



Shire of Derby /
West Kimberley

DERBY COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN



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EXECUTIVE SUMMARY

This Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) has been prepared over the Derby town site following the identification of coastal hazards within the Derby Coastal Vulnerability Study complete in 2015. The study area for both the CVS and CHRMAP includes all land within the Derby town site as identified within the Shire's Town Planning Scheme No. 5, Town Planning Scheme No. 7 and future expansion areas outlined within the Local Planning Strategy. In addition, assets located within the Derby Wharf Area, located approximately 2km from the town site, have also been included with the identification and assessment of coastal hazard risk.

Through this CHRMAP, potential coastal erosion and coastal inundation hazards have been identified, analysed and evaluated in accordance with the methodology outlined within State Planning Policy 2.6 – State Coastal Planning (SPP2.6) and the Coastal Hazard Risk Management and Adaption Plan Guidelines. Under the State Planning Policy Framework, the study area is characterised as a single coastal type being a coastal lowland which exhibits a typically flat/ gently sloping shoreline within a high percentage of finer sentiments. SPP2.6 outlines the contrast between the local shoreline and that of a sandy coast, and acknowledges that coastal lowlands are more strongly influenced by inundation and tidal processes.

In addition to the coastal classification under SPP2.6, the coastal area is comprised of a unique combination of geomorphology, climate and natural environmental factors. The combination of these factors, including the joint probability of climatic and astronomic events, results in the dominant coastal hazard impacting the study area being from single storm events occurring across the 100-year planning timeframe, as opposed to long term coastal recession and/ or permanent inundation. However, under the methodology within the State Planning Policy Framework, the likelihood and consequence of both coastal erosion and coastal inundation impacting the study area has been evaluated through three time scenarios; the present (2010), medium term (2060) and long term (2110). The identified coastal inundation and coastal erosion hazards have been evaluated and mapping individually under each of the three time scenarios.

In relation to coastal erosion, the analysis and evaluation undertaken has determined a low level of hazard risk impacting all assets within the Derby town site across the 100-year planning timeframe. The technical investigation undertaken through the CVS, outlined that the current level of consequence from coastal erosion on the study area is insignificant. In addition, the historical analysis undertaken through the CVS demonstrated that the shoreline surrounding the Derby town site exhibits a stable shoreline, with no evidence of significant erosion since 1949. As such, it is considered very unlikely/ rare that coastal erosion hazards will impact the study area as a result of sea level rise over the 100-year planning timeframe. However, additional modelling undertaken to support this CHRMAP outlined that the storm surge associated with a significant storm event may result in might result in a small extent of coastal erosion, extending up to 5m. This extent of coastal erosion would not impact any assets within the Derby town site.

In light of the above, the potential coastal erosion is considered to be an acceptable hazard risk across the 100-year planning timeframe. As such, no specific adaptation measures are proposed within this CHRMAP, other than to ensure ongoing monitoring and examination be undertaken to ensure decisions making continues to be informed by the most up-to-date technical knowledge.

In relation to coastal inundation, the extent of the hazard impacting assets within the study area ranges from no impact, to either acceptable or tolerable levels of risk within the present day scenario. Over the medium and long term scenarios, the extent of coastal inundation increases principally resulting from the increasing impact of sea level rise on top of the modelled storm event. However, even in the long term scenario the majority of assets within the Derby town site have been evaluated as having acceptable to tolerable levels of hazard risk. In the case of private residential, commercial and industrial properties, there are individual properties which may experience a higher level of coastal inundation hazard risk. Therefore, while the public level of risk can be managed through existing mechanisms, accommodation actions have been outlined to ensure that the level of hazard risk on individual properties is reduced and maintained at acceptable levels. The implementation of

accommodation actions will be considered on a case by case basis using the detailed coastal hazard mapping prepared within this CHRMAP.

In addition to the implementation of accommodation actions on individual private properties, there are a number of public owned assets which may experience coastal inundation impacts over the 100-year planning timeframe. While the majority of the public owned assets experience acceptable/ tolerable levels of hazard risk, the Derby Airport, Derby Wharf and the Wharf Foreshore may experience increasingly levels of risk,

resulting in a potential intolerable level of hazard risk within the long term scenario. Adaptation measures for all publicly owned assets will be implemented through the Shire's asset management policies and procedures in consideration of the hazard level over time, the forecast asset life and the whole of life maintenance costs.

In light of the above, Table 1 below presents the increasing levels of coastal inundation hazard risk as it relates to specific assets impacted within the study area through the present, medium and long term scenarios.

Table 1 - Coastal Inundation Hazard Risk through the 100-year Planning Timeframe.

| ASSET | Present (2015) | Medium Term (2060) | Long Term (2110) |
|-----------------------------|------------------|--------------------|------------------|
| WHARF AREA | | | |
| Wharf Structure | Accept | Tolerable/Accept | Intolerable |
| Wharf Foreshore | Tolerable/Accept | Tolerate | Intolerable |
| Wharf Café | Accept | Accept | Tolerable/Accept |
| Recreational Ramps | Accept | Accept | Accept |
| ACCESS TO WHARF AREA | | | |
| Local Roads | Accept | Accept | Tolerable/Accept |
| Loch Street | No Impact | No Impact | Accept |
| Jetty Road | Accept | Tolerable/Accept | Tolerable/Accept |
| TOWN SITE | | | |
| Derby Highway | No Impact | No Impact | Tolerable/Accept |
| Cattle Race | Accept | Tolerable/Accept | Tolerable/Accept |
| Wool Shed & Tramway | No Impact | Accept | Accept |
| Wharfinger's House | No Impact | No Impact | Tolerable/Accept |
| Picture Gardens | No Impact | No Impact | Accept |
| Fishing Club | Accept | Accept | Tolerable/Accept |
| Shooters Precinct | No Impact | Accept | Accept |
| Town Centre Properties | No Impact | Accept | Tolerable/Accept |
| Residential Properties | No Impact | Accept | Accept |
| Aged Care facilities | No Impact | No Impact | Accept |
| Caravan Park | Accept | Accept | Tolerable/Accept |
| Aboriginal Communities | Accept | Accept | Tolerable/Accept |
| Derby Airport | Accept | Tolerable/Accept | Intolerable |

As outlined on the previous page, the generally low level of risk is the result of the highly protective nature of the local environment and the low joint occurrence probability of climatic and astronomical factors impacting the study area. This is further reflected in a low level of interest and/ or concern shown from the local community in regards to either coastal erosion or coastal inundation hazards. Nevertheless, coastal hazards have been identified and while the current level of risk is generally acceptable/ tolerable, the Shire needs to ensure that suitable management and/ or adaptation actions are put in place to maintain the level of risk. These management and/ or adaptation actions have been considered and adopted within this CHRMAP.

The consideration and assessment of coastal adaptation and management options has been undertaken consistent with the hierarchy of options, and methodology outlined within State Planning Policy 2.6 – State Coastal Planning Policy, and the Coastal Hazard Risk Management and Adaptation Planning Guidelines respectfully. In addition to taking guidance from the State Planning Policy Framework, the full range of local factors has been incorporated to ensure that decision making is reflective of the local context, and that the proposed actions are implemented and achievable. The various influencing local factors that have guided the development of success criteria for this CHRMAP are outlined in Table 2 below.

Table 2 - Project Success Criteria.

| Local Factors | | Success Criteria |
|----------------------|--|---|
| 1 | Local concern with potential limitations for growth of Derby by the imposition of the State Planning Policy Framework. | Ensure the State Planning Policy Framework does not negatively impact future growth of Derby. |
| 3 | Limited guidance within the State Planning Policy Framework to consider the unique local environment. | Develop and implement a program of ongoing monitoring/ examination through a multiagency approach to ensure future decision making is reflective of local factors, and informs a review of the State Planning Policy Framework. |
| 3 | Low level of community knowledge and acceptance. | Ensure community knowledge and awareness is developed through ongoing community consultation. Increase the current level of community knowledge prior to proposing any major adaptation works. |
| 4 | Limited Shire resources and revenue. | Ensure the level/ experience of Shire resources is incorporated into the determination of proposed actions. |
| 5 | Available funding/ grant opportunities available to undertake coastal planning and implement adaptation actions. | Identify funding opportunities to ensure specific adaptation actions, monitoring and further investigation can be undertaken as required and prior to coastal hazards impacting becoming intolerable. |
| 6 | No existing controls in place to consider development and use within areas potentially at risk of coastal hazards. | Ensure a transparent and equitable approach is undertaken in developing a mechanism to guide land use and development decision making. |
| 7 | Shire currently developing holistic Asset Management Plan. | Ensure identified coastal hazards are considered within ongoing strategy development and asset management processes, including the Strategic Community Plan and Asset Management Plan. |

In consideration of the local factors and the generally acceptable/ tolerable level of coastal erosion and coastal inundation hazard risk across the 100-year planning timeframe, it has been determined that no major adaptation actions should be undertaken within the scope of this CHRMAP. Moving into the medium/ long term, further assessment and consideration of adaptions options will need to be undertaken for assets at the

Derby Airport and Derby Wharf Area. In the immediate to short term, accommodation adaptation actions can be undertaken to maintain the level coastal inundation hazard risk levels at acceptable/ tolerable levels. In addition, ongoing monitoring and examination of the shoreline and the impacting coastal hazards should be undertaken to maintain the most up-to-date technical knowledge informs future decision making.

Following the methodology imposed through SPP2.6, the following accommodation actions have been determined as the most suitable given the current level of hazard risk and local factors. Further details regarding the implementation of these actions is outlined within this CHRMAP:

- Update the Shire of Derby / West Kimberley Town Planning Scheme to ensure that the extent of the hazard prone area is mapped and set objectives to ensure land use and development within the hazard prone area has the appropriate consideration of coastal hazard risk.
- Develop a range of suitable development standards through a local planning policy to ensure applications for existing, infill and greenfield land use and development appropriately accommodates the associated level of coastal inundation risk while not negatively impacting the local community.
- Notifications are placed on property titles at the time of subdivision and / or development application to ensure that both existing and future landowners are notified of the specific coastal hazards related to their property.
- Update the Shire of Derby / West Kimberley Asset Management Plan to ensure that the construction and/ or maintenance of public assets incorporates the relative level and extent of coastal inundation over the life of the asset.
- Develop an ongoing monitoring/ examination program of the Derby shoreline and coastal hazards is prepared in collaboration with a range of qualified stakeholders and is implemented.
- Develop a targeted public communication/ education program in collaboration with a range of qualified stakeholders to increase community knowledge and awareness of coastal hazards.
- Seek opportunities to secure funding which allows additional monitoring, examination and consultation to be undertaken prior to hazard risk levels reaching intolerable levels.
- Incorporate measurable actions within the Shire of Derby / West Kimberley Strategic Community Plan that focus on; increasing community awareness; including coastal hazards within asset management planning; including coastal hazards within land use and development decision making; and ongoing monitoring/ examination of the shoreline and coastal hazards to inform future decision making.

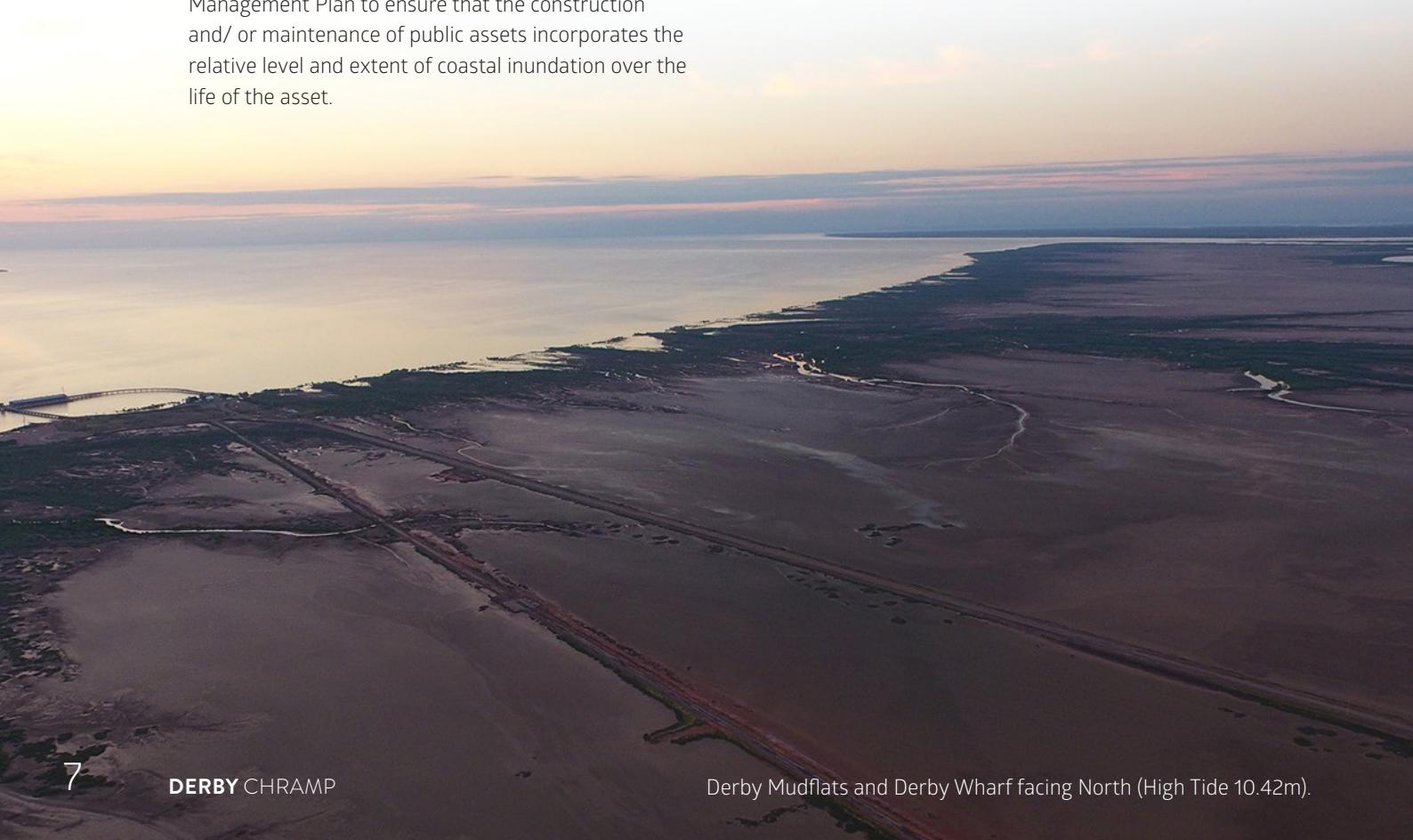


Figure 1: Derby Town Site facing Southeast 1954 (Tide unknown).



Figure 2: Derby Town Site facing Southeast 2017 (Low Tide 2.47m).



INTRODUCTION

In Western Australia the awareness and inclusion of coastal hazards within land use and development planning is gaining increasing importance. Over the past few years, the Western Australia Planning Commission (WAPC) has provided increased guidance to inform local government decision-making in respect to land use and development within coastal settlements.

In response to State Planning Policy 2.6 – State Coastal Planning, the Shire of Derby West / Kimberley (Shire) engaged a consultant team to undertake a Coastal Vulnerability Study (CVS) over the Derby town site and immediate surrounds. The CVS collated the findings of various technical reports and identified potential coastal erosion and coastal inundation hazards impacting the

study area over the 100-year planning timeframe. It must be noted that the CVS was undertaken in response to SPP2.6 rather than in response to a local concern of coastal hazards. This Coastal Hazard Risk Management and Adaption Plan (CHRMAP) has been prepared to provide management and adaptation actions to address the potential coastal hazards identified within the CVS.

The preparation of this CHRMAP is consistent with the methodology outlined within SPP2.6 and the supporting Costal Hazard Risk Management and Adaptation Planning Guidelines (Costal Guidelines). In addition to the State Planning Policy Framework, the proposed management and adaptation responses have been developed in recognition of the unique social, environmental, economic and governance factors.



STATE COASTAL FRAMEWORK

STATE PLANNING POLICY 2.6 – STATE PLANNING POLICY

The overall purpose of SPP2.6 is to ensure that land use and development within the coastal zone accounts for coastal processes and hazards, and that areas of the coastal foreshore are reserved, protected, conserved and enhanced where suitable. Schedule One within SPP2.6 outlines the methodology for calculating coastal processes in respect to different coastal classifications. The examination of coastal processes impacting the study area was undertaken within through the CVS. The components identified within SPP2.6 that were applied to calculate the coastal processes impacting the study area are outlined within Table 3 below.

Table 3 - SPP2.6 - Schedule One: Calculation of Coastal Processes.

| |
|--|
| Planning Timeframe: Based on a 100-year timeframe from when proposal is being assessed. |
| Coastal Classification: Determined with regards to the physical and biological feature of the coast. The study area is defined as a Coastal Lowland. |
| Calculation of Coastal Processes: Defined based on the coastal geology/ geomorphology of the classified coastline. |
| 1. Climate Change: Allowance for sea level rise(SLR) should be based on a vertical SLR of 0.9 metres over the 100-year timeframe to 2110. |
| 2. Horizontal Shoreline Datum (HSD): Defines active limit of the shoreline under the designed storm activity. |
| 3. Coastal Protection Works: Considers the benefit these works provide against coastal processes. |
| 4. Allowance for Erosion: Under SPP2.6, the methodology for determining the allowance for erosion on coastal lowlands, requires the methodology of a sandy coast to be applied. As such the calculation includes: - Storm Erosion (S1): Allowance for erosion under a 1 in 100-year ARI storm event. - Historic Trend Erosion (S2): Allowance for historic shoreline movement. - Sea Level Rise Erosion (S3): Allowance for SLR in planning timeframe - Factor of Uncertainty (FOS): Allowance of 0.2 metres per year. |
| 5. Allowance for Inundation The allowance for inundation is determined as the sum of S4 plus the extent of predicted SLR. The S4 component is calculated as: -Storm Surge Inundation (S4): Maximum extent of a 1 in 500-year ARI storm event, defined as the peak steady water level plus wave run-up |

In addition, SPP2.6 provides guidance to ensure that adequate coastal hazard risk management and adaptation planning is undertaken, and suitable management and adaptation responses are developed. SPP2.6 prescribes a hierarchy of management and adaptation options which preferences the avoidance and managed retreat of assets within coastal hazard prone areas. This CHRMAP incorporates the coastal hazards identified through the CVS and provides appropriate management and adaptation responses following the hierarchy outlined within SPP2.6.

| | |
|------------------------|--|
| Avoid | new development within areas identified to be affected by coastal hazards. |
| Managed Retreat | of assets within areas identified as likely to be subject to intolerable risk of damage from coastal hazards over the planning timeframe. |
| Accommodate | adaptation measures should be provided that suitably address the identified risks. |
| Protect | areas where there is a need to preserve the foreshore reserve, public access, public safety, property and infrastructure that is not expendable. |

Figure 3 - Hierarchy of Risk Management and Adaption Options within SPP2.6.



Derby Town Site and Mudflats facing Southeast (Low Tide 2.47m).

COASTAL HAZARD RISK MANAGEMENT AND ADAPTION PLANNING GUIDELINES

The Coastal Hazard Risk Management and Adaption Planning Guidelines (Coastal Guidelines) were developed in support of SPP2.6 to assist decision-makers in developing and implementing effective CHRMAP. The Coastal Guidelines provides a recommended risk management and adaptation process which has been adopted in the preparation of this CHRMAP. The detailed technical assessment and modelling of coastal hazards was undertaken within the preceding CVS and have been summarised within this CHRMAP.

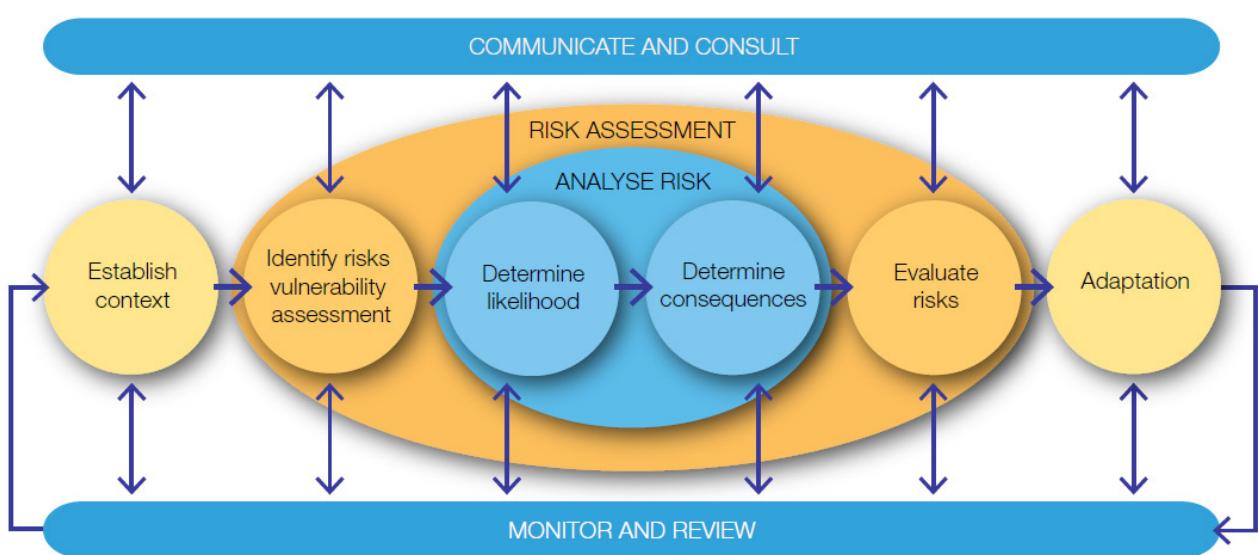


Figure 3 - Risk Management and Adaptation Process Flowchart (Coastal Guidelines).

CONTEXT

PURPOSE

This CHRMAP allows the Shire to analyse and evaluate the coastal hazards identified within the CVS, and develop suitable risk management and adaptation measures. Both the CVS and CHRAMP have been undertaken consistent with the guidance provided within SPP2.6 and the Coastal Guidelines. More generally, this CHRMAP is a mechanism for the Shire to communicate with the wider community and affected stakeholders about the nature and extent of coastal hazards impacting the town site. This communication has been used to determine local values and acceptance of coastal hazards, and to develop and review potential management and adaption measures over time. It is important to note that SPP2.6 adopts a precautionary principle and is therefore conservative in its nature. Therefore, State policy measures need to be implemented with fair consideration of local factors to avoid negative impacts on the local community. Management and adaptation measures need to be understood in the context of the:

- Identified hazard risk levels resulting from coastal erosion and inundation on public and private assets;
- Level of certainty/ technical knowledge of the coastal hazards;
- Appropriateness of the State Planning Policy Framework to provide guidance for the local context; and
- Readiness and awareness of the local community and Shire.

OBJECTIVES

In light of the above, the specific objectives developed for this CHRMAP are to:

1. Identify the range of assets (natural and man-made) in potentially impacted by coastal hazards.
2. Interpret the outcomes from the CVS to better understand the likelihood and consequence of coastal hazards across the Derby town site and determine the levels of hazard risk.
3. Consult with the community and stakeholders to inform, educate and collaborate on coastal hazards and what decision making should be undertaken (e.g. what the level of hazard risk is acceptable/ tolerable).

4. Identify possible management and adaptation actions and incorporate into short and longer term decision-making consistent with SPP2.6.
5. Ensure any proposed action is developed in a transparent and collaborative manner.
6. Undertake multi-criteria analysis in determining management and adaptation measures.
7. Resolve the identified coastal hazard risk(s) to provide suitable direction for the preparation and implementation of statutory planning mechanisms to guide future land use and development.

SCOPE

The scope of this CHRMAP is consistent with the scope outlined within the Coastal Guidelines, as follows:

The CHRMAP should be focussed on the coastal zone, meaning the areas of water and land that may be influenced by coastal processes (SPP2.6) within the planning horizon/ timeframe. It does not include assessment of possible impacts or adaptation strategies outside the coastal zone.

The CHRMAP is specifically designed to address potential adverse impacts from erosion and inundation hazards (in particular where they will be amplified by climate change and sea level rise) upon assets in the coastal zone. It should specifically target coastal risks that are identified as unacceptable/ intolerable, and ensure management and adaptation measures are formulated to reduce these risks down to tolerable or acceptable levels.

SPP2.6 and the Coastal Guidelines focus only on the use and development of assets within the coastal zone and not in relation to the protection of human life. Therefore, the consideration of coastal hazard risk to human life is not within the scope of this CHRMAP.

STUDY AREA

Derby is located within the Kimberley region of Western Australia, within the municipality of the Shire of Derby West / Kimberley (Shire). Derby is located approximately 220km east of Broome and approximately 257km north of Fitzroy Crossing, being the two largest settlements within 500km. The wider area encompasses the Derby town site, Derby Wharf Area, and surrounding rural and rural residential areas.

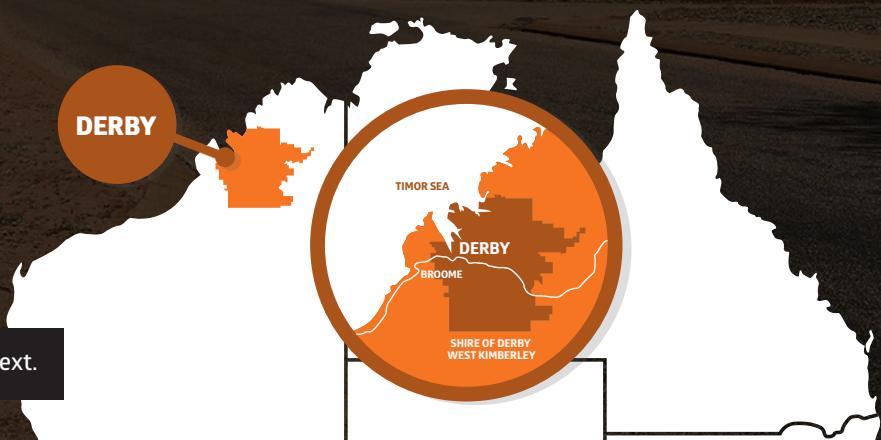


Figure 4: Study Area Regional Context.

The Derby town site is located on the Derby Peninsula, an elevated feature within the southern end of the King Sound and adjacent to the mouth of the Fitzroy River. The Derby Peninsula is surrounded by extensive mudflats that connect through a significant mangrove community. The Derby Wharf Area is located approximately 2km northwest of the Derby Peninsula accessed via a raised road and dual use footpath. The Derby Wharf Area is located on an elevated portion of land protected on the coastal frontage with rock armour. The Derby Jetty itself, constructed in 1963 - 64, is elevated above surrounding mudflats on pylons.

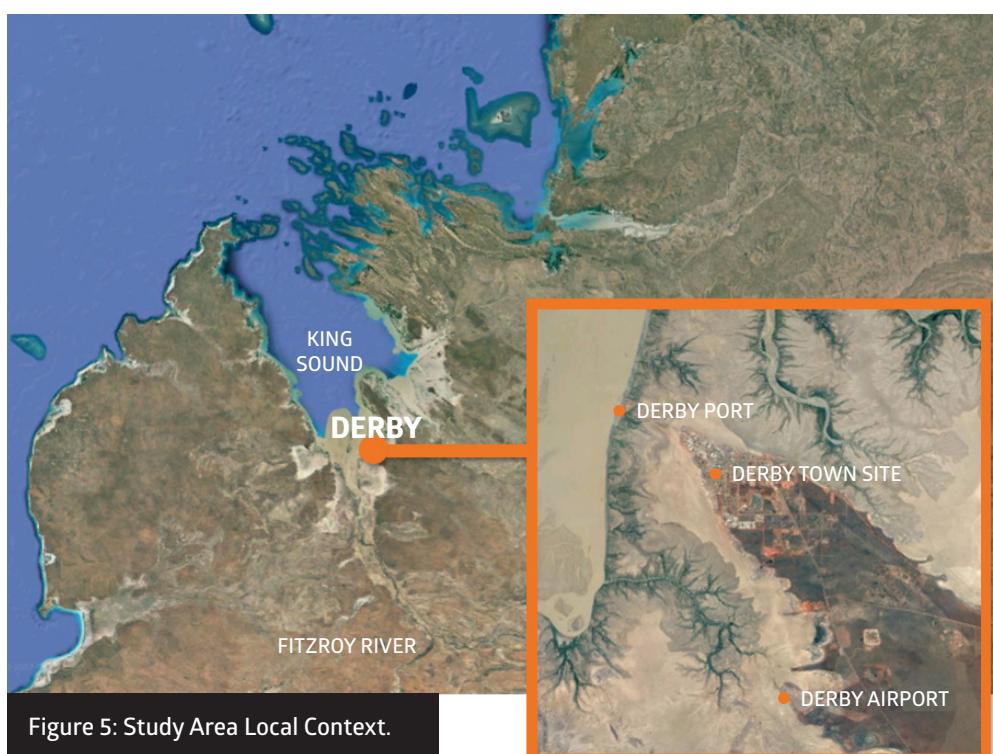


Figure 5: Study Area Local Context.

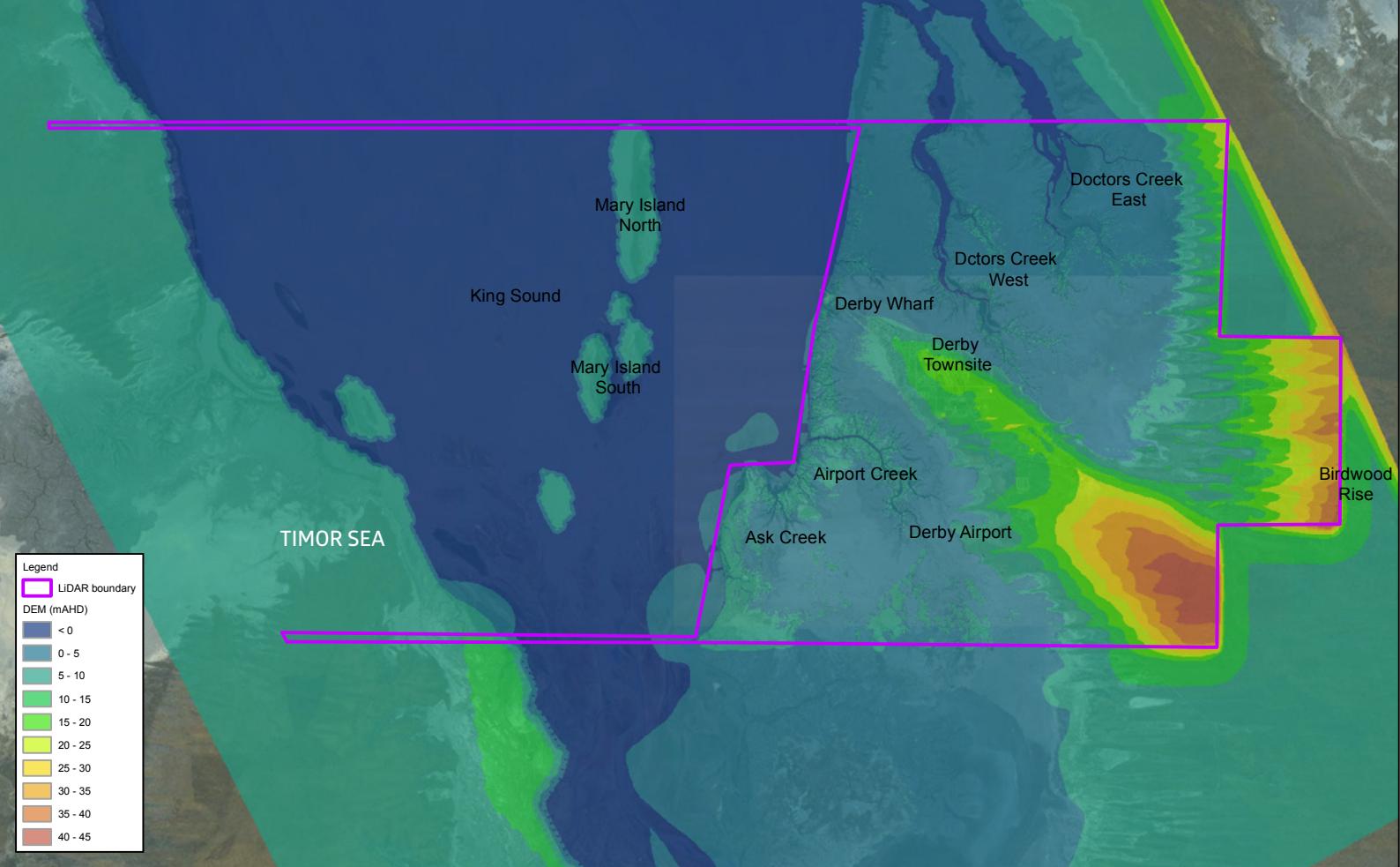
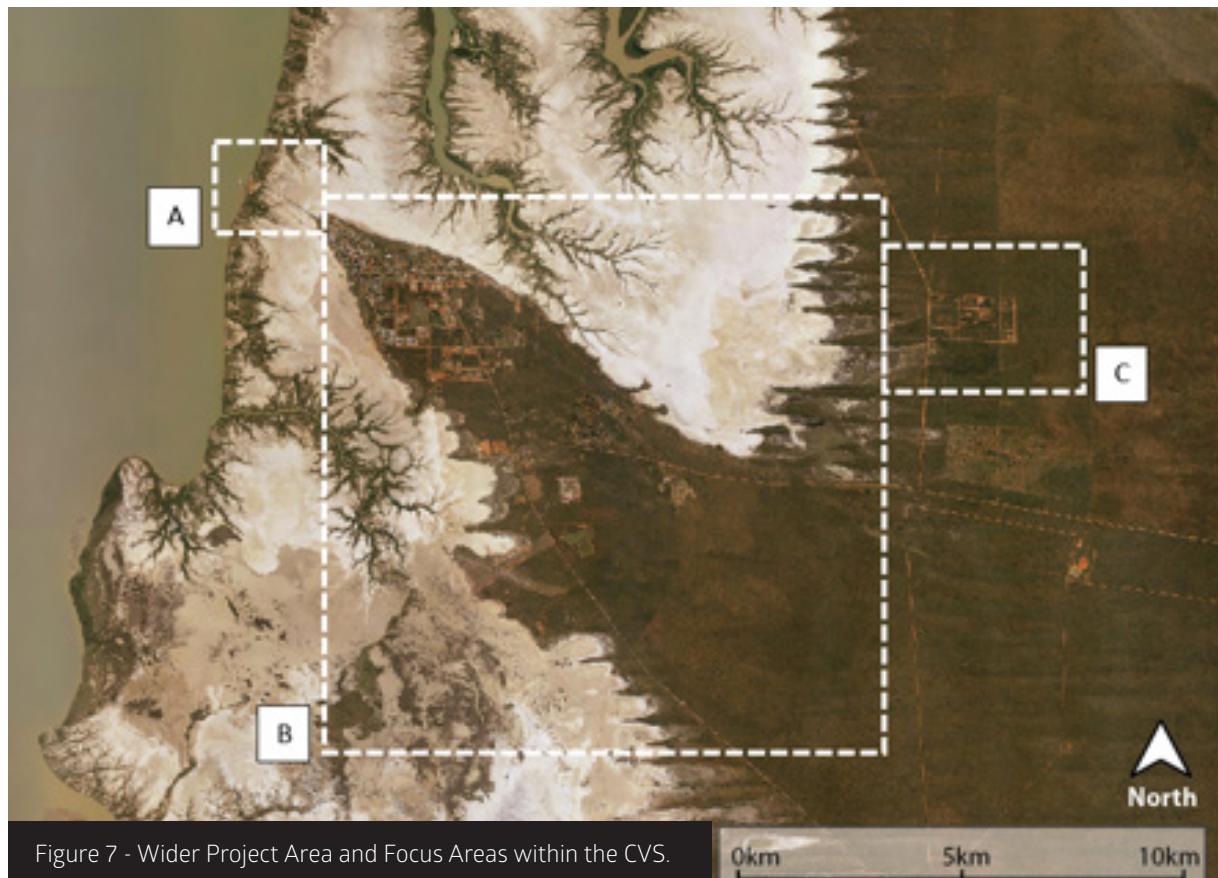


Figure 6: LiDAR Boundary and DEM (mAHM) (Source: Derby Flood Modelling Report, 2015).

As part of the CVS, a project area was identified to include all land within the Shire's Town Planning Scheme No. 5 (TPS5) and No. 7 (TPS7), as well as the Derby Wharf Area. This project area encompassed all land under the Shire's jurisdiction at the time, noting the Derby Wharf is a State-owned asset under management order to the Shire. Within this project area, three specific focus areas were identified to be assessed with a higher level of localised modelling. These focus areas included the Derby Wharf Area, the Derby Town Site and Birdwood Rise (a rural residential area approximately 17km from the town site). The wider project area and focus areas are illustrated in Figure 2 below.

The study area for this CHRMAP is focused specifically on the sections of the coastal area exposed to coastal hazards as defined within the CVS. This includes assets within the Derby Wharf Area and assets with areas of the Derby town site. As Birdwood Rise is not impacted by coastal processes within the 100-year planning timeframe it has been excluded from the scope of this CHRMAP. As outlined within Figure 2, the shoreline characteristics and coastal influences at the Wharf Area and Town Site Area are noticeably different. While both shorelines are classified as coastal lowlands, the exposure of assets to coastal processes is different. In addition, the specific coastal nature and ownership of assets at the Wharf Area require different management and adaption options in comparison to assets within the Derby town site.

| Shoreline Characteristics | Summary of Assets |
|---|---|
| Focus Area A: Derby Wharf Area | |
| Shoreline directly fronts the King Sound and adjacent to extensive mangrove communities. The area is subject to significant tidal movements and potential limited wave action. Aerial photographic review highlights a landward movement of the surrounding mangroves over time (a result of manmade and natural occurrences). | Derby Wharf/ Jetty, vacant laydown areas, car parking, café, public amenities, sheds, boat ramps and recreation areas. Located approximately 2km from the town site via a sealed road and dual use path. |
| Focus Area B: Derby Town Site Area | |
| Sheltered shoreline protected by extensive mudflats, rarely subject to tidal inundation or wave action. The shoreline is marginally elevated above the surrounding mudflats at the tip of the peninsula, becoming steadily more elevated moving southeast. Aerial photographic review highlights a stable shoreline, with no evidence of significant erosion. | The area includes the full spectrum of development expected within a town site including residential, industrial, commercial land uses and public reserves. The main town centre is located on the tip of the peninsula with the majority of built development located around this area, with more undeveloped land further southeast. The Derby Airport is also located within broader town site area on the southwestern fringe of the peninsula. |
| Focus Area C: Birdwood Rise Area | |
| Sheltered shoreline protected by extensive mudflats and not subjected to tidal inundation or wave action. The developed area is considerably elevated and set back from the surrounding mudflats and not impacted by coastal processes within the planning timeframe. However, the area is subjected to a significant risk from rainfall flooding. | The area is a rural/ rural residential area with approximately 30 established lots connected via unsealed roads. Located approximately 17km from the town site via a combination of unsealed and sealed roads. |



SOCIAL AND TOWN SITE FACTORS

SOCIOECONOMIC FACTORS

The current population of the Derby town site is approximately 3,261 people (ABS 2011). Derby has experienced a volatile socioeconomic history underpinned by changing government agendas and the boom bust nature of the mining and resource industries. The aspirational population growth target for next 20 years, as outlined by the Department of Planning, Kimberley Regional Planning and Infrastructure Framework, is set at a 4% Average Annual Growth Rate (AAGR). This must be mediated and understood in the context of the 30-year historic AAGR of 1.2% and the WA Tomorrow average forecasting of a -0.3% AAGR. The anticipated future growth of Derby rests on the development of economic drivers, outlined within the Shire's Local Planning Strategy as being:

- Oil and Gas Sector: Exploration of oil and gas resources in the Browse Basin;
- Mining: Associated with Iron Ore, Diamonds, Lead & Zinc, Coal, Salt and Rare Earth; and
- Tourism: Associated with continuation and development of offshore and hinterland activities.

As it currently stands, a significant percent of the population is employed within the public sector. The top three major industries in Derby comprise school and education, hospitals and public order and safety services. The population demographics of Derby as captured within the 2011 ABS, outlines the majority of the population is between the ages of 20 – 65 years old (60%), followed by young people (33%) and a small population of people over 65 (7%). In addition, Derby has a high percentage of Aboriginal people (37%) in comparison to the State average.

In terms of housing tenure, significantly less people within Derby either own (16.3%) or are purchasing (18.6%) houses in comparison to the State averages (29.5% and 37.8% respectfully). Nearly 60% of people living in Derby have some provision of rental support. A significant portion of houses in Derby are owned either by investors (many of which do not reside in the town site), or government/ not-for-profit agencies providing staff accommodation and/ or social housing.

TOWN SITE LAYOUT

The current distribution of land uses within the study area is prescribed under the Shire's Town Planning Schemes (TPS5 and TPS7), with future land use and development outlined within the Local Planning Strategy (LPS). The main town centre is located on the northern most tip of the peninsula, which is adjoined further south by predominately residential zoned land and further afield by a mixture of predominately residential, rural residential and industrial zoned land. The main entry into the main town site is via Derby Highway which roughly divides the town site northwest – southeast. The Wharf Area is located further northwest of the town site approximately 2km across the surrounding mudflats.

Apart from the northern tip of the peninsula and the Kimberley Entrance Caravan Park located immediately south of the town centre, the majority of the town site is fringed with public reserves for the purpose of 'Parks and Recreation'. There is an approximately 2km portion of the eastern coastal fringe reserved as 'Settlement' and occupied by four Aboriginal communities. The Community Layout Plan (CLP) endorsed over these communities allocates an area for 'Open Space/ Recreation' between existing development within these communities and the surrounding mudflats. As such, the majority of the land fringing the Derby town site is vested as a pseudo coastal foreshore reserve ensuring that future land use and development will be at the discretion of the Shire Council.

Future growth as outlined within the LPS is generally consistent with the current town layout as outlined within Figures 3 and 4 below. While the town site layout will remain relatively consistent, the LPS outlines actions to increase residential density in key areas across the town site. The anticipated growth identified within the LPS for various land uses has been summarised within Table 4 on the next page.

Table 4 - Current and Anticipated Land Use.

| Land Use | Current Provision | Anticipated Provision (2021) |
|-----------------|---|---|
| Residential | Approximately 1,447 developed and undeveloped lots with predominately low density dwellings (~105ha). | Approximately 51 new dwellings proposed through a mixture of infill and greenfield development. |
| Industrial | Approximately 66 developed and undeveloped lots (~70ha). | Capacity within existing lots, subject to land assembly and land clearance. |
| Commercial | Approximately 163 developed and undeveloped lots, some of which have been developed with non-commercial uses (~29ha). | Capacity within the existing Town Centre area to cater for all foreseeable demand. |
| Public Reserves | There is a variety of formalised parks, coastal foreshores and recreation facilities cross the town site under Shire management (~7,930ha). | Sufficient land currently provided, with increased land consistent with new urban development. |

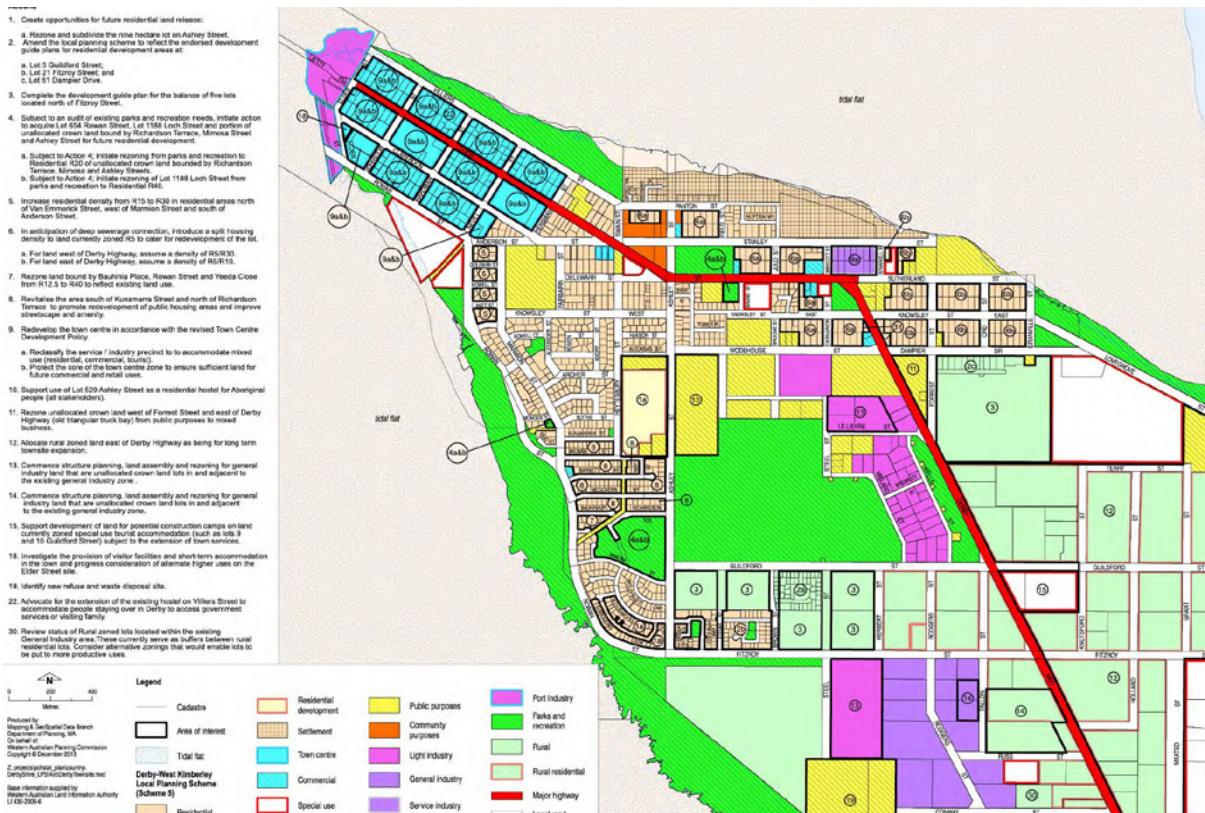


Figure 8: Future Direction for Derby Town Site (Source: Shire of Derby / West Kimberley Local Planning Strategy, 2013).

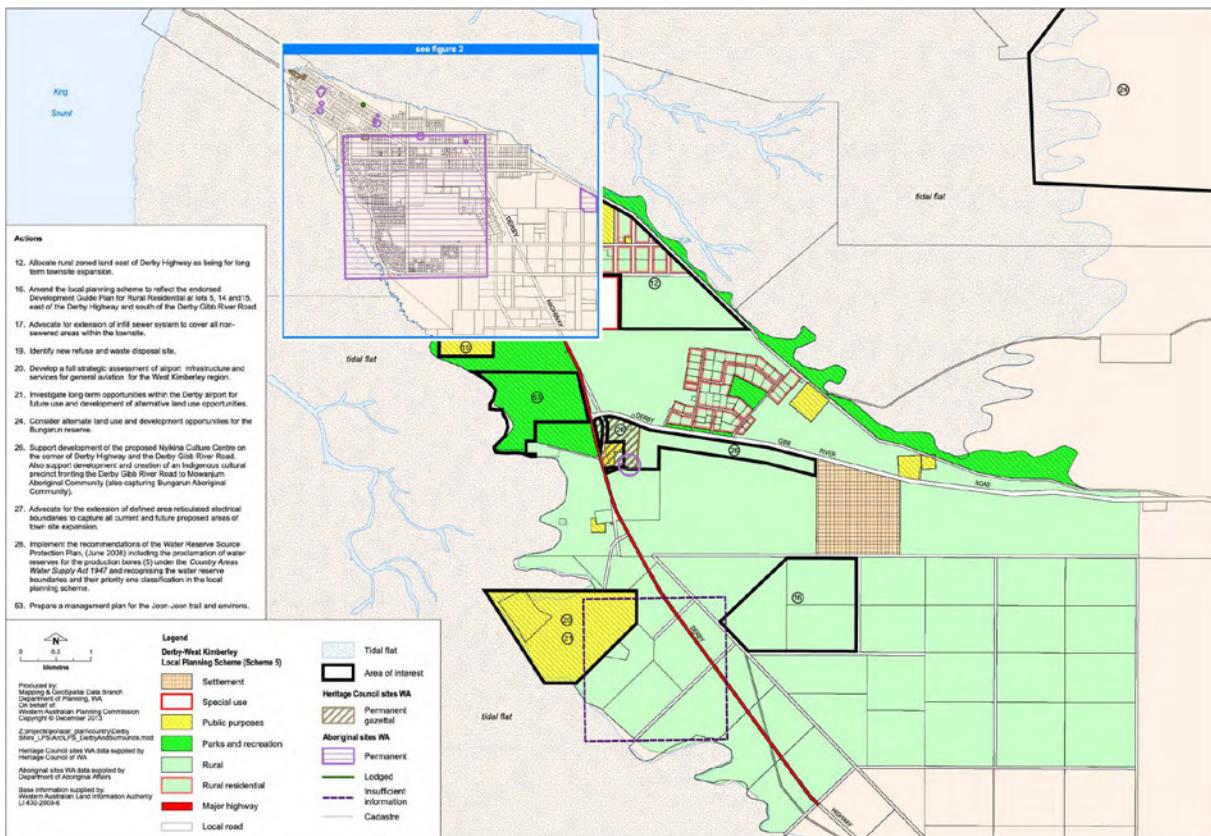


Figure 9 - Future Direction for Wider Derby Town Site (Source: Shire of Derby / West Kimberley Local Planning Strategy, 2013).

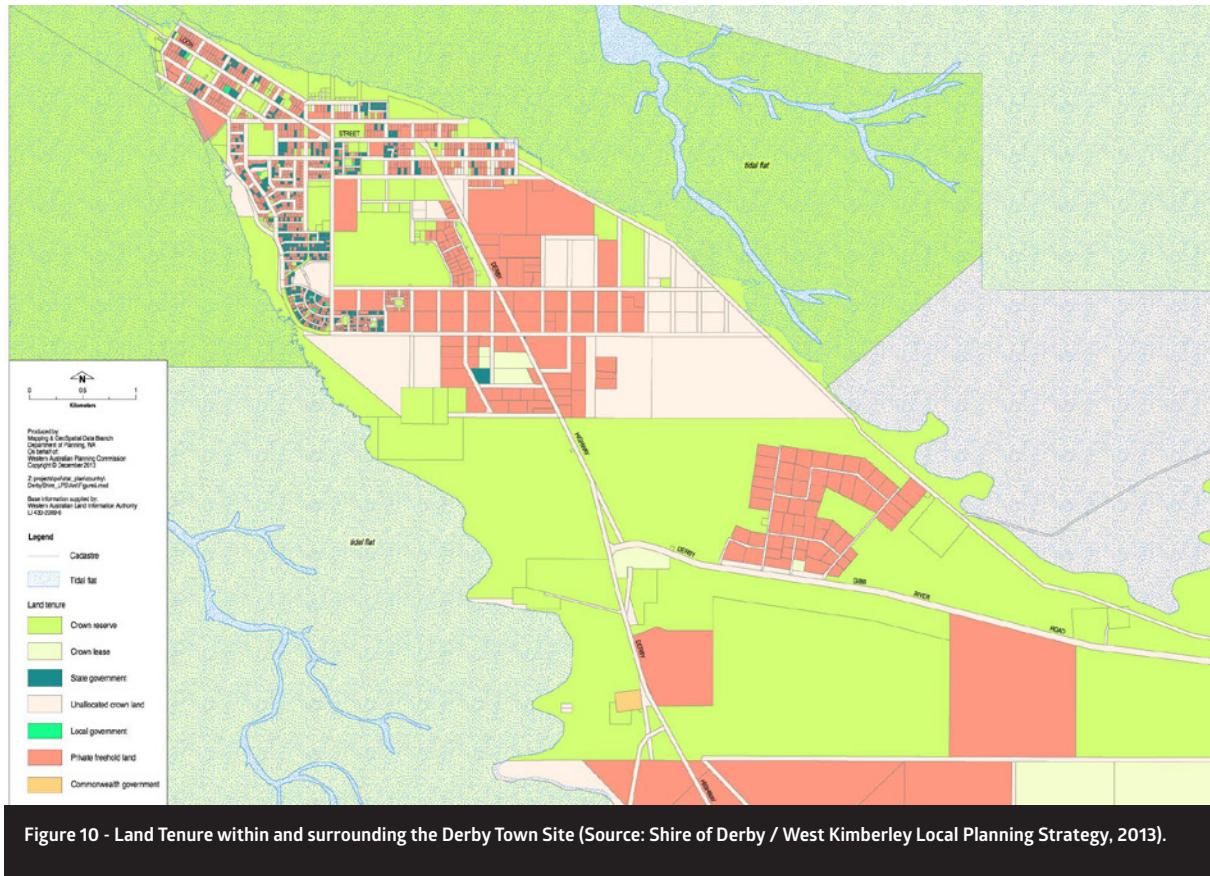
LAND TENURE

Land across the town site comprises a mixture of Freehold and government owned land, with a large amount of residential properties owned by the State Government. Outside of the main developed area of Derby which comprises approximately 960ha, the surrounding undeveloped land is almost entirely comprised of Crown reserves and Unallocated Crown Land.

In addition to identified densification within the main town site, long-term growth will generally occur in a south-easterly direction as demand arises. As such, land has been allocated for future residential and industrial development (Figures 3 and 4 above) which will require significant land assembly and investigation including detailed structure planning, assessment of

Aboriginal heritage clearance, Native Title resolution and other servicing investigations. There are currently two Native Title Claims which include the town site area, namely the Warrwa Combined Claim (WC2014/004 – WAD258/2012) and the Boorroola Moorrol Moorool Claim (WC2016/005 WAD598/2016).

Any greenfield development outside of the main town site area is relatively constrained due to either land ownership, title and/ or servicing knowledge. Figure 5 below illustrates the various land tenure arrangements for land within and surrounding the main town site.



ASSETS

In addition to the various form of land holding, there are a range of assets with the study area. For the purposes of this CHRMAP, three broad categories of asset have been identified. These categories have allowed the community to consider current asset values and potential loss of asset values as a result of potential coastal hazards. A description of each of the asset categories is identified in Table 6 below, with the full range of assets exposed to coastal hazards identified within Table 11.

Table 5 - Types of Assets within the Study Area.

| Asset Category | Description |
|------------------|---|
| Economic | <p>These assets provide a range of services to the local community including; employment; essential services; transportation and economic development (e.g. tourism). Loss of these assets will cause potential disruption to business and individual income and loss of essential services. Long term loss would negatively impact on the tourism industry.</p> |
| Social/ cultural | <p>These assets support the livelihood of local people and visitors and provide historic/ cultural connection to the place.</p> <p>Loss of these assets will cause potential loss of housing and social activity within the town. These will cause social unrest and angst from local residents if not appropriately addressed.</p> |
| Environmental | <p>These assets are the nature features with the study area. They comprise the wide range of flora and fauna habitats. These include any rare or threatened species and important geomorphic features.</p> <p>Loss of these assets will result in the loss of habitats and potential loss of amenity. Long term loss could see changes to the natural coastal processes impacting the study area.</p> |

ENVIRONMENTAL FACTORS

GEOLOGY AND LANDFORMS

The King Sound, a drowned river valley, is characterised by a deeply incised bay framed by rocky headlands and surrounded by archipelagos and reefs. The estuary surrounding the study area is characterised within the CVS as a tidally-dominated delta with highly seasonal discharge, allowing the tide to penetrate a considerable distance upstream.

The King Sound embayment has extensive tidal mudflats and mangroves that are gently sloping with an absence of waves except under extreme cyclonic conditions (WA Coastal Planning and Management Manual 2010). In the application of SPP2.6, the shoreline of King Sound, and more specifically the study area, is described as a Coastal Lowland, characterised as follows:

Coastal lowlands typically feature flat to gently sloping shores often containing high percentages of finer sediments. In contrast to sandy coasts the landforms are generally the result of the historic geologic advance of a deltaic or outwash plain. The near shore environment often comprises tidal flats, salt marshes or mangroves. In many locations where there is an availability of sediments, a chenier plain or storm ridge may be present. These shorelines are strongly influenced by inundation and tidal processes.

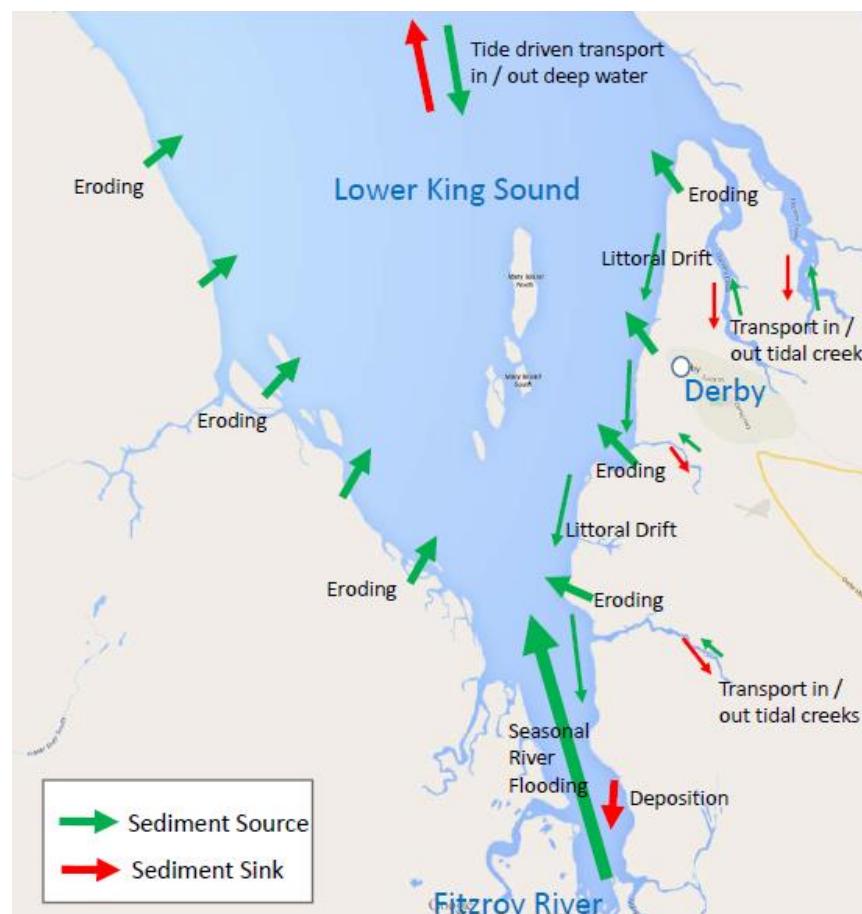
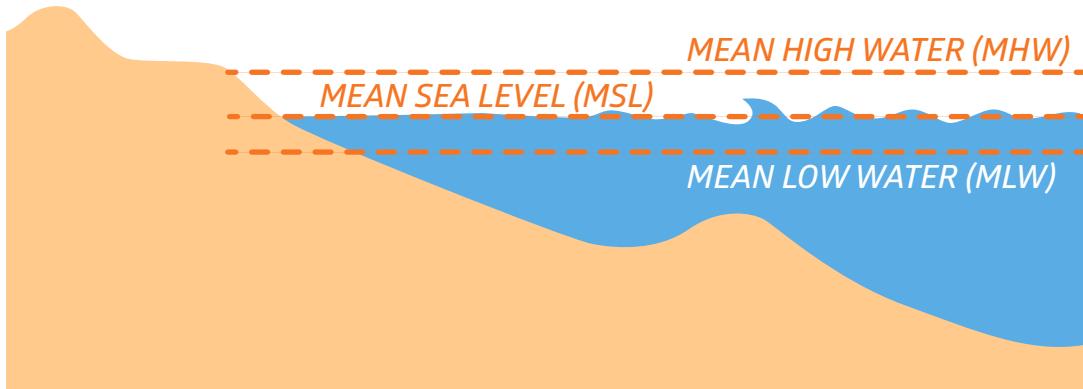


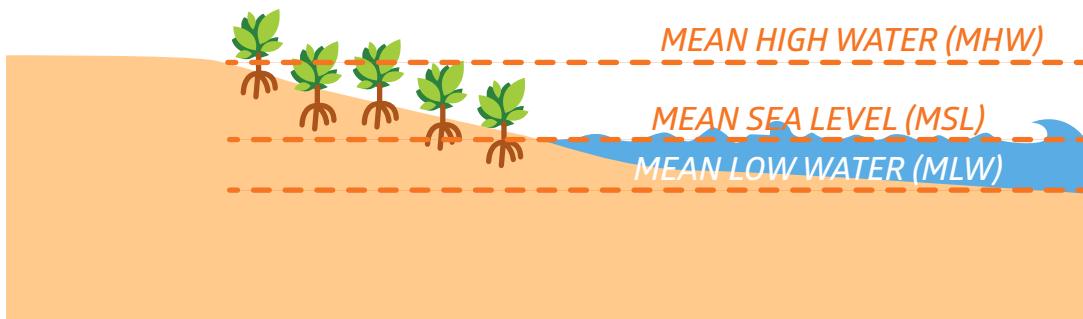
Figure 11: Conceptual Sediment Budget Diagram of the King Sound based on Semenuik Studies (Source: Derby Shoreline Stability Assessment, 2015).

SANDY BEACH SYSTEM



Sandy Beach systems are characterised by a foreshore area with a backshore area, generally comprising a sand dune). The foreshore area compensates the tidal movement with the backshore exposed under coastal hazard events resulting in 'storm bite'.

MANGROVE SYSTEM



Mangrove systems are usually fronted by a tidal flat and are generally characterised with a very flat and monotonic slope profile.

Figure 12: Typical Profiles of a Sandy Beach System and Mangrove System (Source: Wave Attenuation & Erosion Reduction: Coastal Protection, 2014)

MANGROVES

There are two different shoreline areas to consider within the study area. The shoreline around the Derby town site is sheltered by mangroves and extensive mudflats, and is rarely subjected to tidal inundation and wave action. Meanwhile, the shoreline around the Wharf Area lies adjacent to the mangrove communities and is subject to significant tides and some limited wave action. The following description of mangrove ecosystems and their existence within the study area has been taken directly from the CVS Report:

Mangrove ecosystems have an important role in shoreline stabilisation and protecting coasts from extreme weather and tsunami damage through binding

marine and terrestrial sediments, reducing coastal erosion and limiting the extent of wave intrusion (Massel et al. 1999a, 1999b; Badola and Hussain 2005; UNEP-WCMC 2006; McIvor et al. 2012). Within the King Sound region, mangroves are present along 84.6 % of the coastline (273.8 km). (Duke et al. 2010).

Through comparison of aerial photography between 1949 and 1977, Semeniuk (1994) showed that the entire mangrove belt in King Sound was migrating landward, and generally keeping pace with the retreat at the seaward edge. Semeniuk (1994) suggests that future sea level rise within the King Sound region would most likely result in the migration of mangroves, with similar composition and structure, into the new habitats formed by increased inundation.

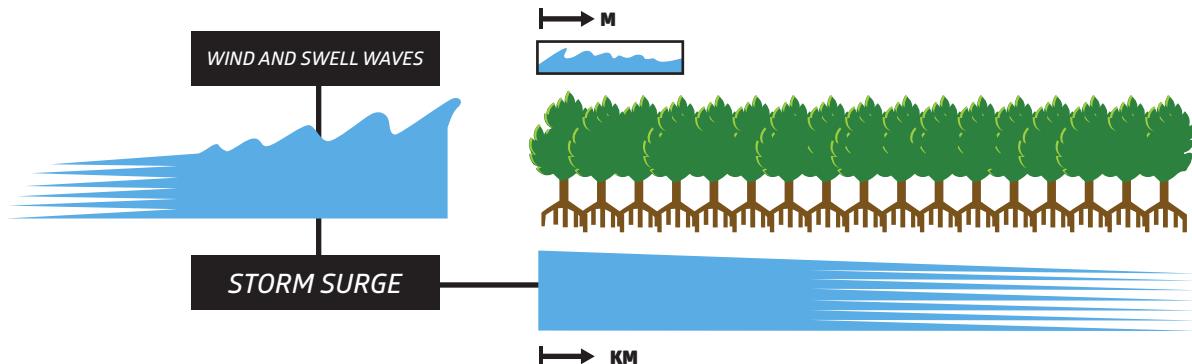


Figure 13: Protective Mangrove Qualities in Reducing Waves and Storm Surge (Source: Mangroves for Coastal Defence, 2014)

In light of the above, the surrounding mangrove ecosystems provide an important role in mitigating the full extent of potential coastal processes on the Derby town site, whereas the Wharf Area, which lies adjacent to these ecosystems, receives much less protective benefit. As the mangroves are migrating with the shoreline, which is a long term process, the natural loss

of this ecosystem is not expected to increase the impact of coastal hazards on the Derby town site within the 100-year planning timeframe. However, should these mangrove communities be destroyed and/ or removed, this could result in an increased coastal impact on the Derby town site. This impact should be understood prior to any removal of mangroves.



Figure 14: Impact of Sea Level Rise on Mangroves (Source: Proceeding of the Symposium on Mangrove Response to Relative Sea-Level Rise and Other Climate Change Effects, 2006).

CLIMATE FACTORS

The local climate is characterised by warm dry winters and hot wet summers, generally referred to as the 'wet' and 'dry' seasons. The 'dry' season is generally characterised by warm and stable conditions. However, the 'wet' is conversely characterised by hot and unstable conditions. During the 'wet' season the region

experiences significant rainfall and storm conditions generated by low pressure events and tropical cyclones. These storm events generate storm surge and fluvial inundation which result from strong winds and heavy rainfall. In addition, the tidal range at Derby is the highest of any Australia port. The largest difference between high tide and low tide occurs during spring tides, with an approximate difference of 9.6m.

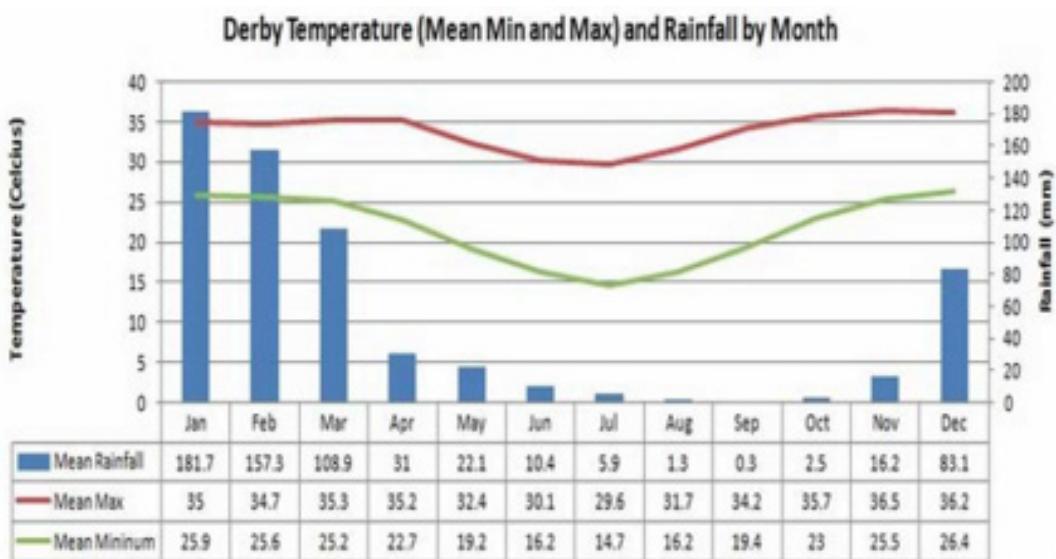


Figure 15: Monthly Climate Statistics for Derby, taken from Kimberley Development Commission (Source: Derby Storm Surge and Coastal Inundation Assessment, 2015).

As outlined within the CVS, the joint probability of these contributing factors presents a complex environment in understanding coastal hazards within the study area. While cyclonic events pose a significant threat to the

assets, the study area is provided relative protection due to its location within the King Sound, low joint probability of contributing factors, large tidal mud flats and the extensive mangroves communities.

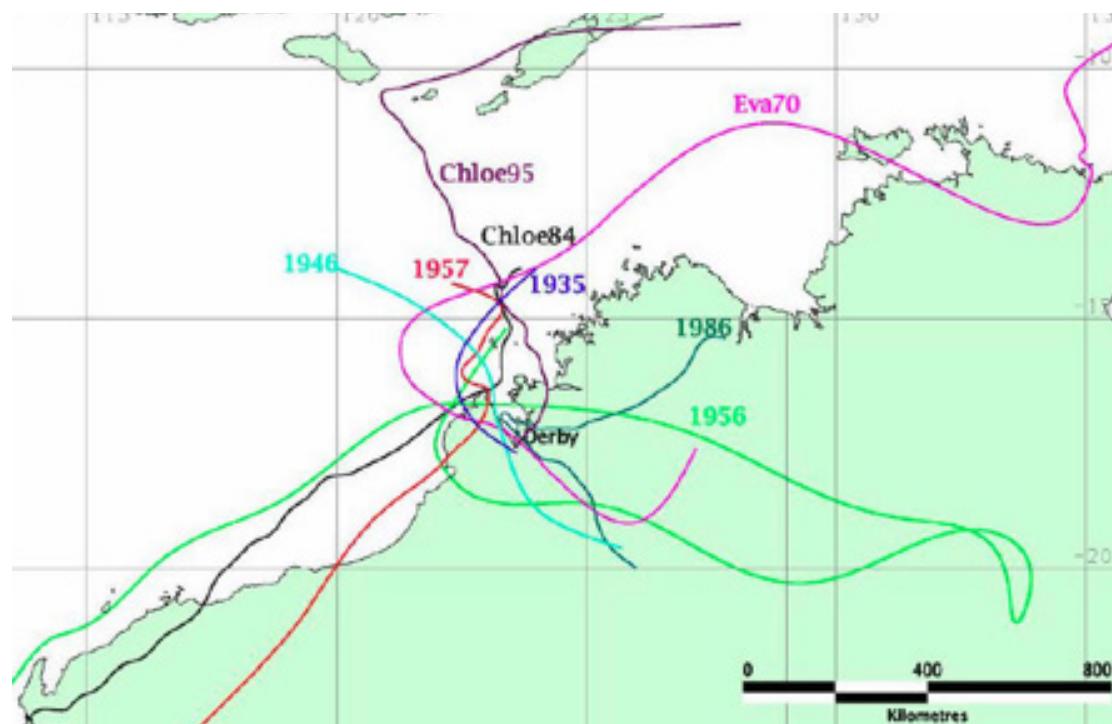


Figure 16: Historical Tropical Cyclone Tracks within 200km of Derby, taken from the Bureau of Meteorology (Source: Derby Storm Surge and Coastal Inundation Assessment, 2015).

GOVERNANCE AND MANAGEMENT

The Shire provides a number of services to the local community comprising a mixture of reactive and proactive functions. The reactive functions include a range of ongoing municipal services in respect to the current population and environmental conditions. Proactive functions are services which understand the future growth/ decline of the economy and/ or population, changes in environmental knowledge and look to develop recommendations and strategies. Due to the small size of the municipality, the Shire has limited resources and finances under its administration to facilitate either reactive or proactive services.

There are generally two types of assets within the Shire's municipality, public assets and private assets. The Shire in most cases has the responsibility to manage and maintain public assets for enjoyment of the wider community. In addition, there are a number of essential service assets managed by respective State Government agencies. In terms of private assets, the Shire guides land use and development in order to maintain public safety and wellbeing. Management and adaptation responses developed within this CHRMAP have considered the Shire's governance and management responsibilities including the:

- Ongoing management of public assets;
- Notification of potential hazards to the wider community; and
- Informed and transparent decision-making in terms of land use and development.

The Shire's responsibilities to undertake any addition management and adaptation actions need to be considered in terms the Shire capability and capacity. The following provides a brief explanation of current Shire responses to address coastal hazard risk.

ASSET MANAGEMENT

The Shire has developed a number of different asset management plans for key infrastructure, housing, roads and recreation facilities. Across these documents is an agreement that global warming presents an increased

risk of flooding within the town site with the potential for significant loss. However, the current asset management documents do not identify any strategies or actions, nor do they quantify the extent of potential impairment. The Shire is currently undertaking a holistic review of the corporate planning framework, including their current asset management plans. Therefore, this CHRMAP needs to inform the develop of the Shire's asset management methodology and approach rather than develop a detailed schedule of works.

PLANNING AND BUILDING

Due to the limited experience of historic coastal hazards and low widespread community concern, the Shire has never prepared any shoreline and/ or coastal management plans. In addition, the Shire's Town Planning Scheme No. 5 (TPS5) and Local Planning Policy framework do not currently outline any coastal hazard prone areas within the Derby town site. However, in respect to orderly and proper planning, TPS5 provides coastal buffers through 'Parks and Recreation' reserves along the majority of the shoreline. The Shire is currently undertaking a local planning scheme review which provides the opportunity to include provisions to inform responsible decision-making in terms of land use and development in areas affected by coastal hazards.

EMERGENCY MANAGEMENT

The Local Emergency Management Committee (LEMA) is represented by multiple agencies and authorities including the Shire, volunteer organisations, emergency response agencies and facility/ asset managers. The LEMA identifies a full range of risks likely to occur within the Shire in compliance with AS: NZS ISO 31000:2009 – Risk Management Principles and Guidelines. This approach is consistent with the methodology outlined with SPP2.6 and applied with this CHRMAP.

STAKEHOLDERS AND ENGAGEMENT

A consultation strategy was prepared to guide communication with the community and affected stakeholders. The approach adopted aligns with SPP2.6 and the Coastal Guidelines. The stakeholder analysis outlined a total of 32 specific stakeholder groups including government agencies, property/ business owners, local residents and community groups. These stakeholders were then analysed and grouped in order to determine appropriate communication mechanisms. A description of these stakeholder groups are outlined in Table 6 below.

Table 6 - Identified Stakeholder Groups.

| | Internal | External |
|--------|--|----------|
| High | Directly impacted by the project as asset/ landowner, or responsibility to make decisions on project direction and outcomes. | |
| Medium | Directly impacted by the project by the need to consider project outcomes as part of existing service delivery. | |
| Low | Directly impacted by the project by the need to administer policies and convey information to the community and stakeholders on delivery of the project. | |
| High | Directly impacted by the project by owning an affected property and/ or asset, or may have a high level of interest in a natural/ cultural feature. | |
| Medium | Directly impacted by the project by owning an affected property and/ or asset affected but is exempt from the Shire provisions. | |
| Low | Not directly impacted by the project but may have a general interest/ concern. | |

Prior to commencing the community and stakeholder engagement, it was anticipated there could potentially be low community interest, concern or knowledge of the project. As such a risk analysis was undertaken to determine potential barriers preventing community and stakeholder involvement and make recommendations to limit these risks. A summary of the key communication tasks undertaken and the anticipated outputs from the community consultation are outlined within Table 8 below.

Table 7 - Communication Tasks and Outputs.

| Key Tasks | Anticipated Outputs |
|--|--|
| Presentation to Council accept completion of Coastal Vulnerability Study (CVS) and the need to undertake CHRMAP. | Council acceptance of CVS and commitment to proceed with CHRMAP. |
| Presentations to Council on the proposed CHRMAP methodology and approach. | Council acceptance of methodology, including the identification of any gaps and/ or fatal flaws. Council advocacy of the project to wider community. |
| Advertising and communication (directly approach key stakeholders) of the CHRMAP including opportunities for involvement. | Widely notify community and stakeholder of the CVS outcomes, the purpose of the CHRMAP and the consultation opportunities. Notification was undertaken through, Shire website and Facebook, community notice boards, postal delivery and direct approach to key local stakeholders and residents. |
| One-on-one interviews via telephone and in person and multi stakeholder interviews and follow up discussions via email, telephone and in person. | Provide both private and public opportunities for various stakeholders to clarify their value of assets, acceptance of the identified risk, proposal of adaptation measures. Following formal workshops, opportunities were provided to discuss concerns, information gaps and or possible adaptation measures. |
| Presentation of draft CHRMAP to Council and public advertising of draft CHRMAP. | Provide formal public opportunity to review the inputs and outputs of the CHRMAP, specifically the proposed adaptation measures. |
| Presentation of final CHRMAP and public advertising of draft CHRMAP. | Provide opportunity for the public to review the amendments made to the CHRMAP following additional public comment. |

COMMUNITY ATTITUDE

While best endeavours were made to mitigate potential barriers for community participation, there was a limited level of engagement achieved through the project. While there was representation from the local community and stakeholder groups, this represented less than 1% of the local population. While this level of engagement is low, it is not surprising considering the population characteristics within Derby. The factors contributing to the low level of interest and/ or concern from the local community is understood to be influenced by:

- The limited extent of the potential coastal hazards identified within the CVS and the respective limited number of properties potentially impacted;

- A general mistrust/ disbelief of the technical studies in respect to local experience and historic knowledge of coastal impacts; and
- The significant transient population in Derby comprising seasonal workers and/ or government contracted workers with limited vested interest in the town.

However, there was a small minority of the population concerned about the level of potential coastal risk posed to Derby. In addition, due to a number of social barriers it is considered that there is an additional percentage of the population who were not able to be reached within the scope of community consultation. In light of all of the above, ongoing commitments need to be made to ensure ongoing community engagement and awareness



SUCCESS CRITERIA

The successful completion of this CHRMAP will result in the development of management and adaptation measures with a clear approach to implementation. The implementation will focus on the immediate/ short terms actions required to reduce and/ or maintain hazard risks at an acceptable/ tolerable levels. In addition, as required under SPP2.6 and the Coastal Guidelines, actions over the entire 100-year planning frame will be considered. To ensure that management and adaptation responses are developed with respect to the range of local factors, specific success criteria have been articulated. A description of these success criteria as they relate to specific local factors is outlined in Table 8 below.

Table 8 - Project Success Criteria.

| Local Factor | | Success Criteria |
|--------------|--|---|
| 1 | Local concern with potential limitations for growth of Derby by the imposition of the State Planning Policy Framework. | Ensure the State Planning Policy Framework does not negatively impact future growth of Derby. |
| 2 | Limited guidance within the State Planning Policy Framework to consider the unique local environment. | Develop and implement a program of ongoing monitoring/ examination through a multiagency approach to ensure future decision making is reflective of local factors, and informs a review of the State Planning Policy Framework. |
| 3 | Low level of community knowledge and acceptance. | Ensure community knowledge and awareness is developed through ongoing community consultation. Increase the current level of community knowledge prior to proposing any major adaptation works. |
| 4 | Limited Shire resources and revenue. | Ensure the level/ experience of Shire resources is incorporated into the determination of proposed actions. |
| 5 | Available funding/ grant opportunities available to undertake coastal planning and implement adaptation actions. | Identify funding opportunities to ensure specific adaptation actions, monitoring and further investigation can be undertaken as required and prior to coastal hazards impacting becoming intolerable. |
| 6 | No existing controls in place to consider development and use within areas potentially at risk of coastal hazards. | Ensure a transparent and equitable approach is undertaken in developing a mechanism to guide land use and development decision making. |
| 7 | Shire currently developing holistic Asset Management Plan. | Ensure identified coastal hazards are considered within ongoing strategy development and asset management processes, including the Strategic Community Plan and Asset Management Plan. |

IDENTIFY

HAZARD IDENTIFICATION METHODOLOGY

The Coastal Guidelines outlines that the risk identification process should establish an understanding of the historical and potential impacts of erosion and storm surge inundation on assets and their values, including the additional impact from sea level rise.

The technical assessment of coastal hazard impact within the study area over the 100-year planning timeframe was undertaken through the CVS in 2015. The sources of the identified coastal hazards include the joint probability of the astronomical tide and tropical cyclone occurrence, the timing of peak flows from the Fitzroy River, and the resultant storm tide, potential wave action and the effect of projected climate change. The importance of joint probability occurrence in defining the nature of coastal hazards within the study area is summarised within the CVS as follows:

SPP2.6 provides the framework for assessing ocean inundation, erosion and flooding in this cyclone prone region. While this policy recommends a scenario based mechanism to assess inundation levels as a minimum requirement, in this study we develop a stochastic based risk assessment particularly for the ocean water levels in order to capture the complex joint probability between the occurrence of the tide and storm surge, and also the probability of cyclone tracks and intensity in this region which experiences relatively few tropical cyclone events.

The scope of works undertaken within the CVS are consistent with Schedule One of SPP2.6. The CVS was undertaken through three technical studies, which were then compiled into a final report. The purpose and outcome of each technical study is outlined within Table 10 below.

Table 9 - CVS Technical Studies - Purpose and Outcomes.

| Technical Report | Purpose | Outcome |
|---|---|--|
| Storm Surge and Coastal Inundation Assessment | Establish, calibrate, validate and apply tropical cyclone and ocean modelling systems simulating winds, tidal movement, storm surge and waves. | Details the coastal process component comprising extreme water levels in accordance with SPP 2.6 in consideration of the joint probability of storm surge and astronomical tide. |
| Shoreline Stability Assessment | Calculation of costal erosion/ recession processes over the planning timeframe, including of historical change in sedimentology, geomorphology and vegetation and allowance for future SLR. | Mapping of the coastal erosion allowance over the planning timeframe in accordance with SPP2.6. |
| Derby Flood Modelling Report | Establish, calibrate and apply combined hydraulic/ hydrological modelling including over land inundation, river flow, ocean water design levels and SLR. | Mapping of the prescribed design storm events for local inland inundation and coastal inundation, (including the Fitzroy River flow) in accordance with SPP2.6. |

The final outcome of the CVS is the development of coastal process allowances for erosion and inundation over the 100-year planning timeframe. This has been presented across three climate change scenarios to demonstrate the increasing risk over the short, medium and long term. In addition, an additional scenario was presented highlighting a 1.5m SLR for the 2110 planning period. While this exceeds the requirements under SPP2.6, it is a useful benchmark moving forward should current climate change predictions increase.

COASTAL PROCESSES

This CHRMAP addresses the identified coastal inundation and coastal erosion processes as they relate to the social, economic and environmental assets within the study area. In determining the extent of coastal erosion and inundation, the CVS analysed a range of oceanographic and climatic influences in combination with local geomorphology and vegetation.

The following outlines the identified source coastal processes contributing towards storm inundation and erosion/ accretion as examined within the CVS. The extent of long term inundation and coastal recession is then determined with the inclusion of climate change and associated sea level rise.

WAVE ACTION AND STORM SURGE

The CVS outlines three contributing factors to the generation of waves within the northwest shelf of Western Australia; Indian Ocean swell, locally generated wind and tropical cyclones. However, the protective nature of the King Sound and the extensive mudflats means that there is an absence of waves at the study area except under extreme cyclonic conditions. While cyclonic activity poses a significant threat in the region, the narrow entrance and geography of the King Sound reduces the likelihood of extreme cyclone threat on the study area. In addition, the limited fetch (e.g. length) of the King Sound means long period swell and wave setup are not contributors to extreme water levels at the study area.

In relation to the two different shorelines within the study area, the CVS outlines specific impacts experienced at each shoreline, outlined as follows:

WHARF AREA:

Generally, the Derby port location experiences minimal direct wind-wave action due to the short fetch length across the King Sound in the alignment of the predominant seasonal wind direction, combined with the very shallow bathymetry. However, during the wet season, persistent north-westerly winds can generate limited wind-waves at the Derby port location.

TOWN SITE AREA:

The Derby town site is provided increased protection from wave action and storm surge due to the mangrove communities and the long flat tidal mudflats. Potential waves impacting the Derby town site are considered to be a result of local wind set-up resulting from the storm activity, which would be small due to shallow water depths across the mudflats and the resulting energy loss from bed friction.

Depth across the tidal flats surrounding the town is in the range of 0.4 m to 0.6 m for the 1 in 100yr event. The waves reaching the shoreline around the town would be depth limited, and based on a wave height to depth ratio of 0.5, the wave heights on the shoreline around town would be up to 0.3 m.

TIDES

The astronomical tide is a key component in determining the storm water level, as the phasing of the tide relative to the peak storm surge is critical factor. While the Fitzroy River flow does have the potential to affect peak steady water levels at the study area, the key water depth influence at the study area is tidal.

While the Wharf Area is subject to the significant tides of the region, the shoreline around the Town Site Area is rarely subjected to tidal inundation and wave action. While the study area appears relatively protected from coastal processes associated with extreme weather events, there is a joint probability for a significant impact. However, the very low probability of this event places it outside of the design storm events identified within SPP2.6. While outside the scope of SPP2.6, the CVS provides as example of a worst case scenario impacting the study area:

A worst case scenario may involve an intense cyclone making landfall south of the town at a distance that directs the maximum winds of the cyclone along the long axis of King Sound, with the peak surge coinciding with spring high tides and floodwaters from the Fitzroy River. The probability of such a joint occurrence is very low.

IDENTIFIED COASTAL HAZARDS

INUNDATION

Inundation at the study area has been determined using the approach outlined with SPP2.6 being the extent of storm inundation for the 1 in 500-year ARI event, defined as the peak water level plus wave run-up. The assessment of inundation at the study area requires assessment of tropical cyclone impacts (including storm surge, strong winds and reduced atmospheric pressure), astronomical tide, fluvial inundation from the adjacent Fitzroy River and local rainfall. In addition, sea level rise needs to be included to understand inundation over the 100-year planning period. The CVS outlines that:

The very large tidal range, extreme rainfall and tropical environment presents a complex environment for the understanding of coastal inundation risk. While not as vulnerable as towns further south along the Western Australian coastline, the study site is exposed to tropical

cyclone impact, bringing potential storm surge and fluvial inundation due to strong winds and heavy rainfall.

The risk posed by these events is modified by the relative protection offered to the site due to the large tide range, which mitigates the potential for coastal inundation to exceed the highest astronomical tide levels.

The model results also demonstrate the additional protection provided by the mangrove area which have increased bed friction and dissipate energy, meaning that the storm tide water level decreases as it propagates through these sites.

Analysis of the model results also shows that contribution of the additional local wind forcing over the tidal flats to the final water level around the town site over and above the storm tide magnitude generated at the inundation model boundary is in the order of approximately 0.1 m.

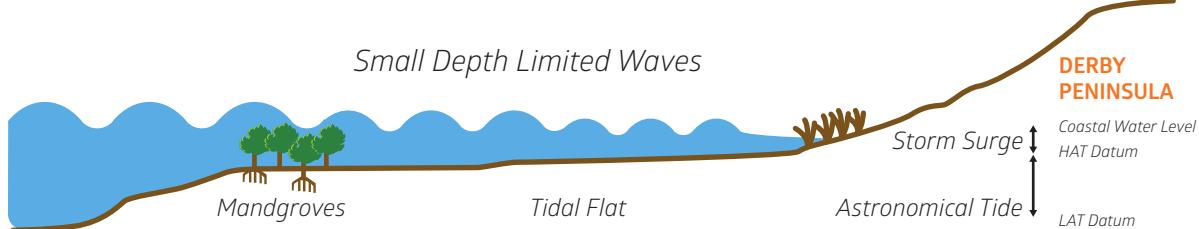


Figure 17: Schematic Diagram Illustrating Components of Coastal Inundation (Source: Derby Coastal Vulnerability Study, 2015).

EROSION

The coastal erosion allowance for the study area has been determined using the methodology outlined within SPP2.6. The approach outlined within SPP2.6 to determine coastal erosion on coastal lowlands is unfortunately limited, and recommends the application of the methodology determined for sandy coastlines. This is calculated as the sum of the factors of Storm Erosion (S1), Historic Shoreline Erosion (S2) and Sea Level Rise Erosion (S3) plus a 0.2 metre per year allowance for uncertainty. S required under SPP2.6, the 1 in 100-year ARI storm event has been adopted in determining erosion over the planning timeframe.

Establishing coastal erosion processes requires the determination of the Horizontal Shoreline Datum (HSD). The HSD is defined as the active limit of the shoreline, measured as the seaward shoreline contour representing peak steady water level under the design storm activity. The application of the HSD with the study area assumes the Wharf Area to be already impacted prior to the design storm events occurring. This is reflected in the mapping outputs from the CVS which depict the HSD located at the edge of the Derby Peninsula. As such, the consideration for coastal erosion processes in this CHRMAP only considers the Town Site Area.

STORM EROSION (S1)

Due to the fine sediment size within the study area, the methodology under SPP2.6 for calculating S1 resulted in a 40m default erosion allowance being adopted within the CVS. However, this was considered excessive in the context of the study area, where wave conditions

affecting the town site would be limited to locally generated wind sea constrained through the mangroves and extensive tidal mudflats. As such, additional analysis was undertaken through this CHRMAP to refine the S1 component. The justification provided within this re-analysis identified the following:

Under SPP2.6 coastal lowlands are assessed for current risk of storm erosion (S1) based on the methodology developed for sandy coasts. There is no recognition of the inherent differences that a coastal lowland area exhibits including that:

1. *Tidal flats such as those surrounding the Derby Peninsula limit the long period wave energy that can arrive at the shore, with wave energy dissipated in the expansive shallow region of the tidal flats offshore. Waves that arrive at the shoreline are largely the result of wind waves generated over the tidal flat, which are short period and depth limited.*
2. *Mangroves that exist on the tidal flats attenuate wave action and storm surge effects on the shoreline*
3. *A shoreline composed of fine sediments (e.g. clays and silts) is consolidated and responds very differently to unconsolidated shorelines such as those composed of sand when subjected to wave action*

The re-analysis of the S1 component was undertaken through a review of similar tidal environments and additional numerical modelling supported by the Department of Planning. As a result, the S1 erosion allowance has been reduced to 5m.

HISTORIC SHORELINE EROSION (S2)

The assessment of long term changes in the shoreline position was undertaken in the CVS through examination of the historical change in position of the vegetation line around the Derby Peninsula. The shoreline around the Derby Peninsula is surrounded by extensive mudflats which are rarely subjected to tidal inundation and wave action. The results of the analysis in the CVS showed that the Derby peninsula exhibits a stable shoreline, with no evidence of significant erosion. On the western side of the township, the shoreline has advanced seaward since 1949 and remained relatively stable from 1992 to 2014. On the eastern side of the township, there has been a progradation of vegetation since 1949, remaining relatively stable from 1992 to 2014.

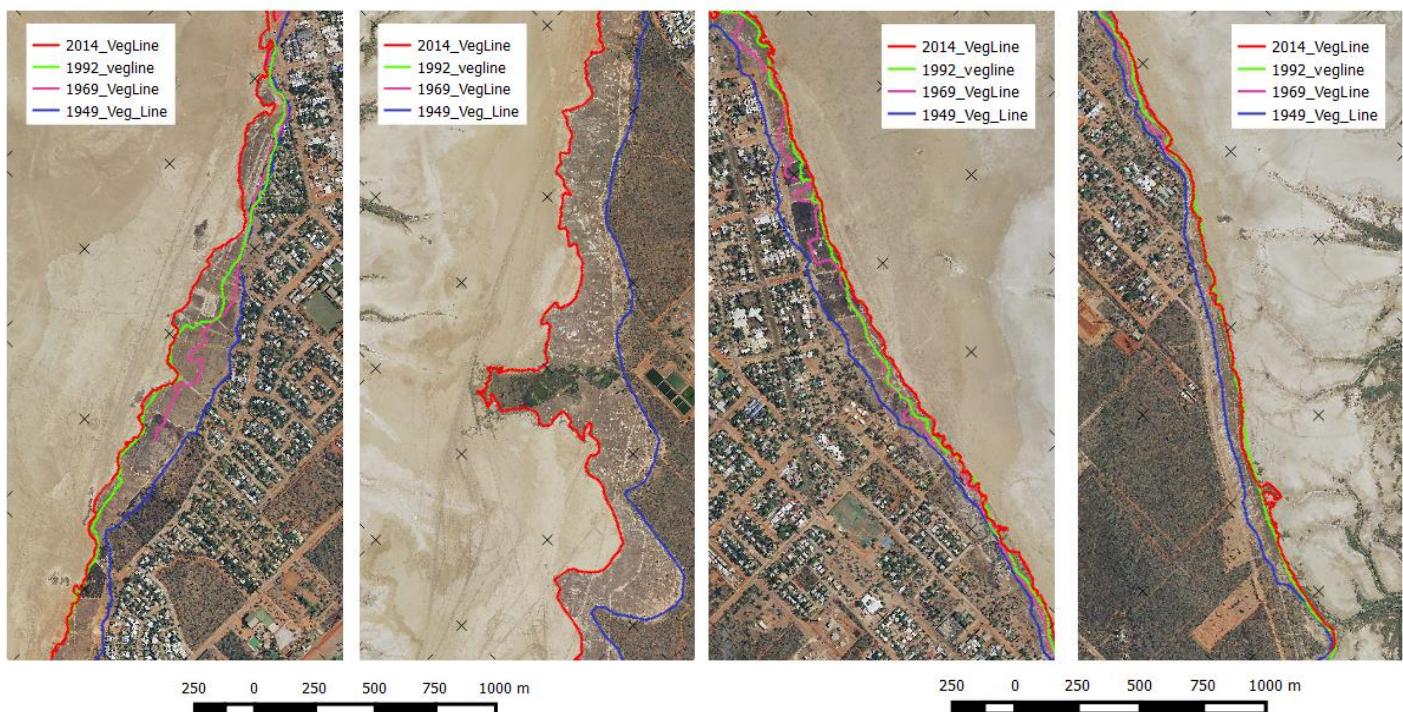


Figure 19: Shoreline Movement on the Eastern and Western Fringes of the Derby Town Site from 1949 - 2014 (Source: Derby Shoreline Stability Assessment, 2015).

In summary, the CVS determined the Derby town site shoreline has had no recession trend over the period of historical data. Under the recommendations within SPP2.6, a stable coastline should adopt an allowance of zero for the S2 component. Based on the historical aerial photography analysis undertaken within the CVS, the S2 component has been determined as 0m.

SEA LEVEL RISE EROSION (S3)

SPP2.6 requires that a vertical sea level rise of 0.3 m for 2060 and 0.9 m for 2110 be applied in the assessment of future coastal erosion allowance. SPP2.6 recommends the allowance for erosion caused by future sea level rise (S3) be calculated as 100 times the adopted sea level rise value. This factor is based on the Bruun Rule which is a recommendation under SPP2.6 for sandy coastlines, and principally derived for wave-dominated open coasts. The coastal processes and local environment within the

study area is characterised by a very large tide range, wide surrounding mudflats and mangrove areas, and a protected and generally flat shoreline profile. These are considered to provide a considerably different response to that of a wave-dominated open coast. The technical position presented within the CVS outlines the inappropriateness of applying the Bruun Rule in the context of the study area as follows:

Baird would argue that the Bruun translation of the shoreface does not hold in this environment, as cross-shore sediment transport pathways due to wave transport are not dominant. Instead, it is expected that projected sea level rise would result in no translation and associated erosion, just inundation corresponding to the magnitude of the sea level rise. However, the SPP2.6 recommendations is adopted in the calculation of the S3 component in this study.

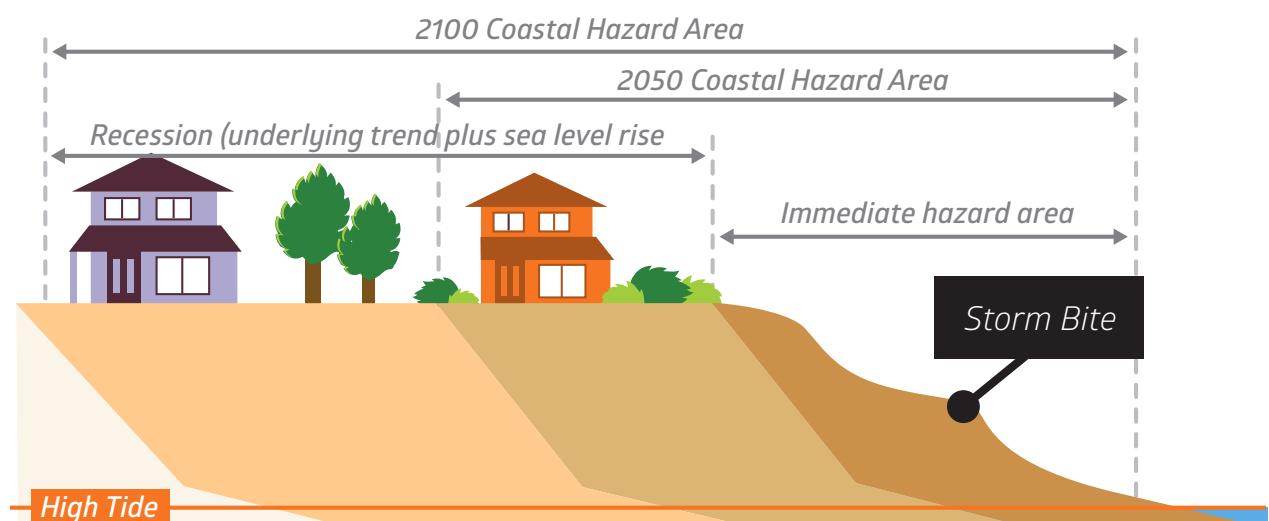
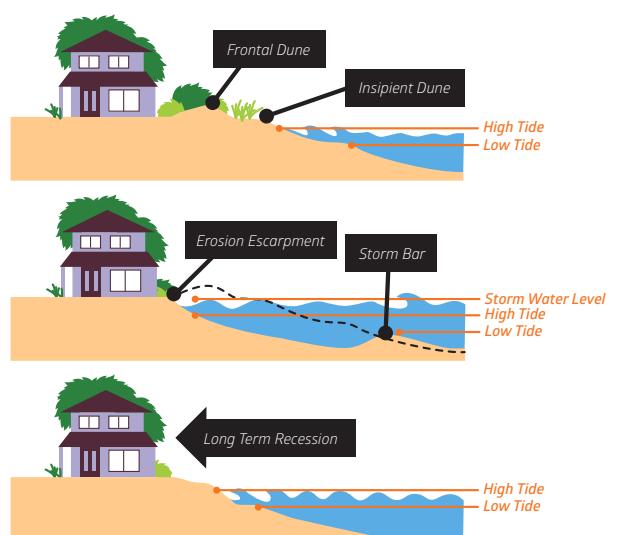


Figure 19: Schematic of Short and Long Term Coastal Recessional derived from a Sandy Coast System (Source: WMA Water, 2016)



While the S3 component as presented under SPP2.6 is not suited to the context of the study area, the scope of works identified within the CVS did not allow development of a locally specific modelling for coastal erosion related to sea level rise. It was generally accepted during the CVS that the S3 component as outlined within

SPP2.6 be adopted, with further assessment undertaken through the analysis of consequence and likelihood in the CHRMAP. The following table provides a summary of the coastal erosion allowance under each of the climate change scenarios as outlined within SPP2.6.

Table 10: Extent of Coastal Erosion under SPP2.6 over the Planning Timeframe.

| Component | Present (2010) | Medium Term (2060) | Long Term (2110) |
|--------------------------|----------------|--------------------|------------------|
| S1 – Storm Erosion | 5m | 5m | 5m |
| S2 – Long Term Recession | 0m | 0m | 0m |
| S3 – Sea Level Rise | 0m | 30m | 90m |
| Uncertainty | 0m | 10m | 20m |
| Total | 5m | 45m | 115m |

EXPOSURE

As a result of the CVS, a series of coastal hazard maps were produced to illustrate the extent and expose of assets within the study area to potential coastal erosion and coastal inundation within the present (2015), medium (2060) and long term (2110) time scenarios. The exposure of assets under coastal inundation and erosion have been mapped separately and a copy of these maps is included within Appendix 1 of this CHRMAP.

The full range of assets exposed to either coastal erosion or coastal inundation over the 100-year planning time frame is outlined within Table 10 below. Further consideration of the likelihood and consequence of these coastal hazards has been analysed and evaluated later in this report.



Derby Wharf and Rock Armour at High Tide (Tide Level Unknown).

Table 11 - Exposure of Assets to Coastal Hazards over the Planning Timeframe.

| Asset | Exposure | | |
|----------------------------|----------------------|----------------------|----------------------|
| | 2015 | 2060 | 2110 |
| Town Site Area | | | |
| Aboriginal Communities | Erosion & Inundation | | |
| Aged Care facilities | No Impact | Erosion | Erosion & Inundation |
| Caravan Park | Erosion & Inundation | | |
| Cattle Race | Erosion & Inundation | | |
| Cemetery | No Impact | Erosion | Erosion |
| Town Centre Properties | No Impact | Erosion & Inundation | Erosion & Inundation |
| Derby Airport | Erosion & Inundation | | |
| Derby Highway | No Impact | No Impact | Erosion & Inundation |
| Dinner Tree | Erosion | Erosion & Inundation | |
| Fishing Club | Inundation | Inundation | Erosion & Inundation |
| Jetty Road | Erosion & Inundation | | |
| Local Roads | Erosion & Inundation | | |
| Loch Street | No Impact | No Impact | Erosion & Inundation |
| Mangroves | Erosion & Inundation | | |
| Picture Gardens | No Impact | No Impact | Erosion & Inundation |
| Residential Properties | No Impact | Erosion & Inundation | |
| Shooters Precinct | No Impact | Erosion & Inundation | |
| Tidal Flats | Erosion & Inundation | | |
| Town Site Foreshore | Erosion & Inundation | | |
| Greenfield Land | No Impact | No Impact | Erosion |
| Wharfinger's House | No Impact | No Impact | Erosion & Inundation |
| Wool Shed & Tramway | No Impact | Erosion & Inundation | |
| Waste Water Treat Facility | No Impact | No Impact | No Impact |
| Wharf Area | | | |
| Recreational Ramps | Erosion & Inundation | | |
| Wharf Café | | | |
| Wharf Foreshore | | | |
| Wharf Structure | | | |

The values of the various assets potentially exposed to coastal processes was identified through the community engagement. Figure 7 below summarises the value of each of the potentially affected assets as identified by the local community. The vast majority of assets potentially exposed to coastal processes hold some level of social and/ or cultural value. In addition, it is noted that all environmental assets where considered to have some additional social/ cultural or economic value.

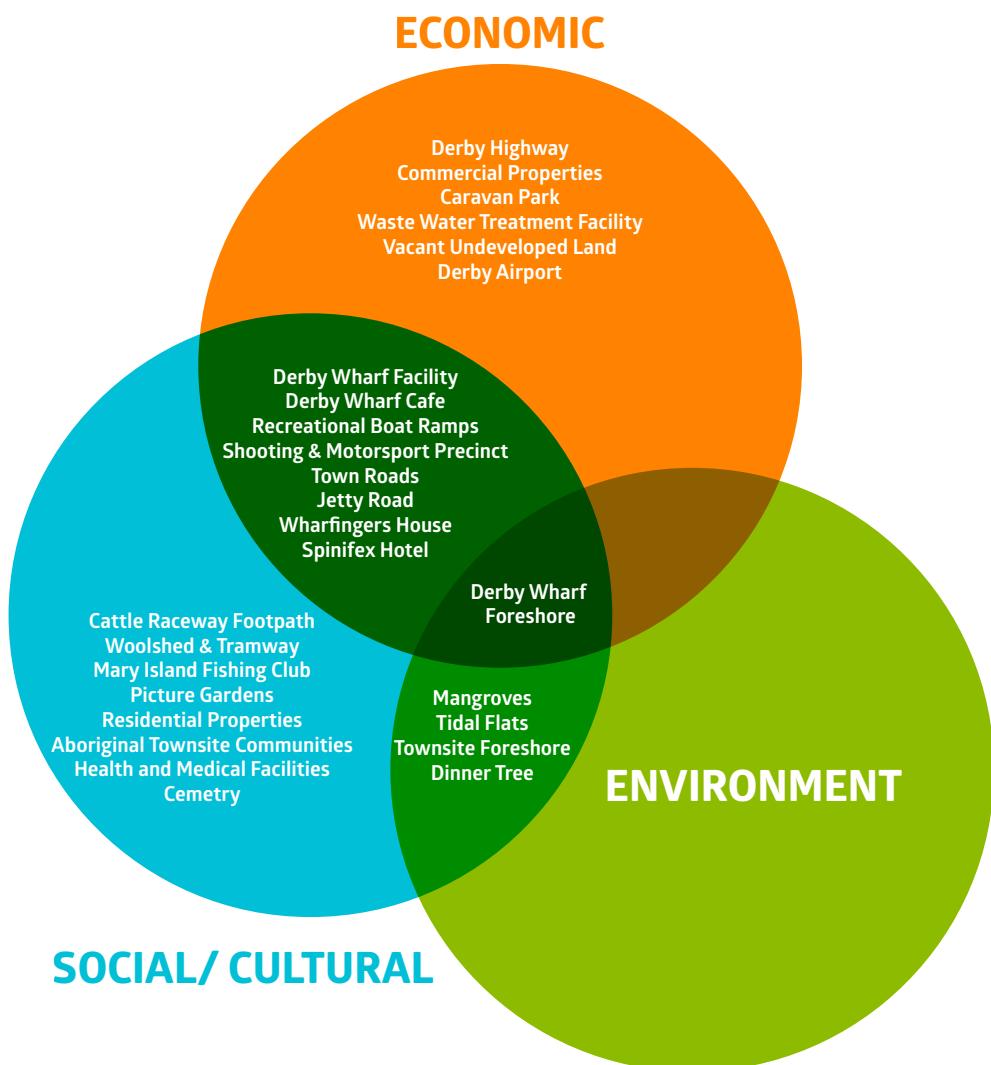


Figure 20 - Asset Values as Identified by Community.

In addition to determining the type of asset value, the community examined the value assets hold in relation to their current location. This was measured by the level of importance the current location of assets added to their value, measured as low, medium or high. Generally, most assets were considered to have a medium to high importance in their current location. This is not unexpected as there are limited assets within small

regional towns, and community members generally have a close connection to their historic development and layout. Assets that were identified to have a medium or high level of importance in their current location, show a preference for adaptation measures which promote the continuation of assets in their current location. The high value assets identified in the community consultation are identified in Table 11 below.

Table 12 - Assets with High Importance to their Current Location.

| Asset | Description of Asset |
|------------------------|---|
| Derby Wharf | Tourism, active wharf, social functions and recreation. |
| Derby Café | Tourism, recreation and culturally important. |
| Local Roads | Access for locals, tourists and workers. |
| Jetty Road | Access for locals, tourists and workers. |
| Wool Shed & Tramway | History and tourism. |
| Wharfinger's House | History and tourism. |
| Residential Properties | Homes for people. |
| Dinner Tree | Natural feature with cultural significance. |
| Cemetery | Resting place for people and historic to Derby. |



Wool Shed & Tramway facing Northwest.

SENSITIVITY

COASTAL INUNDATION

The CVS outlined the inundation exposure of study area under the present (2010), medium (2060) and long term (2110) time scenarios as summarised within Table 13 below.

Table 13 – Sensitivity of the Study Area from Coastal Inundation Processes.

| Coastal Inundation Processes | |
|-------------------------------------|---|
| Present (2010) | <p>Town Site Area: Built assets not inundated in the 1 in 10 or 1 in 100-year ARI events. Minor inundation under the 1 in 500-year ARI event occurs to properties on the northwest tip of the peninsula.</p> <p>Wharf Area: Land areas around the wharf are inundated under the 1 in 10-year ARI event, with inundation increasing under 1 in 100 and 1 in 500-year ARI. Access to the wharf would be cut off in the 1 in 500-year ARI event.</p> <p>Derby Airport: Not inundated under 1 in 10-year ARI event, with inundation increasing under 1 in 100 and 1 in 500-year ARI.</p> <p>Birdwood Rise: Not affected by coastal inundation.</p> |
| Medium Term (2060) | <p>Town Site Area: Built assets not inundated in the 1 in 10 or 1 in 100-year ARI events. In the 1 in 500-year ARI event inundation occurs to a maximum depth of 0.2m to properties along the coastline. A section of the main highway into Derby, north of the Derby airport is inundated under the 1 in 10-year ARI event to a depth of 0.3m, increasing to 0.5 – 1.0m under the 1 in 500-year ARI event.</p> <p>Wharf Area: Land areas inundated under from the 1 in 10-year ARI event. The access road is inundated in the 1 in 10-year ARI event, and experiences inundation to a depth of 0.3m under the 1 in 100-year ARI event and is completely inundated under the 1 in 500-year ARI event.</p> <p>Derby Airport: Larger areas of the runways are inundated under the 1 in 10-year ARI events, progressively greater under the 1 in 100 and 1 in 500-year ARI events.</p> |
| Long Term (2110) | <p>Town Site Area: Built assets inundated up to 0.3m in the 1 in 10-year ARI event and up to 0.5m in the 1 in 100-year ARI. Under the 1 in 500-year ARI event depths are consistent, however the number of properties impacted extends.</p> <p>Wharf Area: All land areas at the wharf are inundated under all 1 in 10, 1 in 100 and 1 in 500-year ARI events. Access to the area is completely cut off under all events.</p> <p>Derby Airport: Majority of the runway inundated in the 1 in 10-year ARI event up to 1.3m at the western edge of the runway. Inundation depth and extent increases across the planning timeframe, with 70% of the airport area inundated in the 1 in 500-year event.</p> |

COASTAL EROSION

The CVS and through other coastal literature, demonstrate the impact of coastal erosion on coastal lowlands with the unique protective characteristics of the study area, is not consistent to that experienced on open sandy coastlines. Therefore, the coastal erosion allowance determined under SPP2.6 for the study area is considered to be highly conservative and potentially detrimental to the future growth and development of the Derby town site.

The extent of likely coastal erosion as a result of storm surge was modelled to extend approximately 5m onto the Derby town site shoreline. This impact would be

almost entirely contained within the coastal reserve and tidal areas, with no impact to existing assets. In relation to long term coastal recession, the CVS outlined that erosion effects caused by sea level rise, "would result in no translation and associated erosion, just inundation corresponding to the magnitude of sea level rise".

In light of the above, while the extent of coastal erosion has been mapped and the exposure of assets identified, no assets are considered to be sensitive to coastal erosion.

ADAPTIVE CAPACITY

The potential loss experienced in relation to coastal hazard events is considered to have either tangible or intangible impacts as outlined within Figure 8 below.

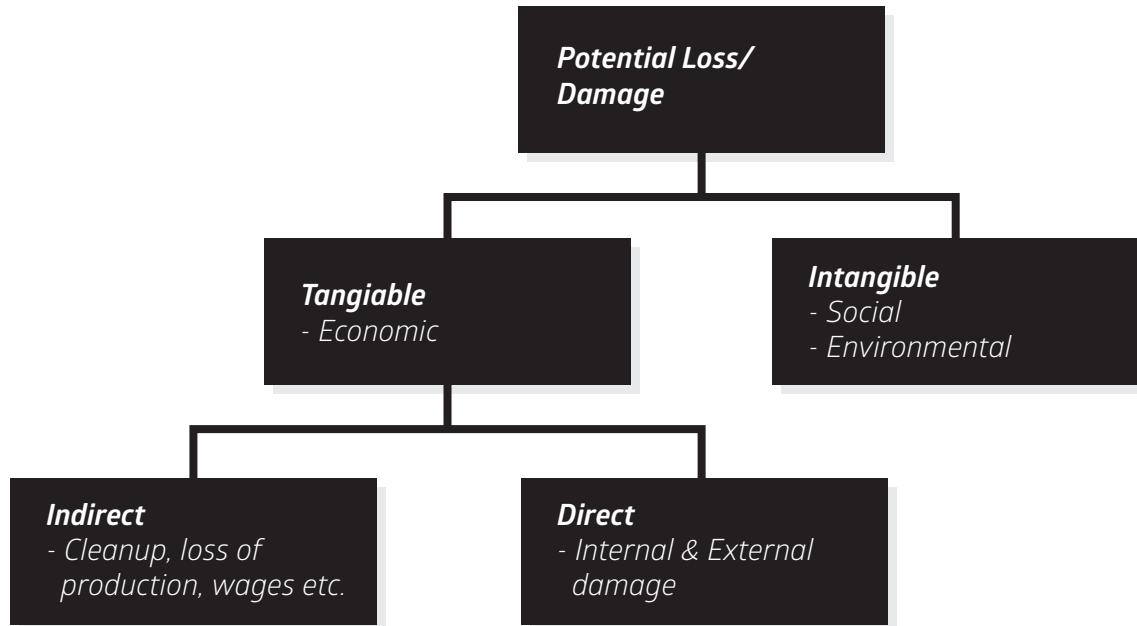


Figure 21 - Categories of Loss/ Damage from Costal Hazards.

The consequence of coastal hazard impacts on assets for each of the time scenarios has been undertaken in the subsequent section of this report. However, prior to determining the extent of impacts assets may experience

over the planning timeframe, there are a number of local factors which outline the adaptive capacity of the Shire and community in response to potential coastal hazards.

Table 14 Local Factors and Adaptive Capacity.

| Local Factor | Impact on Adaptive Capacity |
|----------------------|---|
| Community | <ul style="list-style-type: none"> Generally, have a low level of interest/ concern and no unified shared vision on responding to coastal hazards. This reduces the acceptance of management and adaptation measures being adopted. As such, major options which may have high financial value and potential to have a high social impact will be less favourable. |
| Community Layout | <ul style="list-style-type: none"> Coastal hazards currently impacting the town site are relatively constrained to the foreshore, however they do increase through to 2110. While there is additional undeveloped land outside of the coastal hazard prone areas, this has land is constrained. In addition, any significant relocation of land uses would see the loss of historic connection of the town. Buildings raised. |
| Building Design | <ul style="list-style-type: none"> There are already a number of raised houses within the Derby town site which would suitably accommodate the identified coastal inundation over the 100-year planning timeframe. |
| Shire Resources | <ul style="list-style-type: none"> Low capacity and resources to implement change and/ or undertake significant protection measures. However, there are funding opportunities available to increase capacity. |
| Emergency Management | <ul style="list-style-type: none"> Good practices in place through LEMA to respond to hazards events. |
| Environment | <ul style="list-style-type: none"> The local environment already experiences coastal processes, through tidal action. However, the landward migration of mangroves has been identified and could result in the reduction of protection for the study area coastline if removed. |
| Infrastructure | <ul style="list-style-type: none"> Essential services are generally protected, however the Derby Airport and Derby Wharf Area experience increasing coastal impacts over time. |

ANALYSIS

As outlined within the Coastal Guidelines, the analysis of potential coastal hazard risk requires the consideration of likelihood and consequence on specific assets. This section of the report provides an analysis of range of assets potentially at risk from the coastal inundation and coastal erosion hazards as identified previously in Table 10.

LIKELIHOOD

The Coastal Guidelines provides examples of methodology to quantify likelihood including the approach adopted within the Australian Standard Climate Change Adaption for Settlement and Infrastructure – A Risk Based Approach (AS5334 – 2013). Table 13 below outlines the various qualitative measures outlined within AS5334 – 2013.

In light of the below, there are numerous measures of predicting the likelihood of coastal events, all of which have inherent positives and negatives. The measure of likelihood applied herein was undertaken using a combination of the measures outlined within Table 13 above. The CVS provided an assessment of historic storm events and historical changes in geomorphology and vegetation. The CVS outlined that the most severe event to affect the town was in 1935 leading to 'at least a Category 2 impact on the town'. In addition, the CVS specifically stated that:

Historical storm surge events for Derby are sparse with no records of cyclonic storm tide events exceeding highest astronomical tide reported by the Bureau of Meteorology or in the recorded water level record at Derby.

In relation to the historic shoreline movement, the CVS further outlined that the Derby shoreline exhibits a stable shoreline, with no evidence of significant erosion over the analysis period (1949 – 2014). In light of the historical analysis undertaken within the CVS, in addition to anecdotal information obtained through community conversations, there is no evidence of a 1 in 100-year or 1 in 500-year ARI events occurring within the study area over the previous 80 years. Therefore, under the methodology outlined within AS5334 – 2013, the level of likelihood for the design 1 in 100-year storm event (coastal erosion storm event) and 1 in 500-year storm event (coastal erosion storm event) within SPP2.6 is considered rare.

Table 15 - Examples of Measures for Determining Likelihood (Source: AS5334-2103, 2014).

| Rating | Descriptor | Recurrent or event risk | Long term risks |
|----------------|--|---|--|
| Almost Certain | Could occur several times per year. | Has happened several times in the past year and in each of the previous 5 years. Could occur several times per year. | Has a great than 90% chance of occurring in the identified time period. |
| Likely | May arise about once per year. | Has happened at least once in the past year and in each of the previous 5 years. May arise about once per year. | Has a 60 – 90% chance of occurring |
| Possible | Maybe a couple of times in a generation. | Has happened during the past 5 years but not in every year. May arise once in 25 years. | Has a 40 – 60% chance of occurring. |
| Unlikely | Maybe once in a generation. | May have occurred once in the last 5 years. May arise once in 25 to 50 years. | Has a 10 – 30% chance of occurring. |
| Rare | Maybe once in a lifetime. | Has not occurred in the past 5 years. Unlikely during the next 50 years. | May occur in exceptional circumstances, less than 10% chance of occurring. |

CONSEQUENCE

The Coastal Guidelines outline that consequence needs to consider the impact that coastal hazards have on assets under each adopted time scenarios. Depending on the type of asset, consideration needs to consider either the financial, social and environmental consequences.

| Designation | Rating | Social | Economic | Environment |
|-------------|---------------|--|---|--|
| 1 | Catastrophic | Loss of life and serious injury. Large long-term or permanent loss of services, employment wellbeing, finances or culture (e.g. > 75% of community affected), international loss, no suitable alternative sites exist. | Permanent loss or damage to property, plant and equipment, finances > \$5 million. | Permanent loss of flora and fauna (no chance of recovery) with national impact. |
| 2 | Major | Serious injury. Medium-term disruption to services, employment wellbeing, finances or culture (e.g. < 50% of community affected), national loss, very limited suitable alternative sites exist. | Permanent loss or damage to property, plant and equipment, finances > \$2 - \$5 million. | Long-term loss of flora and fauna (limited chance of recovery) with regional impact. |
| 3 | Moderate | Minor injury. Major short-term or minor long-term disruption to services, employment wellbeing, finances or culture (e.g. < 25% of community affected), regional loss, limited suitable alternative sites exist. | Permanent loss or damage to property, plant and equipment, finances > \$100,000 - \$2 million | Medium-term loss of flora and fauna (recovery likely) with regional impact. |
| 4 | Minor | Small to medium disruption to services, employment wellbeing, finances or culture (e.g. < 10% of community affected), local loss, many suitable alternative sites exist. | Permanent loss or damage to property, plant and equipment, finances > \$10,000 - \$100,000. | Short-term loss of flora and fauna (strong recovery) with local impact. |
| 5 | Insignificant | Minimal short-term inconveniences to services, employment, wellbeing, finances or culture (e.g. < 5% of community affected), neighbourhood loss, many alternative sites exist. | Permanent loss or damage to property, plant and equipment, finances < \$10,000. | Negligible to no loss of flora and fauna (strong recovery) with local impact. |

Figure 22: Consequence Scale (Source: Coastal Guidelines, 2014).

COASTAL INUNDATION

In the context of the study area, the CVS demonstrated that coastal inundation is associated with temporary inundation under storm events as opposed to long term permanent inundation. As a result, the consequence experienced from design storm events is associated more with the time taken to repair and/ or replace damaged asset than the loss of use of an asset during the storm event. As such, understanding the consequence experienced by assets within the study area is primarily associated with the financial implication

resulting from design storm events. The consequence for each identified asset was determined by identifying the extent, depth and duration of coastal inundation experienced by assets within each time scenario.

The Table 14 below identifies the consequence of identified assets within the study area. These assets have been grouped into three areas being the Wharf Area, Town Site Area and area between which comprise the access routes. The increasing consequence is explained by the impact of sea level rise increasing the extent and depth of inundation over the 100-year planning timeframe.

Table 16 - Consequence Matrix Table.

| ASSET | Present (2015) | Medium Term (2060) | Long Term (2110) |
|--------------------------|----------------|--------------------|------------------|
| Wharf Area | | | |
| Wharf Structure | Minor | Moderate | Catastrophic |
| Wharf Foreshore | Moderate | Major | Catastrophic |
| Wharf Café | Minor | Minor | Moderate |
| Recreational Ramps | Insignificant | Minor | Minor |
| Intermediate Area | | | |
| Loch Street | No Impact | No Impact | Minor |
| Jetty Road | Minor | Moderate | Moderate |
| Town Site Area | | | |
| Derby Highway | No Impact | No Impact | Moderate |
| Cattle Race | Minor | Moderate | Moderate |
| Local Roads | Minor | Minor | Moderate |
| Wool Shed & Tramway | No Impact | Insignificant | Insignificant |
| Wharfinger's House | No Impact | No Impact | Moderate |
| Picture Gardens | No Impact | No Impact | Insignificant |
| Fishing Club | Insignificant | Minor | Moderate |
| Shooters Precinct | No Impact | Insignificant | Minor |
| Town Centre Properties | No Impact | Insignificant | Moderate |
| Residential Properties | No Impact | Insignificant | Minor |
| Aged Care facilities | No Impact | No Impact | Minor |
| Caravan Park | Insignificant | Insignificant | Moderate |
| Aboriginal Communities | Insignificant | Insignificant | Moderate |
| Derby Airport | Minor | Moderate | Catastrophic |

As outlined above, the majority of assets experience minor or insignificant levels of consequence within the present to medium term. Within the long term scenario, the level of consequence rises, with the majority of assets experiencing more minor to moderate levels of consequence. Only three assets experience catastrophic consequence levels, these assets are major public assets currently under management of the Shire being the Derby Wharf, Wharf Foreshore Area and the Derby Airport.

In relation to the determined levels of consequence, it must be noted that certain assets have been grouped together to understand the collective public consequence

of coastal inundation. For example, in the case of Town Centre Properties and Residential Properties, social consequence factors have been included to identify at which point the extent of private property consequence becomes a public concern (e.g. when the extent of community inconvenience becomes a public concern). As such, the level of consequence for these assets has been determined to experience insignificant levels of consequence in the medium term scenario and more minor/ moderate levels over the long term. However, depending on the level of sensitivity of individual assets, the resulting consequence for individual properties could be major or catastrophic.

COASTAL EROSION

The adopted policy position under SPP2.6 for identifying coastal erosion does not provide a high level of certainty within the context of the study area. Determining coastal erosion under SPP2.6 requires analysis of storm erosion (S1), historic shoreline movement (S2), erosion associated with sea level rise (S3) plus a factor of uncertainty over the planning timeframe.

The S1 and S2 components calculated for the study area have included local analysis and/ or modelling and are therefore considered appropriately resolved for consideration in calculating the consequence of coastal erosion. However, the S3 component and the factor of uncertainty are default components developed primarily for open sandy coastlines by applying the Bruun Rule. While SPP2.6 outlines this approach be adopted as a default for coastal lowlands, the CVS and other technical research identify this effect will have minimal to no erosive impact on sheltered coastal lowlands surrounded by extensive mudflats and mangrove communities. As explained within the CVS and outlined previously within

this report, the coastal processes impacting the Derby town site will not result in long term recession of the shoreline (Horizontal Shoreline Datum).

As a result of the above, the level of consequence for coastal erosion has been determined using the extent of the S1 and S2 components. The combined impact of the S1 (5m) and S2 (0m) component results in coastal erosion extending up to 5m into the Derby town site over the 100-year planning timeframe. As a result, the corresponding level of consequence on assets experience from coastal erosion is considered insignificant across all three times scenarios. This is supported through the historic review of shoreline movement undertaken within the CVS for the period from 1949 to 2014. This analysis which shows a slightly accreting and stable shoreline.

However, due to the unique sedimentology and geomorphology within the study area and the lack of guidance within the State Planning Policy Framework, additional modelling and time lapse analysis needs to be undertaken to provide more certainty about this hazard into the future.

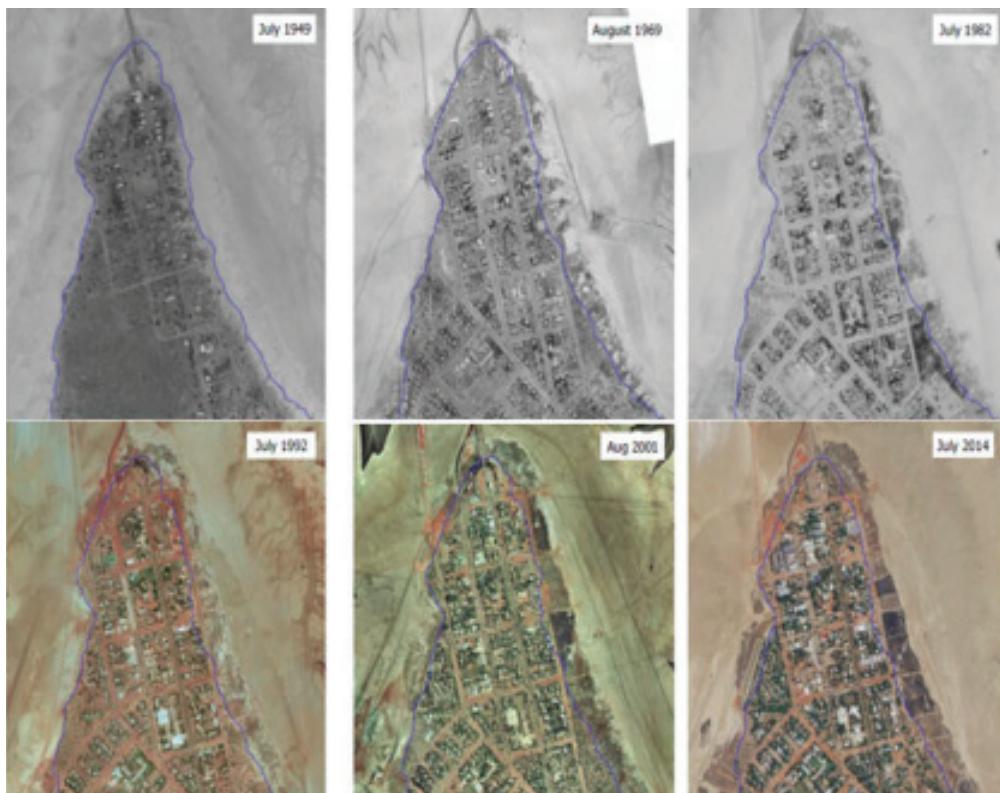


Figure 23: Historical Shoreline Movement 1949 - 2014 (Source: Derby Coastal Vulnerability Study, 2015).



EVALUATE

The evaluation of hazard risk levels has been undertaken under the methodology recommended within the Coastal Guidelines, determined by cross-referencing the likelihood of coastal hazard events with the corresponding level of consequence.

| Consequence | Risk level | | | | |
|--------------------|------------|---------------|---------------|-------------|---------------------|
| | high | extreme | extreme | extreme | extreme |
| 1 Catastrophic | high | extreme | extreme | extreme | extreme |
| 2 Major | high | high | extreme | extreme | extreme |
| 3 Moderate | medium | medium | high | high | extreme |
| 4 Minor | low | low | medium | high | high |
| 5 Insignificant | low | low | low | medium | high |
| | E Rare | D Unlikely | C Possible | B Likely | A Almost certain |
| | Likelihood | | | | |

Figure 24: Risk Priority Level Matrix (Source: Coastal Guidelines, 2014).

Following the recommendations within SPP2.6, once the level of hazard risk has been determined a risk tolerance scale can be developed to identify which risks are deemed acceptable, tolerable, unacceptable or intolerable. The level of acceptance/ tolerance of the hazard risk as it related to specific actions can then inform the determination of action(s). The underlying principle being to ensure that the identified coastal hazard risk is maintained and/ or reduced to acceptable/ tolerable levels.

| Risk level | Action required | Acceptance/tolerance |
|------------|---|--------------------------|
| Extreme | Immediate action required to eliminate or reduce risk to acceptable levels. | Unacceptable/Intolerable |
| High | Immediate to short-term action required to eliminate or reduce risk to acceptable levels. | Tolerable |
| Medium | Short to medium term action to reduce risk to acceptable levels, or accept risk. | Tolerable/Acceptable |
| Low | Accept risk. | Acceptable |

Figure 25 - Risk Tolerance Scale (Source: Coastal Guidelines, 2014).

COASTAL INUNDATION

Table 17 below cross references the likelihood and consequence of coastal inundation and outlines the level of coastal hazard risk for each asset over the three time scenarios.

Table 17 - Determined Risk Levels.

| ASSET | Present (2015) | Medium Term (2060) | Long Term (2110) |
|--------------------------|----------------|--------------------|------------------|
| Wharf Area | | | |
| Wharf Structure | Low | Medium | Extreme |
| Wharf Foreshore | Medium | High | Extreme |
| Wharf Café | Low | Low | Medium |
| Recreational Ramps | Low | Low | Low |
| Intermediate Area | | | |
| Loch Street | No Impact | No Impact | Low |
| Jetty Road | Low | Medium | Medium |
| Town Site | | | |
| Derby Highway | No Impact | No Impact | Medium |
| Cattle Race | Low | Medium | Medium |
| Local Roads | Low | Low | Medium |
| Wool Shed & Tramway | No Impact | Low | Low |
| Wharfinger's House | No Impact | No Impact | Medium |
| Picture Gardens | No Impact | No Impact | Low |
| Fishing Club | Low | Low | Medium |
| Shooters Precinct | No Impact | Low | Low |
| Town Centre Properties | No Impact | Low | Medium |
| Residential Properties | No Impact | Low | Low |
| Aged Care facilities | No Impact | No Impact | Low |
| Caravan Park | Low | Low | Medium |
| Aboriginal Communities | Low | Low | Medium |
| Derby Airport | Low | Medium | Extreme |

In summary of the table on the previous page, the level of coastal inundation risk experienced by assets within the study area is predominately considered acceptable. Therefore, in the public interest this risk can be maintained under review with existing control measures being appropriate. Where the coastal inundation risk increases to medium levels of risk routine operations should be maintained in addition to ongoing review.

In the case of private residential, commercial and industrial properties, the individual level of coastal inundation may cause these properties to experience high to extreme levels of risk. As such, actions will be required and applied when possible to ensure that the level of hazard risk is reduced and maintained at acceptable levels. Due to the limited extent of private properties impacted, the imposition of adaption actions is more equitably applied on a case by case basis as it related to individual properties.

Moving over the medium to long term scenarios, the level of risk on most assets generally remains at acceptable and/ or tolerable levels. The exceptions being the Derby Airport, Wharf Structure and Wharf Foreshore (which includes public amenities, car parking and laydown areas). These assets have been determined to have a potentially extreme level of hazard risk which would be unacceptable should this be experienced within the 100-year scenario. However, given the long lead time the Shire can incorporate actions within their asset management planning to ensure future works are undertaken with consideration to the exposure of coastal inundation over the life of the asset.



Eastern Fringe of the Derby Town Site facing Southeast.

COASTAL EROSION

In applying the risk analysis matrix as outlined within SPP2.6 the level of risk from coastal erosion is considered to be low for all assets across the planning timeframe. This is predominately the result of the expected consequence level being insignificant across the planning timeframe. When cross referenced with the possible likelihood of coastal erosion occurring in the present day, and the rare likelihood across the medium to longer term, the resulting risk level is low. As such the level of risk from coastal erosion processes is considered an acceptable risk under the current level of technical knowledge. However, to ensure future decisions are made with the most current technical information, ongoing monitoring and examination needs to be undertaken over time to increase the level of certainty of the likelihood and consequence of this hazard. This ongoing monitoring and examination will inadvertently address the current gaps within the State Planning Policy Framework.

ADAPDATION

The consideration of management and adaptation options to address the defined coastal hazards has been undertaken consistent with the methodology and hierarchy prescribed within the State Planning Policy Framework. However, to ensure that the adopted management and adaptation measures are appropriate, equitable and most importantly, achievable, the inclusion of local factors is fundamental to successful implementation.



Figure 26 - Methodology to Determine Appropriate Management and Adaptation Actions



STATE PLANNING POLICY FRAMEWORK

The hierarchy of options presented within SPP2.6 is a precautionary approach which places a high preference on avoiding new assets within hazard prone areas, and managing the retreat of assets already located within hazard prone areas. However, where the level of hazard risk is low, and/ or the value of assets within hazard prone areas is intrinsic to the location, SPP2.6 supports

the adoption of accommodation options which suitably address the identified level of risk. The least preferred adaptation option within SPP2.6 is the adoption of protection measures which use either soft solutions (e.g. beach nourishment, dune construction, etc.) and/ or hard solutions (e.g. groynes, seawalls, etc.) to mitigate coastal hazards. Figure 13 below outlines the hierarchy of adaption options as presented within SPP2.6.

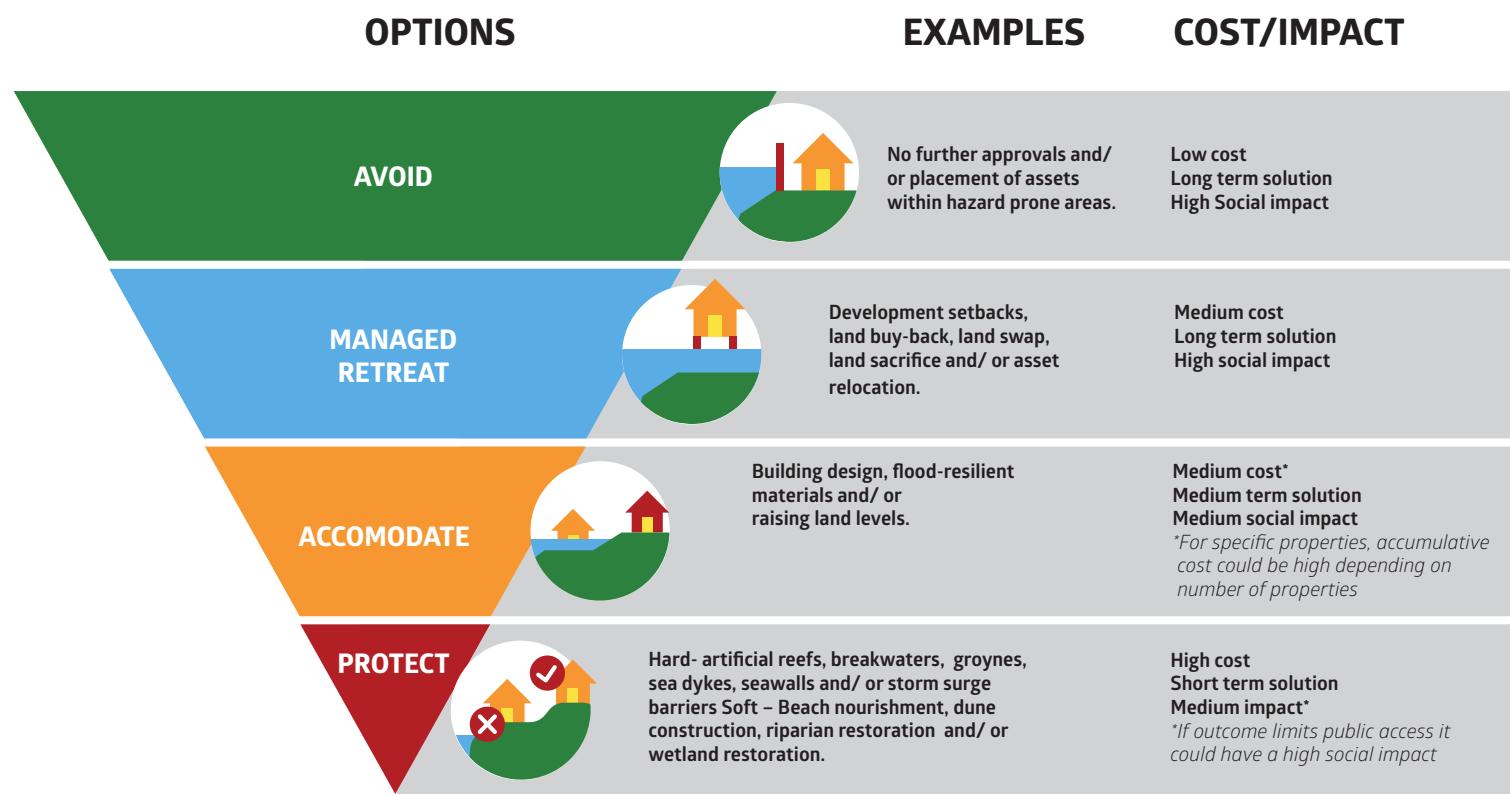


Figure 27 - Adopted Hierarchy of Adaptation Option under SPP2.6 (Source: Adapted from Coastal Guidelines, 2014 and Coastal Climate Change Infographic Series, 2016).

In addition to the recommended hierarchy of actions outlined within SPP2.6, the Coastal Guidelines recommendations how appropriate adaptation and management options can be determined. The various factors outlined within the Coastal Guidelines for consideration of options includes the:

- *Potential benefits;*
- *Effectiveness in reducing losses, or maximising opportunities;*
- *Cost of implementation and ongoing maintenance;*
- *Equity implications:*
 - ◊ *Which stakeholder bears costs of options?*
 - ◊ *Are the costs and/ or benefits shifted between stakeholders and if so is this fair and acceptable?*
 - ◊ *Whose values are being protected and/ or negatively impacted; and*
- *Impact of the treatment option on other objectives, including the introduction of new risks or issues*

SUMMARY OF LOCAL FACTORS

Through this CHRMAP three predominant local factors have identified; the level of hazard risk is acceptable and/or tolerable for almost all assets within the 100-year planning timeframe; the level of community awareness/concern of coastal hazards is low; and the Shire has limited resources and revenue. The combination of these local factors needs to be considered to ensure that adaptation options are equitable and more importantly, are able achievable.

The CHRMAP identified the predominant coastal hazard impacting the study area is short term coastal inundation associated with a major design storm events. As a result of the large tidal range and extensive mudflats protecting the study area, no permanent inundation

has been identified within the 100-year planning timeframe. The resulting level of risk from the coastal inundation hazard over the 100-year planning timeframe has been evaluated to be acceptable/ tolerable for the vast majority of assets. The exceptions being the Derby Airport, Derby Wharf and Foreshore Area which potentially experience extreme level of hazard risk within the 2110-time scenario. Under the methodology applied with SPP2.6 the study area is exposed to a potential coastal erosion hazard. However, the assessment of likelihood and consequence of this coastal hazard has resulted in assets experiencing a low level of hazard risk from coastal erosion, which has been identified as acceptable within the 100-year planning timeframe.

As a result of the acceptable/ tolerable level of risk for the vast majority of assets within the study area, it is not considered that any 'major' adaptation options (e.g. high cost and/ or significant social displacement) will be required within the 100-year planning timeframe. In addition, while a small minority of the community participated within the development of this CHRMAP, the majority of the community has a low level of interest/concern of coastal hazards. Therefore, while the values and concerns of the community have been captured and articulated within this CHRMAP, due to the low level community wide interest it is not further considered inappropriate to undertake any 'major' adaptation options until such time as community awareness/interest has increased.

In summary of the above, it is not considered appropriate for the Shire to allocate any significant finances and/ or resources to address what is in the majority a tolerable level of risk. However, this does not mean that no adaptation options are required, but rather appropriate accommodation actions should be undertaken to ensure the level of hazard risk does not increase. Table 16 outlined the various success criteria for the CHRMAP as identified from the various local factors.

Table 18 - Local Factors and Success Criteria.

| Local Factor | Success Criteria | |
|--------------|--|--|
| 1 | Local concern with potential limitations for growth of Derby by the imposition of the State Planning Policy Framework. | Ensure the State Planning Policy Framework does not negatively impact future growth of Derby. |
| 2 | Limited guidance within the State Planning Policy Framework to consider the unique local environment. | Develop and implement a program of ongoing monitoring/examination through a multiagency approach to ensure future decision making is reflective of local factors, and informs a review of the State Planning Policy Framework. |
| 3 | Low level of community knowledge and acceptance. | Ensure community knowledge and awareness is developed through ongoing community consultation. Increase the current level of community knowledge prior to proposing any major adaptation works. |
| 4 | Limited Shire resources and revenue. | Ensure the level/ experience of Shire resources in incorporated into the determination of proposed actions. |
| 5 | Available funding/ grant opportunities available to undertake coastal planning and implement adaptation actions. | Identify funding opportunities to ensure specific adaptation actions, monitoring and further investigation can be undertaken as required and prior to coastal hazards impacting becoming intolerable. |
| 6 | No existing controls in place to consider development and use within areas potentially at risk of coastal hazards. | Ensure a transparent and equitable approach is undertaken in developing a mechanism to guide land use and development decision making. |
| 7 | Shire currently developing holistic Asset Management Plan. | Ensure identified coastal hazards are considered within ongoing strategy development and asset management processes, including the Strategic Community Plan and Asset Management Plan. |

ASSESSMENT OF MANAGEMENT AND ADAPTATION OPTIONS

In light of the above, a multi-criteria matrix has been developed to ensure that any 'major' decision making is only triggered when coastal hazards become intolerable. The criteria were developed in respect of the predominate local factors and considers capital/on-going cost, climate uncertainty and social disruption. Due to the generally acceptable/tolerable level of risk, low level of awareness and limited resources, the need for extensive cost benefit analysis is not considered cost effect at this stage. Table 17 below outlines the various criteria developed to identify the level of decision making for each proposed adaptation option, as being either:

- Major: Option(s) are not considered appropriate due to the identified hazard level. Options can be investigated in the future as risk increases.
- Considered: Options(s) may be appropriate but should be subject to be more detailed analysis on specific assets.
- Low: Options(s) have minimal negative consequences and can be implemented with no further cost-benefit required.

Table 19 - Multi-Criteria Factors.

| | | Major | Considered | Low |
|----------------------------|---------------------|---|---|---|
| Financial | | | | |
| 1 | Capital Cost | > \$300,000 | \$50,000 - \$300,000 | < \$50,000 |
| 2 | Maintenance Cost | > \$300,000 | \$50,000 - \$300,000 | < \$50,000 |
| 3 | Technical Viability | Requires substantial engineering investigations to determine viability. | Likely to be viable, however requires further investigation to confirm. | Is technically viable with no or limited, further investigation required. |
| Climate Uncertainty | | | | |
| 4 | Flexibility | Irreversible and non-adaptive. | Can be reverse/ adapted, however at considerable cost | Can easily, or naturally, be removed or adapted, or has no longer term negative impact. |
| 5 | Impact | Indirect or direct negative impacts on other critical factors. | No direct impact, however may provide some indirect impacts. | Directly benefits on other critical factors. |
| 6 | Decision Horizon | Does not provide long term solution. | Does not provide long term solution, however may prolong need for a major decision. | Provides a long term solution. |
| Social | | | | |
| 7 | Accessibility | Reduces, or complete stops use of the coastal environment. | Has limited, no negative access or recreation impacts. | Increases access to the coast and recreation opportunities. |
| 8 | Landscape | Will impact negatively on environment quality or amenity. | No net impact on environment quality or amenity. | Will benefit environment quality or amenity. |

As identified previously, the principle coastal hazard impacting the study area within the 100-year planning timeframe is short term coastal inundation associated with a major design storm event. It is not relevant to consider adaptation options designed to managed/ adapt to coastal hazards not experienced within the study area, including permanent coastal inundation, storm bite erosion or long term shoreline recession. Prior to undertaking the multi-criteria analysis, the range of potential adaptation options was narrow to identify only those options effective in responding to short term coastal inundation.

The results of the multi-criteria analysis is outlined within Table 18 below. The criteria have been arranged to allow early identification of inappropriate options (e.g. principally financial implications). Where options

were identified as being 'major' decisions, no further assessment was undertaken. As outlined below, the use of protection measures and the majority of managed retreat options were identified as 'major' considerations due principally to their capital cost. The range of accommodate options analysed were demonstrated to be predominately low decisions, with some criteria being more considered. While the accommodation options appear appropriate, they will need to be applied on to ensure the extent of costal inundation hazard is appropriately accommodated on a case by case basis. While development setbacks could also provide a suitable option, due to the low level of hazard risk, and the potential to cause significant social upheaval, this adaptation option is not considered appropriate at this point in time.

Table 20 - Multi-Criteria Assessment.

| Adaptation Options | 1. Capital Cost | 2. Maintenance Cost | 3. Technical Viability | 4. Flexibility | 5. Impact | 6. Decision Horizon | 7. Accessibility | 8. Landscape |
|------------------------------|-----------------|---------------------|------------------------|----------------|-----------|---------------------|------------------|--------------|
| Regenerative Protect Options | | | | | | | | |
| Dune Construction | Red | White | White | White | White | White | White | White |
| Engineering Protect Options | | | | | | | | |
| Storm Surge Barrier | Red | White | White | White | White | White | White | White |
| Managed Retreat Options | | | | | | | | |
| Development Setbacks | Green | Green | Green | Yellow | Green | Green | Yellow | Green |
| Land buy-back/ Swap | Red | White | White | White | White | White | White | White |
| Land sacrifice | Red | White | White | White | White | White | White | White |
| Relocation | Red | White | White | White | White | White | White | White |
| Accommodate Design Options | | | | | | | | |
| Flood Proof Design | Yellow | Green | Green | Yellow | Green | Green | Yellow | Green |
| Raise Land Level | Yellow | Green | Green | Yellow | Yellow | Yellow | Yellow | Yellow |
| Notifications | Green | Green | Green | Green | Yellow | Yellow | Green | Green |

In summary of the multi-criteria assessment, protect and the majority of managed retreat options are considered 'major' decisions due principally to their initial capital cost. Considering the acceptable/ tolerable levels of risk identified for the majority of assets within the 100-year planning timeframe, it is considered the most equitable approach is to implement accommodation options focused on the specific areas potentially at risk from coastal inundation within the 100-year planning timeframe. In addition to the predominately acceptable/ tolerable level of risk, there are a number of other local factors that would limit the adoption of 'major' adaptation options, namely; the low level of community interest/ concern about coastal hazards; the limited scope of the State Planning Policy Framework for the unique coastline; and limited Shire resources. As such, in addition to adopting an accommodation approach it is important that measures are undertaken to improve community awareness of coastal processes over time, and develop a more site specific mechanism to better understand and record coastal hazard into the future.

In light of the above, the accommodation approach will ensure the level of coastal hazard risk is not increased, and where necessary, the level of coastal hazard risk impacting assets over the 100-year planning timeframe is reduced. This will be undertaken through the assessment of planning and building applications. The development application process will ensure that major modifications to existing developments and new infill development within the Derby town site have suitable measures applied to accommodate identified coastal hazards through a combination of site layout and/ or building design as appropriate. The development application process also provides an opportunity to apply notifications on property title(s) to increase awareness of the specific coastal hazard(s) impacting a particular property. Where applications are received for land use and development within greenfield areas that area at risk of coastal hazards within the 100-year planning timeframe, these applications should not be supported.

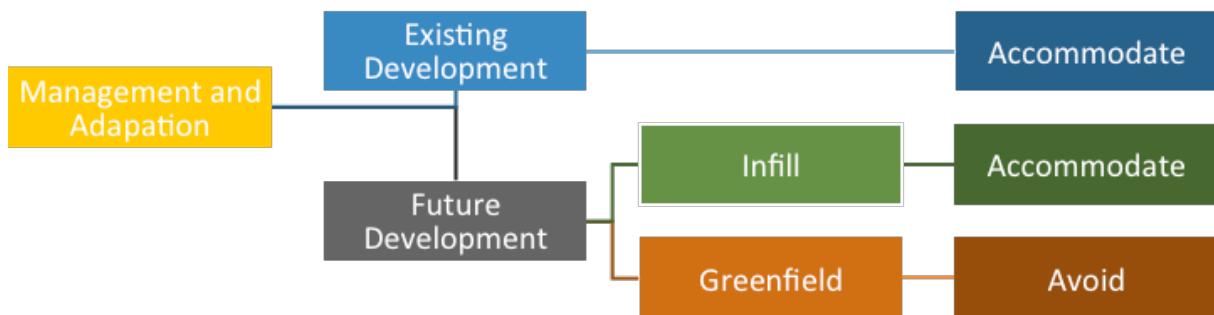


Figure 28 – Adopted High Level Management and Adaptation Approach

IMPLEMENTATION MECHANISMS

As the level of coastal inundation and coastal erosion hazard risk is acceptable/ tolerable, an equitable and practical approach to spending community funds needs to be considered and applied only when hazard risk levels start to become intolerable. Due to the long lead times before assets experience intolerable levels of hazard risk, no ‘major’ adaptation actions should be considered at this stage. Rather, it has been determined that a more suitable approach is to appropriately identify those areas at risk from coastal hazard risk and ensure that suitable mechanisms are implemented to accommodate the relevant coastal hazard. As such the following measures have been determined as appropriate to implement accommodation options and to appropriately advise both current and future owners of assets at risk from coastal inundation and coastal erosion over the 100-year planning timeframe:

- Update the Shire of Derby / West Kimberley Town Planning Scheme to ensure that the extent of the hazard prone area is mapped and set objectives to ensure land use and development within the hazard prone area has the appropriate consideration of coastal hazard risk.
 - Develop a range of suitable development standards through a local planning policy to ensure applications for existing, infill and greenfield land use and development appropriately accommodates the associated level of coastal inundation risk while not negatively impacting the local community.
- Notifications are placed on property titles at the time of subdivision and / or development application to ensure that both existing and future landowners are notified of the specific coastal hazards related to their property.
 - Update the Shire of Derby / West Kimberley Asset Management Plan to ensure that the construction and/ or maintenance of public assets incorporates the relative level and extent of coastal inundation over the life of the asset.
 - Develop an ongoing monitoring/ examination program of the Derby shoreline and coastal hazards is prepared in collaboration with a range of qualified stakeholders and is implemented.
 - Develop a targeted public communication/ education program in collaboration with a range of qualified stakeholders to increase community knowledge and awareness of coastal hazards.
 - Seek opportunities to secure funding which allows additional monitoring, examination and consultation to be undertaken prior to hazard risk levels reaching intolerable levels.
 - Incorporate measurable actions within the Shire of Derby / West Kimberley Strategic Community Plan that focus on; increasing community awareness; including coastal hazards within asset management planning; including coastal hazards within land use and development decision making; and ongoing monitoring/ examination of the shoreline and coastal hazards to inform future decision making.

TOWN PLANNING SCHEME

The Town Planning Scheme (TPS) is the central planning instrument at the local government level. The TPS contains the Scheme Maps and Scheme Text. The Scheme Maps outline the various zones and reserves each which has a particular purpose. The Scheme Text prescribes the land use(s) and development which may, or may not be permitted in the various zones and reserves. In addition, the Scheme Text establishes the standards, conditions and special controls relevant to the use and development of land within the different zones and reserves.

It is proposed to implement a 'Special Control Area' within the Scheme Maps to outline land within the Shire that is exposed to coastal hazard risk over the 100-year planning timeframe. The 'SCA' will encompass the further extent of either coastal erosion or coastal inundation and articulate that this land as potentially subject to coastal hazard risk. While coastal erosion, and to a large extent coastal inundation are considered acceptable/ tolerable risks in the public interest, there still remains the possibility for land and assets within this area to be affected by coastal hazards over the 100-year planning timeframe. As such, the 'SCA' will appropriately advise current and future land owners of the potential coastal hazard risk. To support the Scheme Maps, it is proposed to include modifications to the Scheme Text to appropriately:

- Articulate the extent of land subject to the 'SCA';
- Articulate the intent and purpose of the 'SCA';
- Outline the range of development that is not exempt from planning approval (e.g. single house, and/ or significant modifications to existing developments);
- Outline that development and land use within the 'SCA' will be assessed in consideration of State Planning Policy 2.6 - State Coastal Planning and any Local Planning Policy; and
- Outlined that the Shire may impose a Notification on Title through the assessment of development applications to outline the nature of coastal hazards impacting the subject site.

The Shire is currently preparing a new Local Planning Scheme and it is proposed that the above 'SCA' measures should be adopted and advertised through the preparation of the new Local Planning Scheme.

LOCAL PLANNING POLICY

The highly detailed coastal hazard mapping delivered through the Coastal Vulnerability Study allows for the assessment of land use and development to be determined on a case by case basis. A Local Planning Policy provides a flexible mechanism for the Shire to clarify the application and requirements for land use and development within the 'SCA'. The application of development standards within the Town Planning Scheme is considered too restrictive and does not provide the flexible to develop performance based solutions to accommodate coastal hazards over time.

As coastal erosion risk is considered acceptable within the 100-year planning timeframe for both the public and private interest, no accommodation measures will be required through the development assessment process. However, development on properties at risk of coastal erosion will still be required to be submitted for planning approval. This provides the Shire the ability to ensure that appropriate notifications are placed on the property title to reflect the specific level of hazard risk.

In relation to properties potentially at risk from coastal inundation, the determination of applications for land use and development will depend on the depth, extent and duration of coastal inundation within a particular property. The general methodology is that the larger the extent and/ or the depth of inundation on a particular property, the greater level of accommodation measures required. While applications for development will be considered on a case by case basis, the Local Planning Policy will outline a number of acceptable solutions that can be implemented to accommodate coastal inundation. Where proponents for development seek to implement alternative, performance based criteria, the Shire may accept these proposed solutions subject to consistency with the Local Planning Policy and the State Planning Policy 2.6. While the Local Planning Policy is currently in development, the following outlines examples of

appropriate acceptable development measures applied within other coastal jurisdictions:

- Locating development in portion of the subject site not impacted by coastal inundation;
- Raising the finished floor level of development above the level of the 100-year coastal inundation extent (e.g. 300mm above the highest level of inundation); and/ or
- In the case of multiple storey developments, placing habitable rooms on the second level and above the 100-year coastal inundation extent.

To ensure these actions are undertaken, measurable actions need to be implemented within the Shire of Derby / West Kimberley Strategic Community Plan.

NOTIFICATIONS ON TITLE

In addition to the application of acceptable development and/ or performance criteria through the assessment of planning applications, the Shire may also request that a Notification on Title be placed on the respective property title.

The Notification on Title will ensure that existing and future landowners are aware of the specific coastal hazards as they relate to the particular property. As such, the Shire may request notifications be placed on properties impacted by either coastal erosion and/ or coastal inundation. However, the wording of a particular notification will be specific to accurately describe the nature and extent of the relative coastal hazard. The specific imposition of Notifications of Title will establish an equitable balance between claims for negligence on behalf of the Shire should coastal hazards events occur, and the potential increase in costs for development proponents.

ASSET MANAGEMENT

The Shire is currently undertaking a holistic review of the range of public assets within the study area and developing an integrated asset management process. As such, the nature, extent and timing of coastal hazards will be implemented into the decision making for the maintenance, upgrade and development of new assets.

Any identified coastal adaption works that are required over time should be appropriately captured within the asset management planning and included within the Shire's Corporate Business Plan and Long Term Financial Plan. Due to the generally acceptable/ tolerable level of coastal hazard risk for public assets within the immediate and medium term no coastal adaptation works have been considered within this CHRMAP.

To ensure these actions are undertaken, measurable actions need to be implemented within the Shire of Derby / West Kimberley Strategic Community Plan.

MONITORING/ EXAMINATION

Coastal management and adaptation planning should be undertaken on the best available technical knowledge available. Through the Coastal Vulnerability Study, detailed investigation, assessment and modelling of the study area has been undertaken. As a result, there is a high level of certainty regarding the nature and extent of coastal hazards impacting assets within the study area. While there is currently a high level of technical knowledge of coastal processes impacting the study area, ongoing monitoring and investigation should be undertaken over time to ensure that technical knowledge remains contemporary. At this stage a highly detailed level of investigation has been undertaken which has identified that coastal hazards within the study area are acceptable/ tolerable within the immediate to medium time scenarios.

However, due to the limited scope of the State Planning Policy Framework to consider the unique characteristics of the study area, site specific investigation and monitoring needs to be undertaken to ensure that coastal hazards are appropriately documented and considered into the future. Therefore, prior to the development of any monitoring/ examination program, a Steering Group of relevant agencies needs to consider and approve a site specific monitoring/ examination program that will be acceptable under the current State Planning Policy Framework.

To ensure these actions are undertaken, measurable actions need to be implemented within the Shire of Derby / West Kimberley Strategic Community Plan.

COMMUNITY EDUCATION/ AWARENESS

There is currently a very low level of awareness/ interest from the local community regarding coastal hazards impacting the study area. While it is fortunate that the identified coastal hazard risk is acceptable/ tolerable, should the identified levels of risk increase overtime then 'major' decision making will be required. This 'major' decision making will have significant impact on the community though either high level capital costs and/ or social disruption. Therefore, the Shire will develop a community education/ awareness program to convey the current technical knowledge and to update the community with the subsequent monitoring/ examination.

To ensure these actions are undertaken, measurable actions need to be implemented within the Shire of Derby / West Kimberley Strategic Community Plan.

FUNDING

The current level of coastal hazard risk does not require any significant allocation of Shire resources to accommodate the identified risk. Over the next 5 years the majority of identified actions can be undertaken through the allocation of existing Shire resources. However, the Shire will require additional support to ensure that appropriate monitoring/ examination and community awareness is undertaken over time. There are a number of State funding opportunities directly aligned with coastal adaptation and management that can increase the capacity of the Shire to undertake these identified actions.

Coastal Management Plan Assistance Program (CMPAP) grants are provided by the Western Australian Planning Commission to support coastal land managers to develop strategies and management plans for coastal areas at risk from coastal hazard risks. The funding is available for a range of strategies and management plans that meet the components of the CHRMAP guidelines and the objectives of the CMPAP. Under the CMPAP funding for 2017/18, \$275,000 was made available with a maximum of \$75,000 available for specific projects. While the 2017/18 application period has closed, the CMPAP grant is provided annually.

Coastal Adaptation and Protection (CAP) grants are provided by the Department of Transport to support coastal land managers to understand and adapt to coastal hazards. The range of suitable projects that can be undertaken under the CAP program includes coastal monitoring, investigation, asset management, coastal adaptation and maintenance works. Under the CAP funding there is a between \$10,000 - \$300,000 available for specific projects, provided on a dollar for dollar basis. While the 2017/18 application period has now closed, the CAP grant is provided annually.

While both the CMPAP and CAP application periods have closed for the 2017/18 period, this provides the Shire time to appropriately articulate the scope of works and associated costs for monitoring/ examination projects, and allocate Shire resources prior to requesting funding. In the interim there are a range of actions the Shire can implement under the current resources.

To ensure these actions are undertaken, measurable actions need to be implemented within the Shire of Derby / West Kimberley Strategic Community Plan.

IMPLEMENTATION

This CHRMAP has identified that the level of coastal inundation and erosion hazard risk is generally acceptable/ tolerable over the 100-year planning timeframe. Due to the limited consequence of coastal erosion on all assets within the study area, no management and/ or adaptation actions have been identified to address this coastal hazard. However, a range of accommodation actions have been identified to ensure the hazard risk associated with coastal inundation remains at acceptable/ tolerable levels. The assets that have been identified to experience intolerable levels of coastal inundation risk within the 100-year time scenarios are major public infrastructure being the Derby Airport, Derby Wharf and Derby Foreshore Area. Adaptation of these assets will be informed through the Shire's asset management plan. While the coastal erosion risk is identified as acceptable over the 100-year planning timeframe, ongoing site specific monitoring and examination needs to be developed to better inform gaps within the State Planning Policy Framework.

FIVE-YEAR IMPLEMENTATION PLAN

Under SPP2.6 and the Coastal Guidelines, it is recommended that management and adaptation planning needs to consider the 100-year planning timeframe. However, given the low level of community awareness, the inherent uncertainty in coastal processes and the need to undertake decision making on the most up-to-date technical knowledge a five-year review has been articulated. This five-year review provides an opportunity to incorporate additional technical knowledge and community awareness into coastal hazard risk management and adaption planning for the future.

In light of the above, the approach over the next five years is to accommodate the existing coastal inundation hazard while undertaking ongoing monitoring and examination of the shoreline and ongoing community awareness. Due to the unique environment and geomorphological characteristics of the Derby shoreline, this CHRMAP recommends that prior to implementing any monitoring/ examination program that a specific scope of works is developed as a priority. This scope of works should be developed by a range of stakeholders to ensure the methodology is appropriate and consistent with the State Planning Policy Framework.



Example of a house in Derby with elevated finished floor levels.

Table 22: Five Year Implementation Plan

| Action/ Strategy | Responsibility | Timing |
|--|-----------------------------|-------------|
| Responding to Land Use and Development | | |
| 1. Modifications to Town Planning Scheme | | |
| a. Ensure the new Town Planning Scheme Mapping incorporates the areas at risk of coastal inundation and coastal erosion within a 'Special Control Area'. | SDWK | 2018 |
| b. Develop suitable objectives and development controls for the 'Special Control Area' and incorporate within the new Town Planning Scheme Text. | SDWK | 2018 |
| 2. Development of Local Planning Policy | | |
| a. Liaise with other local government authorities and the West Australian Local Government Association to understand the suitability development controls to manage coastal inundation. | SDWK | 2017 |
| b. Develop a Local Planning Policy to guide the assessment of development applications for properties at risk of coastal inundation. | SDWK | 2017 |
| 3. Implementation of Notifications on Title | | |
| a. Develop suitable notifications which consider the range and extent of coastal hazards impacting properties. | SDWK | 2017 |
| b. Peer review the proposed notifications to determine extent to mitigate liability and equitability for landowners. | SDWK | 2017 |
| c. Implement Notifications on Title through the assessment of development applications. | SDWK | Ongoing |
| 4. Property Settlement Enquires | | |
| a. Identify coastal hazards on Property Settlement Enquiries. | SDWK | Ongoing |
| Asset Management | | |
| 1. Asset Management | | |
| a. Incorporate the identified coastal hazard risk within current asset management planning | SDWK | 2017 |
| b. When considering maintenance and/ or development of new assets ensure coastal hazards are considered and suitable adaption/ management actions implemented. | SDWK | Ongoing |
| c. Establish a coastal hazard adaptation and management fund to provide mechanism to allocating funding when and if required. | SDWK | 2017 |
| Improving Knowledge and Awareness | | |
| 1. Monitoring/ Examination | | |
| a. Establish multiagency reference group to outline a scope of works consistent with SPP2.6 | SDWK | 2017 |
| b. Undertake reference group meeting(s) to development scope of works including where, when and how monitoring and investigation should be undertaken. | SDWK & Reference Group | 2017 – 2018 |
| c. Finalise scope of works and indicative costings and apply for funding from CMPAP and/ or CAP. | SDWK | 2018 |
| d. Appoint consultant team and implement monitoring/ examination. | SDWK & Consultant Team | 2018 - 2022 |
| 2. Communication Program | | |
| a. Approve CHRMAP and upload documents to Shire website. | SDWK | 2017 |
| b. Prepare and distribute CHRMAP project summary and FAQ. | SDWK | 2017 |
| c. Presentation within Local Emergency Management Committee (LEMC) to share information and discuss opportunities for ongoing monitoring and information sharing. | SDWK & LEMC | 2017 |
| d. Develop Community Awareness Plan to: <ul style="list-style-type: none"> - Strengthen profile of coastal hazards and climate change within the community. - Increase awareness of businesses and property owners at risk of coastal hazards to increase preparation - Establish/ strengthen relationships with community members/ groups to facilitate monitoring activities, - raise awareness of adaptation options. | SDWK | 2017 – 2022 |
| 3. Ensure local strategies/ plans incorporate coastal hazard risk. | | |
| Incorporate measurable actions within the Shire's Strategic Community Plan in regards to: <ul style="list-style-type: none"> - Increased community awareness of coastal hazards. - Inclusion of coastal hazards within asset management. - Ongoing monitoring and examination of coastal hazards. | SDWK | 2017 – 2018 |
| 4. Review and update CHRMAP | | |
| a. Collate existing information and prepare scope of works to undertake review of CHRMAP | SDWK | 2021 |
| b. Apply for funding from CMPAP and/ or CAP to appoint a suitably qualified consultant team to review the CHRMAP. | SDWK | 2021 |
| c. Prepare Request for Tender, appoint consultant team and undertake review of the CHRMAP. | SDWK & Appointed Consultant | 2022 |

100-YEAR IMPLEMENTATION PLAN

Under the current level of technical knowledge, the approach over the 100-year planning time is to continue with accommodation strategies for assets within the Town Site Area.

The Derby Airport and Wharf Area could potentially experience intolerable levels of hazard risk level in the long term scenario. These are both public assets which hold a high level of community value. A commitment will need to be made prior to the level of risk becoming intolerable, whether to commit to protect or managed retreat options for these assets. This decision should not be made until coastal hazard have be refined further through additional monitoring and examination. As such, the approach is to accommodate over the next five years, and under the CHRMAP review the long term approach can be confirmed.

Table 23 - Longer Term Implementation Plan

| | | 0 – 5 years | 5 – 20 years | 20 – 50 years | 50 – 100 years | |
|-----------------------|--|---------------|----------------------------|----------------------------|----------------------------|--|
| | | Review CHRMAP | Protect or Managed Retreat | Protect or Managed Retreat | Protect or Managed Retreat | |
| Wharf Area | | | Accommodate | Accommodate | Accommodate | |
| Derby Airport | | | Accommodate | Accommodate | Accommodate | |
| Town Site Area | | | Accommodate | Accommodate | Accommodate | |

Birdseye View of the Tip of the Derby Town Site and the Derby Wharf Area.



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The background of the page is a large, high-angle aerial photograph of a coastal town. The town features several clusters of houses and buildings, some with red roofs, surrounded by green trees and shrubs. A network of dirt roads and paths cuts through the landscape. To the right, a wide, light-colored sandy beach stretches towards the horizon. The sky above is bright and clear.

APPENDIX 1

COASTAL HAZARD MAPS