging or renourishment have been discussed, these are not presented in a manner that would presently support application or performance auditing. Management actions do not have clear triggers for implementation or means of distinguishing whether observed impacts were caused by either the KBMS structures or other mechanisms. This may create conflict between responsible agencies and argument over funding.

Overall, the CPMP requires further stakeholder liaison and refinement. A key objective of the CPMP framework should be to enable performance auditing of coastal process impacts from the KBMS structures, and guide mitigation actions for either predicted or unforeseen impacts.
GHD (2021b) requires a thorough review of links, captions and internal referencing.

Koombana Bay CHRMAP
GHD (2019) *Transforming Bunbury's Waterfront – Koombana Bay CHRMAP. Draft Coastal Hazard Risk Management and Adaptation Plan*, hereafter referred to as Koombana CHRMAP, has been developed to guide the longer-term management of Koombana Bay coastal hazards, specifically inundation and erosion. The CHRMAP reports hazard levels for different forecast timeframes and evaluates whether the hazard is tolerable, or requires management. Management triggers (thresholds at which management actions are to be taken) are not explicitly defined, although they are implied to occur when there is a change of management between timeframes.

The CHRMAP erosion hazard assessment has followed the simplified Schedule One methodology (WAPC 2013). Using this approach, present day risk of 5-33m erosion (increasing to the west) along Koombana Beach is considered tolerable, whereas 23-45m erosion hazard (increasing to the west) by 20230 is deemed intolerable. It is noted that the entirety of present day risk is associated with storm response, with the increased erosion hazard over time being associated with projected coastal recession (i.e. sustained movement of the average beach position). This suggests that 12-18m recession represents the transition from tolerable to intolerable erosion hazard.

As the GHD (2019) modelling has demonstrated that there is limited change to wave climate on Koombana Beach, the main change to the existing nearshore beach system is formation of an area of wave shadow east of the KSCM breakwater. Potential response is increased westward sand transfer, which would cause accelerated recession towards the centre of the beach. Historic rates of change are approximately 0.3-0.5m/yr accretion on the west and 0.2-0.3m/yr erosion towards the centre. Formation of a new moderately-sized sediment source or sink typically increases alongshore transport by 2-3 times the historic rates, as was observed following renourishment along eastern Koombana Beach (Seashore 2019). Using the CHRMAP erosion risk assessment, recession of 6-10m could be used as a trigger for renourishment. Notably, there may be limited ability to distinguish between recession due to the KBMS structures or as a response to variable coastal conditions.

Previous Revisions and Peer Review
Previous versions of the document that have been reviewed include:

- Prelim provided 26 June 2017
- Rev A provided 15 October 2017
- Rev A2 provided 18 February 2018
- Rev C provided 11 September 2018
- Rev 0 provided 15 March 2019

Initial peer reviews of the Preliminary and Rev A versions of the report identified limitations of both the numerical modelling and the overall assessment approach. In particular, the modelling validation demonstrated that a number of physical processes were not fully resolved. As comparison between baseline and developed cases can only describe modelled processes, modelling limitations introduce uncertainty, and require that model results be interpreted with due regard.

Seashore provided a detailed peer review of Rev A2 on 11 April 2018. This document outlined a number of limitations of the draft document, ranging from grammatical errors, word choice, referencing and technicalities, to spatial coverage of reported issues and the overall scope of the assessment (Attachment 3). In particular, it was noted that the overall scope did not fully address the ESD for Coastal Processes, which is likely to be a basis with which OEPA assess the project.

A key direction suggested for Rev A2 was to strengthen the coastal processes monitoring and management plan (Section 6), specifically to provide a basis for managing risks associated with coastal processes.

Rev C addressed grammatical errors, word choice and technicalities identified in the peer review. It also provided interpretation of modelling outcomes across the wider area. A preliminary revision of the CPMP was undertaken, but this was largely deferred until completion of the Koombana Bay CHRMAP. Limitations of GHD's overall study scope to respond to the ESD for Coastal Processes were not addressed.

Peer review of Rev C noted that interpretation of modelling outcomes was predominantly 'no predicted substantive impact'. Where impacts were identified as possible, they were largely derived from engineering judgement, rather than supported by modelling, including the effects of wave channelling (mach-stem waves), reflection and wave shadowing. The peer review noted that when combined with model uncertainty, there is scope for coastal process impacts to be caused by the KSCM or CBHD breakwaters, but not predicted. This may lead to observed changes to be (rightly or wrongly) attributed to the structures, which may therefore lead to debate over management responsibility and funding.

Revision from Rev C to Rev 0 included minor editing through the document. Section 6.2 (*KBMS Coastal Processes Management Plan)* was the most substantially modified section, with Table 6-2 (Monitoring/management action plan) added. This predominantly outlines monitoring activities. Management activities (dredging or renourishment) do not have defined triggers.

Rev 0 retained most of the characteristics of the previous revision (Rev C). The modelling undertaken is limited in scope (although meeting the project brief) and apparently does not incorporate all active processes. The associated model uncertainty needs to be taken into account in interpretation of results. The report does not quantify impacts, which would enable auditing of model performance. The CPMP did not provide a robust framework for managing unforecast coastal process impacts. However, the assessment does demonstrate that Koombana Bay is a low energy setting, which implies that any unforeseen impacts should be of small scale.

Present Revision

Rev D has included restricting associated with separation of the CPMP from the coastal process impact assessment, included presentation of hydrodynamic exchange into Leschenault Inlet and provided further information on wrack modelling. The revision has not modified previously presented modelling outcomes.

Conclusions

GHD (2021a) indicates that Koombana Bay is a relatively low energy environment and confirms that the CBHD and KSCM breakwaters do not substantially alter the swell-wave propagation on to Koombana Beach. On this basis, it has been inferred that coastal process impacts from the structures will be minor. However, by using comparative assessment with weakly validated or unvalidated models, the results include considerable modelling uncertainty. When measured against a primary SPER objective to '*Demonstrate that expected impacts are tolerable, and that risks can be managed*', GHD (2021a) fails to clearly define coastal process impacts associated with the proposed KBMS structures (i.e. they are 'less' than an unquantified criteria). For this reason, the CPMP (GHD 2021b) is a critical document, to provide a basis for managing risks.

It is recognised that substantial modelling effort has been undertaken. However, it is considered that model uncertainties are intrinsic to the modelling framework accepted within the GHD scope. Consequently, it is considered that there is limited value in additional or more refined modelling.

To supplement a conclusion that coastal dynamics within Koombana Bay are likely to be manageable, a summary of coastal observations has been developed (Attachment 2).

Given the strategic nature of the SPER, it is deemed the CPMP provides a suitable basis with which to move forward. However, it is noted that this is presently a preliminary document, requiring stakeholder liaison and further refinement, with focus on implementation and the ability to distinguish between structural impacts and natural coastal variability.

List of Attachments

- **Attachment 1** – Review against Environmental Scoping Document This is based upon Rev D (GHD 2021a,b).

- **Attachment 2** – Summary of Coastal Observations

Koombana Bay Marine Structures SPRER Coastal Processes
Summary of Peer Review against Environmental Scoping Document Date: 15 February 2022

Required work	Adequately addressed?	Peer review comments
1. Characterise the environment by describing the current coastal processes in the proximity of each of the future proposals. This is to include, but not be limited to,	Limitations *	A conceptual model of the current coastal processes, based on review of existing datasets and knowledge, was not presented. Description of the current environment is limited principally to the results of the numerical models. Although a brief review of active coastal dynamics was undertaken, this was not apparently used to guide model selection. Consequently, there are limitations in that some key processes may have been missed. ** A summary of relevant coastal observations for Koombana Bay has been prepared by the peer reviewer (Attachment 2).*
a. modelling the local current and wave climate;	Limitations	Interpretation of local conditions was limited to the model selection and scenario selection.
b. conducting a detailed analysis of existing long-shore sediment movements to estimate erosional and depositional patterns including for cross-shore processes;	No *	Limited analysis of existing sediment movement rates. Insufficient information provided on estimated erosion and deposition patterns. Episodic nature of observed coastal change was not discussed or incorporated into assessment. Impact of redevelopment of the Dolphin Discovery Centre (T or L shaped finger jetty and potentially a boat ramp) not considered. ** A summary of relevant coastal observations for Koombana Bay has been prepared by the peer reviewer (Attachment 2).*
c. determining beach profiles;	No	Changes to beach profiles limited to storm response modelling. No information provided on expected long-term change in beach profiles based on current sediment movement patterns.

d. determining the tidal flows and exchanges between Koombana Bay and Leschenault Inlet; and	Yes	Extracts included from the Marine Environmental Water Quality Modelling report (MEWQ). The main MEWQ report has not been reviewed for adequacy.
e. determining coastal vulnerability and the potential impacts as a result of climate change, including through using multiple tide gauge records in the Bunbury Region to determine local sea level rise.	Limitations	Vulnerability assessment limited to the consideration of erosion. Analysis based on DPLH recommendations regarding sea level rise rather than analysis of local water level recordings, which was not undertaken.
The characterisation is to consider all temporal scales, including seasonal and inter-annual, and the spatial scale must be adequate to address all coastal processes and patterns likely to be affected as a result of the proposal. The characterisation should spatially define the limit of where impacts are expected to occur.	No *	Inter-annual variability limited to consideration of representative years. Seasonal variability not considered. ** A summary of relevant coastal observations for Koombana Bay has been prepared by the peer reviewer (Attachment 2).* Spatial limit of impacts not defined. Scale and modelling approach avoid identification of change adjacent to structures, which is an extremely likely area of change.
2. Identify elements of each of the future proposals which may potentially affect coastal processes, including both direct and indirect impacts and for both construction and operation.	No	Potential impacts have not been clearly related to the elements of each proposal. Impacts of construction have not been considered.
3. Predict the residual impacts from the proposal, both direct and indirect, after outlining any avoidance and mitigation options that will be applied. Impact predictions are to:	Limitations	Did not predict any impacts. Modelling methodology was incapable of resolving anticipated (small) impacts but demonstrated that significant (unquantified) impacts are unlikely.
a. Be provided at a sufficient scale to allow all impacts resulting from each of the future proposals to both up and down coast processes as well as onshore-offshore processes to be assessed.	No	Impacts of the proposals have not been quantified or identified specially. Assessment of impacts has been limited to Koombana Beach. Expected impacts to other beaches (Ski Beach, CBHD beach and KSCM beach) are based upon engineering interpretation of modelling results, including processes (wave channelling and reflection) that have not been modelled.

b. Be informed by monitoring previously undertaken at local harbours, ports and marinas.	Partial *	This application was limited, as coastal change observations were not used for model definition. ** A summary of relevant coastal observations for Koombana Bay has been prepared by the peer reviewer (Attachment 2).*
c. Determine changes to local current and wave climate, long-shore sediment movements and the erosional and deposition patterns (including to cross-shore processes), and beach profiles resulting from each of the future proposals, including within Leschenault Inlet.	No *	Assessment of impacts has been limited to Koombana Beach. Expected impacts to other beaches (Ski Beach, CBHD beach and KSCM beach) are based upon engineering interpretation of modelling results, including processes (wave channelling and reflection) that have not been modelled. Changes to beach profiles limited to storm response modelling. No information provided on expected long-term response of beach profiles. ** A summary of relevant coastal observations for Koombana Bay has been prepared by the peer reviewer (Attachment 2).* Impacts within the Leschenault Inlet not addressed in this report, reference provided to Marine Environmental Water Quality Modelling report (MEWQ). This report has not been reviewed for adequacy.
d. Consider and assess the cumulative effects of each of the future proposals both singularly and in combination to the effects of adjacent approved proposals and proposals currently being assessed by the EPA. These other proposals include stormwater drains, other marinas and the Southern Ports Authority Inner Harbour Structure Plan proposal.	Limitations	Assessment considers only cumulative impact of proposals.
e. Be for both the short and long-term (100 year planning horizon); be provided for best, most likely and worst case scenarios; and consider the likely impacts of climate change.	Limitations	Assessment assumes all areas within the coastal zone will be impacted. No spatial mapping of impacts undertaken.

f. Examine the need (if any) for coastal structures to mitigate the impacts of wave shadows that would be caused by each of the future proposals.	Limitations	Development of wave shadows is identified but considered small and only locally relevant to proposed structures. Details of required (small scale) management measures not provided
g. Address the frequency, volume and potential environmental impacts of wrack and maintenance dredging within and adjacent to each of the future proposals.	Limitations	Uncertainty regarding sediment and wrack transport modelling is proposed to be addressed
h. Address the requirements of State Planning Policy 2.6, particularly with regard to setback and coastal risk management.	Yes	
4. Identify management and mitigation measures for each of the future proposals to demonstrate that the EPA's objectives for coastal processes can be met and to ensure residual impacts are not greater than predicted. This is to include the identification of areas of land and sea within the harbour/marina boundary to allow for management works and buffer areas to manage sand and/or wrack accumulations. Management and mitigation measures are to have regard for existing coastal management plans, including the Bunbury Coastal Protection, Part A – Koombana Bay Coastal Erosion and Design Report (Seashore Engineering 2013).	No	Quantification of potential impacts, including spatial extent, has not been provided. Qualitative description of impacts is provided through engineering interpretation of modelling results, including processes (wave channelling and reflection) that have not been modelled. Insufficient detailing of management works and buffer areas. Insufficient detailing of potential required management triggers and actions.
5. Outline the agency responsible for the management of coastal processes including the roles and responsibilities for wrack management and maintenance dredging.	Limitations	Partly addressed by CPMP. This document requires further stakeholder liaison and refinement for it to be implemented.
6. Include a Coastal Processes Management Plan which details the monitoring and management that will apply during and after construction to demonstrate and ensure that residual impacts to coastal processes are not greater than predicted.	Limitations	CPMP provides a preliminary monitoring framework, auditable performance thresholds and triggers points. These are not yet functional, requiring further stakeholder liaison and CPMP refinement.

Seashore Engineering

Our Ref: SE048-05-01
Your ref: _____

15 February 2022

South West Development Commission
Level 9, 61 Victoria St
Bunbury WA 6231

SE048-05-01 Koombana Bay Observed Coastal Dynamics

Background

Seashore Engineering were engaged from 2016 by South West Development Commission, to provide peer review of coastal processes impact assessment, as part of Koombana Bay Marine Structures (KBMS) Strategic Public Environmental Review (SPER). The SPER has been prepared by RPS, with a coastal processes assessment undertaken by GHD, which includes:

- *Koombana Bay CHRMAP* (GHD 2019)
- *KBMS SPER Coastal Processes Impact Assessment* (GHD 2021a)
- *KBMS SPER Coastal Processes Management Plan* (GHD 2021b)

The approach for coastal processes impact was to undertake numerical modelling (waves, currents, sediment transport, wrack transport) for baseline and fully developed cases, under selected scenarios. Comparison of model outcomes between the two cases was used to identify an indicative response to the proposed structures. In general, outcomes from this assessment were considered to represent marginal change to existing conditions. However, review of the coastal processes modelling indicated low confidence in the modelling framework, particularly for sediment and wrack transport.

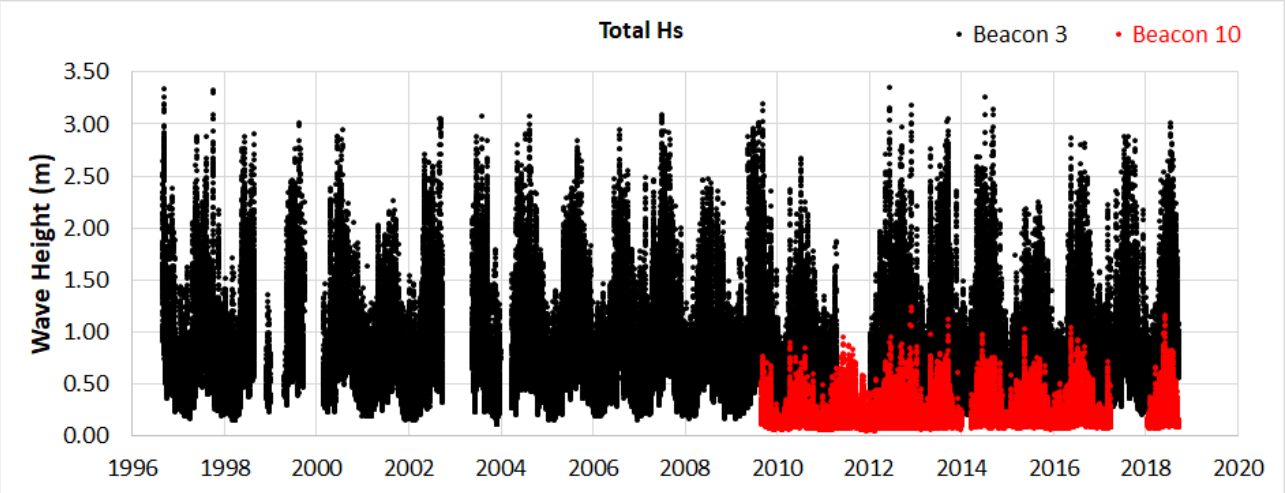
This note summarises some available information describing coastal dynamics of Koombana Bay, relevant to interpretation of modelling.

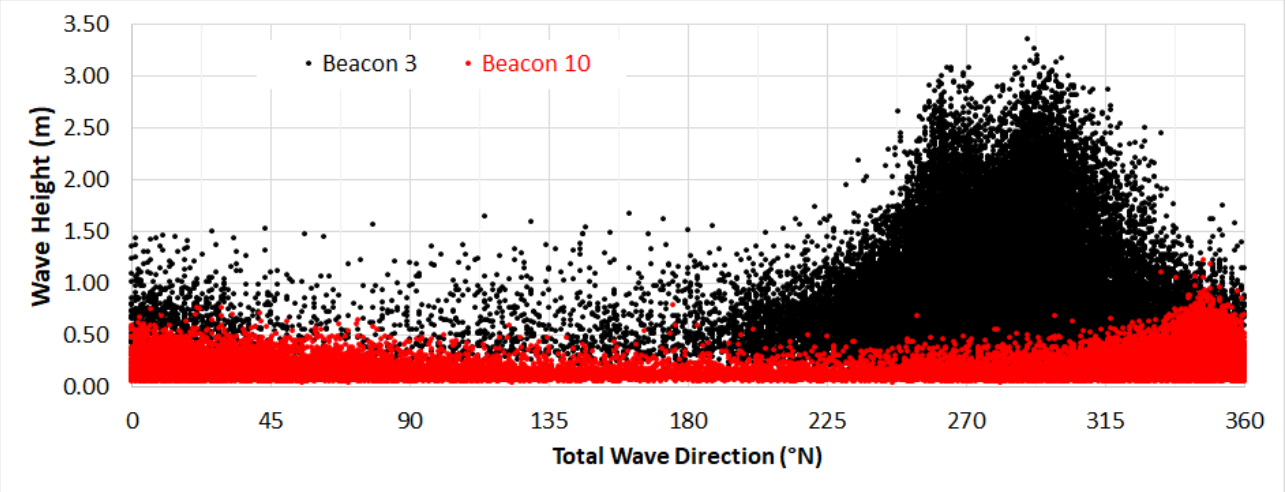
Wave Climate

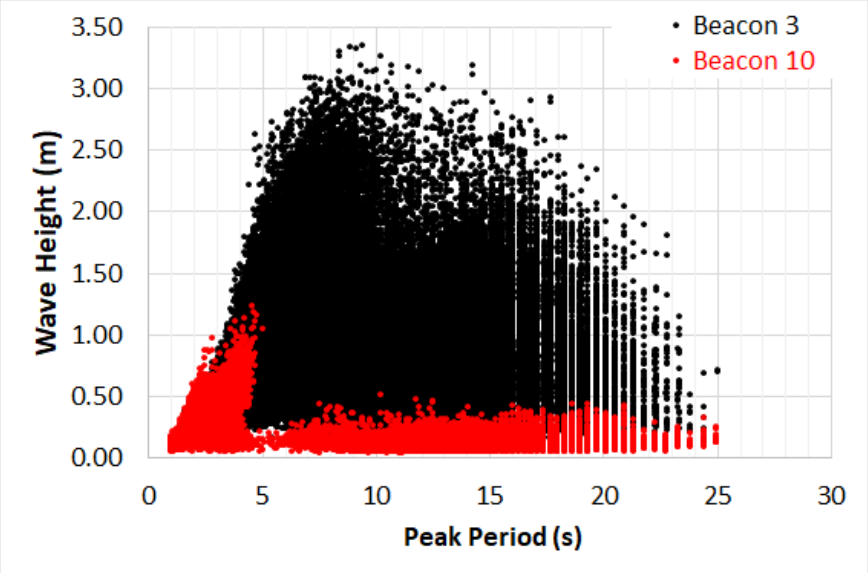
Wave measurements collected by Southern Ports provide the basis for observational understanding of the wave climate within Koombana Bay, with Beacon 3 located outside the port breakwater and Beacon 10 located inside the Bay. Interpreted outcomes from these observations include:

- Wave energy is highly seasonal, with peak conditions typically occurring during winter months
- Waves inside the bay include low amplitude diffracted swell waves (6-25s wave period) and higher amplitude wind waves (up to 5s)
- The highest waves inside the bay are from a direction of approximately 345°N, with energetic waves outside the bay from a wide band around 300°N, indicating significant shelter provided by the port breakwater, and consequent importance of wave diffraction.

Wave data review was completed to support modelling and design for Casuarina Harbour breakwater (Seashore 2018).


Total Hs
Beacon 3
Beacon 10
Wave Height (m)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020


Beacon 3
Beacon 10
Wave Height (m)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
45
90
135
180
225
270
315
360
Total Wave Direction (°N)

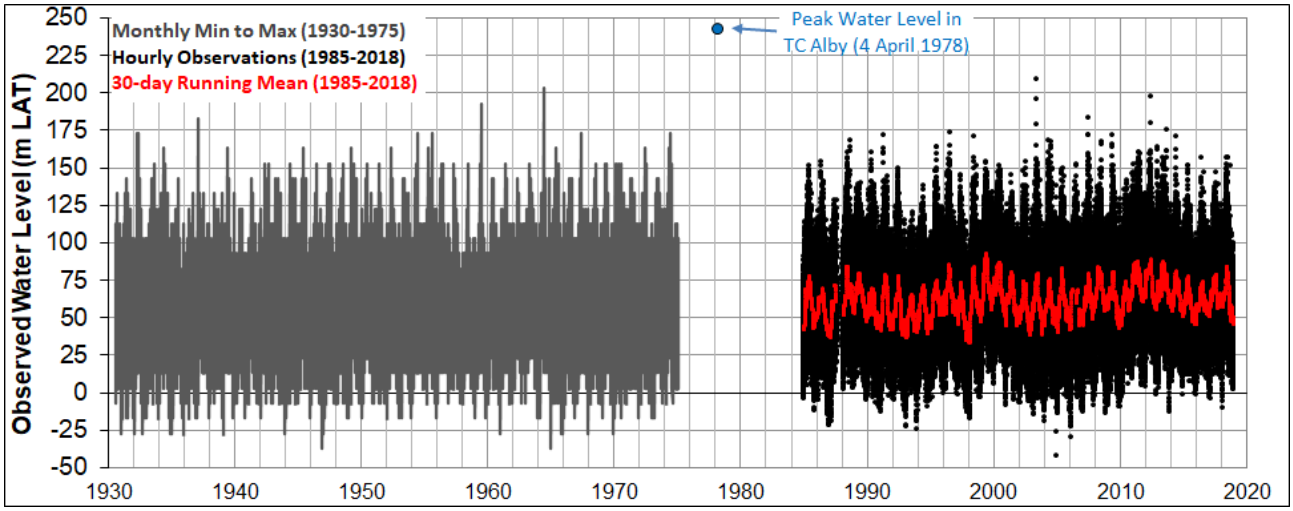

Beacon 3
Beacon 10
Wave Height (m)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
5
10
15
20
25
30
Peak Period (s)

Sea Levels

Water level measurements, including tide board observations and instrumented tide gauge measurements have been collected at Bunbury since 1930. Collation and analysis of associated data sets have been reported as part of different studies:

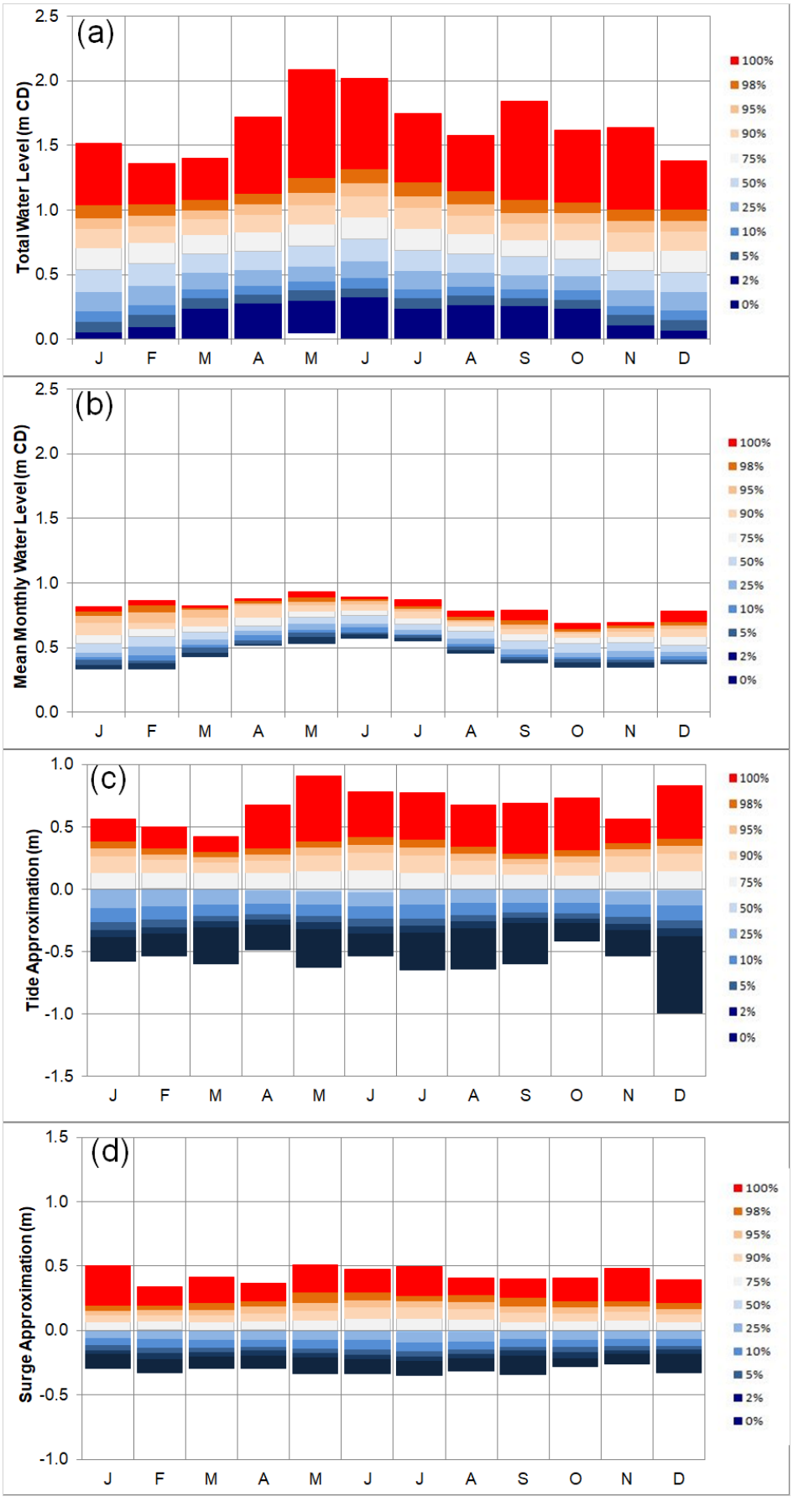
- *City of Bunbury Back Beaches Coastal Management Plan* (DMH 1990)
- *Metocean Data Summary for Bunbury Port Expansion* (GEMS 2008)
- *Bunbury Coastal Protection. Part A – Koombana Beach Coastal Erosion and Design Report (Seashore 2013)*
- *Bunbury Waterfront – Water Level Design Criteria – Technical Note* (Seashore 2018)

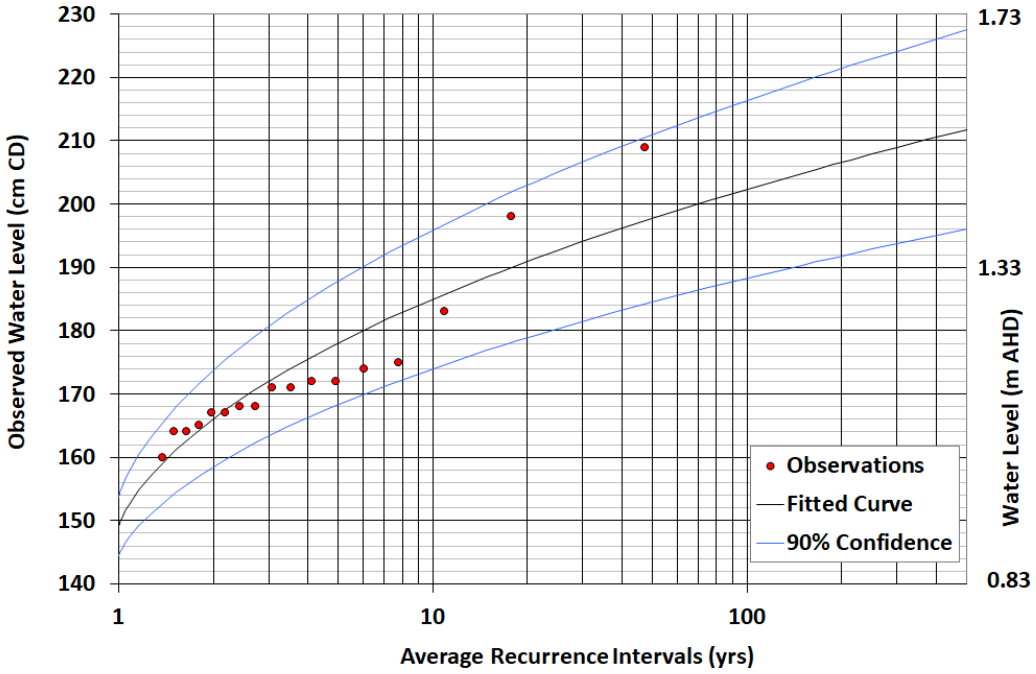
These evaluations have demonstrated behaviour consistent with the Swan River region (Eliot 2012), which has microtidal mainly diurnal conditions, strongly modulated by seasonal and inter-annual variability of surges and mean-sea level fluctuations. Determination of statistics from the Bunbury record are consequently highly affected by the observation period, with a 1.4mm/yr mean sea level rise from 1966-2010 consistent with adjacent tide gauge sites (White *et al*. 2014).



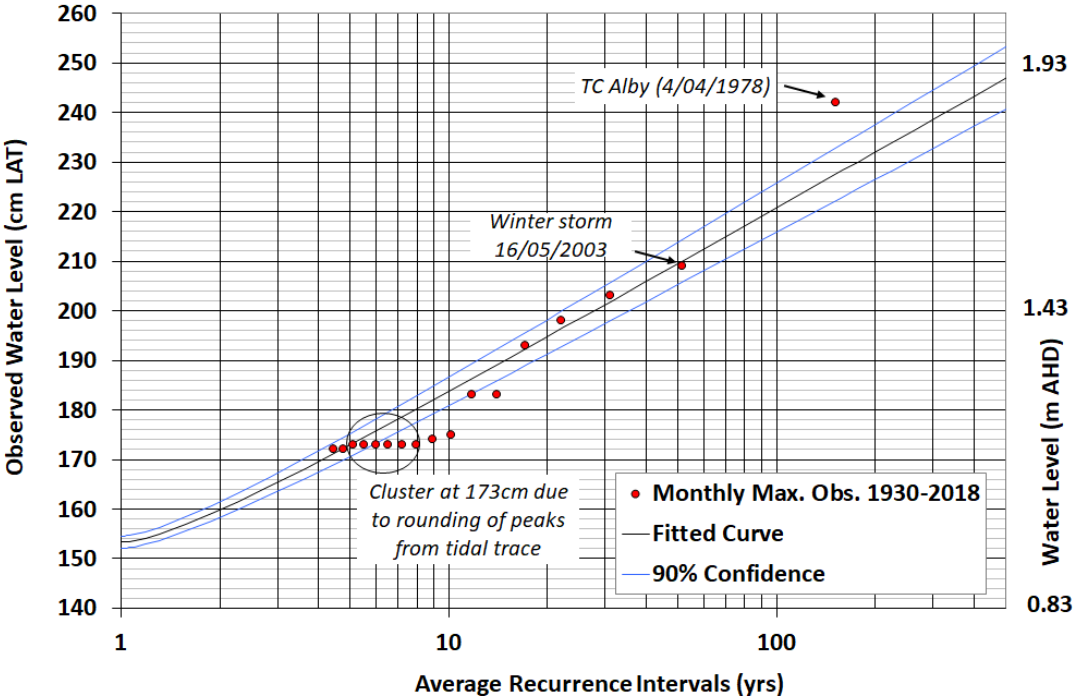
Seasonal variability of surges and mean sea level (peaking around June-July and May respectively) interacts with the twice annual tidal cycle (peaking in June and December) to cause a distinct seasonal peak to water levels around June, although high water levels are possible from frequent winter storms from May to September, or through rare impact of ex-tropical cyclones, such as TC Alby in April 1978 (Fandry & Steedman 1994, Fountain *et al*. 2010).

The combination of multiple oceanographic and synoptic processes to extreme water levels creates a distinctive 'double-curve' for extreme water level events, giving relatively low confidence to extreme water levels distributions extrapolated from data. These are strongly affected by the event sampling basis and data set used.


(a)
Total Water Level (m CD)
2.5
2.0
1.5
1.0
0.5
0.0
J F M A M J J A S O N D
100%
98%
95%
90%
75%
50%
25%
10%
5%
2%
0%
(b)
Mean Monthly Water Level (m CD)
2.5
2.0
1.5
1.0
0.5
0.0
J F M A M J J A S O N D
100%
98%
95%
90%
75%
50%
25%
10%
5%
2%
0%
(c)
Tide Approximation (m)
1.0
0.5
0.0
-0.5
-1.0
-1.5
J F M A M J J A S O N D
100%
98%
95%
90%
75%
50%
25%
10%
5%
2%
0%
(d)
Surge Approximation (m)
1.5
1.0
0.5
0.0
-0.5
-1.0
J F M A M J J A S O N D
100%
98%
95%
90%
75%
50%
25%
10%
5%
2%
0%



Extreme Distribution Derived from 1978-2015 data



Extreme Distribution Derived from 1930-2018 data

Shoreline and Seabed Dynamics

Information collected describing Koombana Bay shoreline dynamics includes:

- Aerial imagery, including demonstration of change following construction of Bunbury Harbour (Damara 2011).
- Beach profiles collected following construction of Bunbury Inner harbour, as part of an assessment of the feasibility for renourishment (DMH 1989), for post-event assessment (Seashore 2013) and as part of post-construction monitoring following construction of Point Busaco revetment and associated renourishment activities (Seashore 2019).
- 'Shoreline' change evaluation, derived from satellite waterline detection from 1988-2019 (Bishop-Taylor *et al*. 2021).
- Beach width measurements, completed as part of the Peron-Naturaliste Region Coastal Monitoring Program (Damara 2017) and reported following three years of data collection (Cardno 2021).

Information describing seabed change within Koombana Bay is mainly collected by hydrographic survey for Southern Ports, as part of port management, and therefore is focused on facilities, including the dredged navigation channel. Regional LIDAR, collected by the Department for Planning in 2009, provides a whole of bay coverage. Analysis of seabed information (Shore Coastal 2009, Seashore 2014) indicates dominance of alongshore sediment supply from the south, spilling around the port breakwater.

Profile measurements demonstrate an overall transfer of sediment from east to west along Koombana Beach, but limited net change in total (i.e. it is effectively a closed system). Elevated rates of alongshore transport were observed following episodes of renourishment, and during winter. The beach width measurements also indicated a seasonal pattern, with the beach up to 15m narrower during winter – however, it is unclear whether beach widths have been corrected for seasonal sea level change.

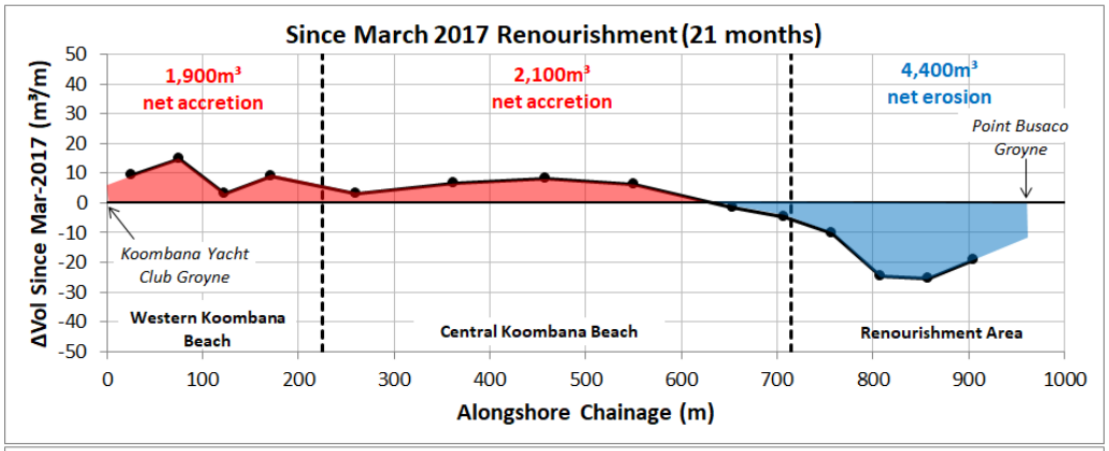
Survey Period	Net Volume Change	Monthly Rate
17/07/2015 to 8/10/2015	-2850m³	-1030m³/month
8/10/2015 to 22/01/2016	-410m³	-120m³/month
22/01/2016 to 5/05/2016	-440m³	-130m³/month
5/05/2016 to 13/06/2016	-1190m³	-920m³/month
13/06/2016 to 7/10/2016	-2300m³	-590m³/month
7/10/2016 to 31/01/2017	440m³	110m³/month
31/01/2017 to 23/03/2017	4110m³	N/A
23/03/2017 to 9/06/2017	-2830m³	-1090m³/month
9/06/2017 to 1/11/2017	-1630m³	-340m³/month
1/11/2017 to 11/05/2018	-130m³	-20m³/month
11/05/2018 to 27/06/2018	-150m³	-100m³/month
27/06/2018 to 24/12/2018	330m³	60m³/month
Total	**-7050m³**	**-170m³/month**

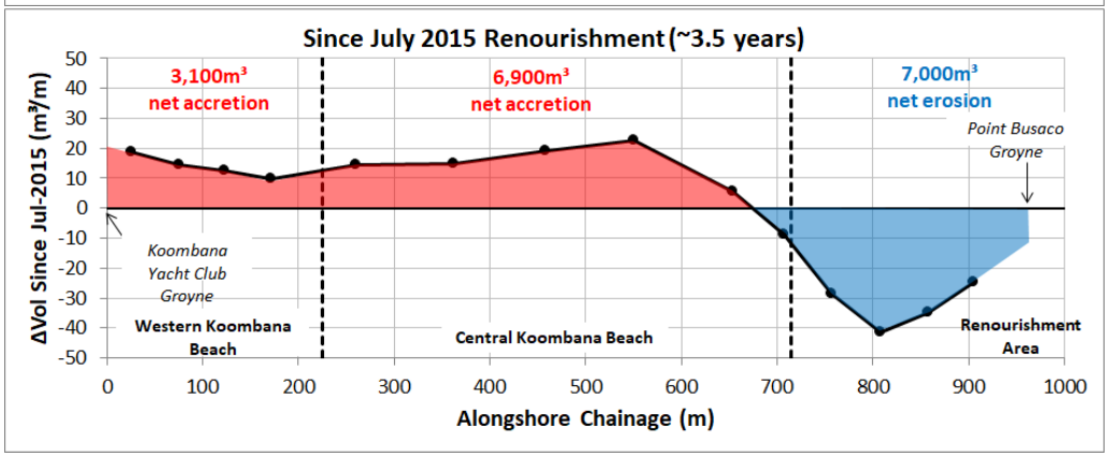
~7-8,000m³ in situ beach renourishment in July 2015

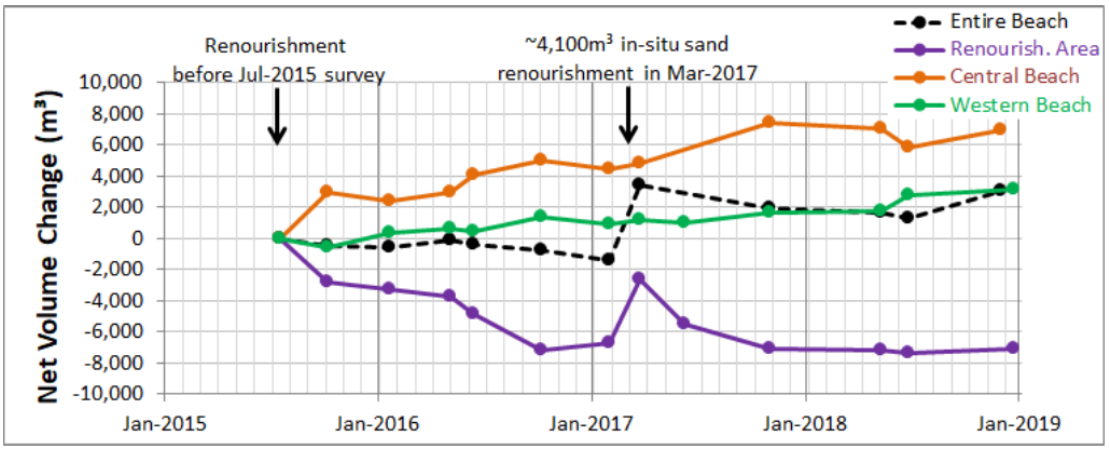
~4,100m³ in situ beach renourishment in March 2017

Monthly erosion rates greater than 500m³/month shown in blue shade

The satellite imagery assessment (Bishop-Taylor *et al*. 2021) indicates the most recent position of the beach is the 'most rotated' it has been since 1988. This creates a potential challenge to use the limit of historic beach positions as a trigger for management. Average rates of change from the satellite images are consistent with those derived from profiles (Seashore 2013).


Since March 2017 Renourishment (21 months)
ΔVol Since Mar-2017 (m³/m)
1,900m³ net accretion
2,100m³ net accretion
4,400m³ net erosion
Point Busaco Groyne
Koombana Yacht Club Groyne
Western Koombana Beach
Central Koombana Beach
Renourishment Area
Alongshore Chainage (m)


Since July 2015 Renourishment (~3.5 years)
ΔVol Since Jul-2015 (m³/m)
3,100m³ net accretion
6,900m³ net accretion
7,000m³ net erosion
Point Busaco Groyne
Koombana Yacht Club Groyne
Western Koombana Beach
Central Koombana Beach
Renourishment Area
Alongshore Chainage (m)


Renourishment before Jul-2015 survey
~4,100m³ in-situ sand renourishment in Mar-2017
Entire Beach
Renourish. Area
Central Beach
Western Beach
Net Volume Change (m³)
Jan-2015
Jan-2016
Jan-2017
Jan-2018
Jan-2019

Conclusions

Information collated for this summary note demonstrates Koombana Bay coast is low-energy and relatively slow to change, with a consistent net east-to-west alongshore transfer of sediment. The bay is strongly influenced by sheltering from the port breakwater, with a highly diffracted wave climate and interception of alongshore sediment supply from the south.

Information available suggests that sediment transport processes modelled as significant by GHD (2021a), including a large onshore supply north of the Inner Harbour and nearshore steepening along Koombana Beach, are not evident. However, in this low-energy setting, it is considered feasible to undertake adaptive coastal management, with appropriate liaison and engagement with coastal stakeholders.

References

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

Cardno Pty Ltd. (2021) *Regional Coastal Monitoring Program – Analysis and Review*. CW1153200.

Damara WA Pty Ltd. (2011) *Point Busaco Revetment – Preliminary Detailed Design*. Prepared for the Bunbury Port Authority. Report 163-01 Rev 0.

Damara WA Pty Ltd. (2017) *Peron-Naturaliste Partnership Regional Coastal Monitoring Program*. Report 245-02.

Department of Marine and Harbours: DMH. (1989) K*oombana Beach, Western Australia: A Proposal for Beach Nourishment Works*. Report DMH 29/89.

Department of Marine and Harbours: DMH. (1990) *City of Bunbury Back Beaches Coastal Management Plan*. Report DMH P1/90.

Eliot M. (2012) Sea Level Variability Influencing Coastal Flooding in the Swan River Region, Western Australia, *Continental Shelf Research*, 33, 14-28.

Fandry C & Steedman R. (1994) Modelling the dynamics of transient, barotropic response of continental shelf waters to tropical cyclones. *Continental Shelf Research*, 14(15): 1723-1750.

Fountain L, Sexton J, Habili N, Hazelwood M & Anderson H. (2010) *Storm surge modelling for Bunbury, Western Australia*. Geoscience Australia, Professional Opinion No. 2010/04.

GEMS Pty Ltd. (2008) *Metocean Data Summary for Bunbury Port Expansion. Technical Report*.

GHD Australia Pty Ltd. (2019) *Transforming Bunbury's Waterfront - Koombana Bay CHRMAP. Coastal Hazard Risk Management and Adaptation Plan*. Rev 0. Project 6136982.

GHD Australia Pty Ltd. (2021a) *Koombana Bay Marine Structures – SPER. Coastal Processes Impact Assessment*. Rev D. Project 6134786.

GHD Australia Pty Ltd. (2021a) *Koombana Bay Marine Structures – SPER. Coastal Processes Management Plan*. Rev A. Project 6134786.

Seashore Engineering Pty Ltd. (2013*) Bunbury Coastal Protection. Part A – Koombana Beach Coastal Erosion and Design Report*. Report SE001-01-Rev0.

Seashore Engineering Pty Ltd. (2014*) Bunbury Outer Harbour Siltation – Management Options*. Report SE011-01-Rev0.

Seashore Engineering Pty Ltd. (2018) *Transforming Bunbury's Waterfront Stage 3 Business Case Development: Coastal Structures. Design Criteria and Design Review*. Report SE074-05-02-Rev0.

Seashore Engineering Pty Ltd. (2019*) Point Busaco Revetment Monitoring Survey #12 – December 2018 (Year 4)*. Report SE009.03-12-RevA.

Shore Coastal Pty Ltd. (2009) *Bunbury Harbour Siltation Investigation*. Prepared for Bunbury Port Authority.

White NJ, Haigh ID, Church JA, Koen T, Watson CS, Pritchard TR, Watson PJ, Burgette RJ, McInnes KL, You Z-J, Zhang X & Tregonning P. (2014) Australian Sea Levels – Trends, Regional Variability and Influencing Factors, *Earth Science Reviews*, doi: 10.1016/j.earscirev.2014.05.011

Limitations of this Report

This report and the work undertaken for its preparation, is presented for the use of the client. The report may not contain sufficient or appropriate information to meet the purpose of other potential users. Seashore Engineering does not accept any responsibility for the use of the information in the report by other parties.

Limitations of this Report

This report and the work undertaken for its preparation, is presented for the use of the client. The report may not contain sufficient or appropriate information to meet the purpose of other potential users. Seashore Engineering does not accept any responsibility for the use of the information in the report by other parties.

Document Control

Index	Author	Date	Review	Date	Comment
Draft A	MJE	15.02.2022			