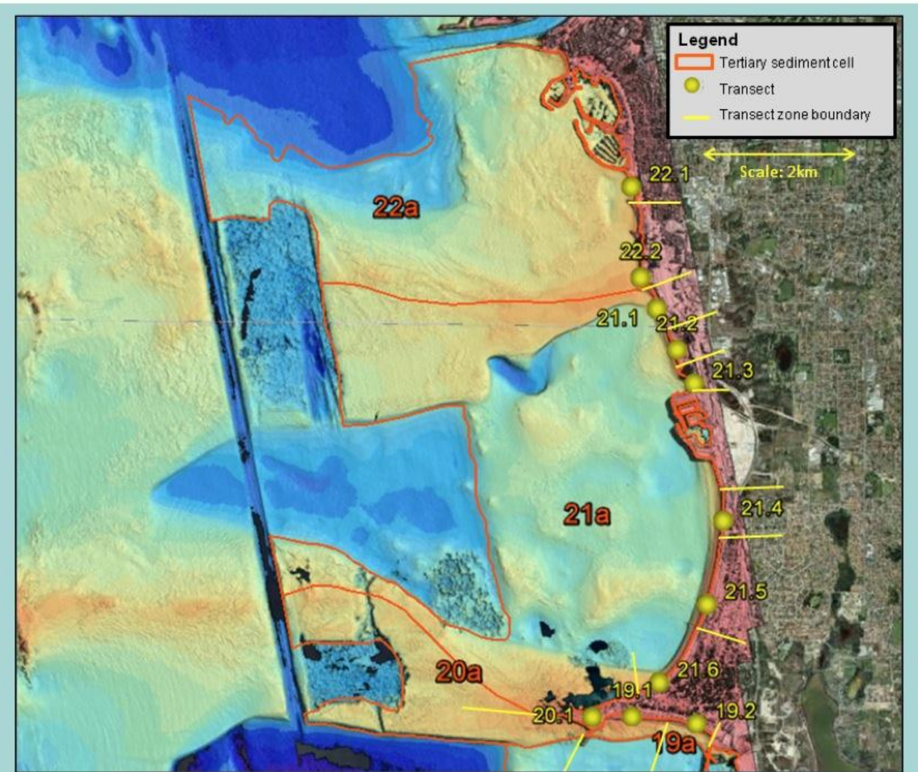
Cockburn Sound Coastal Alliance

Coastal Vulnerability Study

Erosion and inundation hazard assessment report

March 2013



coastal zone management pty ltd

The University of Western Australia

oceanica marine & coastal specialists

Executive Summary

This report summarises the outcomes of a coastal vulnerability assessment undertaken for Cockburn Sound, Owen Anchorage and the east coast of Garden Island (The OACS coast)[1], commissioned by the Cockburn Sound Coastal Alliance[2] and undertaken by a specially assembled consortium of Coastal Zone Management Pty Ltd, the UWA School of Environmental Systems Engineering, Damara WA Pty Ltd and Oceanica Consulting Pty Ltd.

This vulnerability assessment focuses on potential impacts on the OACS coast from climate change and associated sea level rise. The work undertaken has involved the stages of:

- Project Scoping
- Inundation Hazard Representation; and
- Erosion Hazard Representation

Outputs of this coastal vulnerability assessment will inform a subsequent values and risk assessment for coastal assets at threat from these coastal processes, followed by the development of adaptation strategies for informed coastal planning and management cognizant of these risks[3].

PROJECT SCOPING (REPORT SECTION 2)

Data Acquisition (Report Section 2.1)

The project scoping undertaken has built on the coastal data and information inventory previously prepared in 2009[4],[5] establishing the availability of any additional pertinent information. Key additional datasets have been identified and subsequently used, including Laser Airborne Depth Sounder (LADS) and Light Detection and Ranging (LIDAR) datasets collected by Department of Planning and the Department of Water. These datasets provided accurate ground levels and ocean floor depths in the vicinity of the coastline.

[1] See Figure 1 and 2 in body of main report. The study area extends from the Garden Island causeway in the South to Fremantle Harbour in the North and includes the east coast of Garden Island
[2] City of Cockburn; City of Rockingham, City of Kwinana, Department of Defence, City of Fremantle, Cockburn Sound Management Council.
[3] Phase 2 of the Cockburn Alliance Coastal Vulnerability Study
[4] Consultancy commissioned by the City of Cockburn, City of Fremantle, City of Kwinana, City of Rockingham, Cockburn Sound Management Council and Department of Defence (Royal Australian Navy) to produce a Study Brief for a project to assess coastal vulnerability in Cockburn Sound and the Owen Anchorage.
[5] The stakeholder engagement process is summarised in Appendix 1 along with an exert of the updated inventory. Appendices 4 and 5 contain details of useful datasets.

Climate Change Projections (Report Section 2.2)

Climate change scenarios and projection time frames were reviewed and identified[6] with the timeframes selected being present day, 2070 and 2110, which are consistent with the West Australian State Planning Policy (SPP 2.6). Also selected were the associated sea level rises for these timeframes of 0m, 0.5m and 0.9m respectively. Additionally, a sea level rise of 1.5m at Year 2110 was also adopted to determine high-end (worst case) sensitivity.

EXISTING COASTAL DYNAMICS (REPORT SECTION 3)

The Physical Process Assessment[7] has been undertaken to determine and report on wind, wave, water level conditions, sediment dynamics and variability relevant to the study area, together with consideration of the impact of coastal structures on sediment dynamics along the coastline **(Section 3.1-3.6)**.

The OACS coast is a sheltered, relatively low energy and highly modified coastal system with distinct and variable beach morphology (both alongshore and offshore). It is partitioned by geological coastal structures as well as Fremantle Harbours, Catherine Point groyne, Woodman Point groyne and Garden Island causeway.

The coast is presently accreting (building up) slowly through a sand supply-distribution pattern that feeds marine sediment onshore at Success and Challenger banks, and which is then transported alongshore through waves and currents. This situation has enabled moderately effective use of coastal protection structures, which act to control the areas receiving sand supply. This control has been particularly effective in the areas closest to the source of sediment, albeit by reducing the supply of sediment to downdrift areas, which includes South Beach Fremantle, and Coogee Beach.

Evaluation of available beach profiles has indicated that some structures, particularly smaller ones, produce shoreline changes that whilst functional for amenity, have only cosmetic effect on overall coastal evolution.

To facilitate the modelling and spatial interpretation, the sediment cells framework mapped by Stul *et al.* (2012) was adopted to separate the coast into sections that exhibit similar processes and morphology, giving eight mainland and three Garden Island segments. The Physical Process Assessment assisted to inform the approach taken to evaluate coastal hazards.

[6] A discussion on climate change scenarios is provided in the ***Set the Context Report*** available in Appendix 2 and summarised in Section 2.1 of this report.
[7] A Physical Process Assessment Report was produced as an interim Project Deliverable (See accompanying DVD Appendix 3 for full report with a summary of key findings provided in Section 3)

HAZARD ASSESSMENT METHODOLOGY (REPORT SECTION 4)

The approach to the hazard assessment was to use physical observations, as much as possible, to validate the projected coastal change dynamics. This was because observed coastal morphology, including the extensive coastline modification, suggested that active coastal processes are at the edge of valid domains for analytic, empirical and numerical coastal modelling**.** The inundation and erosion hazards have been dealt with separately, each dealt with as follows:

Assessing Inundation Hazard

Inundation hazard was considered using a 'bathtub' approach due to the relatively small extent of flooding (geographically and vertically) that would arise on this coastline on account of wave setup and runup **(Section 4.1).** Work undertaken to complete the inundation hazard assessment involved the following steps:

1. Mapping and analysis of the existing coastal topography;
2. Analysis of existing water level datasets, including with the expected influence of storm events of 1 year, 10 year, 100 year and 500 year Annual Recurrence Interval (ARI) intensity;
3. Addition of projected sea levels for the specified climate change scenarios of 0.5m @ Year 2070, 0.9m @ Year 2110 and 1.5m @ Year 2110; and
4. Application of inundation levels to high resolution topography for presentation in a series of interactive maps

Assessing Erosion Hazard

Potential erosion hazard was determined through a combination of several different processes at multiple scales **(Section 4.2).**

Specifically this has included considering the anticipated change in sediment availability at varying spatial scales and considering local controls such as coastal structures. The approach to the analysis may be summarised as follows:

1. Assessment of potential short-term erosion associated with normal coastal processes and various intensity potential storm events;
2. Assessment of gradual changes in shoreline position arising from both sea level rise (SLR) and storm occurrences, including through evaluation of the amount of sediment removed from the shore arising from these events and processes; and
3. This has enabled a projection of the landward retreat of the shoreline (erosion) within each section of the coast.

This information was used as the basis for establishing erosion hazard lines for each scenario considered in the study (Discussed in Section 6).

INUNDATION HAZARD REPRESENTATION (SECTION 5)

The key output of the inundation hazard assessment is an interactive, layered electronic mapping product (Appendix 7). This mapping tool allows the user to view the areas of the coast likely to be impacted by inundation for 1 year, 10 year, 100 year and 500 year Annual Recurrence Interval (ARI) storm event scenarios coupled with various (present, 0.5m, 0.9m and 1.5m) Sea Level Rise (SLR) scenarios.

Inundation is not expected for much of the coast within the study area due to coastal dunes or topography higher than a 1.5 metre SLR 500 year ARI storm event scenario, even after allowing for erosion. The inundation areas will increase with sea level, but still comprise a smaller area than that identified as potentially affected by coastal erosion.

Under present day conditions, there are a number of areas along the coastline susceptible to coastal flooding due to the local topography, including where the dunes are naturally low or have been removed. These areas with a high present-day inundation risk are:

- Reclaimed land and the three harbours of Fremantle (Cell 22 in City of Fremantle);
- Woodman Point and small areas of Australian Maritime Complex (Cells 18-21 in City of Cockburn); and
- Southern Cockburn Sound including large areas of Rockingham (Cells 15-16 in Town of Rockingham.

Three further areas where inundation will become an issue in the future (in addition to those currently susceptible to inundation) are in Cells 17 and 18 within the City of Kwinana's boundaries, being:

- James Point (+0.5m SLR 100yr ARI);
- BP Australia (+1.5m SLR 100yr ARI); and
- Verve Energy (+1.5m SLR 100yr ARI).

EROSION HAZARD REPRESENTATION (SECTION 6)

Coastal erosion hazards are also presented graphically, in the form of a series of lines that represent a horizontal distance of expected shoreline recession for a range of sea level rise and storm event scenarios. These horizontal distances have been derived through a consideration of anticipated coastal response to present and future erosive pressures. They provide an indication of the relative sensitivity of the shoreline to erosion if no particular coastal management is employed in response to projected occurrences (SLR and storm events).

The seven erosion scenarios are presented in GIS format as lines buffered landward of a baseline of the +1m Australian Height Datum (AHD) contour, provided along with the erosion distance values at the points where they were calculated.

Areas where existing acute erosion hazard threatens infrastructure include:

- Garden Island north of Colpoys Point (Cell GI1b in the jurisdiction of the Department of Defence),
- Palm Beach (Cell 16 in City of Rockingham); and
- Kwinana Bulk Terminal (Transects 18.3 and 18.4 in Cell 18 in the City of Kwinana).

Areas presently experiencing gradual recession due to coastal processes are:

- North of Catherine Point (Cell 22 in the City of Fremantle and City of Cockburn);
- Woodman Point area (Cells 19-21 in the City of Cockburn); and the
- Kwinana Industrial Area to James Point (Cell18 in the City of Kwinana).

Changes to the areas experiencing recession are likely to occur through several different mechanisms, including sea level rise contributing to decrease or cessation of onshore sediment supply, geometric response of the coast (due to shifting the hydraulic zone), and increased exposure of rock.

The study has concluded that the onshore feed of sediment may be insufficient to keep up with these changes by the year 2070. Additional locations that the modelling indicates will experience recession, unless suitably managed, are:

- South of Catherine Point groyne (Cell 21 in the City of Cockburn);
- James Point and Kwinana Industrial Area (Cells 17 and 18 in the City of Kwinana);
- South end of Garden Island (Cell GI2a in the jurisdiction of the Department of Defence);
- South Beach, potentially enhanced by partitioning of the coast (Cell 22 in the City of Fremantle and City of Cockburn); and
- The cliff line of the Spearwood Ridge (which will extend south to Challenger Beach as the coast erodes) (Cell 18 in the City of Kwinana)

In addition, the coast is likely to experience a significant change in behaviour between 2070 and 2110 for the projected sea level rise. Within this timeframe, the loss due to profile adjustment arising from sea level rise coupled with normal storm events will begin to exceed the sediment supply onto the coast, resulting in net erosion. Structures that hold sediment will preferentially recover from storm erosion, at the expense of unprotected areas, which will be progressively eroded, with limited or no recovery after storms. In such a situation, protection of one section of coast will more clearly be at the expense of the adjacent unprotected coast.

CONCLUSIONS AND RECOMMENDATIONS (SECTION 7)

Modeling of beach profile change in response to sea level change has suggested that there is an average retreat of 5m per 0.1m of sea level rise. However, this response is highly variable, determined by the relative ease with which sand can be transferred between and within the resulting coastal segments.

The present sand supply-distribution pattern is likely to change through either decline of sediment feeds or heightened demand from the beach and coastal flats to adjust to higher sea levels. In general, this will result in increased erosion towards the downdrift end of coastal segments. However, where there is potential for higher alongshore sand transport, erosion may be enhanced on the updrift side, with the southern side of Catherine Point most likely to be affected. The capacity for such reversal, along with a relatively small sand supply to balance sea level rise, provides opportunity for significant changes in coastal behavior that will require a change in coastal management approach, projected to be required prior to 2070 using the study scenarios. A more holistic approach within coastal segments is likely to be required.

Evidence used to estimate projected future change is not compelling, and there is uncertainty associated with estimates of sand supply, alongshore transport and the pathways of coastal response to sea level rise. As a consequence, it is appropriate to apply an adaptive framework to coastal management within the OACS region. Key questions that may need to be evaluated through monitoring include: the effectiveness of alongshore sand transfers and post-storm recovery; the role of existing and artificially created sediment sinks; and the relative contributions of coastal terraces and dunes to change.

Seabed (profile) changes appear to provide a better indication of gradual evolution than shoreline or vegetation line, which are more responsive to short-term erosion and recovery. Consequently, it is recommended that management triggers for the OACS coast should be related to the historic and present profile monitoring program that has been applied to varying degrees along the OACS coast. For effective assessment, profiles should occasionally, say every five years, extend offshore past the seaward toe of the terrace. The existing Cockburn Cement and Port Coogee profiles would be sufficient for Owen Anchorage. Funding should be secured for a resurvey of the Cockburn Sound profiles last measured in September 2003.

The near shore terrace behaviour and response could be investigated using these profile datasets and comparison of historic bathymetric datasets. For example, the reasonably detailed 1944 bathymetry could be digitised and compared to more recent digital bathymetry from the 1980s and the 2009 LiDAR to determine longer-term trends in the terrace structures. The profile datasets would be used to detect shorter-term trends and fluctuations. A further recommendation of this study is the consideration of erosion projections to evaluate the likely ongoing presence of beaches around the OACS coast. While the present study evaluated erosion hazard as sediment demand landward of the +1m AHD contour only, a significant value at risk of erosion at the OACS coast is the presence of a beach for amenity and recreation. Further investigation of potential loss of beach width could be used as a proxy for this purpose.

Numerical wave models have limited capacity for calibration to capture the correct process-response relationships without measured wave data at multiple locations. This study identified that numerous wave measurements have been made, but these were not made available for the project. It is recommended that improved data sharing agreements be sought with private industry. In the future, the ability to interpret change and achieve greater consensus between coastal interest groups through a greater knowledge-base for the OACS coast would require long-term deployment of several wave instruments within Cockburn Sound.

Potential changes to sediment transport caused by sea-level change are further complicated by the unknown future modification of the coast by engineering works. Therefore, it is important that a holistic approach to coastal management be developed, with suitable triggers set to indicate a need to change management.