7 Assessment of Shoreline Erosion Risk

7.1 Introduction

The shoreline erosion risks within the study area arise from a combination of:

- The physical processes that are causing or leading to the erosion;
- The assets potentially affected by the erosion; and
- The timeframe over which the threat may act upon the asset.

In order to assess the erosion risks throughout the study area, it is necessary to understand which areas are presently subject to coastal erosion threats and which areas may become subject to erosion threats in the future. Erosion is a naturally occurring process that is affected by a number of climatic factors. Therefore, potential effects of climate change need to be considered in such assessment.

To effectively assess the coastal erosion risks, an erosion vulnerability zone has been determined for a 50-year planning horizon. The erosion vulnerability zone should include the following components, consistent with the Queensland Coastal Hazard Technical Guide (Queensland Government, 2013):

7.2 Basic Considerations

Erosion prone area widths are determined to cater for potential erosion of the shoreline over a specified planning period. Both short term (storm related) and longer term (gradual) trends are included in the assessment together with an allowance for potential sea level rise associated with climate change related sea level rise. Provision is also included for a factor of safety on the estimates and an allowance made for slumping of the foreshore/dune scarp following erosion. The following relationship was used by the former Beach Protection Authority (BPA) for determination of the erosion prone area widths and continues to be recognised by EHP as a reasonable method of assessing shoreline recession risk:

$$E = [(NR) + C + S] \times (1 + F) + D \qquad \text{Equation 1}$$

Where E = Erosion Prone Area Width (m)

N = Planning Period (years)

R = Rate of Long-term Erosion (m/year)

C = Short-term Erosion from the design cyclone (m)

S = Erosion due to Sea Level Rise (m)

F = Factor of Safety

D = Foreshore/Dune Slumping Component (m)

The various components in the above relationship are determined on the basis of the characteristics of the individual study locations together with presently accepted practices as discussed in the following sections.

It should be noted that Equation 1 provides a conservative value of the individual components used to assess the erosion potential and involves a safety factor. The assessment has been undertaken across a wide study area and local features that may resist shoreline erosion (such as dense vegetation, rocky outcrops and/or manmade structures) have not been considered. The calculated erosion widths are therefore expected to be at the upper limit of the erosion that may occur during the planning period. It is most likely that these erosion widths will not be realised within the planning period but serve as a reasonable yardstick to assess shoreline risk.

7.2.1 Planning Period (N)

The duration of the planning period influences the erosion prone area width calculations by affecting:

- The total extent of gradual long-term erosion;
- The extent of possible sea level rise due to climate change; and
- The selection of design cyclone conditions which are based on an accepted risk level.

The planning period only relates to the sea level rise and the long-term erosion components. Following the Queensland Coastal Hazard Technical Guide (Queensland Government, 2013) a period of 100 years has been adopted as the planning period for the assessment of erosion due to sea level rise. The long-term erosion component (excluding sea level rise) of the calculation is often cyclical in nature and typically of a decadal scale. For this reason, it is recommended that the estimated annual rate of long-term erosion is only applied for a 50-year period to avoid over-estimation, unless there is clear evidence to the contrary.

7.2.2 Rate of Long Term Erosion (R)

The rate of long term erosion can be estimated by extrapolating past trends (through analysis of historical survey data) and/or determining any deficit in the local sediment budget (typically via longshore sediment transport modelling).

For this study the rate of long term erosion has been estimated from the longshore sediment transport modelling results described in Section 6.4.1. An estimate of the long term erosion rate was obtained by dividing the annual sediment loss per metre of shoreline (averaged value for each study area location) by an estimate of the active profile height at each location. The active profile is defined as the vertical distance from the foreshore elevation to the depth of the closure. The foreshore elevation was obtained from a recently acquired LiDAR survey of the study area and the depth of closure was estimated to be twice the 20yr ARI wave height for each location.

The annual rate of long-term shoreline erosion potential (R) and the long-term shoreline erosion potential for the 50 year planning horizon (N x R) are presented in Table 7-1. These results suggest the long term erosion potential is relatively low and generally within a few centimetres per year.

Table 7-1 Long-term Shoreline Erosion Potential Inputs and Estimates

Beach Unit	Profile ID	Foreshore Crest Height (m)	Depth of Closure	Shoreline Recession rate (m/year)	50 year Planning Horizon Shoreline Recession (m)
Deception Bay	1	3.3	1.8	<0.01	0.1
Deception Bay	2	5.2	1.8	<0.01	0.1
Deception Bay	3	5.8	1.8	<0.01	0.1
Beachmere	4	2.8	2.2	0.05	2.5
Beachmere	5	3.6	2.2	0.04	2.2
Beachmere	6	3.9	2.2	0.04	2.0
Beachmere	7	3.4	2.2	0.04	2.2
Beachmere	8	2.6	2.2	0.05	2.6
Godwin Beach	9	2.3	2.6	<0.01	0.1
Godwin Beach	10	2.9	2.6	<0.01	0.1
Godwin Beach	11	2.6	2.6	<0.01	0.1
Godwin Beach	12	2	2.6	<0.01	0.1
Godwin Beach	13	2	2.6	<0.01	0.1
Sandstone Point	14	5	2	0.02	1.1
Sandstone Point	15	3.9	2	0.03	1.4
Sandstone Point	16	3.7	2	0.03	1.4
Toorbul	17	2.4	1	-0.05	2.5
Toorbul	18	2.3	1	-0.05	2.6
Toorbul	19	2.3	1	-0.05	2.6
Toorbul	20	1.9	1	-0.06	2.9
Toorbul	21	1.6	1	-0.07	3.3
Donnybrook	22	4	1	-0.05	2.6
Donnybrook	23	2.1	1	-0.08	4.2

7.2.3 Short-term Erosion (C)

Short-term erosion of the upper beach and foreshore can occur from time to time and are typically associated with tropical cyclone or severe storm events. Such events usually involve co-existing storm surges and high wave energy.

Storm erosion involves the movement of sediment in the offshore direction. This material would be returned gradually to the upper beach by wave and wind action over a relatively longer period of time. In cases where the foreshore is low and overtopped, material may also be carried landwards.

Where appropriate, the erosion distance can be calculated on the basis that a characterised equilibrium beach profile is developed during the storm-induced extreme water level and wave conditions and that this profile provides a volume balance between the material eroded from the upper beach/dune and that deposited on the lower zone of the beach slope. The empirical method of by Vellinga (1983) has been used for this assessment and is described in Section 6.4.1. The potential storm erosion width at numerous locations within the study area is listed in Table 6-6 and the estimated storm profiles for all locations are presented in Appendix B.

7.2.4 Erosion Due to Sea Level Rise (S)

Provision is required for coastal recession associated with an expected sea level rise due to climate change. The Queensland Coastal Hazard Technical Guide (Queensland Government, 2013) promotes the use of 0.8m by 2100 however it is noted that this value is based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPPC) and may be updated in line with future IPCC projections.

In assessing the coastal recession associated with an increase in mean sea level, consideration has been given to the geography of the area, existing offshore profiles and sediment characteristics. It is considered that beach ridges are likely to be predominantly wave formed with the coarser particles being moved onshore to the upper beach face/dune and the finer particles remaining in the nearshore zone. This could result in beach profiles with two distinct slopes; a steep upper beach face with sand and a flat nearshore zone with finer sand and silts.

The standard method of Per Bruun has been used to predict the beach response to sea level rise (Bruun, 1962):

$$S = -S_p \frac{W}{d_c + B} \qquad \text{Equation 2}$$

Where S = Erosion due to sea level rise

S_p = Sea level rise projection

W = Width of the beach profile

d_c = Depth of closure

B = Foreshore/Dune crest height

An initial beach profile and design wave height is typically used to estimate W and dc. For this assessment, a profile width 250m offshore has been adopted for all locations within Deception Bay and a width of 100m at Toorbul and Donnybrook (within Pumicestone Passage). The depth of closure is estimated to be twice the 20yr ARI wave height for each location. The so-called "Bruun Rule" is based on the upper foreshore/dune material eroding and depositing in the nearshore zone to maintain the same depths below mean sea level and is illustrated in Figure 7-1. The estimated shoreline erosion potential associated with the adopted sea level rise projections for the 2050 planning period are provided in Table 7-2.

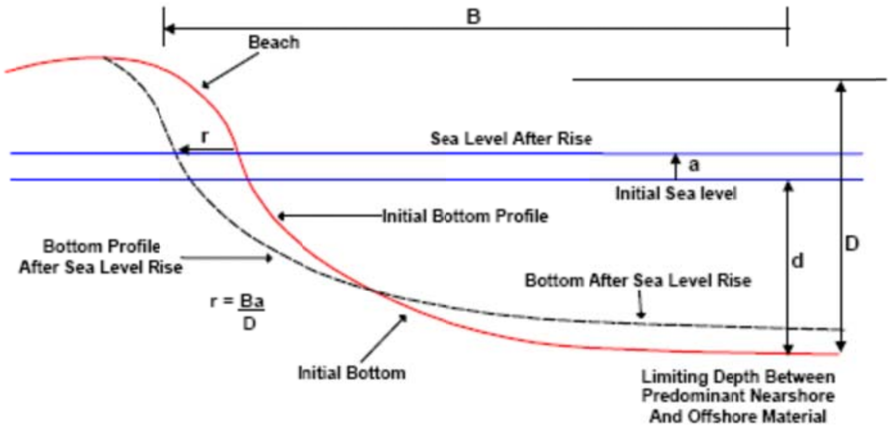

Figure 7-1 Bruun Rule for Shoreline Response to Rising Sea Level

Table 7-2 Erosion Potential due to Sea Level Rise Inputs and Estimates

Beach Unit	Profile ID	Foreshore Crest Height (m)	Depth of Closure	Width of Beach Profile (m)	Erosion due to Sea Level Rise (m)
Deception Bay	1	3.3	1.8	250	39.2
Deception Bay	2	5.2	1.8	250	28.6
Deception Bay	3	5.8	1.8	250	26.3
Beachmere	4	2.8	2.2	250	40.0
Beachmere	5	3.6	2.2	250	34.5
Beachmere	6	3.9	2.2	250	32.8
Beachmere	7	3.4	2.2	250	35.7
Beachmere	8	2.6	2.2	250	41.7
Godwin Beach	9	2.3	2.6	250	40.8
Godwin Beach	10	2.9	2.6	250	36.4
Godwin Beach	11	2.6	2.6	250	38.5
Godwin Beach	12	2	2.6	250	43.5
Godwin Beach	13	2	2.6	250	43.5
Sandstone Point	14	5	2	250	28.6
Sandstone Point	15	3.9	2	250	33.9
Sandstone Point	16	3.7	2	250	35.1
Toorbul	17	2.4	1	100	23.5
Toorbul	18	2.3	1	100	24.2
Toorbul	19	2.3	1	100	24.2
Toorbul	20	1.9	1	100	27.6
Toorbul	21	1.6	1	100	30.8
Donnybrook	22	4	1	100	16.0
Donnybrook	23	2.1	1	100	25.8

7.2.5 Factor of Safety (F)

A factor of safety is included in the assessments of the short-term, long-term and sea level rise erosion components to provide for uncertainties and error margins in the calculation procedures. EHP recommend a 40% factor of safety however considering the relatively detailed assessment of coastal processes in this study, and other conservative assumptions, the factor of safety has been reduced to 20%.

7.2.6 Foreshore/Dune Slumping Component (D)

The short-term erosion calculation permits the assessment of shoreline recession as far as the limit of wave run-up for those cases where the foreshore is not overtopped. To allow for slumping of the foreshore or frontal dune beyond this design run-up level, and the possible undermining and collapse of structures founded on the foreshore, the Queensland Coastal Hazard Technical Guide (Queensland Government, 2013) recommends that a dune scarp component is included in the erosion prone area width estimation. The dune scarp component provides for the horizontal distance between the toe and the crest after slumping to a pre-determined stable slope. For this assessment the foreshore/dune crest elevation, 100 year storm tide level, 0.8m sea level rise and a stability threshold slope of 1:3 have been assumed.

For the 50 year planning horizon the horizontal erosion due to dune slumping is typically less than 5m (with the exception of a few locations with steep foreshore slopes) and is presented in Table 7-3.

Table 7-3 Erosion Potential due to Foreshore/Dune Slumping

Beach Unit	Profile ID	Foreshore Crest Height (m)	100yr ARI Design Water Level (mAHD)	Erosion Potential due to Slumping (m)
Deception Bay	1	3.3	2.2	5.7
Deception Bay	2	5.2	2.2	11.4
Deception Bay	3	5.8	2.2	13.2
Beachmere	4	2.8	2.3	3.9
Beachmere	5	3.6	2.3	6.3
Beachmere	6	3.9	2.3	7.2
Beachmere	7	3.4	2.3	5.7
Beachmere	8	2.6	2.3	3.3
Godwin Beach	9	2.3	2.2	2.7
Godwin Beach	10	2.9	2.2	4.5
Godwin Beach	11	2.6	2.2	3.6
Godwin Beach	12	2	2.2	1.8
Godwin Beach	13	2	2.2	1.8
Sandstone Point	14	5	2.1	11.1
Sandstone Point	15	3.9	2.1	7.8
Sandstone Point	16	3.7	2.1	7.2
Toorbul	17	2.4	1.9	3.9
Toorbul	18	2.3	1.9	3.6
Toorbul	19	2.3	1.9	3.6
Toorbul	20	1.9	1.9	2.4
Toorbul	21	1.6	1.9	1.5
Donnybrook	22	4	2.3	7.5
Donnybrook	23	2.1	2.3	1.8

7.2.7 Summary of Calculated Erosion Prone Area Widths

The erosion prone area width has been calculated following the methodology described above for locations where sufficient data is available. The calculated widths for the 50 year planning horizon are presented in Table 7-4. The erosion prone area is measured landward of the MHWS level. Mapping of the 50-year planning horizon hazard area following this approach presented in Appendix C (mapped together with contemporary storm hazard area described in Section 6.5). It is important to note that the calculated widths do not represent the predicted position of the shoreline in 50 years but rather an area that may be exposed to increasing erosion pressure associated with coastal processes throughout the planning period. Key considerations of the shoreline erosion risk assessment include:

- Existing private and public assets are presently well within the calculated erosion prone area. Many of these areas are currently protected by terminal structures and therefore the predicted erosion potential is not likely to be realised. Ongoing protection of these assets throughout the planning period will require strategic management and adaptation to potentially changing environments. Consideration should be given to situating new infrastructure within the identified erosion prone area.
- The erosion threat associated with sea level rise ranges between 13-45m throughout the study area and represents the most significant component in establishing the erosion prone area widths. Any change to the recommended sea level rise projections adopted for shoreline erosion risk assessments will influence the predicted erosion prone area widths. The Queensland Government is likely to revise their accepted sea level rise projections in line with future IPCC projections (Queensland Government, 2013).
- Shoreline erosion associated short term storm events present an immediate risk to a number of lots throughout the study area. This will be addressed as part of Stage 2 of the NMBSEMP and management options will be developed for Council’s consideration.
- The threat of short term erosion associated with storms is greatest at Beachmere where a number of private and public lots are situated at the shoreline. It is expected that unprotected sections of shoreline and existing shoreline structures will experience increasing erosion pressure throughout the 50-year planning period.
- Short term erosion pressure is also relatively high at Toorbul and Donnybrook however these areas typically have a buffer (foreshore and road) between private assets and the shoreline. This buffer means the risk to existing assets is relatively low and allows some time to develop an appropriate long term management approach.

Table 7-4 Calculated Erosion Prone Area Widths

Beach Unit	Profile ID	50 Year Planning Horizon Erosion Prone Area Widths (m)
Deception Bay	1	75
Deception Bay	2	62
Deception Bay	3	59
Beachmere	4	89
Beachmere	5	69
Beachmere	6	58
Beachmere	7	62
Beachmere	8	68
Godwin Beach	9	74
Godwin Beach	10	64
Godwin Beach	11	69
Godwin Beach	12	63
Godwin Beach	13	73
Sandstone Point	14	56
Sandstone Point	15	62
Sandstone Point	16	64
Toorbul	17	37
Toorbul	18	34
Toorbul	19	37
Toorbul	20	51
Toorbul	21	57
Donnybrook	22	40
Donnybrook	23	39