ALKIMOS COASTAL NODE
LOCAL STRUCTURE PLAN

Appendix 4
Coastal Processes Assessment

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R303 Rev 2

December 2013

LandCorp

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Coastal Processes Assessment

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Limitations of this Document

Table of Contents

Table of Figures

Table of Tables

1. Introduction

1.1 General

Alkimos is located approximately 40 km north of the Perth CBD and forms part of the Northern Metropolitan Corridor which has experienced significant population growth in recent times. Such growth is forecast to continue to occur over coming decades.

LandCorp and Lend Lease Communities (Alkimos) Pty Ltd are proposing to develop a section of the Alkimos coastline. This proposal includes areas of freehold residential, mixed use and potentially leasehold development in accordance with the District Structure Plan for this area. This structure plan is presented in Figure 1.1 and has been amended to also show the extent of the proposed development area.

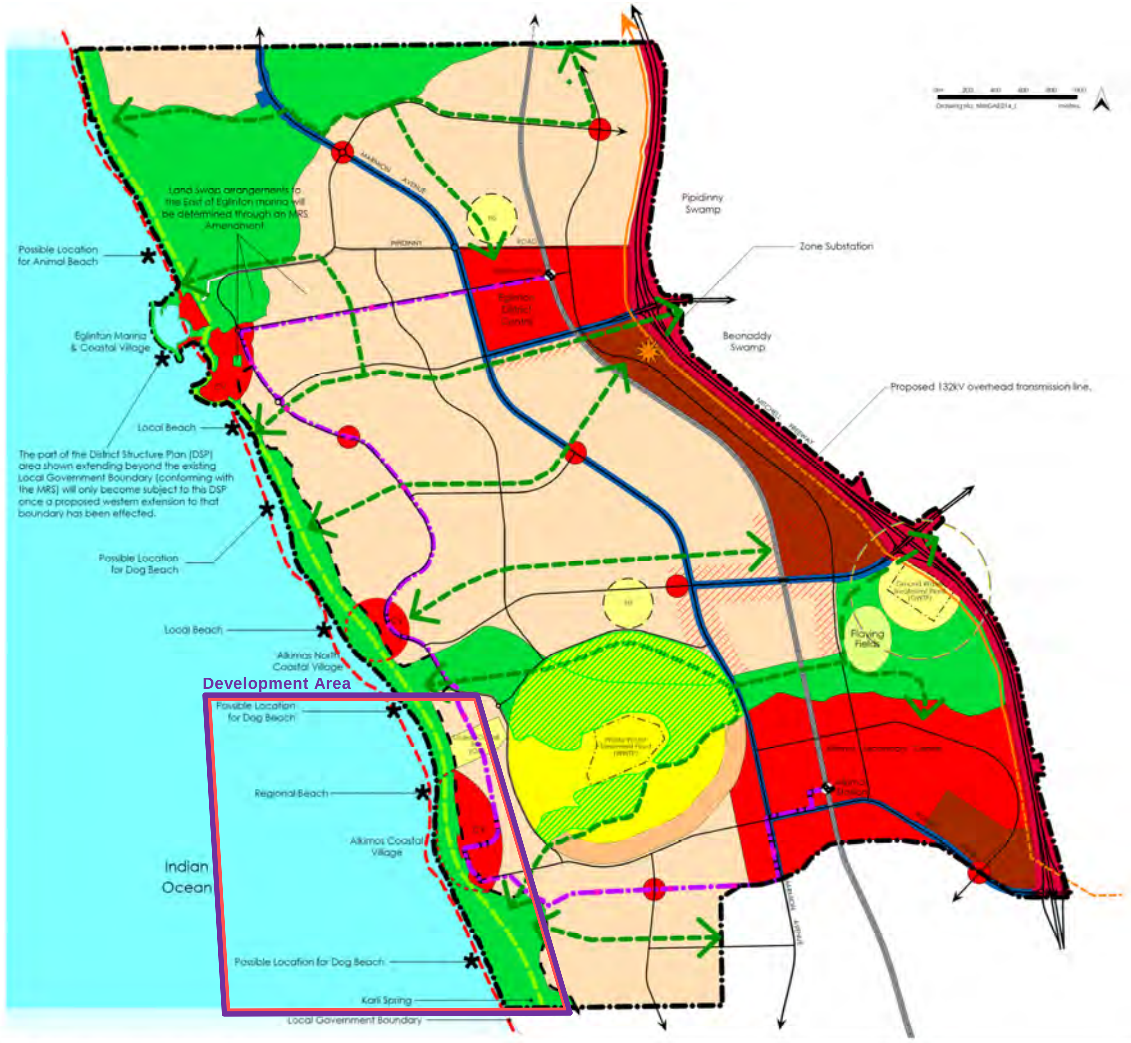
Given the coastal nature of the development it is prudent to consider the potential impacts of coastal processes over the planning horizon. State Planning Policy 2.6: the State Coastal Planning Policy (SPP2.6) was revised in July 2013 (WAPC 2013). This policy provides a methodology for completing an assessment of the potential impacts of coastal processes over the planning timeframe that can be used to inform the planning process. This methodology requires consideration of the potential effects of:

- severe storm erosion (termed the S1 allowance);
- future long term changes to the shoreline position (termed the S2 allowance);
- climate change induced sea level rise (termed the S3 allowance); and
- storm surge inundation (termed the S4 allowance).

Typically, application of SPP2.6 would consider a planning horizon of 100 years on the basis of freehold residential development. However, given that the proposed development area also includes the Alkimos Coastal Village, which is a regional coastal node (refer Figure 1.1), the potential for shorter planning horizons should also be considered given the potential for leasehold or other development arrangements. This is in accordance with SPP2.6, which states that:

> *"The need for the provision of coastal nodes on the coast is recognised and should provide for a range of facilities to benefit the broader public. Such nodes may be developed within the coastal foreshore reserve but should only be located where identified in a strategic plan. Nodes should be located on stable areas; should have no negative impacts on the adjacent environment; and should avoid areas of high natural landscape or resource value."* (Schedule One, Item 7.5; WAPC 2013)

Given the above, planning horizons of 20, 42, 50, 75 and 100 years will all be considered within this coastal processes assessment. This report outlines the data, methods and results of these investigations.



The following notes relate to the Structure Plan:

a. The final locations and configurations of the government school sites depicted on this Structure Plan will occur at the local structure planning stage through landowner consultation with the Department of Education and Training, the City of Wanneroo and the Department of Planning. Locations depicted are notional and approximate to reflect catchment requirements.

b. The coastal setbacks, including any proposed reduction in coastal setback for the coastal activity nodes are to be consistent with State Planning Policy No. 2.6. State Coastal Policy.

c. Final location of railway stations and associated pedestrian and vehicular crossings will need to be determined to the satisfaction of the Public Transport Authority, in consultation with the City of Wanneroo and the WAPC.

d. The north-south road on the western side of the WWTP which transverses the 'Parks and Recreation' reserve is supported in principle and is subject to further approval from the Environmental Protection Authority.

e. Retail floorspace allocation for the proposed activity centres as outline in the Structure Plan has not been assessed in terms of its impact upon other proposed and existing centres. Accordingly, the activity centres are notional and will require compliance with any approved State Planning Policy relating to Activity Centres.

f. Areas identified as being of National Environmental Significance under the Environmental Protection and Biodiversity Conservation Act 1999 may be subject to assessment by the Federal Department of the Environment, Water, Heritage and the Arts. The outcome of any such assessment may require modification to the DSP.

g. District Open Space identified within the Structure Plan does not form part of the public open space allocation.

h. Local Open Space will be determined at the time of Local Structure Plan preparation in consultation with the City of Wanneroo and the WAPC. Detail in relation to drainage credits will be assessed at the Local Structure Planning stage, and will need to be consistent with Liveable Neighbourhoods and WAPC Policy DC 2.3 'Public Open Space in Residential Areas.

i. Activity Centres will be subject to further structure planning, to ensure there is a mix of retail, residential, community and service provision meeting main street design objectives.

j. Subdivision and/or development within the DSP is required to contribute to infrastructure items as identified in the Developer Contribution Plan to be approved by the City of Wanneroo.

k. The Structure Plan is subject to Environmental Conditions, Statement No. 722.

l. Final servicing requirements will need to be accommodated within the Structure Plan, and will be determined at the Local Structure Planning Stage.

m. This DSP is subject to monitoring and review commencing in 2017.

n. An easement of up to 32m may be required for the proposed 132kv overhoed transmission line. This may have implications on adjacent land uses. Final width of the easement to be determined at LSP stage.

LEGEND

- DISTRICT STRUCTURE PLAN BOUNDARY
- LOCAL GOVERNMENT BOUNDARY
- URBAN
- FUTURE POTENTIAL URBAN
- REGIONAL OPEN SPACE
- CONSERVATION
- PUBLIC PURPOSES / COMMUNITY FACILITIES
- HS HIGH SCHOOL
- GWTP GROUND WATER TREATMENT PLANT
- WWTP WASTE WATER TREATMENT PLANT
- OE OCEAN OUTFALL SITE
- SERVICE COMMERCIAL
- SECONDARY & DISTRICT CENTRES
- COASTAL VILLAGE ACTIVITY CENTRES
- NEIGHBOURHOOD CENTRES
- OPPORTUNITY FOR BUSINESS, COMMERCIAL AND MIXED USE DEVELOPMENT
- INDICATIVE LOCATION OF PROPOSED SUBSTATION

ROADS:

- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS
- SECONDARY ROADS
- COASTAL ROADS
- RAILWAY RESERVE, RAILWAY STATIONS
- SECONDARY PUBLIC TRANSPORT SYSTEM
- GROUND WATER TREATMENT PLANT 500m BUFFER
- DISTRICT OPEN SPACE
- SOCIAL/PEDESTRIAN/CYCLE LINKAGES
- COASTAL DUAL USE PATH
- 132KV TRANSMISSION LINE

Figure 1.1 Alkimos Eglinton District Structure Plan

1.2 Site Setting & Physical Characteristics

The area under consideration consists of approximately 2.4 km of coastline. For ease of reference throughout this study, a chainage plan has been development for the coastline with chainages at 100 m increments. The locations of these chainages are shown in Figure 1.2.

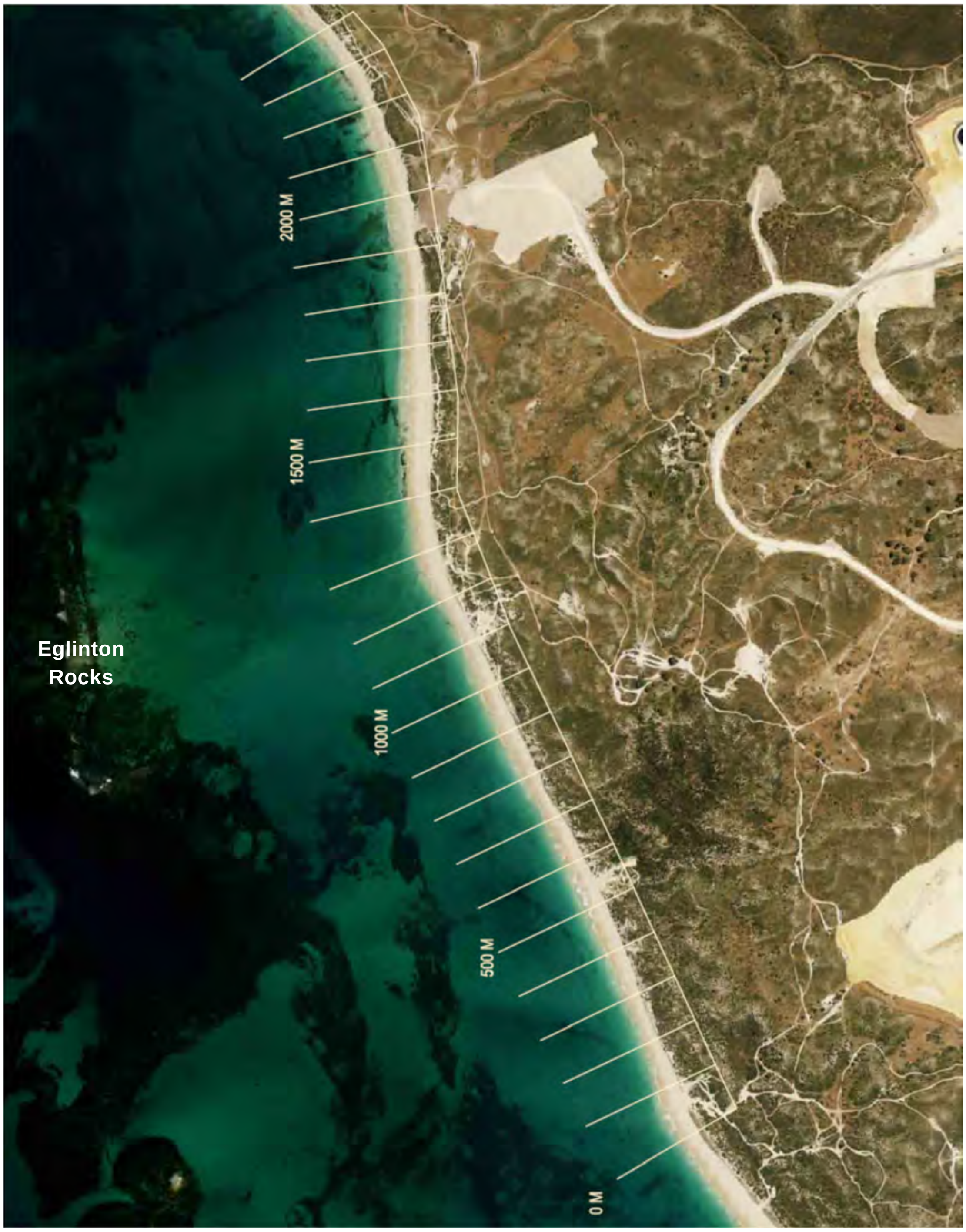


Figure 1.2 Study Area

The physical characteristics of the coastline are described in the following sections.

1.2.1 Chainage 0 m to 1,100 m

The shoreline in this sector is relatively exposed, with a wide flat beach backed by substantial sand dunes with an estimated primary dune crest height in excess of 15 mAHD. The beach remains relatively uniform for the length of this section of shoreline.

A typical example of the shoreline in this sector is shown in Figure 1.3. This photograph indicates that the beach experiences heavy 4WD use which may be impacting on vegetation growth in this section.

Figure 1.3 Typical Shoreline for Chainage 0 m to 1,100 m

1.2.2 Chainage 1,100 m to 1,500 m

This section of shoreline encompasses a small salient that has formed in the lee of Eglinton Rocks and is characterised by a smaller primary dune that is backed by a higher secondary dune system further inland. The beach is relatively flat and narrows as it progresses around the headland. Figure 1.4 shows the shoreline to the south of the salient located at chainage 1,300 m.

Figure 1.4 Shoreline to the South of Chainage 1,300 m

It can be seen once again that 4WD use is prevalent in this region and appears to be affecting the dune vegetation. Figure 1.5 shows the northern side of the headland (looking south), with the lower primary dune and widening beach readily apparent.

Figure 1.5 Shoreline to the North of Chainage 1,300 m

1.2.3 Chainage 1,500 m to 1,900 m

The shoreline in this sector is relatively, with a wide flat beach backed by a small primary dune fronting a substantial secondary dune system. The overall beach characteristics are similar to those observed between chainages 1,100 m and 1,500 m. These features are shown in Figure 1.6.

Figure 1.6 Typical Shoreline for Chainage 1,500 m to 1,900 m

This sector also has limestone rock outcrops present in the dune system. The majority of this limestone was noted as being between chainage 1,600 m and 1,900 m. Figure 1.7 shows an example of the limestone observed onsite. Despite the obvious limestone outcropping, previous investigations in the area have failed to find continuous rock at elevations that would significantly impact the results of the coastal processes assessment.

Figure 1.7 Limestone observed at Chainage 1,900 m

1.2.4 Chainage 1,900 m to 2,400 m

The shoreline in this sector is relatively exposed, with a wide flat beach backed by a steeply sloped dune face. The dune crest heights for this region were estimated to be in excess of 15 mAHD. Figure 1.8 shows a typical section of shoreline for this area.

Figure 1.8 Typical Shoreline for Chainage 1,900 m to 2,400 m

2. Severe Storm Erosion (S1)

Severe storm events have the potential to cause increased erosion to a shoreline, through the combination of higher, steeper waves generated by sustained strong winds, and increased water levels. These two factors acting in concert allow waves to erode the upper parts of the beach not normally vulnerable to wave attack.

If the initial width of the surf zone is insufficient to dissipate the increased wave energy, this energy is often spent eroding the beach face, beach berm and sometimes the dunes. The eroded sand is transported offshore with the return water flow to form offshore bars. As these bars grow, they can cause incoming waves to break further offshore, decreasing the wave energy available to attack the beach. This is shown diagrammatically in Figure 2.1.

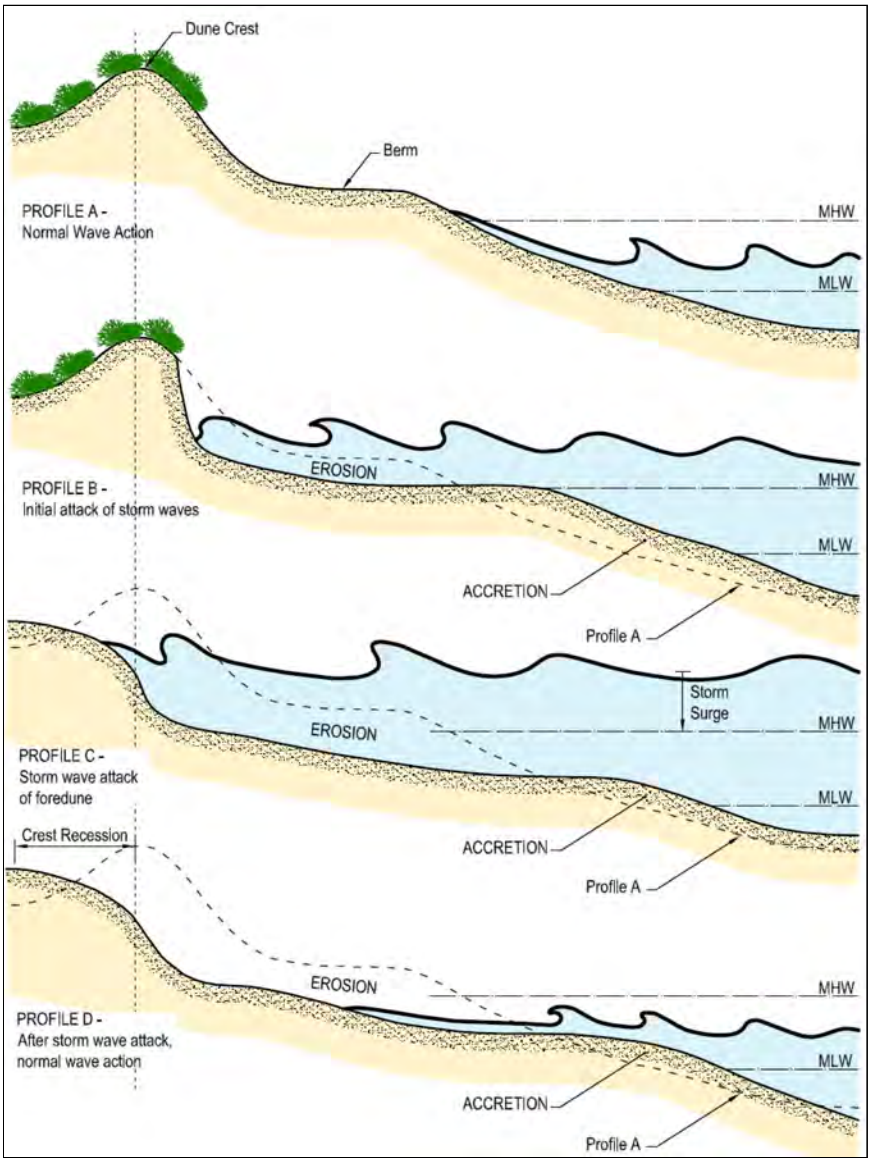


Figure 2.1 - Storm Erosion Process (source: CERC 1984)

The SBEACH computer model was developed by the Coastal Engineering Research Centre (CERC) to simulate beach profile evolution in response to storm events. It is described in detail by Larson & Kraus (1989). Since this time the model has been further developed, updated and verified based on field measurements (Wise et al 1996, Larson & Kraus 1998, Larson et al 2004).

SBEACH has also been validated locally by MRA (Rogers et al 2005). This local validation has shown that SBEACH can provide useful and relevant predictions of the storm induced erosion provided the inputs, which include time histories of wave height, period and water elevation, as well as pre-storm beach profile and median sediment grain size, are correctly applied; and care is taken to ensure that the model is accurately reproducing the recorded wave heights and water levels.

SPP2.6 recommends that the allowance for absorbing acute erosion consider both the effects of longshore and cross shore sediment transport processes. However, given the Alkimos shoreline is a continuous sandy beach with no physical obstructions, there are unlikely to be any issues with longshore transport gradients during severe storm events. As a result, cross shore sediment transport is likely to be the dominant factor for shoreline erosion. SPP2.6 recommends that potential cross shore erosion be determined by modelling the impact of an appropriate storm sequence using acceptable models such as SBEACH (WAPC 2013). It is also specified that the modelled storm should have an annual exceedance probability (AEP) of 1% with regard to beach erosion. This is equivalent to a storm with an average recurrence interval (ARI) of 100 years.

Given the requirement within SPP 2.6 for the modelled storm to have an annual probability of occurrence of 1%, the severity of the modelled storm will be the same for all timeframes considered within this assessment.

It is widely accepted that simulating 3 repeats of a severe storm sequence that effected south west Western Australia in July 1996 provides a conservative representation of the 100 year beach erosion event. This storm sequence had elevated water levels for a period of approximately 111 hours and caused coastal erosion at a number of locations in Western Australia. Modelling three consecutive repeats of this storm therefore simulates the effects of over 330 hours of storm conditions on the shoreline.

To simulate the shoreline response that could occur as a result of the above storm, profiles of the beach, nearshore and offshore areas were developed for 3 locations along the Alkimos Shoreline that were considered to be representative of broader sections of the shoreline. The profiles were aligned perpendicular to the shoreline and extended offshore to -48 mAHD using bathymetry information taken from local nautical charts and LiDAR survey data obtained from the Department of Transport.

The locations of the SBEACH profiles are shown in Figure 2.2.

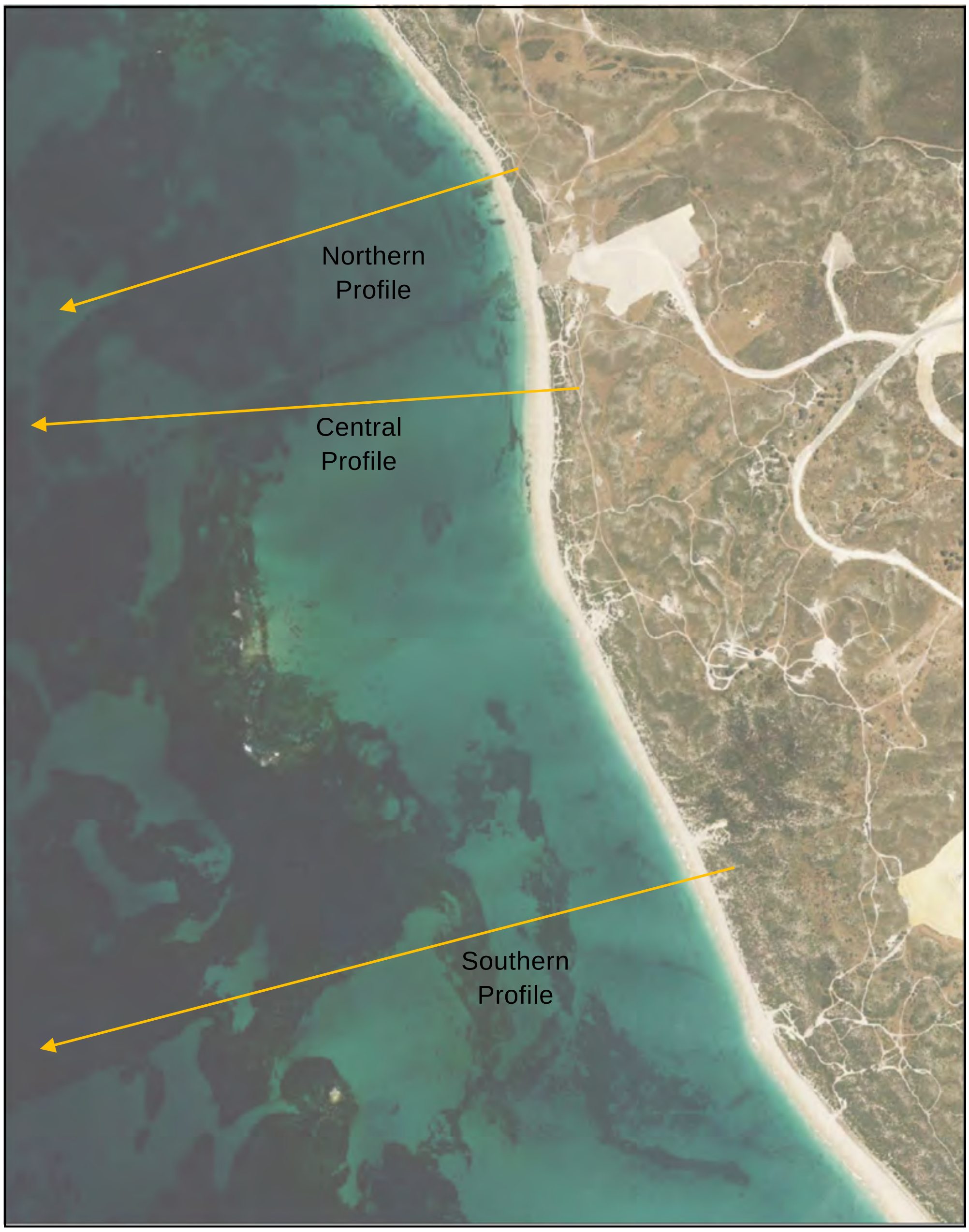


Figure 2.2 SBEACH Profile Locations

In order to model the severe storm erosion, SBEACH requires as an input a representative sediment size. MRA obtained sediment samples for the Alkimos coastline while onsite. The results of the particle size distribution (PSD) analysis are included in Appendix A. The PSD analysis determined that the median grain size (d_{50}) for the Alkimos coastline ranged from 0.33 mm to 0.38 mm. Each SBEACH profile has been modelled with the d_{50} relevant to its location.

Using the parameters outlined above the SBEACH modelling was used to simulate the response of each of the profiles to the storm sequence. The results of these simulations are provided in the following sections.

2.1 Southern Profile (Ch 0 m to 1,100 m)

The SBEACH simulation results for the southern profile are shown in Figure 2.3. This figure shows the initial and final beach profiles, peak water levels and peak wave heights. This SBEACH profile is believed to be representative of the shoreline between chainages 0 m and 1,100 m.

The SBEACH output provided in Figure 2.3 shows that erosion of the beach berm and dune system would be expected during the 1% AEP event on this profile. It can be seen that the landward most extent of erosion predicted by SBEACH is influenced by the avalanching of the primary dune as the toe of the dune is eroded. SPP2.6 recommends that in such instances a maximum profile slope of 30^o from the horizontal should be applied to the model result in order to allow for potential future slope failure.

The 2013 SCPP defines the Horizontal Shoreline Datum (HSD) as the seaward shoreline contour representing the peak steady water level under storm activity. The Policy requires that the allowance for severe storm erosion be taken as the full extent of erosion behind the HSD, including the slope correction allowance. The results of the modelling suggest that a peak steady water level of around 2.3 mAHD would be experienced during the 1% AEP event at this site. As a result, the storm erosion allowance is taken as the extent of erosion predicted beyond the 2.3 mAHD contour. This would be 42 m.

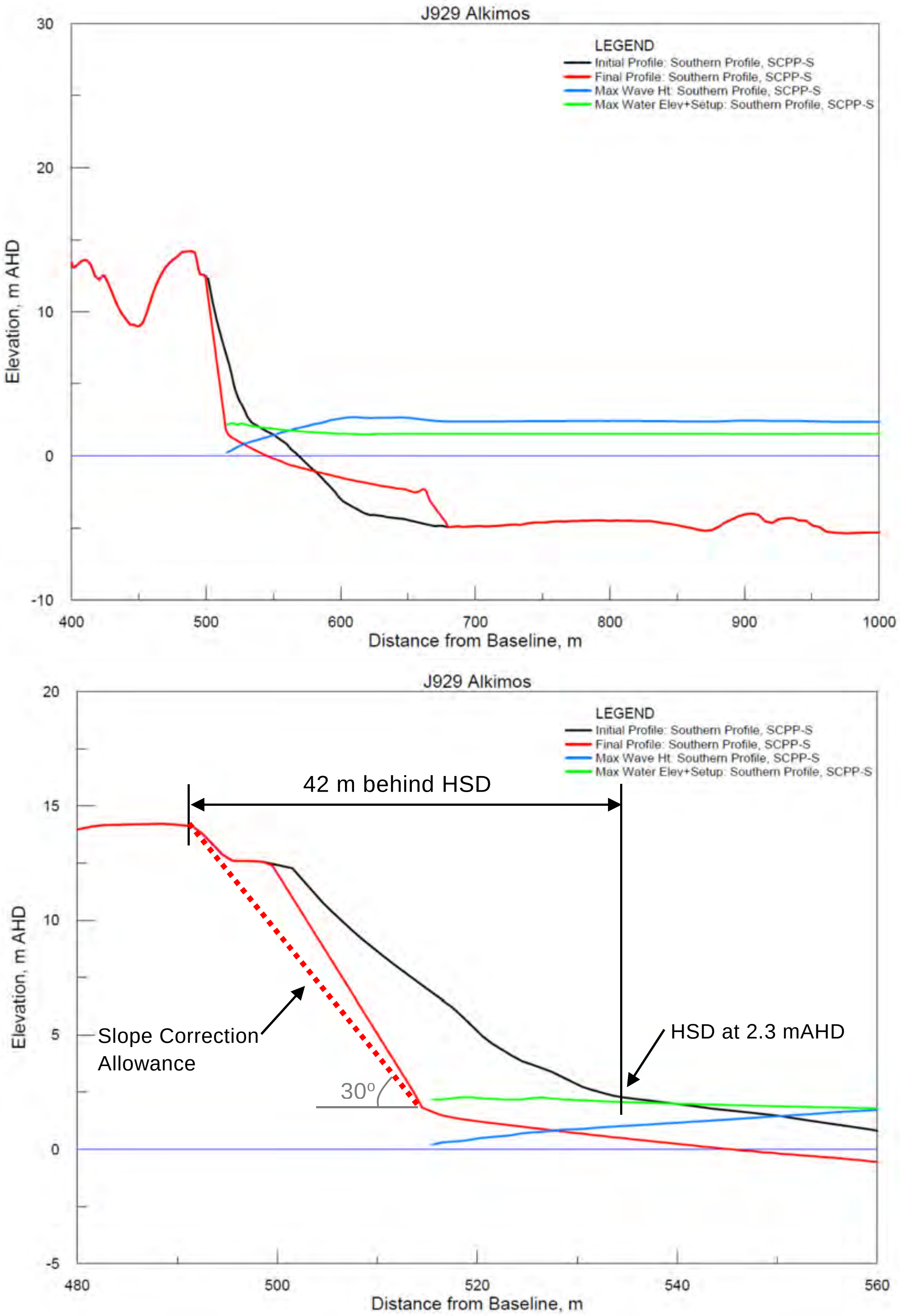


Figure 2.3 SBEACH Results for Southern Profile

2.2 Central Profile (Ch 1,100 m to 1,900 m)

The central SBEACH profile is believed to represent the shoreline between chainages 1,100 m to 1,900 m. This section of shoreline typically has a small primary dune backed by a substantial secondary dune system.

The simulated beach profile response using the SBEACH model is provided in Figure 2.4.

The output provided in Figure 2.4 predicts that the beach berm and face of the primary dune would be are eroded during a 1% AEP event. As with the southern profile, the peak steady water level at the shoreline is approximately 2.3 mAHD. The extent of erosion predicted behind the seaward 2.3 mAHD contour is around 16 m, including the allowance for slope correction.

2.3 Northern Profile (Ch 1,900 m to 2,400 m)

The SBEACH simulation results for the northern profile are provided in Figure 2.5. This SBEACH profile is believed to best represent the shoreline between chainages 1,900 m and 2,400 m.

The output provided in Figure 2.5 suggests that during the 1% AEP event the shoreline could experience around 30 m erosion behind the HSD, including the allowance for slope correction. This is on the basis that the peak steady water level during the simulation, and therefore the elevation of the HSD, was 2.3 mAHD. The allowance for severe storm erosion is therefore taken as 30 m.

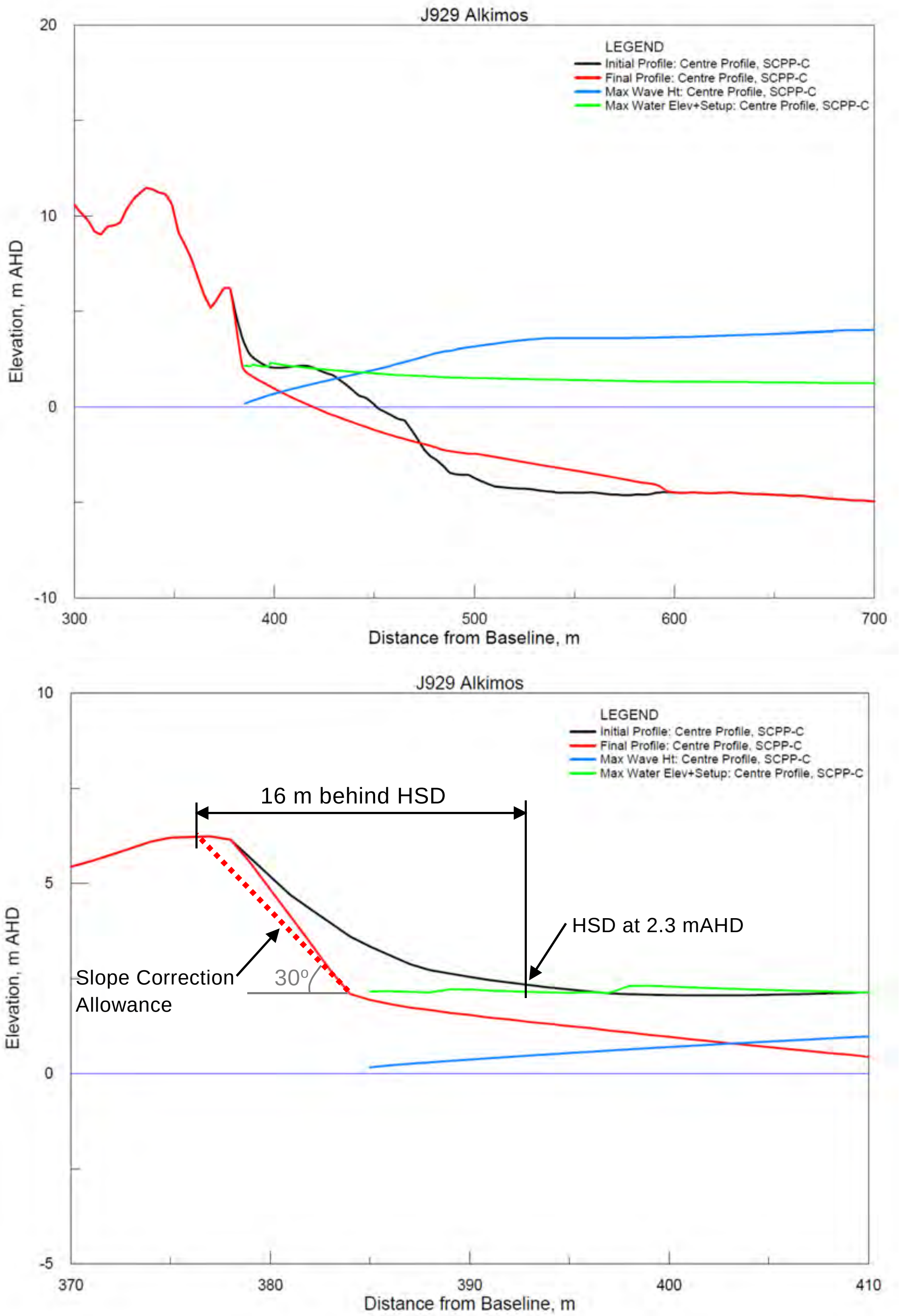


Figure 2.4 SBEACH Results for Central Profile

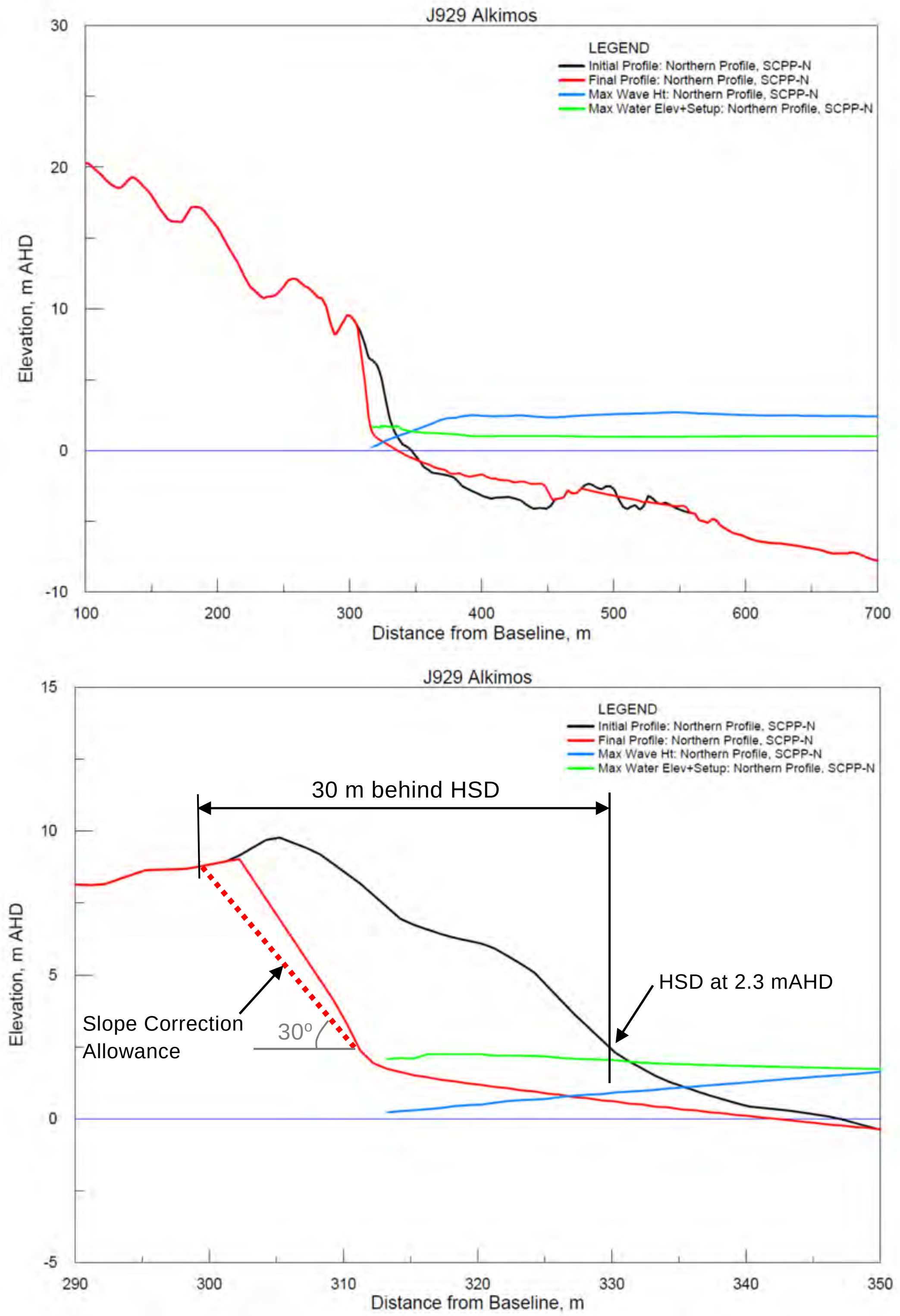


Figure 2.5 SBEACH Results for Northern Profile

2.4 Severe Storm Erosion Summary

During the severe storm erosion modelling it was observed that the erosion values varied along the coastline.

The large simulated erosion on the Southern profile is largely due to the steep slope and substantial height of the primary dune. While the water level remains relatively low compared to the height of the dune, the erosion experienced at the dune toe caused avalanching of the dune slope which resulted in a higher S1 value than would otherwise be expected. This is further influenced by the required slope correction.

As the dunes on the Central and Northern profiles are smaller and flatter than the southern profile less avalanching is predicted and less slope correction is required. This resulted in the S1 values for the Central and Northern profiles being less than those observed on the Southern profile.

Regardless of planning horizon, all coastal development needs to consider the potential effects of the 1% AEP event on the coastline. As a result, the S1 allowances presented in Table 1 will be applied to all is planning horizons considered within this report.

Table 2.1 Severe Storm Erosion Allowances

Chainage	S1 Allowance
0 m to 1,100 m	42 m
1,100 m to 2,000 m	16 m
2,000 m to 2,400 m	30 m

3. Historical Shoreline Movement (S2)

Historically, changes in shorelines occur on varying timescales from storm to post storm, seasonal and longer term (Short 1999). The S1 component accounts for the short term storm timescale of beach change. S2 is intended to account for the longer term movement of the shoreline that may occur within the planning timeframe. To determine the S2 allowance, historical shoreline movement trends are examined, and likely future shoreline movements predicted.

SPP2.6 recommends that shoreline movement analysis be carried out at roughly five yearly intervals over a period of at least 40 years, though ideally longer based on availability of information. Aerial photography of the area was therefore obtained and the locations of the vegetation lines extracted. The location of the seaward limit of vegetation, the vegetation line, is extracted as it provides a proxy for shoreline position. Extraction of the vegetation line was completed using the method outlined in DoT (2009).

The years of the available aerial photography are given below.

- 1965
- 1974
- 1977
- 1981
- 1985
- 1995
- 2000
- 2005
- 2010
- 2013

In addition to the available aerial photography, a High Water Mark (HWM) Survey from 1908 was obtained by the Client. This survey was therefore included in this analysis in order to extend the assessment period to over 100 years.

It is understood that the HWM survey from 1908 picked up either the extent of debris on the beach face that would have been left from wave uprush or the vegetation line, as this was the approach adopted by surveyors of the time to depict the HWM. Further details in this regard have been provided by McMullen Nolan Surveyors and are provided in Appendix A.

For consistency with the vegetation lines obtained from the aerial imagery it is assumed that this survey represents the coastal vegetation line. However, if the high water mark survey was taken as the debris line, the surveyed line would be closer to the beach berm than the vegetation line. This would provide a more conservative depiction of the beach profile change over time due to the fact that the shoreline movement plan would show the shoreline to be further seaward than it actually was. This would essentially mean that any subsequent accretion of the shoreline would appear smaller than in reality, while any erosion would appear larger.

The position of the shoreline in each of the aerial photographs for the years outlined above was determined at 100 m increments along the coast relative to the 1908 HWM survey. The locations of these increments were shown previously in Figure 1.2.

A shoreline movement plan for the area is provided in Appendix B. The movements of the shoreline relative to 1908 were estimated from this shoreline movement plan at 100 m increments along the coast at increments shown previously in Figure 1.2. The relative movement of the shoreline is presented in Figure 3.1. Time history plots of the shoreline movement at selected locations have also been provided in Figure 3.2.

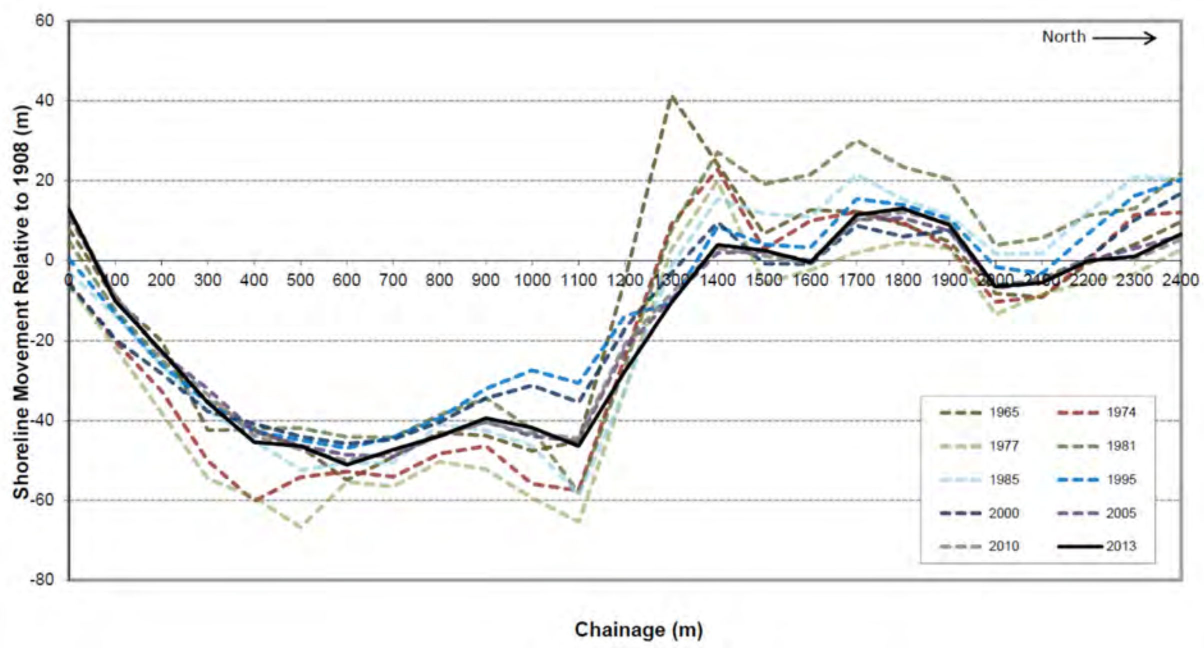


Figure 3.1 Shoreline Movement Relative to 1908

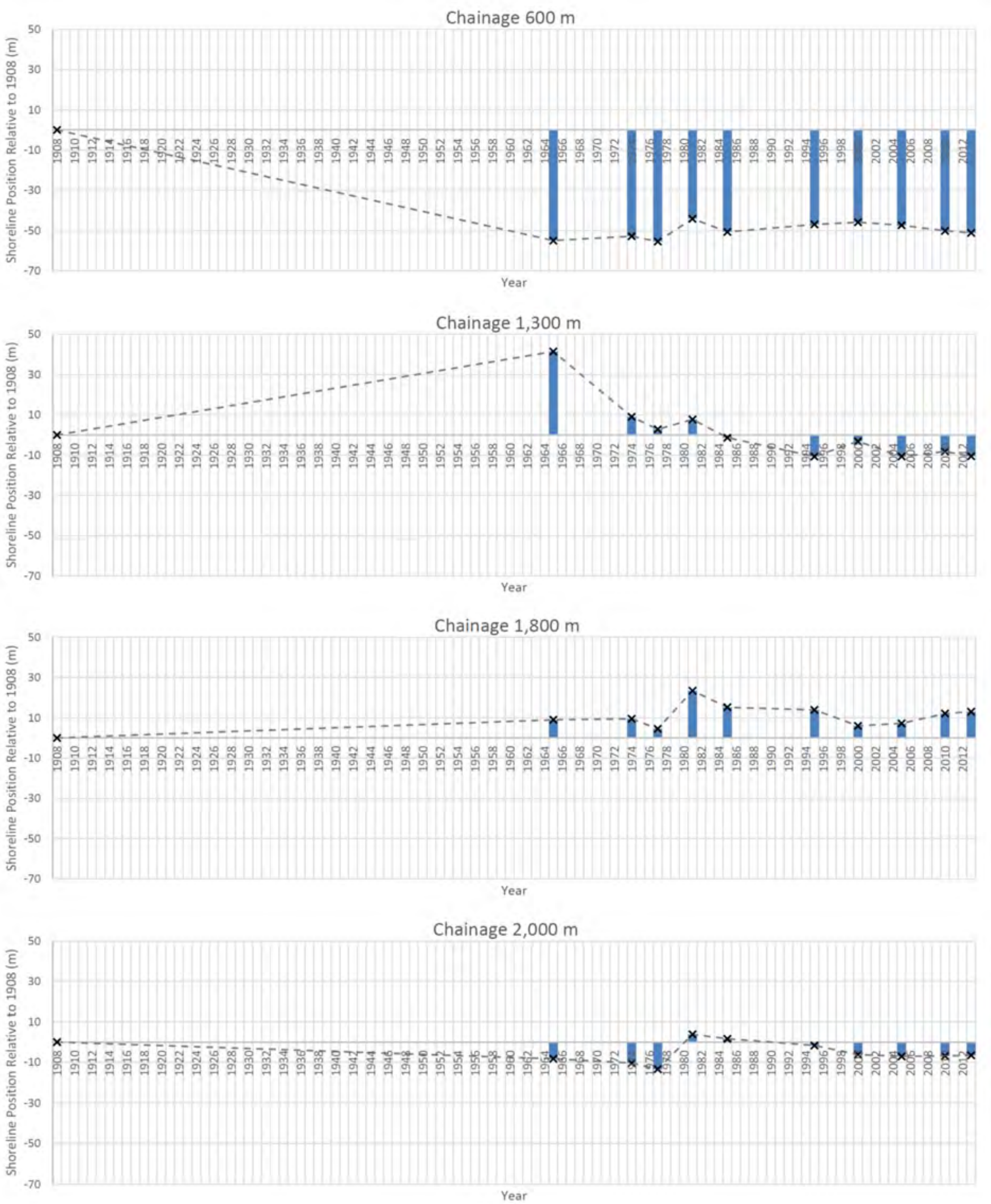


Figure 3.2 Time History Plot for Chainage 0 m

The shoreline movement plots and time histories shows that the shoreline between chainage 0 m and 1,100 m experienced recession in the period between 1908 and 1965. Following this period the shoreline has remained relatively stable with minor fluctuations and no discernable trends evident between 1965 and 2013.

To the north of chainage 1,300 m the shoreline has experienced fluctuations, but is ultimately within around 10 m of its 1908 position.

At Chainage 1,300 m the shoreline position in 1965 was around 40 m seaward of the 1908 survey position. This chainage corresponds to the location of a small shoreline salient that exists in the lee of Eglinton Rocks. Such features are known to be influenced by both seasonal and inter-annual variations in weather patterns, which could explain the variation in shoreline position observed over time at this location. Specifically, from review of the time history plot for this location the shoreline position in 1965 appears to be anomalous. The 1965 shoreline position may therefore have been influenced by a period of weather conditions that promoted the advancement of the salient and vegetation line in the short term. A feature that was subsequently removed prior to the 1974 aerial image.

When considering the allowance for the future movement of the shoreline the rate of historical movement is an important factor. The rate of historical movement from 1908 to 2013 is presented in Figure 3.3.

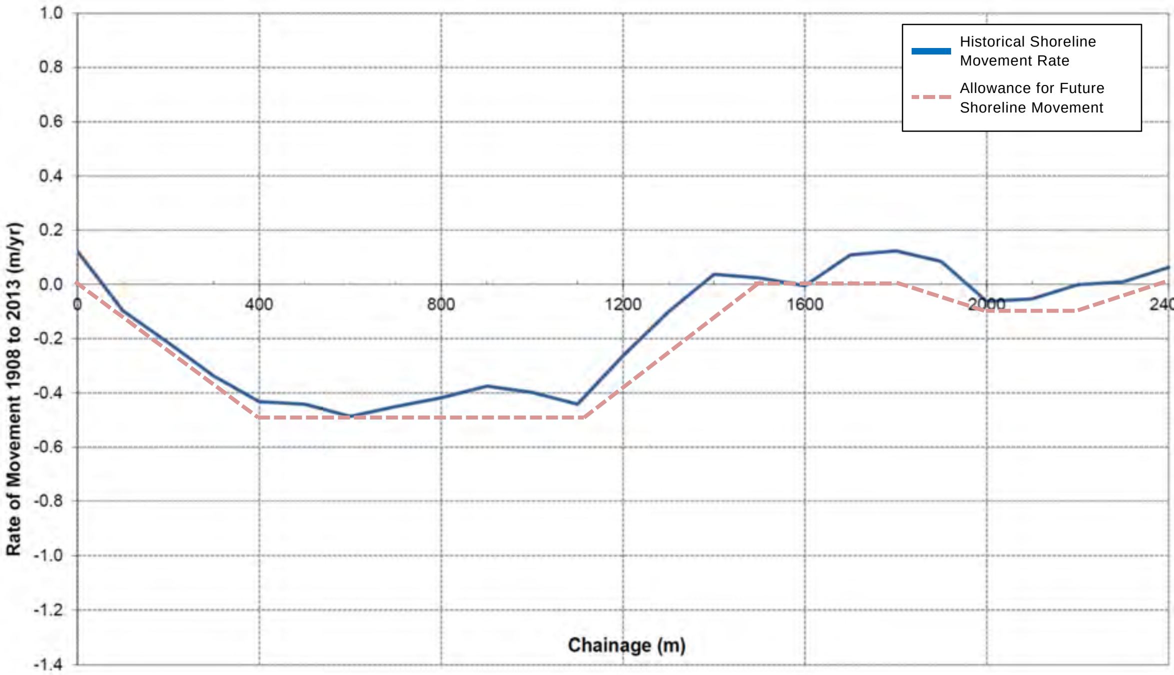


Figure 3.3 Historical Shoreline Movement Rate and Future Allowance

Based on the observed historical rate of shoreline movement an allowance for the potential future movement of the shoreline has been made. This allowance is also shown in Figure 3.3. The proposed allowance provides for a rate of shoreline movement equal to or greater than that observed during the period of shoreline movement records. A summary of the allowed shoreline movement rates is provided in Table 3.1. The allowances for shoreline movement for each of the planning horizons will be determined using these rates.

Table 3.1 Recommended Allowances for Future Shoreline Movement Rate

Chainage	Allowance for Future Shoreline Movement
0 – 400 m	0 – 0.5 m/yr
400 – 1,100 m	0.5 m/yr
1,100 – 1,500 m	0.5 – 0 m/yr
1,500 – 1,800 m	0 m/yr
1,800 – 2,000 m	0 – 0.1 m/yr
2,000 – 2,200 m	0.1 m/yr
2,200 – 2,400 m	0.1 – 0 m/yr

4. Sea Level Change Allowance (S3)

The Intergovernmental Panel on Climate Change (IPCC) has presented various scenarios of possible climate change and the resultant sea level rise in the coming century (IPCC 2001, 2007). There is still some uncertainty as to which of these scenarios will occur. For example it is not known whether greenhouse gas emissions will fall, stay steady or increase in the coming decades and century. The atmospheric and oceanographic processes involved are complex, and numerical modelling of these processes is far from perfect. Due to these uncertainties, there are a wide range of predictions for global sea level rise in the coming century. These predictions are shown in Figure 4.1.

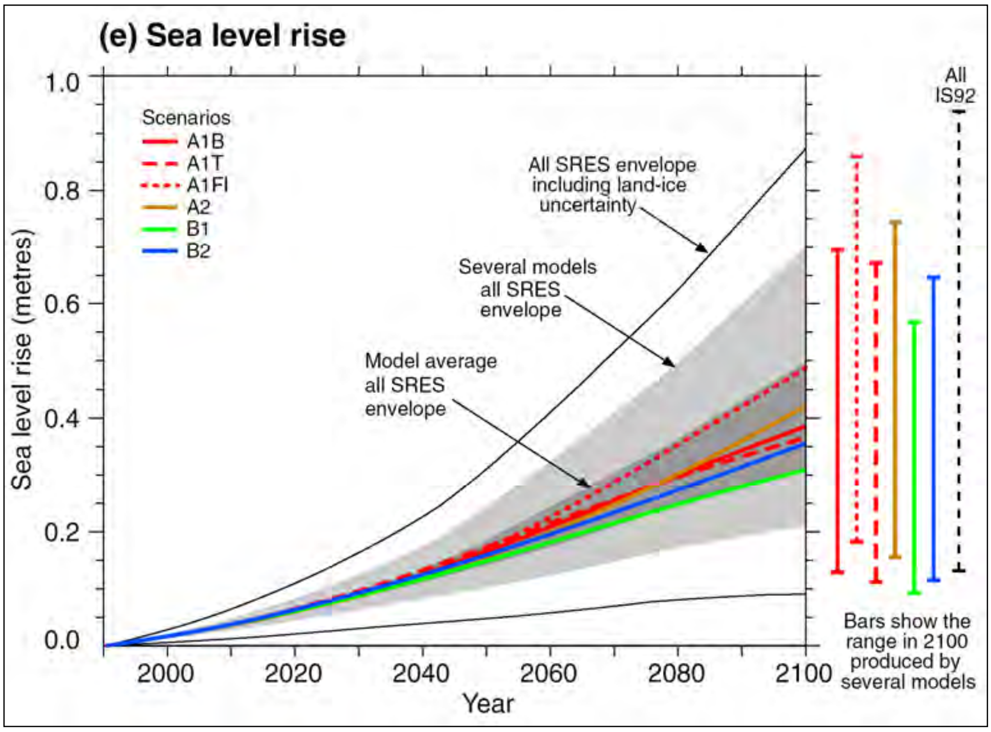


Figure 4.1 IPCC Scenarios for Sea Level Rise

SPP2.6 requires that coastal development allow for a 0.9 m sea level rise over a 100 year planning horizon. This is based on the climate change and sea level rise scenario that has been adopted for coastal planning throughout Western Australia. This sea level rise scenario was recommended by Department of Transport (DoT 2010) and is presented in Figure 4.2.

Whilst a 0.9 m allowance for sea level rise is required for a 100 year planning horizon, the requirements for lesser planning horizons can be determined from Figure 4.2.

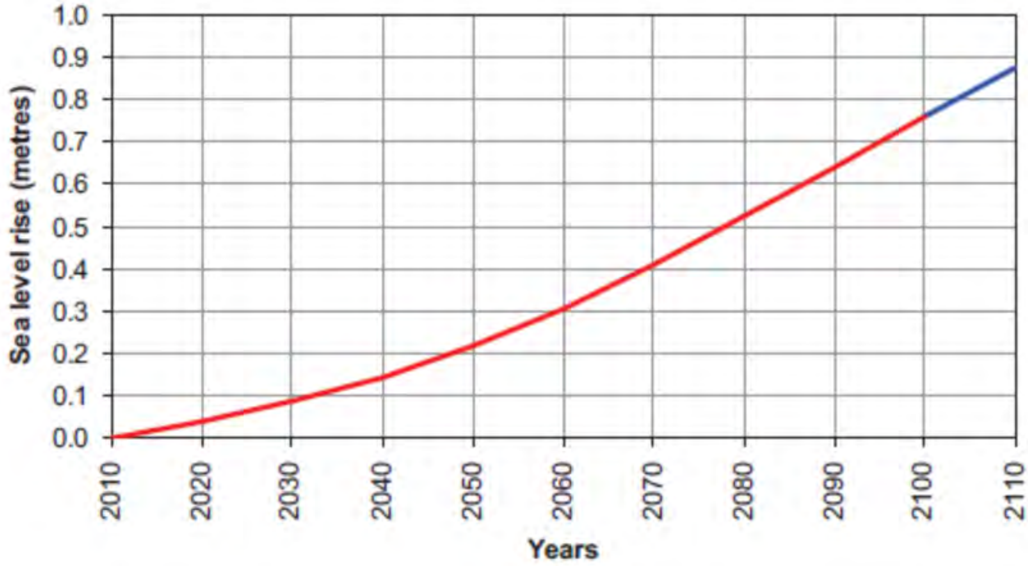


Figure 4.2 Recommended Allowance for Sea Level Rise in Western Australia (Source: DoT 2010)

The effect of sea level rise on the coast is difficult to predict. Komar (1998) provides a reasonable treatment for sandy shores, including examination of the Bruun Rule (Bruun 1962). The Bruun Rule relates the recession of the shoreline to the sea level rise and slope of the nearshore sediment bed:

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

where: R = recession of the shore;

θ = average slope of the nearshore sediment bed; and

S = sea level rise.

Komar (1998) suggests that the general range for a sandy shore is R = 50S – 100S. The SCPP recommends that for sandy coasts the recession be taken as 100 times the estimated rise in sea level. Therefore, the recommended allowances for shoreline recession for each of the timeframes considered within this report are provided in Table 4.1.

Table 4.1 Recommended Allowances for Shoreline Recession due to Sea Level Rise

Planning Horizon	Potential Sea Level Rise	Allowance for Shoreline Recession due to Sea Level Rise
20 years	0.11 m	**11 m**
42 years	0.26 m	**26 m**
50 years	0.34 m	**34 m**
75 years	0.62 m	**62 m**
100 years	0.90 m	**90 m**

5. Storm Surge Inundation (S4)

SPP2.6 requires that the allowance for inundation be taken as the maximum extent of inundation experienced during a water level event with a 0.2% AEP (500 year ARI) plus the appropriate allowance for sea level rise.

In order to estimate the 500 year ARI water level event an extreme analysis was completed on the available water level record from Fremantle. The water level record reliably spans a period of approximately 62 years from 1950 to 2012. Results of the extreme analysis are provided in Figure 5.1.

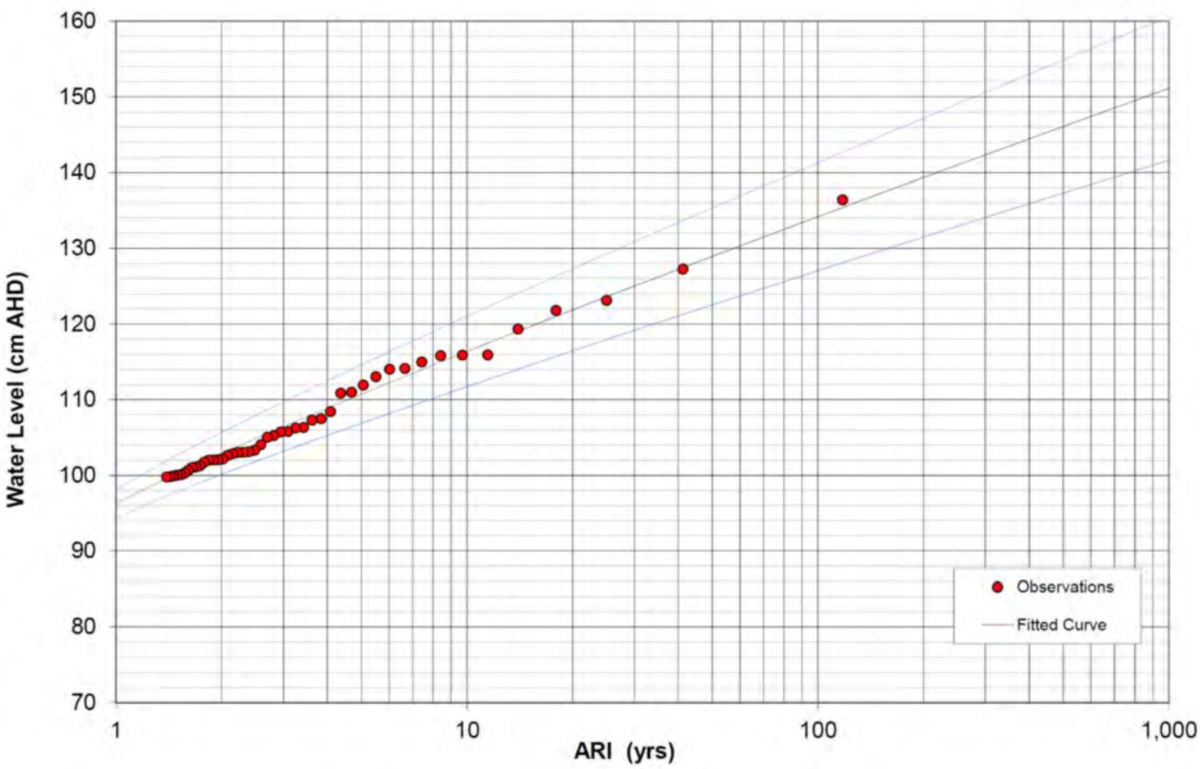


Figure 5.1 Results of Extreme Water Level Analysis for Fremantle

Using the results of the extreme analysis, the 500 year ARI event is estimated to be around 1.46 mAHD. However, this level represents the water level at the Fremantle tide gauge and does not include the nearshore setup that occurs along the coastline due to the action of winds and waves. In order to determine the extent of nearshore setup that would occur SBEACH simulations were completed for each of the profiles modelled in Section 2. All simulations gave similar results, with peak steady water levels at the shoreline of between 2.9 to 3.0 mAHD. As a result a total peak steady water level of 3.0 mAHD was adopted for this assessment. An example of the water level simulated within the SBEACH model is provided in Figure 5.2.

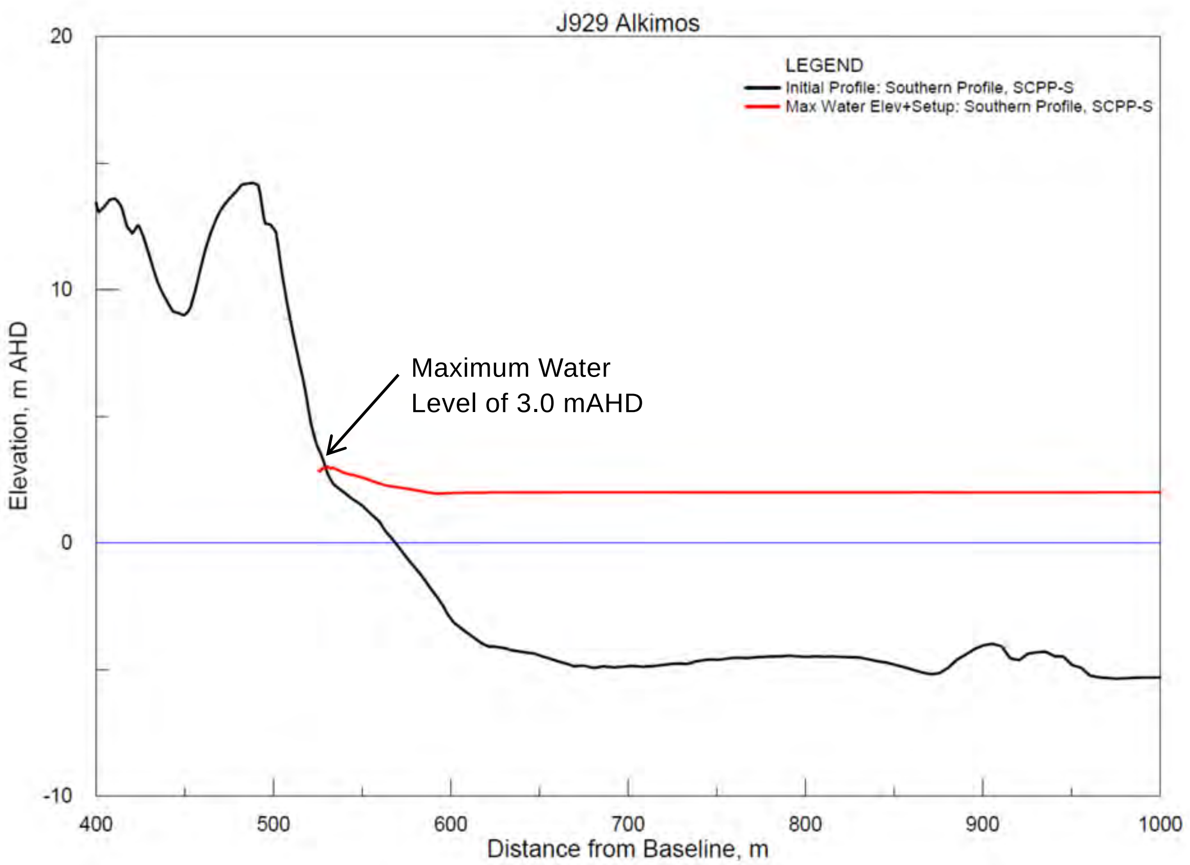


Figure 5.2 SBEACH Simulation to Determine Extent of Nearshore Setup

The simulation was completed with an input water level of 1.46 mAHD (as estimated for the 500 year ARI event at the tide gauge). The maximum predicted water level at the shoreline was estimated to be 3.0 mAHD. As a result, it is expected that the extent of nearshore wind and wave setup would be around 1.54 m.

The minimum recommended development levels to manage the risk of inundation over each of the relevant planning horizons are therefore provided in Table 5.1.

Table 5.1 Recommended Development Level to Manage Inundation Risk

Planning Horizon	20 years	42 years	50 years	75 years	100 years
Estimated 500 year ARI Water Level	1.46 mAHD	1.46 mAHD	1.46 mAHD	1.46 mAHD	1.46 mAHD
Allowance for Nearshore Wind & Wave Setup	1.54 m	1.54 m	1.54 m	1.54 m	1.54 m
Allowance for Sea Level Rise	0.11 m	0.26 m	0.34 m	0.62 m	0.90 m
Total Recommended Minimum Development Levels	**3.11 mAHD**	**3.26 mAHD**	**3.34 mAHD**	**3.62 mAHD**	**3.90 mAHD**

6. Total Recommended Physical Processes Allowances

The appropriate allowances for the S1, S2 and S3 factors have been calculated in previous sections of this report. In addition to these allowances, SPP2.6 also requires that a 0.2 m/yr factor of safety allowance be included. The sum of these factors provides the total recommended allowances for the action of coastal processes over the various planning horizons. Tables 6.1 to 6.5 summarise the total recommended allowances for the planning timeframes of 20, 42, 50, 75 and 100 years respectively.

The physical processes allowances are to be measured from the HSD, which for the Alkimos coastline is around the 2.3 mAHD contour, as determined during the severe storm erosion modelling.

A plan of the recommended physical processes allowances is provided in Appendix B.

Table 6.1 Total Recommended Coastal Processes Allowance for 20 year Planning Horizon

Chainage (m)	S1 – Severe Storm Erosion	S2 – Historic Shoreline Movement	S3 – Climate Change	Factor of Safety	Total Recommended PPS
0 to 400	42 m	0 - 10 m	11 m	4 m	**57 - 67 m**
400 to 1,100	42 m	10 m	11 m	4 m	**67 m**
1,100 to 1,500	42 - 16 m	10 - 0 m	11 m	4 m	**67 - 31 m**
1,500 to 1,800	16 m	0 m	11 m	4 m	**31 m**
1,800 to 2,000	16 - 30 m	0 - 2 m	11 m	4 m	**31 - 47 m**
2,000 to 2,200	30 m	2 m	11 m	4 m	**47 m**
2,200 to 2,400	30 m	2 - 0 m	11 m	4 m	**47 - 45 m**

Table 6.2 Total Recommended Coastal Processes Allowance for 42 year Planning Horizon

Chainage (m)	S1 – Severe Storm Erosion	S2 – Historic Shoreline Movement	S3 – Climate Change	Factor of Safety	Total Recommended PPS
0 to 400	42 m	0 - 21 m	26 m	8.4 m	**77 - 98 m**
400 to 1,100	42 m	21 m	26 m	8.4 m	**98 m**
1,100 to 1,500	42 - 16 m	21 - 0 m	26 m	8.4 m	**98 - 51 m**
1,500 to 1,800	16 m	0 m	26 m	8.4 m	**51 m**
1,800 to 2,000	16 - 30 m	0 – 4.2 m	26 m	8.4 m	**51 - 69 m**
2,000 to 2,200	30 m	4.2 m	26 m	8.4 m	**69 m**
2,200 to 2,400	30 m	4.2 - 0 m	26 m	8.4 m	**69 - 65 m**

Table 6.3 Total Recommended Coastal Processes Allowance for 50 year Planning Horizon

Chainage (m)	S1 – Severe Storm Erosion	S2 – Historic Shoreline Movement	S3 – Climate Change	Factor of Safety	Total Recommended PPS
0 to 400	42 m	0 - 25 m	34 m	10 m	**86 - 111 m**
400 to 1,100	42 m	25 m	34 m	10 m	**111 m**
1,100 to 1,500	42 - 16 m	25 - 0 m	34 m	10 m	**111 - 60 m**
1,500 to 1,800	16 m	0 m	34 m	10 m	**60 m**
1,800 to 2,000	16 - 30 m	0 - 5 m	34 m	10 m	**60 - 79 m**
2,000 to 2,200	30 m	5 m	34 m	10 m	**79 m**
2,200 to 2,400	30 m	5 - 0 m	34 m	10 m	**79 - 74 m**

Table 6.4 Total Recommended Coastal Processes Allowance for 75 year Planning Horizon

Chainage (m)	S1 – Severe Storm Erosion	S2 – Historic Shoreline Movement	S3 – Climate Change	Factor of Safety	Total Recommended PPS
0 to 400	42 m	0 - 37.5 m	62 m	15 m	**119 - 157 m**
400 to 1,100	42 m	37.5 m	62 m	15 m	**157 m**
1,100 to 1,500	42 - 16 m	37.5 - 0 m	62 m	15 m	**157 - 93 m**
1,500 to 1,800	16 m	0 m	62 m	15 m	**93 m**
1,800 to 2,000	16 - 30 m	0 - 7.5 m	62 m	15 m	**93 - 115 m**
2,000 to 2,200	30 m	7.5 m	62 m	15 m	**115 m**
2,200 to 2,400	30 m	7.5 - 0 m	62 m	15 m	**115 - 107 m**

Table 6.5 Total Recommended Coastal Processes Allowance for 100 year Planning Horizon

Chainage (m)	S1 – Severe Storm Erosion	S2 – Historic Shoreline Movement	S3 – Climate Change	Factor of Safety	Total Recommended PPS
0 to 400	42 m	0 - 50 m	90 m	20 m	**152 - 202 m**
400 to 1,100	42 m	50 m	90 m	20 m	**202 m**
1,100 to 1,500	42 - 16 m	50 - 0 m	90 m	20 m	**202 - 126 m**
1,500 to 1,800	16 m	0 m	90 m	20 m	**126 m**
1,800 to 2,000	16 - 30 m	0 - 10 m	90 m	20 m	**126 - 150 m**
2,000 to 2,200	30 m	10 m	90 m	20 m	**150 m**
2,200 to 2,400	30 m	10 - 0 m	90 m	20 m	**150 - 140 m**

7. Conclusions

M P Rogers and Associates Pty Ltd was commissioned to complete a coastal processes assessment for the Alkimos coastline. This coastal processes assessment has been completed in accordance with the requirements of the revised 2013 SPP2.6.

The purpose of this assessment was to highlight areas that could potentially be at risk through the action of physical coastal processes over various planning horizons. The assessment has included investigation into the potential effects of the following on the future position of the shoreline.

- Severe storm erosion;
- Long term shoreline movement; and
- Coastal recession due to potential sea level rise.

In addition to the above, an assessment of the required development level to minimise the potential risk of inundation to that which is deemed to be acceptable by the policy has also been completed.

The results of the above investigations have been used to determine the areas potentially at risk from the action of physical coastal processes over planning horizons of 20, 42, 50, 75 and 100 years. This information should be considered when completing planning for the proposed development.

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10. Appendices

Appendix A McMullen Nolan Surveyors Advice on HWM Survey

Appendix B Shoreline Movement Plan

Appendix C Coastal Processes Allowance Lines

Appendix A McMullen Nolan Surveyors Advice on HWM Survey

20 May 2011
Our Ref: 5310pro

MP Rogers & Associates
Unit 2, 133 Main Street
OSBORNE PARK WA, 6017

Attention: Clinton Doak

Dear Clint,

RE: ALKIMOS EGLINTON – HIGH WATER MARK

You have asked if we were aware if any information prior to 1950 in relation to the coast line on the Eglinton Alkimos area. Our search has revealed that the original survey for LOC 1370 that established the current foreshore boundary was carried out by surveyor J Ewing in 1908. In surveying the foreshore boundary, the surveyor noted offsets to “High Water Mark” at approximately 1000 link (200m) intervals and the offsets were measured to the nearest 25 links (5m).

The question then remains, is the surveyors reference to “High Water Mark” in the field book a reference to actual HWM or a vegetation line. In 1994, Department of Land Administration Inspecting Surveyor Eric Horlin wrote a paper entitled “Water Boundaries and Legal Definitions of High Water Mark” and in that stated the “practice adopted by surveyors in years past has been to select a position on the ground, taking due regard of local evidence in the form of debris etc”.

In the normal course of events and if the purpose of the survey by Ewing in 1908 was to establish HWM then it is likely the offsets would refer to them as evidenced. However, and after discussion with senior surveyors and inspecting surveyors within Landgate, the considered opinion is that the purpose of the survey was to establish the foreshore boundary of LOC 1370 and the surveyors instruction would have been to allow a setback of around 300 links (60m), and so the offsets shown are most likely to represent the vegetation line as evidence of the setback. If surveyor Ewing had established the HWM from evidence, the offsets would also have been to a greater precision.

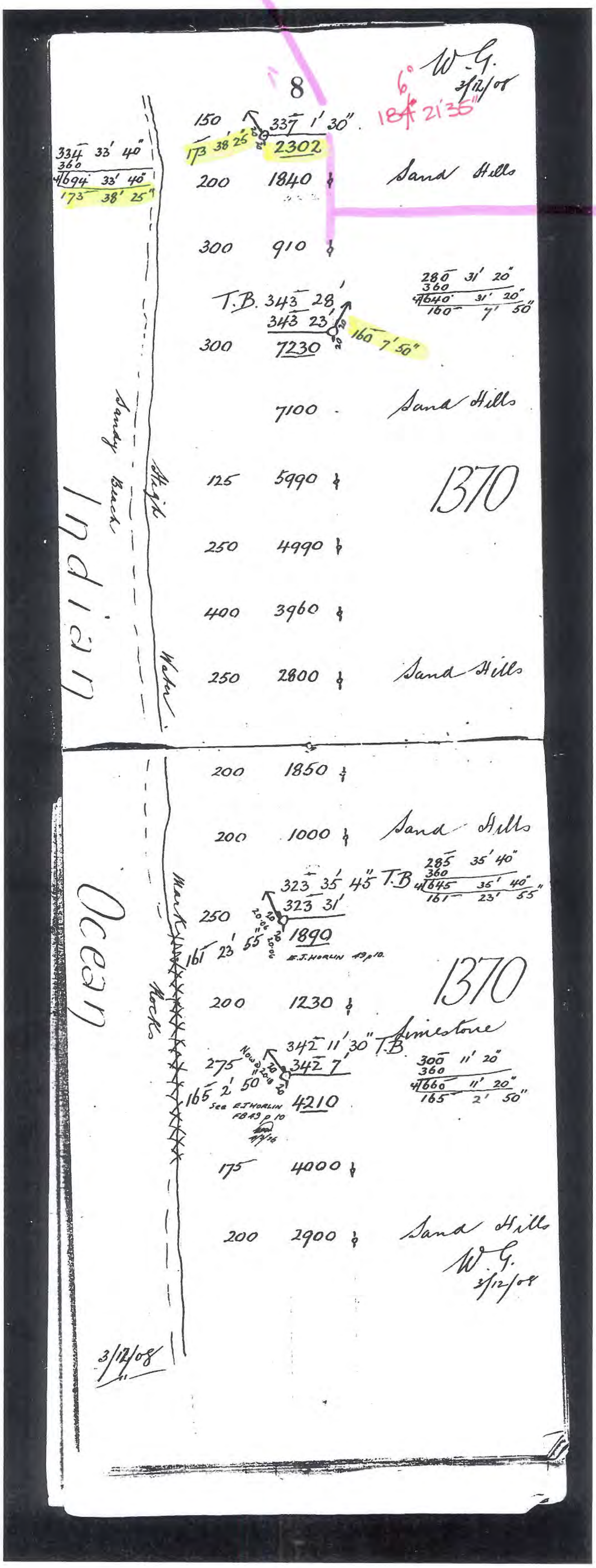
Please find attached copies of pages 8 & 9 from surveyor J Ewing’s field book # 31 and excerpt from Eric Horlins paper.

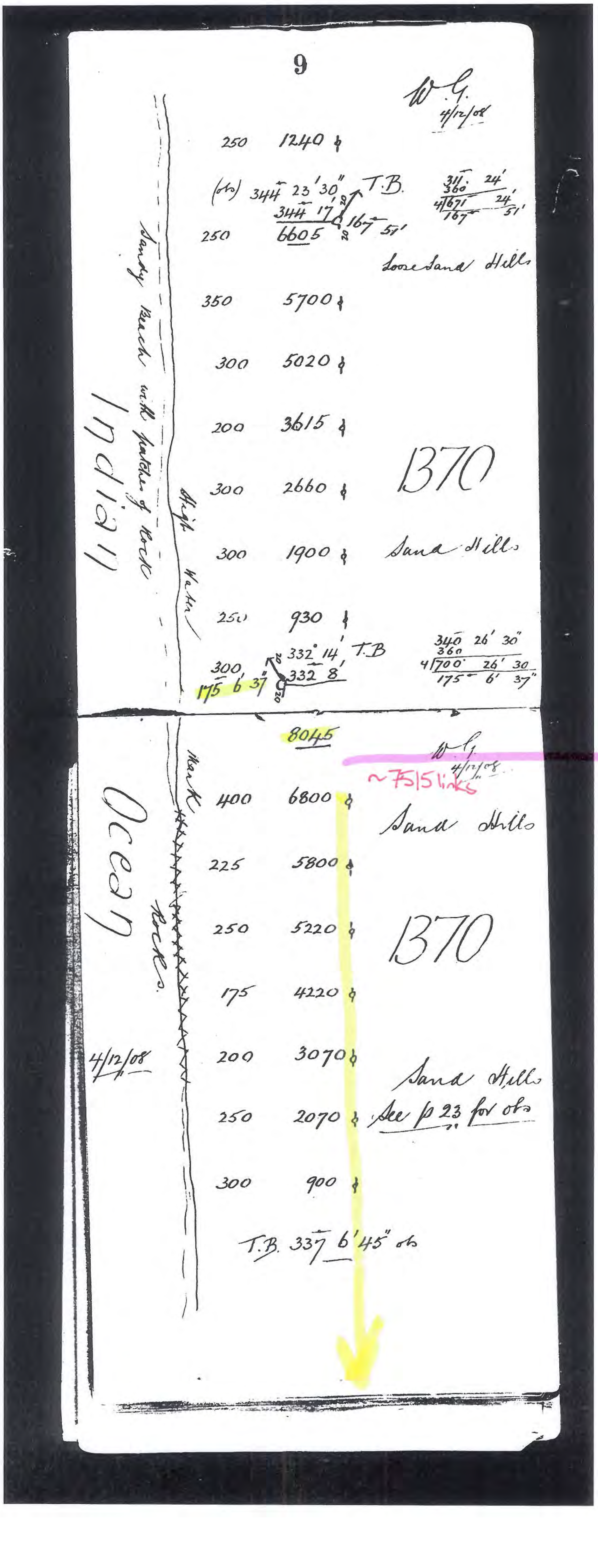
Yours Faithfully,

JOHN MCMULLEN
Director

J. EWING 31

11
P17935





~7515 links

APIDINM

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WATER BOUNDARIES AND LEGAL DEFINITIONS OF HIGH WATER MARK

BY

ERIC HORLIN

JUNE 1994

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I ......ERIC JAMES HORLIN......, hereby consent that my project " ...WATER BOUNDARIES AND LEGAL ...DEFINITIONS OF HIGH WATER MARK..." may be loaned to any library at the discretion of the Head of School of Surveying and Land Information and that the Head of School shall be authorised to allow a copy of all or part of the project for the purpose of study or research.

SIGNED: ...E Horl...

DATE: ...10.6.94...

ABSTRACT

The laws related to the survey of water boundaries are predominantly "common law" principles which have evolved over several centuries. Many surveyors when confronted with a survey of a riparian or littoral boundary are unaware of the legal principles involved and therefore rarely meet the requirements of a Court of law.

In this paper the common law principles and statutory provisions related to water boundaries are covered in detail, especially the definitions of "mean high water mark" for tidal waters and the "ordinary high water line (mark)" for inland (non-tidal) waters. Methods of determining high water mark boundaries by survey are also described.

It is concluded that ambiguities in the legal definitions of mean high water mark in Western Australia need to be resolved and that surveyors require published guidelines to ensure they perform water boundary surveys in a manner consistent with the current decisions of the courts.

Chapter 6

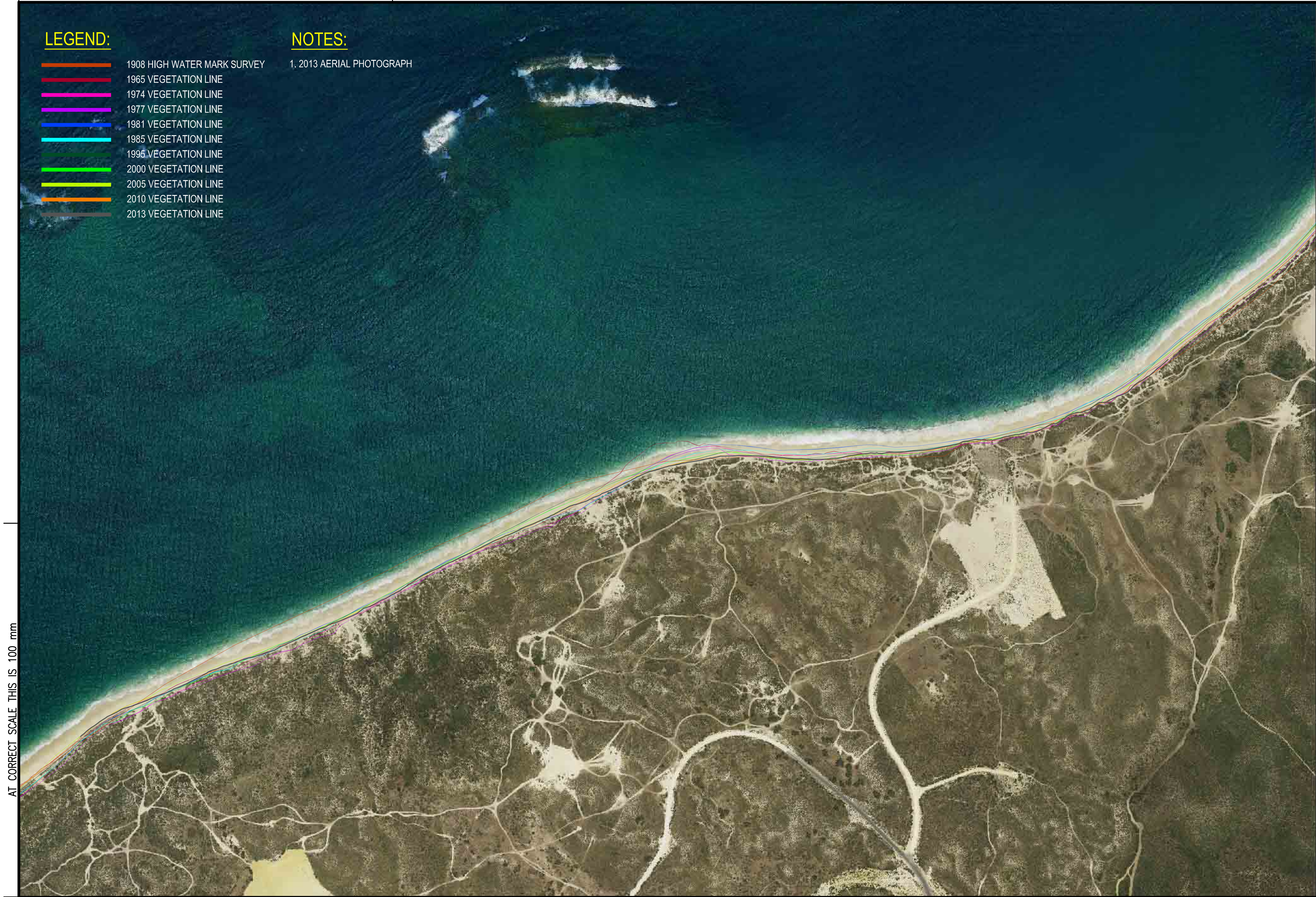
SURVEY OF HIGH WATER MARK

It is one thing for a court, of whatever jurisdiction, to sit in judgement on a set of circumstances and determine where a tidal boundary should lie and another to actually physically delimit such a boundary on the ground. Traditionally it has been the responsibility of land surveyors to locate such boundaries but in the United States there has been a trend to involve geologists, biologists and hydrographers to enable an accurate fix, commensurate with legal principles, to be determined (Nichols and McLaughlin, 1984).

Obviously, any survey to locate a high water mark boundary must adhere not only to legal principles but also to cost limitation factors. A survey cost which is totally disproportionate to accuracy requirements and the basic intention of the survey would be unacceptable in almost all situations. The practice adopted by surveyors in years past has been to select a position on the ground, taking due regard of local evidence in the form of debris etc. This approach is a practical one, cost effective and tending to preserve what many believe is the basic intention of such boundaries, ie. that alienated land shall seldom if ever, be subject to inundation, although surveyors would need to comply with the accuracy requirements of the Act and regulations (in particular Regulation 5 of Licensed Surveyors Regulations 1961). With the advent of remote sensing, in the form of aerial photography, it became possible to delineate water boundaries for mapping purposes at much less cost. In these cases, the

Appendix B Shoreline Movement Plan

AT CORRECT SCALE THIS IS 100 mm



AT CORRECT SCALE THIS IS 100 mm

REV	DATE	APP'D	DESCRIPTION
2	6.12.13	C.D	ADDED 2013 INFORMATION
1	13.12.11	C.D	ADDED 1908 HWM SURVEY
0	05.08.11	C.D	ISSUED FOR REPORT

CLIENT: LANDCORP

DESIGNED: D.S.H | CHECKED: C.R.D | APPROVED:

DRAWN: D.S.H | CHECKED: C.R.D

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PROJECT: ALKIMOS

TITLE: COASTAL PROCESSES ASSESSMENT SHORELINE MOVEMENT PLAN

SCALE AT A3: 1:8,000 | DRAWING NUMBER: D929-01-01 | REV: 2

Appendix C Coastal Processes Allowance Lines

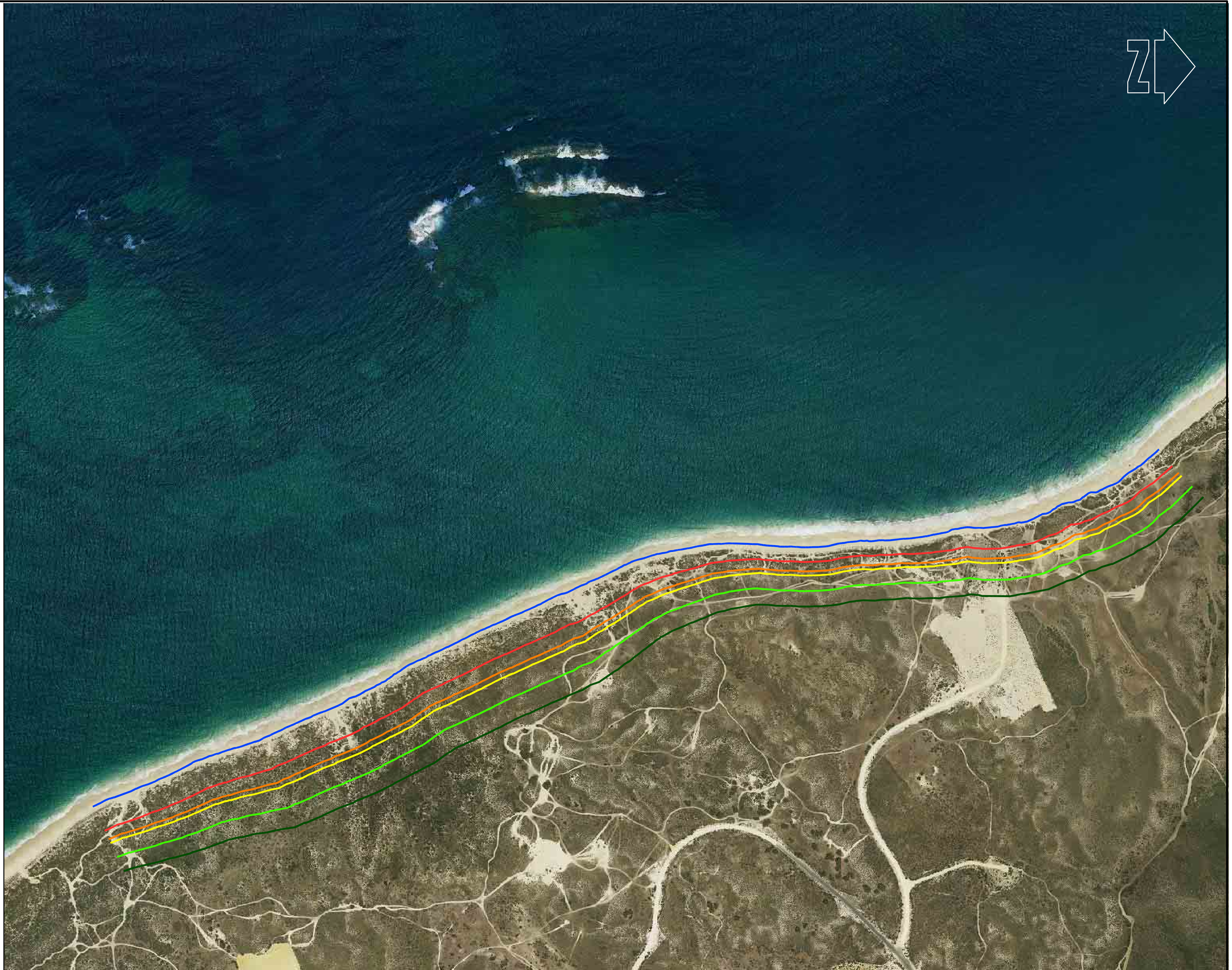
AT CORRECT SCALE THIS IS 100 mm

LEGEND:

- HORIZONTAL SHORELINE DATUM (HSD)

COASTAL PROCESSES ASSESSMENT PLANNING HORIZONS

- 20 YEARS
- 42 YEARS
- 50 YEARS
- 75 YEARS
- 100 YEARS



AT CORRECT SCALE THIS IS 100 mm

NOTES:

1. 2013 AERIAL PHOTOGRAPH
2. PPS MEASURED LANDWARD FROM HSD

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COASTAL PROCESSES ASSESSMENT

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